


Recent Advances in Engineering, Science and Technology Volume - I

Chief Editor : Dr. S. B. Warkad

Editor : Dr. R. D. Ghongade

Affiliation

P. R. Pote (Patil) Education & Welfare Trust's, Group of Institutions,
College of Engineering & Management, Amravati



Recent Advances in Engineering, Science and Technology

Volume - I

Chief Editor : Dr. S. B. Warkad

Editor : Dr. R. D. Ghongade

Affiliation

**P. R. Pote (Patil) Education & Welfare Trust's College of
Engineering & Management, Amravati**



Copyright © DnyanPath Publication, Amravati (INDIA)

No part of this publication may be reproduced or distributed in any form or by any means, electronic, mechanical, photocopy, recording, or otherwise or stored in a database or retrieval system without the prior written permission of publishers. This edition can be exported from India only by the Publishers.

The editorial board does not necessarily agree with all the research articles included in this edited book.

Recent Advances in Engineering, Science and Technology

Volume - I

Chief Editor : Dr. S. B. Warkad

Editor : Dr. R. D. Ghongade

Published by the **DnyanPath Publication (INDIA)**

A Leading **National Books Publishing** House In India

The First edition published in 1st March 2022

ISBN 13 : 978-93-91331-40-5

DnyanPath[®]
Publication
Write well - Right now
ISO 9001 : 2015

A Leading **National Books Publishing** House In India

Visit us



www.dnyanpath.org

Reg. Office : FFS-A, Block C, First Floor, Venus Plaza, Shegaon Naka, V.M.V. Road,
Amravati - 444 603 (Maharashtra)

Our Network : Maharashtra, Delhi, Gujrat, Chattisgarh, Telangana, Bihar.

Visit us : www.dnyanpath.org

Contact us : dnyanpathpub@gmail.com

Phone : 08600353712, 09503237806

Printed at Shri Gurudeo Printers, Amravati.

Mahatma Fule Sankul, Shegaon Naka,

V.M.V. Road, Amravati - 444603 (Maharashtra)

Price : ₹ 500/-



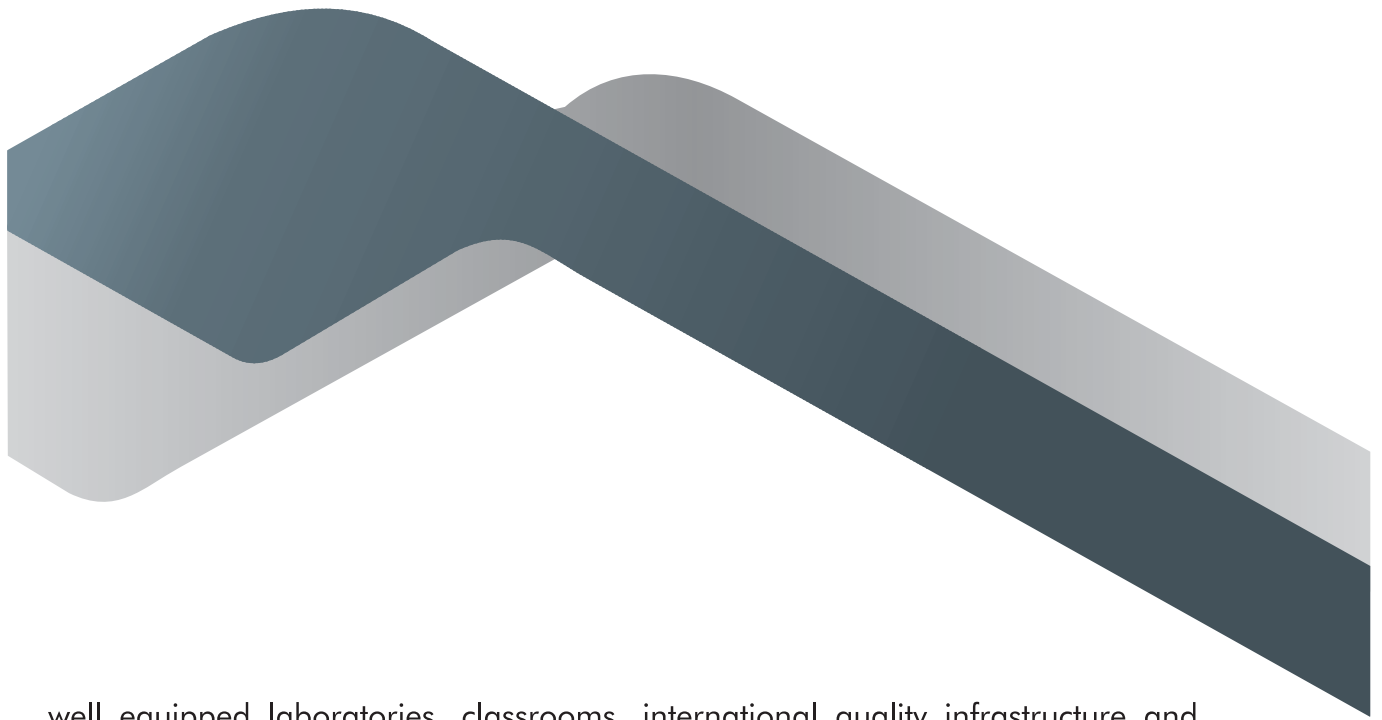
From the Desk of the Principal

It gives me a great pleasure to published Book entitled "Recent_Advances in Engineering, Science & Technology-Vol-I".

Academic research has gone through many revolutions. However, the advent, rapid succession and subsequent widespread use of information technology have completely revolutionaries the emerging research trends. Traditional environment in academic technologies have change to advance. Continuous development in technologies have brought change in traditional human life and converted these into digital life.

We are sure that scholars are eagerly waiting for the same kind of platform to showcase their achievements, skill, and experiences. Your contribution in this book will definitely encourage us and moreover will guide to change the outlook of our new generation toward the modern and advance professional engineers.

P. R. Pote (Patil) Education & Welfare Trust's Group of Institutions, Amravati is a foremost name in higher Education in Maharashtra. Since its inception, the trust has been successfully conducting undergraduate and post graduate courses in emerging areas. It has 10 institutes under one roof. The Group offers undergraduate as well as post graduate courses in various disciplines of Engineering, Management and Technology. Various courses offered by the Group include ME, BE, MBA, MCA, B. Arch, B.Ed., B. Pharma, and CBSE Schooling. By the blessings of Shri Sant Gajanan Maharaj, we aim at developing a pursuit of knowledge in students, commitment to economic, social & cultural uplifting of masses. The Institute College of Engineering & Management is highly believing in nurturing ethics and moral values in students. We realize that education is the basis for the complete development of individual and for this purpose we have dedicated teaching staff, digital Classrooms, sophisticated equipment, Wi-Fi campus, finishing school, Placement cell, state-of-art auditorium,



well equipped laboratories, classrooms, international quality infrastructure and enriched library facility. Our constant endeavour is to provide gamut of opportunities for our students to make them practical engineers, top class managers and also good citizens of India

The basic objective of this institute is to provide 'holistic' education for an integrated personality by striking equilibrium between modern outlook and traditional values. The same hold true for emerging technology also, which has witnessed the contribution made by faculty in this book. The editorial board has done a good job in bringing out this book.

Dr. Mohammad Zuhair
Principal



Chief Editor
Dr. S. B. Warkad
Professor

Electrical Engineering Department

Editorial



Editor
Dr. R. D. Ghongade
Associate Professor

Electronics & Telecom. Department

Education is a mechanism that develops and enhances person's body, mind and character. It brings together brain, heart and mind and helps a person to build a full personality that recognizes the best in it. Over the last six decades since higher education over India has grown very rapidly but it is not equally open to all. A substantial part of the population also has analphabetic, and many children are not even taught in primary school. Not only has a significant part of the population not been excluded from making a complete contribution to the country's growth, but they also have been discouraged from making full use of the benefits of any growth to the public. There are definitely many challenges facing India in higher education during COVID-19 Pandemic Period, but it is most important to resolve these challenges and improve higher education.

India is a nation with tremendous potential for human capital, which has to be discussed in order to make effective use of this potential. Opportunities are abundant, but it is of concern whether such opportunities can be gained and made accessible to others. There is a need to urgently evaluate financial resources, access and equity, efficiency, standards, relevance, infrastructure and ultimately responsiveness to achieve and meet future requirements.

In this light, our college is going to publish Book on Recent Advances in Engineering, Science & Technology-Vol-I" to make available a platform to academicians, for exchange of ideas, experiences, collection and dissemination of information on various subjects of engineering, science and technology.

We are proud to state that we got overwhelming responses from the academicians from our college.



We are also thankful to the contributors for sending their papers in publication process.

We hope that this book will be appreciated by the readers, and it will provide a wide spectrum about different areas of Engineering, Science and Technology. I Take this opportunity to extend my gratitude towards Hon. Shri Pravin R. Pote, Ex. MLA, former Guardian Minister, Amravati and President P. R. Pote (Patil) Welfare Trust, Shri Shreyas Pote, Secretary, P. R. Pote (Patil) Welfare Trust's college of Engineering & Management, Amravati.

Our special Thanks to Principal of our college, Dr. Mohammad Zuhair, Principal for their efforts in publishing this book.

Last but not the least, we are also thankful to the contributors for sending their chapters in time and also cooperating in the publication process.

Finally, we are sincerely thankful for the DnyanPath Publication, Amravati for bringing out this publication in all its glory.

I N D E X

| | |
|--|-----------|
| 1. Experimental Investigation on the replacement of natural sand with Manufactured sand in the Concrete with partial replacement of cement by silica fume | 1 |
| Anup K. Chitkeshwar Prof. Dr. P. L. Naktode Subodhkumar V. Dhoke | |
| 2. Advanced Equipments for Earthquake Resistant Building | 10 |
| Dr. S. S. Saraf Prof. S. V. Pawar Prof. M. A. Rehman | |
| 3. Importance of Dalvik Virtual Machine in Android OS | 17 |
| Prof. Zeeshan I. Khan Dr. Ajay B. Gadicha Prof. Mayur S. Bhurange | |
| 4. Deep Learning for Digital Signal Processing | 21 |
| Sunpreet Kaur Nanda Vaishali Bhagat Akshay Dhande Pravin Soni Dr. A. B. Gadicha | |
| 5. Digital Forensics | 25 |
| Sunpreet Kaur Nanda Prachi Kale Vishal Padole Sneha Sontakke | |
| 6. A New Contingency Analysis Approach Based online Stability Indices for the Assessment of Voltage Stability | 28 |
| A. S. Telang Y.D.Shahakar | |
| 7. A Genetic Algorithm Based Optimal Power Flow for HVAC-DC Power System | 38 |
| Dr. S. B. Warkad Prof. A. A. Ghute | |
| 8. Switched Reluctance Motor- A suitable option for Electric Vehicle | 47 |
| Mr. Deepak A. Shahakar Ms. P. M. Mankar | |
| 9. Automated Garbage Monitoring System Using Gps, Gsm And Iot | 59 |
| Dr. G. D. Dalvi Prof. S. P. Bhonge | |
| 10. Image Segmentation And Classification For Vision Based Detection And Tracking of Moving Object In Video Surveillance | 63 |
| Dr. R.D.Ghongade Prof. A. R. Pawade | |
| 11. Comparative Analysis for Lane Detection System Using Canny Edge Detection, Hough Transform and Kalman Filter | 68 |
| Prof. U.W. Hore Prof. V. B. Langote | |
| 12. Applications Of Laplace Transform In Engineering Field | 72 |
| Dr. S. P. Shahare | |

| | |
|--|------------|
| 13. “study Of Dc Electrical Conductivity Of The Polypyrrole” | 76 |
| Thakare N. R. Daware A.S. | |
| 14. Synthesis And Charecterization of 2,4 - (substitutedphenyl) pyrimidin-5-ol Derivatives | 78 |
| G. P. Deshpande | |
| 15. “HRM Practices and Innovation- An Empirical Systematic Review” | 91 |
| Ms. Florence Thomas Mr. Vishal A Ingole | |
| 16. Recent Trends in NBFCs Lending to MSME Sector | 97 |
| Prof. Sagar R. Shah Prof. Nikhilesh S. Kariya | |
| 17. Multidimensional Data model in Data Warehouse and its representation | 110 |
| Prof Aparna S Bhande Prof R. V. Mahule | |
| 18. Experimental Study On Power Generation From Waste Heat Using Thermoelectric Generator In Vehicles | 116 |
| Prakash Ingle Vijay Gore Dr.P.R.Wadnerkar | |
| 19. Concept, Evolution, Philosophy and Performance measurement of Supply Chain Management | 120 |
| Dr.P.R.Wadnerkar Prof. R. S.Pokle | |
| 20. Ergonomic Intervention for Sewing Workstation | 141 |
| Dr. S.M.Tondre Dr.P.R.Wadnerkar | |

Experimental Investigation on the replacement of natural sand with Manufactured sand in the Concrete with partial replacement of cement by silica fume

Authors

Anup K. Chitkeshwar | Prof. Dr. P. L. Naktode | Subodhkumar V. Dhoke

- Abstract -

The manufactured sand is abundantly available in the quarry nearby to every major cities in India. The manufactured sand is the by-product material from the quarries. The process of crushing and the screening in the quarry industry leads to the manufactured sand. This quarry fine majorly consisting the sand particles in the different sizes i.e. fine, medium and coarse. The present work is to carry out the experimental investigation on the replacement of the natural sand with the manufactured sand (m-sand) for the different grade of the concrete i.e. M20, M30 and M40. The replacement of cement with silica fume was also carried out. The replacement level of the natural sand by the m-sand is ranging from 0% to 100%. For these replacement of sand the hardened properties of the concrete are investigated in terms of the compressive strength, split tensile strength and the flexural strength. The regression analysis was also carried out and the relationship between the compressive strength and the flexural strength was obtained. It was concluded that the m-sand can be used in the concrete and leading to the increased strength in the concrete.

Keywords : Silica Fume, m-sand, cement, compressive strength and flexural strength

- Introduction -

The concrete is the material which is used worldwide and in different construction sector. The use of this is major just after the water (Saravanan, Nagajothi and Elavenil 2019). The conventional concrete consisting cement, fine aggregate, coarse aggregate and water. The importance of the aggregate (fine and coarse) in the concrete is investigated since many years (Yang, et al. 2019).

It was found that the quarry fines get generated because of the process of extraction and the processing action in the quarry industry (Suleman and Needhidasan 2020). The different parameters majorly influences the fines produced in the quarry, the characteristics of the rock and the process involved in the quarry play a vital role. It was reported that the different fines which are produced in the quarry depends on the crusher type as well as the parent rock used in the quarry (Shen, Liu and Wang, et al. 2018). The primary crusher, secondary crusher and the tertiary crusher produces the fines ranging from 1 % to 30%. The different type of the rock produces different percentage of the fines (Needhidasan, Ramesh and Joshua Richard Prabu 2020).

*Corresponding author, Tel: +919021409523; *E-mail address:* anupkchitkeshwar@gmail.com

The rock type include the limestone, sandstone, igneous and metamorphic rock which produces different fines ranging from the 20% to 40% (Li, et al. 2016). The different techniques in terms of the mechanical as well the chemical treatments are investigated by the author so that the properties of Recycled coarse aggregates studied (Guan, Lai, et al. 2019). Compressive strength was found to be increased up to 25% for the case of treated aggregates (Vengadesh Marshall Raman and Ramasamy 2021). The performance of the m-sand concrete was studied using the methylene blue value (MBV) for the case of the microfines. The results obtained consisting that the microfines which have the low MBV found increased in the workability in the concrete. The properties of the concrete are enhanced due to the use of MBV (Chen, et al. 2020).

The study was carried out to propose three tree based

models which include regression tree, random forest tree and gradient boosted regression tree (Zhang, Li and Wang 2020). While the experimental investigation was carried for the study related to the axial compression on the RC column having concrete grade M-30 with the use of m-sand (Vijaya, Senthil Selvan and Vasanthi 2021).

The axial compressive behaviour was also studied for the case of short columns having circular steel tube which are occupied with m-sand concrete (Guan, Wei, et al. 2020). The utilization process of the super absorbing polymer in the concrete with m-sand was also studied experimentally (Desineni and Kommineni 2020). The ultra high strength concrete with the use of m-sand was also carried out using experimental studies, the innovative method is obtained for the C120 degree (Shen, Liu and Cao, et al. 2017).

The test specimens of the concrete were prepared using 8% silica fume and the PVC waste powder varying from 0% to 30% by the weight of cement (Manjunatha, et al., 2021). The concrete pavement performance was improved when the silica fume, nanosilica and polypropylene fibers were used in the pavement. The performance shows that the compressive strength, split tensile strength and the flexural strength were considerably improved up to 30 % (Brescia-Norambuena, et al., 2021).

The three different concrete ingredients used containing silica fume, fly ash and waste glass powder. The replacement percentage varying from 0% to 20% for the cement (Ibrahim, 2021). The high performance concrete was prepared using the fly ash and silica fume combined, partial replacement of the cement was carried out (Patil, et al., 2021). The performance of the concrete was improved when the steel slag, nano silica and silica fume were used in the concrete. The strength was increased up to limited extent when the proportions used in the concrete (Kansal & Goyal, 2021).

The ordinary Portland cement was replaced partially with the rice husk ash in the percentage ranging from 10% to 20%, silica fume by 10% to 20% and GGBS in the percentage ranging from 10% to 40%. The compressive strength was increased up to the limited extent (Gupta, et al., 2021). The cement was replaced with the glass powder, metakaolin and the silica fume with the varying percentage in the concrete. The development of the strength when checked under the

electron microscope was observed (Chand, et al., 2021).

The research was carried out for the use of silicomanganese slag, marine sand and the sea water in the concrete. The prediction of the compressive strength of the concrete which contains the fly ash and silica fume was carried out (Ting, et al., 2021). The properties of the geopolymer concrete was investigated experimentally for the use of the lime as well as the silica fume. The compressive strength was increased up to the certain extent for the 7.5% of lime and 2% silica fume combined (Das, et al., 2020).

2. Materials

2.1 Cement

The Ordinary Portland Cement as per the IS 1489-1991 was used in this experimental investigation. The different physical as well as the chemical properties related to the cement are also investigated. The physical properties are mentioned in the table 1 as follows.

Table 1: Physical Properties of Cement

| Component | Value |
|----------------------------|-------|
| Fineess (m2/kg) | 325 |
| initial Setting time (min) | 47 |
| Final Setting Time (min) | 378 |
| Standard Consistency (%) | 25.8 |
| Soundness (mm) | 1.2 |
| Specific Gravity | 3.21 |

2.2 Silica Fume

Silica Fume was collected from the MIDC near to the city confirming to ASTM C1240. The silica fume available was in the dry densified form. The properties of the silica fume are mentioned in the table 2 as follows. Silica Fume was added in 7.5% as cement replacement.

Table 2: Properties of Silica Fume

| Properties | Values |
|----------------------|--------|
| Specific Gravity | 2.31 |
| Surface Area (m2/kg) | 20500 |
| Size (micron) | 0.11 |
| Bulk Density (kg/m) | 581 |

2.3 Coarse Aggregate

The locally available aggregate having size gradation as per the IS 2386-1963 are used for this experimental investigation. The different test as per IS code are also performed on the coarse aggregate.

2.4 Fine Aggregate

The locally available river sand was used as the fine aggregate for this experimental investigation. The different physical and the chemical properties for the case of natural sand and the m-sand were investigated. The figure 1 gives the particle size (mm) analysis by the hydrometer.

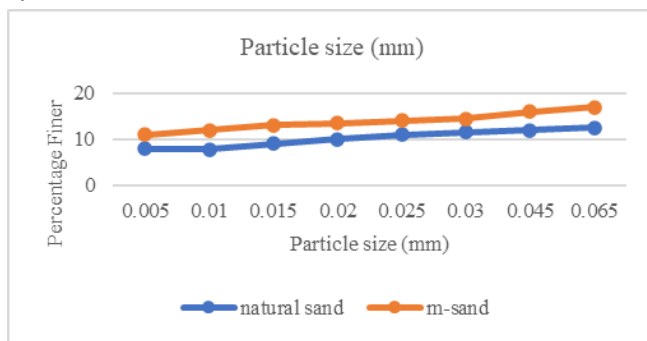


Fig.1: Particle size (mm) analysis by the hydrometer

This indicates that the finer fraction obtained below 75 microns are higher in the case of m-sand as compared to the natural sand.

2.5 Water

The potable water was used in this experimental investigation.

2.6 Superplasticizer

To improve the workability of the concrete, super plasticizer was used in the form of the Sulphonated Naphthalene Polymers, this is in accordance with IS 9103:1999. The specific gravity of the superplasticizer was found to be 1.205.

2.7 Mix Proportioning

The mix design was carried out for the materials used in the experiment using IS 10262-1982.

3. Methodology

The experiments were carried out using the natural sand and m-sand in the concrete. The different replacement levels for the m-sand were made i.e. 0% to 100%. The

concrete was prepared using mix design for the case of M20, M30 and M40 grade of concrete. The fineness modulus as well as the specific gravity for the different replaced m-sand and the natural sand was considered for the mix design. The mix proportion for the M20 grade of concrete for the percentage replacement varying from 0% to 100% is as follows in the table 3. The required quantities of the materials were mixed in the laboratory using drum type mixer machine to the five minutes. The superplasticizer was added gradually as well as the water was also mixed. The mix was continuously revolved for a minute so that the workability can be achieved properly. The specimen of cube, beams were prepared for the determination of the compressive strength, split tensile strength and flexural strength for the different grades of the concrete.

Table 3: Mix proportion for M-20 grade concrete

| % FA | Cement (kg) | Silica Fume (kg) | NA (kg) | M-sand (kg) | CA (kg) | water (Lit) |
|------|-------------|------------------|---------|-------------|---------|-------------|
| 0 | 345 | 0 | 750 | 0 | 1170 | 195 |
| 10 | 319.125 | 25.875 | 675 | 75 | 1170 | 195 |
| 20 | 319.125 | 25.875 | 600 | 150 | 1170 | 195 |
| 30 | 319.125 | 25.875 | 525 | 225 | 1170 | 195 |
| 40 | 319.125 | 25.875 | 450 | 300 | 1170 | 195 |
| 50 | 319.125 | 25.875 | 375 | 375 | 1170 | 195 |
| 60 | 319.125 | 25.875 | 300 | 450 | 1170 | 195 |
| 70 | 319.125 | 25.875 | 225 | 525 | 1170 | 195 |
| 80 | 319.125 | 25.875 | 150 | 600 | 1170 | 195 |
| 90 | 319.125 | 25.875 | 75 | 675 | 1170 | 195 |
| 100 | 319.125 | 25.875 | 0 | 750 | 1170 | 195 |

The mix proportions of the M 30 grade concrete for the replacement varying from 0% to 100% is as follows in the table 4.

Table 4: Mix proportion for M-30 grade concrete

| % FA | Cement (kg) | Silica Fume (kg) | NA (kg) | M-sand (kg) | CA (kg) | water (Lit) |
|------|-------------|------------------|---------|-------------|---------|-------------|
| 0 | 427 | 0 | 730 | 0 | 1130 | 190 |
| 10 | 394.975 | 32.025 | 657 | 73 | 1130 | 190 |
| 20 | 394.975 | 32.025 | 584 | 146 | 1130 | 190 |
| 30 | 394.975 | 32.025 | 511 | 219 | 1130 | 190 |
| 40 | 394.975 | 32.025 | 438 | 292 | 1130 | 190 |
| 50 | 394.975 | 32.025 | 365 | 365 | 1130 | 190 |
| 60 | 394.975 | 32.025 | 292 | 438 | 1130 | 190 |
| 70 | 394.975 | 32.025 | 219 | 511 | 1130 | 190 |
| 80 | 394.975 | 32.025 | 146 | 584 | 1130 | 190 |
| 90 | 394.975 | 32.025 | 73 | 657 | 1130 | 190 |
| 100 | 394.975 | 32.025 | 0 | 730 | 1130 | 190 |

The mix proportions of the M 40 grade concrete for the replacement varying from 0% to 100% is as follows in the table 5.

Table 5: Mix proportion for M-40 grade concrete

| % FA | Cement (kg) | Silica Fume (kg) | NA (kg) | M- sand (kg) | CA (kg) | water (Lit) |
|------|----------------|------------------------|------------|--------------------|------------|----------------|
| 0 | 440 | 0 | 710 | 0 | 1110 | 185 |
| 10 | 407 | 33 | 639 | 71 | 1110 | 185 |
| 20 | 407 | 33 | 568 | 142 | 1110 | 185 |
| 30 | 407 | 33 | 497 | 213 | 1110 | 185 |
| 40 | 407 | 33 | 426 | 284 | 1110 | 185 |
| 50 | 407 | 33 | 355 | 355 | 1110 | 185 |
| 60 | 407 | 33 | 284 | 426 | 1110 | 185 |
| 70 | 407 | 33 | 213 | 497 | 1110 | 185 |
| 80 | 407 | 33 | 142 | 568 | 1110 | 185 |
| 90 | 407 | 33 | 71 | 639 | 1110 | 185 |
| 100 | 407 | 33 | 0 | 710 | 1110 | 185 |

4. Results

The concrete grade of M20, M30 and M40 were prepared for the different replacement percentage of the natural sand. The different tests are performed and the results are discussed here.

4.1 Sodium Sulphate Soundness Test

The sodium sulphate soundness test results for the case of natural sand as well as the m-sand are mentioned in the fig.2.

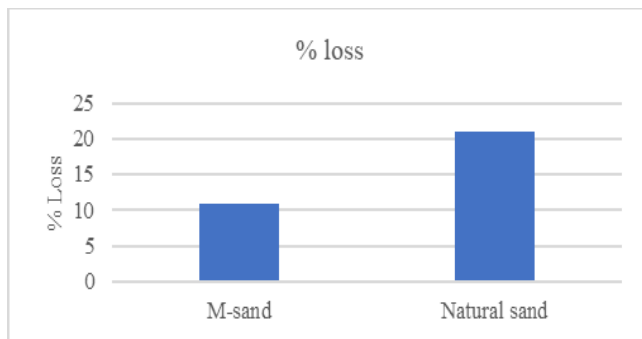


Fig.2: Percentage loss of Natural sand and m-sand

From the figure it can be observed that there is a comparatively lesser percentage loss in the m-sand with respect to natural sand. From this it can be incurred that the m-sand used is sound material for the concrete.

4.2 Methylene Blue Absorption value (MBV)

The methylene blue values for the different percentage replacement of natural sand by m-sand is mentioned in the fig.3.

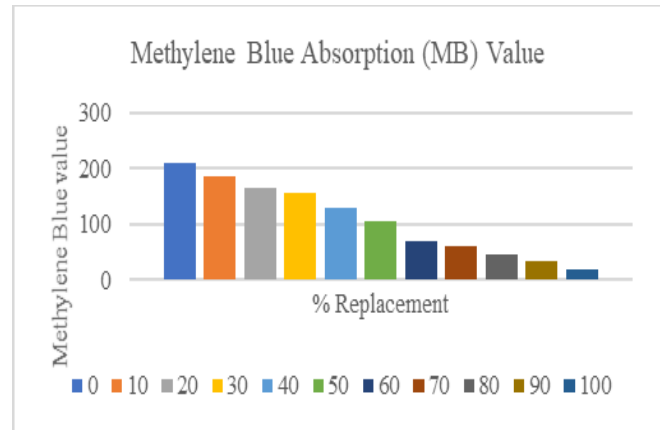


Fig.3: Methylene Blue Absorption value for natural sand and m-sand

The above figure shows that the MBV which represents the content of clay present in the sand. The MBV goes on reducing as the percentage replacement is increasing in the m-sand. This incurred that the strength of the concrete shall be improved.

4.3 Settling method

The following fig.4 shows the clay value as well as the silt value for the different percentage of the replacement for m-sand.

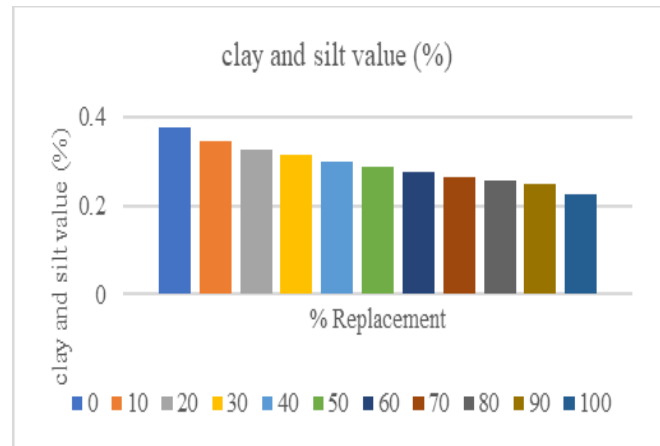


Fig.4: Clay and silt value for natural sand and m-sand

From the above figure it is observed that the clay value and the silt value get reduced once the percentage replacement goes on increasing. This incurred that the strength of the concrete prepared using the m-sand shall be with good strength.

4.4 Sand Equivalence Test

The following fig.5 shows the sand equivalent test for the different percentage replacement for the m-sand.

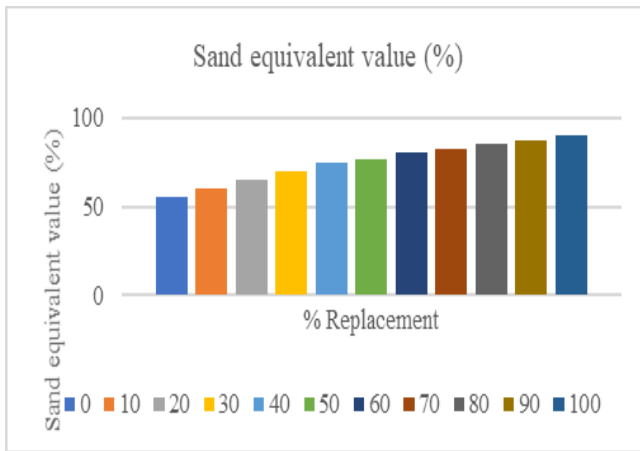


Fig.5: Sand Equivalence value for natural sand and m-sand

4.5 Particle size Distribution analysis

Following Fig.6 shows the particle size distribution analysis of the m-sand.

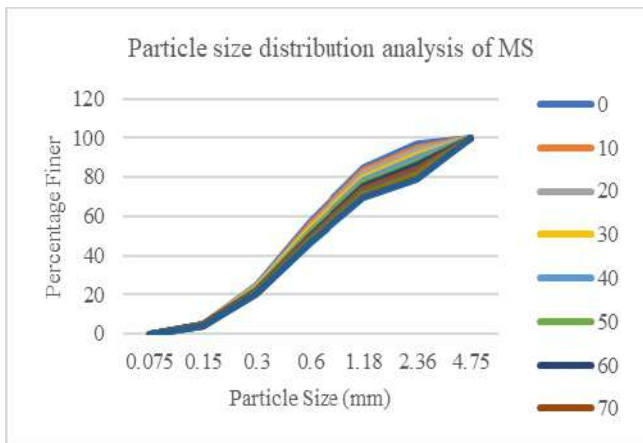


Fig.6: Particle size distribution analysis for m-sand

The above figure shows the grading curves for the natural sand and the m-sand with different percentage replacement level. It can be incurred that the particles of sizes having less than 300 microns found to be having high proportions for the percentage replacement from 80% to 100%.

4.6 Workability of the concrete

The workability of the concrete for the M20, M30 and M40 grade of concrete are investigated for the different percentage replacement varying from 0% to 100%. The figure 7 gives the workability result for the concrete.

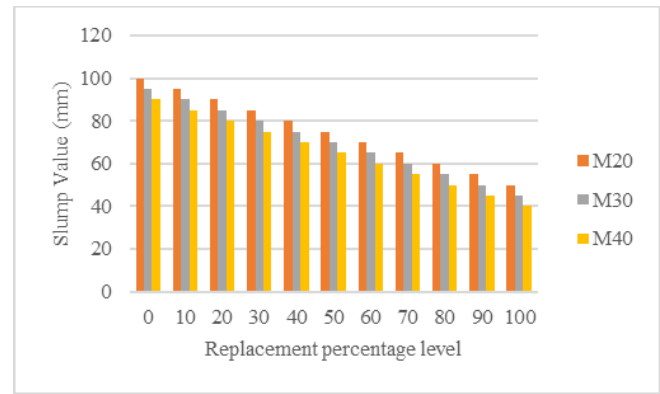


Fig.7: Slump value of the concrete

From the above graph it can be observed that the slump values of the concrete goes on decreasing as the replacement percentage goes on increasing for the m-sand. This is observed for all the grade of concrete i.e. M20, M30 and M40. The m-sand plays a vital role for the water requirement of the concrete. Since m-sand have the angular shape as well as the rough texture for the surface, the internal friction goes on improving and thereby the slump value goes on decreasing. As there are large amount of fine material in the higher percentage replacement there is a low slump value obtained in the concrete mix.

4.7 Compressive strength of the concrete

The following figure 8 shows the compressive strength of M20 grade of the concrete

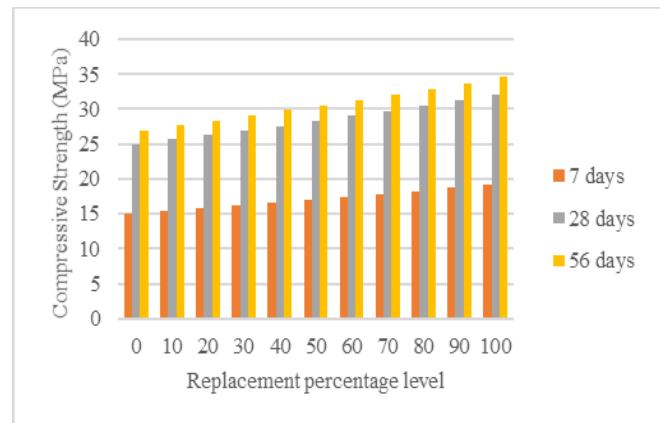


Fig.8: Compressive strength of M20 grade of concrete

The following figure 9 shows the compressive strength of M30 grade of the concrete.

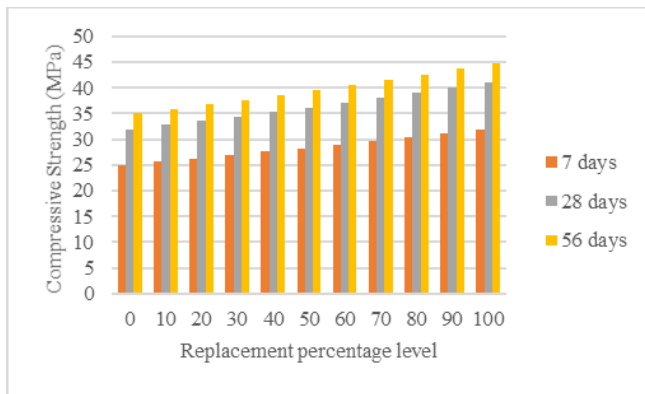


Fig.9: Compressive strength of M30 grade of concrete

The following figure 10 shows the compressive strength of M40 grade of the concrete.

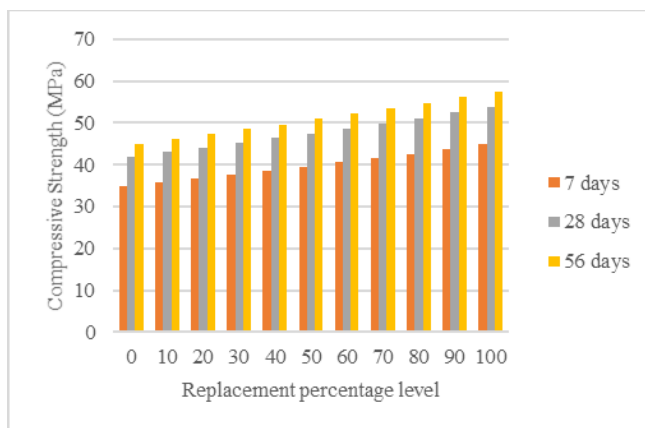


Fig.10: Compressive strength of M40 grade of concrete

From the above figures it is observed that the compressive strength of the concrete increases as the percentage of the m-sand goes on increasing. This is observed in all the grade of concrete i.e. M20, M30 and M40 grade concrete. It can be incurred that the angular particles of the m-sand as well as the rough surface gives the interlocking of the aggregate and the cement in the concrete. It can also be incurred that the not much improvement of the strength beyond the 70% replacement level of the m-sand. This is due to the fact that the amount of fine particles present in the m-sand beyond 70% are much higher comparative to the others.

4.8 Split Tensile Strength

The split tensile strength for the M20 grade of concrete is mentioned in the following figure 11.

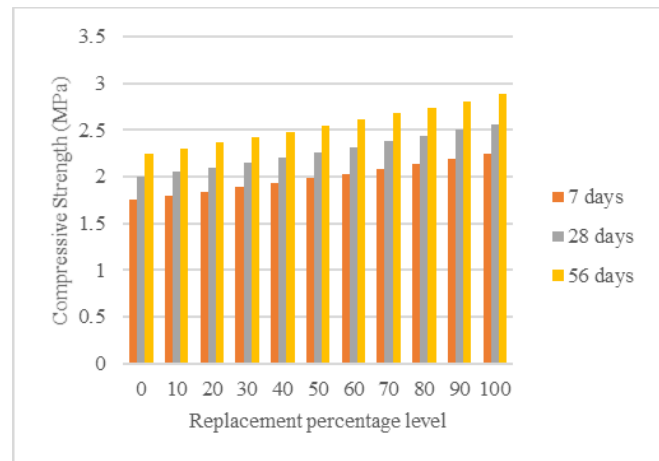


Fig.11: Split Tensile Strength of M20 grade concrete

The split tensile strength for the M30 grade of concrete is mentioned in the following figure 12.

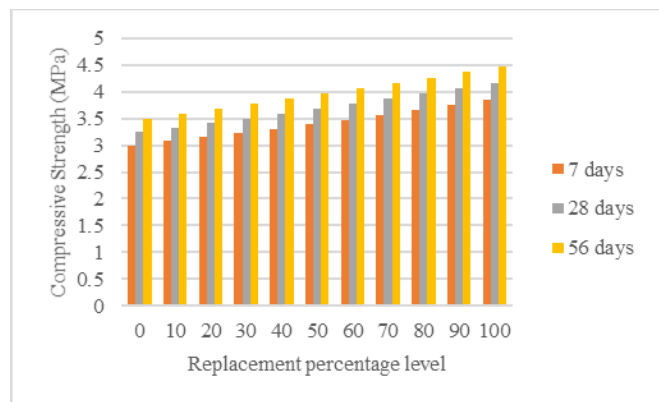


Fig.12: Split Tensile Strength of M30 grade concrete

The split tensile strength for the M20 grade of concrete is mentioned in the following figure 13.

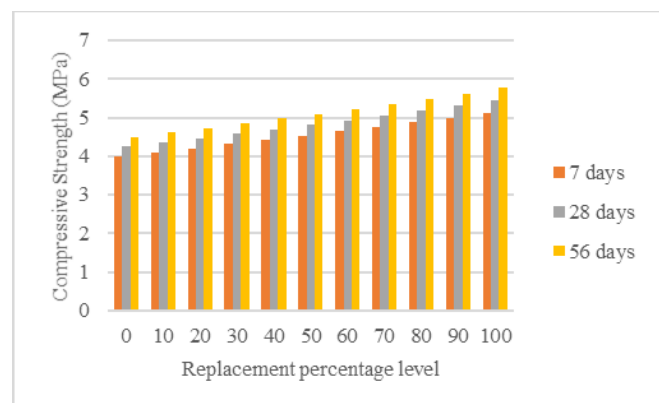


Fig.13: Split Tensile Strength of M40 grade concrete

The above figures give the tensile strength for the grade of concrete M20, M30 and M40 with different percentage replacement for m-sand. It can be observed that the split tensile strength of the concrete found to be increased up to the percentage replacement level of 70%. The split tensile strength of the concrete for M40 grade of concrete found to be higher compared to other grade of concrete as there is higher cement content as well as the lower water content.

Also it is observed that not much improvement in the split tensile strength after percentage replacement level of 70%. For higher percentage replacement level the amount of fine particle present for the m-sand is much higher compared to others.

4.9 Flexural Strength

The split tensile strength for the M20 grade of concrete is mentioned in the following figure 14.

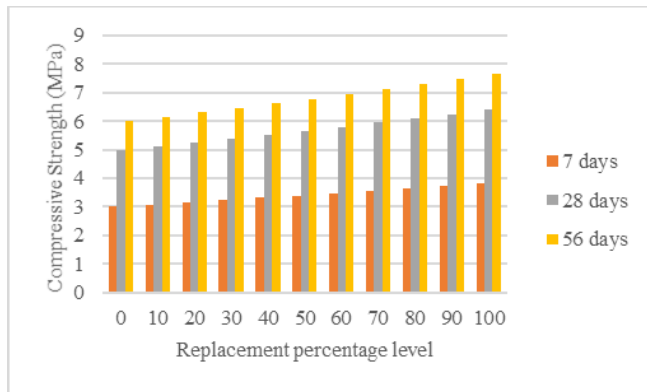


Fig.14: Flexural Strength of M20 grade concrete

The split tensile strength for the M30 grade of concrete is mentioned in the following figure 15.

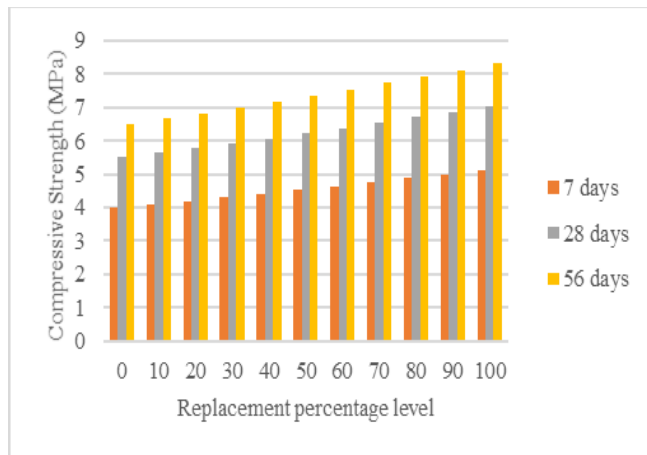


Fig.15: Flexural Strength of M30 grade concrete

The split tensile strength for the M40 grade of concrete is mentioned in the following figure 16.

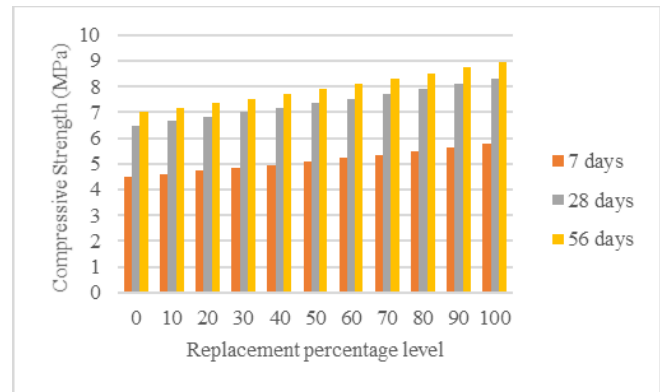


Fig.16: Flexural Strength of M40 grade concrete

The above figures shows the flexural strength for the M20, M30 and M40 grade of concrete with the different percentage replacement level for m-sand. The figures shows that the flexural strength keep on increasing with the increase in the percentage of the m-sand. This found up to the 70% replacement level for m-sand. After 70% there is not much improvement for the flexural strength i.e. from 80% to 100%. This is because much finer particles are present for the percentage replacement level from 80% to 100%.

4.10 Relationship for the mechanical properties of the concrete with percentage replacement of m-sand

The relationship between the split tensile strength and the compressive strength of the concrete with different percentage replacement level ranging from 0% to 100% is mentioned in the following fig.17.

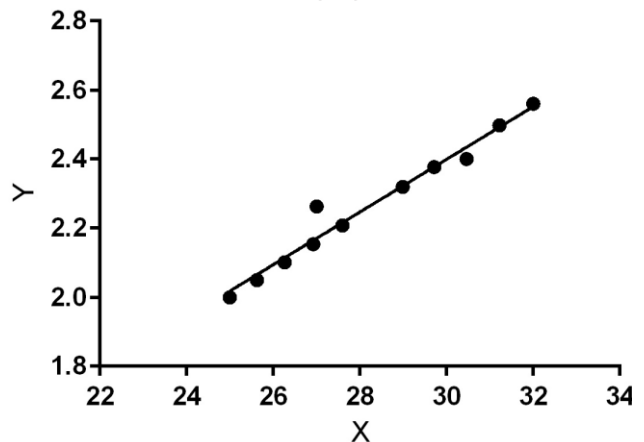


Fig.17: Compressive strength v/s Split tensile strength ($R^2=0.97$, $y=0.38x^{0.51}$)

The relationship between the flexural strength and the compressive strength of the concrete with different percentage replacement level ranging from 0% to 100% is mentioned in the following fig.18.

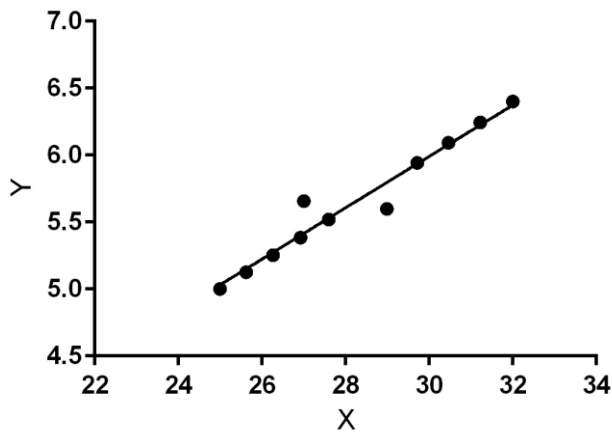


Fig.18: Compressive strength v/s Flexural strength ($R^2=0.96$, $y=1.01x^{0.45}$)

The regression analysis was carried out for the relationship between the flexural strength and the compressive strength as in the above figure. The plot obtained was almost straight line gives the good conjunction of the results.

5. Conclusions

The concrete with silica fume when mixed with m-sand gives the good results in terms of the compressive strength, flexural strength and the split tensile strength. The angular particles of the m-sand and the rough surface gives the good interlocking property for the aggregate and the cement giving good binding of the concrete. If the maximum percentage replacement of 70% of m-sand with 30% of natural sand is used in the concrete then the optimum strength of the concrete obtained. The smaller percentage of replacement of cement by silica fume in the concrete mixture found to be saving in the consumption of cement content. Therefore it is suggested to use the, m-sand and the silica fume in the concrete effectively for the minimization of the environmental pollutions.

References :

- 1) M. Gupta, D. R. Raj and D. A. Kumar Sahu, "Effect of Rice Husk Ash, silica fume & GGBFS on compressive strength of performance based

- concrete," *Materials Today: Proceedings*, 2021.
- 2) G. Chand, S. K. Happy and S. Ram, "Assessment of the properties of sustainable concrete produced from quaternary blend of portland cement, glass powder, metakaolin and silica fume," *Cleaner Engineering and Technology*, vol. 4, p. 100179, 2021.
- 3) K. Ali, M. I. Qureshi, S. Saleem and S. U. Khan, "Effect of waste electronic plastic and silica fume on mechanical properties and thermal performance of concrete," *Construction and Building Materials*, vol. 285, p. 122952, 2021.
- 4) M. Z. Y. Ting, K. S. Wong, M. E. Rahman and M. Selowarajoo, "Prediction model for hardened state properties of silica fume and fly ash based seawater concrete incorporating silicomanganese slag," *Journal of Building Engineering*, vol. 41, p. 102356, 2021.
- 5) M. Manjunatha, D. Seth, K. V. G. D. Balaji and S. Chilukoti, "Influence of PVC waste powder and silica fume on strength and microstructure properties of concrete: An experimental study," *Case Studies in Construction Materials*, vol. 15, p. e00610, 2021.
- 6) J. Vengadesh Marshall Raman and V. Ramasamy, "Augmentation of dissimilar techniques for enhancing the concrete properties with recycled coarse aggregate and manufactured sand," *Journal of Materials Research and Technology*, vol. 14, pp. 1180-1190, 2021.
- 7) L. Brescia-Norambuena, M. González, S. Avudaiappan, E. I. Saavedra Flores and Z. Grasley, "Improving concrete underground mining pavements performance through the synergic effect of silica fume, nanosilica, and polypropylene fibers," *Construction and Building Materials*, vol. 285, p. 122895, 2021.
- 8) B. Vijaya, S. Senthil Selvan and P. Vasanthi, "Experimental investigation on the behaviour of reinforced concrete column containing manufactured sand under axial compression," *Materials Today: Proceedings*, vol. 39, pp. 446-453, 2021.
- 9) K. I. M. Ibrahim, "Recycled waste glass powder as a partial replacement of cement in concrete containing silica fume and fly ash," *Case Studies in Construction Materials*, vol. 15, p. e00630, 2021.
- 10) S. Patil, H. M. Somasekharaiah, H. S. Rao and V. G.

- Ghorpade, "Durability and micro-structure studies on fly ash and silica fume based composite fiber reinforced high-performance concrete," *Materials Today: Proceedings*, 2021.
- 11) C. M. Kansal and R. Goyal, "Analysing mechanical properties of concrete with nano silica, silica fume and steel slag," *Materials Today: Proceedings*, vol. 45, pp. 4520-4525, 2021.
 - 12) J. Zhang, D. Li and Y. Wang, "Toward intelligent construction: Prediction of mechanical properties of manufactured-sand concrete using tree-based models," *Journal of Cleaner Production*, vol. 258, p. 120665, 2020.
 - 13) S. K. Das, S. M. Mustakim, A. Adesina, J. Mishra, T. S. Alomayri, H. S. Assaedi and C. R. Kaze, "Fresh, strength and microstructure properties of geopolymer concrete incorporating lime and silica fume as replacement of fly ash," *Journal of Building Engineering*, vol. 32, p. 101780, 2020.
 - 14) X. Chen, G. Yuguang, B. Li, M. Zhou, B. Li, Z. Liu and J. Zhou, "Coupled effects of the content and methylene blue value (MBV) of microfines on the performance of manufactured sand concrete," *Construction and Building Materials*, vol. 240, p. 117953, 2020.
 - 15) S. Suleman and S. Needhidasan, "Utilization of manufactured sand as fine aggregates in electronic plastic waste concrete of M30 mix," *Materials Today: Proceedings*, vol. 33, pp. 1192-1197, 2020.
 - 16) B. O. R. Desineni and H. R. Kommineni, "An experimental study on strength characteristics of self curing concrete with manufacture sand using super absorbed polymer," *Materials Today: Proceedings*, vol. 33, pp. 333-337, 2020.
 - 17) S. Needhidasan, B. Ramesh and S. Joshua Richard Prabu, "Experimental study on use of E-waste plastics as coarse aggregate in concrete with manufactured sand," *Materials Today: Proceedings*, vol. 22, pp. 715-721, 2020.
 - 18) M. Guan, C. Wei, Y. Wang, Z. Lai, Q. Xiao and H. Du, "Experimental investigation of axial loaded circular steel tube short columns filled with manufactured sand concrete," *Engineering Structures*, vol. 221, p. 111033, 2020.
 - 19) R. Yang, R. Yu, Z. Shui, C. Guo, S. Wu, X. Gao and S. Peng, "The physical and chemical impact of manufactured sand as a partial replacement material in Ultra-High Performance Concrete (UHPC)," *Cement and Concrete Composites*, vol. 99, pp. 203-213, 2019.
 - 20) M. Guan, W. Liu, M. Lai, H. Du, J. Cui and Y. Gan, "Seismic behaviour of innovative composite walls with high-strength manufactured sand concrete," *Engineering Structures*, vol. 195, pp. 182-199, 2019.
 - 21) M. Guan, Z. Lai, Q. Xiao, H. Du and K. Zhang, "Bond behavior of concrete-filled steel tube columns using manufactured sand (MS-CFT)," *Engineering Structures*, vol. 187, pp. 199-208, 2019.
 - 22) S. Saravanan, S. Nagajothi and S. Elavenil, "Investigation On Compressive Strength Development Of Geopolymer Concrete Using Manufactured Sand," *Materials Today: Proceedings*, vol. 18, pp. 114-124, 2019.
 - 23) W. Shen, Y. Liu, Z. Wang, L. Cao, D. Wu, Y. Wang and X. Ji, "Influence of manufactured sand's characteristics on its concrete performance," *Construction and Building Materials*, vol. 172, pp. 574-583, 2018.
 - 24) W. Shen, Y. Liu, L. Cao, X. Huo, Z. Yang, C. Zhou, P. He and Z. Lu, "Mixing design and microstructure of ultra high strength concrete with manufactured sand," *Construction and Building Materials*, vol. 143, pp. 312-321, 2017.
 - 25) H. Li, F. Huang, G. Cheng, Y. Xie, Y. Tan, L. Li and Z. Yi, "Effect of granite dust on mechanical and some durability properties of manufactured sand concrete," *Construction and Building Materials*, vol. 109, pp. 41-46, 2016.

Advanced Equipments for Earthquake Resistant Building

Authors

Dr. S. S. Saraf | Prof. S. V. Pawar | Prof. M. A. Rehman

- Abstract -

Apart from the modern techniques which are well documented in the codes of practice, there are some other old traditional earthquake resistant techniques which have been proved to be more effective for resisting earthquake loading and are also cost effective with easy constructability. Base isolation is a collection of structural elements which should substantially separate a superstructure from its substructure resting on a shaking ground which protects the integrity of building or non-building structures. It is one of the most powerful equipment's of earthquake engineering which uses the passive structural vibration control technologies. Soil Structure Interaction is the process in which the response of the soil influences the motion of the structure and the motion of the structure influences the response of the soil. General goal of the Soil Structure Interaction analysis is to calculate seismic response of structure bases on seismic response of free field.

Keywords : Analysis methods, Base isolation, Soil structure interaction

- Introduction -

A natural calamity known as earthquake has taken the toll of millions of lives through the ages in the unrecorded, and recorded human history. A disturbance that causes shaking of the top surface of the earth where major man made engineering structures are constructed. Building liability usually results from a shortage of awareness of engineering science and inadequate implementation of building codes. The challenge is most

difficult in emerging countries where peoples are increasing, cities and towns are enlarging, and buildings are more subjected to damage. An Earthquake is the cause of a unexpected discharge of energy in the earth's crust that generates seismic waves. Earthquakes are dignified by with seismometers. Earthquakes are so far away unpredictable and unpreventable; the only alternative is to construct and build the building structures which by earthquake resistant. There are so many techniques to withstand earthquake, but they are costly are not used by ordinary people. Here a variety of beneficial small cost techniques to resist earthquake effects. This is sustained by negligible damage devoid of loss of life when relative to severe earthquake attacks developed countries, whereas still moderate earthquake cause wide-ranging spread destruction in emerging countries as has been observed in recent earthquakes.

Basic Terminology of Earthquake

An Earthquake is Earth's Shaking or in other words release of energy due to the movement of tectonic plates. This can be destructive enough to kill thousands of people and bring huge economic loss. This natural disaster has many adverse effects on earth like ground shaking, landslides, rock falls from cliffs, liquefaction, fire, tsunami etc. Due to underground seismic energy transformation the movement along a fault plane or from volcanic activity is called earthquake. As two faults plane rub on each other create huge amount of energy beneath the ground surface which converts the waves. The P Waves and S Waves travel thought the Epi-centre to top of the ground, which shake the affected earth surface to certain magnitude. The nature of forces induced is reckless, and lasts only for a short duration of time. Yet, bewildered are the humans with its uncertainty

in terms of its time of occurrence, and its nature. However, with the advances made in various areas of sciences through the centuries, some degree of predictability in terms of probabilistic measures has been achieved.

Buildings are highly affected by an earthquake, and in some cases they are shattered down to the ground level. When the ground shaking occurs beneath the building's foundations they vibrate in an analogous manner with that of the surrounding ground. The inertia force of a structure can develop shearing effect on it which in turn causes stress concentration on the connections in structure and on the fragile walls. This results in partial or full failure of structure.

Focus:-It is the point in the earth from point at the seismic waves originate.

Focal Depth:-It is the vertical distance between Focus and epicentre.

Epicentre:-It is the point on surface of the earth from vertically above the origin of an earthquake.

Literature Survey :

In the modern and complex society, community requirement for building structures has improved and they are expecting buildings to stay safe after large earthquakes. Consequent to these demands, a different seismic design methodology to produce flexible building structures due to large earthquakes is needed. Unique structures such as power plants, fire-fighting stations and hospitals, are constructed to stay on fully operational even though after large earthquakes. Plastic distortions are permitted for large seismic risks below the hypothesis of ductile actions in steel members and RC structures. The objective of this amendment was to defend efficiently human lives against large seismic risks by permitting building destruction. Thus, the building Damage was deemed for saving lives. Multistorey unreinforced masonry buildings were used, significantly in quite a few decades, and a large quantity of buildings is still established at economical. The structure provides many advantages, but their accomplishments during seismic risks are not satisfactory in the Tangshan earthquake. SCC is a primary structural design in seismic construction of masonry buildings in China, and

masonry buildings with SCC are still counted as URM system propagating to the very low reinforcement ratio and also for small section of SCC. Opinion of seismic destruction to URM piers, masonry piers endangered to in-plane packing may exhibition two characteristic types of behaviour shear deformations, flexural, and consistent conceivable disaster modes perform such as diagonal tension, rocking, toe compression, diagonal stepped cracking and bed-joint sliding.

IV. Factors Affecting The Seismic Performance Of A Building

Following factors influence the seismic performance of a building and are given below.

A. Height of the building

The seismic response of a building to a ground vibration is a function of its natural frequency. It is inherent mass and stiffness. These impacts vary with the height of the building and vulnerability. This outcome, in high seismic zones, the building height is constrained in accordance with the seismic hazard estimate for the specific to a region.

B. Irregularities

The obstacle to the load path in transporting the forces from roof to the foundation is produced by the vertical and horizontal irregularities present in the building. It is described about the irregularities is given in IS 1893.

C. Quality of Construction

The quality informed by the local construction practices in terms of compliance with code provisions and the status of maintenance or visual appearance is a major factor. Poor quality construction is responsible for more destruction of structure at the time of earthquake.

D. Ground Slope

In hilly regions a large number of buildings are constructed on sloping terrain. Based on the sloping angle, the slopes are classified into two types they are as the gentle slope ($\leq 20^\circ$) and steep slope ($> 20^\circ$). If the building is constructed on a steep slope, the foundation will differ in terms of elevation beside the plan of the building. Consequently the vertical members with changing mass and stiffness which leads to the vertical irregularity. The constancy of the ground plays the major

constraints that impact the seismic performance of a building construction.

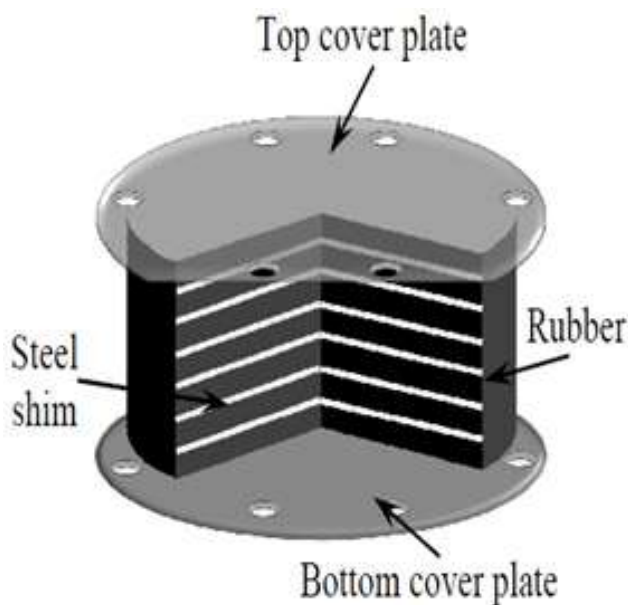
V. Advanced Equipments For Earthquake Resistant Building

A. Elastomeric Base Isolation Systems

The developments in rubber technology made the base isolation a practical reality. In the implemented projects of base isolation worldwide, it is observed that elastomeric based systems are the most common. Typically, these systems consist of big rubber block, which can be natural or synthetic (in case of neoprene) that are generally characterized by high vertical stiffness compared to the horizontal stiffness and damping capacity.

a. Laminated Rubber Bearing

The laminated rubber bearings (LRB) represent the most commonly used elastomeric isolation system. The basic components of LRB are steel and rubber plates, built through vulcanization process in alternate layers. The dominant feature of LRB is parallel action of linear spring and damping. LRB is characterized with high damping capacity, horizontal flexibility and high vertical stiffness. The relatively low shear stiffness in the horizontal plane is provided by the rubber, and the high vertical stiffness is provided by steel shims to control the bouncing effect on the structure due to vertical vibration caused by the earthquake.



b. New Zealand Bearing

The second category of elastomeric bearings are lead-rubber bearings, which are similar to the LRB except that a central lead-core is used as in, to provide additional means of energy dissipation, and initial rigidity against minor earthquakes and winds. As this bearing is developed, and widely used in New Zealand, it is generally referred to as N-Z system. The lead-core provided, reduces the isolation level displacement by virtue of its energy absorbing capacity. The N-Z systems also provide an additional hysteretic damping through the yielding of the lead-core. This seismic isolation system provides the combined features of vertical load support, horizontal flexibility, restoring force and damping in a single unit.

B. Sliding Base Isolation Systems

Sliding systems with restoring force offers advantages over elastomeric isolation systems.

a. Pure Friction System

The simplest sliding isolation system, used popularly for bridges in particular, is the pure friction (P-F) system based on the mechanism of sliding friction. The use of layer of sand or roller in the foundation of the building is the example of P-F base isolator. Under normal conditions of ambient vibrations, and small magnitude earthquakes, the system acts like a fixed base system due to the static frictional force. For large earthquake, the static value of frictional force is overcome, and sliding occurs with reduced dynamic resistance thereby reducing the accelerations. The horizontal frictional force at the bearing interface offers resistance to the motion, and dissipates energy

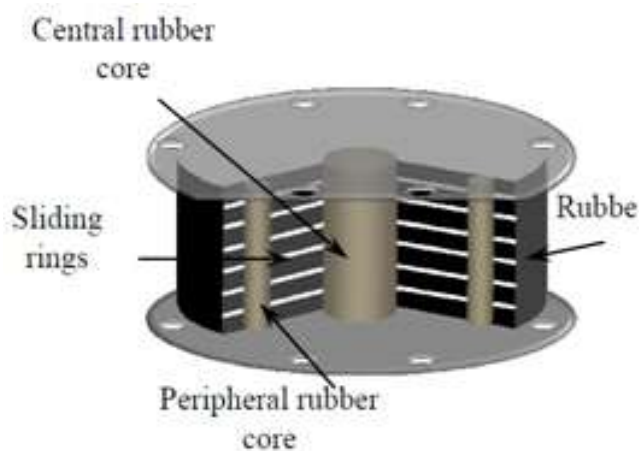
b. Friction Pendulum System

One of the most popular and effective techniques for seismic isolation is through the use of sliding isolation devices. The sliding systems exhibit excellent performance under a variety of severe earthquake loading and are very effective in reducing the large levels of the superstructure acceleration. These isolators are characterized by their insensitivity to the frequency content of earthquake excitation, because of the tendency of sliding system to reduce and spread the earthquake energy over a wide range of frequencies. There is another advantage of sliding isolation systems over conventional rubber bearings. Due to development

of the frictional force at the base, it is proportional to the mass of the structure and the centre of mass and centre of resistance of the sliding support coincides. Consequently, the torsional effects produced by the asymmetric building are diminished. The concept of sliding bearings is combined with the concept of a pendulum type response, resulting in a conceptually interesting seismic isolation system known as a friction pendulum system (FPS). The system is activated only when the earthquake forces overcome the static value of friction and coefficient of friction depends upon the velocity attained. The FPS develops a lateral force equal to the combination of the mobilized frictional force, and the restoring force that develops because of the rising of the structure along the spherical concave surface

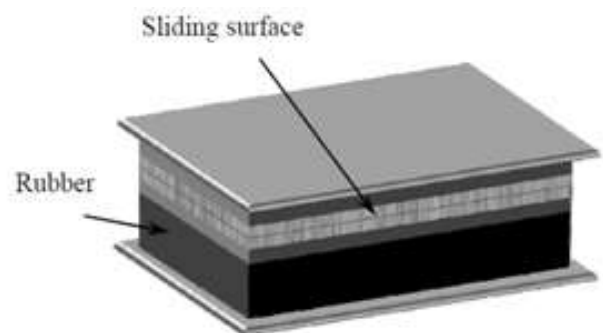
c. Resilient-Friction Base Isolation System

Resilient-friction base isolator (R-FBI) system consists of concentric layers of Teflon coated plates in friction contact with each other, and a central rubber core. It combines the beneficial effect of damping provided through friction, and the resiliency of the rubber. The rubber core distributes the sliding displacement, and velocity along the height of the RFBI. The rubber does not carry any vertical loads, and are vulcanized to the sliding ring. The system provides isolation through the parallel action of friction, damping, and restoring force. A schematic diagram of the mechanism is As the R-FBI is very rigid in the vertical direction it does not provide isolation against vertical ground motion. The ideal force-deformation characteristic of R-FBI is as shown in figure along with the schematic diagram.



d. Electricite-de-France System

This system was developed under the auspices of Electric de France (EDF) standardized for nuclear power plants in region of high seismicity. The EDF base isolator consists of laminates (steel reinforced) of neoprene pad topped by lead-bronze plate which is in friction contact with steel plate anchored to the base-raft of the structure. The EDF base isolator essentially uses elastomeric bearing and friction plate in series. An attractive feature of EDF isolator is that for lower amplitude ground excitations, the lateral flexibility of neoprene pad provides seismic isolation, and at high level of excitation sliding will occur which provides additional protection. Such dual isolation technique was intended for small earthquakes where the deformations are concentrated only at the bearings. However, for larger earthquakes the bronze and steel plates are used to slide, and dissipate seismic energy.



C. Seismic Dampers

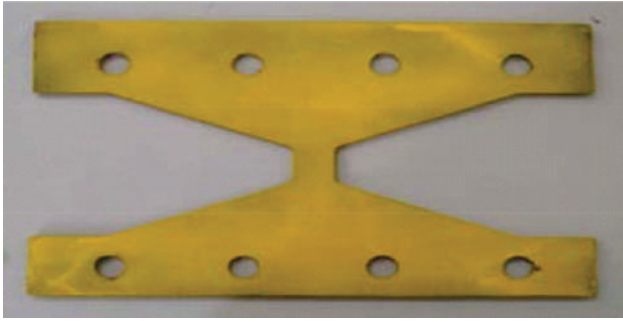
Another approach for controlling seismic damage in building and improving their seismic performance is by installing seismic dampers in place of structural elements such as diagonal braces.

Energy dissipation by dampers helps in overall reduction in displacements of the structure.

a. Metallic Yield Dampers

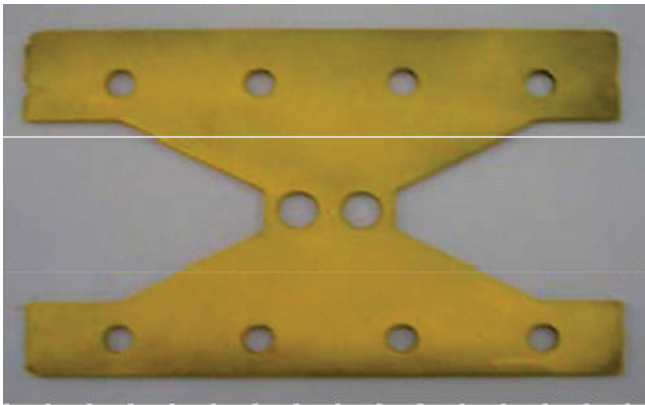
i. X-shaped metallic damper

The photograph of X-shaped damper is shown in Fig. Typical hysteresis curves from the test is depicted in It is noted that the X-shaped damper has such properties as large initial stiffness and high bearing capability. Yet, pinching in the middle of curve is observed from the experimental results. A reason of the above phenomena may be explained as stress concentration at the range of the center and the corner of the damper, and another is that the shear deformation is more than bending deformation.



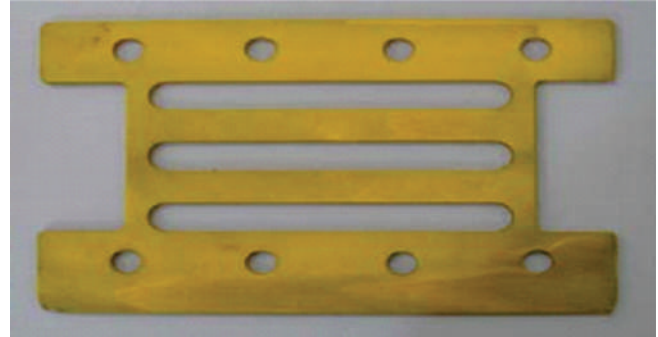
II. Double Round-hole Metallic Damper

The photograph of double round-hole metallic damper and its typical hysteretic curves from the test are shown in Fig.a and 3(b), respectively. During the test, it was observed from the hysteretic curves that the damper is good with large initial and (b), respectively. During the test, it was observed from the hysteretic curves that the damper is good with large initial stiffness. However, the crack along horizontal direction appeared around the center of damper as soon as the deformation reached to only about 6mm. The results of test reveal that the geometrical shape of double round-plate damper is undesirable.



III. Strip Metallic Damper

Fig. depicts the photograph of strip metallic damper. Its typical hysteretic curves from the test is shown in Fig. The experimental results exhibit that the strip metallic damper has both large initial stiffness and better capability of plastic deformation, except for a reduction of load due to buckling observed at the final stage of the test. Hence, the strip plate damper is of good energy-dissipated capability.



D. Friction Dampers

A variety of friction devices has been proposed and developed for energy dissipation in structures. Most of these devices generate rectangular hysteresis loops, which indicates that the behaviour of friction dampers is similar to that of Coulomb friction. Generally, these devices have good performance characteristics, and their behavior is relatively less affected by the load frequency, number of load cycles, or variations in temperature. Furthermore, these devices have high resistance to fatigue. The devices differ in their mechanical complexity and in the materials used for the sliding surfaces.

E. Visco Elastic Dampers

Flour Daniel, Inc., has developed a unique friction device, called the Energy Dissipating Restraint or EDR. The EDR was originally developed as a seismic restraint device for the support of piping systems in nuclear power plants. The EDR mechanism, figure 3.7, consists of sliding friction through a range of motions with a stop at the ends. The principal components of the device are internal springs, compression wedges, friction wedges, stops and a cylinder. The EDR is the only frictional device that generates non-rectangular hysteresis loops and a slip load proportional to displacement. Thus, in contrast to other frictional devices which exhibit rectangular hysteresis loops, EDRs are activated even by small excitations.

F. VISCOUS DAMPERS

Dampers which utilize the viscous properties of fluids have been developed and used in structural applications. A viscous-damping (VD) wall system was developed by Sumitomo Construction Company. Japan. The device consists of an outer steel casing attached to the lower floor and filled with a highly viscous fluid. An inner moving steel plate hanging from the upper floor is

contained within the steel casing. The viscous damping force is induced by the relative velocity between the two floors. Fluid viscous dampers may be used as passive energy dissipation elements in seismic isolation systems.

G. TUNED MASS DAMPERS.

A typical tuned mass damper (TMD) consists of a mass which moves relative to the structure and is attached to it by a spring and a viscous damper in parallel. When the structure vibrates, it excites the TMD and the kinetic energy is transferred from the structure to the TMD and is absorbed by the damping component of LHE device. The mass of LHE TMD usually experiences large displacements (stroke lengths). A tuned mass damper (TMD) is a device consisting of a mass, a spring, and a damper that is attached to a structure in order to reduce the dynamic response of the structure. The frequency of the damper is tuned to a particular structural frequency so that when that frequency is excited, the damper will resonate out of phase with the structural motion. Energy is dissipated by the damper inertia force acting on the structure.

H. Tuned Liquid Dampers.

Tuned liquid dampers (TLD) which have been used extensively in space satellites and marine vessels, are being implemented in structures for vibration control, TLDs, consist of rigid tanks filled with shallow liquid, where the sloshing motion absorbs the energy and dissipates it through viscous action of the liquid, wave breaking, and auxiliary damping appurtenances such as nets or floating beads. The principle of absorbing the kinetic energy of the structure is similar to TMDs where the fluid functions as the moving mass and the restoring force is generated by gravity. TLDs have several advantages over TMDs such as reducing the motion in two directions simultaneously and not requiring large stroke lengths. On the other hand, the relatively small mass of water or other fluids compared to the large mass of TMDs (usually steel, concrete, or lead) necessitates larger spaces to achieve the same damping effect. According to Sun et al. (1989), the natural frequency of TLDs can be computed from.

CONCLUSION :

Earthquake is of serious concern in the construction field. There are some very complex design procedures which are very important. These are used not only in the

foundation as a base isolation but also in the whole structure with protective elements of earthquake. Using different analysis methods very large and complex buildings can be modelled. The vibration of tall buildings with symmetrical or asymmetrical configuration is simulated for both harmonic loadings and real earthquake loadings. The mass asymmetrical tall building suffers more damages than the corresponding symmetrical buildings. It shows that the asymmetrical building is less seismic resistant than a symmetrical building during an earthquake. If the damping is underestimated and the stiffness is overestimated then the assumption about higher buildings on an undone soil structure interaction rigid base does not represent the earthquake response.

Earthquake is of serious concern in the construction field. It shows that the asymmetrical building is less seismic resistant than a symmetrical building during an earthquake

References :

- 1) Li Hong-Nan and Ying Jia. (2004). Theoretical and experimental studies on reduction for multi-modal seismic responses of high-rise structures by TLDs. *Journal of Vibration and Control* 10:7, 1041-1056.
- 2) Li Hong-Nan, Yin Yong-Wei, Wang Su-Yan. (2003). Studies on seismic reduction of story-increased buildings with friction layer and energy-dissipated devices. *Earthquake Engineering & Structural Dynamics* 32:14, 2143-2160.
- 3) Kelly J. M., Skinner R. I., Heine A. J.. (1972). Mechanisms of energy absorption in special devices for use in earthquake-resistant Structures.
- 4) Bull. N. Z. National Society for Earthquake Engineering 5:3, 63-88.
- 5) Whittaker A. S., Bertero V. V., Thompson C. I. and Alsonson L. J.. (1991). Seismic testing of steel plate energy dissipation devices. *Earthquake Spectra* 7:4, 563-604.
- 6) Tsai K. C., Chen H. W., Hong C. P. and Su Y. F.. (1993). Design of steel triangular plate energy absorbers for seismic resistant construction, *Earthquake Spectra* 19:3, 505-528.
- 7) Skinner R I., Kelly I. M., Heine A. J and Robinson W. H.. (1980). Hysteresis dampers for the protection for the protection of structures from Earthquake,

- Bull. N.Z. Nat. Soc. for Earthquake Engineering 13:1, 22-26.
- 8) Martinez-Romero. E. (1993). Experiences on the use of supplemental energy dissipators on building structures. *Earthquake Spectra* 9:3, 581-624.
 - 9) Seismic Design Code for Buildings (GB 50011—2001). China Architectural Industry Press, Beijing.
 - 10) Soong T. T., Dargush G. F. (1997). *Passive Energy Dissipation Systems in Structural Engineering*, John Wiley & Sons.
 - 11) Tehranizadeh M. (2001). Passive energy dissipation device for typical steel frame building in Iran. *Engineering Structures* 23:6, 643-655.
 - 12) Tnanka T, Makii K, Ueda H, Kushibe A, etc. (2003). Study on practical application of a new seismic damper using a Zn-Al alloy with a nanocrystalline microstructure. *Mechanical Sciences* 45:15, 99-1612.

Importance of Dalvik Virtual Machine in Android OS

Authors

Prof. Zeeshan I. Khan | Dr. Ajay B. Gadicha | Prof. Mayur S. Bhurange

- Abstract -

Dalvik Virtual Machine which plays an important role in the efficient execution of the application in Android Operating System made by Google. Instead of using a Standard JVM, the decision of making an alternative virtual machine while using Java code in the android application development suggest many reasons for the efficiency as well as fast execution. The Report helps to show the overall architecture, functionality, advantages behind using Dalvik Virtual Machine which is treated as the heart of Android Operating System. Keywords: Dalvik, Stack, Register, Dex, Virtual Machines

- Introduction -

Dalvik is the process virtual machine (VM) in Google's Android Operating System. It is the software that runs the apps on Android devices. Dalvik is thus an integral part of Android, which is typically used on mobile devices such as mobile phones and tablet computers as well as more recently on embedded devices such as smart TVs and media streamers. Programs are commonly written in Java and compiled to byte code. They are then converted from Java virtual machine-compatible Java class files to Dalvik-compatible .dex (Dalvik Executable) and odex (Optimized Dalvik Executable) files before installation on a device, giving rise to the related terms odexing and de-odexing. The compact Dalvik Executable format is designed to be suitable for systems that are constrained in terms of memory and processor speed. Dalvik is open-source software. It was originally written by Dan Bornstein, who named it after the fishing village of Dalvík in Iceland.

ANDROID ARCHITECTURE Every Android application runs in its own process, with its own instance of the Dalvik virtual machine. Dalvik has been written so that a device can run multiple VMs efficiently. The Dalvik VM executes files in the Dalvik Executable (.dex) format which is optimized for minimal memory footprint. The VM is register-based, and runs classes compiled by a Java language compiler that have been transformed into the .dex format by the included "dx" tool. The Dalvik VM relies on the Linux kernel for underlying functionality such as threading and low-level memory management. Given every application runs in its own process within its own virtual machine, not only must the running of multiple VMs be efficient but creation of new VMs must be fast as well.

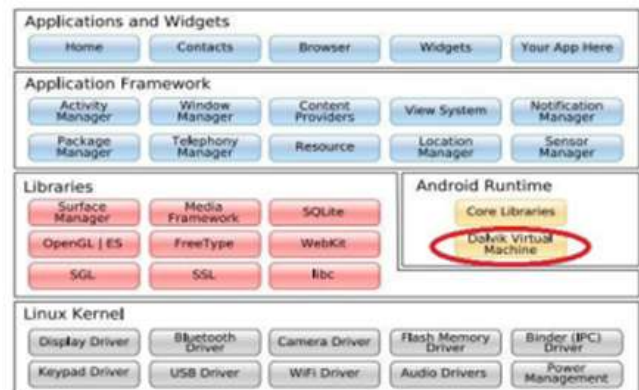


Fig 1. Android Architecture

The Dex File Format

THE DEX FILE FORMAT In standard Java environments, Java source code is compiled into Java byte code, which is stored within .class files. The .class files are read by the JVM at runtime. Each class in your Java code will result in one .class file. This means that if you have, say, one .java source

file that contains one public class, one static inner class, and three anonymous classes, the compilation process (javac) will output 5 .class files. On the Android platform, Java source code is still compiled into .class files. But after .class files are generated, the “dx” tool is used to convert the .class files into a .dex, or Dalvik Executable, file. Whereas a .class file contains only one class, a .dex file contains multiple classes. It is the .dex file that is executed on the Dalvik VM. The .dex file has been optimized for memory usage and the design is primarily driven by sharing of data. The following diagram contrasts the .class file format used by the JVM with the .dex file format used by the Dalvik VM.

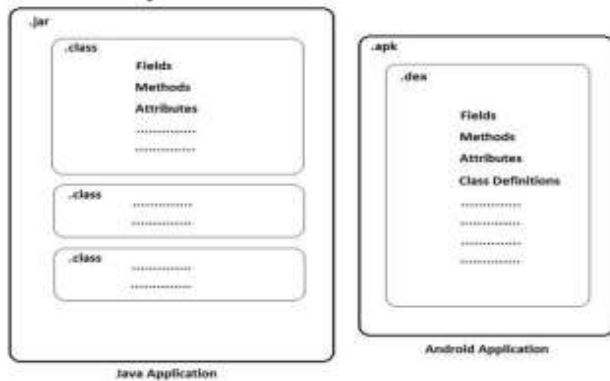


Fig 2. Format of DM

Analyzing Efficient Nature Of Dalvik

If the primary goal of utilizing shared constant pools is to save memory, how much memory is actually being saved? Early in the life of the .class file format, a study found that the average size of a .class file is actually quite small. But since the time to read the file from storage is a dominant factor in startup time, the size of the file is still important. When analyzing how much space each section of the .class file takes on average: the biggest part of the Java class files is the constant part [pool] (61 percent of the file) and not the method part that accounts for only 33 percent of the file size. The other parts of the class file share the remaining 5 percent. So it is clear that optimization of the constant pool can result in significant memory savings. The Android development team found that the .dex file format cut the size in half of some of the common system libraries and applications that ship with Android.

| Code | Un-Compressed Jar | Compressed Jar | dex file |
|-----------------|-------------------|----------------|---------------|
| Web Browser App | 470,312 (100%) | 232,065 (49%) | 209,248 (44%) |
| Alarm Clock App | 119,200 (100%) | 61,658 (52%) | 53,020 (44%) |

Fig 3. Analysis

VMS PROCESS

Since every application runs in its own instance of the VM, VM instances must be able to start quickly when a new application is launched and the memory footprint of the VM must be minimal. Android uses a concept called the Zygote to enable both sharing of code across VM instances and to provide fast startup time of new VM instances. The Zygote design assumes that there are a significant number of core library classes and corresponding heap structures that are used across many applications. It also assumes that these heap structures are generally read-only. In other words, this is data and classes that most applications use but never modify. These characteristics are exploited to optimize sharing of this memory across processes. The Zygote is a VM process that starts at system boot time. When the Zygote process starts, it initializes a Dalvik VM, which preloads and pre initializes core library classes. Generally these core library classes are read-only and are therefore a good candidate for preloading and sharing across processes. Once the Zygote has initialized, it will sit and wait for socket requests coming from the runtime process indicating that it should fork new VM instances based on the Zygote VM instance. Cold starting virtual machines notoriously takes a long time and can be an impediment to isolating each application in its own VM. By spawning new VM processes from the Zygote, the startup time is minimized. The core library classes that are shared across the VM instances are generally only read, but not written, by applications. When those classes are written to, the memory from the shared Zygote process is copied to the forked child process of the application's VM and written to there. This “copy-on-write” behavior allows for maximum sharing of

memory while still prohibiting applications from interfering with each other and providing security across application. In traditional Java VM design, each instance of the VM will have an entire copy of the core library class files and any associated heap objects. Memory is not shared across instances.

Using Register-based Architecture Rather Than Stack-based Architecture

Traditionally, virtual machine implementers have favored stack-based architectures over register-based architectures. This favoritism was mostly due to “simplicity of VM implementation, ease of writing a compiler back-end (most VMs are originally designed to host a single language and code density (i.e., executable for stack architectures are invariably smaller than executable for register architectures).” The simplicity and code density comes at a cost of performance. Studies have shown that a registerbased architecture requires an average of 47% less executed VM instructions than the stack based architecture]. On the other hand the register code is 25% larger than the corresponding stack code but this increased cost of fetching more VM instructions due to larger code size involves only 1.07% extra real machine loads per VM instruction which is negligible. The overall performance of the register-based VM is that it take[s], on average, 32.3% less time to execute standard benchmarks. Given that the Dalvik VM is running on devices with constrained processing power, the choice of a register-based VM architecture seems appropriate. Although register-based code is about 25% larger than stackbased code, the 50% reduction in the code size achieved through shared constant pools in the .dex file offsets the increased code size so you still have a net gain in memory usage as compared to the JVM and the .class file format.

STACK BASED VIRTUAL MACHINES

A stack based virtual machine implements the general features described as needed by a virtual machine in the points above, but the memory structure where the operands are stored is a stack data structure. Operations are carried out by popping data from the stack, processing them and pushing in back the results in LIFO (Last in First Out) fashion. In a stack based virtual machine, the operation of adding two numbers would

usually be carried out in the following manner (where 20, 7, and 'result' are the operands):

1. POP 20 2. POP 7 3. ADD 20, 7, result 4. PUSH result
- Because of the PUSH and POP operations, four lines of instructions is needed to carry out an addition operation. An advantage of the stack based model is that the operands are addressed implicitly by the stack pointer (SP in above image). This means that the Virtual machine does not need to know the operand addresses explicitly, as calling the stack pointer will give (Pop) the next operand. In stack based VM's, all the arithmetic and logic operations are carried out via Pushing and popping the operands and results in the stack.

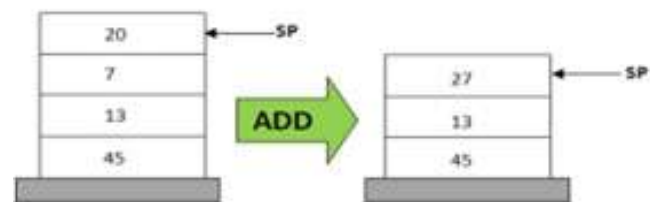


Fig 4. Stack Based VM

Register Based Virtual Machines

In the register based implementation of a virtual machine, the data structure where the operands are stored is based on the registers of the CPU. There is no PUSH or POP operations here, but the instructions need to contain the addresses (the registers) of the operands. That is, the operands for the instructions are explicitly addressed in the instruction, unlike the stack based model where we had a stack pointer to point to the operand. For example, if an addition operation is to be carried out in a register based virtual machine, the instruction would more or less be as follows:

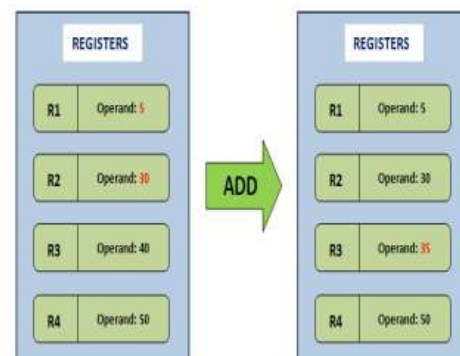
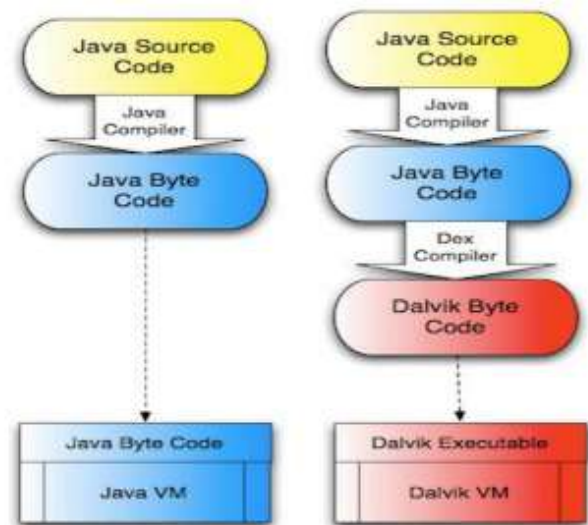


Fig 5. Register Based VM

As it is mentioned earlier, there is no POP or PUSH operations, so the instruction for adding is just one line. But unlike the stack, we need to explicitly mention the addresses of the operands as R1, R2, and R3. The advantage here is that the overhead of pushing to and popping from a stack is nonexistent, and instructions in a register based VM execute faster within the instruction dispatch loop. Another advantage of the register based model is that it allows for some optimizations that cannot be done in the stack based approach. One such instance is when there are common sub expressions in the code, the register model can calculate it once and store the result in a register for future use when the sub expression comes up again, which reduces the cost of recalculating the expression. The problem with a register based model is that the average register instruction is larger than an average stack instruction, as we need to specify the operand addresses explicitly. Whereas the instructions for a stack machine is short due to the stack pointer, the respective register machine instructions need to contain operand locations, and results in larger register code compared to stack code.

Conclusion :

The use of Dalvik Virtual Machine with Register Based Architecture to convert a .class file into a .dex file format which helps the application to execute in a fast manner as well as in a own process.



References :

- 1) David Ehringer- "The Dalvik Virtual Machine Architecture".
- 2) [http://en.wikipedia.org/wiki/Dalvik_\(software\)](http://en.wikipedia.org/wiki/Dalvik_(software)).
- 3) Dalvik (<http://source.android.com/devices/tech/dalvik/>).
- 4) Stack based and Register based Architecture (<http://markfaction.wordpress.com/2012/07/15/stack-based-vs-register-based-virtual-machinearchitecture-and-the-dalvik-vm/>).

Deep Learning for Digital Signal Processing

Authors

Sunpreet Kaur Nanda | Vaishali Bhagat | Akshay Dhande | Pravin Soni | Dr. A. B. Gadicha

- Abstract -

The reason for this article is to acquaint the pursuers with the developing innovations empowered by deep learning and to audit, the examination work led right now is of direct importance to flag preparing. We in like way call attention to, in our view, the future research headings that may pull in interests of and require attempts from dynamically signal preparing specialists and specialists that are driving sign and information taking care of advancement and applications. Any cerebrum PC interface framework must decipher signals from the client's mind into messages or orders. Many signal preparing and deep learning applications have been created for this signal interpretation, and this part surveys the most widely recognized ones. Thus in this paper, we are accentuating profound learning in signal preparation and we are additionally talking about certain uses of the equivalent.

Keywords: Deep learning, Digital signal processing, Data handling

- Introduction -

In signal dealing, a sign is a limit that passes on measurements about a wonder. In gadgets and communication correspondences, it implies each time contrasting voltage, present-day, or electromagnetic wave that passes on information. A sign may likewise in like manner be described as an unmistakable change in quality, for instance, sum. Any quality, for example, the physical amount that shows variety in space or time can be utilized as a sign to share messages between onlookers. Signal handling is an electrical building subfield that centers on breaking down, altering, and blending signs, for example, sound, pictures, and natural estimations. Signal handling methods can be utilized to improve transmission, stockpiling productivity, and

abstract quality and to likewise underline or identify segments of enthusiasm for a deliberate sign. Profound learning (otherwise called profound organized learning or differential writing computer programs) is a piece of a more extensive group of artificial intelligence material examination and prepackaged game projects, where they have created results equivalent to and at times outperforming human master execution. Numerous conventional AI and sign preparing strategies abuse shallow structures, which contain a single layer of nonlinear segment change. Examples of shallow plans are conventional (HMMs)Hidden Markov models, (CRFs) Conditional Random Fields, straight or nonlinear dynamical structures, (SVMs)Support Vector Machines, Maximum entropy (MaxEnt) models, part relapse, and procedures subject to counterfeit neural frameworks with depiction acing. Learning might be overseen, semi-managed, or solo [1-3]. Profound acing models, for instance, significant neural frameworks, significant conviction structures, dull neural structures, and convolutional neural structures were done to fields comprehensive of PC vision, talk affirmation, normal language taking care of, sound affirmation, easygoing network filtering, framework understanding, bioinformatics, calm structure, clinical photograph examination, material examination, and prepackaged game projects, where they have created results equivalent to and at times outperforming human master execution. Numerous conventional AI and sign preparing strategies abuse shallow structures, which contain a solitary layer of nonlinear part change. Instances of shallow plans are standard Hidden Markov models (HMMs), straight or nonlinear dynamical structures, Conditional Random Fields (CRFs), Maximum entropy (MaxEnt) models, Support Vector Machines (SVMs), part descend into sin, and

MultiLayer Perceptron (MLP) with a solitary concealed layer. A property typical to these shallow learning models is the crucial arrangement that incorporates just one layer obligated for changing the unpleasant data signals or highlights into an issue unequivocal part space, which might be unobtrusive. Take the occurrence of an SVM, it is a shallow straight division model with one segment change layer when a bit stunt is utilized, and with zero segment change layer when a part stunt isn't utilized. Human information taking care of frameworks (e.g., vision and talk), in any case, propose the need for significant plans for expelling complex structure and building inside depiction from rich unmistakable wellsprings of data (e.g., regular picture and its development, talk, and music). For instance, human discourse creation and recognition frameworks are both furnished with plainly layered various leveled structures that utilize a lot of unlabeled preparing information for separating structures and regularities in the information highlights.

2. Deep Learning Applications in Digital Signal Processing Areas

In the extended specialized extent of sign preparing, the sign is enriched with not just the customary kinds, for example, soundchanging records from the waveform stage to the etymological degree and the other manner around. It is normal to simply accept that class satisfaction can be stepped forward in managing these varieties of media alerts if talented and powerful profound studying calculations are created. Signal coping with frameworks with profound structures are made out of numerous layers of nonlinear creation prepared stages, where each lower layer's yields are arranged to its fast higher layer because of the data. The productive significant acing approaches became so far give two additional key properties: the generative idea of the model, which commonly requires a more noteworthy top layer to play out the discriminative task, and a solo pre getting ready to advance, discourse, picture, and video, yet additionally content, language, and archive that pass on an elevated level, semantic data for human utilization. Also, the extent of handling has been reached out from the regular coding, improvement, examination, and acknowledgment to incorporate progressively human-driven assignments of translation,

getting, recovery, mining, and user interface [4]. Many signs preparing specialists have been taking a shot at least one of the sign handling zones characterized by the lattice built with the two tomahawks of "sign" and "preparing" examined here. The profound learning strategies talked about right now as of late have been applied to a lot of expanded sign preparing zones. We presently give a short review of this assemblage of work in three fundamental classifications. Because of the constraint on the number of references, we have precluded some reference postings in the accompanying review.

2.1 Audio and Speech

The customary multilayer perceptron has been being used for discourse acknowledgment for a long time and when applied alone, their presentation is frequently decreased than the first-rate in elegance Hidden Markov Model frameworks with belief chances approximated with (GMMs) Gaussian Mixture Models. As of late, the profound learning system changed into effectively applied to telephone [2,3] and Large Vocabulary Continuous Speech Recognition (LVCSR) assignments through incorporating the ground-breaking discriminative preparing capacity of the deep belief networks and the consecutive demonstrating capability of the HMMs. Such a version is typically named DBN-HMM, where the belief likelihood is evaluated utilizing the Deep Belief Network (DBN) and the consecutive fact is confirmed utilizing the Hidden Markov Model (HMM). In [3], a five-layer Deep Belief Network (DBN) changed into utilized to supplant the Gaussian blend a part of the Gaussian mixture model-based HMMs (GMM-HMM), and the monophonic state became utilized as the showing unit. Even though the monophonic model changed into utilized, the DBN-HMM technique done serious Smartphone acknowledgment exactness with the first-class in-class triphone GMMHMM frameworks. The work in [2] advanced the DBN-HMM applied in [3] through making use of the CRF in place of the HMM to expose the consecutive records and by using making use of the Man-Machine-Interface (MMI) making ready machine efficaciously created in discourse acknowledgment to the new Conditional Random Field (CRF) model (named DBN-CRF) getting ready. The progressive

discriminative learning strategy made in [3] simultaneously improves the Deep Belief Network (DBN) loads, exchange loads, and telephone language model and did higher exactness than the Deep Belief Network- Hidden Markov Model (DBN-HMM) wireless recognizer with the edge discriminativepreparing measure verifiable inside the DBN's adjusting machine actualized in [3]. The DBN-HMM can be reached out from the putting autonomous version to the setting subordinate version and from the phone acknowledgment to the LVCSR- large vocabulary continuous speech recognition. Tests at thehard Bing portable voice seek informational index gathered belowthe realutilization situation show that the setting subordinate DBN-HMM beats the satisfactory in elegance HMM framework. Three elements transfer to the accomplishment: the use of triphone Senonesbecause the DBN exhibiting units, utilizing the top-notch accessible triphone GMM-HMM to give the telephone game plan, and the tuning of the advancement possibilities. Tests moreover show that the unraveling time of a five-layer DBN-HMM is kind of as that of the realm of the craftsmanship triphone GMM-HMM. In [5], the significant auto-encoder [1] is explored in the talk including codingissues with the objective to p.c. the realities to a predefined scope of bits with insignificant age screw up. DBN pre getting ready is viewed as significant for unnecessary coding capability.

2.2 Video and Image

The first Deep Belief Network and significant auto-encoder had been made and shown with progress on the direct picture affirmation and dimensionality decline (coding) assignments (MNIST) in [1]. It is fascinating to know that the development of coding capability utilizing the Deep Belief Network -set up auto-encoder concerning the image information over the standard strategy for head component assessment as affirmed in [1] is in a general sense equivalent to the expansion presented in [5] at the talk measurements over the customary technique for vector quantization. In [4], Nair and Hinton built up a changed Deep Belief Network in which the top-layer model utilizes a third-demand Boltzmann gadget. They actualized this type of Deep Belief Network to the NORB database—a three-d article affirmation task. A bungle charge near the superb

circulated result on this task becomes represented. In particular, it changed into showed that the DBN broadly beats shallow models, for instance, SVMs. Tang and Eliasmith made two frameworks to improve the quality of the Deep Belief Network in [4]. In any case, they used insufficient relationships in the essential layer of the Deep Belief Network as a strategy to regularize the rendition. Second, they developed a probabilistic denoising computation.The two structures are tested to be viable in enhancing the powerin opposition toimpediment and arbitrary clamor in a boisterous picture acknowledgment task. Another excitingpainting on photo acknowledgment with a more broad methodology than Deep Belief Network suggests up in [5]. DBNs have likewise been effectively carried out to make minimal however crucial portrayals of photos for recovery purposes.

2.3 Information retrieval and Language Processing

Exploration in language, report, and content managing has visibleexpanding prominence as of late by using signal coping with analysts and has been assigned as one in all the primarymiddle zones throughthe overall public's sound, discourse, and language preparingspecialized panel. LM- language model has been utilizing neural systems for a long time- a sizablepart in discourse acknowledgment, gadget interpretation, content recordshealing, and in characteristic language getting ready. As of late, profound systems have begun status out inside thearea of language preparation and statisticsrecovery. Transiently calculated restricted Boltzmann device has been put in for LM. Dissimilar to the customary N-gram version- a sequence of N words, the calculated restricted Boltzmann machineutilizes conveyed portrayals for settingwordsin addition to for the words being anticipated. This techniquecan be straightforwardly summed up intomore profound structures.

Conclusion

We have presented the fundamental thought of profound gaining knowledge of, the general profound models, for example, DBN, and the mainstream and successful profound getting to know calculations such as the RBM and denoising automobile encoder-primarily basedpre-making ready approaches. Writings display that profound getting to knowmethods have simplyshown

promising results in many signs dealing with applications. Profound gaining knowledge is a growing innovation. In this manner, we infer that notwithstanding the precise promising results targeted up until now, much needs to be created.

References :

- 1) Y. Bengio, "Learning deep architectures for AI," *Found. Trends Mach. Learn.*, vol. 2, no. 1, pp. 1-127, 2009.
- 2) G. Hinton, S. Osindero, and Y. Teh, "A fast learning algorithm for deep belief nets," *Neural Comput.*, vol. 18, pp. 1527-1554, 2006.
- 3) L. Deng, "Expanding the scope of signal processing," *IEEE Signal Processing Mag.*, vol. 25, no. 3, pp. 2-4, May 2008.
- 4) Y. Tang and C. Eliasmith, "Deep networks for robust visual recognition," in *Proc. ICML*, 2010.
- 5) G. Hinton, "A practical guide to training restricted Boltzmann machines," Univ. Toronto, Tech. Rep. 2010-003, Aug. 2010.

Digital Forensics

Authors

Sunpreet Kaur Nanda | Prachi Kale | Vishal Padole | Sneha Sontakke

- Abstract -

Digital Forensics is defined as the process of preservation, identification, extraction, and documentation of computer evidence that can be used by a court of law. It is the science of finding evidence from digital media like a computer, mobile phone, server, or network. It provides the forensic team with the best techniques and tools to solve complicated digital-related cases. Digital Forensics helps the forensic team to analyze, inspect, identify, and preserve the digital evidence residing on various types of electronic devices. Different aspects of digital forensics, its process, use and variables influencing crime scene investigation are discussed in this chapter. In this chapter, we are also emphasizing the advantages and disadvantages of digital forensics.

Keywords: Digital forensics, crime scene investigation.

- Introduction -

Digital forensics (sometimes known as virtual forensic technology) is a department of forensic technology encompassing the healing and research of material observed in virtual devices, frequently about pc crime. The term virtual forensics become at the beginning used as a synonym for laptop forensics however has increased to cover the investigation of all devices capable of storing digital information. With roots in the private computing revolution of the past due to the 1970s and early 1980s, the field developed haphazardly at some stage in the 1990s, and it was not till the early twenty-first century that national regulations emerged.

The technical component of research is divided into numerous sub-branches, regarding the type of digital gadgets involved; computer forensics, community forensics, forensic information evaluation,

and mobile device forensics. The regular forensic method encompasses the seizure, forensic imaging (acquisition) and analysis of digital media, and the manufacturing of a record into gathered proof. As nicely as figuring out direct evidence of a crime, virtual forensics can be used to attribute proof to unique suspects, verify alibis or statements, decide the intent, perceive sources or authenticate documents. Investigations are plenty broader in scope than other areas of forensic analysis often involving complex time strains or hypotheses.

2. Goals of PC crime scene investigation

Here are the fundamental destinations of utilizing Computer crime scene investigation:

- It assists with recuperating, dissecting, and protecting PC and related materials in such a way, that it causes the examination office to introduce them as proof in an official courtroom.
- It assists with proposing the rationale behind the wrongdoing and personality of the fundamental guilty party.
- Structuring systems at a speculated wrongdoing scene which causes you to guarantee that the advanced proof acquired isn't debased.
- Information procurement and duplication: Recovering erased records and erased parcels from advanced media to extricate the proof and approve them.
- Causes you to recognize the proof rapidly and permits you to evaluate the potential effect of the malevolent movement on the person in question delivering a PC measurable report which offers a total report on the examination procedure.

- Protecting the proof by following the chain of authority.

3. Process of Digital Forensics

Digital forensics entails the following steps that are explained below:

- **Identification:** It is the first step inside the forensic technique. The identification process mainly consists of things like what evidence is present, where it is stored, and lastly, how it's far stored. Electronic storage media can be personal computers, Mobile phones, PDAs, etc.
- **Preservation:** In this phase, information is isolated, secured, and preserved. It consists of stopping humans from using virtual devices so that digital evidence isn't always tampered with.
- **Analysis:** In this step, investigation marketers reconstruct fragments of facts and draw conclusions based totally on evidence found. However, it'd take numerous iterations of the exam to support a particular crime theory.

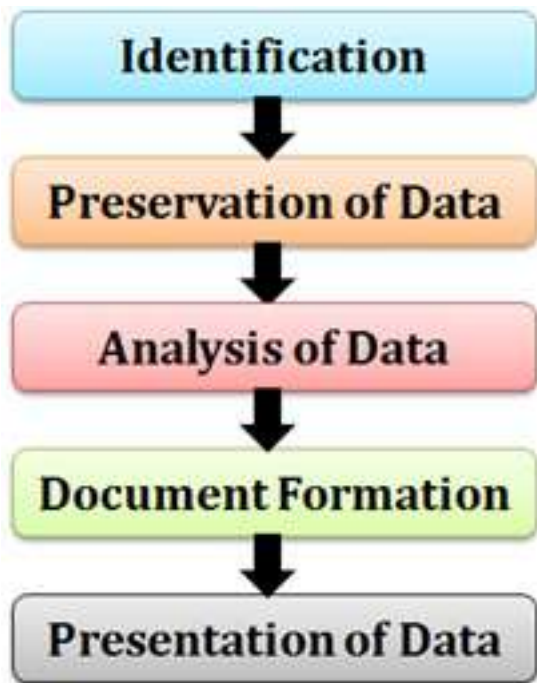


Figure 1: Process of digital forensics

- **Documentation:** In this technique, a report of all of the visible statistics ought to be created. It enables recreating the crime scene and reviewing it. It involves the right documentation of the crime scene along with photographing, sketching, and crime-scene mapping.
- **Presentation:** In this final step, the technique of summarization and clarification of conclusions is done.

1. Difficulties looked through Digital Forensics

Here, are full-size problems looked at with the aid of the Digital Forensic:

- The enlargement of PCs and extensive utilization of internet access
- Simple accessibility of hacking instruments
- Absence of physical proof makes indictment troublesome.
- The large degree of more room in Terabytes makes these investigations troublesome.
- Any innovative changes require an update or adjustments to arrangements.

2. Model Uses of Digital Forensics

In late time, enterprise associations have applied automatic prison sciences in the following a sort of cases:

- Licensed innovation robbery
- Mechanical reconnaissance
- Business questions
- Misrepresentation examinations
- Improper usage of the Internet and email inside the working environment
- Fabrications related issues

3. Advantages of Digital criminal sciences

Here, are some advantages of Digital criminal sciences

- To guarantee the honesty of the PC framework.
- To deliver evidence in the court, this can spark off the field of the guilty party.

- It encourages the agencies to catch massive information if their PC frameworks or systems are undermined.
- Proficiently finds cybercriminals from anywhere on the planet.
- Assists with ensuring the association's cash and significant time.
- Permits to concentrate, process, and decipher the verifiable proof, so it demonstrates the cybercriminal activity inside the court.

4. Detriments of Digital Forensics

Here, are sizable cons/downsides of using Digital Forensic

- Advanced proof stated in court. In any case, its miles have to be proven that there's no altering.
- Creating electronic records and placing away them is an amazingly luxurious undertaking.
- Lawful specialists ought to have huge PC data.
- Need to create authentic and persuading evidence.
- In the occasion that the instrument applied for automatic criminology isn't always as per indicated gauges, at that point in the legit courtroom, the evidence may be opposed via equity.
- Absence of specialized information by way of the examining reputable probably might not offer the proper outcome.

Conclusion

Digital Forensics is the preservation, identification, extraction, and documentation of pc evidence which can be used inside the court docket of law Process of Digital forensics consists of 1) Identification, 2) Preservation, 3) Analysis, 4) Documentation and, 5) Presentation.

Different types of Digital Forensics are Disk Forensics, Network Forensics, Wireless Forensics, Database Forensics, Malware Forensics, Email Forensics, Memory Forensics, etc. Thus we conclude that digital forensic science can be used for cases like 1) Intellectual Property theft, 2) Industrial espionage 3) Employment disputes, and 4) Fraud investigations.

References :

- 1) Sundresan Perumal; Norita Md Norwawi; Valliappan Raman; Internet Of Things(IoT) Digital Forensic Investigation Model: Top-Down Forensic Approach Methodology; IEEE Fifth International Conference on Digital Information Processing and Communications (ICDIPC) **2015**, DOI: **10.1109/ICDIPC.2015.7323000**
- 2) Kwaku Kyei; Pavol Zavarsky; Dale Lindskog; Ron Ruhl; A Review and Comparative Study of Digital Forensic Investigation Models; ICDF2C Digital Forensics & Cyber Crime; **2012**, https://doi.org/10.1007/978-3-642-39891-9_20
- 3) Harleen Kaur and Khairaj Ram Choudhary, "Digital Forensics: Implementation and Analysis for Google Android Framework," Springer International Publishing Switzerland 2017 I.M. Alsmadi et al. (eds.), Information Fusion for Cyber-Security Analytics, Studies in Computational Intelligence 691, DOI 10.1007/978-3-319-44257-0_13.
- 4) What is Digital Forensics? History, Process, Types, Challenges; < <https://www.guru99.com/digital-forensics.html>>
- 5) Digital forensics; < https://en.wikipedia.org/wiki/Digital_forensics>

A New Contingency Analysis Approach Based online Stability Indices for the Assessment of Voltage Stability

A. S. Telang | Y.D.Shahakar

- Abstract -

A new approach to power system contingency analysis and ranking using line voltage stability indices for the assessment of voltage stability is proposed here. Traditional Newton –Raphson (NR) method of load flow is used. The results of load flow calculations are used to construct the line voltage stability indices, namely Fast Voltage Stability Index (FVSI), Line Stability Index (Lmn) and Line Stability Factor (LQP) which reflect the degree of severity of contingencies and hence critical contingencies are marked. Those critical contingencies are screened for ranking of the contingencies and so also for the assessment of voltage stability. The effectiveness of the proposed method is demonstrated on various standard IEEE bus test systems, standard IEEE-14 bus test system specifically. The proposed methodology is implemented in the MATLAB platform which offers a comprehensive solution not only for contingency analysis and ranking but also for finding voltage stability condition for highly ranked contingency, under novel load increase scenario.

Keywords : Voltage Stability; Contingency analysis; Line outage; Line stability indices; Critical line; NR-load flow.

- Introduction -

Recently, the steady state voltage stability has become a matter of great concern in the modern power systems. As the modern power systems are more complex and more heavily loaded, very often they are forced to operate close to voltage stability limits, resulting in voltage instability or voltage collapse [1-2]. This causes adverse effect on the system's security. Contingency analysis is an important aspect of power

system security assessment. It helps the system engineer to know which line outage is dangerous to the system and what preventive action is to be taken to protect the system from that particular line outage. Thus determining the severity of contingency is a key issue in voltage stability studies [3]. It has been demonstrated experimentally that there is a simultaneous occurrence of both line outage and voltage collapse [4]. Line outages, in fact, can be treated as the secondary cause of voltage collapse. Hence, contingency analysis techniques and the ranking of contingencies are the most important constituents of voltage stability assessment methods. These techniques help in rapid and accurate determination of those contingencies which may cause power system instability according to their severity, and thus in implementing suitable preventive control actions taking into consideration those contingencies that are likely to affect the power system performance [5]. The process of identifying severe contingencies is referred to as contingency selection and this can be done by calculating voltage stability indices for each contingency [6]. Various methods for contingency analysis and ranking have been proposed in the literature. The algorithm for automatic contingency analysis and ranking technology using line based voltage stability index is described by Ismail Musirin et.al [7]. A novel index called Fast Voltage Stability Index (FVSI) is presented in [8] to predict the occurrence of voltage collapse and the contingency caused by line outage in a power system. M.Moghavvemi et.al [9-10] studied real time contingency evaluation and ranking technology using Voltage Collapse Proximity Indicator (VCPI) based on maximum power transfer between two buses, using Thevenin's equivalent network. A normal power flow is

utilized for the evaluation of VCPI. The proposed method was found to be capable of identifying the exact location of voltage collapse in a power system. Reference [11] presents an improved Line Collapse Proximity Index (LCPI) to predict the occurrence of voltage collapse and severity of the loading stress in the line. The contingency selection by calculating active and reactive power performance index (PIP and PIV) for single transmission line outage is presented in [12]. An algorithm for contingency analysis using N-R load flow has been developed with main focus on the contingency selection for line outage for multibus power systems. A new contingency ranking approach based on genetic algorithm is proposed in [13] where a contingency ranking is formulated as an optimization problem with the objective of finding all critical cases. A new method based on curve fitting approach has been proposed in [14] for contingency screening and ranking for voltage stability analysis.

In this paper, all line stability indices viz. FVSI, Lmn and LQP are used as an index for contingency analysis and ranking along with for estimation of voltage stability. The contingency evaluation using traditional NR load flow is carried out under novel load increase pattern with single transmission line outage. The ranking in terms of line outage severity has been achieved by identifying the highest value of these indices for every line outage simulation. In order to realize the effectiveness of the proposed approach, simulations have been performed on several IEEE test systems and the results of standard IEEE 14 bus test system have been presented specifically. Furthermore, a novel idea of finding voltage stability condition for highly ranked contingency under load increment, using Newton Raphson (N-R) power flow is also presented here.

The method proposed here is deemed to be simple and fast since it uses only the power flow solutions.

II. Contingency Analysis and Ranking

Contingency analysis is an important aspect in the power system to give the operators an indication of what might have happen to the power system in the event of an outage (generator or line outage). A number of methods are available for contingency analysis [6]. The most popular is the performance index based method. In

the present research work, line stability indices have been used as the performance indices. The conventional power flow is used efficiently to calculate these indices. Ranking of the contingencies is done based on the values of these indices (0, 1). The contingency with the highest value of these line indices, FVSI specifically (1), is ranked first. Then the estimation of voltage stability is carried out for higher ranked contingencies.

III. Line Stability Indices

Line stability indices are both simple in nature and easy to calculate. They may have a value that varies from zero to one. Any line exceeding the maximum limit of these stability indices

(1) can cause voltage collapse. Brief description of these indices has been give as follows:

A) Fast Voltage Stability Index FVSI

The line stability index FVSI proposed by I. Musirin *et al.* [7] and [8] is based on the concept of power flow through a single line. It is calculated as

$$FVSI_{ij} = \frac{4 * Z^2 * Q_j}{V_i^2 * X}$$

taking the symbol “i” as sending bus s and “j” as the receiving bus r.

A] Line Stability Index Lmn

The line stability index Lmn [9-10] is formulated based on a power transmission concept in a single line. It is given by-

$$Lmn = \frac{4 * X * Q_j}{[V_i * \sin(\theta - \delta)]^2}$$

A] Line Stability Factor LQP

The line stability factor LQP is obtained using the same concept as in [9-10]. This factor is sensitive to change in reactive power. It is expressed as-

$$LQP = 4 * \frac{[V_i * \sin(\theta - \delta)]^2}{X * Q_j}$$

where Z is the line impedance X is the line reactance
 Q_j is the reactive power at the receiving end, and V_i is
the sending end voltage
 P_i is the real power at the sending end
 q is the line impedance angle, and
 d is the angle difference between the supply voltage
and the receiving voltage.

I. Methodology

Line stability indices viz. FVSI, Lmn and LQP have been calculated on the basis of NR- load flow to perform the contingency selection process under a novel load increment scenario. The ranking of the line outage contingency is then decided on the basis of values of these indices in general and FVSI in particular. The

higher values indicate higher ranks and higher level of severity. The line with highest values of line indices is considered to be the most critical one and its outage as the critical outage which will result in a great impact on the whole system.

Generally contingency analysis is separated into three parts as contingency selection, ranking and evaluation. Much work has been done on these parts. In this work, inclusion of the analysis of voltage stability condition along with contingency analysis and ranking, based on all three line stability indices, adds the significant as well as unique contribution to the conventional contingency analysis technique. Figure 1 shows the flow chart of the complete methodology of analysis. The results are simulated on standard IEEE 14 bus test system. The figure shows the implementation of three sections viz., contingency selection, contingency ranking and voltage stability analysis taken together, for efficient and effective study of voltage stability.

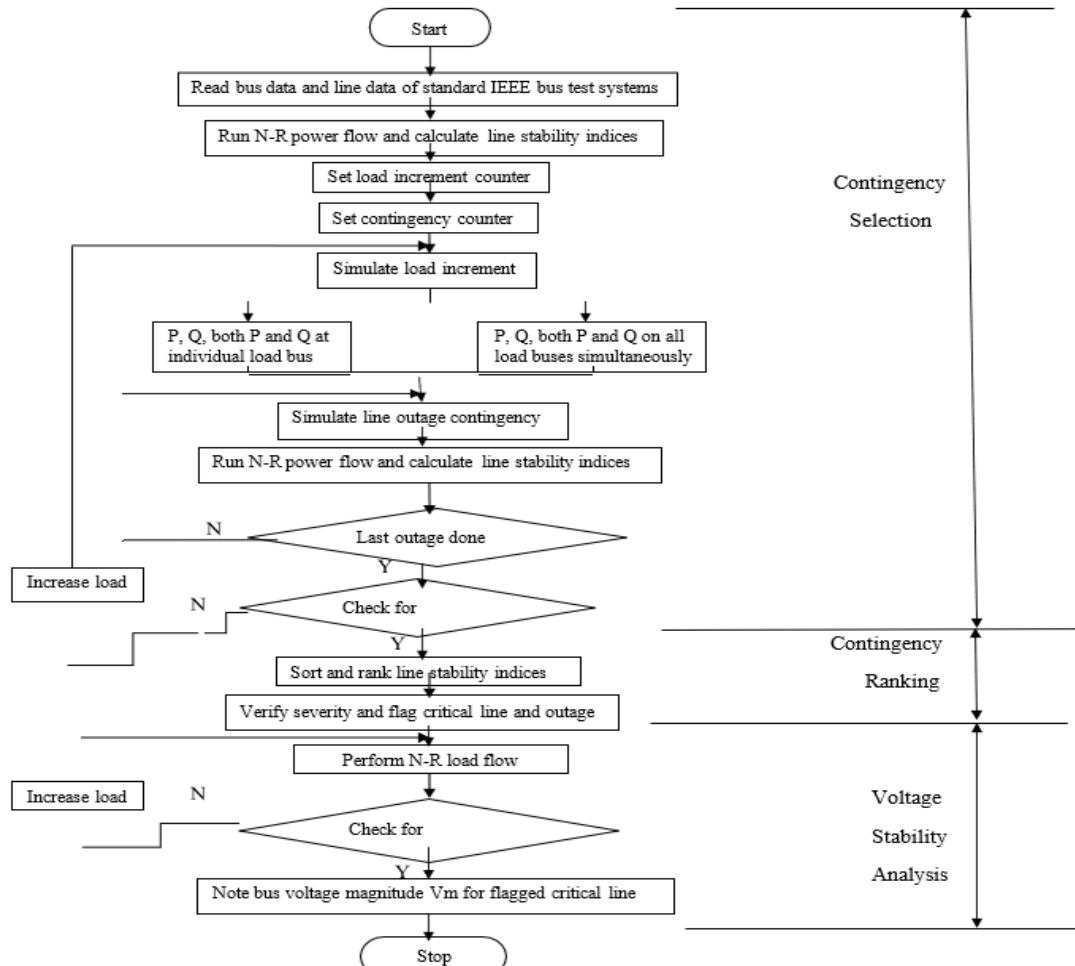


Fig. 1 flowchart of complete methodology of analysis

I. Results and Discussions

For rigorous investigation of the effect of line outages under stressed conditions, using the line indices on the power system, the following two cases are considered mainly-

A] Contingency analysis, ranking and assessment voltage stability under stressed condition B] Contingency analysis and ranking under novel load increase scenario The results for above cases are simulated on various standard IEEE test bus systems and the results of IEEE 14 bus test system have been shown specifically. For both the cases, load pattern has been chosen in such a way that the Newton-Raphson load flow will not diverge.

A] Contingency analysis, ranking and assessment voltage stability under stressed condition.

Reactive power deficient systems are more prone to voltage instability. Hence reactive power loading is considered in this case for the contingency analysis, ranking and voltage stability assessment. A heavy reactive loading in the range of 3 p.u. to 10 p.u. in steps of 0.5 p.u. at the maximum affected nodes 4, 9, 13 and 14 have been shown in the Table 1 and the ranking of critical contingencies are presented in Table 2. These are ranked according to the values of line stability indices, i.e. the ranking is based on the highest values of all three line stability indices viz., FVSI, Lmn, and LQP, specifically FVSI.

Table 1
Contingency analysis with heavy reactive loading

| Line | Line outage | Most stressed line (from-to) | FVSI | Lmn | LQP |
|--|-------------|------------------------------|--------|--------|--------|
| Prespecified reactive load $Q_4=3\text{p.u.}, Q_9=3\text{p.u.}, Q_{13}=10\text{p.u.}, Q_{14}=10\text{p.u.}$ | | | | | |
| 8 | 4-7 | 4-9 | 1.4883 | 1.5279 | 1.2013 |
| | | 14-9 | 1.0157 | 1.0029 | 0.8231 |
| | | 14-13 | 1.2321 | 1.1722 | 0.9792 |
| | | 13-14 | 1.0185 | 1.0157 | 0.8104 |
| 11 | 6-11 | 9-4 | 0.9128 | 0.9199 | 1.0077 |
| | | 4-9 | 1.4448 | 1.5131 | 1.2084 |
| | | 14-9 | 0.9837 | 0.9660 | 0.7975 |
| | | 14-13 | 1.2302 | 1.1823 | 0.9777 |
| 12 | 6-12 | 13-14 | 1.0207 | 1.0086 | 0.8122 |
| | | 9-4 | 0.8956 | 0.9013 | 0.9869 |
| | | 4-9 | 1.5030 | 1.5142 | 1.2103 |
| | | 14-9 | 1.0000 | 0.9716 | 0.8106 |
| 13 | 6-13 | 14-13 | 1.2426 | 1.2060 | 0.9875 |
| | | 13-14 | 1.0429 | 1.0163 | 0.8296 |
| | | 9-4 | 0.9086 | 0.9153 | 1.0027 |
| | | 4-9 | 1.5044 | 1.5171 | 1.2112 |
| 15 | 7-9 | 14-9 | 1.0721 | 1.0333 | 0.8683 |
| | | 14-13 | 1.2710 | 1.2043 | 1.0026 |
| | | 13-14 | 1.2966 | 1.2649 | 1.0266 |
| | | 9-4 | 0.9939 | 1.0166 | 1.0165 |
| 18 | 10-11 | 4-9 | 1.4896 | 1.5270 | 1.2021 |
| | | 14-9 | 1.1781 | 1.1501 | 0.9531 |
| | | 14-13 | 1.2605 | 1.2056 | 1.0001 |
| | | 13-14 | 1.0480 | 1.0327 | 0.8336 |
| 19 | 12-13 | 9-4 | 0.9061 | 0.9125 | 0.9996 |
| | | 4-9 | 1.5014 | 1.5136 | 1.2094 |
| | | 14-13 | 1.2229 | 1.1809 | 0.9720 |
| | | 13-14 | 1.0189 | 1.0018 | 0.8107 |
| | | 9-4 | 0.8945 | 0.9001 | 0.9857 |
| | | 4-9 | 1.5025 | 1.5134 | 1.2100 |
| | | 14-9 | 0.9997 | 0.9684 | 0.8063 |
| | | 14-13 | 1.2356 | 1.1961 | 0.9820 |
| | | 13-14 | 1.0322 | 1.0087 | 0.8212 |

Table 2
Critical contingency ranking

| Line | Contingency (from-to) | Rank |
|------|-----------------------|------|
| 13 | 6-13 | 1 |
| 12 | 6-12 | 2 |
| 19 | 12-13 | 3 |
| 18 | 10-11 | 4 |
| 15 | 7-9 | 5 |
| 8 | 4-7 | 6 |
| 11 | 6-11 | 7 |

Now the contingency which is ranked as number 1 is analyzed for the static voltage stability. Table 3 depicts the bus voltages for the following cases-

Case 1 – Base

case without

line outage

Case 2 – Base

case with line

13 outage

Case 3 – Static voltage stability analysis with proportionate load increase on load buses 9, 13, and 14 without line outage.

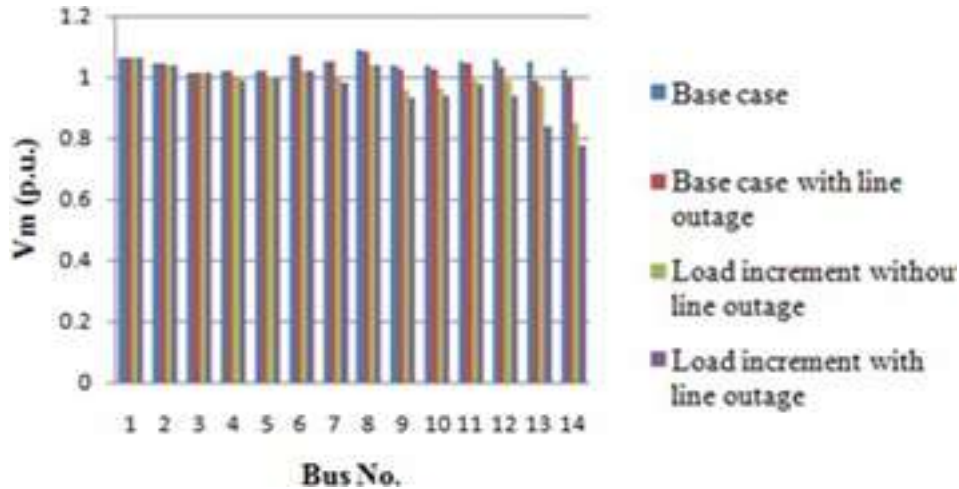
Case 4 – Static voltage stability analysis with proportionate load increase on load buses 9, 13, 14 with line 13 outage.

Table 3

Bus voltages (vm) in p.u. for various operating conditions

| Bus No. | Base case (p.u.) | Base case with line13 out (p.u.) | Proportionate p.u. load increase without line outage (p.u.) | Proportionate p.u. load increase with line 13 out (p.u.) |
|---------|------------------|----------------------------------|---|--|
| 1 | 1.0600 | 1.0600 | 1.0600 | 1.0600 |
| 2 | 1.0450 | 1.0450 | 1.0350 | 1.0350 |
| 3 | 1.0100 | 1.0100 | 1.0100 | 1.0100 |
| 4 | 1.0187 | 1.0169 | 0.9939 | 0.9895 |
| 5 | 1.0214 | 1.0206 | 0.9986 | 0.9958 |
| 6 | 1.0700 | 1.0700 | 1.0200 | 1.0200 |
| 7 | 1.0527 | 1.0480 | 0.9948 | 0.9826 |
| 8 | 1.0900 | 1.0800 | 1.0400 | 1.0400 |
| 9 | 1.0363 | 1.0274 | 0.9566 | 0.9332 |
| 10 | 1.0353 | 1.0277 | 0.9603 | 0.9406 |
| 11 | 1.0489 | 1.0448 | 0.9859 | 0.9757 |
| 12 | 1.0548 | 1.0297 | 0.9894 | 0.9354 |
| 13 | 1.0479 | 0.9895 | 0.9691 | 0.8363 |
| 14 | 1.0231 | 0.9921 | 0.8507 | 0.7735 |

From Figure 2, it has been observed that bus voltage drops drastically for bus 14 for line 13 outage. This implies that line 13 as well as line outage 6-13 is critical one, with bus 14 as a weak bus.



B) Contingency analysis and ranking under novel load increase scenario

The novelty of the approach proposed here lies in the method of load increase scenario as-

- Active load change
- Reactive load change
- Both Active and Reactive load changes, simultaneously on all load buses.

All the results, along with those pertaining to the most stressed lines with line outages under consideration have been presented in Table 4. Though simulations are carried out for every single line outage, results for only specific line outages have been shown here, to avoid lengthiness. These line outages show significant changes in line indices and hence have been mainly considered here.

Table 4

Line indices for specific line outages at different load changes simultaneously on all load buses

Set a] active load change simultaneously on all load buses

| Line | Line outage | Most stressed line (from-to) | FVSI | Lmn | LQP |
|------|-------------|------------------------------|--------|--------|--------|
| 8 | 4-7 | 4-2 | 1.0230 | 0.9263 | 1.3457 |
| | | 5-1 | 1.0893 | 1.0634 | 1.0455 |
| | | 5-2 | 0.9914 | 0.9058 | 0.9055 |
| | | 5-6 | 1.3341 | 1.6526 | 1.3552 |
| | | 11-6 | 1.1507 | 1.0575 | 0.9393 |
| | | 12-6 | 1.3815 | 1.3006 | 1.1320 |
| 11 | 6-11 | 4-2 | 1.6537 | 1.4917 | 2.1345 |
| | | 5-1 | 1.1788 | 1.1839 | 1.1372 |
| | | 5-2 | 1.5573 | 1.4162 | 1.4209 |
| | | 5-6 | 1.1320 | 1.2737 | 1.1623 |
| | | 12-6 | 1.1648 | 1.0884 | 0.9600 |
| 12 | 6-12 | 5-1 | 0.9142 | 0.8888 | 0.8785 |
| | | 5-6 | 0.9238 | 1.0200 | 0.9429 |
| 13 | 6-13 | 4-2 | 0.9416 | 0.8510 | 1.2595 |
| | | 5-1 | 0.9691 | 0.9461 | 0.9310 |
| | | 5-2 | 0.8976 | 0.8210 | 0.8201 |
| | | 5-6 | 1.0366 | 1.1455 | 1.0564 |
| | | 12-6 | 1.3377 | 1.1769 | 1.1008 |
| 15 | 7-9 | 4-2 | 1.0473 | 0.9480 | 1.3637 |
| | | 5-1 | 1.1142 | 1.0915 | 1.0692 |
| | | 5-2 | 1.0265 | 0.9366 | 0.9372 |
| | | 11-6 | 1.9545 | 1.8031 | 1.5944 |
| | | 13-6 | 1.1869 | 1.0983 | 0.9585 |
| 18 | 10-11 | 5-1 | 0.9211 | 0.8945 | 0.8851 |
| 19 | 12-13 | 5-1 | 0.9062 | 0.8802 | 0.8709 |
| | | 5-6 | 0.8748 | 0.9648 | 0.8939 |

Set b] reactive load change simultaneously on all load buses

| Line | Line outage | Most stressed line (from-to) | FVSI | Lmn | LQP |
|------|-------------|------------------------------|--------|--------|--------|
| 8 | 4-7 | 4-9 | 1.4884 | 1.5279 | 1.2014 |
| | | 14-9 | 1.1768 | 1.1762 | 0.9521 |
| 11 | 6-11 | 4-9 | 1.5491 | 1.5657 | 1.2382 |
| | | 14-9 | 1.2491 | 1.2429 | 1.0099 |
| 12 | 6-12 | 4-9 | 1.5123 | 1.5236 | 1.2160 |
| | | 14-9 | 1.1620 | 1.1429 | 0.9403 |
| 13 | 6-13 | 4-9 | 1.5363 | 1.5506 | 1.2305 |
| | | 14-9 | 1.4393 | 1.4210 | 1.1612 |
| 15 | 7-9 | 4-9 | 1.5062 | 1.5468 | 1.2123 |
| | | 5-6 | 1.3241 | 1.3736 | 1.3256 |
| | | 11-6 | 1.6818 | 1.6951 | 1.3698 |
| | | 12-6 | 1.7508 | 1.7303 | 1.4236 |
| | | 14-9 | 1.5508 | 1.5244 | 1.2448 |
| 18 | 10-11 | 4-9 | 1.5392 | 1.5534 | 1.2323 |
| | | 14-9 | 1.2128 | 1.2020 | 0.9809 |
| 19 | 12-13 | 4-9 | 1.5110 | 1.5220 | 1.2152 |
| | | 14-9 | 1.1453 | 1.1280 | 0.9269 |

Set c] both active and reactive load change simultaneously on all load buses

| Line | Line outage | Most stressed line (from-to) | FVSI | Lmn | LQP |
|------|-------------|------------------------------|--------|--------|--------|
| 8 | 4-7 | 4-9 | 1.1177 | 1.4375 | 1.4720 |
| | | 5-1 | 0.9271 | 0.8861 | 0.8859 |
| | | 5-6 | 1.2806 | 1.4751 | 1.2936 |
| | | 11-6 | 1.2079 | 1.1328 | 0.9852 |
| | | 12-6 | 1.4253 | 1.3595 | 1.1649 |
| 11 | 6-11 | 4-9 | 1.1240 | 1.2268 | 1.4947 |
| | | 5-1 | 0.8663 | 0.8263 | 0.8281 |
| 12 | 6-12 | 4-9 | 1.0978 | 1.1679 | 1.4009 |
| | | 5-6 | 1.0394 | 1.1171 | 1.0517 |
| 13 | 6-13 | 4-9 | 1.1240 | 1.2205 | 1.4948 |
| | | 5-1 | 0.8777 | 0.8393 | 0.8390 |
| | | 5-6 | 1.1092 | 1.1949 | 1.1220 |
| | | 11-6 | 1.0626 | 1.0244 | 0.8670 |
| | | 12-6 | 1.5574 | 1.4017 | 1.2760 |
| 15 | 7-9 | 4-9 | 1.1337 | 1.5766 | 1.5307 |
| | | 5-1 | 0.9888 | 0.9485 | 0.9447 |
| 18 | 10-11 | 4-9 | 1.1136 | 1.2008 | 1.4571 |
| | | 5-1 | 0.8551 | 0.8155 | 0.8175 |
| | | 5-6 | 0.8166 | 0.8690 | 0.8291 |
| 19 | 12-13 | 4-9 | 1.0951 | 1.1622 | 1.3907 |
| | | 5-6 | 1.0063 | 1.0809 | 1.0186 |
| | | 12-6 | 1.1025 | 1.0679 | 0.9020 |

Here, the lines having values of all three line indices close to 1 or more than 1 are considered as the most stressed lines. Table 5 shows the results for the contingency ranking. The contingencies are ranked according to their severity. For such ranking, the line stability indices for each line outage have been arranged in descending order so that the highest index is ranked one. The line outage with the highest rank implies that the particular line outage is very critical and also points towards the critical line.

Table 5

Critical contingency analysis and ranking for load change simultaneous on all load buses

| Loading pattern | Line | Contingency (from to) | Critical line |
|--------------------------------------|------|-----------------------|---------------|
| Active load change | 11 | 6-11 | 5-1 |
| | 15 | 7-9 | |
| | 8 | 4-7 | |
| | 13 | 6-13 | |
| | 18 | 10-11 | |
| | 12 | 6-12 | |
| | 19 | 12-13 | |
| Reactive load change | 11 | 6-11 | 4-9 |
| | 18 | 10-11 | |
| | 13 | 6-13 | |
| | 12 | 6-12 | |
| | 19 | 12-13 | |
| | 15 | 7-9 | |
| | 8 | 4-7 | |
| Both Active and Reactive load change | 11 | 6-11 | 5-1 |
| | 13 | 6-13 | |
| | 15 | 7-9 | |
| | 8 | 4-7 | |
| | 18 | 10-11 | |
| | 12 | 6-12 | |
| | 19 | 12-13 | |

The results presented in Table 5 show that there is a consistency in the ranking for all three cases. This indicates that the line outage criticality is accurately ranked. For instance, line 11 is ranked the highest for all cases of loading pattern, implying that this line is the most critical one. Also, it is observed that seven common lines (viz., lines 11, 15, 8, 13, 18, 12, and 19) were identified as the most critical lines in the list where values of all three indices are found to be greater than 1.

Conclusions :

A new and simple approach for contingency analysis and ranking in the view of voltage stability assessment has been presented in this paper. This approach is based on the line voltage stability indices viz. FVSI, Lmn and LQP and these indices are calculated using N-R load flow with single line outages, under novel load

increment scenario. Inclusion of the analysis of voltage stability condition along with contingency analysis and ranking, based on all three line stability indices together, adds the significant as well as unique contribution. Contingency ranking is made according to the highest value of these indices in general and FVSI in particular. The critical contingency has been selected for the voltage stability analysis. This gives the information about the most vulnerable buses which needs additional reactive power compensation. This brings the voltages within normal limits from the viewpoint of voltage security.

References :

- 1) Van Cutsem Therry, Voltage instability: phenomena, countermeasures and analysis methods, Proc IEEE 2000; 88(2): 208-27.

- 2) T. Van Cutsem and C. Vournas, Voltage stability of electric power systems, Massachusetts, USA: Kluwer Academic Publishers; 1998.
- 3) Nima Amjady and Masoud Esmaili, Application of a new sensitivity analysis framework for voltage contingency ranking, IEEE Trans. Power Syst 2005; 20(2): 973-83.
- 4) Mahmoud Moghawemi, F.M. Omar, A Line outage study for prediction of static voltage collapse, IEEE Power Engineering Review 1998: 52-54.
- 5) Zhihong Jia and B. Jeyasurya, Contingency ranking for on-line voltage stability assessment, IEEE Trans. Power Syst 2000; 15(3): 1093-97.
- 6) K. Shanti Swarup, G. Sudhakar, Neural network approach to contingency screening and ranking in power systems, Elsevier Neurocomput 2006; 70(1-3): 105-18. doi:10.1016/j.neucom.2006.05.006.
- 7) Ismail Musirin and Titik Khawa, Abdul Rahnian, Fast automatic contingency analysis and ranking technique for power system security assessment, IEEE Student conference on research and development (SCORED) Putrajaya, Malaysia, 2003: 231-36.
- 8) Musirin I, Rahman TKA, On-line voltage stability based contingency ranking using fast voltage stability index (FVSI), IEEE/PES transm distrib and exhibition conference 2002: 1118-23.
- 9) M. Moghavvemi, O. Faruque, Real-Time contingency evaluation and ranking technique, IEEE Proceeding on Generation, Transmission and Distribution September 1998; 145(5): 517-24.
- 10) M. Moghavvemi, F.M. Omar, Technique for contingency monitoring and voltage collapse prediction, IEEE Proceeding on Generation, Transmission and Distribution November 1998; 145: 634-40.
- 11) Rajive Tiwari, K.R. Niazi, Vikas Gupta, Line collapse proximity index for prediction of voltage collapse in power systems, Electrical Power and Energy Syst April 2012; 41: 105-11. http://dx.doi.org/10.1016/j.ijepes.2012.03.022
- 12) S.D. Naik, M.K. Khedkar, S.S. Bhat, Effect of line contingency on static voltage stability and maximum loadability in large multi bus power system, Electrical Power and Energy Syst December 2014; 67: 448-52. http://dx.doi.org/10.1016/j.ijepes.2014.12.00[13]
- J.W. Nims, A.A. El-Keib, R.E. Smith, Contingency ranking for voltage stability using a genetic algorithm, Electric Power Systems Research 1997; 43: 69-76.
- 14) G. C. Ejebel, G. D. Irisani, S. Mokhtari, Obadina P. Ristanovic, J. Tong, Methods for contingency screening and ranking for voltage stability analysis of power systems, IEEE Trans. Power Syst February 1996; 11(1): 350-56.

A Genetic Algorithm Based Optimal Power Flow for HVAC-DC Power System

Dr. S. B. Warkad | Prof. A. A. Ghute

- Abstract -

One of the most important requirements in power system operation, control and planning in energy management system (EMS) of modern power system control centers is optimal power flow (OPF). It is characterized as a difficult optimization problem and involves the optimization of an objective function, For example, minimization of total generation cost, and minimization of total loss in transmission networks, subject to a set of equality and inequality constraints such as generation and load balance, bus voltage limits, power flow equations, and active and reactive power limits.

In recent years, the incorporation of High Voltage Direct Current (HVDC) link in an existing AC transmission networks brought significant techno-commercial changes in the transmission of the electric power in developing countries. This paper aims to present Genetic Algorithm approach to solve OPF, problem formulation with incorporation of HVDC link in a AC transmission system, demonstrating the proposed methodology for standard power systems and to assess the performance of GAOPF with the traditional OPF method. The paper concludes that the proposed scheme of OPF is effective for the power system.

Index Terms : HVDC-AC system, Optimal Power Flow, Genetic Algorithms

- Introduction -

In electrical power systems, Optimal Power Flow (OPF) is a nonlinear programming problem, used to determine generation outputs, bus voltages and transformer tap with an objective to minimize total generation cost [1].

Presently, application of OPF is of much importance for power system operation and analysis. In a deregulated environment of electricity industry, OPF recently been used to assess the spatial variation of electricity prices and transmission congestion study etc [2].

In most of its general formulation, the OPF is a nonlinear, non-convex, large-scale, static optimization problem with both continuous and discrete control variables [3]. It is due to the presence of nonlinear power flow equality constraints. The presence of discrete control variables, such as switchable shunt devices, transformer tap positions, and phase shifters etc., complicates the solution [2]. However, they are not assured to converge to the global optimum of the general nonconvex OPF problem, although there exists some empirical evidence on the uniqueness of the OPF solution within the domain of interest [4].

Effective OPF is limited by the high dimensionality of power systems and the incomplete domain dependent knowledge of power system engineers. Numerical optimization procedures addressed the former one based on successive linearization using the first and the second derivatives of objective functions and their constraints as the search directions or by linear programming solutions to imprecise models [5-9]. The advantages of such methods are in their mathematical underpinnings, but disadvantages exist also in the sensitivity to problem formulation, algorithm selection and usually converge to a local minimum. The lateral one precludes also the reliable use of expert systems where rule completeness is not possible.

Since OPF was introduced in 1968 [10], several methods have been employed to solve this problem, e.g. *Gradient base*, *Linear programming* method [11] and

Quadratic programming [12]. However, all these methods suffer from problems. First, they may not be able to provide optimal solution and usually get stuck at a local optimal. Some methods, instead of solving the original problem, solve the problem's Karush–Kuhn–Tucker (KKT) optimality conditions. For equality-constrained optimization problems, the KKT conditions are a set of nonlinear equations, which can be solved using a Newton-type algorithm. In Newton OPF [13], the inequality constraints have been added as quadratic penalty terms in the problem objective, multiplied by appropriate penalty multipliers. Interior Point (IP) method [14-16], converts the inequality constraints to equalities by the introduction of nonnegative slack variables. A logarithmic barrier function of the slack variables are added to the objective function, multiplied by a barrier parameter, which is gradually reduced to zero during the solution process. The unlimited point algorithm [17] uses a transformation of the slack and dual variables of the inequality constraints, converts the OPF problem KKT conditions to a set of nonlinear equations, thus avoiding the heuristic rules for barrier parameter reduction required by IP method. Recent attempts to overcome the limitations of these mathematical programming approaches include the application of simulated annealing-type methods [18-19], and genetic algorithms (GAs) etc., [20-21].

GAs are essentially search algorithm based on mechanics of nature and natural genetics [22]. They combine solution evaluation with randomized, structured exchanges of information between solutions to obtain optimality. GAs are a robust method because restrictions on solution space are not made during the process. The power of GAs stem from its ability to exploit historical information structures from previous solution guesses in an attempt to increase performance of future solutions [23]. GAs have recently found extensive applications in solving global optimization searching problem when the closed form optimization technique cannot be applied. GAs are parallel and global search techniques that emulate natural genetic operators. The GA is more likely to converge toward the global solution because it, simultaneously, evaluates many points in the parameter space. It does not need to assume that the search space is differentiable or continuous [24].

In [25], the Genetic Algorithm Optimal Power Flow (GAOPF) problem is solved based on the use of a genetic algorithm load flow, and to accelerate the concepts, it is proposed to use the gradient information by the steepest decent method. The method is not sensitive to the starting points and capable to determining the global optimum solution to the OPF for a range of constraints and objective functions. In Genetic Algorithm approach, the control variables modeled are generator active power outputs and voltages, shunt devices, and transformer taps. Branch flow, reactive generation, and voltage magnitude constraints have treated as quadratic penalty terms in the GA Fitness Function (FF). In [21], GA is used to solve the optimal power dispatch problem for a multi-node auction market. The GA maximizes the total participants' welfare, subject to network flow and transport limitation constraints. The nodal real and reactive power injection that clears the market have selected as the problem control variables.

The GAOPF approach overcomes the limitations of the conventional approaches in the modeling of non-convex cost functions, discrete control variables, and prohibited unit-operating zones. However, they do not scale easily to larger problems, since the solution deteriorates with the increase of the chromosome length, i.e., the number of control variables.

In the coming years, power consumption in developing and transition countries is expected to more than double, whereas in developed countries, it will increase only for about 35-40%. In addition, many developing and transition countries are facing the problems of infrastructure investment especially in transmission and distribution segment due to fewer investments made in the past. To reduce the gap between transmission capacity and power demand, the trend is to adopt HVDC transmission system in the existing AC networks to gain techno-economical advantages of the investment. In such scenario, it is obvious to address this trend to design optimal power flow scheme for a real network system. In this paper full ac-dc based GAOPF is developed. This methodology also discussed the redesign of fitness function by refining penalty scheme for system constraints to get faster convergence. This avoids the necessity to perform early load flows as reported in several literatures [1-3, 9, 22].

After this introduction, section II presents the ac-dc based optimal power flow formulation. The Genetic Algorithm methodology is explained in section III. The performance of AC-DC based GAOPF is assessed and demonstrated with the IEEE 6-Bus, IEEE14-Bus, IEEE 30-Bus test systems in section IV. Finally, the conclusions are presented in section V.

II. Formulation Of Hvac-dc Optimal Power Flow

Problem Formulation:

Optimal power flow (OPF), which is characterize as a difficult optimization problem, involves the optimization of an objective function that can take various forms. For example, minimization of total generation cost, and minimization of total loss in transmission networks, subject to a set of physical and operating constraints such as generation and load balance, bus voltage limits, power flow equations, and active and reactive power limits. The objective function considered in this paper is to minimize the total generation cost. OPF formulation consists of three main components: objective function, equality constraints, and inequality constraints. The methodology is as follows,

AC System Equations

Let $P = (p_1, \dots, p_n)$ and $Q = (q_1, \dots, q_n)$ for a n buses system, where p_i and q_i be active and reactive power demands of bus- i , respectively. The variables in power system operation to be $X = (x_1, \dots, x_m)$, such as real and imaginary parts of each bus voltage. So the operational problem of a power system for given load (P, Q) can be formulated as OPF problem [26]

$$\begin{array}{ll} \text{Minimize} & f(X, P, Q) \quad \text{for } X \\ \text{Subject to} & S(X, P, Q) = 0 \\ & T(X, P, Q) \leq 0 \end{array}$$

$f(X, P, Q)$ is a scalar, short term operating cost, such as fuel cost. The generator cost function (PG_i) in \$/MWh is considered to have cost characteristics represented by,

$$f = \sum_{i=1}^{NG} a_i P_{Gi}^2 + b_i P_{Gi} + c_i$$

Where, P_{Gi} is the real power output; a_i, b_i and c_i represents the cost coefficient of the i^{th} generator, NG represents the generation buses,

The various constraints to be satisfied during optimization are as follows,

(1) Vector of equality constraint such as power flow balance (i.e. Kirchoff's laws) is represented as,

$$S(X, P, Q) = 0 \quad \text{or} \quad P_G = P_D + P_{DC} + P_L \quad \text{and} \quad Q_G = Q_D + Q_{DC} + Q_L$$

Where D represents the demand, G is the generation, DC represents dc terminal and L is the transmission loss.

(2) The vector, inequality constraints including limits of all variables i.e. all variables limits and function limits, such as upper and lower bounds of transmission lines, generation outputs, stability and security limits may be represented as,

$$T(X, P, Q) \leq 0$$

$$\begin{aligned} \text{(i)} \quad & P_{Gi}^{\min} \leq P_{Gi} \leq P_{Gi}^{\max} \quad (i \in G_B) \quad \text{and} \\ & Q_{Gi}^{\min} \leq Q_{Gi} \leq Q_{Gi}^{\max} \quad (i \in G_B) \end{aligned}$$

$$\text{Where, } P_{Gi}^{\min}, P_{Gi}^{\max}, Q_{Gi}^{\min}, Q_{Gi}^{\max}$$

are the minimum and maximum real and reactive power outputs.

(ii) Voltage limits (Min/Max) may be denoted by the following constraints,

$$|V_i^{\min}| \leq |V_i| \leq |V_i^{\max}| \quad (i = 1, \dots, N_B)$$

Where, N_B represents number of buses.

(iii) Power flow limits refer to the transmission is expressed by the following constraints,

$$P_f^{\min} \leq P_f \leq P_f^{\max} \quad (f = 1, \dots, N_{ele})$$

Where, N_{ele} represents number of transmission lines connected to grid.

Then the operating conditions of an AC-DC system is described by the vector,

$$X = [d, V, x_c, x_d]^t$$

Where, d and V are the vectors of the phases and magnitude of the phasor bus voltages; xc is the vector of control variables and xd is the vector of dc variables.

DC System Equations

The following relationship is for the dc variables. Using the per unit system [27], the average value of the dc voltage of a converter connected to bus 'i' is

$$V_{di} = a_i V_i \cos \alpha_i - r_{ci} I_{di}$$

Where, α_i is the gating delay angle for rectifier operation or the extinction advance angle for inverter operation; r_{ci} is the commutation resistance, and a_i is the converter transformer tap setting.

By assuming a lossless converter, the equation of the dc voltage is given by,

$$V_{di} = a_i V_i \cos f_i$$

Where, $f_i = \delta_i - \xi_i$, and f_i is the angle by which the fundamental line current lags the line-to-neutral source voltage.

The real power flowing in or out of the dc network at terminal 'i' can be expressed as,

$$P_{di} = V_i I_i \cos f_i$$

The reactive power flow into the dc terminal is

$$Q_{di} = V_i I_i \sin f_i \quad \text{or} \quad Q_{di} = V_i a_i I_i \sin f_i$$

The equation (2.13) and (2.14) is submitted in the equation (2.5) to form part of the equality constraints.

Based on these relationships, the operating condition of the dc system can be described by the vector,

$$X_d = [V_d, I_d, a, \cos \alpha, f]^t$$

The dc currents and voltages are related by the dc network equations. As in the ac case, a reference bus is specified for each separate dc system; usually the bus of the voltage controlling dc terminal operating under constant voltage (or constant angle) control is chosen as the reference bus for that dc network equation.

Equations (1) – (3) are an OPF problem for the demand (P, Q). There are many efficient approaches which can be used to get an optimal solution such as linear

programming, Newton method, quadratic programming, nonlinear programming, interior point method, artificial intelligence (i.e. artificial neural network, fuzzy logic, genetic algorithm, evolutionary programming, ant colony optimization and particle swarm optimization etc.) methods [26, 28].

II. Genetic Algorithm Based Optimal Power Flow

2.1 Genetic Algorithms

GAs operates on a population of candidate solutions encoded to finite bit string called chromosome. To attain optimality, each chromosome exchanges the information using operators borrowed from natural genetics to produce the better solution. GAs differs from other optimization and search procedures in four ways [24]: firstly, it works with a coding of the parameter set, not the parameters themselves. Therefore, GAs can easily handle integer or discrete variables. Secondly, it searches within a population of points, not a single point. Therefore, GAs can provide a globally optimal solution. Thirdly, GAs use only objective function information, not derivatives or other auxiliary knowledge. Therefore, it can deal with the non-smooth, non-continuous and non-differentiable functions that actually exist in a practical optimization problem. Finally, GAs use probabilistic transition rules, not deterministic rules. Although GAs seem to be a good method to solve optimization problems, sometimes the solution obtained from GAs is only a near global optimum solution.

2.2 GA applied to Optimal Power Flow: A simple Genetic Algorithm is an iterative procedure, which maintains a constant size population of candidate solutions. During each iteration step, (generation) three genetic operators (reproduction, crossover, and mutation) are performing to generate new populations (offspring), and the chromosomes of the new populations have evaluated via the value of the fitness, which is related to cost function. Based on these genetic operators and the evaluations, the better new populations of candidate solutions are formed. If the search goal has not achieved, again, GA creates offspring strings through above three operators and this process is continued until the search goal is achieved. This paper now describes the details in employing the simple GA to solve the optimal power flow problem.

2.2.1 Coding and Decoding of Chromosome: GAs perform with a population of binary string instead the parameters themselves. This study used binary coding. Here the active generation power set of n-bus system ($PG_1, PG_2, PG_3, \dots, PG_n$) would be coded as binary string (0 and 1) with length L_1, L_2, \dots, L_n . Each parameter PG_i has upper bound $(\max p_{biGi})$ and lower bound $(\min p_{biGi})$. The choice of L_1, L_2, \dots, L_n for the parameters is concerned with the resolution specified by the designer in the search space. In this method, the bit length B_i and the corresponding resolution R_i is associated by,

$$R_i = \frac{b_i - a_i}{2^{L_i} - 1}$$

This transforms the PG_i set into a binary string called *chromosome* with length L_i and then the search space has to be explored. The first step of any GA is to generate the initial population. A binary string of length L is associated to each member (individual) of the population. This string usually represents a solution of the problem. A sampling of this initial population creates an intermediate population.

2.2.2 Genetic Operator: Crossover: It is the primary genetic operator, which explores new regions in the search space. Crossover is responsible for the structure recombination (information exchange between mating chromosomes) and the convergence speed of the GA and is usually applied with high probability (0.5 – 0.9). The chromosomes of the two parents selected have combined to form new chromosomes that inherit segments of information stored in parent chromosomes. The strings to be crossed have been selected according to their scores using the roulette wheel [24]. Thus, the strings with larger scores have more chances to be mixed with other strings because all the copies in the roulette have the same probability to select. Many crossover schemes, such as single point, multipoint, or uniform crossover have been proposed in the literature. A single point crossover [1] has been used in our study.

2.2.3 Genetic Operator: Mutation: Mutation is used both to avoid premature convergence of the population (which may cause convergence to a local, rather than global, optimum) and to fine-tune the solutions. The mutation operator has defined by a random bit value change in a chosen string with a low probability of such change. In this study, the mutation operator has been applied with a relatively small probability (0.0001-0.001) to every bit of the chromosome. A sample mutation process has shown as below.

$$\begin{array}{cccccccc} 0 & 1 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ \underbrace{}_{P_{G1}} & \underbrace{}_{P_{G2}} & \underbrace{}_{P_{G3}} & \underbrace{}_{P_{G4}} & \underbrace{}_{P_{G5}} & \underbrace{}_{P_{G6}} & \underbrace{}_{P_{G7}} & & & & & & & & & & & & & & & & & \text{After mutation} \end{array}$$

$$\begin{array}{cccccccc} 0 & 1 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ \underbrace{}_{P_{G1}} & \underbrace{}_{P_{G2}} & \underbrace{}_{P_{G3}} & \underbrace{}_{P_{G4}} & \underbrace{}_{P_{G5}} & \underbrace{}_{P_{G6}} & \underbrace{}_{P_{G7}} & & & & & & & & & & & & & & & & & \end{array}$$

2.2.4 Genetic Operator: Reproduction: Reproduction is based on the principle of survival of the fittest. It is an operator that obtains a fixed number of copies of solutions according to their fitness value. If the score increases, then the number of copies increases too. A score value is associated with a given solution according to its distance from the optimal solution (closer distances to the optimal solution mean higher scores).

2.2.5 Fitness of Candidate Solutions and Cost Function: The cost function has defined as:

$$f = \sum_{i=1}^{NG} a_i P_{Gi}^2 + b_i P_{Gi} + c_i \quad P_{Gi}^{\min} \leq P_{Gi} \leq P_{Gi}^{\max}$$

To minimize $F(x)$ is equivalent to getting a maximum fitness value in the searching process. A chromosome that has lower cost function be assigning a larger fitness value. The objective of OPF is changed to the maximization of fitness to be used in the simulated roulette wheel. The fitness function is used [3] as follows:

$$FitnessFunction(FF) = \frac{C}{\sum_{i=1}^{NG} F_i(P_{Gi}) + \sum_{j=1}^{N_c} w_j * Penalty_j}$$

$$Penalty_j = h_j(x, t) \cdot H(h_j(x, t))$$

Where C is the constant; $F_i(P_{Gi})$ is cost characteristics of the generator i ; w_j is weighting factor of equality and inequality constraints j ; $Penalty_j$ is the penalty function for equality and inequality constraints j ; $h_j(x, t)$ is the violation of the equality and inequality constraints if positive; $H(.)$ is the Heaviside (step) function; N_c is the number of equality and inequality constraints.

The fitness function is implemented in Matlab in such a way that it should firstly satisfy all inequality constraints by heavily penalizing if they have been violated. Then the equality constraints is satisfied by less heavily penalizing for any violation. Here this penalty weight is not the price of power. Instead, the weight is a coefficient set large enough to prevent the algorithm from converging to an illegal solution. Then the GA tries to generate better offspring to improve the fitness. Using these components, a standard GA procedure for solving the OPF problem is shown in Figure 1.

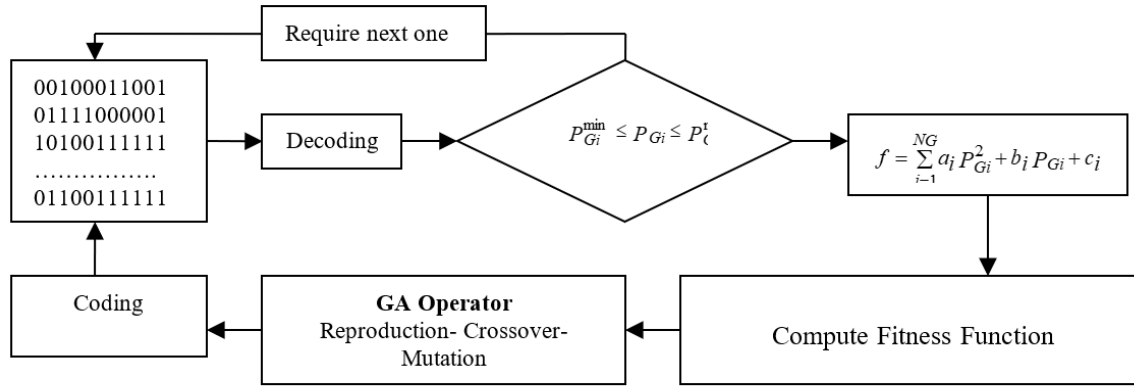


Fig.1: Flowchart of a Simple Genetic Algorithm for OPF

III. Example, Simulation And Results

3.1 IEEE-30 Bus Test System

This system consists of 6 generators and 43 transmission lines as shown in figure 3.1. A HVDC link connected between bus 1 and bus 28. The ratings of the converter at buses 1 and 28 were 1.0 p.u. In addition, the upper and lower bounds (reactive power) for all generators are $Q_{Gi}^{\min} \leq Q_{Gi} \leq Q_{Gi}^{\max}$. The voltage values for all buses have bounded between 0.95 and 1.05. The fuel cost function for generators is expressed as $f_i = a_i P_{Gi}^2 + b_i P_{Gi} + c_i$ in (\$/MWh) and demand at various buses are shown in table C1. All the values are indicated in PU. For this

system there are 2×24 equality constraints of S corresponding with their respective real and reactive power balances of the buses without a generator, and about 72 inequality constraints of T corresponding to 30 pairs of voltage, 2×6 pairs of generation output and one pair of line flow upper and lower bounds respectively. Table 3 indicates the results for GAOPF best and worst solutions and for Newton method.

Again, results indicates that the voltage profile at few buses have improved for best GAOPF solution as compared to Newton's OPF method. In addition, total cost of generation by best GAOPF is marginally low as compared to Newton's OPF method.

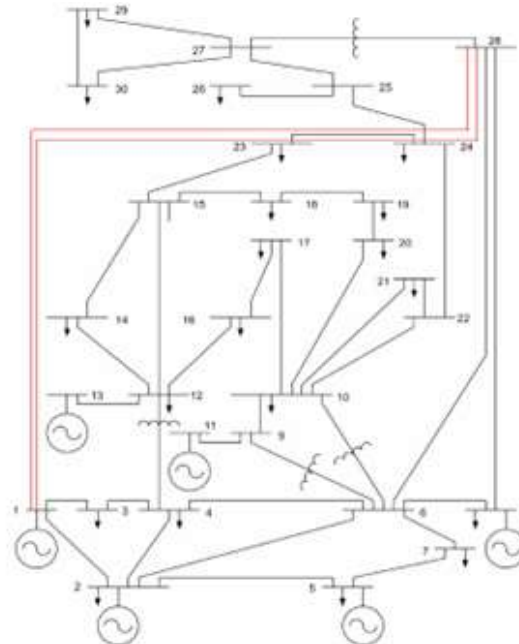


Fig. 3.1: One line diagram of modified IEEE-30 Bus system

Table 3: IEEE- 30 Bus System: GAOPF results and Comparison with Traditional OPF Method

| Bus No. | GAOPF | | | | | | Traditional Method | | |
|--------------|---------------|-------------|---------------|--------------|------------|---------------|--------------------|-------------|---------------|
| | Best Solution | | | Bad Solution | | | | | |
| | Voltage (PU) | P (PU) | Cost (\$/MWh) | Voltage (PU) | P (PU) | Cost (\$/MWh) | Voltage (PU) | P (PU) | Cost (\$/MWh) |
| 1 | 0.99 | 0.30 | 8.17 | 0.99 | 1.67 | 30.40 | 1.00 | 0.37 | 10.55 |
| 2 | 0.97 | 0.21 | 7.23 | 1.00 | 1.06 | 21.33 | 0.99 | 0.10 | 6.53 |
| 3 | 0.97 | | | 0.98 | | | 0.99 | | |
| 4 | 0.99 | | | 0.96 | | | 0.98 | | |
| 5 | 1.03 | 0.25 | 8.03 | 1.02 | 1.40 | 26.41 | 0.99 | 0.10 | 6.52 |
| 6 | 0.98 | | | 1.00 | | | 0.97 | | |
| 7 | 0.99 | | | 0.95 | | | 0.98 | | |
| 8 | 0.95 | 0.20 | 8.05 | 0.99 | 0.57 | 16.02 | 1.03 | 0.10 | 6.93 |
| 9 | 0.99 | | | 1.01 | | | 0.99 | | |
| 10 | 1.03 | | | 1.02 | | | 1.02 | | |
| 11 | 0.99 | 0.14 | 8.17 | 1.00 | 0.54 | 13.07 | 1.01 | 0.46 | 11.87 |
| 12 | 1.02 | | | 0.95 | | | 1.00 | | |
| 13 | 0.98 | 0.07 | 5.01 | 1.01 | 0.56 | 15.64 | 1.01 | 0.10 | 6.90 |
| 14 | 0.99 | | | 0.96 | | | 0.99 | | |
| 15 | 1.02 | | | 1.00 | | | 0.99 | | |
| 16 | 0.97 | | | 0.97 | | | 1.00 | | |
| 17 | 0.98 | | | 0.96 | | | 1.00 | | |
| 18 | 0.99 | | | 1.01 | | | 0.99 | | |
| 19 | 1.00 | | | 0.98 | | | 0.99 | | |
| 20 | 0.97 | | | 1.01 | | | 1.03 | | |
| 21 | 0.98 | | | 0.97 | | | 0.99 | | |
| 22 | 0.99 | | | 0.99 | | | 0.98 | | |
| 23 | 0.99 | | | 1.01 | | | 0.99 | | |
| 24 | 1.03 | | | 1.01 | | | 1.02 | | |
| 25 | 0.96 | | | 0.97 | | | 1.03 | | |
| 26 | 0.98 | | | 1.01 | | | 1.02 | | |
| 27 | 0.97 | | | 0.97 | | | 1.05 | | |
| 28 | 0.98 | | | 0.95 | | | 0.99 | | |
| 29 | 1.02 | | | 0.98 | | | 1.05 | | |
| 30 | 0.97 | | | 0.98 | | | 1.05 | | |
| Total | | 1.17 | 44.66 | | 5.8 | 122.88 | | 1.23 | 49.30 |

IV. Conclusion

Optimal power flow has been received considerable attentions from reseachers for the past few decades as it is one of the most important tools in energy management system (EMS). This study proposes an AC-DC based GA optimal power flow solution, which may be applied to different size power systems. Application of Genetic approach to Optimal Power Flow has been explored and tested. A simulation results show that a simple genetic algorithm can give a best result using only

simple genetic operations such as proportionate reproduction, simple mutation, and one-point crossover in binary codes. It is clear that in large-scale system the number of constraints is very large consequently, the GA accomplished in a large CPU time. Finally, the result obtained by this scheme is quite comparable with the traditional OPF methodology.

V. References

- 1) M. Younes, M. Rahli and Abdelhakem-Koridak, "Optimal Power Flow Based on Hybrid Genetic

- Algorithm", *Journal of Information Science and Engineering* 23 (2007) 1801-1816.
- 2) A. G. Bakirtzis, P. N. Biskas, C. E. Zoumas, and V. Petridis, "Optimal Power Flow by Enhanced Genetic Algorithm", *IEEE Transactions on Power Systems*, Vol. 17, No. 2 (2002) 229-236.
 - 3) I. G. Damousis, A.G. Bakirtzis, and P.S. Dokopoulouset, "Network Constrained Economic Dispatch Using Real-Coded Genetic Algorithm", *IEEE Transactions on Power Systems*, Vol. 18, No. 1, (2003).
 - 4) D. Papalexopoulos, C. F. Imparato, and F. F. Wu, "Large-scale optimal power flow: Effects of initialization decoupling and discretization," *IEEE Transactions on Power Systems*, Vol. 4 (1989) 748-759.
 - 5) H. W. Dommel, W. F. Tinney, "Optimal Power Flow Solutions", *IEEE Transactions on power apparatus and systems*, Vol. PAS-87, No. 10 (1968) 1866-1876.
 - 6) K. Y. Lee, Y.M. Park, and J.L. Ortiz, "A United Approach to Optimal Real and Reactive Power Dispatch", *IEEE Transactions on Power Systems*, Vol. PAS-104 (1985) 1147-1153.
 - 7) M. Sasson, "Non linear Programming Solutions for load flow, minimum loss, and economic dispatching problems", *IEEE Transactions on Power Apparatus and Systems*, Vol. PAS-88, No. 4 (1969).
 - 8) T. Bouktir, M. Belkacemi, K. Zehar, "Optimal power flow using modified gradient method", *Proceeding ICEL'2000, U.S.T.Oran, Algeria*, Vol. 2 (2000) 436-442. [9] T. Bouktir, L. Slimani, and M. Belkacemi, "A Genetic Algorithm for Solving the Optimal Power Flow Problem", *Leonardo Journal of Sciences*, Issue 4 (2004) 44-58.
 - 10) H. W. Dommel, "Optimal power dispatch," *IEEE Transactions on Power Apparatus and Systems*, Vol. PAS93 (1974) 820-830.
 - 11) O. Alsac, J. Bright, M. Prais, and B. Stott, "Further developments in LP-based optimal power flow," *IEEE Transactions on Power Systems*, Vol. 5 (1990) 697-711.
 - 12) J. Nanda, D. P. Kothari, and S. C. Srivatava, "New optimal power-dispatch algorithm using Fletcher's quadratic programming method," in *Proceedings of the IEEE*, Vol. 136 (1989) 153-161.
 - 13) D. I. Sun, B. Ashley, B. Brewer, A. Hughes, and W. F. Tinney, "Optimal power flow by Newton approach," *IEEE Transactions on Power Apparatus and Systems*, Vol. PAS-103 (1984) 2864-2880.
 - 14) H. Wei, H. Sasaki, J. Kubokawa, and R. Yokoyama, "An interior point nonlinear programming for optimal power flow problems with a novel data structure," *IEEE Transactions on Power Systems*, Vol. 13 (1998) 870-877.
 - 15) G. L. Torres and V. H. Quintana, "An interior-point method for nonlinear optimal power flow using voltage rectangular coordinates," *IEEE Transactions on Power Systems*, Vol. 13, (1998) 1211-1218.
 - 16) J. A. Momoh, M. E. El-Hawary, and R. Adapa, "A review of selected optimal power flow literature to 1993," *IEEE Transactions on Power Systems*, part I and II, Vol. 14 (1999) 96-111.
 - 17) G. Tognola and R. Bacher, "Unlimited point algorithm for OPF problems," *IEEE Transactions on Power Systems*, Vol. 14 (1999) 1046-1054.
 - 18) L. Chen, H. Suzuki, and K. Katou, "Mean field theory for optimal power flow," *IEEE Transactions on Power Systems*, Vol. 12 (1997) 1481-1486.
 - 19) L. Chen, S. Matoba, H. Inabe, and T. Okabe, "Surrogate constraint method for optimal power flow," *IEEE Transactions on Power Systems*, Vol. 13 (1998) 1084-1089.
 - 20) L. L. Lai, J. T. Ma, R. Yokoyama, and M. Zhao, "Improved genetic algorithms for optimal power flow under both normal and contingent operation states," *Electric Power Energy System*, Vol. 19, No. 5 (1997) 287-292.
 - 21) T. Numnonda and U. D. Annakkage, "Optimal power dispatch in multinode electricity market using genetic algorithm," *Electric Power System Research*, vol. 49 (1999) 211-220.
 - 22) M. M. El-Saadawi, "A Genetic-Based Approach For Solving Optimal Power Flow Problem", *Mansoura Engineering Journal*, (MEJ), Vol. 29, No. 2 (2004).
 - 23) D. Walters, G. Sheble, "Genetic Algorithm Solution for Economic Dispatch with Valve Point Loading", *IEEE Transactions on Power Systems*, Vol. 8, No. 3 (1993).

- 24) D. E. Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Addison Wesley Publishing Company, 1989.
- 25) J. Yuryevich, K. P. Wong, "Evolutionary Programming Based Optimal Power Flow Algorithm", *IEEE Transactions on Power Systems*, Vol. 14, No. 4 (1999).
- 26) L. Chen, H. Suzuki, T. Wachi, and Y. Shimura, "Components of Nodal Prices for Electric Power Systems", *IEEE Transactions on Power Systems*, Vol. 17, No. 1 (2002) 41-49.
- 27) C. N. Lu, S. S. Chen, C. M. Ong, "The Incorporation of HVDC Equations in Optimal Power Flow Methods using Sequential Quadratic Programming Techniques", *IEEE Transactions on Power Systems*, Vol. 3, No. 3 (1988) 1005-1011.
- 28) Pandya K.S., Joshi S. K., "A survey of Optimal Power Flow Methods", *Journal of Theoretical and Applied Information Technology*, Issue 5, (2008) 450-458.

Switched Reluctance Motor- A suitable option for Electric Vehicle

Mr. Deepak A. Shahakar | Ms. P. M. Mankar

- Abstract -

The rapid consumption of fossil fuel and increased environmental damage caused by it has given a strong impetus to the growth and development of fuel-efficient vehicles. Increasing the use of electric vehicles (EVs) has been offered as a double option to decrease fuel energy consumption and greenhouse gas emissions (GHG), in a wide effort to mitigate the bad environmental impact and climate change. Recently, the EV industry has been known as a huge development. The key component of the EV is the electric motor and, therefore, its choice is very important. Many types of electric motors have been analyzed during last decades and evaluated for EVs. Switched reluctance motors (SRM) have some advantages in comparison with other electric motors due to their simple structure, flexibility of control, high efficiency, lower cost and robustness to run under failure conditions. The machine rotor does not have any windings or permanent magnets, being suitable for very high speed drive applications. The switched reluctance motors drives (SRDs) need more advanced control technology than DC and AC motors drives. High torque ripple, high noise and vibrations are the most important drawbacks of the SRM.

Background and Motivation

Nowadays, the shortage of energy and environmental pollution are considered as relevant problems due to the high amount of traditional automotive vehicles with internal combustion engines (ICEs). Electric vehicle (EV) is one of the solutions to localize the energy source and the best choice for saving energy and provide zero emission vehicles. EVs will

form an important part of the solution addressing the concerns regarding carbon emissions, energy security and the ongoing need for the personal transportation. EV has the following advantages over the ICE:

- 1) Emissions- EV can result in zero tail pipe emissions when used with a renewable energy source. This also leads to reduced energy dependence on fossil fuels.
- 2) Energy conversion- The EV is approximately three times more efficient than the ICE for energy usage. This also includes the energy loss in transporting the fuel and motor/engine using the energy to run the car.
- 3) Torque- Electrical motors typically have high torques (e.g., the EV can run 0 to 60km within 4 seconds from Tesla Roadster)
- 4) Less maintenance- EVs have no oil refills required, reducing overall maintenance and are also quite to operate as they have no mufflers
- 5) Simplified design- the EV has fewer moving parts than the ICE for a same sized car. It has no fuel tank, muffler, catalytic converter, and oil filters. This simplifies the design.

The key technical challenges of the EV are:

- 1) Drive trains (electric motors for increased power density)
- 2) Energy storage (increase energy density of the battery)
- 3) Infrastructure (fast chargers to overcome delayed charging times)
- 4) Vehicle mass (reduce overall mass to increase range)

Different machines have been used in EVs so far [10],

[15]: DC machines, induction machines (IMs), permanent magnet synchronous machines (PMSMs), and switched reluctance machines (SRM).

DC machines (DCMs) were used before the evolution of power electronics devices, which gave the possibility of controlling the induction machines. DC machines use brushes and a commutator to draw current through the armature. The friction between these elements causes their wear and this requires replacing and maintenance. Also, the DC machine has low power/weight ratio resulting in machines of big dimensions and high weight, making to be preferred in automotive applications where the weight is not a primordial factor (i.e. railway traction).

The induction motor (IM) is a low cost and robust option but with low power density (when compared to PMSMs). In addition problems may appear when removing the hear from the rotor. Furthermore, the heat that has to be removed from the rotor may determine additional issues. IMs were preferred in numerous EV projects, mostly in the US (like EV series of projects in the early 90's). Moreover a rather successful implementation can be considered the electrified drive-trains developed by Tesla Motors.

Permanent magnet synchronous machines (PMSMs) have numerous advantages over the rest of EMs [16], [17], including high efficiency, compactness, high

power density, fast dynamics and high torque/inertia ratio. Interior permanent magnet (IPM) machines come with extra features of mechanical robustness, capability of flux weakening and high speed operation. In spite of benefits and well suited characteristics of PMSMs for HEV application, they suffer from the high cost mainly due to the cost of permanent magnets. The maximum speed of PMSMs is usually limited by output power. This feature may be a problem in EVs in high speed operations. The properties of the permanent magnets (PM) are dependent on temperature. The parameters of PMs may vary on wide scale with the variation of the temperature and the reach of high values of temperature can permanently modify the properties of the permanent magnets. This drawback can lead to a malfunction or even to a stop of the motor. Another disadvantage of the permanent magnets is that they are made from rare earth material which are in the category of very limited resources as the extraction and post-processing of minerals is conducted at a very high cost. If it will get to a mass production of an electric vehicle with a PMSM there might arise a serious problem regarding the PMs supply. Yet, due to their numerous advantages they are preferred (and successfully implemented) by various auto-makers, worldwide, for HEVs applications (i.e. Toyota Prius) as well as full EVs (i.e. Nissan Leaf).

| Quantities | Types of EMs used in EVs | | | |
|--------------------|--------------------------|---------|----------|------|
| | PMBDC | IM | SRM | DC |
| Rated Speed, [rpm] | 1000 | 1000 | 1000 | 1000 |
| Peak Torque, [Nm] | 2866 | 2866 | 2866 | 2866 |
| Max. Speed, [rpm] | 4000 | 4000 | 4000 | 4000 |
| Rated Torque, [Nm] | 2866 | 2866 | 2866 | 2866 |
| Voltage, [V] | 380 | 380 | 190/300 | 500 |
| Current, [A] | 753-486 | 980-630 | 1000/500 | 520 |
| Frequency, [Hz] | 156 | 133 | 500 | 133 |
| Weight, [kg] | 300 | 600 | 500 | 1000 |
| Efficiency, [%] | | | | |
| @ 1000rpm | 95 | 93 | 94 | 85 |
| @ 4000rpm | 97 | 95 | 96 | 89 |
| Cooling | oil | oil | oil | air |

TABLE 1.1: State of the art in 1992 of EMs used in electrified heavy trucks [10]

The key component of the EV is the electric motor and, therefore, its choice is very important. Many types of electric motors have been analyzed during last decades and evaluated for EVs. Switched reluctance motors (SRM) have some advantages in comparison with other electric motors due to their simple structure, flexibility of control, high efficiency, lower cost and robustness to

run under failure conditions. The machine rotor does not have any windings or permanent magnets being suitable for very high speed drive applications. The switched reluctance motors drives (SRDs) need more advanced control technology than DC and AC motors drives. High torque ripple, high noise and vibrations are the most important drawbacks of the SRM.

TABLE 1.2: State of the art in 2011 of EMs used in electrified vehicles [11], where the

| | Req. | Cycle | | | |
|-----------------|----------|-------|-------|-------|-------|
| | | DCM | IM | PMSM | SRM |
| Specific power | > 1kW/kg | 1 | 2.5 | 5 | 5 |
| Peak Efficiency | > 95% | 85-89 | 90-95 | 95-97 | 85-95 |
| Maximum speed | > 6krpm | 6 | 15 | 15 | > 15 |
| Reliability | 1 | 1 | 4.5 | 4-4.5 | 5 |
| Cost | 5 | 5 | 2 | 3-4 | 2 |

number from 1 to 5 indicates the degree from low to high

Nevertheless, SRMs are not only a trend in research conducted by Universities, as it is considered by industry as well. The companies try to benefit from its very high speed and torque capability. Therefore for the rest of the machines, speed values of 20krpm or beyond can be impossible to reach, mainly because of mechanical reasons. As for the high torque production capability, it has to be stated that what is advantageous for the SRM is the ratio between peak torque and the quantity of expensive materials (i.e. permanent magnets). In order to illustrate this, in Table 1.1 the same torque (2866Nm) is obtained either using an SRM with 500kg of iron or using PM-based motor with 264kg of iron and 36kg of magnet materials. In a context in which the prices are increasing at a very high rate and the resources are owned mainly by one country, in order to obtain very high torque at a reasonable price, SRMs may represent a viable solution. *Jaguar* [22] profited of the SRMs very high speed capability with its prototype CX-5, where the energy produced by two turbines rotating at 80000rpm is converted into electrical energy by two SRGs. Moreover, the high torque capability is exploited by *Le Tourneau Technologies*, with their world's largest wheel loader with four in-wheel 300kW SRMs [23].

2. Objectives and Contributions

Switched reluctance motor drive system (SRD) is a

new type of Ac speed regulating system with main advantages of both Dc drive and traditional Ac drive. Switched reluctance motor (SRM) has become one of the best considered motor for electric vehicles (EV) drive system due to its prominent advantages such as low construction cost, simple manufacturing process, high fault-tolerant ability, wide speed range of operation etc. The SRM inevitably generates large torque ripple, causing acoustic noises and vibrations. However, the more obvious torque ripple of SRM can do harm to the transmission system of EV, in addition, the electric efficiency of SRM directly decides the travel distance of EV. As a result, the suppression of the torque ripple is a hot topic in the research of SRM, so it is of great significance to reduce the torque ripple and improve the electric efficiency of SRM applied in EV. The main objective of the research, which are to (i) search for optimization tools to reduce the torque ripple of the SR machine in EV applications; (ii) Apply the space mapping technique for shortening the optimization time without lowering the accuracy of optimization results and (iii) conduct relevant experiments and tests on the existing SR machine model in order to validate the results of the optimization process.

There have been lots of researches on the torque ripple reduction in terms of the design of SRM. For

instance, embedding the magnetic barriers in the rotor yoke is proposed based on the finite element analysis (FEA), which may change the radial component of the magnetic flux into the tangential component. By increasing the tangential component of magnetic flux, the torque ripple could be reduced and the average torque could be improved. Another way to restrict the torque ripple is to utilize multiple teeth per stator pole, in which the number of rotor poles is more than that of stator teeth. A new structure including a flat-topped rotor pole and a non-circular stator pole face is proposed to form a variable air-gap. Nevertheless, due to the asymmetry of this new structure, it is only suitable for the SRM in one-direction rotation. The non-uniform air gap formed by the relative eccentric structure between rotor and stator shaft is presented in [9], which increases the average torque along with an increase in the ripple content. In [10], the arcs of stator and rotor pole of the multimode SRM are optimized by multi-objective genetic particle swarm optimizer to minimize the torque ripple and copper loss per torque and maximize the torque per ampere. The rotor with notched tooth in one-direction rotation is studied to alleviate the fringing flux suppressing the torque ripple [11]. However, this method can only restrain the torque ripple when the SRM rotates in the forward direction, which is not suitable for the frequent forward and reverse rotation switching occasions.

The researcher will proposed, a perfectly symmetrical structure of the stator and rotor pole to suppress the torque ripple in the positive and negative rotating conditions. The torque ripple and the average torque with variable optimization parameters will be calculated. Then, the multi-objective optimization will carry out by the PR models of the optimization objectives combined with the Pareto genetic algorithm (PGA).

2.1 PRINCIPLES OF SRM

A. Operation principles

The principle of SRM operation is to generate torque by varying magnetic reluctance. The SRM motor has double saliency, meaning it has a saliency in the stator as well as saliency in the rotor. Depending on the rotor and stator pole number, multiple SRM configurations can be constructed (figure 1). The basic electromagnetic equation that

governs a SRM individual phase is the following:

$$V = iR + \frac{d\psi}{dt} + \frac{d\psi}{d\theta} \frac{d\theta}{dt}$$

where v is the phase voltage, i is the phase current, R_m is the phase resistance, $L(\theta, i)$ is the instantaneous inductance and $K_b(\theta, i)$ is the instantaneous Back-EMF.

At the excitation moment of each stator pole, the nearest rotor pole tends to come to the minimum reluctance position. In other words, the resultant torque due to the current flow in a phase prefers to move the rotor in a direction that leads to a decrease in the reluctance and, hence, an increase in the inductance [4]. Neglecting magnetic saturation, the torque produced by the machine can be expressed as:

$$T = \frac{1}{2} i^2 \frac{dL}{d\theta}$$

From (2), it is shown that torque does not depend on the polarity of the stator current (because of the square term) and can only be developed when the inductance changes. Thus, positive torque is produced on the rising inductance region, while negative torque is produced on the decreasing inductance region. When a pair of rotor poles is aligned to a pair of stator poles, the other pairs of rotor poles are out of alignment. Then, a pair of stator poles (which is the closest to any other pair of rotor poles) is excited to bring this rotor poles into alignment. Therefore, by such a sequentially switching and flowing current into the pairs of stator windings, the rotor can rotate continuously. These switching and their control are applied by SRDs [4]. If all pairs of stator poles were aligned with the rotor poles, the initial torque could not be produced. In order to avoid such a situation, the SRMs are usually designed to have unequal number of rotor and stator poles [4], as seen in figure 1.

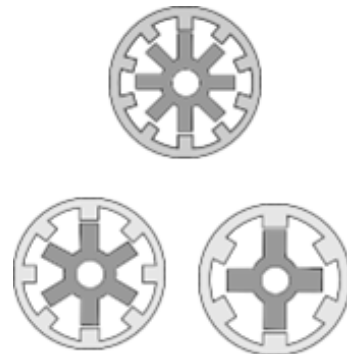


Fig. 1: Most common SRM topologies.

Comparing with other electric machines, SRM has high torque ripple due to the independent phases and discrete torque production. The main drawback of SRM is the torque ripple that causes restriction on their application in EVs [5]. To solve this problem, many control techniques have been investigated and proposed recently [3], [6].

A. Advantages and limitations

In most of the cases, SRM has windings on the stator, but no permanent magnet or windings on the rotor, which allow it to operate at higher temperatures. This property also leads to a lower manufacturing cost, simple and rugged structure, allowing it to be designed with reduced dimensions [3]. On the other hand, if any fault occurs in one phase or winding, the machine can continue its operation at a reduced load. This is an essential

advantage that can be useful for pumps and fans [3], and also can be exploited in the EV industry. But there is a non-linear characteristic on SRM due to the magnetic saturation that makes it difficult to control the torque precisely. Various types of permanent magnet machines have been used for small and medium size EVs, but the cost of permanent magnets is increasing, so there is a limitation to use permanent magnets for heavy duty vehicles. Therefore, the SRM and the induction machines are futuristic for the EV applications due to their rugged and cost effective characteristic. Furthermore, since SRMs do not need windings or permanent magnets in their rotors, so they can operate under higher temperature situations.

The most significant advantages and disadvantages provided by the SRM technology are summarized in table I.

| Advantages | Disadvantages |
|---|---|
| Low manufacturing cost | High torque ripple |
| Robustness because of its simple construction and material composition | High acoustic noise (this disadvantage can be considered as an advantage in the EV context) |
| Rugged and simple regarding to the physical form of the motor | High EMI generation |
| Easier to cool the machine because it has no windings on its rotor and the stator phase windings are concentrated | High DC bus current ripple |
| Lack of permanent magnets lowers reliance on imported rare-earth materials and improves the heat tolerance of the motor | Converter must be carefully matched to a given motor for maximum performance |
| SRM is inherently fault tolerant. Each phase in the machine is electrically independent, so a short circuit fault on one phase does not affect the other phases | It requires more conductor connections than the more conventional three-phase induction motors, Permanent Magnet Synchronous Machines (PMSM) and Synchronous Reluctance Machines (SynRel) |

| | |
|--|--|
| | Machines (PMSM) and Synchronous Reluctance Machines (<u>SynRel</u>) |
| SRM allows high speed operation and low inertia, making it an excellent candidate for actuators and traction drives | The electromagnetic behavior is highly non-linear |
| The converter only needs to conduct unidirectional current, so only one switch is required in series with the phase windings. This prevents the possibility of a shoot through fault that is a common failure mode in the bidirectional converters required by other types of motors | The non-linear nature of the SRM operating in saturation makes analytical modelling extremely difficult. Thus, measurements or finite element predictions for magnetization curves are required to formulate control schemes and predict performance during the design process |
| | External control is more complex than comparable induction and DC motors |

A. Switched Reluctance Drive (SRD) Systems

Recently, SRD systems have been developed and they are considered as advanced mechatronic systems. They mainly consist of SRM, power converter, controller, and detector [7]. In SRMs the torque is totally independent from the polarity of the excitation current, therefore only one switch for each phase winding in SRM drives is sufficient. The phase windings of SRM are always in series with a switch. If a shoot-through fault happens, the rate of rise in current can be limited by the inductance of the winding. Hence it provides a short time to initiate protective relying to isolate the shoot-through faults. One of the most important features of SRM that can be considered as an advantage in comparison with other electrical motor is that its phases are independent; hence if any fault happens to one of its phases, the motor and SRD are able to continue their operation with reduced output power. In [8] a comprehensive review of different types of power converters for SRDs have been presented and analyzed. The most popular and common converter that used for SRDs is the asymmetric bridge converter that is shown in figure 2. Note that this converter requires two transistors and two diodes for each phase [8].

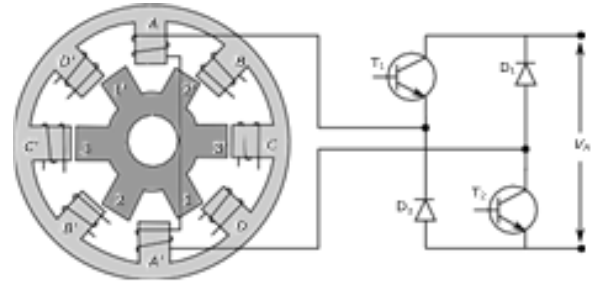


Fig. 2: Asymmetric bridge converter for SRD.

The SRMs need an advanced control technology in their drive systems in comparison with other AC and DC motor drives. However, the SRM has some other drawbacks that include vibration, noise, and necessity of using position sensor that makes the SRD system more complex and less reliable. The SRDs are more complex because of the non-linearity in their operational region and this non-linearity is due to the following factors [8]:

- 1) Non-linearity of B-H characteristics of the magnetic material.
- 2) Dependency of the phase flux linkages of the SRMs on both the current magnitude and rotor position; for other machines, the phase flux linkage depends only on current magnitude,

because of the artificial elimination of the rotor position dependency by the trigonometric transformations which are not possible for an SRM.

3) The single source of excitation.

2.2 SRM STRUCTURES

A. Conventional SRM structures

SRMs with more stator poles than rotor poles are the most commonly used structures (figure 1) [8], [9]. Three different topologies of SRM with different numbers of phases and different combinations of rotor and stator pole number for electric vehicle applications are designed and compared in [9]. These three topologies are shown in figure 1 (6/4 three- phase, 8/6 four-phase, 10/8 five-phase). The results of this investigation has shown that the 10/8 and 8/6 topologies are the most suitable for electric vehicle propulsion. The 10/8 SRM needs a more expensive converter than the others, whereas the 8/6 SRM has more torque ripple. The most appropriate topology will depend on the specific application.

The high torque ripple drawback can be attenuated by choosing a proper control strategy. This research has shown that without applying of any proper optimized control technique the 6/4 SRM topology is inefficient for electric vehicle applications and automotive industry [9].

B. Advanced SRM structures

In order to overcome the most significant SRM technology drawbacks, a set of advanced SRM structures have been proposed in the scientific literature.

In [10], a multilayer SRM (MSRM) structure consisting of two conventional one-layer machines connected in one shaft was proposed and designed. The rotor poles of each layer are disaligned, reducing the torque ripple. The following objectives have been reached:

- 1) To have enough space for proper coil windings.
- 2) Using the centrifugal switch to achieve a faster turn on time.
- 3) To achieve a higher starting torque [11].

Later on, another type of MSRM was presented and analyzed to reduce the torque ripple and acoustic noise with high starting torque [12]. This prototype (figure 3) has been built and tested experimentally. These advantages have been achieved at the cost of adding complexity to the electric machine.

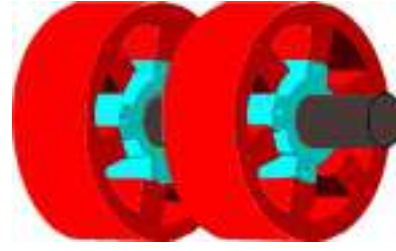


Fig. 3: Illustration of the proposed MSRM in [12]

Special types of SRMs that have lower number of stator poles than rotor poles can be constructed. Figure 4 shows one particular structure of the aforementioned type [13]. This structure leads to have better performance with a higher torque per unit volume. They also



Fig. 4: Configuration of four phase 8/14 SRM presented in [13].

have lower torque ripple and manufacturing costs in comparison with a conventional 6/4 SRMs that has the same constrains in volume and the same number of phases.

In [14], another structure of SRM with two phases (A_j and B_j , being $j = \{0, 1, 2\}$) has been proposed to provide a higher full-load starting performance and high efficiency operation for any initial rotor position (figure 5). This particular topology has the following features:

- It has no flux reversals in its stator. Therefore, it has lower core losses and lower stator acceleration that lead to lower acoustic noise.
- Three-quadrant operation capability that leads to higher operational efficiency.

Special rotor pole shape, leading to produce overlapping torque to provide self-starting feature by enhancing the starting torque.

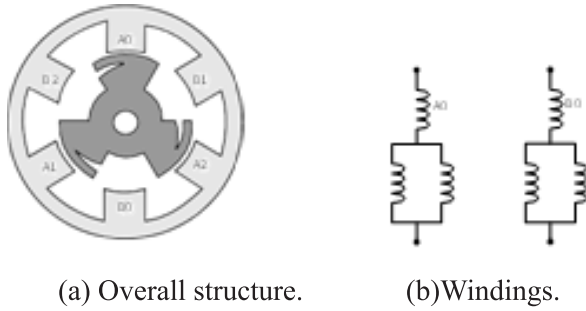


Fig. 5: Structure of a two-phase SRM proposed in [14] and its winding

Two particular types of SRM with E-core and C-core stator shape were presented in [15] and [16], respectively. In [15], a SRM with two phases and E-core stator has been proposed and analyzed (fig. 6). In the E-core, the two poles at the end of core have windings, but the central pole has no winding. The advantages of this structure are as follows:

- It can save the stator core up to 22 %.
- It has almost a flux-reversal-free stator.
- It has less copper. Hence, it has lower copper losses due to its structure with smaller cross section of stator pole in comparison with conventional SRM (which is up to 50 %).
- The radial forces are balanced.
- Higher efficiency and power density lead to higher performance [15].

Later on, three different topologies for E-core SRM with two phases were proposed to reduce

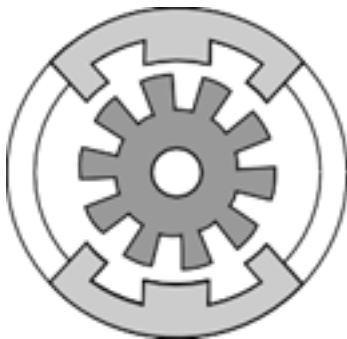


Fig. 6: E-core SRMs Stator and rotor laminations

the cost, improve the performance, and having better manufacturability in [17].

A particular double-stator SRM, which consists of two stators (outer and inner) and one rotor in the middle (figure 7) was presented and analyzed in [18] for electric vehicle applications. The results of their investigations indicated that the proposed geometry offers superior performance in terms of higher torque per mass [18]. Generally speaking, the main drawback of these advanced structures is their added manufacturing complexity and additional costs.

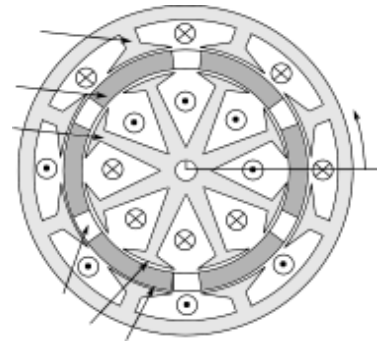


Fig. 7: stator and rotor of the DSSRM [18].

2.3 Srm Control Strategies

One of the important research topics in the SRD systems is their control strategy. Different torque control strategies to improve the efficiency and reduce the torque ripple are investigated so far. There are primarily two strategies for SRM torque control [19]: direct and indirect SRM torque control strategies.

A. Direct Torque Control (DTC)

DTC methods use a hysteresis controller and a simple control scheme. This method also includes two different sub-categories, which are the direct instantaneous torque control (DITC) and advanced DITC (ADITC) [6].

The motor non-linear characteristics are considered in these control strategies, in order to compensate the variation of output torque (ripple) according to the rotor position and current. In some advanced methods, these characteristics are used to vary the reference current vector according to the reference torque and the rotor position [19].

1) *Direct Instantaneous Torque Control (DITC)*: By using a hysteresis controller and estimation of the

instantaneous torque, the average torque can be controlled to be in a bandwidth, but the instantaneous torque cannot be controlled to be in the given bandwidth. The advantages of this method are fast torque response, high robustness and the reduction of switching. However, the switching frequency is not constant. The torque ripple can be limited by controlling the sample time; hence, it will increase with speed [6]. A typical control system of a DTC is shown in figure 8.

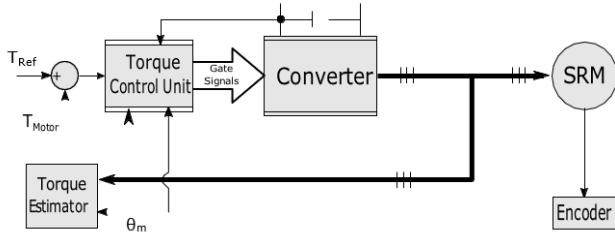


Fig. 8: Block diagram of a typical DTC

Advanced Direct Instantaneous Torque Control (ADITC): In order to control a variety of phase current in one sample time, the ADITC method can adjust the average phase voltage. By extending the sample time, it can achieve a smaller torque ripple in comparison with the conventional DITC. However, for the worst case and with the same sample time for both control methods, the switching frequency of the ADITC is almost double in comparison with the DITC; hence the switching loss and EMC emissions in ADITC are more than DITC. In contrast, the torque ripple in ADITC is smaller for the same sample time [6]. In ADITC the phase current and phase torque are smooth but the produced switching frequency by PWM module is high.

A. Indirect Torque Control (IDTC) method

Indirect torque control is another method. A typical block diagram of IDTC is shown in figure 9. There are three types of IDTC that have been introduced yet; the linear, cosine, and nonlinear logical torque sharing function (TSF). Comparisons of these torque control methods, as well as their advantages and disadvantages, were presented in [6].

2) Commonly, in AC machines the torque is controlled by converting its reference into equivalent phase current references. In the SRMs, the similar approach is followed and by controlling the current the torque can be controlled indirectly. The conversion of torque to current

in SRMs is not straight- forward, because the torque depends on the rotor position. In the SRMs the current, torque and rotor position have nonlinear relationship, hence it is not possible to formulate this relationship with an analytical expression [3].

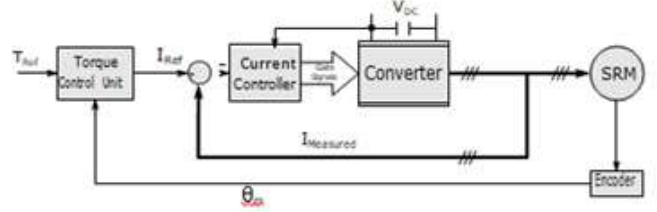


Fig. 9: Block diagram of IDTC

There are two methods have been introduced in the literature to apply this conversion. One is to use a look-up table to store the static $T-i-\theta$ characteristics, and the other method is to apply artificial neural networks (ANN). To apply the look-up table method a large online memory is required, whereas the ANN method needs intensive online computation [3].

2.4 Challenges In Torque Ripple And Vibration Reduction

Much research effort is focused on overcoming different challenges in torque ripple and vibration reduction. In [20], a combination of multi-objective technique by using the FEM to optimize a 4/2 SRM is presented. In this proposed approach, the torque ripple reduction and the minimal degradation for the mean torque and starting torque are considered. In [21], it is mentioned that the general cause for the torque ripple that leads to make the current non-linear is the fringing flux. In this investigation, a new rotor shape with notched teeth in the forward rotating direction has been proposed to reduce the torque ripple by improving the inductance profile. Some different shapes of stator and rotor have been designed and analyzed to improve the torque and minimize the torque ripple [22]–[26]. In [27], an investigation about the contribution of the SRM windings on the resonant frequencies has been done. Small vibrations can be ignored in any electric machine but it is harmful to have large amplitude of vibration because of these three reasons:

- Large dynamic stresses that can leads to parameter fatigue failure.

- Some components may get damaged due to the high inertia forces.
- The last but not the least is that they can cause damage to internal human's organs [28].

In [29], [30], a hybrid controller to minimize the torque ripple by infusing a balanced commutator with torque sharing over an extended region has been introduced. In [29], the proposed method includes a new PWM current controller that follows a contour to produce a constant torque. In [31], a controller with DTC by using sliding mode control has been presented. In some researches, torque ripple reduction up to a certain range was achieved, where the upper speed limit, with accurate torque control, was decided by the controller bandwidth which in turn depends on the sampling frequency and DC link voltage. In [32], two improved torque sharing functions were proposed, dependent on turn on angle, overlap angle and the expected torque using genetic algorithm to optimize these torque sharing functions. Exponential torque sharing function is found to give better results if maximum speed with torque control is considered as the evaluating target. In [33], a family of TSFs by using different secondary objectives was introduced, such as power loss minimization and drive constraint consideration. However, the consideration of linear magnetic characterization and a simple torque equation may reduce drive efficiency and performance. In [34], a novel method of profiling the phase currents to minimize the torque ripple of a switched reluctance machine was proposed. The method is a combination of machine design and control algorithm designed to function from zero speed to the maximum speed for the application.

Conclusion :

In this chapter, some studies and researches about different SRM topologies and structures to improve their performance were presented. It was also shown that, by some optimizations in the design of SRMs, their efficiency can be improved by reducing their torque ripple. The results of such designs can be very helpful and important for the selection of a proper SRM structure for the particular applications, such as in EV applications.

Regarding to conventional SRM structures, studies

suggest that 8/6 and 10/8 configurations best suit for EV applications. The features of these conventional structures can be improved to a some extend using more advanced SRM topologies. However, in general these improvements are made at the cost of adding extra complexity to the electric machine and power electronics system. Taking into account that price is a key factor in the automotive industry, a trade-off between cost and performance should be done in order to determine the preferred SRM topology.

Different control strategies were also introduced. The advantage of DTC is its high performance and simplicity. Fast torque response and high robustness can be feasible by using hysteresis controllers and instantaneous torque feedback in the SRD. In the DITC method, the performance depends on sample time. However, in ADITC, the average phase voltage can be adjusted applying a PWM module, leading to a smaller torque ripple. Several methods for IDTC were proposed in the literatures; linear TSF, cosine TSF, and non-linear logical TSF. Investigations have shown that the non-linear logical TSF is the best between the three TSF methods.

References :

- 1) A. Y. Anekunu, S. P. Chowdhury, and S. Chowdhury, "A review of research and development on switched reluctance motor for electric vehicles," in *Power and Energy Society General Meeting (PES)*, 2013, pp. 1–5.
- 2) P. Lawrenson, J. Stephenson, P. Blenkinsop, J. Corda, and N. Futon, "Variable-speed switched reluctance motors," in *IEE Proc. B of the Electric Power Applications*, vol. 127, no. 04, 1980, pp. 253–265.
- 3) R. Suryadevara and B. G. Fernandes, "Control techniques for torque ripple minimization in switched reluctance motor: An overview," in *8th IEEE International Conference on In Industrial and Information Systems (ICIIS)*, 2013, pp. 24–29.
- 4) S. Kurian and G. K. Nisha, "State of the art of switched reluctance motor for torque ripple minimization," *International Journal of Industrial Electronics and Electrical Engineering*, vol. 02, no. 12, pp. 68–74, 2014.

- 5) A. Labak and N. Kar, "Outer rotor switched reluctance motor design for in-wheel drive of electric bus applications," in *Proc. of the XXth International Conf. on Electrical Machines (ICEM)*, 2012, pp. 418–423.
- 6) J. Ahn, "Torque control strategy for high performance sr drive," *Journal of Electrical Engineering and Technology*, vol. 3, no. 4, pp. 538–545, 2008.
- 7) Z. Yueying, W. Dafang, Z. Guifan, Y. Dongyu, and W. Yu, "Research progress of switched reluctance motor drive system," in *International Conference on Mechatronics and Automation (ICMA)*, 2009, pp. 784–789.
- 8) R. Krishnan, *Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications*. CRC Press, 2001.
- 9) V. Petrus, A. C. Pop, C. S. Martis, J. Gyselinck, and V. Iancu, "Design and comparison of different switched reluctance machine topologies for electric vehicle propulsion," in *XIX International Conference on Electrical Machines (ICEM)*, 2010, pp. 1–6.
- 10) E. S. Afjei and H. A. Toliyat, "A novel multilayer switched reluctance motor," *IEEE Transactions Energy Conversion*, vol. 17, no. 02, pp. 217–221, 2002.
- 11) M. R. Feyzi, S. M. Aghdam, and Y. Ebrahimi, "A comprehensive review on the performance improvement in switched reluctance motor design," in *24th Canadian Conference on Electrical and Computer Engineering (CCECE)*, 2011, pp. 348–353.
- 12) F. Daldaban and N. Ustkoyuncu, "Multi-layer switched reluctance motor to reduce torque ripple," *Energy Conversion and Management*, vol. 49, no. 05, p. 974979, 2008.
- 13) P. C. Desai, M. Krishnamurthy, N. Schofield, and A. Emadi, "Novel switched reluctance machine configuration with higher number of rotor poles than stator poles: concept to implementation," *IEEE Transactions on Industrial Electronics*, vol. 57, no. 02, pp. 649–659, 2010.
- 14) S. Oh and R. Krishnan, "Two-phase srm with flux-reversalfree stator: concept, analysis, design, and experimental verification," *IEEE Transactions on Industry Applications*, vol. 43, no. 05, pp. 1247–1257, 2007.
- 15) C. Lee, R. Krishnan, and N. S. Lobo, "Novel two-phase switched reluctance machine using common-pole e-core structure: concept, analysis, and experimental verification," *IEEE Transactions on Industry Applications*, vol. 45, no. 02, pp. 703–711, 2009.
- 16) S. H. Mao and M. C. Tsai, "A novel switched reluctance motor with c-core stators," *IEEE Transactions on Magnetics*, vol. 41, no. 12, pp. 4413–4420, 2005.
- 17) C. Lee and R. Krishnan, "New designs of a two-phase e-core switched reluctance machine by optimizing the magnetic structure for a specific application: concept, design, and analysis," *IEEE Transactions on Industry Applications*, vol. 45, no. 05, pp. 1804–1814, 2009.
- 18) B. Abbasian, M. and Fahimi and M. Moallem, "High torque double stator switched reluctance machine for electric vehicle propulsion," in *Vehicle Power and Propulsion Conference (VPPC)*, 2010, pp. 1–5.
- 19) D. H. Lee, S. Y. Ahn, and J. W. Ahn, "Advanced torque control scheme for the high speed switched reluctance motor," *Intech Open*, pp. 87–114, 2011.
- 20) S. I. Nabeta, I. E. Chabu, L. Lebensztajn, D. Correa, W. M. Da Silva, and K. Hameyer, "Mitigation of the torque ripple of a switched reluctance motor through a multi objective optimization," *IEEE Transactions on Magnetics*, vol. 44, no. 06, pp. 1018–1021, 2008.
- 21) J. W. Lee, H. S. Kim, B. I. Kwon, and B. T. Kim, "New rotor shape design for minimum torque ripple of srm using fem," *IEEE transactions on magnetics*, vol. 40, no. 02, pp. 754–757, 2004.
- 22) N. Sheth and K. Rajagopal, "Optimum pole arcs for a switched reluctance motor for higher torque with reduced ripple," *Magnetics, IEEE Transactions on*, vol. 39, no. 5, pp. 3214–3216, 2003.
- 23) Y. K. Choi, H. S. Yoon, and C. S. Koh, "Pole shape optimization of a switched-reluctance motor for torque ripple reduction," *IEEE Transactions on Magnetics*, vol. 43, no. 04, pp. 1797–1800, 2007.

- 24) W. Cai, P. Pillay, Z. Tang, and A. M. Omekanda, "Low-vibration design of switched reluctance motors for automotive applications using modal analysis," *IEEE Transactions on Industry Applications*, vol. 39, no. 04, pp. 971–977, 2003.
- 25) J. P. Hong, K. H. Ha, and J. Lee, "Stator pole and yoke design for vibration reduction of switched reluctance motor," *IEEE transactions on magnetics*, pp. 929 – 932, 2002.
- 26) J. Li and Y. Cho, "Investigation into reduction of vibration and acoustic noise in switched reluctance motors in radial force excitation and frame transfer function aspects," *IEEE Transactions on Magnetism*, vol. 45, no. 10, pp. 4664–4667, 2009.
- 27) W. Cai, P. Pillay, and Z. Tang, "Impact of stator windings and end-bells on resonant frequencies and mode shapes of switched reluctance motors," *IEEE Transactions on Industry Applications*, vol. 38, no. 4, pp. 1027–1036, 2002.
- 28) K. Srinivas and R. Arumugam, "Static and dynamic vibration analyses of switched reluctance motors including bearings, housing, rotor dynamics, and applied loads," *IEEE Transactions on Magnetism*, vol. 40, no. 4, pp. 1911–1919, 2004.
- 29) H. Iqbal and M. Ehsani, "Torque ripple minimization in switched reluctance motor drives by pwm current control," *IEEE Transactions on Power Electronics*, vol. 11, no. 1, pp. 83–88, 1996.
- 30) H. Iqbal, "Minimization of torque ripple in srm drives," *IEEE Transactions on industrial electronics*, vol. 49, no. 1, pp. 28–39, 2002.
- 31) S. Sahoo, S. Panda, and J. Xu, "Direct torque controller for switched reluctance motor drive using sliding mode control," in *Power Electronics and Drives Systems, 2005. PEDS 2005. International Conference on*, vol. 2, 2005, pp. 1129–1134.
- 32) X. D. Xue, K. W. E. Cheng, and S. L. Ho, "Optimization and evaluation of torque-sharing functions for torque ripple minimization in switched reluctance motor drives," *Power Electronics, IEEE Transactions on*, vol. 24, no. 9, pp. 2076–2090, 2009.
- 33) V. P. Vujicic, "Minimization of torque ripple and copper losses in switched reluctance drive," *Power Electronics, IEEE Transactions on*, vol. 27, no. 1, pp. 388–399, 2012.
- 34) R. Mikail, I. Husain, Y. Sozer, M. S. Islam, and T. Sebastian, "Torque-ripple minimization of switched reluctance machines through current profiling," *Industry Applications, IEEE Transactions on*, vol. 49, no. 3, pp. 1258–1267, 2013.

Automated Garbage Monitoring System Using GPS, GSM And IoT

Authors

Dr. G. D. Dalvi | Prof. S. P. Bhonge

- Abstract -

In India, SWACCHA BHARAT ABHIYAN is a mission started by our P.M, Which aims to clean up the roads, streets and to develop the infrastructure digitally of India's city and rural areas. Focusing towards the clean India mission, we have provided an efficient solution for monitoring the waste level on the real time basis. Whole system is Internet of things based. The level ultrasonic sensors in the garbage dustbin detect the garbage level continuously and accordingly the system provides the information to the control office. This will avoid the overflowing of the garbage dustbins. Ultimately it will help us to keep our environment clean and also reduce the health issues. This project Internet of things Based Garbage Monitoring System is a very smart system which will help to keep our village and cities. We see that in our cities public bins are overloaded and it create unhygienic conditions for people and that place leaving a bad smell. To avoid all these things we are going to implement a project Internet of things based garbage monitoring System. These bins are interfaced with Arduino Uno base system having ultrasonic sensor along with central system showing the Current status of waste on display and web browser HTML page with Wi-Fi module. To increase the cleanliness in the country government started the various project.

Keywords : IOT, Cloud, GPS, Ultra Sonic sensor, ESP8266, ATMEGA328, GSM, etc...

- Introduction -

Due to increase in population of India it also leads to increase in the garbage also. India faces major environmental changes associated with inadequate waste garbage collection, transport and disposal[6]. we

need many man powers, by this waste management monitoring system we reduce the man power with the help of embedded system is interfaced with Internet of things[6] Implementation is done with the help of Internet of things concept. The Internet of things is a concept in which surrounding objects are connected through wired and wireless networks without user intervention. Objects communicate and exchange information. In this system multiple bins are located throughout the cities or the Campus, these bins are provided with a ultrasonic sensor which helps in tracking the level and weight of the garbage dustbins and a unique ID will be provided for every bin in the city so that it is easy to identify which garbage dustbin is full[5]. The model uses a Wi-Fi module (ESP8266) which sends data to a web server which is developed by the authors using Bootstrap. The data sent with a timestamp by the RTC module which also provides the user with the location of the dustbin by the use of a GSM module. The solutions created for management of waste garbage faces its own difficulties. The solution proposed by suggest the use of only a GSM module and an sensor which send the status of the dustbin directly to the registered number.

For effective usage of the monitoring system, IOT concept has been used for data communication, processing, storing and retrieving. The proposed work helps to eradicate the everyday difficulty of managing the garbage in the environment which is possible with the help of Internet of things [7]. This system consists of an Arduino Uno microcontroller, a garbage dustbin loaded with ultrasonic sensors and they are monitored continuously through a monitoring panel at the control office with the help of GSM & GPS module [7]. We may dump the waste in the government allocated bins in

area/locality or hand it over to the door to door collectors and after that the garbage should reach its end site which is very crucial and that's where our proposed model is going to fit in[8].

II. Literature Review

S.S.Navghane, M.S.Killedar[1]2017 These dustbins are interface with microcontroller based system having IR wireless systems along with central system showing current status of garbage, on mobile web browser with HTML page by Wi-Fi module.. The main aim of this project is to reduce human resources and efforts along with the enhancement of a clean city vision. Ashima Bajaj [2]2017 This method is advance in which garbage monitoring system management is automated. This project Garbage Monitoring system using Internet of things is a very innovative system which will help to keep the cities clean.

The author proposed a system for organizing the collection of the garbage in the commercial and residential areas of the cities [3]. In this system, the level of garbage in the bin was detected by the sensor which will send the data to the corporation room using the GSM module.

In [8] the authors have proposed an Internet of things enabled bin, which uses RFID tags to identify the bins with a web-based online system approach and identifies the weight of the garbage that is added, all this data is calculated and added a host server to the parent database. Also, it has a mechanism that gives the level of the bins and updates the data of each bin on the parent server. It notifies the authority when the bin is full and provides the shortest route to the collection a truck to empty all the bins.

In [9] this system, the ultrasonic sensor detects the level of garbage and sends the value to control room through the GSM module. A GUI based on MATLAB was developed to check the information related to the garbage for different locations. Two units were present in the system, slave unit was placed in the bin whereas the master unit was there in the control room.

In [10] the authors have proposed a smart waste dustbin which uses a cloud based system which is

connected to a raspberry pi which can identify when the garbage dustbin levels by the help of a sensor which measures the volume occupied and the left volume in the smart garbage dustbin. If the volume is full then there is a trigger generated that sends an alert message through raspberry pi and also sends an alert and location of the dustbin to the authority to collect the waste.

III. Proposed Methodology

In this project methodology model takes the fundamental process activities of Project Plan, specification, Analysis, hardware and software Design, development, validation and represents them as separate process phases.

Now, let us see the particulars of the various blocks of the hardware of an garbage monitoring system. As shown in Fig. the blocks are:

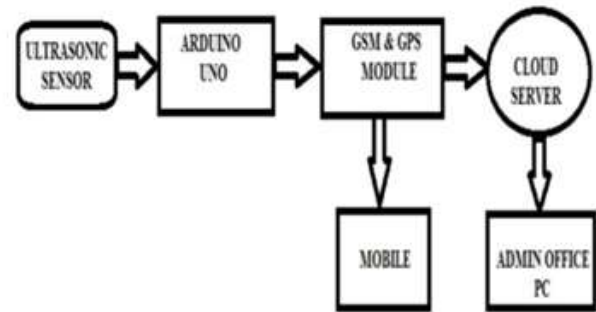


FIG 1: BLOCK DIAGRAM OF SMART GARBAGE MONITORING SYSTEM USING IOT

GPS – Global Positioning System

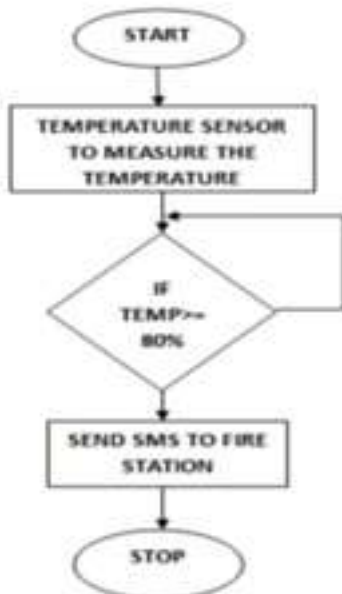
GSM – Global System for Mobile communication

The working objects of the slave unit are Arduino Uno, ultrasonic sensor, Potentiometer, GSM & GPS SIM908 module. The entire unit is kept at the top of the bin. The trigger pulse is sent from the ultrasonic sensor into the bin and as a result, the echo pulse will be received back by it. Thus the time lagging between the sent and received sound signal is used to determine the distance to the object. Through this it continuously checks the level of garbage in the bin. Once the garbage reach the specified threshold values, sensor gives indication to the Arduino uno.

Flow chart:

The municipality dashboard shows real time tracking of the garbage collecting trucks employed for collecting, it shows the truck capacity of the garbage trucks on duty, it has an option where it can send alerts to

the consumers of the particular pin code saying that the truck is in their area for collection. It also has an attention board where any request/queries raised by the consumer is made available there.



Conclusions :

This system also helps to monitoring the fake reports and hence can reduce the corruption in the overall management system. This reduces the total number of trips of waste collection vehicle and the overall expenditure associated with the garbage collection. It ultimate helps to keep cleanliness in the cities. Therefore, the smart garbage management system makes the garbage collection more efficient the use of solar panels in such systems may reduce the energy consumption. Such systems are valuable to plundering of components in the system in different ways which needs to be worked on.

Acknowledgment :

The whole process of this project which is presented in this paper was such a difficult task. We have rendered valuable guidance during the preparation of our project. First of all, we extend our deepest gratitude to my revered Principal Dr. Mrs. S. D Wakde for their support. I am grateful to Prof. G.D.Dalvi, Department of Electronics and Telecommunication Engineering and my guide for providing immense support and guidance.

References :

- 1) S.S.Navghane, M.S.Killedar, Dr.V.M.Rohokale. "IOT Based Smart Garbage and Waste Collection Bin", International Journal of Advanced Research in Electrical and Communication Engineering(IJARECE), Volume 5, Issue 5,May 2017.
- 2) Ashima Bajaj, Sumanth Reddy. "Garbage Monitoring System Using IOT", International Journal of Pure and Applied Mathematics, Volume.114No.12 2017, 155-161
- 3) Kasliwal Manasi H and Suryawanshi Smithkumar B 2017 A Novel approach to Garbage Management Using Internet of Things for smart cities International Journal of Current Trends in Engineering & Research 2 348-53.
- 4) Norfadzlia Mohd Yusof, Mohd Faizal Zulkifli, Nor Yusma Amira Mohd Yusof, Azziana Afifie Azman. "Smart Waste Bin with Real-Time Monitoring System". International Journal of Engineering & Technology, 7 [2.29] [2018] 725-729.

- 5) MS. AMRUTHA P.V. MS. CHAITHAR B.N. "IOT BASED WASTE MANAGEMENT USING SMART DUSTBIN" PROJECT REFERENCE NO.: 40S_BE_2142_2018 : SHRIDEVI INSTITUTE OF ENGINEERING AND TECHNOLOGY
- 6) Shobana G1, Sureshkumar R2 1PG Scholar, Dept. of EEE, Kumaraguru College of Technology, Coimbatore 2Assistant Professor, Dept. of EEE, "AUTOMATED GARBAGE COLLECTION USING GPS AND GSM" Volume 118 No. 20 2018, 751-755.
- 7) Mr.D.Poornakumar , "Smart Garbage Monitoring System Using IOT" INTERNATIONAL JOURNAL FOR TRENDS IN ENGINEERING & TECHNOLOGY VOLUME 27 ISSUE 1 – MARCH 2018 - ISSN: 2349 – 9303.
- 8) Sahil Mirchandani, Sagar Wadhwa, Preeti Wadhwa, Richard Joseph, "IoT Enabled Dustbins", 2017 International Conference on Big Data, IoT and Data Science (BID) Vishwakarma Institute of Technology, Pune, Dec 20-22, 2017, Pg 73-76
- 9) A Anitha. "Garbage monitoring system using IoT", IOP Conference Series: Materials Science and Engineering, 2017.
- 10) Sneha Patil, 2Snehal Mohite, 3Aishwarya Patil, 4Dr. S.D.Joshi "International Journal of Advanced Research in Computer Science and Software Engineering".

Image Segmentation And Classification For Vision Based Detection And Tracking of Moving Object In Video Surveillance

Authors

Dr. R.D.Ghongade | Prof. A. R. Pawade

- Abstract -

Most moving object detection methods operate by trying a binary classifier to sub-windows of an image, after that a non-maximum suppression step comes where detections on overlapping sub-windows are eliminated. As the number of feasible sub-windows in even middling sized image datasets is very large, the classifier is usually learned on only a subset of the windows. This circumvent the computational complexity of dealing with the entire set of sub-windows, however, this paper address that, it leads to sub-optimal detector performance. Specifically, the main offering of this paper is the initiation of a new method, Max-Margin object detection (MMOD), for understanding how to detect objects in images. This method does not execute any sub sampling, but instead optimizes overall sub-windows. MMOD is used to enhance any object detection method which is linear in the learned parameters, such as Histogram of Oriented Gradient (HOG) or bag-of-visual-word models. Using this strategy we manifest substantial performance gains in three publicly available datasets. Evidently, we represent that a single firm HOG filter can conquer a set-of-the-art deformable part model on the object detection data set and benchmark when the HOG filter is assimilated via MMOD.

Keywords : Python, Open CV component, video surveillance, detection, tracking, moving images, object detection.

- Introduction -

nowadays, most of the living locality viz parks, metro stations, streets, shopping malls, schools and banks are supervise by video surveillance systems. accordingly, the researchers has been concentrating on moving object detection and tracking. These system predominantly comprise an breakthrough component

for motion detection, object recognition, tracking, performance learning ,video retrieval. The technological advancement of cameras and computers used for recording and scrutinizing the video leads the requirement of automatic video scrutiny. But the fully automated surveillance systems are still deficient, So many research work has been done in this emanating field[4].

This paper addresses the real time object detection and tracking which are predominant and challenging function in many computer vision applications such as video surveillance, robot navigation, vehicle navigation & blind man navigation system. Object detection includes detecting the object in a succession of frames. Every tracking technique needs object detection mechanism either in each frame or in the video sequence. Object tracking is the process of locating an object or multiple objects using either static or dynamic webcam. Video surveillance makes it feasible that the computer can involuntarily locate, perceive and track the changes by the automatic examination of images in an order which is recorded by cameras in natural circumstances. Each and every application needs disparate requirements to use video processing by systematic manner. However, the common first step between all applications is finding regions that related to moving object. Motion detection is a difficult problem because of changes in scenes [4].

The accessibility of high power computers, high quality and low cost camera increases interest in object tracking algorithms. Three key steps for video analysis are: Detection of moving Objects, Tracking of that objects from frame to frame, Analysis of Object tracking to recognize their performance. The main application areas of object detection and tracking are: Motion based recognition, automated surveillance, video indexing, traffic monitoring, vehicle navigation and etc

Nowadays Image segmentation and classification for

vision based detection and tracking of moving object in video surveillance is very useful for industrial purpose and also in security system .if we used this technique as security system in banking, court , hospitals ,school etc.. then it will be very useful for them. For example in a bank thief entered with a knife, gun etc., and when it is captured by the webcam then it automatically margin that particular image ,capture the photo of that image and send it on a mobile of authority as a alert message to them.

In this paper we are using MMOD algorithm. Max-Margin Object Detection (MMOD), used for learning to detect objects in images. This technique does not carry out any sub-sampling, but instead optimizes over all sub-windows. On all datasets, using MMOD to discover the parameters of the detector lead to substantial enhancement [10].

II. Literature Review

Staffan Reinius et al. [1] proposed a work on Object recognition using the OpenCV Haar cascade-classifier on the iOS platform. The aim of this project was to recognize four objects on the car dashboard using OpenCV on the iOS platform. OpenCV Haar cascade classifier can also separately arrange that 4 objects.

Souhail Guennouni et al.[2] proposed a work on Multiple Object Detection using OpenCV on an Embedded Platform. This work represent multiple objects detection based on OpenCV libraries. The offered application accord with real time systems execution and the results gives a sign of where the cases of object detection applications is more difficult and where it is simpler.

Sabri M.A.A Ahmed et al.[3] proposed a work on vision based detection and tracking of moving target in video surveillance. This paper represent real time detection and tracking of moving object, in which continuous object tracking uses kalman filter, because of that tracking system can recover a target shape and successfully track a moving target.

M. Gomathy Nayagam et al.[4] proposed a work on Real time Object Detection and Tracking Algorithms .This paper represent the various object detection and tracking algorithms. Author address some object detection techniques which are Point Detector, Background Modelling, Segmentation, Optical Flow and Supervised Classifier and for tracking Silhouette

Tracking, point tracking, Kernel Tracking etc which helps us to understand which one is better technique.

Far'es Jalled et al.[5] proposed a work on object detection using image processing. The main purpose of this article is to thrive an OpenCV-Python code using Haar Cascade algorithm for object detection. Currently, Unmanned ariel vehicle (UAVs) are used for detecting and attacking the invaded ground targets. The main issueofr this type of UAVs is that sometimes the object are not properly detected, which thereby causes the object to hit the UAV. This project aims to avoid such unwanted collisions and damages of UAV.

Mrs Poonam Khare et al.[6] proposed a work on the various methods of object detection in video surveillance systems. .In this paper study of various phases of video surveillance system is made and for each phase various alternative solutions with their advantages and disadvantages have been discussed. For image acquisition author used RGB color space along with edge ratio that allows determining moving object and shadow separately. Author used technique for feature selection and extraction like edge information, texture, time-domain characteristics etc.

Bhumika Gupta et al.[7] proposed a work on Study on Object Detection using Open CV – Python. Object detection using of OpenCV library of python 2.7, improves the efficiency and accuracy. The main objective is to recognize a specific object in real time from a large number of objects.

Wu Runze et al.[8] proposed a work on Improved Object Tracking Algorithm Based on Tracking-Leaning-Detection Framework. ³'Tracking-Leaning-Detection' was proposed by Zdenka Kalal. Long-term tracking is the process of locating an object in a video succession, where the object moves in and out of the camera view, first, we propose a tracking framework(TLD) that fragmented the long-term tracking task into three sub-tasks: tracking, learning and detection. the tracker and the detector work concurrently to get the location of the object independently, and the learning is an information exchanger between tracker and detector .For real time purpose TLD is a very good framework.

Zhong-Qiu Zhao et al.[9] proposed a work on Object Detection with Deep Learning. Object detection based on traditional architecture are complex and to overcome this difficulty deep learning is used, which has more powerful tools which are able to understand high

level features of the object. Overcoming the object detection issues means placing a tight bounding box around these objects and associating the correct object class with each bounding box. Deep learning is the state-of-art method to accomplish object detection. Region-based convolutional neural networks, or R-CNNs, are some deep learning techniques.

III. Proposed Methodology

In computer vision province, object detection and tracking plays a vital role. Object detection means placing/identifying objects in frame of video sequence and tracking means the process of locating moving object or multiple objects over a period of time using camera. Technically, tracking is evaluating trajectory of an object in the image.

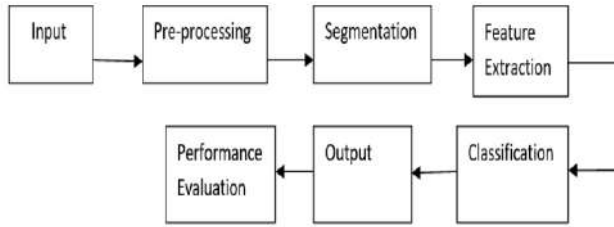


Figure1: Block diagram of moving object detection and tracking.

A. Object Detection:

Object detection is the methodology of determining the occurrence of the class to which the object belongs and evaluating the location of the object by bounding box around the object. Detecting single occurrence of class from image is called as single class object detection, and detecting the classes of all objects present in the image is known as multi class object detection. Different challenges such as partial/full occlusion, varying illumination circumstances, poses, scale, size etc are required to handle while performing the object detection. The object detection is the operation of locating objects in the succession of frames. Every tracking algorithm needs an object detection methodology either in every frame or when an object occurs newly in a frame. There are some object detection methods which are: 1. Point Detector, 2. Background Modelling, 3. Segmentation, 4. Optical Flow and 5. Supervised Classifier [11].

B. Pre-processing:

It is process in which the image is converted into

frames. Pre-processing is a ordinary name for operations with images at the lowest level of abstraction, both input and output are intensity images. The goal of pre-processing is an enhancement of the image data that represses unwanted deformations or enhances some image features vital for further processing.

C. Segmentation:

Image **segmentation** is the procedure of dividing a digital image into multiple **segments**. The aim of **segmentation** is to simplify and change the depiction of an image into something which is more significant and easier to scrutinize. There are various types of segmentation algorithm accessible such as 1) Watershed algorithm, 2) sliding window, 3) region proposal, 4) Max-Margin object detection (MMOD). In this paper we are using MMOD algorithm. Max-Margin Object Detection (MMOD), used for learning to detect objects in images. This method does not execute any sub-sampling, but instead uses over all sub-windows. MMOD can be able to enhance any object detection method

D. Informative region selection:

While dissimilar objects may emerge in any stance of the image and have different aspect ratios or sizes, it is a natural choice to scan the entire image with a multi-scale sliding window. This strategy can find out all feasible positions of the objects, its deficiencies are also obvious. Due to a large number of candidate windows, it is economically expensive and creates too many unessential windows. However, if only a specified number of sliding window templates are applied, undesirable regions may be produced [9].

E. Feature extraction:

To perceive unlike objects, we need to extract visual features which can furnish a semantic and strong delineation. scale-invariant feature transform (SIFT), Histogram oriented gradient (HOG) and Haar-like ,deep learning, gray-level co-occurrence matrix (GLCM) features are some techniques. However, due to the diversity of emergence, illumination conditions and backgrounds, it's strenuous to manually design a robust attribute descriptor to excellently describe all kinds of objects [9].

F. Classification:

Besides, a classifier is required to discriminate a target object from all the other classes and to make the

delineation more hierarchical, semantic and informative for visual recognition. Generally, the Supported Vector Machine (SVM), AdaBoost, random forest and Deformable Part-based Model (DPM) are good choices. Among these classifiers, the SVM A support vector machine (SVM) is machine learning algorithm that scrutinizes data for stratification and regression analysis. SVM is superintend learning technique that focuses on data and sorts it into one of two categories. An SVM results a map of the sorted data with the boundaries between the two as far apart as possible. SVMs are utilized in text categorization, image stratification, and in handwriting recognition. A support vector machine is also known as a support vector network (SVN) [9].

G. OpenCV:

OpenCV is an open source computer vision library that is used in real time . Open CV was evolved by Intel and now assisted by Willow Garage and Itseez. Open CV is constructed & optimized for real time applications, though it is developed in C and C++ languages, it is a crossplatform library that runs on Linux, Windows and Mac OS . The Open CV library consists hundreds functions that cover many areas in computer vision such as robotics, medical image processing, and security [2].

H. HOG:

The histogram of oriented gradients (HOG) is attribute descriptor used in computer vision and image processing for the motive of moving object detection. This method counts instances of gradient orientation in localized parts of an image. This method is corresponding to that of shape contexts, edge orientation histogram, & scale-invariant attribute transform descriptors, but varies in that it is determined on a dense grid of consistently spaced cells and uses overlapping local different normalization for improved precision.

I. Confusion Matrix:

A confusion matrix presents the number of correct and incorrect projections made by the stratification model compared to the authentic results (target value) in the data. It is a $N \times N$, where N represents number of target values. Accomplishment of such models is generally estimated using the data in the matrix.

II. Conclusions :

In this paper, we did the ubiquitous literature survey on Image segmentation and classification for vision based detection and tracking of moving object in video surveillance. Based on the survey, we observed that moving object detection and tracking is prime research field today. Day by day crimes are increasing and to prevent it, security system is necessary and we can use this object detection and tracking technique in banks, hospitals, school etc. for example if criminals entered the bank with knife, gun etc, then it is harmful to banks and people, but by video surveillance object detection and tracking we can get the image of that harmful object on a mobile of authority as a alert to them

This paper shows Python has been preferred over MATLAB for integrating with OpenCV because when a Matlab program is run on a computer, it gets busy attempting to elucidate entire Matlab code which is built on Java. OpenCV is fundamentally a library of functions written in C/C++ languages. Furthermore, OpenCV is easier to use for someone with little programming background. So, it is better to use any concept of object detection using OpenCV-Python.

In this paper we are using Max-Margin object detection (MMOD) technique which can be used to enhance any **object detection technique** which is linear in the learned parameters, such as HOG or bag-of-visual-word models. Using this perspective we show significant performance gains on three publicly available datasets. This system is very useful for security purpose.

References :

- 1) Staffan Reinius, Uppsala Universitet, "Object recognition using the OpenCV Haar cascade-classifier on the IOS platform ",IT 13 007 Examensarbete 15 hp Januari 2013.
- 2) Souhail Guennouni, Anass Mansouri, Ali Ahaitouf, Sidi Mohammed Ben Abdellah University School of Science and Technology Signals Systems and Components Laboratory B.P. 2202, 30000 Fez, Morocco, "Multiple Object Detection using OpenCV on an Embedded Platform ",978-1-4799-5979-2/14/\$31.00 ©2014 IEEE.
- 3) Sabri M.A.A Ahmed college of computer science & information technology, Sudan university of science and technology Khartoum, Sudan and

- Othman O. Khalifa Electrical and Computer Engineering International Islamic University Malaysia,” vision based detection and tracking of moving target in video surveillance”, 10.1109/ICCCE.2014
- 4) M.Gomathy Nayagam , Research Scholar, Einstein College of Engineering, Tirunelveli, Tamil Nadu, India, Dr.K.Ramar Professor, Einstein College of Engineering, Tirunelveli,Tamil Nadu,India, “Real time Object Detection and Tracking Algorithms”, International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 9 - 2015
 - 5) Far’es Jalled and Ilia Voronkov, Moscow Institute of Physics & Technology, Department of Radio Engineering & Cybernetics,”object detection using image processing”, arXiv:1611.07791v1 [cs.CV] 23 Nov 2016
 - 6) Mrs Poonam Khare, M.Tech NIT, Bhopal Associate Professor, Department of Information Technology MLR Institute of Technology, Hyderabad, Telangana, India,” various methods of object detection in video surveillance systems “,IRJET DEC-2016
 - 7) Bhumika Gupta, PhD Assistant Professor, Ashish Chaube B.Tech , Ashish Negi B.Tech, Umang Goel B.Tech C.S.E.D G.B.P.E.C, Pauri Uttarakhand, India,” Study on Object Detection using Open CV – Python “,International Journal of Computer Applications (0975 – 8887) Volume 162 – No 8, March 2017
 - 8) Wu Runze 1 Institute of Optics and Electronics, Chinese Academy of Sciences, Chengdu, China 610209 2 University of Chinese Academy of Sciences, Beijing, China 100039 ,Wei Yuxing and Zhang Jianlin Institute of Optics and Electronics, Chinese Academy of Sciences, Chengdu, China,” Improved Object Tracking Algorithm Based on Tracking-Learning-Detection Framework”, 610209, 978-1-5090-3025-5/17@2017IEEE.
 - 9) Zhong-Qiu Zhao, Member, IEEE, Peng Zheng, Shou-tao Xu, and Xindong Wu, Fellow, IEEE “Object Detection with Deep Learning”,., arXiv:1807.05511v2 [cs.CV] 16 Apr 2019
 - 10) Davis E. King,” Max-MarginObjectDetection”, arXiv:1502.00046v1 [cs.CV] 31 Jan 2015
 - 11) Ajeet Ram Pathaka,*, Manjusha Pandeya, Siddharth Rautaraya aSchool of Computer Engineering, Kalinga Institute of Industrial Technology (KIIT) University, Bhubaneswar, India,” Application of Deep Learning for Object Detection”, ICCIDS 2018

Comparative Analysis for Lane Detection System Using Canny Edge Detection, Hough Transform and Kalman Filter

Authors

Prof. U.W. Hore | Prof. V. B. Langote

- Abstract -

Many of the researchers are developing an efficient technology for automated alarm system while crossing through lanes on roads. Lane detection through image processing is one of the major tasks. A camera has been mounted in the front of vehicle to take real time images; and a fast processor can be used to automatically detect lanes according to image processing algorithms. This paper is based on algorithm development using Canny edge detector and Hough transform. The Raspberry Pi is used for real time processing of image. Global Positioning System, which is the technology used to find the location. GPS can be interfaced with the Raspberry Pi serially to get the positioning parameters like Latitude and Longitude. The live position of the vehicle on road has been detected on map.

Keywords : Lane detection, Canny Edge Detector, Hough Transform, GPS modem, Raspberry Pi.

- Introduction -

Vehicle accidents on roads are the major problem faced by the government of any country. There may be various reasons of accidents; it can be due to bad visibility, consumption of alcohol during driving, inattention during driving a car, etc. Whatever be the reason of accidents, it causes severe loss in form of infrastructure or a life. One of the major reasons of accident is sudden change in lane on a fast driving road. If all vehicles will follow single lane then traffic jam will be minimized, so lane detection can avoid unnecessary traffic jams. It is essential to develop systems that can assist driver while navigating on the road.

Lane identification system can immensely help the purpose. Detection of tracks and obstacle on roads can be done by using proximity sensors, which can identify the

ground plane but it cannot identify shape and various properties of the object or ground.

An IR sensor can be used to detect roads, but it has various limitations. Considering these facts, today's research focuses more on digital image processing approaches. Autonomous lane detection is challenging due to range of environmental conditions under which these systems operate: rain, shadow, sunshine, day, night, fog etc. This paper is describing lane detection using Canny edge detector and Hough transform with Kalman filter.

II. Literature Review

This paper develops a robust and effective vision-based lane detection approach as in [1]. In the proposed method, gray-scale images are converted to two binary images from a fixed region of interest (ROI). These images are then merged using a novel neighborhood AND operator and then transformed to a bird's eye view (BEV) via inverse perspective mapping (IPM). Experimental results show that the proposed method accurately detects lanes in complex situations including worn-out and curved lanes. This paper proposes a robust lane detection method under the assumption that lane markings are parallel.

Y. Xu, X. Shan as in [2] has proposed a method for lane detection based on combined fuzzy control with RANSAC algorithms. Author suggested the traditional lane detection methods based on the RANSAC algorithm used to cause many false detections and unable to accurately detect the lanes in complex road environment, because of the existence of interferential noise points in the set of sampling points.

M. Kodeeswari has developed a method based on image processing techniques to identify the lane lines on the

hilly road based on Hough transform as in [3]. The proposed method processes the live video stream from a monocular camera using matlab and extracts the position of lane markings and an algorithm is used to find the lane lines present on the road.

Jieh-Shian Young proposed a method for the positions of the lane marks can be evaluated by visual information of the image captured from a single charge-coupled device (CCD) camera as in [4]. This proposed approach originally utilizes the properties of the CCD array in a camera to achieve the aim of objects positioning. The results show that the proposed approach is able to achieve object positioning. The accuracy of the position evaluations depends on the pixels of objects picked out in an image, while it is sometimes not easy to discern the exact pixels of objects in the image. The image disturbances from vehicle vibrations or image background are also significant for the position evaluation accuracy.

Jongin Son proposed strategy for functions admirably in different lighting conditions like awful climate conditions and at evening time as in [5]. They have considered the three noteworthy segments: 1)they distinguished a flight point in view of a voting map and recognize a versatile region of interest (ROI) to diminish computational complexity.2) They have utilized the distinctive property of path hues to finish lighting invariant path marker applicant location. 3) Lastly they locate the principle path utilizing a clustering technique from the path marker competitors. At the season of lane departure, their framework closes driver caution flag. The creators got a normal discovery rate of 93% under different lighting conditions and the general procedure takes just 33 ms for every frame.

Jae-Hyun Cho applied the Hough transform with optimized the accumulator cells in the four ROI in parallel and detects lanes with high efficiency as in [6]. Although Hough Transform can detect only straight lines, the poor lane recognition rate on the curve road has been resolved fairly.

III. Proposed Work

A. Lane Detection

Using a Raspberry Pi Camera, we continuously read the provided images and process each frame to detect the lane markings. It is also important to first calibrate the

camera to obtain the extrinsic calibration matrix that tells us how the camera is rotated and translated relative to the world coordinate system – of the car in our case. This is especially important when we need to project points from three-dimensional coordinates to two-dimensional ones..We first convert the input image to grayscale and select two regions of interest in the areas of the image where we know that it will be most likely to encounter a line marking. Next, we apply an canny edge detection algorithm which applies the vertical Sobel operator and reacts to changes in intensity whenever an edge is encountered. After that, we apply Probabilistic Hough transform to detect the lines. We choose only one for each ROI (Region of Interest), and we set some flags that tell us which line is missing. According to this, we have three cases:

1. No line missing – we take the intersection of both lines to find the position of the vanishing point. We also intersected these two lane markings with a horizontal line found at the bottom of the image, to find the left and right points of the lane.
2. Left or right line missing – we perform a birds-eye projection of the points and obtain an image in which both lane markings are parallel. Since we know the two points that characterize one line, by translating them with a certain distance to the left (if the left line is missing) or to the right (when the right line is missing), we are able to find all the information we need. We then perform the inverse projection, which gets us back to the original image, only now we know the position of both lane markings.
3. Both lines missing – The Kalman Filter Predict step, without performing the Update step. This will correctly estimate the position of the lane markings. After processing the image the live position of the vehicle will be displayed on the map.

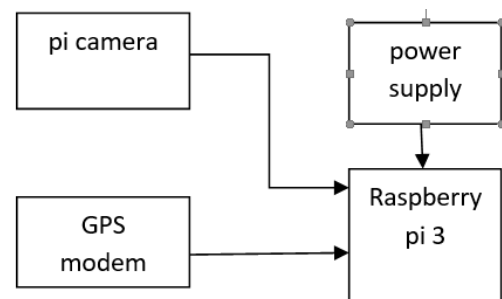


fig.1 Block Diagram

B. Algorithms

1) Canny edge detection algorithm:

1. Apply Gaussian filter to smooth the image in order to remove the noise
2. Finding the intensity gradient of the image
3. Applying non-maximum suppression to get rid of spurious response to edge detection
4. Apply double threshold to determine potential edges
5. Track edge by hysteresis :finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

2) Hough Transform algorithm:

The Hough transform (HT), transforms between the Cartesian space and a parameter space in which a straight line (or other boundary formulation) can be defined. Let's consider (x, y) points in a road lane image, where all straight lines passing through that point satisfy the following equation for varying values of line slope and intercept (m,c)

$$y=mx+c$$

To reverse variables the above equation becomes:

$$c=y-mx$$

Which describe a straight line on a graph of c against m .

Considering two pixels P1 and P2 lied on the same line in the (x, y) space. Each pixel represented all the possible lines by a single line in the (m,c) space. Thus a line in the (x, y) space passes through the both pixels must lie on the intersection of the two lines in the (m,c) space.

3) Kalman Filter based Lane Tracking:

We have chosen to use Kalman Filter to track the lane markings because it is a robust method that accounts for noisy or missing measurements. It is a two-step process that estimates the lane parameters in each frame. The 3D lane model that we use is characterized by 4 variables:

x_0 —which is the lateral displacement of the car to the middle of the lane;

ϕ —the heading displacement of the car from the lane direction;

w —the width of the lane;

c —the curvature of the road.

The first step of the Kalman Filter is Prediction. For this, we need to know the model that characterizes the state

variable, the state covariance matrix, and the process covariance matrix, and solve the following equations:

$$X(t)=A.X(t-1)$$

$$P(t)=A.P(t-1).A^t+Q$$

The transition model has the following equations:

$$X_0(t)=X_0(t-1)+V.\Delta t.\phi(t-1)$$

$$\phi(t)=\phi(t-1)+V.\Delta t.c(t-1)$$

$$w(t)=w(t-1)$$

$$c(t)=c(t-1)$$

The second step of the Kalman Filter is Measurement Update, and it is characterized by the equations:

$$K=(P.H^t).(H.P(H^t+R))^{(-1)}$$

$$X(t)=X(t)+K.(Z-ZP)$$

$$P=(I-K.H).P$$

where K is the Kalman gain, H is the measurement matrix – which is the Jacobian of the measurement model, Z is the measurement vector, ZP is the predicted measurement vector, I is the identity matrix, and R is the measurement covariance matrix

IV. Conclusion :

Accidents on road are the major problem for government of any country. Any type of accident causes loss of life or infrastructure. The main reason of accidents is sudden change in lane on fast driving roads. To solve this problem this paper proposed an algorithm based on canny edge detector and Hough transform and kalman filter. The algorithms were implemented on raspberry pi so that it can use in real time lane detection.

References :

- 1) Yasin YENİAYDIN, Klaus Werner SCHMIDT "A Lane Detection Algorithm Based on Reliable Lane Markings" Electrical and Electronics Engineering Middle East Technical University Ankara, Turkey(2018).
- 2) Y. Xu, X. Shan, B. Y. Chen, C. Chi, Z. F. Lu and Y. Q. Wang, "A lane detection method combined fuzzy control with RANSAC algorithm," 2017 7th International Conference on Power Electronics Systems and Applications - Smart Mobility, Power Transfer & Security (PESA), Hong Kong, Hong Kong, 2017,pp. 1-6.
- 3) M. Kodeeswari and P. Daniel, "Lane line detection in real time based on morphological operations for driver assistance system," 2017 4th International Conference on Signal Processing, Computing and

- Control (ISPPC), Solan, 2017, pp. 316-320.
- 4) Jieh-Shian Young "Lane Detection via Object Positioning System based on CCD Array Geometry" IEEE 2016.
 - 5) Jongin Son , Hunjae Yoo, Sanghoon Kim, Kwanghoon Sohn, "Real-time illumination invariant lane detection for lane departure warning system", Expert Systems with Applications 42 (2015) 1816–1824.
 - 6) Cho, Jae-Hyun, Young-Min Jang, and Sang-Bock Cho. "Lane recognition algorithm using the Hough transform with applied accumulator cells in multi-channel ROI." In Consumer Electronics (ISCE 2014), The 18th IEEE International Symposium on, pp. 1-3. IEEE, 2014.
 - 7) Bianca-Carasela-Zelia Blaga, Mihai-Adrian Deac, Rami Watneq Yaseen Al-Doori, Mihai Negru, Radu Danescu "Miniature Autonomous Vehicle Development on Raspberry pi" in Technical University of cluj Napoca Computer Science Department Cluj-Napoca,Romania, IEEE 2018.
 - 8) Xuqin Yan, Yanqiang Li "A Method of Lane Edge Detection based on canny algorithm" Institute of Automation Shandong Academy of science Shandong Provincial key laboratory of automotive electronic Techniques Qilu University of technology,Jinan,China IEEE 2017.

Applications Of Laplace Transform In Engineering Field

Dr. S. P. Shahare

P. R. Pote Patil College of Engineering and Management Amravati
sarikashahare83@gmail.com

- Introduction -

The Laplace transform is one of the important tool in mathematics which transform a function from one domain to another. It plays a vital role in technical approaches to studying and designing problems in engineering and science. It offers simple and efficient methods for solving many science and engineering problems, including: control system analysis; heat conduction; analyzing signal transport; mechanical networks; electrical networks; communications systems; and analog and digital filters. This chapter is aimed explicitly at undergraduates and graduates in physics, applied mathematics, electrical and electronic engineering, and computer science. Laplace transform is named in honor of the French mathematician Pierre Simon Laplace. The Laplace transform enables us to deal efficiently with the differential equations with constant coefficients which transform into algebraic expressions. It later can then simply be transformed once again, into the solution of the original problem. Using Laplace transforms, we can also design a meaningful mathematical model of the impulse force provided by a hammer blow or an explosion.



2 Definition Of Laplace Transform

Suppose that $f(t)$ is a real or complex-valued function of the (time) variable $t > 0$ and s is a real or complex parameter. We define the Laplace transform as

$$F(s) = L\{f(t)\} = \int_0^{\infty} e^{-st} f(t) dt \quad (1)$$

where the limit exists as a finite number. 's' is a fixed parameter (real/complex) when evaluating the integral (1). However, the reader should understand that, in advanced applications of Laplace transforms - basically to solve partial differential equations in digital signal processing, it is essential to consider 's' as a complex number.

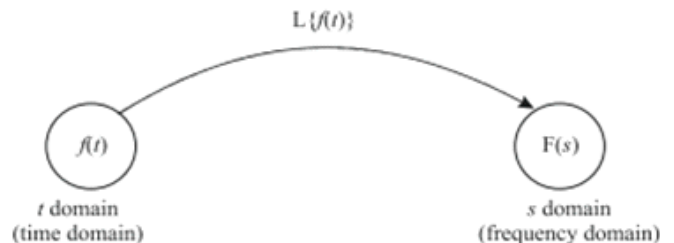


Fig: Laplace transform Operator

A Laplace transform has no physical meaning except that it transforms the time domain function to a frequency domain (s). The Laplace transform is applied to simplify mathematical computations and allow the effortless analysis of linear time-invariant systems.

3 Existence Of Laplace Transform

The Laplace transform does not exist for all functions. If it exists, it is uniquely determined. Laplace transform of $f(t)$ exist, if the given function has to be

continuous on every finite interval, piecewise continuous and of exponential order.

I) the magnitude of the transform is finite, that is, $|F(s)| < \infty$

II) $f(t)$ must be piecewise continuous.

Piecewise continuous: A function $f(t)$ is piecewise continuous on a finite interval $A \leq t \leq B$, if f is continuous on $[A, B]$, except possibly at many finite points. Each of these finite points f has a finite limit on both sides. That means $f(t)$ must be single valued but can have a finite number of finite isolated discontinuities for $t > 0$. In other words, a function is called piecewise continuous on an interval if the interval can be broken into a finite number of subintervals on which the function is continuous on each open subinterval (i.e. the subinterval without its endpoints) and has a finite limit at the end points of each subinterval.

III) $f(t)$ must be exponential order which means that, Here M is a positive constant and a is a real positive number.

4 Laplace Transform Of Some Standard Functions:

| | |
|---------------------------------------|---|
| $L\{1\} = \frac{1}{s}$ | $L\{t^n\} = \frac{n!}{s^{n+1}}, n = 1, 2, 3, \dots$ |
| $L\{e^{at}\} = \frac{1}{s-a}$ | $L\{e^{-at}\} = \frac{1}{s+a}$ |
| $L\{\sin at\} = \frac{a}{s^2 + a^2}$ | $L\{\cos at\} = \frac{s}{s^2 + a^2}$ |
| $L\{\sinh at\} = \frac{a}{s^2 - a^2}$ | $L\{\cosh at\} = \frac{s}{s^2 - a^2}$ |
| $L\{u(t)\} = \frac{1}{s}$ | $L\{u(t-a)\} = \frac{e^{-as}}{s}$ |
| $L\{\delta(t)\} = 1$ | $L\{\delta(t-a)\} = e^{-as}$ |

5 Properties of Laplace Transform

Linearity Property: If $f(t)$ and $g(t)$ are any two functions of t and a, b are any two constant then

$$L\{a f(t) + b g(t)\} = a L\{f(t)\} + b L\{g(t)\}$$

Shifting Property: If $L\{f(t)\} = F(s)$, then $L\{e^{at} f(t)\} = F(s-a)$

Multiplication by t^n Property: If $L\{f(t)\} = F(s)$, then

$$L\{t^n f(t)\} = (-1)^n \frac{d^n}{ds^n} F(s)$$

Laplace Transform of Derivative: If $L\{f(t)\} = F(s)$, then

$$L\{f'(t)\} = sF(s) - f(0)$$

$$L\{f''(t)\} = s^2 F(s) - s f(0) - f'(0)$$

$$L\{f'''(t)\} = s^3 F(s) - s^2 f(0) - s f'(0) - f''(0) \text{ and so on.}$$

6 Applications Of Laplace Transform

6.1 Applications in various engineering field

- **Analysis of electronic circuits:** Laplace Transform is widely used by electronic engineers to quickly solve differential equations while studying electronic circuits.
- **System modeling:** Laplace Transform is used to simplify calculations in system modeling in which differential equations are used.
- **Digital signal processing:** Solving Problems of digital signal processing can be solved by employing Laplace Transform.
- **Nuclear Physics:** In order to get the true form of radioactive decay a Laplace Transform is used. It makes it easy to study the analytic part of Nuclear physics possible.
- **Process Control:** One cannot imagine the use of Laplace Transform to analyze the variables in the process controls which when altered, produce the desired manipulations in result.
- **Applications In Mechanical Engineering**
Laplace Transform plays a very huge and important role in the field of Mechanical Engineering. It ranges from its application to mechanical vibratory system to the mathematical modeling of mechanical systems as well as finding transfer function of a control system.

6.2 Application in Electric Circuit Theory

The Laplace transform is used to solve the switching transient phenomenon in the series or parallel LCR, RC or RL circuits. To show this application, consider a simple example of LCR series circuit in which a direct current of voltage V is induced.

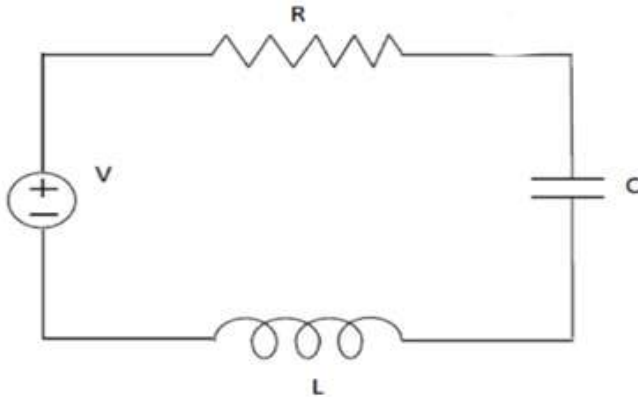


Fig: LCR Series Circuit

By applying Kirchhoff's Voltage Law (KVL) to the LCR circuit, we have,

$$L \frac{dI}{dt} + \frac{\int I dt}{C} + RI = V \quad (i)$$

On differentiating both sides with respect to t , we get

$$L \frac{d^2 I}{dt^2} + \frac{I}{C} + R \frac{dI}{dt} = 0$$

Now divide both sides by L , above equation takes the form

$$\frac{d^2 I}{dt^2} + \frac{R}{L} \frac{dI}{dt} + \frac{1}{LC} I = 0 \quad (ii)$$

Applying Laplace transform on above equation. Let its solution be

$$I(t) = m e^{nt} \quad (iii)$$

Where m and n constants (may be real, imaginary or complex), are determined from the initial conditions.

With the help of equation (iii), eqn.(ii) reduces to

$$\begin{aligned} \left(a^2 + \frac{R}{L} a + \frac{1}{CL} \right) m e^{at} &= 0 \quad (iv) \\ \Rightarrow \left(a^2 + \frac{R}{L} a + \frac{1}{CL} \right) &= 0 \\ \Rightarrow a_1 &= -\frac{R}{2L} + \sqrt{\frac{R^2}{4L^2} - \frac{1}{CL}}, \quad a_2 = -\frac{R}{2L} - \sqrt{\frac{R^2}{4L^2} - \frac{1}{CL}} \end{aligned}$$

$$\Rightarrow a_1 = -\alpha + \sqrt{\alpha^2 - \omega_n^2}, \quad a_2 = -\alpha - \sqrt{\alpha^2 - \omega_n^2}$$

Where $\alpha = \frac{R}{2L}$ is the damping coefficient, $\omega_n = \frac{1}{\sqrt{CL}}$ is an undamped natural frequency or resonant frequency.

Thus,

$$I(t) = m_1 e^{a_1 t} + m_2 e^{a_2 t} \quad (v)$$

Nature of solution depends upon value of $\sqrt{\frac{R^2}{4L^2} - \frac{1}{CL}}$, whether it is positive, negative or zero.

Hence there arises three cases as follows, which can be investigated based on the given initial conditions:

$$\sqrt{\frac{R^2}{4L^2} - \frac{1}{CL}} > 0, \quad \text{Over damped case}$$

$$\sqrt{\frac{R^2}{4L^2} - \frac{1}{CL}} = 0, \quad \text{Critically damped case}$$

$$\sqrt{\frac{R^2}{4L^2} - \frac{1}{CL}} < 0, \quad \text{Underdamped case}$$

6.3 Laplace Transform to solve Differential Equation

Example: A condenser of capacity 5×10^{-5}

Farad is charged to a resistance 200 ohm by steady voltage 2000 volts. At $t=0$, If current in the circuit and charge on the capacitor are zero at $t=0$. Then find the charge and current at any time $t>0$.

Solution: Here $V=2000$ volts,

Farad and $R=200$ ohms 5×10^{-5}

This is RC circuit. By Kirchhoff's Voltage Law,

$$R \frac{dQ}{dt} + \frac{1}{C} Q = V$$

$$\Rightarrow \frac{dQ}{dt} + \frac{1}{RC} Q = \frac{V}{R}$$

$$\frac{dQ}{dt} + \frac{1}{200 \times 5 \times 10^{-5}} Q = \frac{2000}{200}$$

$$\Rightarrow \frac{dQ}{dt} + 100Q = 10$$

Now taking Laplace transform on both sides, gives

$$\begin{aligned} s Q(s) - Q(0) + 100 Q(s) &= \frac{10}{s} \\ \Rightarrow (s + 100) Q(s) &= \frac{10}{s} \\ \Rightarrow Q(s) &= \frac{10}{s(s + 100)} \end{aligned}$$

By applying partial fraction,

$$\Rightarrow Q(s) = \frac{0.1}{s} + \frac{0.1}{(s + 100)}$$

Finally, take inverse Laplace transform on both sides,

$$\Rightarrow Q(s) = 0.1[1 - e^{-100t}]$$

Hence

$$I = \frac{dQ}{dt} = 10 e^{-100t}$$

This is required expression for charge and current at any time

Limitations: Laplace transform is used to solve differential equations with known constant coefficients. Method fails for differential equations with unknown constant coefficients.

References :

- 1) B. V. Ramanna, Higher Engineering Mathematics, Tata McGraw Hill Publication.
- 2) M. N. S. Charles K. Alexander, Fundamentals of Electric Circuits (McGraw Hill, 2006), 2nd ed.
- 3) H.K.Dass and Er. Rajnish Verma, Higher Engineering Mathematics, S. Chand Publication, New Delhi.
- 4) A. D. Poularikas, The Transforms and Applications Handbook (McGraw Hill, 2000), 2nd ed.
- 5) Sarina Adhikari, Laplace Transform and its applications, University of Tennessee. (Department of Electrical Engineering).

“Study of DC Electrical Conductivity of The Polypyrrole”

Authors

Thakare N. R. | Daware A.S.

- Abstract -

The Present research contains that the electrical properties of the Poly-pyrrole examined. The pallets of the poly-pyrrole prepared. The two pallets of poly-pyrrole synthesised for pure (PPy-0) and zinc oxide doped (PPy-ZnO). The direct current electrical conductivity measured at various applied voltages which are in the increasing pattern i.e 5V, 50V, 100V, 200V with the different constant temperatures which are in the range of 313K- 353K).

Keywords : PolyPyrrole, DC electrical conductivity.

- Introduction -

The availability and compatibility of the material, cost effectiveness and easy methods for its preparation makes the material very practically applicable. The particular materials chosen in the field of research to accomplished the objective of the research. In the study of the conducting polymers, the response to applied electrical and temperatures parameters is observed. The Conducting polymers used in portable battery [1], in the application of the sensors[2].

The Pyrrole when subjected to the process of the polymerisation[3] the Polypyrrole gets prepared. The polypyrrole is capable of implemented in the various application but in this research the direct current electrical properties of samples of the pure polypyrrole pallet and polypyrrole blend with the zinc oxide studied. The conducting polymers, conducting properties altered with the help of the blending of the suitable materials

2. Experimental Procedure:

Sample Preparation:

The amorphous fine powder of the polypyrrole i.e pure polypyrrole and polypyrrole doping [4] with 15% zinc oxide, were used to prepare pallets with the help of the hydraulic press with the use of 5 tonnes of the pressure. The conducting electrodes of silver painted on the sufficient large surface of the pallet which implemented as the electrodes. The two probe method implemented for measurement of the electrical conductivity [5]. The PPy-0 and PPy-1 samples electrical conductivity measured in the temperature range of the 313K–353K.

Results And Discussion:

The electrical conductivity response of the polypyrrole pure and polypyrrole zinc oxide blending examined in the the variation of the voltage along with the constant temperature. The findings of electrical response to both samples were represented as follows,

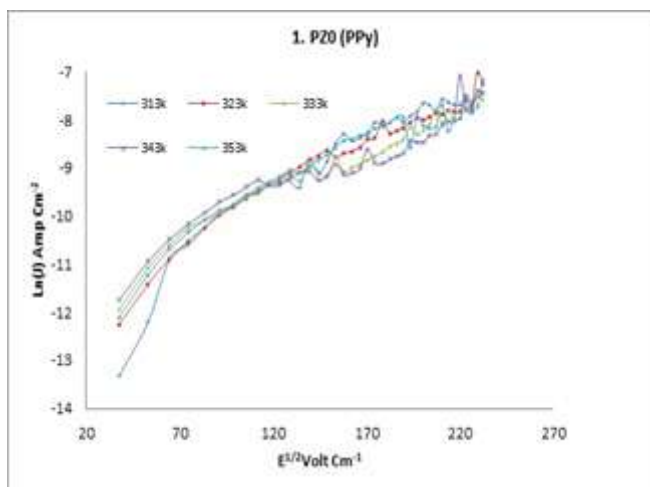


FIGURE-1: Polypyrrole Pure (PPy-O)

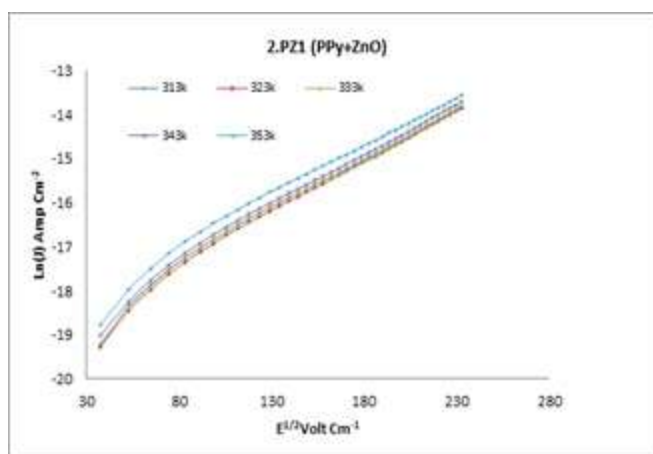


FIGURE-2: Polypyrrole- ZnO blend (PPy-Zn)

Conclusion:

The response to the increasing voltage, current also increases at particular constant temperature. These signifies that ohm's law is obeyed. The nature of the graph reveals that electrical conductivity in the polypyrrole-zno blend is significant higher than pure sample. The both samples shows very well stability in each temperature within range.

5. References :

1) B.N. Grgur, M.M. Gvozdenović, J. Stevanović, B.Z.

Jugović, V.M. Marinović, Polypyrrole as possible electrode materials for the aqueous-based rechargeable zinc batteries, *Electrochimica Acta* 53 (14) (2008) 4627-4632.

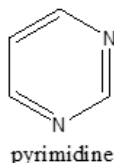
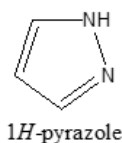
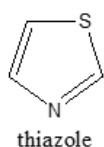
- 2) T. Zhang, Y. He, R. Wang, W.C. Geng, L.J. Wang, L.G. Niu, et al., Analysis of DC and AC properties of humidity sensor based on polypyrrole materials, *Sensors and Actuators B: Chemical* 131 (2) (2008) 687-691.
- 3) Abdirahman Yussuf et al Mohammad Al-Saah, Salah Al-Enezi and Gils Abraham, "Synthesis and Characterization of Conductive Polypyrrole: The Influence of the Oxidants and Monomer on the Electrical, Thermal, and Morphological Properties", *International Journal of Polymer Science*, Volume 2018, Article ID 4191747, 8 pages.
- 4) D. Bormann, J.L. Sauvajol, M. Armand, R. Aznar, P. Bernier, A new type of p-doping for polyacetylene, *Synthetic Metals* 69 (1995) 2122.
- 5) V.S. Shanthala et al S.N. Shobha Devi and M.V. Murugendrappa, "Synthesis, characterisation and DC conductivity and studies polypyrrole/copper zinc iron oxide nanocomposites", *Journal of Asian Ceramic Societies*, Volume 5, Issue 3, September 2017, Pages 227-234.

Synthesis And Charecterization of 2,4 - (substitutedphenyl) pyrimidin-5-ol Derivatives

Author

G. P. Deshpande

Heterocyclic compounds are the cyclic compounds which contain one or more different atoms other than carbon in a ring structure. These compounds are sometimes aromatic or anti-aromatic. Heterocyclic compounds are useful in our daily life. They have higher significance in our living system and also having a wide range of applications in agrochemicals, pharmaceuticals, veterinary products etc. The most commonly occurring heterocyclic compounds are pyridine, pyrrole, furan, thiophene, pyrimidine, purine, thiazole, pyrazole and so on. In all these compounds pyrimidine, pyrazole and thiazole are potent heterocycles widely found in nature.



The genetic material DNA is composed of heterocyclic bases pyrimidine and purines. Pyrimidine is a simple hexacyclic aromatic ring composed of two nitrogen atoms in 1 and 3 positions. Pyrimidine derivatives are mostly present in nucleic acids, vitamins, amino acids, antibiotics, alkaloids, and a variety of toxins. Synthesis of pyrimidine derivatives have been largely studied by various researchers with their own methodology as mentioned in literature. Numerous modes of pyrimidine synthesis have been reported starting from thiobarbituric acid¹ (TBA), chalcones² and thioureas³, one-pot three component condensation of benzaldehyde derivatives, methylcyanoacetate and thiobarbituric acid in water as a green solvent synthesized methyl-7 amino-4-oxo-5-phenyl-2-thioxo-2,3,4,5-tetrahydro-1H-pyrano[2,3-d]pyrimidine-6-

carboxylates⁴. Ethyl-2-(4-carboxyphenylazo) acetoacetate on condensation with various aromatic aldehydes in ethanolic NaOH solution yielded the corresponding chalcones. These chalcones were further reacted with urea in the presence of base in ethanol, which led to the formation of pyrimidine derivatives⁵. E. Gayon and et al⁶ synthesized pyrimidine by using amide along with β -enaminones. In the present work researcher attempted to synthesize biologically potent pyrimidine derivatives by condensation of amide, amino acid and aldehyde under microwave irradiation.

Microwave assisted synthesis technique reduced the cost of synthesized compound which will be more beneficial for the society, as it is responsible for the production of compound in bulk with less energy, more yield, less time⁷⁻¹². So this pollution free, ecofriendly method of synthesis is commonly used for synthesis of pyrimidine derivatives. This section reports the synthesis of 2,4-(Substitutedphenyl)pyrimidin-5-ol derivatives from aromatic amide, glycine and aromatic aldehyde under microwave irradiation, to get 2,4-(Substitutedphenyl)pyrimidin-5-ol derivatives (I_a-I_i)

All the compounds have been characterized on the basis of chemical properties, elemental and spectral analysis. The melting points were measured in an open glass capillary and are uncorrected. IR spectra in KBr was recorded on instrument model spectrum one, serial No. 68515, ¹H and ¹³C NMR spectra was recorded on Bruker Avance II 400 NMR(DMSO and CDCl₃ solvent) spectrophotometer using TMS as internal standard. All reactions were monitored by TLC using silica gel 60-f 254 plates. The reactions were carried out in scientific microwave oven (scientific microwave system model-RG31L1, 700w, 2450MHz). Satisfactory C, H, N, S, analyses were carried out for most of compound on

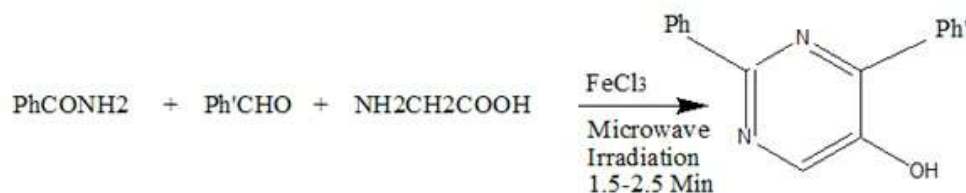
Thermo Finnigan CHN analyser at SAIF, Punjab University, Chandigarh.

General procedure for synthesis of 2,4-(substitutedphenyl) pyrimidin-5-ol derivatives

EXPERIMENT NO.-1-10

A mixture of substituted amide (0.01M), aldehyde (0.015M), and amino acid (0.01M) in presence of ferric

chloride (FeCl_3) catalyst was irradiated in microwave oven on medium power for appropriate time. After completion, the reaction mixture was cooled to room temperature and poured over crushed ice, filtered out and crystallized in ethanol as a crystalline solid with maximum yield and appropriate melting point.



| Compound | Ph | Ph' | M.P.(°C) |
|----------------------|---------------------------------|---|----------|
| <u>I_a</u> | C ₆ H ₅ | C ₆ H ₄ Br | 250 |
| <u>I_b</u> | C ₆ H ₅ | C ₆ H ₄ NO ₂ | 211 |
| <u>I_c</u> | C ₆ H ₅ | C ₆ H ₅ | 225 |
| <u>I_d</u> | C ₆ H ₅ | C ₆ H ₄ Cl | 190 |
| <u>I_e</u> | C ₆ H ₅ | C ₆ H ₃ Cl ₂ | 230 |
| <u>I_f</u> | C ₅ H ₄ N | C ₆ H ₄ Cl | 255 |
| <u>I_g</u> | C ₅ H ₄ N | C ₆ H ₄ NO ₂ | 221 |
| <u>I_h</u> | C ₅ H ₄ N | C ₆ H ₃ Cl ₂ | 185 |
| <u>I_i</u> | C ₅ H ₄ N | C ₆ H ₅ O | 295 |
| <u>I_j</u> | C ₅ H ₄ N | C ₇ H ₇ O | 305 |

Experiment No. 1:

Synthesis of 4-(4-bromophenyl)-2-phenylpyrimidin-5-ol (I_a)

A mixture of benzamide (0.01M), 4-bromobenzaldehyde(0.015M), and glycine(0.01M) was irradiated in presence of FeCl_3 as a catalyst in microwave oven on medium power for 1 minutes with intermittent cooling. After completion, reaction mixture was cooled

to room temperature and poured over crushed ice, filtered out and crystalized in ethanol as a pale yellowcrystalline solid with 76% yield.

Properties and constitution of compound(I_a)

- The compound (I_a) is a pale yellow crystalline solid.
- Melting point of compound (I_a) is 250°C.
- TLC showed single spot R_f 0.6 in ethanol and ether (1: 3) as eluent.

Elemental analysis :-

| Analytical Data | % Carbon | % Hydrogen | %Nitrogen |
|-----------------|----------|------------|-----------|
| Observed | 55.67 | 3.18 | 7.81 |
| Calculated | 57.71 | 3.36 | 8.56 |

Elemental analysis revealed the molecular formula of compound as $C_{16}N_2OBrH_{11}$.

Spectral analysis of the compound (Ia) is described as under.

- A) **IR(KBr) (ν_{\max} in cm^{-1}):** IR spectrum of compound (I_a) recorded in KBr and showed the following absorption bands spectrum.

| Frequency (cm^{-1}) | Intensity | Correlaion |
|--------------------------------|-----------|---|
| 3285 | m | O-H hydrogen bonded Str. |
| 3087 | m | Aromatic C-H Str. |
| 2966 | s | Aliphatic C-H Str. |
| 1966 | m | Disubstituted aromatic stretching |
| 1545-1652 | s | C=O(keto) and C=C overlap band Str. |
| 1484 | s | CH ₂ assymetric bending |
| 1350 | s | Aromatic C-N Str |
| 1048 | s | C-O Str. |
| 799 | s | P- substituted aromatic ring bending |
| 717-696 | s | Mono substituted aromatic bending vibration |
| 567 | s | C-Br bending |

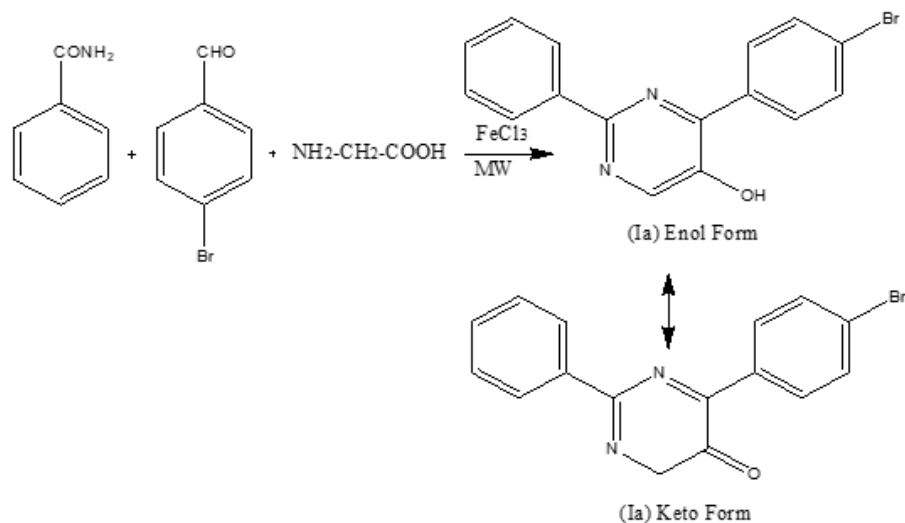
- B) **^1H NMR(δ value in PPM)** The PMR spectrum of compound (I_a) recorded in DMSO- d_6 with TMS as an internal standard and are reproduced on Spectrum. The observed chemical shift and their correlation are as follows.

| Peak observed in δ PPM | Multiplicity | Assignment |
|-------------------------------|--------------------------|-------------------------------|
| 2.1 | s | 2H (CH ₂ -CO) keto |
| 7.9 | d($J^3=7.28\text{Hz}$) | 2H (Ar-H) |
| 7.5 | d($J^3=7.28\text{Hz}$) | 2H (Ar-H) |
| 7-7.5 | m | 5H (Ar-H) |
| 8.9 | s | 1H (-CH=C-OH) enol form |

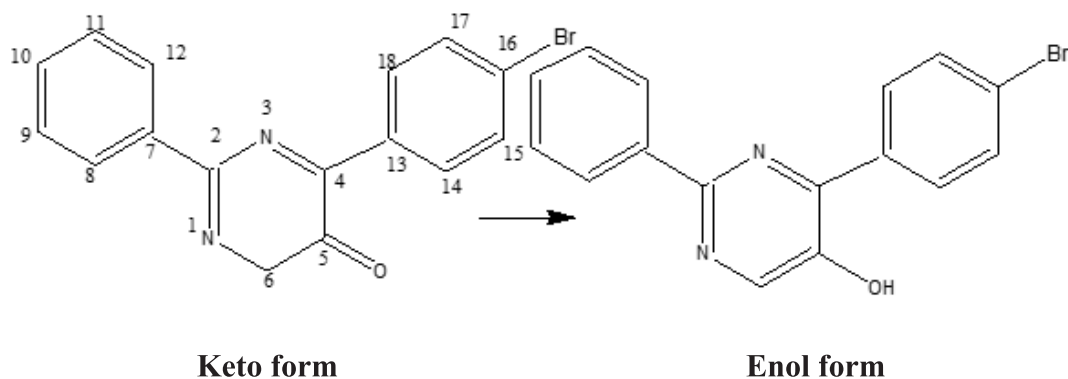
B) C^{13} NMR (δ value in PPM) The CMR spectrum of compound (I_p) recorded in DMSO- d^6 with TMS as an internal standard and are reproduced on Spectrum. The observed chemical shift and their correlation are as below.

| C^{13} Nuclei | Chemical shift in δ PPM |
|---|--------------------------------|
| C_2 | 131.3 |
| C_4 | 133.7 |
| C_6 | 58.5 |
| C_5 (Enol) | 165.33 |
| C_5 (Keto) | 200.10 |
| C_7 | 127.3 |
| $\text{C}_{10}, \text{C}_{16}$ | 126.3 |
| C_{13} | 140.3 |
| $\text{C}_8, \text{C}_{12}, \text{C}_{14}, \text{C}_{18}$ | 127.4 |
| $\text{C}_7, \text{C}_{11}, \text{C}_{15}, \text{C}_{17}$ | 128.1 |

• **Reaction:**



- From the chemical, elemental and spectral data of compound I_a , revealed the structure of 4-(4-bromophenyl)-2-phenylpyrimidin-5-ol as



Plausible Mechanism :

In this work a novel route of synthesis of pyrimidine has been attempted by researcher using benzamide, aldehyde and glycine in presence of FeCl_3 as catalyst under microwave irradiation.

Fe(III)Cl_3 is extensively used in organic synthesis as an ideal Lewis acid catalyst. Since, it is inexpensive, efficient, stable, environmental friendly and convenient reagent for several useful reactions such as polymerization, oxidation oxidative coupling, reduction and one pot multicomponent condensation etc. Lewis acidity of the catalyst probably has an important role in promotion of cyclisation process. The role of FeCl_3 is

limited to activation of -OH or -OEt group and breaking of CO bond.

Amino acid has both acidic -COOH and :NH_2 basic groups leading to internal transfer of proton to give amphoteric ion called as zwitter ion, It exist in solid state as well as in solution.



Zwitter ion is a compound with no overall electrical charge but contains separate parts which are positively and negatively charged, when an amino acid dissolve in water the zwitter ion interact with water molecule and act as both weak acid and weak base.

As an acid :

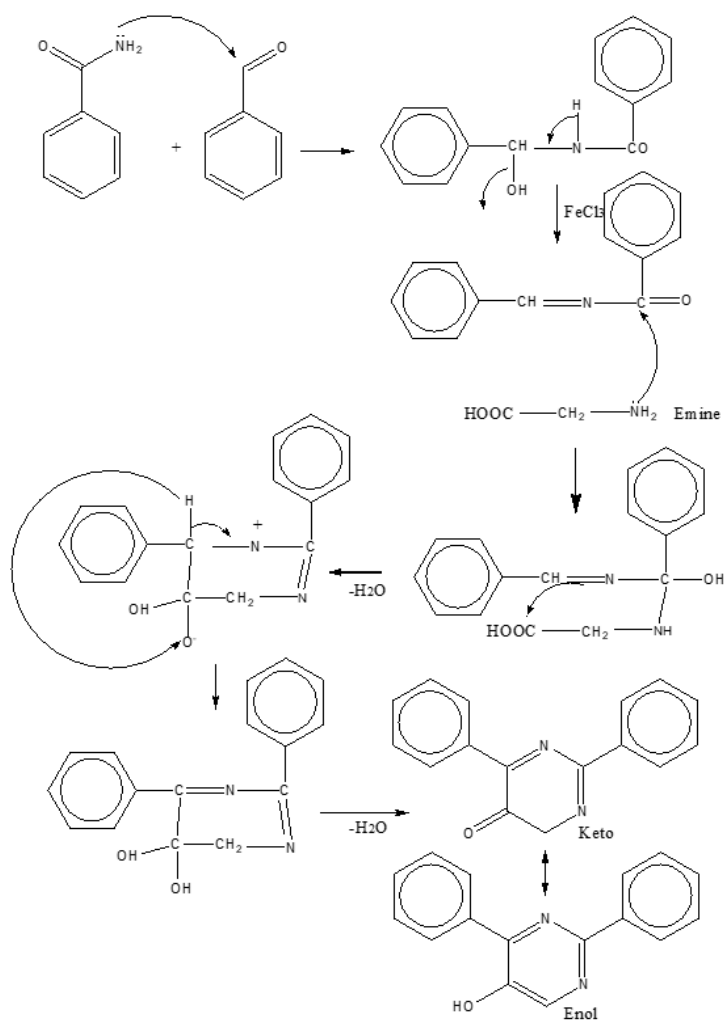


As a base :



This tendency facilitates the cyclodehydration process in the reaction. The addition of amino acid to a carboxyl group involves nucleophilic attack by the nitrogen of amino acid to electron deficient carbonyl carbon.

In first step the nucleophilic addition of amide nitrogen to carbonyl carbon of aryl aldehyde in presence of FeCl_3 leading to the formation of intermediate imine followed by interaction with glycine zwitter ion where nucleophilic nitrogen interact with carbon of imine and formation of transition state. It leads to intermolecular cyclodehydration with the loss of water molecule resulting the formation of product I Reaction –



Experiment No. 2

Synthesis of 2,4-diphenylpyrimidin-5-ol(I_c)

A mixture of benzamide(0.01M), benzaldehyde(0.015M), and glycine (0.01M) was irradiated in presence of FeCl₃ as catalyst in microwave oven on medium power for 1.5 minutes. After completion, the reaction mixture was cooled to room temperature and poured over crushed ice, filtered out and crystalized in ethanol as a solid with 85.7% yield.

Properties and constitution of compound (I_c)

- Compound I_c is a dirty white crystalline solid.
- Melting point of compound (I_c) is 225°C.
- TLC showed single spot R_f 0.9 in ethanol and ether (1: 3) as eluent.

• Elemental analysis:-

| Analytical Data | % Carbon | % Hydrogen | % Nitrogen |
|-----------------|----------|------------|------------|
| Observed | 71.69 | 5.18 | 7.81 |
| Calculated | 77.41 | 4.83 | 11.29 |

- Elemental analysis is indicating the molecular formula of compound as C₁₆N₂OH₁₂
- Spectral analysis of compound (I_c) are as follows.
A) **IR (KBr) (ν_{max} value in cm⁻¹):** IR spectrum of compound (I_c) recorded in KBr and showed the following absorption bands on Spectrum.

| Frequency (cm ⁻¹) | Intensity | Correlation |
|-------------------------------|-----------|--------------------------------|
| 3264 | m | O-H hydrogen bonded Str. |
| 3083 | m | Aromatic C-H Str. |
| 2968 | m | Aliphatic C-H Str. |
| 1813-1963 | m | Mono substituted aromatic str. |

| Frequency (cm ⁻¹) | Intensity | Correlation |
|-------------------------------|-----------|---|
| 1649 | s | C=C and C=O overlap str. |
| 1485 | s | Asymmetric CH ₂ bending |
| 1275-1345 | s | Aromatic C-N Str. |
| 1056-1141 | s | C-O str. |
| 677-720 | s | Mono substituted aromatic bending Vibration |

- A) **¹H NMR (δ value in PPM) :-** The PMR spectrum of compound (I_c) recorded in DMSO-d⁶ with TMS as an internal standard and are reproduced on Spectrum. The observed chemical shifts and their correlation are as follows.

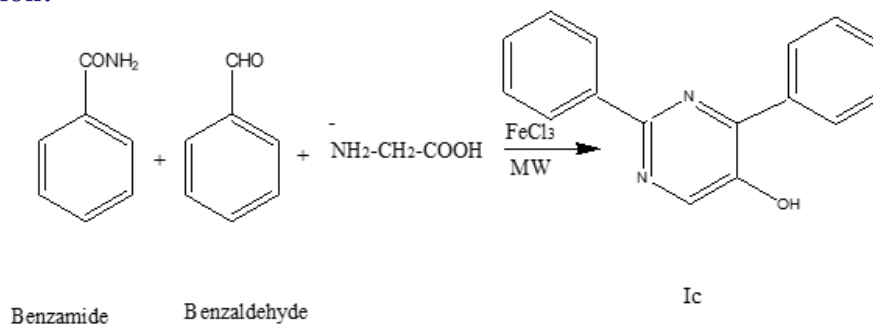
| Peak observed in δ PPM | Multiplicity | Assignment |
|------------------------|--------------|--------------------|
| 7.02-7.92 | m | 12 Aromatic proton |
| 9.02 | s | -CH=COH |

- B) **¹³C NMR (δ value in PPM):-** The CMR spectrum of compound (I_c) recorded in DMSO-d⁶ with TMS as an internal standard and are reproduced on Spectrum. The observed chemical shift and their correlation are as below.

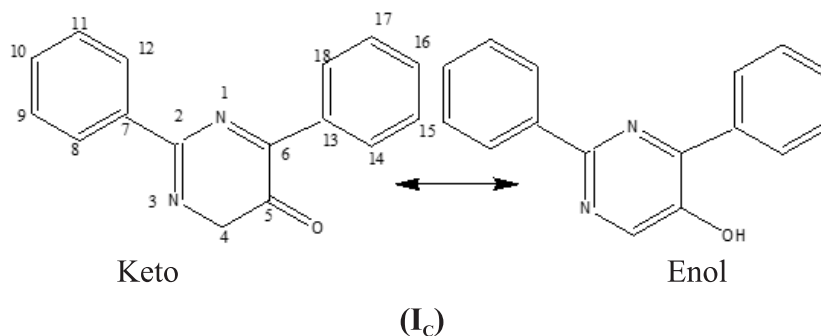
| C ¹³ Nuclei | Chemical Shift in δ PPM |
|------------------------|----------------------------|
| C ₂ | 165.59 |
| C ₄ | 139.68 |
| C ₅ | 190.90(C=O), 168.05 (C-OH) |
| C ₆ | 58.29 |

| C ¹³ Nuclei | Chemical Shift in δ PPM |
|--|-------------------------|
| C ₇ | 131.39 |
| C ₁₃ | 133.64 |
| C ₈ , C ₁₂ | 130.94 |
| C ₁₄ , C ₁₈ | 128.57 |
| C ₉ , C ₁₁ , C ₁₅ , C ₁₇ | 128.09 |
| C ₁₀ | 137.38 |
| C ₁₆ | 137.91 |

• **Reaction:**



- From the chemical, elemental and spectral data of compound I_c, revealed the structure of 2,4-diphenylpyrimidin-5-ol as



Experiment No. 3

Synthesis of 4-(2-chlorophenyl)-2-(pyridin-3-yl)pyrimidin-5-ol(I_f)

A mixture of nicotinamide(0.01M), 2-chlorobenzaldehyde(0.015M), and glycine (0.01M) was irradiated in presence of FeCl₃ as catalyst in microwave oven on medium power for 1 minutes. After completion, the reaction mixture was cooled to room temperature and poured over crushed ice, filtered out and crystallized in ethanol as a solid with 85.7% yield.

Properties and constitution of compound (I_f)

- Compound I_f is white crystalline solid.
- Melting point of compound (I_f) is 255°C.
- TLC showed single spot R_f=0.72 in ethanol and ether (1:3) as eluent.

• Elemental analysis:-

| Analytical Data | % Carbon | % Hydrogen | % Nitrogen |
|-----------------|----------|------------|------------|
| Observed | 61.06 | 4.07 | 14.97 |
| Calculated | 63.49 | 3.52 | 14.81 |

- Elemental analysis revealed the molecular formula of compound as C₁₅N₃OClH₁₀.
- Spectral analysis of the compound (I_f) is as given below.

A) **IR (KBr) (ν_{max} value in cm⁻¹):** IR spectrum of compound (I_f) recorded in KBr and showed the following absorption bands on Spectrum.

| Frequency (cm ⁻¹) | Intensity | Correlaion |
|-------------------------------|-----------|--|
| 3423,3272 | sh,b | O-H free,H-bonded Str. |
| 3175 | m | Aromatic C-H Str. |
| 2999 | m | Aliphatic C-H Str. |
| 1623 | s | C=C and C=O overlap str. |
| 1328 | m | C-N str. |
| 1261 | s | C-O str. |
| 693-748 | s | Monosubstituted aromatic bending Vibration |

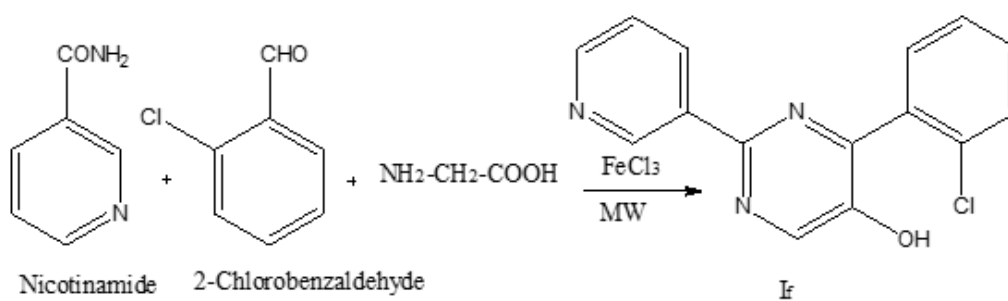
- b) **¹H NMR (δ value in PPM)** :- The PMR spectrum of compound (I_r) recorded in DMSO-d⁶ with TMS as an internal standard and are reproduced on Spectrum No. 8. The observed chemical shift and their correlation are as follows.

| Peak observed in δ PPM | Multiplicity | Assignment |
|------------------------|---------------------------|------------|
| 8.2 | d(J ³ =7.32Hz) | 1Ar-H |
| 8.7 | s(J ⁴ =2.8) | 1Ar-H |
| 9 | s | 1Ar-H |
| 9.3 | d(J ³ =6.24Hz) | 1Ar-H |
| 7.2-7.7 | m | 4Ar-H |

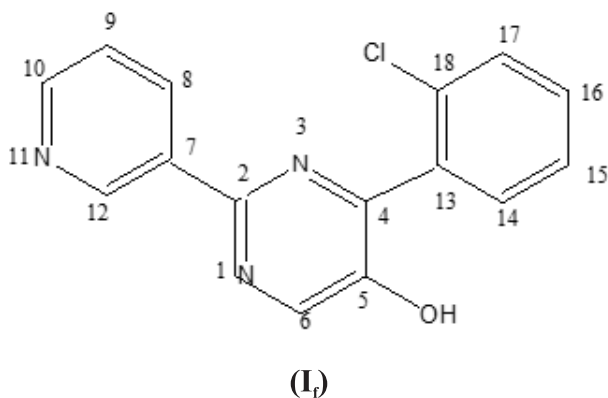
- C) **¹³C NMR (δ value in PPM)**:- The CMR spectrum of compound (I_r) recorded in DMSO-d⁶ with TMS as an internal standard and are reproduced on Spectrum No. 9. The observed chemical shift and their correlation are as below.

| C ¹³ Nuclei | Chemical Shift in δ PPM |
|-----------------------------------|--------------------------|
| C ₂ | 148.7 |
| C ₆ | 57.20 |
| C ₅ | 164.4(C-OH), 200.01(C=O) |
| C ₄ | 151.96 |
| C ₉ | 136.70 |
| C ₁₁ | 135.37 |
| C ₆ | 132.65 |
| C ₇ | 129.57 |
| C ₁₃ | 129.39 |
| C ₁₄ | 129.30 |
| C ₁₅ , C ₁₇ | 128.31 |
| C ₁₆ , C ₁₈ | 126.96 |
| C ₈ , C ₁₂ | 123.21 |

• **Reaction:**



- Chemical, elemental and spectral data of compound I_r , revealed the structure of 4-(2-chlorophenyl)-2-(pyridin-3-yl)pyrimidin-5-ol as.



Similarly, analogous compounds have been synthesized by treating with different aromatic aldehyde, aromatic amide and glycine and details are given in table 1.1

Table:-1.1 Synthesis of 2,4-(Substitutedphenyl)pyrimidin-5-ol derivatives (I_a-I_j)

| Expt. No. | COMPOUND | % YIELD | M.P. (°C) | MOLECULAR FORMULA |
|----------------------|---|--------------------|------------------|---|
| 1 | 4-(4-bromophenyl)-2-phenylpyrimidin-5-ol (I _a) | 76.21 | 250 | C ₁₂ N ₂ OBrH ₁₁ |
| 2 | 4-(4-nitrophenyl)-2-phenylpyrimidin-5-ol (I _b) | 58.02 | 211 | C ₁₆ N ₃ O ₃ H ₁₁ |
| 3 | 2,4-diphenylpyrimidin-5-ol (I _c) | 76.61 | 225 | C ₁₆ N ₂ OH ₁₂ |
| 4 | 4-(4-chlorophenyl)-2-phenylpyrimidin-5-ol (I _d) | 82.14 | 190 | C ₁₆ N ₂ OClH ₁₁ |
| 5 | 4-(2,4-dichlorophenyl)-2-phenylpyrimidin-5-ol (I _e) | 85.17 | 230 | C ₁₆ N ₂ OCl ₂ H ₁₀ |
| 6 | 4-(2-chlorophenyl)-2-(pyridin-3-yl)pyrimidin-5-ol (I _f) | 85.71 | 255 | C ₁₅ N ₃ OClH ₁₀ |
| 7 | 4-(4-nitrophenyl)-2-(pyridin-3-yl)pyrimidin-5-ol (I _g) | 74.82 | 221 | C ₁₅ N ₄ O ₃ H ₁₀ |
| 8 | 4-(2,4-dichlorophenyl)-2-(pyridin-3-yl)pyrimidin-5-ol (I _h) | 84.90 | 185 | C ₁₅ N ₃ OCl ₂ H ₉ |
| 9 | 4-(2-hydroxyphenyl)-2-(pyridin-3-yl)pyrimidin-5-ol (I _i) | 71.69 | 295 | C ₁₅ N ₃ O ₂ H ₁₁ |
| 10 | 4-(4-methoxyphenyl)-2-(pyridin-3-yl)pyrimidin-5-ol (I _j) | 72.41 | 305 | C ₁₆ N ₃ O ₂ H ₁₃ |

Conclusion :

The compound 2,4-(substitutedphenyl) pyrimidin-5-ol of high medicinal value have been synthesized with green protocol under microwave in maximum yield. The spectral data analysis supports the structure of synthesized compounds. The spectral data indicate the keto and enol form of synthesized compound have been form but more prominently enol form is observed.

References :

1. V. K. Ahluwalia, H. R. Sharma, R.Tyagi, Tetrahedron, 42(14), 4045, 1986.
2. F. G.Weber, U. Pusch, B. Brauer, Pharmazie1979, 34(7), 443, Chem. Abstr., 92, 41877, 1980.
3. M. Kidwai, S Saxena, R. Mohan, R. Venkataramanan, J. Chem.Soc. Perkin Trans. I, 2002, 1845.
4. A. R. Bhat, A. H. Shalla, R.S. Dongre, Journal of Advanced Research, 6, 941–948, 2015.
5. A. R.Trivedi, D. K. Dodiya, N. R. Ravat, V. H. Shah, ARKIVOC, 131-141, 2008.
6. E. Gayon, M. Szymczyk, H. Gérard, E. Vrancken, J.-M. Campagne, J. Org. Chem., 77, 9205-9220, 2012.
7. J. Quiroga, P. Hernandez, B. Insuasty, R. Abonia, J. Cobo, A. Sanchez, M. Nogueras, J.N. Low, J. ChemSoc Perkin Trans1, 4, 555-559, 2002.
8. K. Mahajan, N. Fahmi, R.V. Singh, Indian J. Chem., 46A, 1221-1226, 2007.
9. K. Mahajan, M. Swami, R.V. Singh, Russ J. Co-ord Chem., 35, 179-185, 2009.
10. K. Mohanan, S. Kumari, G. Rijulal, J. Rare Earth, 26, 16-21, 2008.
11. R. Garg, M.K. Saini, N. Fahmi, R.V. Singh, Trans. Met. Chem., 31, 362-369, 2006.
12. K. Sharma, R. Singh, N. Fahmi, R.V. Singh, Spectrochim. ActaA mol. Biomol. Spectrosc., 75A, 422-429, 2010.

“HRM Practices and Innovation- An Empirical Systematic Review”

Ms. Florence Thomas | Mr. Vishal A Ingole

- Abstract -

The relationship between human resource management practices (HRMP) and innovation has been described as a black box, where a lot still needs to be investigated. Thus, the aim of this paper is to investigate the nature of the link that exists between HRMP and innovation in both public and private organizations. To do so, theoretical underpinnings and existence of a mediating or a moderating mechanism is inspected. Based on an empirical systematic review of research conducted between 2010 and 2018, content analysis has been conducted for 31 peer-reviewed articles in the English language. Inspecting the nature of relations existed in the chosen articles, interesting findings are addressed relative to the nature of the human resource management systems (HRMS) used, practices encompassed and their different utility. HRMS has been shown to be associated with product innovation yet more evidence is needed for supporting process innovation. The HRMS/HRMP and innovation relationship is inspected, important practices that would guide managers to induce innovation are highlighted. Usage of multiple HRMS and contingency in constructing such systems is indicated. Contribution to comprehend the black box and areas for future research has been offered.

Keywords: Innovation, Systematic review, HRM practices, HRM systems

- Introduction -

Human resource management practices (HRMP) have been gaining an increased attention especially in the fields of economics of the organization, strategic management and human resource management (HRM) (). Moreover, the past two decades were characterized by noticeable progress in researching

human resource management systems (HRMS) (). HRMS and innovation relationship in firms is growing as many researchers inspected this area (Vogus and Willbourne, 2003; ; ; ;).

This growing interest is because of the continuous search for having a competitive advantage in a highly turbulent environment (;).

This study seeks to contribute for the comprehension of the HRM and innovation relationship. It has been identified as a black box by several researchers including (; ; Messersmith and Guthrie, 2011). Thus, this study tries to inspect the way by which HRM and innovation are linked. Moreover, if there is a need for a mediating or moderating mechanism to understand such a relation.

Methodology of the review

The 31 studies analyzed were published from January 2003 to December 2018 in 18 Journals (). The list is mainly based on high ranking journals with a proven history and impact in the HRM research. The database used includes the following: Academy of Management, Sage Journals, Wiley online library, Taylor and Francis online, science direct, Oxford Academic and Emerald insight.

Data Collection Method :

The database on HRMP and innovation in firms was built through specific inclusion criteria. resembles the selection process adopted; as a start, the AJG Academic journal guide for journal ranking was examined to select, which journals to include in the study. Second, the main concentration was on HRM and employment journals. Moreover, the secondary and supportive source of data were, namely, general management, organization studies, innovation, psychology, economics, international business and

hospitality. Third, titles, abstracts and keywords are inspected within the selected journals using the following key terms: “HRMP;” innovation and firm. Studies identified counted 3,118, however, those that were not listed in AJG (2018) academic guide for journal ranking was dropped. Moreover, books, reviews, case

studies, introductions, editorials, proceedings and abstracts were also excluded; only empirical articles were taken into consideration. Studies that had zero citations, except those published in 2018 was dropped. Next, all articles published before 2010 and included in

| Journal title | Article count | (%) | Journal ranking grade (AJG,2018) |
|---|---------------|-----|----------------------------------|
| Human Resource Management Journals | | | |
| <i>Human Resource Management</i> | 6 | 20 | Grade 4 |
| <i>Human Resource Management Journal</i> | 2 | 6 | Grade 4 |
| <i>The International Journal of Human Resource Management</i> | 6 | 20 | Grade 3 |
| <i>International Journal of Manpower</i> | 2 | 9 | Grade 2 |
| <i>Employee Relations</i> | 1 | 3 | Grade 2 |
| <i>Personnel Review</i> | 1 | 3 | Grade 2 |
| General Management/Organization Studies/Innovation Journals | | | |
| <i>Academy of Management Journal</i> | 1 | 3 | Grade 4* |
| <i>Journal of Management</i> | 2 | 6 | Grade 4* |
| <i>Journal of Management Studies</i> | 1 | 3 | Grade 4 |
| <i>Journal of Business Research</i> | 1 | 3 | Grade 3 |
| <i>Organization Studies</i> | 1 | 3 | Grade 4 |
| <i>Human Relations</i> | 1 | 3 | Grade 4 |
| <i>Journal of product Innovation Management</i> | 1 | 3 | Grade 4 |
| <i>Creativity and Innovation Management</i> | 1 | 3 | Grade 2 |
| Psychology/Economics/ International Business/Hospitality | | | |
| <i>Journal of Organizational Behavior</i> | 1 | 3 | Grade 4 |
| <i>Cambridge Journal of Economics</i> | 1 | 3 | Grade 3 |
| <i>International Business Review</i> | 1 | 3 | Grade 3 |
| <i>International Journal of Hospitality Management</i> | 1 | 3 | Grade 3 |
| Total | 31 | | |

However, studies that used companies and firms interchangeably were adopted, which gave us an addition of 2 articles, leaving us with 31 articles. Human resource management practices and innovation in firm research

The HRMP and innovation relationship in firms is tested in a variety of contexts in this systematic review. This review declares that HRMP and innovation in firms are being empirically explored and has an international appeal as different countries are encompassed.

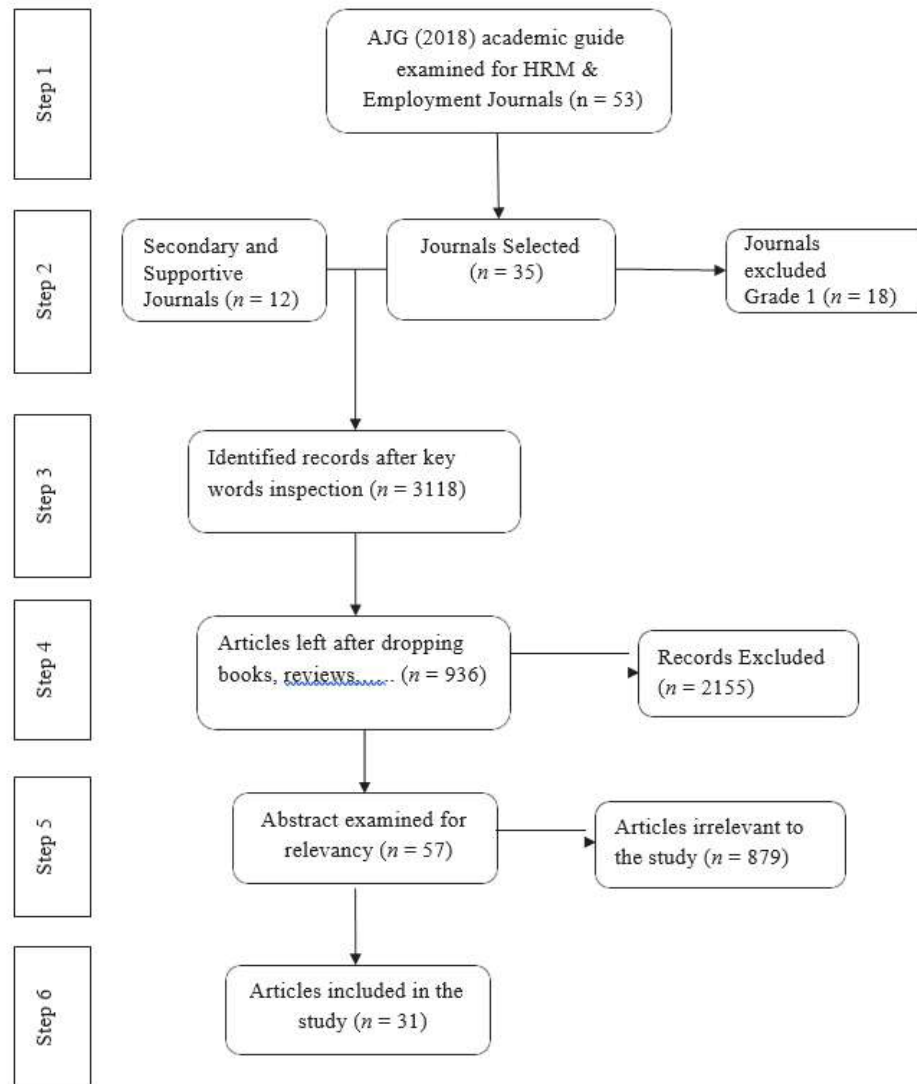
Distribution of studies

Thus, the current study took the year 2003 as a starting point to inspect the previously mentioned relationship. The variance of interest in such a

relationship is quite noticed since 2010 (). The years 2010-2018 accounts for the most empirical output in the field of study ($n = 22$). Moreover, the main journals in the study are the following: *Human Resource Management* (6 articles), *The International Journal of Human Resource Management* (6 articles), *International Journal of Manpower* (2 articles), *Human Resource Management Journal* (2 articles) and *Journal of Management* (2 articles). Two third of the articles were published in human resource management journals ($n = 20$).

Furthermore, the quality of the journals used was distributed accordingly.

Figure 1. Chart of articles selection method



Methodology

To analyze the methodology characteristics three aspects have been examined, namely, the industry, the unit of analysis and methods adopted.

Industry

The main industry that has been noticed in the chosen articles is the manufacturing sector as it is present in 11 articles. The information and communication technology, is present in 6 papers. The food and beverage, automotive and service industry is present in four research studies. The wholesale trade, computer software industry, electronics, chemical industry, construction and hotel industry was noticed to be covered in 3 articles. The catering, transportation, financial service and textile industry is allocated in two

papers. The health and personal service, retail trade, internet and added values services, biotechnology and pharmaceuticals and metallurgy industry were inspected in one article each. What is noticed of what been mentioned above that the focus is on the manufacturing industry and there are still some industries to be covered such as oil, education and advertising industries. However, what is interesting that one of the articles excluded the agriculture sector. This may raise some questions and would constitute an opportunity for future research.

Methods used

The empirical systematic literature review revealed some aspects about the methodological trends used. In total, 27 studies used questioners or surveys

(interchangeably) for data collection, only two of them were longitudinal, while the rest were cross-sectional. Moreover, two studies used a mixed approach of a questionnaire and an interview. Furthermore, the rest two articles have adopted an interview approach with a longitudinal nature, thus a total of four articles having a longitudinal approach.

Content analysis :

The content analysis of HRMP and innovation in firms focused on the following aspects: HRMP (bundle/single); existence of a moderating or a mediating variable, namely, characteristics of HRMS; definitions of innovation; outcomes of HRMP in an indication for innovation in all its forms.

Human resource management systems or human resource management practices

defined an HRMS as “a set of distinct but interrelated activities, functions and processes that are directed at attracting, developing and maintaining or disposing of a firm's human resources.” Thus, indicating for the complementary and interrelated nature of the practices formulating an HRMS that imposes a competitive advantage for the firm. Moreover, high-performance work systems (HPWS) in accordance with what have been mentioned earlier is defined as “a system of HRMP designed to enhance employees' skills, commitment and productivity in such a way that employees become a source of sustainable competitive advantage” ().

In summary, papers that used HRMP as a bundle was ($n = 26$); in isolation ($n = 4$); a mixture of a bundle and isolation ($n = 1$). It is noticed that most researchers agree on the notion of the bundle, however, lack of agreement is noticed relative to the type of practices to integrate in the system (Jimenez-Jemenez and Sanz-Valle, 2005).

Human resource management practices in isolation

Utilization of HRMP in isolation is quite noticed and adopted in recent research studies. The practices used can be categorized according to their purpose of usage. Lau and Ngo (2004) used three practices directed toward mindfulness; adopted eight practices to evoke employee creativity; used four innovation-oriented practices; and incorporated four

practices aiming at enhancing employee abilities, motivation and opportunity to innovate.

Innovation by definition :

Different definitions of innovation have been encountered, thus a trial has been conducted to set a certain trend for the definitions adopted. The definition by West and Far, used by , and . It captures the deliberate behavior directed toward new (products, ideas and processes), that is new to the adopting unit and beneficial for the organization and society. Moreover, its usage has been noticed to be mainly for the technological products and processes.

Human resource management systems :

First, trying to find the best bundle of practices for product innovation in firms, adopted two systems, namely, the first composed of nine practices and the second composed of two; however, both having a learning objective. Their sample was 913 Danish firms with at least 100 employees. Results indicated that the complementarities effect between practices enhances their impact on innovation, however, only seven of the first system had a positive significant impact. Moreover, examined the British context by sampling 32 firms having at least 70 employees. The system adopted is learning-oriented composed of six practices. Results indicated a significant impact on product production and technology innovation, however, no impact on the process. This notion was supported by Jiménez-Jiménez and Sanz-Valle (2008), when exploring the Spanish context, with a sample of 173 firms having more than 50 employees.

In summary, different usage of HRMP systems shown a positive association with product innovation, however, little evidence is provided to support the emergence of process innovation. Moreover, innovation level varies among sectors as some are influenced by specific types of system of practices. Thus, according to the sector, careful selection of practices should be adopted. Furthermore, it was noticed that when implementing two different types of systems, the impact of both systems on innovation is diminished. This is explained according to ambidexterity as there should be a balance if more than one system is adopted.

Human resource management practices in isolation

Next, Vogus and Wellborne (2003) examined the USA

by a sample of 184 firms having an average of 238 employees. HRMP was used in isolation, results indicated that innovation output is strongly increased by these practices. Moreover, examined the Dutch context with a sample of 988 firms having a minimum of 5 employees. Outcomes highlighted the importance of adopting practices that stress training and incentives to induce incremental innovation such as follows: training, performance-based pay. While, for radical innovation the adopted practices should induce autonomy.

Combination :

Then, inspected the UK context through 22 firms having an average of 236 employees. They adopted a set of practices that evoke exploratory learning; results indicated that induction, appraisal, training and teamwork had a significant impact on product innovation yet; appraisal had no impact on technical system innovation. Moreover, contingent reward had no impact on both types of innovation, however, when combined with other practices as a system its impact becomes obvious. In addition, the combined influence had a stronger impact on technical innovation.

In summary, various HRMP have been examined if being used would enhance innovation, surprisingly most studies revealed that single practices would evoke innovation. However, when combined with each other innovation will be hindered. Thus, contradicting what has been mentioned above relative to the impact of bundles of HRMP on innovation.

Mediators and moderators :

Finally, The system impact on innovative behavior is studied through middle managers innovative behavior; this relation is moderated by work-family conflict and work climate. The managers' innovative behavior successfully mediates the relationship between HCWS and firm innovative performance. However, the direct relationship was not significant, moreover work-family conflict had a negative impact on innovative behavior. Furthermore, the combined effect of HCWS with both moderating variables indicated a positive impact on innovative behavior.

In summary, the research is rich with trials to explain the relationship between HRMP and innovation through a

mechanism. However, the mediating mechanism is more popular among research, thus, what would be beneficial is search for further moderators to explain the above-mentioned relationship. In what follows managerial implications for practice are presented.

Practical implications :

Important practical implications are uncovered for managers that need to acquire human resources skills and competencies, which would enhance the firm's survival rate. First, it has been noticed that the existence of training in most of the HRMS is present and plays a vital role in inducing innovation. Lack of training might be reflected in the absence of innovation, however, presence of training would prevent employees from being square minded. Thus, managers are required to focus on human capital development and adopt practices that foster knowledge and enrich employees' skills. Fostering knowledge includes the process of acquiring and sharing information among employees. Sharing information can be motivated through a bonus system that reward combined effort rather than individual ones.

Future research :

As noticed in the review the theoretical underpinning of the HRMP, innovation relationship is quite noticed. However, there is still a space to examine more theories to explain this relationship, for example. Trait theory can be adopted as it explains the individual-level factors, which might impact HRMS positively or negatively ().

Conclusion :

The 31 empirical articles reviewed suggest some improvement toward understanding the HRMP and innovation relationship in firms. The context diversity in which the studies have been conducted reveals that the HRMP and innovation relationship is a rich field yet a lot to be discovered. Practical implication are indicated, which would act as guidance for what of practices would induce innovation if implemented. However, as noticed there no specific system to apply as firms and cultural has to be dealt with according to contingency. Moreover, it suggests some additional theories to be used for inspecting the HRMP and innovation relationship.

References :

- Andreeva, T., Vanhala, M., Sergeeva, A., Ritala, P. and Kianto, A. (2017), “When the fit between HR practices backfires: exploring the interaction effects between rewards for and appraisal of knowledge behaviours on innovation”, *Human Resource Management Journal*, Vol. 27 No. 2, pp. 209-227.
- Bailey, T. (1993), “Organizational innovation in the apparel industry”, *Industrial Relations*, Vol. 32 No. 2, pp. 30-48.
- Ceylan, C. (2013), “Commitment-based HR practices, different types of innovation activities and firm innovation performance”, *The International Journal of Human Resource Management*, Vol. 24 No. 1, pp. 208-226.
- Chang, S., Gong, Y. and Shum, C. (2011), “Promoting innovation in hospitality companies through human resource management practices”, *International Journal of Hospitality Management*, Vol. 30 No. 4, pp. 812-818.
- Damanpour, F., Szabat, K.A. and Evan, W.M. (1989), “The relationship between types of innovation and organizational performance”, *Journal of Management Studies*, Vol. 26 No. 6, pp. 587-602.
- Jimenez-Jimenez, D. and Sanz-Valle, R. (2008), “Could HRM support organizational innovation?”, *The International Journal of Human Resource Management*, Vol. 19 No. 7, pp. 1208-1221.
- Laursen, K. and Foss, N.J. (2003), “New human resource management practices, complementarities and the impact on innovation performance”, *Cambridge Journal of Economics*, Vol. 27 No. 2, pp. 243-263.
- Lee, H.W., Pak, J., Kim, S. and Li, L.Z. (2016), “Effects of human resource management systems on employee proactivity and group innovation”, *Journal of Management*, p. 149206316680029.
- Nonaka, I. (1994), “A dynamic theory of organizational knowledge creation”, *Organization Science*, Vol. 5 No. 1, pp. 14-37.
- Pfeffer, J. and Jeffrey, P. (1998), *The Human Equation: Building Profits by Putting People First*, Harvard Business Press Rogers, M.E. (1983), *Diffusion of Innovations*, The Free Press.

Recent Trends in NBFCs Lending to MSME Sector

Prof. Sagar R. Shah | Prof. Nikhilesh S. Kariya

- Introduction -

NBFCs over the years have played a very critical part in the economic system. They have been at the forefront of catering to the financial needs and creating livelihood sources for the so-called un-bankable masses in the rural and semi-urban regions. Through strong linkage at the grassroots level, they have created a medium of reach and communication and are very effectively serving this segment. Thus, NBFCs have all the key characteristics like other lending agencies to accomplish the mission of financial inclusion in the rural and urban area. (Finance, 2012)

Non-banking finance companies consists mainly of finance companies which carry on hire purchase finance, housing finance, investment, loan, equipment leasing or mutual benefit financial companies but do not include insurance companies or stock exchanges or stock-broking companies. (Bulletin, 2017)

A study of NBFCs faces serious definitional and data difficulties. The number of such companies at work is very large, and it runs into thousands. But only a small proportion of them reports to/files return with the RBI. There has also been a blurring of categories due to the emergence of many multi-service companies. The RBI (Amendment) Act 1997 defined NBFC as an institution or company whose principal business is to accept deposits under any scheme of arrangement or in any other manner, and to lend in any manner. As a result of this new definition, a number of loan and investment companies registered under the Companies Act by business houses for the purpose of making investment in group companies are now included as NBFCs. In the past, the definition of NBFC was not so extensive and the categorization of such institutions used to be somewhat

different from the one officially followed at present.

A residuary non-banking company is a company which receives any deposit under any scheme of arrangement, by whatever name called, in one lump sum or in installments or any other manner and which is not an equipment leasing company, hire purchase company, a housing finance company, an insurance company, an investment company, a loan company, mutual benefits financial company or a miscellaneous non-banking company.

1.1. Non Banking Financial Company – Meaning And Definitions

Non-banking financial companies (NBFCs) engaged in varied financial activities are part of the Indian financial system providing a range of financial services. NBFCs do offer all sorts of banking services, such as loans and credit facilities, retirement planning, money markets, underwriting, and merger activities. The number of non-banking financial companies has expanded greatly in the last several years as venture capital companies, retail and industrial companies have entered the lending business.

'NBFC', is defined under sec. 45-I(f) of the Act, as under "non-banking financial company" means-

- i. a financial institution which is a company;
- ii. a non banking institution which is a company and which has as its principal business the receiving of deposits, under any scheme or arrangement or in any other manner, or lending in any manner;
- iii. such other non-banking institution or class of such institutions, as the bank may, with the previous approval of the Central Government and by notification in the Official Gazette, specify.

For this purpose, the definition of 'Principal Business' given, vides Press Release 1998-99/1269

dated April 8, 1999 may be followed:

“The company will be treated as a non-banking financial company (NBFC) if its financial assets are more than 50 per cent of its total assets (netted off by intangible assets) and income from financial assets is more than 50 per cent of the gross income. Both these tests are required to be satisfied as the determinant factor for principal business of a company”.

Definitions of NBFC

Whereas the 'Reserve bank of India Act 1934' itself defines the term NBFC, there is a different definition of the same term viz. NBFC in the 'Non-Banking Financial Companies Acceptance of Public Deposits (Reserve Bank) Directions, 1988' that the RBI itself has issued under the aforesaid Act of 1934.

According to the Reserve Bank (Amendment Act) 1997, “A Non-banking finance company (NBFC) means a financial institution which is a company; A non-banking institution which is a company and which has as its principal business the receiving of deposits under any scheme or arrangement or in any other manner or lending in any manner; such other non-banking institution or class of such institutions as the Bank may with the previous approval of the Central Government specify”.³ The definition excludes financial institutions besides institutions which carry on agricultural operations as their principal business.

2. A brief history of NBFC

- NBFCs started humbly in India in the 1960s as an alternative for savers and investors whose financial needs were not sufficiently met by the existing banking system. The NBFCs initially operated on a limited scale without making much impact on the financial industry. They invited fixed deposits from investors and worked out leasing deals for big industrial firms.
- In the first stages of development, the Companies Act regulated financing. However, the unique and complex nature of operations and with financial companies acting as financial intermediaries, there was a call for a separate regulatory mechanism.
- Hence, Chapter III B was included in the Reserve Bank of India Act, 1934, which assigned the Bank with limited authorities to regulate deposit-taking

companies. Since then the RBI has initiated measures to regulate the NBFC sector.

- The RBI accepted and implemented that hire purchase and leasing companies could accept deposits to the extent of their net owned funds, as per the key recommendations of James S. Raj Study Group formed in 1975. The Companies were also required to maintain liquid assets in the form of unencumbered approved government securities.
- Between the 1980s and 1990s, NBFCs, with their customer-friendly reputation, began to attract a huge number of investors. The number of NBFCs rose swiftly from a mere 7000 in 1981 to around 30000 in 1992, which made the RBI feel the need to regulate the industry. In 1992, the RBI formed a Committee headed by the former Chairman of Bank of Baroda, Mr. A. C. Shah, to suggest measures for effective regulation of the industry. The Shah Committee's recommendations included most things from compulsory registration to prudential norms.
- In January 1997 there were huge changes in the RBI Act, 1934, especially the Chapters III-B, III-C, and V of the Act seeking to put in place a complete regulatory and supervisory structure, which would protect the interests and also ensure the smooth functioning of NBFCs.
- After the amendment of the Act in 1997, the NBFCs have grown significantly in terms of operations, range of instruments and market products, technological advancement, among others.
- In the last 20 years, the NBFCs have gained prominence and added depth to the financial sector. In August 2016, the union cabinet gave the go-ahead for foreign direct investment (FDI) under the automatic route in regulated NBFCs. (Blog, 2019)

3. Literature Review

From the purpose of proposed research project entitle 'An Impact study of role of NBFCs: new path of Development MSME Business in India'. The data for this purpose has been collected from numerous books, journals, articles, newspapers, and various reports published time to time. Some of them reviewed are as following.

Arun Kumar (2014) has made an attempt on the

topic “Non Banking Financial Companies: A Review” and after observing twelve studies of different authors he concluded that due to the regulations of the Reserve Bank of India, still the NBFCs are not entering into more credit and suggested to the NBFC credit policy to reduce rates of interest. The study finds a research gap which is 'evaluation of performance of NBFCs in India'.

Mohan (2014) observed on the topic “Non Banking Financial Companies in India: Types, Needs, Challenges, and Importance in Financial Inclusion” and suggested to improve Corporate Governance Standards and concluded that NBFCs have turned out to be engines of growth and are integral part of the Indian financial system, enhancing competition and diversification in financial sector, spreading risks specifically at times of financial distress and have been increasingly recognized as complementary of banking system at competitive prices.

Shollapur M.R in his article in 'The Indian Journal of Commerce' has revived concept of NBFCs. As per him the abstract NBFCs constituted a significant part of financial system and compliment the service provide by commercial bank in India. The efficiency of financial services and flexibilities helped them build a large body of client including small borrower and bigger corporate establishment. The pace of financial liberalization has a intensified the competition. As a result, there has been a shift towards strategic perspective marketing process of NBFCs. This perspective enable them to predict the future impact of change and help to move out of week area and grab new opportunity through continuous monitoring system.

Subina Syal and Menka Goswami (2012) writes on “Financial Evaluation of Non-Banking Financial Institutions: An Insight” in financial system'Indian Journal of Applied Research'. The Indian financial instruments and financial institutions, consists of the various financial markets that facilitate and ensure effective channelization of payment and credit of funds from the potential investors of the financial institutions in India are one of the economy. Non-banking financial institutions in India are one of the major stakeholders of financial system and cater to the diversified financial services like investment needs by providing specialized

financial advisory, leasing, asset management, etc. Non-banking sector in India has been a considerable growth in the recent years.

4. Objectives of the study:

The main objectives of study are;

- To study the role of NBFCs in development of Indian MSMEs.
- To examine the growth and performance MSMEs
- To analyze various challenges faced by NBFC sector.

5. Role of NBFC developing MSMEs:

Due to limited access to mainstream funding in the sector, this presents a huge opportunity for the NBFCs to the tune of INR 384 billion over the next 5 years in the MSME Small Loan Credit Market. The role of NBFCs as a credit delivery channel to micro and small business has been well acknowledged and has been primarily driven by the need to meet the unmet demand for credit by developing various innovative and tailored financial products for specific sub-segments. Though the NBFCs do not have any meet any PSL guidelines like the banks, they are governed by different set of regulations prescribed by the RBI with lower compliance requirements. Due to the simpler structure and business processes of NBFCs vis-à-vis the banks, the branch outreach is comparable to regional banks and the ability to provide timely and flexible repayments terms based on cash flow assessment to clients is quite high. This has benefited the NBFCs in better understanding the micro lending segment while also improving their credit appraisal system.

NBFCs have been operating various businesses under sound economics. Many businesses started by the sector have later been taken up by banks and become regular banking services. For instance, car financing, which was started by NBFCs, has now become one of the larger revenue streams for banks. The NBFCs themselves have now moved on to financing second hand cars. Other businesses, namely, infrastructure finance, asset finance, hire purchase and, in the recent past, microfinance have been the major areas of operations for NBFCs. Additionally, NBFCs play a supportive role in the economy and also in financial inclusion and therefore need to be encouraged. Some of the economic roles played by NBFCs are:

5.1 Infrastructure financing

While the RBI doesn't have any specific sector exposure limits, it has asked the banks to formulate internal policies for exposure to the infrastructure sector. The banking sector's exposure to infrastructure was Rs. 5,50,178 crore as on May 2011, which was 15% of total non-food bank credit of the banks. In comparison, the Infrastructure Finance

NBFCs had an outstanding infrastructure loan book size of Rs.1,96,158 crore. Banks' further exposure to infrastructure is constrained by prudential internal limits (which typically are 12-15%) and asset liability mismatch due to long tenure of assets and short tenure of liabilities.

Given the projected capital requirement for infrastructure sector in the 12th five-year plan, NBFCs will play a part in supplying capital to the sector. However, proper credit rating, accounting and financial norms have to be ushered in for greater transparency and soundness of the sector as also operating in the NBFC sector.

5.2 Serving unbanked customer segments

NBFCs have traditionally focused on customer segments which were not served by banks like micro, small and medium enterprises (MSMEs), funding of commercial vehicles including old vehicles, farm equipments viz. tracking, harvesters, etc. loan against shares, funding of plant and machinery; etc.

NBFCs typically are specialized vehicles –both in terms of products and the geographies in which they operate. This specialization provides them a unique framework to assess the risk in the undertaken business. Much closer market awareness provides them the ability to rate borrowers, monitor them, price the relative credit suitably and affect recoveries from them.

NBFCs also provide credit for certain sectors which are not served by banks and Financial Institutions because Banks/FIs do not have adequate market relationships and infrastructure for the same. Some of these sectors are:

- a) Used Trucks
- b) Used passenger vehicles
- c) Consumer durable loans
- d) Personal Loans
- e) Funding to the Small & Medium Enterprises

(SME Sector) which do not have access to institutionalized funding, etc. Traditionally, these sectors were financed entirely by the unorganized financiers at exorbitant high interest rates. In the last 10 years, with their retail strength, NBFCs have rendered significant service by extending credit to these sectors. Now banks and financial institutions are availing of the reach and expertise of NBFCs for employing funds in these sectors through NBFCs. This has brought in lot of funds into these sectors, thereby reducing interest rates.

5.3 Strong understanding of customer segments and ability to deliver customized products

The ability of NBFCs to produce innovative products in consonance with needs of their clients is well recognized. This, in addition to the proximity to the clients, makes the NBFCs distinct from its banking sector counterparts. In a short period of time, NBFCs have become market leaders in most of the retail finance segments like commercial vehicles, car financing and personal loans. In the last decade or so, the Indian retail finance markets have seen several new products being developed and introduced by NBFCs. The following are some cases in point - Used vehicle financing, Small ticket personal loans (ST-PL), Three-wheeler financing, Loan against shares.

NBFCs have a significant economic role, especially servicing the under-banked and unbanked populace and geographies. Bringing the diverse set of NBFCs under regulation rather than curtailing their operations would help orderly growth of the sector.

6. The specific role and importance of NBFCs

a) Term loan assistance: Term loans are provided for (i) Setting up of new projects and for technology up gradation / modernization, diversification, expansion, energy efficiency, adoption of clean production technologies, etc. of existing MSMEs (ii) Service sector entities and (iii) Infrastructure development and up gradation. It also includes Privileged Customer Scheme, Scheme for Energy Saving and Clean Production Technology Projects in MSME Sector, Risk Capital Fund.

- b) **Working capital assistance:** The objective of the Scheme is to provide term loans to MSMEs to meet the shortfall in working capital including WC margin. It also includes Working Capital arrangement with NBFCs.
- c) **Saving Utilization and Promotion:** NBFCs help mobilizing savings by offering attractive schemes suitable to respective target segments. This is particularly important when it helps reach sections where commercial banks have limited reach.
- d) **Easy Credit Access:** Given the universal target access, the formalities and processes at NBFCs are far simpler. It also offers financial access for unusual means like religious functions etc. which don't find mention in commercial banks product portfolio. The Banking sector has always been highly keeping pace, however easy approval procedures, flexibility in working style and timeliness in meeting the credit needs and low operation cost skew the balance in favor of NBFCs in providing funding.
- e) **Reduce Credit Funding Gap:** There is a huge latent credit demand in the country that gets aggravated for specific segments like self-employed or small businesses with little or low income proof. The gap is further compounded with public sector banks already under severe bad-debts. This impacts the credit appetite for banks in medium to short run, which is serviced by NBFCs, thereby reducing the credit funding gap
- f) **Product Innovation and Competitiveness:** There are a range of financial products and services which were first provided by the NBFCs instead of banks, thereby pushing the envelope of financial portfolio and product development. For instance, the loans against gold were also introduced by the NBFCs much earlier than nationalized banks. In the same way, the commercial vehicle financing, in particular, were also first initiated by the NBFCs.
- g) **Promote Economic Growth and Inclusion:** The role of NBFCs as engine of growth through creation of a multi layered finance system that enables universal access is well acknowledged. They enable small scale businesses by providing them awareness, access and diversification of securities and investment. They also have an active role in the capital markets and its stability.
- h) **Credit to MSMEs:** MSME sector has large employment potential of 59.7 million persons over 26.1 million enterprises and is considered as an engine for economic growth and promoting financial inclusion in rural areas. The outstanding credit provided by the NBFC sector to MSMEs stood at Rs.625 billion as at end March 2013 against Rs.464 billion in the previous year. Statistics based on 4th Census on MSME sector revealed that only 5.18% of the units (both registered and un-registered) had availed finance through institutional sources. 2.05% got finance from non-institutional sources the majority of units say 92.77% had no finance or depended on self-finance. The fact that a large segment in the micro and small industries sector does not have access to formal credit provides a window of opportunity for the NBFCs to design suitable innovative products. [RBI Speech, 2014]

Fig.1 Credit Growth of NBFC as % of total credit



Source: Pwc 2016

1. Growth & Performance of MSME in India:

For developing countries across the globe, access to proper financial resources to support flourishing businesses is imperative to infuse growth into their economies. In India, the MSME sector, over the years, has become the backbone of the Indian economy, playing an instrumental role in the development of the country. While the government has taken proactive measures to usher in a revolution that promises banking and rural divide, fuelling a balanced GDP growth, reducing imports to placing the economy on a global scale, the sector holds great importance. Yet, despite these well-known facts, access to finance for small enterprises remains elusive till date. According to the International Financial Corporation (IFC), the total financing demand of the Indian MSME sector is approx Rs. 32.5 trillion. This includes entrepreneur's contribution of INR 4.6 trillion and estimated external finance demand of INR 27.9 trillion.

In line with its mission to hit the \$5 trillion-economy mark by 2025, the government has nonetheless deliberated to give a shot in the arm to the sector. One of its recent initiatives was targeted to bring relief to MSME borrowers registered under Goods and Services Tax (GST). Increasing the repayment period from 90 to 180 days along with changes in asset classification is a small yet a welcome move. Although these measures ensure that the formalization of businesses doesn't become a pain point for smaller enterprises, the MSME sector is longing for initiatives that will quench their thirst for financial support. Therefore, there exists an urgent need to address this concern and classify NBFC loans to MSME sector under PSL. (Narayan, 2018)

Let's take the example of MSMEs in China. The sector accounts for about 58% of the country's GDP and the Chinese MSMEs are responsible for over 80% of job creation and more than 70% of technological innovations. However, that is not the case in India. In order to boost the current growth pattern of MSMEs in India, lending to MSMEs in India should be made a priority in order to ensure consistent development of the sector and guarantee higher contribution to India's GDP.

The need for better MSME financing: The MSME sector can reap greater dividends from a stronger alliance between NBFCs and the financial muscle of banks. At present, out of the total 63.3 million MSMEs in the

country, less than 5 million have access to formal credit. This scenario can change drastically if MSME loans from NBFCs are classified under the Priority Sector Lending (PSL).

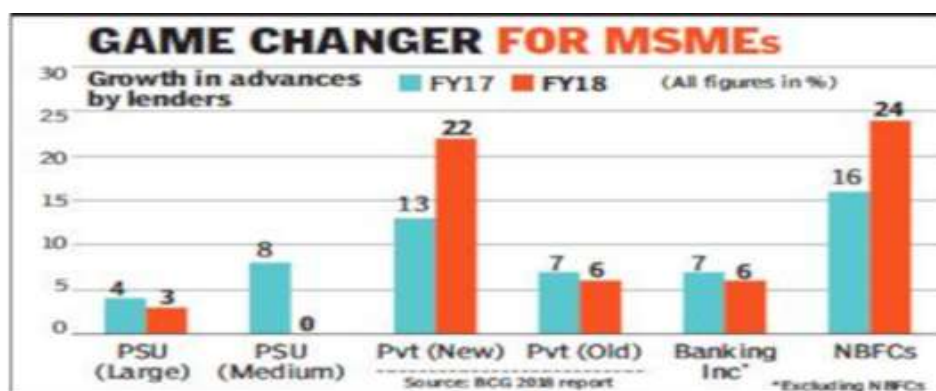
Mandated by the Reserve Bank of India, banks were allowed to achieve priority sector lending targets by refinancing NBFCs that focused on small ticket retail and SME loans. This suddenly changed in April 2011 when the RBI made banks' refinance to NBFCs for on-lending to the MSME sector, ineligible for priority sector classification. As a result of this, the MSMEs still continue to grapple for working capital. With the loss of the PSL tag, financing to MSMEs has been affected tremendously.

The bank wise loan (to the MSME sector) activity from Dec 2015-Dec 2017:

- Public Sector Banks lending has decreased from 61.5% to 55.4%
- Private Banks lending has increased from 25.4% to 28.5%
- NBFCs lending to the MSME sector has increased from 7.9% to 10.4%

With approx. 4 lakh New to Credit (NTC) MSME borrowers entering the formal credit sector (up from 2.7 lakh borrowers from Jan to June 2016), the RBI needs to revise its priority sector lending classification again if a boost needs to be given to the economy. (Narayan, 2018)

A closer look at MSME financing by NBFCs: Given the small loan size, longer tenures, lack of digital and technical infrastructure and high expense involved in reaching out to the MSME sector, banks provide little to no help. Despite the emergence of certain NBFC lending platforms in the past five years, the financial woes of the MSMEs still continue. Therefore, NBFCs need a better grip on finer nuances of smaller players along with systematic and technologically advanced processes in order to assist MSMEs, in smaller towns as well. Although, the above figures establish the important role that NBFCs are playing at present, they need to do a lot more to make the sector reach to its full potential



MSMEs sector neglected by Bank funding: Due to limited access to mainstream funding in the sector, this presents a huge opportunity for the NBFCs to the tune of INR 384 billion over the next 5 years in the MSME Small Loan Credit Market. The role of NBFCs as a credit delivery channel to micro and small business has been well acknowledged and has been primarily driven by the need to meet the unmet demand for credit by developing various innovative and tailored financial products for specific sub-segments.

Though the NBFCs do not have any meet any PSL

guidelines like the banks, they are governed by different set of regulations prescribed by the RBI with lower compliance requirements. Due to the simpler structure and business processes of NBFCs vis-à-vis the banks, the branch outreach is comparable to regional banks and the ability to provide timely and flexible repayments terms based on cash flow assessment to clients is quite high. This has benefited the NBFCs in better understanding the micro lending segment while also improving their credit appraisal system.

| MSME Market Segment | Typical Loan Products | | |
|---------------------|-------------------------------------|--|---|
| | Short-Term Business Loan | Long-Term Business Loan | Asset-Based Financing |
| | Loan Amount: < INR 100,000 | Loan Amount: INR 100,000–INR 1,000,000 | Loan Amount: INR 1,000,000–INR 50,000,000 |
| | Tenor: 1 - 2 years | Tenor: 2 - 5 years | Tenor: 5 - 7 years |
| | Interest Rate: 20% - 24% | Interest Rate: 20% - 24% | Interest Rate: 16% - 21% |
| | Loan Purpose: Working Capital needs | Loan Purpose: Capital Expenditure | Loan Purpose: Purchasing assets |

Possible Measures to Help MSMEs Improve Access to Finance

While there have been significant efforts by the Centre and financial bodies to develop and implement numerous support mechanisms for the MSME segment, we, at Power to MSME, feel that the following efforts can be undertaken to further improve the MSME financing issue.

- Enhance debt access to non-banking finance companies focused on these units and give perks for participation in the sector.
- Create an IT-enabled platform to track MSME receivables to facilitate securitization of these trade receivables.
- Give credit guarantee support for MSME finance to non-banking finance companies.
- Delayed payments increases the working capital needs of MSMEs and tightens their financial position.
- Mechanisms to leverage other sources such as factoring can potentially help MSMEs liquidate receivables faster, and possibly afford them an opportunity to leverage their creditworthiness to avail financing.
- Endorse establishments to syndicate finance and give advisory support to MSMEs in rural and semi-urban areas.
- Embark on further research activities to have better understanding of financing patterns of services enterprises in the MSME sector.
- Bolster the MSME credit information bureau and expand the scope of the information.
- Bureau to collate and process important transaction data. (MSME Schemes, 2016)

1. Reasons behind the success of NBFC's

Non-Banking Financial Companies have proven their mettle and acquired a strong position in India. Let's take a look at the factors that led to the success of NBFC

Business Model:

- **Tailor-made financial services**– NBFC particularly apprehend the needs of the unorganized and underserved segments. Thus, it enables customized products and services based on the customer's profile.
- **Agile risk management system**– NBFC minimizes the tendency of any risks through a pro-active and robust risk management model. It increases the credibility of NBFC's among the customers.
- **Faster loan facilities**– A Non-Banking Financial Company aims to accentuate the customer experience by facilitating rapid credit with the use of advanced technology. By deploying SaaS technology, NBFC optimizes business operations, automate the process of the credit assessment and gives real-time solutions. (PWC, 2019)

2. Trends in NBFC Business Model that makes it next-generation ready

Here is the list of NBFC trends that will help this business model sustain for an extended period in the financial market.

Partnership with Fintech Companies

The collaboration of NBFC's with Fintech startups creates a win-win situation for both the parties. Since it boosts the lending capabilities of NBFC's and provides a competitive edge to Fintech newbie. The benefits that NBFC's accrue by cooperating with Fintech players are as follows:

Generating new product offerings: NBFC innovates new products by using technology-based tools of Fintech. The partnership of NBFC's and Fintech helps to launch new product offerings such as POS Financing, Invoice Financing, Consumer Durable Loans, Payday Loans and more.

Reinforce digital business operation: Non-Banking Financial Companies get access to the advanced techniques by uniting with a Fintech Company. It compels NBFC to replace the existing manual process with paper-less digital methods. Consequently, digital on boarding and verification have reduced the operational cost.

Higher productivity– Fintech has streamlined the internal and external functions of NBFC. Hence,

encourage NBFC's to revamp their back-office activities, resulting in increased productivity.

Video KYC :

Video KYC will soon be a notable trend in NBFC Business Model. Since several fraud identity cases were reported in the financial realm, it calls for a new initiative. Presently, the financial institutions verify the customer's identity through documents and signature on the forms. However, this method is proven to be unsafe in contrast to authenticating the live digital footprints.

The industry seeks to remove identity theft cases through numerous digital video KYC checks. In the method of Video KYC, the investors shall have to upload their identity proofs like address proof, PAN Card, photograph and signatures via Mobile Application or website. Once, the investors upload all the documents, they need to start real-time video recording by using the front camera of their Smartphone and display a hard copy of each document for at least 10 seconds.

Automation :

NBFC can harness automation to speed up the lending procedure by predetermining certain steps to process a Loan Application. Automation can bring radical changes in the functioning of Non-Banking Financial Companies.

Alternative Credit Scoring

NBFC will adopt alternative credit scoring based on non-financial data, as many citizens of India still do not have adequate financial footprint data. The new-age platforms such as ATMs, Mobile Banking, Social Media, Smartphones, and Internet Banking leave the footprints of transactions everywhere. Thus, NBFC can utilize the data of such transactions to check the credit score.

Pro-active Risk Detection

NBFC must develop risk management frameworks to pro-actively manage, detect and mitigate any types of internal or external risks. The non-banking financial lenders should protect against information leaks. If NBFC does not take any rigorous action, then it

can potentially threaten the customer's financial security and tarnish the lender's image. Therefore, the NBFC lenders need to periodically assess IT controls which are responsible to maintain information integrity. (Building the, 2018)

9.1 Role of emerging technologies and strategic partnerships for NBFCs

Non-banking financial companies (NBFCs) have played a pivotal role in meeting the financial needs of individuals and business that have traditionally remained un-served or underserved by banks. But the regulations for NBFCs have become stricter in recent times, the cost of borrowing has increased and NBFCs are focusing on niche markets and personalized products and services. NBFCs are now more focused on developing innovative products and catering to low-income, urban customers in unorganised sectors. In such a scenario, NBFCs are adopting business and operational models powered by technologies that seamlessly facilitate the design, launch, implementation and execution of tailored products and services. Investing in new technologies and strategic partnerships with incumbent financial institutions and FinTechs also allows NBFCs to lower their costs when it comes to increasing their customer base, lowering customer acquisition costs, servicing existing customers or de-risking the portfolio while trying to overcome the increasing formal credit penetration in a growing economy.

9.2 Technologies defining a new paradigm for FinTechs and NBFC

FinTechs have been creating a strong buzz across value chains in the Indian financial space. They have also become a part of the Indian government's mission of financial inclusion for the last few years. Because of its vast potential to disrupt the current and traditional banking system, the [FinTech](#) space is now gaining traction in the areas of lending, asset management, deposits and credit system. Present-day [FinTech](#) companies are efficiently making use of new-age technologies to overcome challenges and build products and services such as last mile reach and delivery, alternative credit models, fraud detection, regulatory compliance, enterprise automation for

accounting, treasury and reconciliation for traditional NBFCs.

Traditionally, lenders have adopted a 'one size fits all' approach, evaluating all types of customers against a single credit policy, resulting in the exclusion of a large population of creditworthy customers. With FinTechs adopting and building models on AI combined with ML and advanced analytics, NBFC lenders can adopt a personalised approach to underwriting by incorporating segment-definitive guidelines, empowered by alternative data sources, and apply scorecard-based credit decisions. The approach should help broaden the customer base, allowing sales teams to target a large pool of prospective customers and offer relevant products, as per their credit scores.

Some NBFCs are moving forward in testing and deploying solutions in collaboration with [FinTech](#) software as a service (SaaS), to automate back-end and middleware software applications, which shall make the origination and underwriting process swift, structured and transparent.

The technology-driven business model of NBFCs, which aims to reduce dependency on manual tasks and is built on the capabilities of RPA, leads to wider inclusion, cost-effectiveness, prowess in credit quality and a quicker turnaround time than traditional lending models of banks. Rather than having key resources scan pages of documentation to assess creditworthiness and risks involved in lending to an individual, technologies like RPA can enable such resources to focus on core business needs.

Technologies like AI and RPA can also aid NBFCs with on-the-spot decision making. Technologically advanced NBFCs can transform the manual, time-consuming, human judgment-based underwriting process to provide instant, real-time approvals. The transformation shall benefit NBFCs' lenders differentiate from fellow players and traditional banks, improve customer experience, ensure uniform application of credit policies and reduce costs.

AI and ML can also help in continuous evaluation of the underwriting and risks model. A periodic re-evaluation helps determine the efficiency and effectiveness (e.g. service delivery, risk management, cost efficiency) in dynamic scenarios, and therefore, determines remediation steps to improve

performance.

Advanced analytics and AI can power NBFCs with robust collections of payments and monitoring decisions. NBFCs have relied on customer account balances and credit scores to prioritize non-performing and delinquent accounts and formulate strategies for collections. But with the next level of growth slated to come from accounts with little or no credit history, NBFCs would need to leverage wider data sets and big data processing ability to derive and synthesize insights from existing and previously used data sets of non-performing or delinquent accounts, by looking at large sets of information.

9.3 Strategic partnership models between FinTechs and NBFCs

The [FinTech](#) sector is working speedily with cutting-edge technologies, to ease borrowing for customers and solve the limitations of the banking and NBFC sectors. Banks and NBFCs are also changing their mode of operations, but at a much slower pace due to their legacy infrastructure, technologies used, frameworks, approval processes and tight-knit integration across business and technological value chains.

This does not mean that banking institutions and NBFCs are not innovating. The challenge for banks and NBFCs is to identify which ideas to actively pursue to embed capital and technology. The complexity, scale and siloed nature of banks restrict them from doing all this effectively.

Given the pace of change and customer expectations, the common trait among NBFCs is that they rightly understand that they have a better chance of succeeding by collaborating and seeking strategic partnerships with new-age FinTechs.

Traditional NBFCs have an inherent advantage which [FinTech](#) companies don't. Similarly, [FinTech](#) companies have agility and technology, which acts as a great equalizer. We explore below the strategic partnership and innovation models adopted by banking institutions, NBFCs and FinTechs for going to market. (emerging technologies are helping NBFCs evolve, 2021)

3. Challenges faced by NBFCs Sector

While NBFCs have witnessed substantial

growth over the years, there are few areas of concern which need to be addressed. For instance, while NBFCs have enjoyed an edge over banks in semi-urban & rural markets where banking network is not yet strong, they have limited spread in urban markets. Nonetheless, in recent years, NBFCs have begun to create niches for themselves that are often neglected by banks. These primarily include providing finance to non-salaried individuals, traders, transporters, stock brokers, etc.

In the past few years, the increased competition from banks in the retail finance segment has led to excess diversification by NBFCs from their core business activities. The sector has witnessed introduction of various innovative products such as used vehicles financing, small personal loans, three-wheeler financing, IPO financing, finance for tyres & fuel, asset management, mutual fund distribution and insurance advisory, etc. Besides, NBFCs are aspiring to emerge as a one-stop shop for all financial services.

NBFCs have also ventured into riskier segments such as unsecured loans, purchase finance for used commercial vehicles, capital market lending, etc. Moreover, NBFC's customer profile is concentrated on the self-employed segment. The earlier mentioned factors increase their risk profile which could have adverse impact on the financial health of NBFCs.

Although some improvement has been witnessed in auto sales in last few months, the demand for vehicle finance is likely to remain subdued. Besides, given the significant slowdown in the Indian economy, NBFCs were encountering structural challenges such as increased refinancing risk, short-term asset-liability mismatch leading to decelerating growth and declining margins. This is expected to have a bearing on the profitability of NBFCs in the medium term.

Given that growth in vehicle finance might remain low in the medium term, NBFCs are expected to focus on rural and semi-urban markets. Credit requirements of rural population are primarily met by banks from organized sector or local money lenders. Though, in recent years there has been some penetration of NBFCs in this segment, the market still remains largely untapped. There is a large section of rural population which does not have access to credit either because of their inability to meet the lending covenants of banks or due to high interest rates of local money

lenders. This provides a huge opportunity for NBFC sector to spread their business in the rural & semi-urban markets. (NON-BANKING FINANCIAL COMPANIES, 2018)

11. Area of future research of NBFCs sector

Non Banking Finance Companies have been the talk of the town with their remarkable ability to cater to the diverse entrepreneurial demands of the country. The sector has been an epitome of innovation and has ventured into infrastructure financing and micro-finance, mitigating the debt crunch of every segment of the Indian Economy. While mainstream banks have been crippled by the weight of their Non Performing Assets, NBFCs have responded positively to regulatory norms by addressing such risks through regulations. It has been a remarkable story of evolution for the sector which began as an informally governed fragmented entity to being well-regulated and in most cases adhering to state of the art technological innovation, risk management and governance.

NBFC's are fast turning out to be a clear alternative to mainstream banking. The sector is also emerging as an integral part of the Indian financial system and has actively contributed to the Government's agenda of financial inclusion. They have lead from the front in offering credit to retail consumers beyond the reach of conventional banking. NBFC Regulations which has been broadly derived from the banking framework has been modified overtime by the RBI to ensure the ease of doing business in the midst of global volatilities. The modification in the regulatory approach has been in keeping with the global standards even though the demand of the Indian economy has been quite different from its global counterparts.

NBFCs have been playing a very important role both from the macroeconomic perspective and the structure of the Indian financial system. NBFCs are the perfect or even better alternatives to the conventional Banks for meeting various financial requirements of a business enterprise. They offer quick and efficient services without making one to go through the complex rigmarole of conventional banking formalities. However to survive and to constantly grow, NBFCs have to focus on their core strengths while improving on weaknesses. They will have to be very dynamic and

constantly Endeavour to search for new products and services in order to survive in this ever competitive financial market.

Since NBFCs have been kept outside the purview of SARFAESI Act, a reform in this area is quite urgently needed. A suitable legislative amendment extending the operation of the said Act to NBFCs too would go a long way in fortifying the faith of the investors and which in turn would greatly contribute to the growth of this Sector. The coming years will be very crucial for NBFCs and only those who will be able to face the challenge and prove themselves by standing the test of time will survive in the long run. (NON-BANKING FINANCIAL COMPANIES, 2018)

Conclusion :

NBFCs have turned out to be engines of growth and are integral part of the Indian financial system, enhancing competition and diversification in the financial sector, spreading risks specifically at times of financial distress and have been increasingly recognized as complementary of banking system at competitive prices. The Banking sector has always been highly regulated, however simplified sanction procedures, flexibility and timeliness in meeting the credit needs and low cost operations resulted in the NBFCs getting an edge over banks in providing funding. Since the 90s crisis the market has seen explosive growth, as per a Fitch Report, the Compounded Annual Growth Rate of NBFCs was 40% in comparison to the CAGR of Banks which was only 22%.

From the SWOT Analysis, it is clear that NBFCs can themselves take steps to minimize their weakness and face all threats by making better use of their strengths and opportunities, identified by them. The areas where active intervention is required is the area of debt recovery for which the support and encouragement of the government is required. The future of the NBFC sector is bright with ample opportunities thrown open to the NBFC sector. Those NBFCs with staying power and long term vision would be in the sector and others will be forced to leave the financial services sector.

NBFCs as innovators, serving unbanked and under-banked geographies and customer segments and services

not provided by banks, it is imperative that the growth and development of the sector be accorded some degree of priority. With adequate regulatory oversight of systemically important NBFCs, implementation of prudential norms, regular reporting and monitoring, etc., NBFCs may be looked at playing a larger part in the financial services sector.

References :

- 1) Brij Mohan “Non Banking Financial Companies in India: Types, Needs, Challenges and Importance in Financial Inclusion” (SSIJMAR) Vol. 3, No. 6, December 2014
- 2) Reserve Bank of India Bulletin, January 2014.
- 3) Dr. Rajeev Jhalani “an Impact Study Of Role Of Nbf: New Path Of Development” Ijmss Vol.03 Issue-06, (June, 2015)
- 4) Suresh Vadde ., Performance Of Non-banking Monitory Companies N India - An Evaluation Researchers World - Journal of Arts Science & Commerce.
- 5) Report of Assocham Non-Banking Finance Companies: The Changing Landscape i. www.pwc.in 2016
- 6) Bothra, N. & Sayeed, K. (n.d). An Overview of the Indian NBFC Sector Performance in 2010, prospects in 2011. Legal Updates, Vinod Kothari & Company
- 7) Bhaskar, V. (Jan 23, 2014). Non-Banking Finance Companies: Game Changers. Retrieved from www.rbi.org.in/scripts/BS_SpeechesView.aspx?ld=870
- 8) Gorden, E and K.Natarajan, Financial Markets, Himalaya Publishing House, New Delhi, 2003
- 9) Research Paper on NBFCs Volume 2 issue 8 Aug 2013 ISSN No 2277–8160
- 10) Role of NBFCs in Promoting Inclusive Growth. Retrieved from www.ficci.com
- 11) <http://www.rbi.org.in>
- 12) <http://www.microfinanceinsigh>
- 13) <http://www.ifmr.a>
- 14) <http://www.dnb.co.in/BFSISectorInIndia/NonBankC2.asp>
- 15) Blog. (2019, November 26). Retrieved May 2021, from <https://www.nelito.com/history-of-non-banking-financial-companies-in-india>

- Banking-Financial-Institutions.html
- 16) (2018). Building the. New Delhi: PWC.
- 17) Bulletin, R. (2017). Provisions Relating To Non-Banking Institutions Receiving Deposits And Financial Institutions. New Delhi: RBI.
- 18) emerging technologies are helping NBFCs evolve. (2021, March 14). Retrieved April 2021, from PWC:
<https://www.pwc.in/industries/financial-services/fintech/fintech-insights/breaking-new-ground.html>
- 19) Finance, M. o. (2012). Report of the Key Advisory Group on NBFC's. New Delhi: Ministry of Finance.
- 20) (2016). MSME Schemes. New Delhi: MSME Ministry.
- 21) Narayan, R. (2018, June 13). India's Mammoth Priority of Classifying Non-Banking Financial Loans to the MSME Sect. Retrieved May 2020, from <https://www.entrepreneur.com/>:
<https://www.entrepreneur.com/article/314996>
- 22) (2018). NON-BANKING FINANCIAL COMPANIES. Kolkata: Vinod Kothari.
- 23) PWC. (2019). Fit-for-future NBFCs:. New Delhi: PWC.

Multidimensional Data model in Data Warehouse and its representation

Prof Aparna S Bhande I Prof R. V. Mahule

Introduction to Data Warehouse: A data warehouse is a computer system designed to store and analyze large amounts of structured or semi-structured data. It serves as a central repository, accessible to authorized business users who rely on analysis to make better-informed decisions. A data warehouse is a key component of most business intelligence (BI) strategies. Data warehouses are a far cry from the single-stack warehouses of the past. Instead of focusing primarily on data processing, as those early warehouses did, the modern version is all about storing lots of data from multiple sources, in various formats, and [gaining insights compelling enough to drive business decisions](#).

Data warehouses are computer systems that used to store, perform queries on and analyze large amounts of historical data, which often come from multiple sources. Over time, it builds a historical record that can be invaluable to data scientists and business analysts. And because data entering a data warehouse goes through a series of cleaning and prepping processes, the data stored is of a high quality. Thus, the data warehouse's records are often considered an organization's definitive source of accurate data.

Data warehouses usually include:

- Automated, secure data pipelines connecting management systems to the warehouse
- Software to clean and prep data
- Data and metadata management tools
- A semantic layer to restructure data for fast, complex analytics and queries
- Analytics and reporting software ranging from basic to highly advanced
- Multiple options for presenting information meaningfully

Big data, cloud computing, and advanced analytics have all played major roles in the development of the modern data warehouse. In fact, they demanded it. Conventional data warehouses typically struggle to keep up with the growing challenges of large volumes of data—whether it's structured and unstructured data managed on premises or cloud-based data hosted by third parties. The data warehouse is "best represented by the convergence of the traditional data warehouse and [the data lake](#)," said [John Santaferro](#), research director at Enterprise Management Associates (EMA). In fact, it is "better defined as a unified analytics warehouse" (UAW). A data lake is simply a repository that takes in data from multiple sources and can store it in any format.

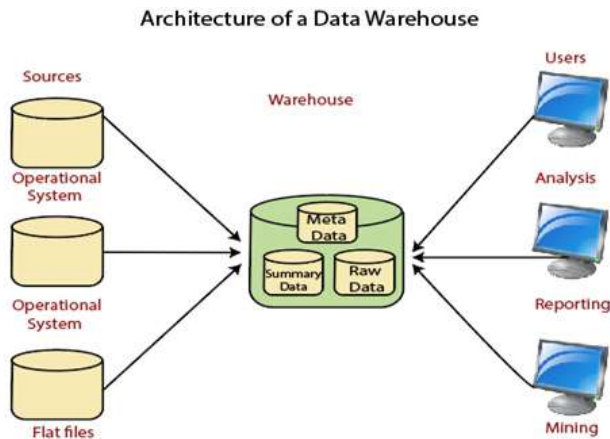
The modern data warehouse is unified because it adequately handles multi-structured data in a single platform. It is an analytics platform because the primary use case for both the data lake and the data warehouse has always been analytics, Santaferro said. It is a warehouse "because it stores multi-structured data in an organized and accessible manner for a broad range of analytics use cases."

Traditionally, data lakes have focused more on data science use cases, while the data warehouse focused more on enterprise analytics. Enterprise data warehouses, by contrast, were designed to focus on specific raw data to draw conclusions about only that information and use a set of practices aimed at regular analysis for reporting and dashboards.

[Data scientists](#) take a broader approach that applies scientific methods, processes, and algorithms to extract insights from data overall, whether structured or unstructured, and can involve data mining and deep

learning techniques.

1.1 Data warehouse Architecture: A data warehouse architecture is a method of defining the overall architecture of data communication processing and presentation that exist for end-clients computing within the enterprise. Each data warehouse is different, but all are characterized by standard vital components.



What are the three layers of data warehouse architecture?

Three-tier architecture:

- The bottom tier, the database of the data warehouse servers.
- The middle tier, an online analytical processing (OLAP) server providing an abstracted view of the database for the end-user.
- The top tier, a front-end client layer consisting of the tools and APIs used to extract data.

1.2 What are the 5 components of data warehouse?

There are five components of a Data Warehouse are:

- Data Warehouse Database. Data warehouse database is the central database and core component that forms the base for a data warehousing environment. ...
- Sourcing, Acquisition, Clean-Up And Transformation Tools (Etl Tools) ...
- Metadata. ...
- Query Tools. ...
- Data Marts.

1.3 What are data warehouse models?



Data warehouse modeling is the process of designing the schemas of the detailed and summarized information of the data warehouse. The goal of data warehouse modeling is to develop a schema describing the reality, or at least a part of the fact, which the data warehouse is needed to support.

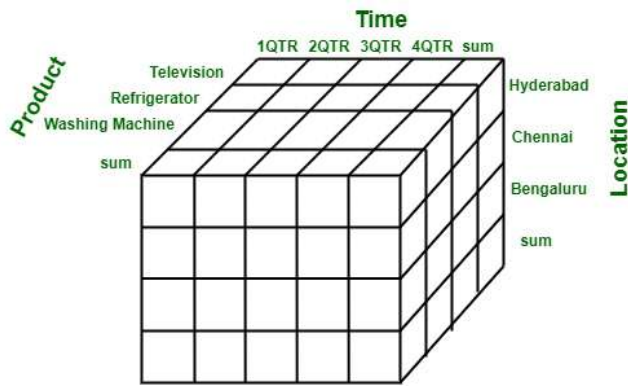
1. Multidimensional Data Model:

2.1 Introduction: The multi-Dimensional Data Model is a method which is used for ordering data in the database along with good arrangement and assembling of the contents in the database.

The Multi Dimensional Data Model allows customers to interrogate analytical questions associated with market or business trends, unlike relational databases which allow customers to access data in the form of queries. They allow users to rapidly receive answers to the requests which they made by creating and examining the data comparatively fast.

OLAP (online analytical processing) and data warehousing uses multi dimensional databases. It is used to show multiple dimensions of the data to users.

It represents data in the form of data cubes. Data cubes allow to model and view the data from many dimensions and perspectives. It is defined by dimensions and facts and is represented by a fact table. Facts are numerical measures and fact tables contain measures of the related dimensional tables or names of the facts.



2.2 Working of Multidimensional Data Model

On the basis of the pre-decided steps, the Multidimensional Data Model works.

The following stages should be followed by every project for building a Multi Dimensional Data Model :

Stage 1 : Assembling data from the client : In first stage, a Multi Dimensional Data Model collects correct data from the client. Mostly, software professionals provide simplicity to the client about the range of data which can be gained with the selected technology and collect the complete data in detail.

Stage 2 : Grouping different segments of the system :

In the second stage, the Multi Dimensional Data Model recognizes and classifies all the data to the respective section they belong to and also builds it problem-free to apply step by step.

Stage 3 : Noticing the different proportions : In the third stage, it is the basis on which the design of the system is based. In this stage, the main factors are recognized according to the user's point of view. These factors are also known as “Dimensions”.

Stage 4 : Preparing the actual-time factors and their respective qualities : In the fourth stage, the factors which are recognized in the previous step are used further for identifying the related qualities. These qualities are also known as “attributes” in the database.

Stage 5 : Finding the actuality of factors which are listed previously and their qualities : In the fifth stage, A Multi Dimensional Data Model separates and differentiates the actuality from the factors which are collected by it. These actually play a significant role in the arrangement of a Multi Dimensional Data Model.

Stage 6 : Building the Schema to place the data, with respect to the information collected from the steps above : In the sixth stage, on the basis of the data which was collected previously, a Schema is built.

2.3 Model

- need abstract model with above operations
- suitable datastructures
- very large databases

Relational Model?

- one-dimensional access via primary key n*m „relationships“ are 2-dimensional: (FK1, FK2)

2.3 Relational Representation of Multidimensional Data with Example :

Let us take the example of the data of a factory which sells products per quarter in Bangalore. The data is represented in the table given below :

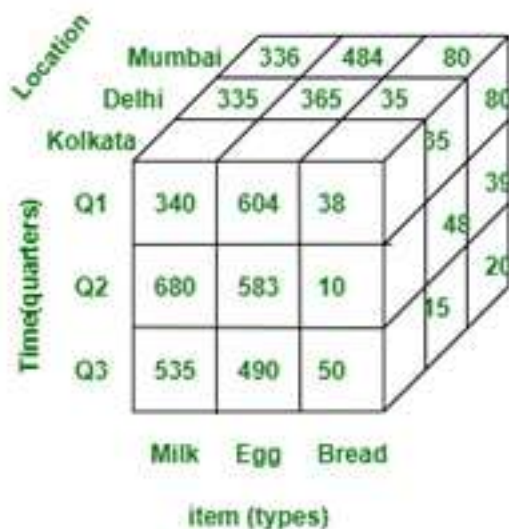
| Location = "Bangalore" | | | | |
|------------------------|--------------|-------|-------|------|
| Time (quarter) | Type of item | | | |
| | Jam | Bread | Sugar | Milk |
| Q1 | 350 | 389 | 35 | 50 |
| Q2 | 260 | 528 | 50 | 90 |
| Q3 | 483 | 256 | 20 | 60 |
| Q4 | 436 | 396 | 15 | 40 |

In the above given presentation, the factory's sales for Bangalore are, for the time dimension, which is organized into quarters and the dimension of items, which is sorted according to the kind of item which is sold. The facts here are represented in rupees (in thousands).

Now, if we desire to view the data of the sales in a three-dimensional **table**, then it is represented in the diagram given below. Here the data of the sales is represented as a two **dimensional table**. Let us consider the data according to item, time and location (like Kolkata, Delhi, Mumbai). Here is the table :

| Time | Location="Kolkata" | | | Location="Delhi" | | | Location="Mumbai" | | |
|------|--------------------|-----|-------|------------------|-----|-------|-------------------|-----|-------|
| | item | | | item | | | item | | |
| | Milk | Egg | Bread | Milk | Egg | Bread | Milk | Egg | Bread |
| Q1 | 340 | 604 | 38 | 335 | 365 | 35 | 336 | 484 | 80 |
| Q2 | 680 | 583 | 10 | 684 | 490 | 48 | 595 | 594 | 39 |
| Q3 | 535 | 490 | 50 | 389 | 385 | 15 | 366 | 385 | 20 |

This data can be represented in the form of three dimensions conceptually, which is shown in the image below :



1.4 Typical OLAP Operations:

In the multidimensional model, the records are organized into various dimensions, and each dimension includes multiple levels of abstraction described by concept hierarchies. This organization support users with the flexibility to view data from various perspectives. A number of OLAP data cube operation exist to demonstrate these different views, allowing interactive queries and search of the record at hand. Hence, OLAP supports a user-friendly environment for interactive data analysis.

Consider the OLAP operations which are to be performed on multidimensional data. The figure shows data cubes for sales of a shop. The cube contains the dimensions, location, and time and item, where the **location** is aggregated with regard to city values, **time** is aggregated with respect to quarters, and an **item** is

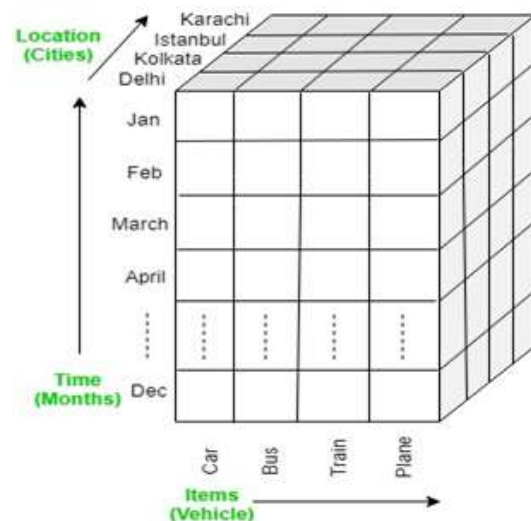
aggregated with respect to item types.

There are five basic analytical operations that can be performed on an OLAP cube:

1. Drill down: In drill-down operation, the less detailed data is converted into highly detailed data. It can be done by:

- Moving down in the concept hierarchy
- Adding a new dimension

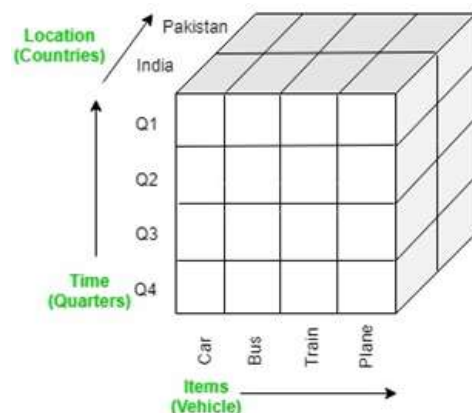
In the cube given in overview section, the drill down operation is performed by moving down in the concept hierarchy of *Time* dimension (Quarter -> Month).



1. Roll up: It is just opposite of the drill-down operation. It performs aggregation on the OLAP cube. It can be done by:

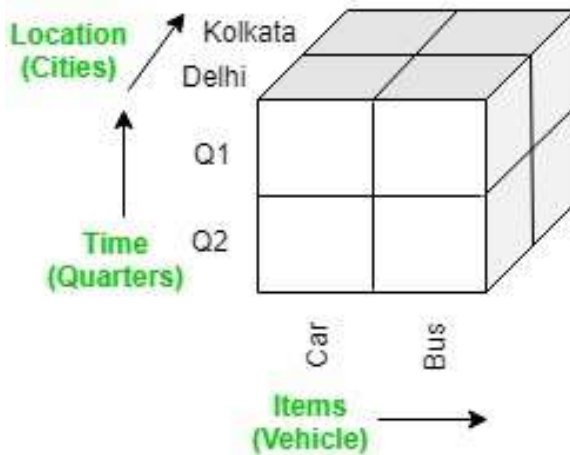
- Climbing up in the concept hierarchy
- Reducing the dimensions

In the cube given in the overview section, the roll-up operation is performed by climbing up in the concept hierarchy of *Location* dimension (City -> Country).

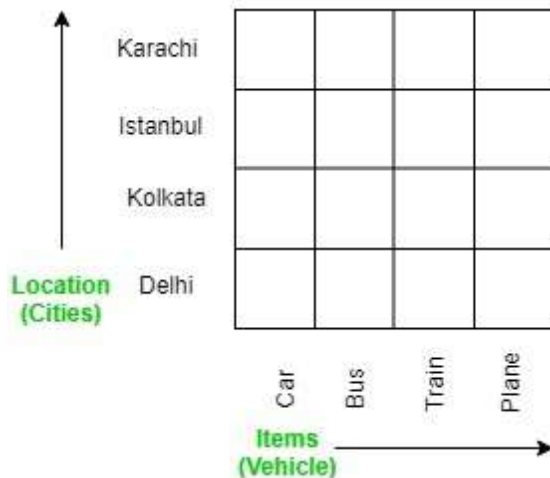


1. Dice: It selects a sub-cube from the OLAP cube by selecting two or more dimensions. In the cube given in the overview section, a sub-cube is selected by selecting following dimensions with criteria:

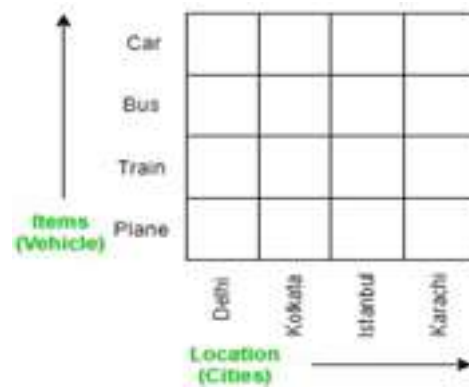
- Location = “Delhi” or “Kolkata”
- Time = “Q1” or “Q2”
- Item = “Car” or “Bus”



1. Slice: It selects a single dimension from the OLAP cube which results in a new sub-cube creation. In the cube given in the overview section, Slice is performed on the dimension Time = “Q1”.



1. Pivot: It is also known as *rotation* operation as it rotates the current view to get a new view of the representation. In the sub-cube obtained after the slice operation, performing pivot operation gives a new view of it.



2.5 Advantages of Multi Dimensional Data Model

The following are the advantages of a multi-dimensional data model :

- A multi-dimensional data model is easy to handle.
- It is easy to maintain.
- Its performance is better than that of normal databases (e.g. relational databases).
- The representation of data is better than traditional databases. That is because the multi-dimensional databases are multi-viewed and carry different types of factors.
- It is workable on complex systems and applications, contrary to the simple one-dimensional database systems.
- The compatibility in this type of database is an upliftment for projects having lower bandwidth for maintenance staff.

2.6 Disadvantages of Multi Dimensional Data Model

The following are the disadvantages of a Multi Dimensional Data Model :

- The multi-dimensional Data Model is slightly complicated in nature and it requires professionals to recognize and examine the data in the database.
- During the work of a Multi-Dimensional Data Model, when the system caches, there is a great effect on the working of the system.
- It is complicated in nature due to which the databases are generally dynamic in design.
- The path to achieving the end product is complicated most of the time.
- As the Multi Dimensional Data Model has complicated systems, databases have a large

number of databases due to which the system is very insecure when there is a security break.

Conclusion:

The Multi Dimensional Data Model allows customers to interrogate analytical questions associated with market or business trends, unlike relational databases which allow customers to access data in the form of queries. The *multidimensional data model* is important because it enforces simplicity.

References:

1. J. Han and M.Kamber: Data Mining Concepts and Techniques, Elsevier Pub. Indian Reprint, 2004.
2. R. Kimball: The Data Ware House Life Cycle Tool Kit, Wiley Press, John Wiley and Sons ASIA) Pvt.
3. Berson : Data Ware Housing, Data Mining and OLAP, Tata McGraw Hill.
4. Arun K. Pujari : Data Mining Techniques, University Press (Orient Longman)
5. <https://www.netsuite.com/portal/resource/articles/data-warehouse/data-warehouse.shtml>
6. <https://www.geeksforgeeks.org/multidimensional-data-model/>
7. <https://techbeacon.com/enterprise-it/key-elements-modern-data-warehouse>
8. https://www.dremio.com/glossary_term/data-warehouse/
9. Topic selected from the syllabus from the SGBAU, Amravati MCA PG Course 3yrs for the subject Data Mining and Data Warehousing.

Experimental Study On Power Generation From Waste Heat Using Thermoelectric Generator In Vehicles

Authors

Prakash Ingle I Vijay Gore I Dr.P.R.Wadnerkar

- Abstract -

This project presents the investigation of power generation using the mixture of waste heat and thermoelectric generators. A majority of thermal energy within the industry is dissipated as waste heat to the environment. This waste heat are often utilized further for power generation. The related problems of worldwide warming and dwindling fuel supplies has led to improving the efficiency of any process being a priority. One method to enhance the efficiency is to develop methods to utilize waste heat that's usually wasted. Two promising technologies that were found to be useful for this purpose were thermoelectric generators and warmth pipes. Therefore, this project involved making a bench type, proof of concept model of power production by thermoelectric generators using heat pipes and simulated hot air.

Key Words : Waste heat, waste heat Recovery, TEGs, Temperature Measurement, Voltage Measurement, Electricity etc.

- Introduction -

In recent years, an increasing concern of environmental problems with emissions, especially heating and therefore the limitations of energy resources has resulted in extensive research into novel technologies of generating electrical power. Thermoelectric power generators have emerged as a promising alternative green technology thanks to their distinct advantages.

Previous research shows that TEG as a waste heat harvesting method is beneficial. Due to distinct benefits of thermoelectric generators, they have become a promising alternative green technology. Thermoelectric generator direct converts waste-heat energy into electric

power where it's unnecessary to think about the value of the thermal energy input. The application of this technology also can improve the general efficiency the of energy conversion systems.

A thermoelectric power generator may be a solid state device that gives direct energy conversion from thermal energy (heat) thanks to a gradient into electricity supported "Seebeck effect". The thermoelectric power cycle, with charge carriers (electrons) serving because the working fluid, follows the elemental laws of thermodynamics and intimately resembles the facility cycle of a standard engine. Thermoelectric power generators offer several distinct advantages over other technologies.

They are extremely reliable (typically exceed 100,000 hours of steady-state operation) and silent operational since they need no mechanical moving parts and need considerably less maintenance;

- They are simple, compact and safe;
- They have very small size and virtually weightless;
- They're capable of operating at elevated temperatures;
- They're fitted to small-scale and remote applications
- Typical of rural power supply, where there is limited or no electricity;
- They are environmentally friendly;
- They are not position-dependent; and
- They are flexible power sources.

2. Problem Statement

Energy Intensive automobile require high temperatures to run the vehicles. There is often still heat 'energy' left as a byproduct of processing that is frequently simply wasted, vented through smokestacks, and into the air and created air pollution. To deal this waste heat power generation is very essential in every

automobile.

- Industrial Manufacturing
- Automobile/vehicles
- Steel, Chemicals, Paper, Cement, Glass, Food Processing
- Oil and Gas Processing
- Gas Compressor Stations
- Refineries etc.

3. Literature Survey :

1. Basel I. Ismail*, Wael H. Ahmed. Thermoelectric Power Generation Using Waste-Heat Energy as an Alternative Green Technology, May 2020, Recent Patents on Electrical Engineering 2009, 2, 27-39

In this paper, a background on the basic concepts of thermoelectric power generation is presented and recent patents of thermoelectric power generation with their important and relevant applications to waste-heat energy are reviewed and discussed.

2. 1PRASHANTHA.K, 2SONAM WANGO, SMART POWER GENERATION FROM WASTE HEAT BY THERMO ELECTRIC GENERATOR, Sep.-2018, International Journal of Mechanical and Production Engineering, ISSN: 2320-2092

In this paper, The application of this option green technology in converting waste-heat energy directly into electrical power can too improve the overall efficiencies of energy conversion systems. Heat source which is need for this conversion is less when contrast to conventional methods.

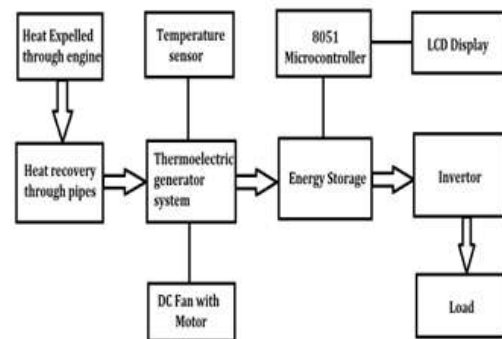
3. M.F Remelia,b*,L. Kiatbodina, B.Singha,b ,K.Verojporna,A.Datea, A.Akbarzadeha, Power generation from waste heat using Heat Pipe and Thermoelectric Generator, Aug 2017 The 7th International Conference on Applied Energy – ICAE2015. This paper presents the investigation of power generation using the combination of heat pipes and thermo-electric generators. A majority of thermal energy in the industry is dissipated as waste heat to the environment.

4. Kewen Li^{1,2}, Geoffrey Garrison³, Michael Moore³, Experimental Study on the Effects of Flow Rate and Temperature on Thermoelectric Power Generation, Feb 2019, 44th Workshop on Geothermal Reservoir Engineering Stanford University, SGP-TR-214

4. Objective :

1. To study the available literature and research on TEG application and its performance
2. To determine the appropriate suitable working of warmth Heat to electricity through TEG Module and collect the literature on the studies
3. To develop the experimental setup for the investigation
4. To conduct testing and sample run
5. To conduct final experimentation and compile
6. To analyse the Result.

5. BLOCKDIAGRAM



6. Working

- In this project concept it invented exhaust gas-based thermoelectric power generator for an automobiles application.
- In this invention, the exhaust gas gases in the pipe provide the heat source to the thermoelectric power generator. So, this project proposes and implements a thermoelectric waste heat energy recovery system from the exhaust heat from the running machineries in automobiles.
- This waste heat is strike to thermoelectric generator system which convert into electricity using seeback effect. The key is to directly

convert the heat energy from automobiles waste heat to electrical energy using a thermoelectric generator. This heat is measure with temperature sensor attached to it.

- In this project we are generating electrical power as non-conventional method by heat energy .Non-conventional energy systems.
- Non-conventional energy using is converting mechanical energy into the electrical energy. Here in this project a mechanical arrangement is made. Use of embedded technology makes this system efficient and reliable.
- Produce energy is passed through dc motor with turbine for representation purpose only.
- Same amount of electricity is stored in battery of capacity 12v.
- Controller based armament is made to monitor the voltage status of system.

Inverter module is applied, which convert DC to AC.

AC load is attached at the output of system.

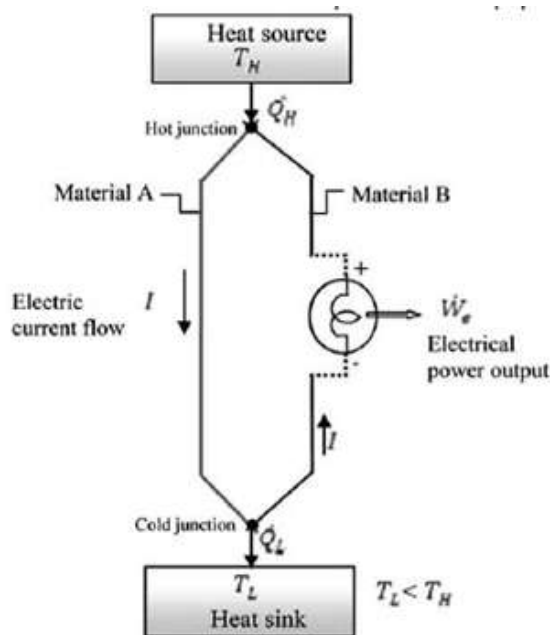


Fig. Working Principle

- TEG consists of one hot side and one cold side. The hot side with higher temperature, will drive electrons in the n-type leg toward the cold side with lower temperature, which cross the metallic interconnect, and pass into the p-type leg, thus developing a current through the circuit.
- If temperature difference is kept constant, then the diffusion of charge carriers will form a constant heat current, hence a constant electrical current.

7. Advantages :

1. Electricity can used for many purposes
2. Efficient and eliminate the grid searching
3. Promising technology for solving power crisis to an affordable extent.
4. Clean, Noise less, Cost is less .
5. This is a Non-conventional system ,No fuel is require
6. Easy maintenance, portable, Charging time is less (maximum temp)
7. Simple in construction, Pollution free, Reduces transmission losses.
8. Wide areas of application# Required less space
9. It can be use at any time when it necessary.
10. Less number of parts required.

8. Disadvantages :

1. Improper variation of temperature gradient difference may damage the TEG, Complex design.
2. Need proper maintenance every time.

9. Applications :

1. Thermoelectric Generators are basically used in where the power production is less.
2. In many vehicles amount of heat is executed and been wastage. We can used this hear for electricity using TEG.
3. In automobile vehicle produce heat that can be used for generating electricity by using TEG.
4. Recharge the battery where ever waste heat is obtained.
5. Self-charging battery by fixing the TEG at radiator or two wheeler silencers pipe.

Conclusion :

- Waste heat recovery entails capturing and reusing the waste heat from engine in automobile and using it for generating electrical work. It would also help to recognize the improvement in performance and emissions of the engine if these technologies were adopted by the production automobile.
- If this concept of thermoelectric system is taken to the practical level then there will be large amount of electricity can be generated, which will be used to run industrial load itself. Also large amount of wastage heat for pollution is also uses in this system in continue manner. And such automobile also somehow help to protect the environmental pollution.

References :

- 1) T. Endo, S. Kawajiri, Y. Kojima, K. Takahashi, T. Baba, S. Ibaraki, T. Takahashi, "Study on Maximizing Exergy in Automotive Engines," SAE Int. Publication 2007-01-0257, 2007.
- 2) K. NanthaGopal, RayapatiSubbarao, V. Pandiyarajan, R. Velraj, "Thermodynamic analysis of a diesel engine integrated with a PCM based energy storage system," International Journal of Thermodynamics 13 (1) (2010) 15-21.
- 3) HakanÖzcan, M.S. Söylemez, "Thermal balance of a LPG fuelled, four stroke SI engine with water addition," Energy Conversion and Management 47 (5) (2006) 570-581.
- 4) Jaydeep. V. Joshi1 and N. M. Patel (2012), Thermoelectric system to generate electricity from waste heat of the flue gases, Advances in Applied Science Research, 3 (2):1077-1084
- 5) G. Jeffrey Snyder and Tristan S. Ursell (2003), Thermoelectric Efficiency and Compatibility, Physical Review Letters 3 October 2003
- 6) Basel I. Ismail, Wael H. Ahmed (2009), Thermoelectric Power Generation Using Waste heat as an Alternative Green Technology, Recent Patents on Electrical Engineering, 2, 27-39
- 7) Adegbile A.S. (2013), Generation of Electricity from Gasoline Engine Waste Heat, Journal of Energy Technologies and Policy, Vol.3, No.5,
- 8) Peltier application notes 20050 SW 112th Ave. Tualatin, Oregon 97062
- 9) KTH Information and Communication Technology, Thermoelectric-Generator-Based DCDC Conversion Network for Automotive Applications. Master of Science Thesis Stockholm, Sweden 2011.Trita-ICT-EX-2011:58.Molanli
- 10) Rowe DM, Min G. Evaluation of thermoelectric modules for power generation. J Power Sources 1998; 73: 193-198.

Concept, Evolution, Philosophy and Performance measurement of Supply Chain Management

Dr.P.R.Wadnerkar | Prof. R. S.Pokle

- Introduction -

It has been universally acknowledged that no work can be meaningfully conceived and soundly accomplished without critical studying what already exists in relation to it, in the form of general literature and in the shape of outcomes of specific studies. It is the study of already established knowledge of the area that enables us to perceive clearly what is already lighted up in that area and what remains enveloped in darkness. Once we come to know the lighted up and dark part of an area and life, we can then do logically, purposefully, provided we have the necessary ability and will change any segment of its dark part into real knowledge. Review of literature helps to expand the present problem to enable us to see its importance and to relate it to many other studies. It helps to expand the present problem to enable us to see its importance and to relate it to many other studies. In fact, this is the real purpose of the review of related literature. Through the review of existing

research, one can find and define his problem clearly. The review helps to understand the earlier problem and in writing of this review, help to see how the problem is important and is going to fit into a wider pattern of universalizing the results of the present study. Apart from the above consideration, the review of literature goes a long way in building up and accumulating knowledge over a period through the reflection of primarily empirical studies. Whatever may be the mode of building up knowledge, it is invariably realized that no one can embark upon a new venture in any area of life without critically acquainting himself with-what already exists in the form of knowledge in that area. Needless to say, the study of related literature goes a long way in equipping the research with these understandings and knowledge which is necessarily needed to put one's own problem in a proper perspective and which are essential for a valid interpretation of the findings of one's own research efforts.

Definition of Supply Chain Management

Supply chain management is defined differently by different researchers. Some of the definitions are given in table 2.1

| Year | Author | Definition |
|------|-----------------|--|
| 1973 | Balton | SCM includes freight, transportation, warehouse, material handling, protective packing, inventory control, market forecasting and order processing. |
| 1982 | Dadzie | Supply chain distribution process concerned with efficient movement of finished product from end of the production line to customer and also movement of material from the source of supply to the beginning of production line. |
| 1989 | Lascelles& Dale | Poor communication and suppliers' lack of understanding of the buyer's requirement was barrier to quality improvement. |
| 1990 | Lyons | That reduce supplier base means closure, long term relationship can be established with few supplier who then play a critical role contributing to new service design and thus reducing cost and improve quality |
| 1993 | Monczkr | Good suppliers can help manufacturing during the development of new products and processes with long term quality improvements and cost reduction and can provide enhanced delivery performance. |
| 1993 | Lamming | Competitive advantages gained by Japanese companies through their use of long term, close |

| | | |
|------|-----------------------|--|
| | | relationship with suppliers and developed a four-phase descriptive model of the car industry that move towards closer buyer supplier relationship and partnership. He also published empirical data demonstrating the reduction in no. Of supplier in automobile industry. |
| 1994 | Burt, Larson | Close cooperation with suppliers quickly bring lower unit cost, longer terms, even greater quality at lower cost. |
| 1994 | Nayyar&Bantel | Agriculture Supply chain in Service industry are capable of rapid adaptation in response to unexpected and unpredicted changes and event, market opportunity and customer requirement |
| 1995 | Browsersox& Daugherty | Concept of formation in SCM perspective can be consistent with organizational perspective. |
| 1997 | Harwick | Supplier relations are a major issue in global supply chain management. The key phrase in today's supplier relations is a partnership alliance, which means working closely together for the mutual benefits of all parties. |
| 1998 | Powell | Development of suitable relations with inbound and outbound logistics suppliers and with customers is core of modern supply chain. Efficient transportation is necessary for SCM success at it involves the criteria of line, place, quantity, form and processing. |
| 1998 | Christopher, M. C | Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service Martin Christopher described the goal of supply chain management as to link the marketplace, the distribution network, the manufacturing process and |

| | | |
|------|------------------|--|
| | | the procurement activity in such as way that customers are serviced as higher levels and yet at a lower total cost.. |
| 1999 | Powell | Use internet base technology and its implementation for its supply chain management. |
| 1999 | Hewitt | Customer satisfaction, return on trading assets, and flexibility of supply chain management activities as the measurements for supply chain performance. |
| 2000 | Wisner & Choon | Supply chain management does encounter several obstacles. Some of these obstacles are: an increasing variety of products, decreasing product life cycles, more demanding customers, globalization, and difficulty executing new strategies. |
| 2000 | Wisner & Choon | Supply chain management projects are undertaken to respond to marketplace demand and intense global competition. |
| 2000 | Youngdahl | Four elements as necessary components in any supply chain effectiveness: planning, sourcing, making, and delivering. From a different |
| 2001 | Croom | Complex content of supply chain where inter connectivity of factor results in multiple relationships including supplier, client and distributor. |
| 2001 | Kehoe & Boughton | Internet provides the opportunity for demand data and supply capacity data to be visible to all companies within a manufacturing supply chain and, as such, companies are in a position to anticipate demand fluctuations and respond accordingly. |
| 2001 | Li & Chen | Successful, companies will not seek to achieve cost reductions or profit improvement at the expense of |

| | | |
|------|-------------------------------|---|
| | | their supply chain partners, but rather seek to make the supply chain as a whole more competitive. |
| 2001 | Mainardi& Gryna | Successful implementation of supply chain management has been credited with helping to cut, increase technological innovation, increase profitability and reduce risk, and improve organizational competitiveness. |
| 2002 | Faisst&Kanet | IT impact on supply chain management relationships with reference to internet base technology and SCM relevance |
| 2003 | Boyson, Corsi, Verb | Information technology can help overcome the problems that play many supply chain. It leads to reduction in number of errors that leads to efficiency in work place. The negative effects of uncertainty and are mitigating. The lower level of uncertainty is replaced by lower inventory level. Most systems are not enabled for this change. |
| 2003 | Rubian& Marquez | Supply chain management requires the integration of inter organization and intra organization in order to reach the coordination of the different types of flow that runs along the entire supply chain i.e. Knowledge information and material |
| 2003 | Mattsson&Wallenverg | SCM must respond prompt to the flow market place information and provide data for the customer orders, complaints, needs etc |
| 2005 | Rao, Ragu-Nathan &Ragu-Nathan | Conceptualized, developed and validated six dimensions of SCM practices including strategic supplier partnership. |
| 2012 | Wisner, Tan and Leong | “Supply chain management is the integration of trading partners’ key business processes from initial raw material extraction to the final or end customer, |

| | | |
|------|---------|--|
| | | including all intermediate processing, transportation and storage activities and final sale to the end product customer.” |
| 2016 | Harjeet | “Supply chain management is simply the management of transport or flow of goods and services, it also includes storage, shelf life, analysis of goods procured and goods sold logistics, etc. Supply chain management helps in planning and executing various supply chain activities of a particular organization to build up a net value of the organization, determining the current market trend related to the demand and supply of any goods or services and synchronizing the same for measuring the performance of the organization” |
| 2016 | Desai | “Supply chain management (SCM) is defined as the integration of key business processes from end users through original suppliers that provide products, services and information which add value to customers and other stakeholders”. |
| 2017 | Dias | “SCM is the task of integrating organizational units along a supply chain and coordinating materials, information and financial flows to fulfill customer demands to improve the competitiveness of the supply chain as a whole |
| 2017 | Wibowo | “Supply Chain Management is the key business processes from end-user through original suppliers that provides products, services, and information that add value for the customer and other stakeholders |
| 2018 | Kain | Supply Chain is defined as a system of organizations, people, activities, information, and |

| | | |
|------|--------|---|
| | | resources involved in moving a product or service from supplier to customer. Supply chain activities involve the transformation of natural resources, raw materials, and components into a finished product that is delivered to the end customer. The network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer |
| 2019 | Ellram | The process of planning, implementing and controlling the operations of the supply chain with the purpose to satisfy customer requirements as efficiently as possible. Supply chain management spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point-of-origin to point-of-consumption |

Table : Definition of SCM

Concept, Philosophy and Evaluation of SCM After Second World War there was a high need to increase production, most parts of the world were suffering from hunger. The world entered in the Productive era, most manufacturers gave priority to mass production to decrease unit production cost as the primary operations strategy. This was the first stage of the creation of economies of scale. However, these years 1950s and 1960s the concept of supply chain management was unknown. During these years new product development was slow and counted only in a firm's own technology and capacity. Inventory cushioned bottleneck operations to keep up a balanced line low, resulting in huge investment in work in process (WIP) inventory (Tan, 2001). Logistics cost were high as well. At a national level in the USA and UK, they accounted for 15% and 16% of the gross national product (Ballou 2007).

Furthermore, issues concern with purchasing was neglected by managers at that time, since purchasing was considered as a service to production (Famer, 1997). As mentioned above increasing production was the main aim of this period, little emphasis was on cooperative and strategic buyer-supplier partnership. According to Tan (2001), Sharing technology and ability with customers or suppliers was considered too risky and unacceptable. Tan 2001 argues that, in The 1970s, managers become aware of the huge WIP on manufacturing cost, new product development, quality, and delivery time. One of the factors of this increased awareness was the introduction of Manufacturing Resource Planning (MRP). The focus in this period changed; it is not just increasing production through spreading the fixed cost to a bigger output (economies of scale), rather, to increase performance. The introduction of IT (MRP) in planning

the resources of the firm proves this. In the 1980s and 1990s, firms deal with increased demands for 'better, faster, cheaper logistical service. As a result, many manufacturers outsourced logistics activities and their focus transferred to core competencies (Daugherty, 2011). According to Daugherty (2011), the outside specialist presented an economically viable means of achieving productivity and efficiency. Therefore, many manufactures went more for a relationship 'oriented approach with their supplier and customer. They understood the benefits of cooperative relationship with the other firms in the different chain levels (Stank at al, 1999). Stank (1999), show in their paper some of the advantages and benefits that this cooperative relationship had: synergy gain through shared ability and resources, better planning and support, exchange of information, and joint problem-solving. Another reason that influenced the partnership between suppliers 'buyer was the increased global competition (Tan, 2001).

In the 1990s was the introduction of Enterprise Resource Planning (ERP), this gave a boost to the evolution of the SCM and buyer-supplier relationship. Movahedi (2009) argues, while the previous IT resource planning systems (e.g. EDI – Electronic Data Interchange) used by manufactures were concern mainly with inter – organizational integration, ERP systems were mainly concern with intra – organizational integration. The evolution continues in the 21st century with the development of more advanced IT systems (internet-based solution systems) which are concerned for both inter-organizational integration and intra-organizational integration. Moreover, the relationship buyer ' suppliers in this period have gone one-step send, from normal partnership to long-term relationship and strategic alliances. Manufacturers and retailers now commonly exploit supplier strengths and technology in support of new product development, distribution channels, cost reduction etc (Morgan and Monczka, 1995). For example retailers like Tesco use supplier strengths and technology to make own-label products which give to Tesco overall image. The latest trend of evolution in the supply chain management is the movement towards systems of supplier relations over national boundaries and into other continents (Movahedi, 2009). Global Supply Chain Management (GSCM) is the latest concept introduced to the literature of SCM. Now

day's firms are much bigger than they used to be. They have achieved economies of scale and with the establishment of trade liberalization policies, they are internationalized their businesses to find the lowest sources of inputs and growing markets to sell their products. The concept of SCM is not enough for being efficient and competitive in the new environment that is why new concepts and management strategies (i.e. GSCM) are emerging. An integrated supply chain gives a much competitive advantage to the individual actors participating in the chain. Nowadays in the developed economies, there is a switch from firm 'firm competition to chain 'chain competition (Koh, 2007). This last sentence describes best how the supply chain management has evolved over the past decade, by making the different actors in a chain to run as one big entity.

Supply Chain Performance Measurement

Performance measurement is the choice and use of quantitative measures of capacities, processes, and outcomes to develop information about critical aspects of activities, including their effect on the public (Bernard J. Turnock). Many experts believe performance measurement is a very important part of supply chain planning and control. Appropriate performance measurement and performance management is an asset for enterprise resource management and business mission control. Performance measurement can give feedback on the effectiveness of the plans and their implementation (Chow, G. & Heaver, T.D. &Henriksson, L.E. 1994.). Therefore, after complete “Chain Supermarket + Agricultural Cooperative Organizations” project, Supply Chain performance needs to be evaluated to check the efficiency of operation needs and find out the existing issues to create a perfect foundation for further development.

Supply Chain Performance Measurement

Principle Many experts provide good Supply Chain Performance Measurement principles, and each of these says essentially the same thing. They might use different words to describe performance measurement or look at performance measurement from different angles, but the underlying concept is the same. Beamon (1996) presents a number of

characteristics that are found in effective performance measurement systems, and can therefore be used in evaluation of these measurement systems. These characteristics include: inclusiveness (measurement of all pertinent aspects), universality (allow for comparison under various

operating conditions), measurability (data required is measurable), and consistency (measures are consistent with organization goals).

Bernard J. Turnock and John T. Thompspon defined 8 key attributes of performance measure.

| | |
|--------------------------|--|
| Validity | A valid measure is one that captures the essence of what it professes to measure. |
| Reliability | A reliable measure has a high like hood of yielding the same results in repeated trials, so there are low levels of random error in measurement. |
| Responsiveness | A responsive measure should be able to detect change. |
| Functionality | A functional measure is directly related to objectives. |
| Credibility | A credible measure means is supported by stakeholders. |
| Understandability | An understandable measure means easily understood by all, with minimal explanation. |
| Availability | An available measure is readily available through the means on hand. |
| Abuse-proof | An abuse-proof measure is unli kely to be used against that which is, or those who are, measured. |

Based on the characteristics of agriculture products and “chain supermarket + agricultural cooperative organizations” project, certain principles will be followed during the thesis research

a) **Systematization** The Supply Chain Performance Measurement System of “chain supermarket + agricultural cooperative organizations” project is a multi-factor, multi-target system. So the measurement index needs to be visible in as full-scale as possible, indicating both the internal organizational performance and the connection with external environment.

a) **Practicality** The purpose of establishing “chain supermarket + agricultural cooperative

organizations” project Performance Measurement System is to find the bottlenecks of the Project, in order to optimize the project performance. Hence, the Measurement System should have clearly defined layer, a simple measurement method. The meaning of indicator should be simple and be easily understood.

b) **Accessibility** Performance Measurement is a complicated task. Before establishing an indicator, the accessibility and collectability of data should be considered.

c) **Integration of Descriptive Standards and Numerical Standard** Performance Standards can be descriptive or numerical. A descriptive standard

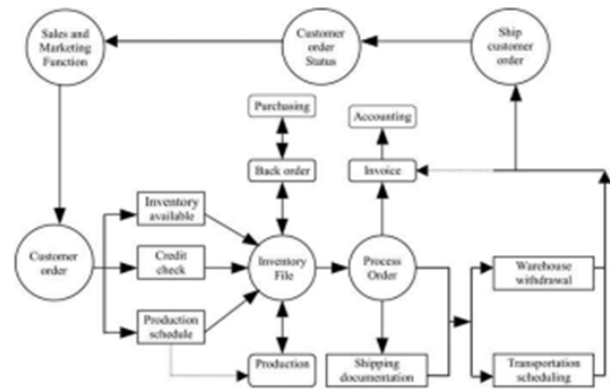
characterizes certain infrastructure components or certain activities – that is, certain capacities or processes – that are expected to be in place. A numerical standard establishes a quantifiable level of achievement. (Bernard J. Turnock and John T. Thomson) In this thesis research, we will combine these two standards, and use qualitative and quantitative index in order to build up the mathematical model for measurement system

2.1 Measures & Metrics of Supply Chain Performance

a) Metrics for Performance Evaluation of Planned Order Procedures For any firm, the first activity to begin with is to procure orders. A typical order path is shown in figure. From the figure, it is clear that the way the orders are generated and scheduled determines the performance of downstream activities and inventory levels. Hence, the first step in assessing performance is to analyze the way the order-related activities are carried out. To do this, the most important issues ± such as the order-entry method, order lead-time and path of order traverse ± need to be considered. The details of these are provided hereunder.

b) The Order Entry Method The order entry method determines the way and the extent to which the customer specifications are converted into useful information, and are passed down along the supply chain. According to MasonJones and Towill (1997), such information connects all levels of supply chain and affects the scheduling of all activities. Proper control of the order is possible, provided that the order entry method is capable of providing timely, accurate and usable data at various entry levels, and hence, can be used as a metric of performance measure.

c) Order Lead-Time The total order cycle time, which is called "order lead-time", refers to the time which elapses between the receipt of the customer's order and the delivery of the goods. This includes the following time elements:



Elements of order lead time

Total order cycle time = Order entry time (through forecasts/direct order from the customer) + Order planning time (Design + Communication + Scheduling time) + Order sourcing, assembly and follow up time + Finished goods delivery time. A reduction in the order cycle time leads to a reduction in the supply chain response time. This is an important measure as well as a major source of competitive advantage (Bower and Hout, 1988; Christopher, 1992). According to Towill (1997), it directly influences the customer satisfaction level. Equally important is the reliability and consistency of lead-time. Because of bottlenecks, inefficient processes and fluctuations in the volume of orders handled, there will be variations in activity completion times. The overall effect of this may lead to a substantial reduction in delivery reliability and customer service level. To deal with these, for example, the concept of "manufacturing cell" can be applied, in which well-integrated actions are performed in parallel by cross functional teams to effectively decrease the order lead-time and reduce the redundancies (Schonberger, 1990). In fact, Schonberger notes that, in one case study, Ahlstrom, a Finnish company, was able to reduce the order lead-time from one week to one day. It is safe to say that measurement of total cycle time is relevant both in the context of customer service, and to serve as a feedback to control the day-to-day operations.

a) The Customer Order Path The path that orders traverse is another important measure whereby the time spent in different routes and non-value adding activities can be identified, and suitable steps can be taken to eliminate them. For example, by tracing through the order path, the delays in paperwork, time consumed

while the product sits in the warehouse, time spent in checking and rechecking can be identified and eliminated using methods such as JIT, reengineering, and information technology (e.g. e-commerce, electronic data interchange (EDI) and the Internet).

b) Supply Chain Partnership and Related Metrics Fisher (1997) reports that a recent study in US food industry estimated that poor co-ordination among supply chain partners are wasting \$30 billion annually. This clearly indicates the importance of partnership in a supply chain. It is not uncommon for outsourcing to contribute nearly 50 per cent of the goods produced (Thomas and Griffin, 1996). Hence, faster introduction of a product now considerably depends on the reliability and quick responsiveness of suppliers. This helps to evaluate the level of competitiveness. A strong partnership emphasizes direct, long-term association, encouraging mutual planning and problem-solving efforts. Recently, buyer-supplier partnership has gained

a tremendous amount of attention from industries and researches, resulting in a steady stream of literature promoting it (e.g. Ellram, 1991; Toni et al., 1994; MacBeth and Ferguson, 1994; Graham et al., 1994; Landeros et al., 1995; New, 1996; Towill, 1997; Maloni and Benton, 1997). Most of these studies stress the partnership for better supply chain operations. Accordingly, an efficient and effective performance evaluation of buyer and/or suppliers is not just enough; the extent of partnership that exists between them needs to be evaluated and improved, as well. An effort is needed to draw a clear picture of the partnership in the supply network with the objective of preparing steps to increase efficiency and speed. A set of criteria/parameters needs to be considered in evaluating partnership. For example, the level of assistance in mutual problem solving supports the buyer-supplier partnership development. This also shows the extent of partnership that exists between them. The parameters that measure the level of partnership are summarized in Table below

| Partnership Evaluation Criteria | References |
|---|---|
| Level and degree of information sharing | Toni et al. (1994), Mason-Jones and Towill (1997) |
| Buyer-vendor cost saving initiatives | Thomas and Griffin (1996) |
| Extent of mutual co-operation leading to improved quality | Graham et al. (1994) |
| The entity and stage at which supplier is involved | Toni et al. (1994) |
| Extent of mutual assistance in problem solving efforts | Maloni and Benton (1997) |

Table : Partnership Evaluation Criteria

a) Production Level Measures and Metrics Once orders are planned and the goods sourced, the next step is to make/ assemble them. The performance of this "make/assemble" has a major impact on product cost, quality, speed of delivery, and on delivery reliability and flexibility (Mapes et al., 1997; Slack et al., 1995). As an important part of SCM, the performance of the production process also needs to be measured, managed, improved, and suitable metrics for it should be established

b) Range of product and services

According to Mapes et al. (1997), a company that manufactures a wide range of products is likely to introduce new products at a slower rate than companies with a narrow product range. Based on a statistical analysis of "UK Best Factory Awards Database," these authors show that plants that manufacture a wide range of products are likely to perform poorly on added-value per employee, speed and delivery reliability. Furthermore, a company with an extensive product portfolio less frequently breeds new products of innovation. This indicates the impact of "product range" on supply chain performance, and so, it needs to be measured. The same analysis can be applicable for services, as well.

According to Fisher (1997), the selection of a right supply chain strategy depends upon the nature of product variety and innovation. This also implies that the range of products and services acts as an important strategic metric, and hence, it should be considered in performance evaluation.

c) Capacity utilization According to Wild (1995): "All the operations planning takes place within the framework set by capacity decisions." From the above statement, the role of "capacity" in determining the level of all supply chain activities is clear. This

highlights the importance of measuring and controlling the capacity utilization. According to Slack et al. (1995), capacity utilization directly affects the speed of response to customers' demand. Hence, by measuring capacity, gains in flexibility, lead-time and deliverability will be achieved.

d) Effectiveness of scheduling techniques

Scheduling refers to the time or date at which activities are to be undertaken. Such fixing determines the manner in which the resources flow through an operating system. The effectiveness of this has a significant impact on the performance of a supply chain. For example, scheduling based on JIT has a tremendous influence on inventory levels. Similarly, computer-generated schedules based on systems like MRP, and more recently ERP, give a detailed and correct bill of materials. These impact the effectiveness of purchasing, throughput time, and batch size. However, the application of such systems should not be limited to scheduling of shop floor activities and comparing their performance with others. In the case of supply chains, since the schedule depends heavily on customer demand and supplier performance, the scheduling tools/methods should also be viewed from that context.

These are the high-performance metrics that target broader functional areas of the supply chain as well as its total attributes such as supply chain response time. For instance, a firm that is interested in benchmarking and performance evaluation must first analyze its performance using the metrics discussed. Once strong and weak areas are identified, and then other metrics can be employed to gain greater insights into achieving the goals as underlined in the study. Table shows Factors affecting to the effectiveness of scheduling techniques of SCM

| Performance Metric | Financial | Non-Financial | References |
|---|-----------|---------------|--|
| Total cash flow time | | √ | Stewart (1995) |
| Rate of return on investment | √ | | Christopher (1992); <u>Dobler</u> and Burt (1990) |
| Flexibility to meet particular customer needs | | √ | Bower and Hout (1988); Christopher (1992) |
| Delivery lead time | | √ | Rushton and Oxley (1989) |
| Total cycle time | | √ | Cristopher (1992); Stewart (1995) |
| Level and degree of buyer supplier partnership | √ | | Toni et al. (1994); Mason-Jones and <u>Towill</u> (1997) |
| Customer query time | | √ | |
| Extent of co-operation to improve quality | √ | | Graham et al. (1994) |
| Total transportation cost | √ | | <u>Rushton</u> and Oxley (1991) |
| Truthfulness of demand predictability/forecasting methods | | √ | Fisher (1997); Harrington (1996) |
| Product development cycle time | | √ | Bower and <u>Hout</u> (1988) |
| Manufacturing cost | √ | | Wild (1995) |
| Capacity utilization | | √ | |
| Information <u>carrying</u> cost | √ | | Stewart (1995) |
| Inventory carrying cost | √ | | Levy (1997); Lee and <u>Billington</u> (1992); Stewart (1995); <u>Dobler</u> and Burt (1990); Slack et al. (1998); Pyke and Cohen (1994) |

Table :Performance Metric

Challenges for Supply Chain Performance Measurement

One of the main challenges in SCM performance measurement is that measures are mainly internal logistics performance measures and do not capture the way the SC has performed as a whole. Internal logistics measures such as fill rate, lead-time, on time performance; damage and responsiveness do not measure the whole SCM performance [Lambert D.M., Pohlen T.L 2001]. There are some in-depth problems of PMSs in the SC context :

- A. The lack of a balanced approach in integrating financial and non-financial measures.
- B. The lack of system thinking, in which a SC must be viewed as a whole entity and the measurement system should span the entire SC.
- C. The loss of the SC context. According to Lin [2010], there are four challenges in SC performance measurement. First, the majority of articles are focused on the study of intra organizational performance – measures that do not measure SC performance as a whole. Secondly, the previous research did not consider the variation of measured values. The decision makers found it difficult to find real performance

values, identify weak areas, take corrective actions, and make continual improvements. Thirdly, no common metrics existed for evaluating different processes on the same scale. Different characteristics of associated processes cannot be compared without using the correct metrics. Fourthly, the process teams should have motivation, capacity, and authority to improve processes and their results. Human attributes such as cooperation, skill, communication, etc. should have been considered as important dimensions of SC performance, but previous researches did not integrate these human attributes into the SC performance measurement model. Almost every researcher state in their articles that SCM performance measurement is not studied enough. Furthermore, almost every researcher identifies that more research regarding SCM performance or capability measurement should be carried out. Research-related issues are the factors influencing the successful implementation of performance

measurement systems [Bourne M., Mills J., Wilcox M., Neely A., Platts K 2000] the forces which shape the evolution of performance measurement systems [Kennerley M., Neely A 2002] and the way performance measurement systems are maintained over time so they remain aligned with dynamic environments and changing strategies [Bourne M., Mills J., Wilcox M., Neely A., Platts K, Kennerley M., Neely A 2002]. Gunasekaran A., Patel C., McGaughey R.E, 2004 state that problems in performance measurement frame of references include:

- a. Incompleteness and inconsistencies in performance measurement and metrics.
- b. Inability to represent a set of financial and nonfinancial measures in a balanced framework, some measures concentrating on financials, others concentrating on operational measures.
- c. Large number of metrics, makes it difficult to identify the critical few among trivial many
- d. Inability to connect the strategy and the measurement
- e. Biased focus on financial metrics.
- f. Too much inward looking. It is very clear that SC performance should be measured using various types of approaches. In measuring SC performance, it seems to be relevant to use the following Supply Chain operations: plan, source, make, deliver and return. Furthermore, there should be financial and non-financial metrics as well as quantitative and qualitative measures. SCM should be measured at multiple levels [Shepherd C., Gunter H]. It is important to develop more non-financial metrics due to the fact that these metrics can present more information than the basic financial metrics. The total SC performance measurement is challenging. However, even if it is challenging it is possible.

Existing Models Proposed by various Authors

a) Pittiglio Rabin Todd's Model [1995] The Supply Chain Operations Reference – model (SCOR) has been developed and endorsed by the Supply–Chain Council (SCC) as the cross-industry standard for supply

chain management. The SCC was established in 1996 by Pittiglio Rabin Todd and McGrath (PRTM) and Advanced Manufacturing Research (AMR), and initially included 69 voluntary member companies. The SCC is an independent, not-for-profit, global corporation with membership open to all companies and organizations interested in applying and advancing state-of-the-art supply chain management systems and practices. All who use the SCOR-model are asked to acknowledge the SCC in all documents describing or depicting the SCOR-model and its use. All who use SCOR are encouraged to join the SCC, both to further model development and to obtain the full benefits of membership. The SCOR model is still being developed the latest version of SCOR-model is numbered 7.0. SCOR is a management tool. It is a process reference model for supply-chain management, spanning from the supplier's supplier to the customer's customer. The SCOR-model has been developed to describe the business activities associated with all phases of satisfying a customer's demand. By describing supply chains using process building blocks, the model can be used to describe supply chains that are very simple or very complex using a common set of definitions. As a result, disparate industries can be linked to describe the depth and breadth of virtually any supply chain. The model has been able to successfully describe and provide a basis for supply chain improvement for global projects as well as site-specific projects. The first step the SCC made was to establish a standard vocabulary and a notation that could be used to describe any supply chain. Therefore, the first step for a team that wants to use SCOR must be acquiring the same vocabulary, to assure they all talk about the same things in the same way. SCOR methodology assumes that all supply chain processes can be subdivided into one of five general subtypes: Plan, Source, Make, Deliver, and Return. Complex supply chains are made up of multiple combinations of these basic processes. SCOR also defines 3 levels of details (top, configuration and process element). In top the scope and content for the supply chain are defined, at the configuration level the company's supply chain is configured in order to company strategy, at the process element level there is a “fine tuning” of company's operations strategy and

consists of: process element definitions, inputs–outputs, process performance metrics, best practices. SCOR uses the historical data of the supply chain to see how it performs and develops; it defines five generic performance attributes and three levels of measures that the analysts can use. Once a company has a good understanding of the strengths and weaknesses of the As-Is process, they are in a good position to think about how they want to compete and what they will have to do to implement regardless from a supply chain strategy they choose. In essence, the SCOR methodology helps companies to create new designs, and then assumes that individual companies will determine how to implement the changes.

b) Kaplan& Norton's Model [1992]

Kaplan and Norton's Balanced Scorecard is a concept still widely used and respected in today's business environment. What follows, provides guidance and advice on the development and implementation of a Balanced Scorecard for those organizations considering the introduction of a Scorecard or those that have adopted the approach with limited success. It is applicable for both public and commercial enterprises. One of the major strengths of the Balanced Scorecard is its adaptability. Indeed, the originators make it clear that their four quadrants are only a template. Although the term, Balanced Scorecard, might conjure up an initial impression of a table of measurements or key performance indicators, it is in fact a process comprising of a number of carefully interlinked steps. The real power of a properly developed Balanced Scorecard is that it links the performance measures to the organization's strategy. Organizations implementing a Scorecard process are forced to think clearly about their purpose or mission; their strategy and who the stakeholders in their organization are and what their requirements might be. They also need to evaluate quite clearly the time scales in which they hope to achieve their strategic objectives.

c) Bradley Hull's Model [2004] Bradley Hull develops a model that describes the performance of supply chains based on their elasticities of supply and demand. The model can be used to predict a supply chain's ability to respond to supply interruptions, cost increases, and demand shifts, while also quantifying the degree to which it is prone to the bullwhip effect. The

bullwhip effect is a behavioral phenomenon by which orders are distorted as they are transmitted through the chain. Four types of supply chains are identified and their distinct operating characters are examined. The impact of rival firms and the impact of a decoupling point on supply chain performance are also examined.

Measures of Supply Chain & Its Evaluation Criteria

a) Ernst &Whinney [1987]

According to his survey SCM of Manufacturing units and service industry relies to a great extent on proper logistics support. Logistics is the process of planning, implementing and controlling the efficient, cost effective flow and storage of raw materials This study seeks to investigate the following research questions

- A.** What are the underlying critical dimensions of SCM?
- B.** Does a positive relationship exist between SCM dimensions amongst each other and SCM performance measures?
- C.** What specific dimensions of SCM performance are directly related amongst each other and to organizational performance measures?

b) Ford, D. [1990] Focused on empirically-driven research with episodic interactions (related to a transaction of industrial goods) within relationships (described in terms of adaptations, commitments, trust and conflict) between companies. Four theoretical assumptions underpin the interaction model produced:

- A.** Buyer and sellers are active participants.
- B.** Secondly, buyer-supplier relationships are frequently long term, enduring and involve a complex pattern of interactions between companies.
- C.** Thirdly, these links often become institutionalized into expected roles which can involve both cooperation and conflict. And finally, the focus of such relationships is on raw material or component supply. Accordingly, the buyer-supplier relationship forms the unit of analysis and equal attention is paid to industrial marketing and purchasing.

c) Christopher, M.C. [1998] Martin Christopher described the goal of supply chain management as to link

the marketplace, the distribution network, the manufacturing process and the procurement activity in such a way that customers are serviced at higher levels and yet at a lower total cost.. He found out how service levels can be used to segment markets and explores appropriate measures to assess logistics productivity and service performance. It provides information on how to map and audit logistics systems, describes how greater supply chain responsiveness can be achieved through lead time reduction

d) Wisner and Choon; Beamon; Christopher [2000] According to this perspective, supply chain management projects are undertaken to respond to marketplace demand and intense global competition. Wisner and Choon (2000), for instance, suggested that the intense global competition of the past decade has led many organizations to create cooperative, mutually beneficial partnerships with suppliers, distributors, retailers, and other firms within the supply chain. The objective of those partnerships has been to offer lower-cost, higher-quality products and services with greater design flexibility.

e) Chen, I. J. and Paulraj, A. [2004] Identified, consolidated supply chain initiatives and factors to develop key supply chain management. They identified constructs for supply uncertainty, demand uncertainty, customer focus, competitive priorities, supply network structure, long-term relationships, communication, cross-functional teams, supplier involvement and logistics integration.

f) Kemppinen, K. and Vepsäläinen, A. P. J. [2003] Drawing upon survey research conducted across supply chain in the electronics, mechanics and paper industries, and this study argues that the management and structure of 1990s supply chains has transformed from the linear flow of materials to a multi-tier structure, enabled by information sharing and collaborative planning. A distinction is drawn between efficiency-driven and platform-based networks. Though coordination efforts remain limited to order process and operational scheduling, specialization and outsourcing are identified as the preconditions for networking. Typical product factories are being replaced by high volume component suppliers, flexible assembly and installation operations. Service relationships have polarized from general services into internet-based self-serve and expert provision. Firms need to position themselves strategically either as integrators or general component developers. The geographical scope of operations will be determined by functional focus.

g) Storey, J., Emberson, C., Godsell, J. and Harrison, A. [2006] It was a detailed study of supply chains which encompassed 72 companies across Europe. It suggests that supply management is at best, still emergent. Four drivers of supply management were identified: globalization, outsourcing, fragmentation and market polarization. Substantial gaps were revealed between theory and practice.

Brief Description of Available Literature on SC Evaluation

| Author | Year | Methodology (Frameworks/ methods / models) |
|--|------|---|
| Burt, larson | 1989 | <ul style="list-style-type: none"> • Novel Acoustic Backscatter Array |
| KeahChoon Tan | 2000 | <ul style="list-style-type: none"> • Strategic vision of supply chain management. • A framework of supply chain management literature. |
| Douglas M. Lambert Martha C. Cooper | 2000 | <ul style="list-style-type: none"> • Supply chain management framework: elements and key decisions • Types of intercompany business process links • Supply chain management: the disconnects • Supply chain management: fundamental management components • An illustration of a supply chain combining the integrated and managed business process links • Network structure linkages for four tiers of a supply chain |
| Agostino Villa | 2001 | <ul style="list-style-type: none"> • Proposes market-oriented programming such as the multi-agent-based concept to facilitate the solution of the distributed management problem |
| Li and chen | 2001 | <ul style="list-style-type: none"> • The order information sharing policy • The demand information sharing policy • The inventory information sharing policy. • The shipment information sharing policy. • Products assume their identity after stage k. • Benefits comparing Models |
| Injazz J. Chen Antony Paulraj | 2003 | <ul style="list-style-type: none"> • A research framework of supply chain management. • The instrument development process. |
| RohitBhatnagar Amrik S. Sohal | 2003 | <ul style="list-style-type: none"> • Sampling procedures • Analytic technique • Analysis and findings |

| | | |
|--|------|--|
| | | <ul style="list-style-type: none"> • Supply chain performance measures • Reliability analysis |
| Mattsson&wallenverg | 2003 | <ul style="list-style-type: none"> • The Supply Chain Strategizing Was Investigated by A Case of Customer Ordered Production inBorgstrom’S (2010) Doctoral Thesis |
| A. Gunasekaran C. Patel Ronald E.McGaughey | 2004 | <ul style="list-style-type: none"> • Empirical analysis • Planning performance evaluation metrics • Supply link evaluation metrics • Production performance evaluation metrics • Delivery performance evaluation metrics |
| Mark A.Vonderembse MohitUppal Samuel H. Huang John P. Dismukes | 2005 | <ul style="list-style-type: none"> • agile supply chain |
| Suhong Li S. SubbaRao T.S. Ragu-Nathan Bhanu Ragu-Nathan | 2005 | <ul style="list-style-type: none"> • Theoretical framework linking SCM practices constructs and performance • Illustrative example of measurement model testing discriminate validity. • Illustrative example of structural equation model testing predictive validity. |
| Mark A. Vonderembse MohitUppal Samuel H. Huang John P. Dismukes | 2006 | <ul style="list-style-type: none"> • Black and Decker’s lean supply chain • IBM’s agile supply chain • DaimlerChrysler’s hybrid supply chain • Strategic partnership with Dana Corporation |
| Shao-hui dong Bao xi Li-natian Qiu-guohuang Hong-xiachen | 2006 | <ul style="list-style-type: none"> • The agent-based architecture for SCM |
| SooWook Kim | 2006 | <ul style="list-style-type: none"> • Derives organization types for supply chain management according to the formalization and centralization level of an independent department responsible for supply chain management (SCM) activities |
| Taco van der Vaart Dirk Pieter van Donk | 2007 | <ul style="list-style-type: none"> • Performance Model |
| John w. Upson David j. Ketchen Jr. R. Duane Ireland | 2007 | <ul style="list-style-type: none"> • Avon’s SSCM |
| Hsiao Ching Chen Hui Ming Wee Yao-Hung Hsieh | 2009 | <ul style="list-style-type: none"> • The MLP ANN scheme • Optimal hybrid inventory decision |
| Frank Teuteberg, David Wittstruck | 2010 | <ul style="list-style-type: none"> • Framework of Analysis (cf. Dibbern et al. 2004) • Research Process (vomBrocke et al. 2009, Webster and Watson 2002.) • Research Perspectives on sscm |
| Dominique Estampe Samir Lamouri | 2010 | <ul style="list-style-type: none"> • Supply chain maturity grid. |

| | | |
|--|------|---|
| Jean-Luc Paris SakinaBrahim-Djelloul | | |
| Noor Aslinda Abu Seman NorhayatiZakuan Ahmad Jusoh MohdShoki MdArif | 2012 | <ul style="list-style-type: none"> • Research direction framework |
| Ashwini Sharma1, Dixit Garg2) Ashish Agarwal3) | 2012 | <ul style="list-style-type: none"> • Supply chain structure • Factors influencing the supply chain • Methodologies adopted by researchers • Papers reviewed from various international journals |
| RamazanErturgut | 2012 | <ul style="list-style-type: none"> • The Outsourcing in The Supply Chain Management and 3rd Party Service Providers • The Freight Forwarder Operations in Providing Logistic Service • The Necessity of Operational Service Providers in Future Logistic Environment |
| KannanGovindan HamedSoleimani DevikaKannan | 2014 | <ul style="list-style-type: none"> • A generic form of forward/reverse logistics • Distribution of publications per year across the period of the study • Distribution of publications based on different journals • Deterministic and nondeterministic approaches. |
| Aziz Muysinaliyev SherzodAktamov | 2014 | <ul style="list-style-type: none"> • A Comparison of a Value Chain with a Supply Chain • The cause-effect diagram: 20 performance indicators in the supply chain of SCC* • A typical Tourism Supply Chain within a destination |
| Constantin Manuel HILA Oana DUMITRA CU | 2014 | <ul style="list-style-type: none"> • In sourcing and Outsourcing • Outsourcing life-cycle |
| Rubian and marquez 2003 | 2015 | <ul style="list-style-type: none"> • propose dynamic modeling options to connect customer value to business targets • financial Collaboration modeling |
| Y. Artsiomchyk H. Zhivitskaya | 2015 | <ul style="list-style-type: none"> • The Supply Chain Model as a Complex System • Background and mathematical model |

Table :Evolution of supply chain management suggested by different researchers

Gaps in Literature

Following Table consist of objectives and suggested by many researchers:

- a) The business literature has done much to uncover the realities of the offshoring equation, but in the process, it has reached into the areas of business model design and supply chain risk management. A future area of potential

- b) development is to integrate the findings
Some leading organizations adopt a strategic approach to managing the value chain, such as forming strategic alliances with suppliers and distributors instead of vertical integrating; inter-company competition is elevated to inter-supply chain competition.
- c) A top priority should be research to develop a

normative model that can guide managers in their efforts to develop and manage their supply chains. It is much easier to write a definition for SCM than it is to implement.

- d) For direct industrial practice, is to analyze the impact of the deferent planning and scheduling procedures on the supply chain efficiency and electiveness, thus offering suggestions to managers for a better integration of their respective stages.
- e) Many suppliers, particularly the second-tier or third-tier suppliers, usually are smaller companies with limited financial resources and technical expertise, it is infeasible and very expensive to use real demand information to drive decisions. Hence, the use of one-stage inventory information sharing to improve service level and responsiveness is appropriate for them.
- f) The integration of the requirements for an eco-efficient product in already highly complex product development processes increases complexity once more and brings the today's development processes and tools to their limits.
- g) Uncertainty has a significant negative effect on supply chain performance. Managers should assess different locations in terms of the potential uncertainty that they may cause in the firm's supply chain.
- h) Retailer communicates his risk aversion limits and the demand distribution to the supplier. The important question to check here is whether the retailer has an incentive to cheat the supplier by telling that he is more risk-averse than he actually is, and by exaggerating his demand distribution.
- i) Proportion of conceptual work seemed to not be justified by a discussion of the fundamental assumptions of SCM (theory, methodology, philosophy of science), as references to this literature are limited in the sample, to say the least.
- j) As markets begin to grow and customers demand rapid change and high levels of innovation, strategic partnerships among supply chain members are essential to create the

knowledge-rich environment needed to support these efforts.

- k) Corporate entrepreneurship is critical to long-term survival. However, developing corporate entrepreneurship often requires fundamental change at several levels of the firm.
- l) AI concept is employed to play different rules in the SC system and a BP ANN is used to derive the ideal inventory decision
- m) The stock level obtained is the ideal value that is necessary to find the stock levels needed to be hoarded at the holding points in order to make sure minimal supply chain cost
- n) Public organizations need to differentiate their known awkward and bureaucracy intensely supply process to be able to make use of the new generation suppliers and them are especially obliged to say this to their supply and logistic service providing agreements.

In this chapter the attempt has been made to check the literature on Supply Chain Management. We have presented a literature review for 45 research papers for the period between 2005 and 2016. Articles for review were chosen in a random way where the only criterion for the research topic was to be done after 2005. Some reviewed papers are from same class, but we did not take into consideration papers with absolutely the same results. So papers can be very close in results, but there is no same result papers included.

We tried to use the discussion method in the analysis of these papers and had no attempt to make any quantitative analysis, which can be used in future researches. During the selecting of research papers for literature review we used simple methods trying to select ones from different sources. The main source for using these papers was the Science Direct internet portal for research papers and other Internet journals on Operations Management. In order to have a broader view on SCM we reviewed papers which have different objects, were we can divide them into such groups:

1. Papers which research SCM in context of its improvement and quality,
2. Papers which focus on sustainability of SC and logistics,
3. Papers which based on comparison of SCs or comparison of implementing methods on

- different locations,
4. Papers which look towards SCM through different industry.
 5. Finally, the most important number of researches are about methods of supply and efficiency of SCs, which in our opinion make greater contribution for understanding of SCM.

Concluding remark

To find out the research area, it is necessary to have a previous study. A literature review of previous happened work has been done by referring more than 50 standard quality research paper publish within a decade. Studied conserved was not from only Agro implements manufacturing industries but also other industrial sectors like small medium and large-scale industries of food production and others.

Basic Moto behind literature survey it's too aware reviewer about the things that happened in the past and the challenges exist in the past are removed in propose research methodology. It is intended for every user to go for a literature survey before to put objectives for current research.

References :

- 1) B. K. Dileep, R. K. Grover, and K. N. Rai, "Contract Farming in Tomato: An Economic Analysis, "Indian Journal of Agricultural Economics, 57(2):197-210, (April-June 2002).
- 2) B. Samuel, C. J. Philip, and J. L. Timothy, "Coordinating the supply chain in the agricultural seed industry," European Journal of Operational Research, vol. 185, no. 1, pp. 354–377, 2008.
- 3) Beamon, B. M., "Supply Chain Design and Analysis: Models and Methods", International Journal of Production Economics, Vol. 55, 281-294, 1998.
- 4) Bechini A., Cimino M. G.C.A., Marcelloni F., Tomasi A., (2007), Patterns and technologies for enabling supply chain traceability through collaborative e-business, Information and Software Technology, Vol. 50, No.4, pp. 342 – 359. 5.
- 5) Berry, D., Towill, D.R., Wadsley, N., 1994. Supply chain management in the electronics product industry. International Journal of Physical Distribution & Logistics Management 24 (10), 20-32. 6.
- 6) Birthal, P.S., and V.K. Taneja. 2006. Livestock sector in India: Opportunities and challenges for smallholders. Paper presented in the international workshop on Smallholder livestock production in India: Opportunities and challenges. Indian Council of Agricultural Research, New Delhi; and the International Livestock Research Institute, Nairobi. New Delhi: January 31-February 1, 2006.
- 7) Brintrup A., Ranasinghe D., & McFarlane D., (2010), RFID opportunity analysis for leaner manufacturing, International Journal of Production Research, Vol. 48, No.9, pp.2745-2764.
- 8) Carine Pionetti, Sowing Autonomy: Gender and Seed Politics in Semi-arid India, International Institute for Environment and Development (2005) (<http://www.iied.org>).
- 9) Chircu, A.M. and Kauffman, R.J., Strategies for Internet Middlemen in the Intermediation/Disintermediation/Re-intermediation Cycle, Electronic Markets, 9, 1/2, (1999), 109-117.
- 10) Christopher, M., 1992. Logistics and Supply Chain Management. Pitman Publishing, London
- 11) Clemons, E., Reddy, S.P., and Row, M.C., The Impact of Information Technology on the Organization of Economic Activity: The Move to the Middle Hypothesis, Journal of Management Information Systems, 10, 2, (1993), pp.9-36.

Ergonomic Intervention for Sewing Workstation

Authors

Dr. S.M.Tondre | Dr.P.R.Wadnerkar

- Overview -

In the era of globalization, India is largest developing democracy heading towards superpower. The rapid industrial developments of the nation resulted socio-economic development and sustainable economy with hand to hand resulted health related issues which changes the Indian occupational morbidity drastically. In the vibrant mode of rapid industrial growth, Indian economy has preponderance of informal and unorganized sector both in terms of number of workers and enterprises, where the workers facing traditional occupational health problems and inadequate medical care. Health at the workplace and healthy working conditions are crucial factor for progress of individual as well as enterprise.

Occupational safety and health concern about maintaining or protecting health, safe working conditions and welfare of individuals engaged in work or employment. The goal of occupational safety and health programme is to spread and enforce a healthy and safe working environment. According to World Health Organization (1948) 'health is state of complete physical, mental and social well being not merely the absence of diseases or infirmity'. The health and safety of employees is the important aspect to enhance the productivity by maintaining smooth and effective functioning of the organization.

The invention of hand operated sewing machine by Elias Howe in 1846 and further development by Isaac Singer in 1859 open the door for the garment production business. Consequently the concept of Ready-to-Wear garments came after 1860 & the garment production business started to grow and develop in the beginning of 20th century.

In India, ready-made garment industry begins

during the first half of the twentieth century, later on it shows remarkable growth during the last decades. According reports it is the second highest contributor to India's export basket, after gems and jewellery (Uchikawa, 1998). The contribution of textiles sector in India is about 14 per cent to industrial production, 4percent to gross domestic product (GDP), and 27 per cent to the country's foreign exchange inflows. The ready garment industry is a big source of employment, it provides direct employment to over 45 million people, second only to agriculture as an employer. The readymade garment (RMG) sector is one of the largest source of employment in India and is a one of the driving force of the national economy. Over the past two decades, it has transitioned from a largely informal to a largely formal, factory-based industry, highly dependent on labour inputs [E1].

The garment sector offers entry-level jobs for unskilled labourers. It is the second largest source of employment for the rural and urban population due to growing demand. The low skill requirements and large opportunity for employment in garment sector made it an important source of non-agrarian employment. It has mushroomed in the developing countries, especially in the urban and suburban areas, because of the availability of cheap& unskilled labour. Moreover, it is a sector where relatively modern technology can be adopted even in poor countries at relatively low investment costs. The average garment unit requires Rs. 15 lakhs to Rs. 20 lakhs in plant and machinery, the machines not exceeding 15 to 20 (Vora et al., 2002).

The nature of work in the garment manufacturing units require prolonged hours of standing or sitting in a forward bending posture. It is

highly repetitive in nature, requiring a combination of both static and rhythmic muscular activity. The sewing operation involves coordination of feet, hand and eye and the machine operators maintain a constant sitting posture on a stool with the body inclined forward. Such stressful postures adopted for 8 hours or more per day would be regarded as health hazards (Bridger, 2003). Studies (Nag, 1996; Delhanthy, 1998; Frynas, 2000) reveal that the workers in these units work in several cycles during working hours. The nature of work in garment unit is repetitive one without sufficient rest breaks, adding strain on the related muscles during the work hours. This repetitive strenuous work leads towards musculoskeletal disorders of neck, shoulders among the garment workers.

As per study, the postural load of sewing machine operators causes degenerative tissue changes and functional defects in the musculoskeletal system due to the stress induced by misdistribution of tissue pressure and prolonged static loading on the muscles. This can cause acute localized muscle fatigue leading to Work Related Musculoskeletal Disorders (WRMSDs). The causative factors of the work related musculoskeletal disorders may be the physical factors (workplace layout, tool design, nature of work) and work organization factors (number of cycles repeated over a period of time, pace of work and spacing of rest periods) (Nag, 1996).

According to survey of American Apparel Manufacturers' Association (AAMA) during mid 1990 in the USA revealed that the incidence of musculoskeletal disorders in the apparel industry was five times the average in the general industry (Devadas, 2001). The reports and evidences from a large number of researchers suggest and accept that the root cause of MSD disorders are due to the awkward constrained work posture, monotonous and repetitive task and psychological stress.

According to Paul-Majumder and Begum (2000) the workers all over the world in this industry exposed to number of health hazards arising out of abysmal working conditions like environmental stressors such as noise, heat, inadequate lighting and ventilation which expose to occupational health problems to the workers. Health hazards also arise due to non-application of ergonomic principles resulting in badly designed machinery and mechanical devices and tools used by the workers and poorly designed work practices.

A joint definition of occupational health endorsed by the ILO and WHO (as revised in 1995) states that: "Occupational health should aim at: the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention amongst workers from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health; the placing and maintenance of the workers in an occupational environment adapted to their physiological and psychological capabilities; and, to summarize: the adaptation of work to man and of each man to his job" (ILO, 2009).

The modern concept of occupational health deals with three broad categories of job related health concerns, namely occupational diseases, injuries due to accidents and risk factors (Greene and Morton, 1985). Occupational diseases are closely linked to prolonged exposure to hazardous agents or conditions unique to occupational settings. Injuries due to accidents primarily result from unsafe equipment, compounded by lack of safety ethics among the workers and exacerbated by fatigue and carelessness. Risk factors are the precursors to health problems, which can be identified and ameliorated by activities or actions originating at the work site. Though researchers univocally accept that there is a threat to the health of the workers in the garment making industry, not much effort has been taken to identify and quantify the specific contributory factors. Improvements can be suggested only if the problems are understood in their full depth and breadth. Even though the globalized economy puts tremendous pressure on institutions to enforce occupational health and safety regulations, the labour laws are easily flouted.

A dismal picture of the occupational health and safety aspects of the garment units arena in the Indian context is the workers were exposed to inappropriate work station geometry leading to awkward poor work posture, unsafe working condition, poor ventilation, noise, suffocation, congestion, inadequate lighting, especially for precision jobs were the inconveniences noticed. These unhealthy constraints can lead to occupational diseases and extensive absenteeism among

the workers. Studies present a dismal picture of the occupational health and safety aspects in this industrial arena in the Indian context (Sumitha et al., 2000; CSR World Report 2002).

2. Backgrounds

2.1 Ergonomics

In 1717, Prof. Bernardino Ramazzini published a book called 'The Diseases of Workers', which documented links between many occupational hazards and the type of work performed. The development of cumulative trauma disorder, was believed to be caused by repetitive motions of the hand, by constrained body posture, and by excessive mental stress, although the findings did not have the present tools of science to support (such as statistical testing).

In Europe, ergonomics started seriously with industrial applications in the 1950s, and used information from work physiology, biomechanics, and anthropometry for the design of workstations and industrial processes. The focus was on the well-being of workers as well as on improved manufacturing productivity. Ergonomics was well established in the 1960s, particularly in the U.K., France, Germany, Holland, Italy, and the Scandinavian countries. In many European countries, labor unions took an early interest in promoting ergonomics as being important for worker safety, health, comfort, and convenience. The labor unions are particularly strong in the Scandinavian countries, in France, and in Germany, where they can often dictate what type of production equipment a company should purchase. Good ergonomics design is now taken for granted, as a result, even heavy equipment, such as construction machines, is designed to be very comfortable and convenient to operate. In current ergonomics there is a realization that human error is mostly caused by poor design, and one should not blame operators for accidents. Instead the goal should be to design environments and artifacts that are safe for all users (Bridger, 2003).

As per International Ergonomics Association (2000) "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to

optimize human well-being and overall system performance."Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people.

Ergonomics is the science of work: of the people who do it and the ways it is done; the tools and equipment they use, the places they work in, and the psychosocial aspects of the working situation.

The word 'ergonomics' comes from the Greek: *ergos*, work; *nomos*, natural law. The word was coined by the late Professor Hywell Murrell, as a result of a meeting of a working party, at which it was resolved to form a society for 'the study of human beings in their working environment'. The members of this working party came from backgrounds in engineering, medicine and the human sciences.

Ergonomics is also defined as the study of the design of a workplace, equipment, machine, tool, product, environment, and system which takes into consideration human being's physical, physiological, biomechanical, and psychological capabilities and optimizes the effectiveness and productivity of work systems while assuring the safety, health, and well being of the workers (Fernandez and Marley, 1998).

In general, the goal of ergonomics is to fit the task to the individual, not the individual to the task. An ergonomist evaluates the demands of a specific task with reference to the capacity of workers to perform the task over a certain time period. When developing a particular job design, the demands of the task would ideally be held within the capacity of a fixed percentage of the working population (so that 75 to 95 per cent of the population is accommodated). When the task demands of an existing job are such that it is beyond the capacity of this predetermined percentage of the population, then the work, procedures, and/or work tools should be redesigned in order to accommodate the predetermined percentage of the working population. If the accommodated percentage is unacceptable (e.g., below 75 per cent) and redesign is not possible, then the final alternative is to place workers so that only those whose capacity exceeds the task demands are allowed to perform the task (Fernandez and Marley, 1998).

The word 'work' admits a number of meanings.

There is a broader sense, however, in which the term 'work' may be applied to almost any planned or purposeful human activity, particularly if it involves a degree of skill or effort of some sort. In defining ergonomics as a science concerned with human work, it will in general be using the word in this latter and broader sense. Having said this, it would also be true to say that throughout its forty-five years of history, the principal focus of the science of ergonomics has tended to be upon 'work' in the occupational sense of the word.

Work involves the use of tools. Ergonomics is concerned with the design of these and by extension with the design of artifacts and environments for human use in general. If an object is to be used by human beings, it is presumably to be used in the performance of some purposeful task or activity. Such a task may be regarded as 'work' in the broader sense. Thus to define ergonomics as a science concerned with work, or as a science concerned with design, actually means much the same thing at the end of the day.

The ergonomic approach to design may be summarized in:

The principle of user-centered design

If an object, a system or an environment is intended for human use, then its design should be based upon the physical and mental characteristics of its human users (in so much as these may be determined by the investigative methods of the empirical sciences). The object is to achieve the best possible match between the product and its users, in the context of the (working) task that is to be performed (Figure 1).



Figure1 : User-centered design: the product, the user and the task.

In other words: ergonomics is the science of fitting the job to the worker and the product to the user.

Criteria for successful match that are commonly important include the following:

- functional efficiency (as measured productivity, task performance, etc.);
- ease of use;
- comfort;
- health and safety;
- quality of working life and so on(Stephen Pheasant,2003).

Ergonomic Principles in Workplace Design

Some ergonomics principles that should be applied to the workplace, whether in an industrial or an office environment, include the following:

1. Use Proper Tools

Tools should be appropriate for the specific tasks being performed. Tools should allow keeping hands and wrists straight. Bend the tool – not the wrist, the tool should fit comfortably into user's hand. If the grip size is too large or too small it will be uncomfortable and will increase the risk of injury. Tools should not have sharp edges, create contact stresses in user's hand, or vibrate.

2. Keep Repetitive Motions to a Minimum

Workstations or tasks can often be redesigned to reduce the number of repetitive motions that must be performed. Using a power-driven screwdriver or tools with a ratchet device can reduce the number of twisting motions with the arm. Some tasks can be automated or redesigned to eliminate repetitive movements and musculoskeletal injuries.

3. Avoid Awkward Postures

The job should not require operator to work with hands above shoulder height on a regular basis. Arms should be kept low and close to user's body. Bending and twisting of wrists, back and neck should also be avoided.

4. Use Safe Lifting Procedures

Avoid lifting objects that are too heavy. Use more than one person or a mechanical device to reduce the load. Workstation should not require operator to lift objects above his head or twist the back while lifting. While lifting keep the load close to body and ensure a good grip. Heavy and frequently lifted objects should be

stored between knee and shoulder height – not on the ground or above the head.

5. Get Proper Rest

Rest is necessary for body and mind in order to prevent injuries. Give relaxation to body muscles during regular breaks, lunches and weekends by doing something different from what somebody doing regularly at the job. (Gade Rohan et.al. 2015)

The application of ergonomic principles in the workplace can result in the following:

- Increased productivity,
- Improved health and safety of workers;
- Lower workers' compensation claims;
- Compliance with government regulations such as Occupational Safety and Health Administration (OSHA) standards;
- Improved job satisfaction;
- Increased work quality;
- Lower worker turnover;
- Lower lost time at work;
- Improved morale of workers;
- Decreased absenteeism rate (Jeffrey E. Fernandez & Michael Goodman)

2.2 Work Posture

From the studies of earlier researchers, it is univocally accepted that awkward and constrained postures result in musculoskeletal stress on the head, neck and trunk of seated operators (Chaffin, 1973; Lee et al., 1986; Schuldt et al., 1986), and are a contributing factor in the development of musculoskeletal disorders (Van Wely, 1970; Grandjean and Hunting, 1977; Aaras et al., 1988). It is also found that decreased efficiency and performance with body discomfort is associated and the result from the restricted postures (Corlett, 1981; Bhatnager et al., 1985). Sewing machine operators are known to experience considerable musculoskeletal problems due to the static postures that have to be maintained during their whole working period, as well as those due to the highly repetitive manual tasks performed (Vihma et al., 1982; Punnett et al., 1985). The sewing operation is characterized by a sitting posture with the operator's head and trunk flexed. The task

involves simultaneous but different motions with the two hands, the continuous operation of foot pedals, and awkward and extreme joint postures, which arise when pushing the materials forward with the left hand, manipulating and holding materials in the sewing position with the right hand, and looking at the sewing point with the head flexed forward. This work activity is maintained throughout the whole work shift, except perhaps for a few ancillary tasks, which may permit occasional changes in the working position.

As a result of the poor static posture of the trunk, neck and upper extremities, and the highly repetitive movements, there is a high prevalence of musculoskeletal complaints affecting back, neck and upper limbs among sewing machine operators (Keyserling et al, 1982; Vihma et al., 1982; Punnett et al., Westgaard and Jansen, 1992). Keyserling et al., (1982) found in a survey of workers in the garment industry that substantial numbers of sewing machine operators suffered persistent musculoskeletal pain (defined as 'most days for at least one month') in at least one part of the body. Although the most frequent location of the pain was in the hand (reported by 25% of the sewing machinists), the musculoskeletal problems were more extensive. Nineteen percent reported pain in neck or back, and the majority of these (58%) said that the pain was in the neck, upper back or shoulders. In addition, 16% experienced pain in the hip, and significant numbers in knee, leg or foot.

'Posture is defined as the average orientation of the body parts over time.' (Bridger, 2003). An undergraduate textbook on human movement also keeps it simple: 'posture means simply position or alignment of body parts' (Trew and Everett, 2001). A dictionary defines it as 'the way one holds one's body while standing, sitting or walking', or 'a particular position or attitude of the body [E2].

Probably a more useful reflection of aspects of posture are the dimensions considered relevant in analyzing static workloads (Corlett, 2005):

- Angular relations between body parts
- Distribution of mass of body parts
- Forces exerted on environment during posture
- Length of time held in that posture
- Effects on individual who maintain that posture

The posture that a person adopts when performing a particular task is determined by the relationship between the dimensions of the person's body and the dimensions of the various items in his or her workspace (a tall person using a standard kitchen will stoop more than a short one, etc.). The extent to which posture is constrained in this way is dependent upon the number and nature of the connections between the person and the workspace. These connections may be either physical (seat, worktop, etc.) or visual (location of displays, etc.). If the dimensional match is inappropriate the short- and long-term consequences for the well-being of the person may be severe. Posture may be defined as the relative orientation of the parts of the body in space. To maintain such an orientation over a period of time, muscles must be used to counteract any external forces acting upon the body (or in some minority of cases internal tensions within the body). The most ubiquitous of these external forces is gravity.

Physiologists call the muscular activity that results from this loading 'static work'. Muscle as a tissue responds badly to prolonged static mechanical loading. (The same is probably true of other soft tissues, and even perhaps of bone, but the physiology of these cases is much less well understood.) Static effort restricts the flow of blood to the muscle. The chemical balance within the muscle is disturbed, metabolic waste products accumulate and the condition of 'muscular fatigue' supervenes. The person experiences a discomfort which is at first vague but which subsequently develops into a nagging pain until it becomes a matter of some urgency that relief is sought by a change of position. Should you require evidence of this course of events, you should raise one of your arms and hold it out in front of you as you continue to read (or attempt to do so). Provided our workspace and/or working schedule allows us to make the frequent shifts of posture which are subjectively desirable, all will be well since the physiological processes of muscular fatigue are relatively rapidly reversible by rest or change of activity (particularly if the activity involves stretching the fatigued muscle).

In general, fidgeting of body is a defence against postural stress. This mechanism characteristically operates at a subconscious level,

usually human body fidget before it become consciously aware of discomfort. In relaxed sitting the sensory stimuli probably come more from the compression of the soft tissues of the buttocks and thighs than from muscle tension. The crossing and uncrossing of the legs is a characteristic way of redistributing the pressure on the buttocks and, hence, pumping blood through the tissues. The rate of fidgeting can be used as an index of the comfort of chairs—the less comfortable, the more fidget. It is a matter of common experience that other factors are involved. Some people fidget more than others and people fidget more when they are bored—presumably because mental activity can 'shut out' the sensory stimuli that cause the fidgeting (or raise our threshold of discomfort).

Physiologically, comfort is the absence of discomfort, as it is known that no nerve endings capable of transmitting a positive sensation of comfort from a chair. Comfort is a state of mind which results from the absence of unpleasant bodily sensations (The same relationship does not hold, however, for pleasure and pain). If the working circumstances are such as to closely constrain to a particular posture and prevent postural change, the consequences may be divided into those occurring over the short term and those occurring over the long term. In the short term, mounting discomfort may distract the operator from his task leading to an increased error rate, reduced output, accidents, etc. From the physiological standpoint, the symptoms are relieved by rest or by a change of activity. At some point, nevertheless (and this point is not well defined since the transition is probably gradual rather than sharp), pathological changes in the muscle or soft tissue take over.

Typically, pain comes on after increasingly short periods of postural loading and rest is less certain to bring relief. Back pain, neck pain and the class of conditions affecting the hand, wrist and arm which refer to as work-related upper limb disorders (WRULD) or repetitive strain injuries (RSI) are all conditions that characteristically result from over-use of the muscles and other soft tissues in question. This over-use may be due to prolonged static loading, repetitive motions, acute over-exertion or some combination of these. Psychological factors may also be involved (probably

because psychological stress leads to increased muscle tension).

In general, a varied working posture is better than a fixed working posture; but if circumstances demand that operator work in a fixed position (as in practice will very often be the case), then the deleterious effects that ensue will increase with the degree of static work required to maintain the position concerned.

The following are simple guidelines are ;

(i) Encourage frequent changes of posture

Sedentary workers, should be able to sit in a variety of positions some office chairs are now being designed with this in mind. For many industrial tasks a sit-stand workstation is to be advocated. The task is typically set at a height that is suitable for a standing person and a high stool or 'perch' is provided as an alternative. There seems little doubt that most sedentary workers would be better off if their jobs required them to get up and move around once in a while.

(ii) Avoid forward inclination of the head and trunk

This commonly results from visual tasks, machine controls or working surfaces that are too low.

(iii) Avoid causing the upper limbs to be held in a raised position

This commonly results from a working level that is too high (or a seat that is too low). If manipulative tasks must be performed in a raised position, perhaps for visual reasons, arm supports should be provided. In addition to being a considerable stress to the shoulder muscles, tasks that must be performed at above the level of the heart impose an additional circulatory burden. The upper limit for manipulative tasks should be around halfway between elbow and shoulder level.

(iv) Avoid twisted and asymmetrical positions

These commonly result from expecting an operator to have eyes in the back of head, i.e. from the mislocation of displays and controls.

(v) Avoid postures that require a joint to be used for long periods at the limit of its range of motion

This is particularly important for the forearm and wrist.

(vi) Provide adequate back support in all seats

It may be that for operational reasons the backrest cannot be used during the performance of the work task but it will still be important in the rest pauses.

2.3 Workstation Design

Industrialization brought widespread use of tools and machines to the workplace and these have steadily grown in number and complexity since that time. Design was driven by technical requirements and rarely took account of the needs and characteristics of the operators. As a result, workers often had to adapt to processes determined by the technical system. Only in the middle of the 20th century, the operator gain more attention in the design process of work systems, leading to changes in design paradigms, culminating over recent decades in a shift to user-centered design [E3].

A basic philosophy in ergonomics is to design workstations that are comfortable, convenient, and productive to work at. Ideally, workstations should be designed to fit both the body and the mind of the operator. Using anthropometric design principles it is possible for a variety of people to find physical comfort at a workstation. On the other hand, not taking these physical requirements into consideration may create bad work postures leading to fatigue, loss of productivity, and sometimes injury.

Engineers who design production processes have a great responsibility. They must consider how the workstation will be laid out and what type of work posture is convenient for the job. Many engineers tend to focus on the engineering aspects; the work station, if even considered, is designed as an afterthought.

Workplace design deals with the shape, the dimensions, and the layout (i.e., the placement and orientation) of the different material elements that surround one or more working persons. Examples of such elements are the seat, working surfaces, desk, equipment, tools, controls, and displays used during the work as well as the passages, windows, and heating/cooling equipment.

The ergonomic workplace design aims at improving work performance (both in quantity and quality) as well as ensuring occupational safety and health through:

- Minimizing the physical workload and the associated strain on the working person
- Facilitating task execution, that is, ensuring effortless information exchange with the environment, minimization of the physical

constraints, and so on

- Achieving ease of use of the various workplace elements, putting together a workplace which meets ergonomics requirements while at the same time satisfies task demands is not a trivial problem. In fact, to achieve this one should consider an important number of interacting and variable elements, and try to meet many requirements, some of which may be contradictory. As shown in Figure 1.2, in any work setting there is a continuous mutual adjustment between the workplace components, the task demands, and the working person.

This mutual adjustment shown in Figure 2 is also subject to broader environmental conditions. Therefore, regardless of how well each individual component of the workplace is designed, the habitual body movement and postures in everyday work emerge by an exploration of the constraints and affordances of the workplace as a whole. Consequently, when designing a workplace, one has to adopt a systemic view, considering at least the characteristics of the working person, the task demands, and the environment in which the task will be performed. Furthermore, the elements of the work system are variable. The task demands may be multiple and variable.

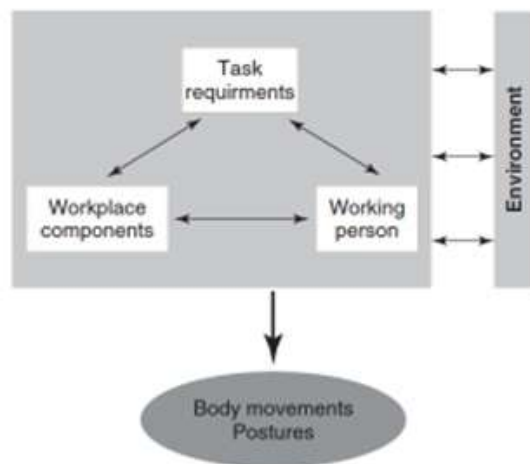


Figure 2: There is interdependence between the working person, task demands, workplace elements, environment, and body movements and postures.

The workplace environment may be noisy or quiet, warm or cool, with annoying air streams, illuminated by natural or artificial light, and all the above may change during the course of a working day. If to the complexity of the work system and the multiplicity of ergonomics criteria one adds the financial and aesthetic issues, successful design of a workplace becomes extremely complex. Hence, some people mention that designing a good workplace is more an “art” than a “discipline” as there is no standard theory or method that ensures a successful result, the output depending heavily on the designer's “inspiration”. Although this is true to a certain extent, good knowledge of the characteristics of the working persons who will occupy the workplace, of the tasks' demands, and of the broader environment, combined with an effort for discipline during the design process, contribute decisively to a successful design (Gavriel Salvendy, 2012).

2.4 Work related musculoskeletal disorders (WMSDs)

Work related musculoskeletal disorders (MSDs) are impairment of bodily structures, which are caused or aggravated primarily by the performance of work and by the effects of the immediate environment in which work is carried out. Musculoskeletal pain can interfere with activities at work and cause a reduction in productivity, an increase in sickness absence and chronic occupational disability (Laura Punnett & David H, 2004). A high rate of sick leave due to upper limb disorders was found in new workers compared with experience ones (M. Hakkanen et.al, 2001).

In the 18th century, Italian physician Bernardino Ramazzini was the 1st to recognize the relationship between work and certain disorders of the musculoskeletal system due to the performance of sudden and irregular movement and the adaptation of awkward postures.

Bernardo Ramazzini, who documented the disorders that observed in workers with insistent and irregular movements in unnatural postures. These work related disorders of the neck, shoulder, lower back, upper limbs and loco motor organs continue to be of the interest to workers, researchers and companies due to the significant temporary or permanent disability of workers (Ufuk Berberoglu & Burcu Tokue, 2013).

Musculoskeletal disorders arise from movements such as bending, straightening, gripping and holding, twisting, clenching, squatting, kneeling and reaching. These common movements are not particularly harmful in the ordinary activities of daily life (Eike Sehneider & Xabier Irastorza, 2010). Most repetitive strain injuries (RSI) are caused by work related activities. India is another country where a repetitive strain injury has become quite common and also no attention is given to the health and safety of workers in unorganized sectors.

Over the past years, subdue work related musculoskeletal disorders (WRMSD) are also known as cumulative trauma disorder (CTD), Repetitive strain/stress injuries (RSI), Overuse injuries (OI), Occupational overuse syndrome (OOS), Repetitive motion injuries (RMI), Troubles musculo-squelettiques, Regional musculoskeletal disorders or soft tissue disorders (Laura punnett,2004).

According to world health organization (WHO),

in 1948 health is defined as “State of complete physical, mental and social well being and not merely the absence of disease or infirmity”.

Health is not something that one possesses as commodity, but it is a way of functioning within one's environment (work, recreation and living). The work environment constitutes an important part of man's environment, so health to a large extent is affected by work condition. The impact of musculoskeletal pain on working life is huge.

Most of the occupation caused musculoskeletal problem are first among the health problem in the frequency with which they affect the quality of life of the work performance and quality of work environment. Heavy workload and high mental stress will lead to psychological problems like anxiety and depression. Maintaining constrained postures for prolonged period of time contributes to the restricted blood flow to the muscle.

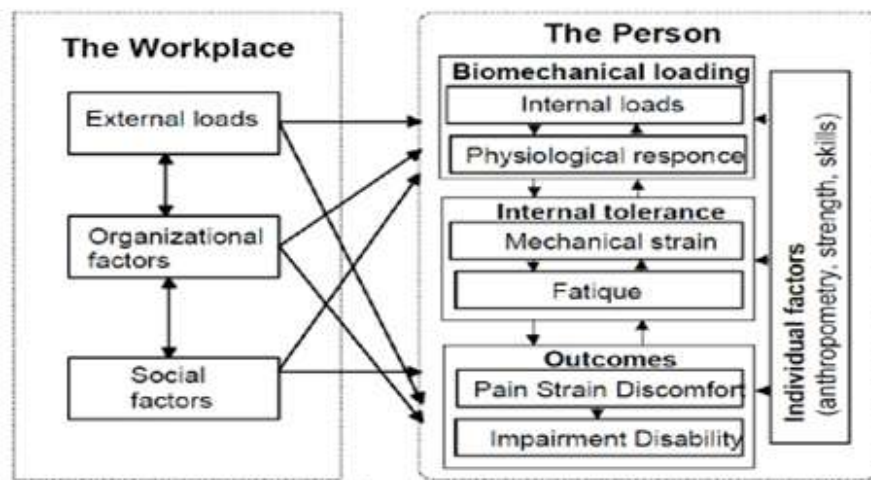


Figure 3: Conceptual model of work related musculoskeletal disorder (Adopted from the review by panel on MSD and work place, 2001).

Over the past three decades there has been a growing belief in all sectors of employment and in government that the experience of stress at work has undesirable consequences for health and safety of the individuals and for the health of their organizations.

The world health organization (WHO) has characterized 'work related disorders' as multifactorial to indicate that a number of risk factor (eg. physical,

work organizational, psychological, individual, socio cultural) contribute to causing these diseases (WHO-1985).

One important reason for the controversy surrounding work related MSD's is their multifactorial nature. The affected areas mainly involve the lower back and the upper extremities such as the hands, wrists, elbows, arms, shoulders and neck (Bruce P. Bernard).

According to federal bureau of labor statistics (BLS), Musculoskeletal disorders (MSDs) often referred to as ergonomic injuries or illness affecting the connective tissues of the body such as muscles, nerves, tendons, joint, cartilage or spinal discs (Bureau of Labor statistics, 2008). Regional musculoskeletal disorders or soft tissue disorders have become as a serious issue in various industries.

For the purpose of developing injury prevention strategies, many health and safety agencies include only disorders that develop gradually and are caused by the overuse of the above constituents of the musculoskeletal system. The traumatic injuries of the muscles, tendons and nerves due to accidents are not considered to be WMSDs or are considered separately. However, there are organizations, such as the European Agency for Safety and Health at Work, that include acute traumas and fractures within in the WMSD group [E4].

This document will discuss those injuries resulting from overuse and those that develop over time. Work activities which are frequent and repetitive, or activities with awkward postures cause these disorders which may be painful during work or at rest. Almost all work requires the use of the arms and hands. Therefore, most WMSD affect the hands, wrists, elbows, neck, and shoulders. Work using the legs can lead to WMSD of the legs, hips, ankles, and feet. Some back problems also result from repetitive activities.

WMSDs are very difficult to define within traditional disease classifications. These disorders have received many names, such as:

- Repetitive motion injuries.
- Repetitive strain injuries.
- Cumulative trauma disorders.
- Occupational cervicobrachial disorders.
- Overuse syndrome.
- Regional musculoskeletal disorders.
- Soft tissue disorders.

Most of the names do not accurately describe the disorders. For example, the term "repetitive strain injuries" suggests that repetition causes these disorders, but awkward postures also contribute. These terms are used synonymously. In the absence of an agreement, WMSD term is used in this document.

1) Risk factors for WMSDs

WMSDs arise from arm and hand movements such as bending, straightening, gripping, holding, twisting, clenching and reaching. These common movements are not particularly harmful in the ordinary activities of daily life. What makes them hazardous in work situations is the continual repetition, often in a forceful manner, and most of all, the speed of the movements and the lack of time for recovery between them. WMSDs are associated with work patterns that include:

- Fixed or constrained body positions.
- Continual repetition of movements.
- Force concentrated on small parts of the body, such as the hand or wrist.
- A pace of work that does not allow sufficient recovery between movements.

Generally, none of these factors acts separately to cause WMSD. WMSDs commonly occur as a result of a combination and interaction among them. Heat, cold and vibration also contribute to the development of WMSD.

2) Occurrence of WMSDs

WMSDs that develop gradually as a result of repeated trauma.

WMSDs include three types of injuries:

- Muscle injury.
- Tendon injury.
- Nerve injury.

A) Muscle Injury

When muscles contract, they use chemical energy from sugars and produce by-products such as lactic acid which are removed by the blood. A muscle contraction that lasts a long time reduces the blood flow. Consequently, the substances produced by the muscles are not removed fast enough, and they accumulate in the muscles. The accumulation of these substances irritates muscles and causes pain. The severity of the pain depends on the duration of the muscle contractions and the amount of time between activities for the muscles to get rid of those irritating substances.

B) Tendon Injury

Tendons consist of numerous bundles of fibres that attach muscles to bones. Tendon disorders related to repetitive or frequent work activities and awkward postures occur in two major categories -tendons with sheaths (Figure 1.4), found mainly in the hand and wrist; and tendons without sheaths (Figure 5), generally found around the shoulder, elbow, and forearm. The tendons of the hand are encased in sheaths through which the tendon slides.

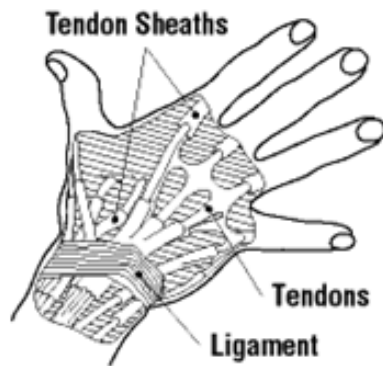


Figure 4 : Finger tendons and their sheaths

The inner walls of the sheaths contain cells that produce a slippery fluid to lubricate the tendon. With repetitive or excessive movement of the hand, the lubrication system may malfunction. It may not produce enough fluid, or it may produce a fluid with poor lubricating qualities. Failure of the lubricating system creates friction between the tendon and its sheath, causing inflammation and swelling of the tendon area. Repeated episodes of inflammation cause fibrous tissue to form. The fibrous tissue thickens the tendon sheath, and hinders tendon movement. Inflammation of the tendon sheath is known as tenosynovitis.

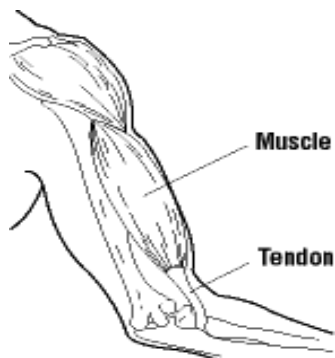


Figure 5 : Tendon, muscle, bone unit

When inflamed, a tendon sheath may swell up with lubricating fluid and cause a bump under the skin. This is referred to as a ganglion cyst. Tendons without sheaths are vulnerable to repetitive motions and awkward postures. In fact, when a tendon is repeatedly tensed, some of its fibres can tear apart. The tendon becomes thickened and bumpy, causing inflammation. Tendonitis is the general term indicating inflammation of the tendon. In some cases, such as in the shoulder, tendons pass through a narrow space between bones. A sac called the bursa filled with lubricating fluid is inserted between the tendons and the bones as an anti-friction device. As the tendons become increasingly thickened and bumpy, the bursa is subject to a lot of friction and becomes inflamed. Inflammation of the bursa is known as bursitis.

C) Nerve Injury

Nerves carry signals from the brain to control activities of muscles. They also carry information about temperature, pain and touch from the body to the brain, and control bodily functions such as sweating and salivation. Nerves are surrounded by muscles, tendons, and ligaments. With repetitive motions and awkward postures, the tissues surrounding nerves become

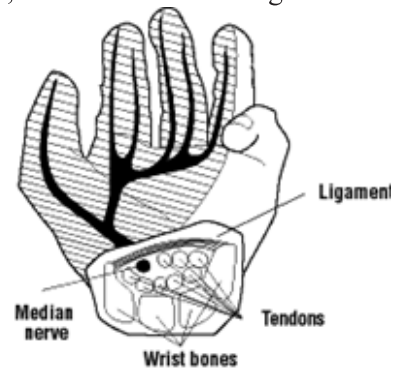


Figure 1.6: Wrist in natural condition

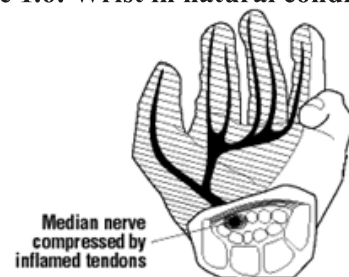


Figure 7: Wrist showing symptoms of Carpal Tunnel Syndrome
Compression of a nerve causes muscle weakness, sensations of "pins and needles" and numbness. Dryness of skin, and poor circulation to the extremities, may also occur.

d) Low Back Pain

Eighty percent of adults will experience significant low back pain sometime during their lifetime. Low back pain usually involves muscle spasm of the supportive muscles along the spine. Also, pain, numbness and tingling in the buttocks or lower extremity can be related to the back. There are multiple causes of low back pain (see below). Prevention of low back pain is extremely important, as symptoms can recur on more than one occasion.

Common Causes :

Muscle strain -The muscles of the low back provide the strength and mobility for all activities of daily living. Strains occur when a muscle is overworked or weak.

Ligament sprain -Ligaments connect the spinal vertebrae and provide stability for the low back. They can be injured with a sudden, forceful movement or prolonged stress.

Poor posture -Poor postural alignment (such as slouching in front of the TV or sitting hunched over a desk) creates muscular fatigue, joint compression, and stresses the discs that cushion your vertebrae. Years of abuse can cause muscular imbalances such as tightness and weakness, which also cause pain.

Age -“Wear and tear” and inherited factors may cause degenerative changes in the discs (called degenerative disc disease), and joint degeneration of the facet joints of the spine (called degenerative joint disease). Normal aging causes decreased bone density, strength and elasticity of muscles and ligaments. These effects can be minimized by regular exercise, proper lifting and moving techniques, proper nutrition and body composition, and avoidance of smoking.

Disc bulge or herniation, can cause pressure on a nerve, which can radiate pain down the leg. This generally responds well to a strengthening and stretching exercise and rarely requires surgery.

Other causes of low back pain include bladder/kidney infection, endometriosis, cancer, or ovarian problems [E5].

E) Lumbar spinal stenosis

Lumbar spinal stenosis (LSS) is a medical condition in which the [spinal canal](#) narrows and compresses the [spinal cord](#) and nerves at the level of the [lumbar vertebra](#). This is usually due to the common occurrence of spinal degeneration that

occurs with aging. It can also sometimes be caused by spinal disc herniation, osteoporosis or a tumor. In the cervical (neck) and lumbar (low back) region it can be a [congenital](#) condition to varying degrees. Spinal stenosis may affect the cervical or [thoracic](#) region in which case it is known as [cervical spinal stenosis](#) or thoracic spinal stenosis. In some cases, it may be present in all three places in the same patient. Lumbar spinal stenosis results in low back pain as well as pain or abnormal sensations in the legs, thighs, feet or buttocks, or loss of bladder and bowel control.

Causes

Spinal stenosis may be congenital (rarely) or acquired (degenerative), overlapping changes normally seen in the aging spine, resulting from degenerative changes or as consequences of local infection, trauma or surgery. Degeneration is believed to begin in the intervertebral disk where biochemical changes such as cell death and loss of proteoglycan and water content lead to progressive disk bulging and collapse. This process leads to an increased stress transfer to the posterior facet joints, which accelerates cartilaginous degeneration, hypertrophy, and osteophyte formation; this is associated with thickening and buckling of the ligament flatus. The combination of the ventral disk bulging, osteophyte formation at the dorsal facet, and ligament flatus hypertrophy combine to circumferentially narrow the spinal canal and the space available for the neural elements. This compression of the nerve roots of the caudal equine leads to the characteristic clinical signs and symptoms of lumbar spinal stenosis.

F) Spinal disc herniation

A Spinal disc herniation (prolapsed disc intervertebral) is a [medical](#) condition affecting the [spine](#) in which a tear in the outer, fibrous ring ([annulus fibrosus](#)) of an [intervertebral disc](#) (discus intervertebralis) allows the soft, central portion ([nucleus pulposus](#)) to [bulge out](#) beyond the damaged outer rings. Disc herniation is usually due to age related degeneration of the annulus fibrosus, although [trauma](#), lifting [injuries](#), or straining have been implicated. Tears are almost always posterolateral in nature owing to the presence of the [posterior longitudinal ligament](#) in the spinal canal. This tear in the disc ring may result in the release of inflammatory chemical mediators which may

directly cause severe pain, even in the absence of nerve root compression.

Disc herniations are normally a further development of a previously existing disc "protrusion", a condition in which the outermost layers of the annulus fibrosus are still intact, but can bulge when the disc is under pressure. In contrast to a herniation, none of the nucleus pulposus escapes beyond the outer layers.

Most minor herniations heal within several weeks. Anti-inflammatory treatments for pain associated with disc herniation, protrusion, bulge, or disc tear are generally effective. Severe herniations may not heal of their own accord and may require surgical intervention.

The condition is widely referred to as a slipped disc, but this term is not medically accurate as the spinal discs are firmly attached between the vertebrae and cannot "slip".

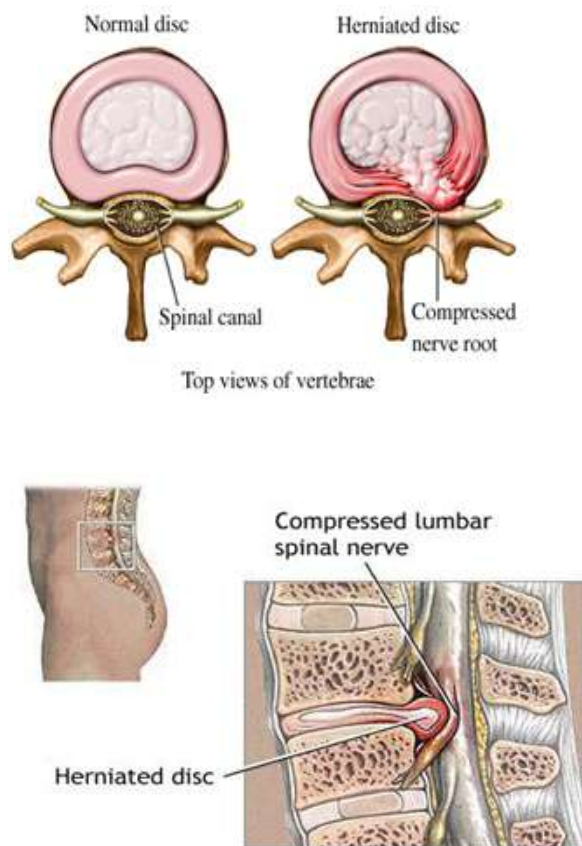


Figure 8 : a) & b) Herniation of disk

Cause

Disc herniations can result from general wear and tear, such as when performing jobs that require constant sitting and squatting. However, herniations often result from jobs that require lifting. Minor back pain and chronic back tiredness are indicators of general wear and tear that make one susceptible to herniation on the occurrence of a traumatic event, such as bending to pick up a pencil or falling. When the spine is straight, such as in standing or lying down, internal pressure is equalized on all parts of the discs. While sitting or bending to lift, internal pressure on a disc can move from 17 [psi](#) (lying down) to over 300 psi (lifting with a rounded back).

G) Sciatica

Sciatica or lumbar radiculopathy is a set of symptoms including [pain](#) caused by general compression or irritation of one of five spinal nerve roots of each [sciatic nerve](#) or by compression or irritation of the left or right or both sciatic nerves. Symptoms include [lower back pain](#), buttock pain, and pain, numbness or weakness in various parts of the leg and foot. Other symptoms include a "[pins and needles](#)" sensation, or tingling and difficulty moving or controlling the leg. Typically, symptoms only manifest on one side of the body. The pain may radiate below the knee, but does not always.

Sciatica is a relatively common form of low back and leg pain, but the true meaning of the term is often misunderstood. Sciatica is a set of symptoms rather than a diagnosis for what is irritating the root of the nerve to cause the pain. Treatment for sciatica or sciatic symptoms often differs, depending on underlying causes and pain levels. Causes include compression of the sciatic nerve roots by a herniated (torn) or protruding disc in the lower back.

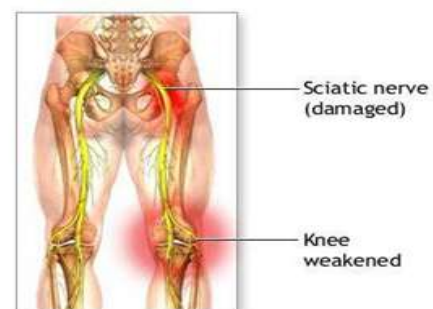


Figure 1.9: Damaged Scatia nerve

Causes

- Spinal disc herniation

[Spinal disc herniation](#) pressing on one of the [lumbar](#) or [sacral nerve](#) roots is the primary cause of sciatica, being present in about 90% of cases. Sciatica caused by pressure from a disc herniation and swelling of surrounding tissue can spontaneously subside if the tear in the disc heals and the pulpous extrusion and inflammation cease.

- Spinal stenosis

Other compressive spinal causes include [lumbar spinal stenosis](#), a condition in which the spinal canal (the spaces the spinal cord runs through) narrows and compresses the spinal cord, [caudal equine](#), or sciatic nerve roots. This narrowing can be caused by bone spurs, [spondylolisthesis](#), inflammation, or [herniated disc](#), which decreases available space for the spinal cord, thus pinching and irritating nerves from the spinal cord that travel to the sciatic nerves.

H) Prevention of WMSD

Hazards are best eliminated at the source; this is a fundamental principle of occupational health and safety. In the case of WMSDs, the prime source of hazard is the repetitiveness of work. Other components of work such as the applied force, fixed body positions, and the pace of work are also contributing factors. Therefore the main effort to protect workers from WMSDs should focus on avoiding repetitive patterns of work through job design which may include mechanization, job rotation, job enlargement and enrichment or teamwork. Where elimination of the repetitive patterns of work is not possible or practical, prevention strategies involving workplace layout, tool and equipment design, and work practices should be considered.

Job Design

1) Mechanization

One way to eliminate repetitive tasks is to mechanize the job. Where mechanization is not feasible or appropriate, other alternatives are available.

2) Job Rotation

Job rotation is one possible approach. It requires

workers to move between different tasks, at fixed or irregular periods of time. But it must be a rotation where workers do something completely different. Different tasks must engage different muscle groups in order to allow recovery for those already strained.

However, job rotation alone will not be effective in reducing WMSDs if not combined with the proper design of workstations. And it will not be effective while the high pace of work persists.

3) Job Enlargement and Enrichment

Another approach is job enlargement. This increases the variety of tasks built into the job. It breaks the monotony of the job and avoids overloading one part of the body. Job enrichment involves more autonomy and control for the worker.

4) Team Work

Team work can provide greater variety and more evenly distributed muscular work. The whole team is involved in the planning and allocation of the work. Each team member carries out a set of operations to complete the whole product, allowing the worker to alternate between tasks, hence, reducing the risk of WMSDs.

5) Workplace Design

The guiding principle in workplace design is to fit the workplace to the worker. Evaluation of the workplace can identify the source or sources of WMSD. Proper design of the workstation decreases the effort required of the worker to maintain a working position. Ideally, the workstation should be fully adjustable, providing a worker with the options to work in standing, sitting or sitting-standing positions, as well as fitting the worker's body size and shape.

6) Tools and Equipment Design

Proper design of tools and equipment significantly decreases the force needed to complete the task. Providing the worker with the proper jigs or fixtures for tasks that require holding elements saves a lot of muscular effort in awkward positions. Good tools, maintained carefully and where necessary frequently changed, can also save a lot of muscle strain.

7) Work Practices

A well-designed job, supported by a well-

designed workplace and proper tools, allows the worker to avoid unnecessary motion of the neck, shoulders and upper limbs. However, the actual performance of the tasks depends on individuals. Training should be provided for workers who are involved in jobs that include repetitive tasks. Workers need to know how to adjust workstations to fit the tasks and their individual needs. Training should also emphasize the importance of rest periods and teach how to take advantage of short periods of time between tasks to relax the muscles, and how to consciously control muscle tension throughout the whole work shift.

Increased communication and support together with an increased ability of the worker to control his job (where possible) are work practices that improve worker's satisfaction and have a positive impact on reducing the risk of WMSDs

3. Need Of Ergonomic Intervention

“Work-related health issue and injury constitutes a costly affair for workers, employers and society” (Baldwin, 2004). If companies are to increase profitability, managers need to maximize productivity and minimize medical costs (Pheasant, 1991). Likewise, if workers are to maintain the quality of their work and home life, they need to take responsibility for protecting their health. Furthermore, if healthcare is to alleviate disability, health professions must step beyond the clinics onto the 'real world' of industry and business. Cooperatively, productivity must be balanced with health, considering long-term gains versus short-term profit, and re-examining the value of work for the modern-day worker (Sanders, 1997) [E6].

Garment workers play a significant role in preparing the dressing material. It is widely accepted that garment workers have one of the most stressful job in India with increase expectations in the job performance, shift schedules, organizational demands and personal life, garment worker have little to no time to exercise.

The job is physically demanding as well as mentally challenging. How efficiently one will deliver services depends on the number of factors like interest, benefits received, good health, proper co-ordination and co-operation among the staff etc. If somebody works out of compulsion, then the output is not expected to be very

high in terms of quality and resulting into health disorders and stress. The impact of prolonged working/long shift is leading to severe musculoskeletal disorder in garment workers in India. The continuous long term sitting or standing and very poor physical exercise program to maintain their health status are the factors responsible for musculoskeletal disorders.

It is not surprising that in developing countries like India no attention is given to health and safety of worker in unorganized sectors. The working hours of garment worker personnel are 8-10 hours per day. MSDs which can affect the person performances in different way which can lead to further complications.

Researchers stated that the interrelationships between the different health dimensions (pain, disability, general health, quality of life) with work related musculoskeletal complaints (Van Duijn H. et.al.,1970).

Sickness absence is a major public health problem because of the loss of economic productivity, the social insurance costs and the direct medical costs of long term disability. In the past sickness absence was considered to be socio-economic and political matter, rather than a medical or public health problem. However opinion changed after it was reported that men and women with more than 15 days of sickness absence per year are at increased risk of early retirement on medical grounds and have a higher risk of mortality. Researcher on sickness absence focus on interventions aimed at expediting return to work. They concluded that sickness absence due to MSD had the highest recurrence (RS=118.7/1000 person-years)(C.A.M.Rolen et.al. 2010).

Due to this long standing or sitting problem the person may be sick or cannot perform the work and it can result in absenteeism and this can affect the garment industry in number of issues, so due to these problems it makes the sense to adopt preventive measures and modification on different areas i.e. working area.

Although it is not clear to what extent MSD are caused by work, their impact on working life is huge. MSD can interfere with activities at work can cause a reduction in productivity, an increase in sickness absence, chronic occupational disability and Presence of musculoskeletal complaints often leads to functional limitation in daily life (Freek J.B.Lotters, 2005).

Most researchers' agree that exposure to combination of work place risk factors is a major contributor to these disorders. Along with personal factors (age, gender etc.) specific examples of workplace psychological factors include monotonous work, time pressure, high work load, lack of peer support and a poor supervisor-employee relationship (Laura Punnett & David H, 2004). Though several type of environment exist, it is the physical environment. Which play important role on health.

A mismatch between individual's physical capacities and physical work demands enhance the risk of MSDs, poor work ability and sickness absence (Pinchieh Wang et.al.2007). Psychological factors are well accepted to have an important role for perception experience and behaviours regarding musculoskeletal disorders because consequences of pain are included by the pain tolerance.

Postural alignment in working class of garment people and environmental factors around it leads to acquired MSDs which cause pain are most common in garment workers.

References :

1. Aaras & A., Westgaard, R.H. and Strandén, E. 1988. Posture angles as an indicator of postural load and muscular injury in occupational work situations. *Ergonomics* 31 (6), 915-933.
2. Bridger, R.S., 2003. Introduction to Ergonomics. Taylor and Francis publication 2nd Edition.
3. C.A.M. Rolen, P.C. Koopmans, J.R. Anema, A.J. Vanderbeek, 2010. Recurrence of Medically certified sickness absence according to diagnosis : A sickness absence register study, *Journal of Rehabilitation*. March, 20(1):113-121.
4. Chaffin, D.B., Andersson, G.B. and Martin, B.J., 1999. *Occupation Biomechanics*. New York, John Wiley and Sons, Inc.
5. Corlett, E.N., 1981. Pain, posture and performance. In Corlett, E.N. and Richardson, J. (eds), *Stress. Work Design and Productivity*. John Wiley & Sons, London 2742.
6. Delhanty, J. 1998. *Global Industry / Global Solutions: Options for Change in Garment Sector*. Proceedings of the Conference on Global Industry / Global Solutions. Toronto: North-South Institute.
7. Devadas, W. 2001. Ergonomics and the Apparel Industry. *The Textile Magazine*. 42(9), 50-51.
8. Eike Schneider, Xabier Irastorza, 2010. European agency for safety and health at work. Institute of occupational safety and health.
9. Fernandez, I.E. and Marley, R.M., 1998. *Applied Occupational Ergonomics: A Textbook*, Kendall-Hunt Publishing.
10. Freek J.B. Lotters, 2005. Impact of work on musculoskeletal complaints and work disability.
11. Frynas, J.G. 2000. Human Rights and the Transnational Garment Industry in South and South - East Asia : a Focus on Labour Rights, Paper presented at the International Conference of the Comparative Interdisciplinary Studies Section (CISS) of the International Studies Association (ISA), Washington USA.
12. Gade Rohan, Chandurkar Pranjali, Upasani Harshada, Khushwaha Devesh, 2015. Ergonomic Intervention to Improve Safety and Productivity. *International journal on Textile Engineering and Processes* Volume 1, Issue 3.
13. Gavriel Salvendy, 2014. *Handbook of Human Factors and Ergonomics*, Fourth Edition, John Wiley & Sons, Inc.
14. Grandjean, E. and Hunting, W. 1977. Ergonomics of posture -review of various problems of standing and sitting posture. *Applied Ergonomics* 8 (3), 135-140.
15. Greene, W.H. and Morton, B.S., 1985. *Introduction to Health Education*. New York : Mac Millan Publishing House.
16. International Labour Organisation., 2009. *ILO Standards on Occupational Safety and Health: Promoting a safe and healthy working environment*. International Labour Conference, 98th Session. Geneva.
17. Jeffrey E. Fernandez & Michael Goodman, *Ergonomics in the Workplace*, Exponent Health Group, Alexandria.
18. Keyserling, W.M., Donoghue, J.L., Punnett & L.

- and Miller, A.B. 1982. Repetitive trauma disorders in the garment industry Report No. 81-3220, Department of Environmental Health Sciences, Harvard School of Public Health, Boston
19. Laura Punnett, David H. Wegman, 2004. Work related musculoskeletal disorders: the Epidemiologic evidence and the debate. *Journal of Electromyography and Kinesiology* Feb.: 14(1):13.
 20. Lee, K.S., Waikar, A.M., Aghazadeh, F. and Tandon, S. 1986. An electromyographic investigation of neck angles for microscopists in Proc Human Factors Society 30th Annual Meeting, 29 Sept.-3 Oct., Dayton, OH, QQ 548-551.
 21. M. Hakkanen, E Viikari-Juntura and Martikainen, 2001. Job experience, work Load and risk of musculoskeletal disorders. *Occupational Environment Medicine*, feb : 58(2) 129-135.
 22. Nag, A., 1996. Women in Industry - Repetitive Work and Postural Stress In. Nag, P.K. (Ed). *Ergonomics and Work Design - Emerging Issues in Organizational Sciences*. New Delhi: New Age International Pvt. Ltd.
 23. Paul-Majumder, P. and Begum, A., 2000. The Gender Imbalances in the Export Oriented Garment Industry in Bangladesh. Policy Research Report on Gender and Development - Working Paper Series No. 12, World Bank.
 24. Pin-chieh wang, David M. Rempel, Robert J. Harrison, Jacqueline Chan, Beate R., 2007. Work organizational and personal factors associated with upper body musculoskeletal disorders among sewing machine operators. *Occupational Environmental Medicine*, 64:806-813.
 25. Punnett, L., Robins, J.M., Wegman, D.H. and Keyserling, W.M., 1985. Soft tissue disorders in the upper limbs of female garment workers' *Stand J Work Environ Health* 11, 417-425.
 26. Schuldt, K., Ekholm, J., Harms-Ringdahl, K., Nemeth, G. and Arborelius, U.P., 1986. Effects of changes in sitting work posture on static neck and shoulder muscle activity. *Ergonomics* 29 (12), 1525-1537.
 27. Schultz, A.B., Andersson, B.J. G. Ortengren R., Haderspeck K., and Nachemson, A., 1982. Load on the lumbar spine, *Journal Bone and Surgery*, 64A, 713-720.
 28. Stephen Pheasant, 2003. *Bodyspace, Anthropometry, Ergonomics and the Design of Work: A Textbook*, Taylor & Francis Publication, Second Edition, London.
 29. Sumitha, C., Bobby, J. and Subbanna. J., 2000. Absenteeism in Garment Manufacturing Industry. *Indian Journal of Occupational and Environmental Medicine*. 4(2), 78-80.
 30. Uchikawa, S., 1998. *Indian Textile Industry. State Policy, Liberalization and Growth*, New Delhi; Manohar Publications.
 31. Ufuk Berberoglu, Burcu Tokue, 2013. Work related musculoskeletal disorders at two textile factories in Edirne. [Balkan Medical Journal](#) 30(1); 23-27.
 32. Van Duijn H., Lotters, Burdorf A. Interrelationship between pain, disability, general health and quality of life and associations with work-related and individual factors : a study among workers on sickness absence for 2 to 6 weeks for musculoskeletal complaints.
 33. Van Wely, P., 1970. Design and disease. *Applied Ergonomics* 1 (5), 262-269.
 34. Vihma, T., Nurminen, M. and Mutanen, P., 1982. Sewing-machine operators' work and musculo-skeletal complaints. *Ergonomics* 25 (4), 295-29.
 35. Vora, C.S. et al., 2002. IT Based Sewing Room Data for Improved Performance of SME's in Garment Sector. Proceedings of the 43rd Technological Conference. Bombay: North Indian Textile Research Association.
- Web References :**
- E1. Insights into working conditions in India's garment industry (Copyright © International Labour Organization 2015.). website: www.ilo.org/fundamentals.
 - E2. Posture-the-lumbar-spine-and-back-pain. Available from : <http://www.corewerks.com>

- /blog/ 2014 / 3 /26/ posture-the-lumbar-spine-and-back-pain.
- E3. US Department of labour. Bureau of Labor statistics. The editors desk ; 2008. Available from://www.bls.gov/opub/ted/2008dec/wk1/art02.htm.
- E4. Occupational Hygiene - Occupational Disease. Available from: .
- E5. Lower back pain causes. [online]. Available from: URL:http://www.seasonindia.com.
- E6. <https://repository.up.ac.za/bitstream/handle/2263/28796/01chapters1-2.pdf?sequence=2>.

Courses Offered:

BE (Bachelor of Engineering)

- Electronics and Telecommunication Engineering
- Computer Science Engineering
- Electrical Engineering
- Mechanical Engineering
- Civil Engineering
- Artificial Intelligence and Data Science

ME (Master of Engineering)

- Thermal Engineering
- Computer Science and Engineering
- Electrical and Power System
- Electronics and Telecommunication Engineering

MBA (Master of Business Administration)

MCA (Master of Computer Applications)

**P. R. Pote (Patil) Education & Welfare Trust's, Group of Institutions,
College of Engineering & Management, Amravati**

Pote Estate, Pote Patil Rd, Kathora, Amravati, Maharashtra 444602

Tel: +91 – 07212970110, +91 – 07212970338

Website: www.prpcem.org

DnyanPath[®]
Publication
Write well - Right now
ISO 9001 : 2015

A Leading **National Books Publishing** House In India

✉ dnyanpathpub@gmail.com 🌐 www.dnyanpath.org ☎ 08600353712, 09503237806

Price : 500/-

