



Sinhgad Institutes

Sinhgad Technical Education Society's®

# NBN SINHGAD TECHNICAL INSTITUTES CAMPUS

Approved by AICTE, New Delhi, Recognized by Government of Maharashtra &  
Affiliated to University of Pune (ID No. - PU/PN/Engg/432/2012)

S. No. 10/1, Ambegaon (Budruk), Off Sinhgad Road, Pune 411041

•Tel. : +91-20-24355042 / 46, +91-20-24610880/881 • Tele Fax : +91-20-24355042 • Website : www.sinhgad.edu  
• Email : nbnssoe@sinhgad.edu / nbnsoms@sinhgad.edu / nbnsocs@sinhgad.edu

## INDEX

Number of papers published per teacher in the Journals notified on UGC website and in other journals during the year 2020

Sr. No.	Title of Paper	Page No
1	Implementation On Emotion Recognition By Speech Signal	1
2	M-Commerce Analytical Study Alast Decade Period and post Covid Pandemic Situation	8
3	ANNAPURNA: Diet Recommender System.	16
4	Sherlock: based deep learning framework for fake news detection	20
5	Vibration Analysis of Disc Brake by using FEA and FFT Analyzer	26
6	A Review Paper on: Containment Test and Impeller Burst Simulation using Explicit Dynamics	31
7	Design and FEA Analysis of Boiler Chimney against Fouling	39
8	Design Manufacturing and Vibration Analysis of Worm and Worm Wheel Gear Box	52
9	Weight Optimization and Manufacturing of Composite Leaf Spring	64
10	Design and Analysis of Filter Tube Sheet of Pressure Vessel Against Fatigue and Fouling	69
11	Design fabrication of e-bicycle and comparative analysis of lead acid battery and lithium ion battery	80
12	A study of Quality Services Provided by MSRTC with Special Reference to Pune Division	93
13	Study the relationship between Employee value proposition and employee turnover in Management Institutes with reference to Pune.	130
14	“Study the Consumer Interaction in FMCG product through the Voice Search Technology”	142

## Implementation On Emotion Recognition By Speech Signal

Yasmin P. Shaikh<sup>#1</sup>, Sunita Deshmukh<sup>\*2</sup>, U. J. Suryawanshi<sup>#3</sup>

<sup>1,2,3</sup>Department of E&TC,<sup>1,2,3</sup>NBN Sinhgad School of Engineering Pune, India

<sup>1</sup>yasmin.shaikh.09@gmail.com

<sup>2</sup>sunita.deshmukh.nbnssoe@sinhgad.edu

<sup>3</sup>umarani.suryawanshi.nbnssoe@sinhgad.edu

### Abstract

*Emotions are vital in our day to day life. Emotions are the natural physiological response of the human body which may be recognized by the voice of an individual. In the proposed system analysis has been worn out in the sector of human-computer Interaction (HCI). This project is classed into 3 major steps i.e. Pre – process, feature extraction, and classification. Within the 1st part, speech detection has been done. Then the options are extracted from the speech signal. Extracted features are compared with the Classification of speech emotions to recognize the feeling.*

*Keywords— Human computer Interaction (HCI), Vokaturi algorithm, F0 features extraction.*

### I. INTRODUCTION

In spite of the method that feeling acknowledgment from speaks is a fairly new field of analysis, its numerous potential applications. In human-PC or human-human participation systems, feeling affirmation structures may outfit customers with improved organizations by being all-mains to their emotions. In virtual universes, feeling affirmation may facilitate copy logically cheap image association. The gathering of work on recognizing the sensation within the speak is exceptionally limited. Directly, researcher's ars up 'til currently talking concerning what options sway the affirmation of inclination in speak. There is furthermore noteworthy helplessness with relevancy the most effective count for requesting feeling, and those sentiments to category together. A talk sign could be a real game-plan of sounds. Our neural structure plays out a confusing course of action of examinations of sound-related information (for instance sounds). It changes over the sounds into some determined contemplations and insights which structure the explanation for headings, bearings, info, and beguilement. Changed affirmation is generally mulled over in sentiment of perceiving feeling among some fastened game arrange of categories. Speak feeling affirmation could be a quite examining vocal lead. The speak taking care of incorporates three essential advances, as an example, pre-taking care of, feature extraction and model affirmation. On the off likelihood that there got to emerge an occurrence of speak signal, vowels pass on the large little bit of the illuminating half. Vowels are generally voiced a small amount of the communicated words. In this manner, it's customary to separate voiced half from associate unvoiced little bit of the data verbally communicated and proceed with more with sign taking care of on merely voiced part. For a convincing and customary HMI, feeling affirmation accept a vital activity. Emotions replicate the condition of the person through talking, outward appearances, body positions, and flag and furthermore alternative physical parameters like blood heat, beat, muscle action, etc. The mental state of the person in associate indirect manner impacts speaks created by the person. as an example, in human-human affiliation, talk rate is speedier if there got to emerge an occurrence of disturbance/fulfillment and therefore the pitch vary is in like manner progressively broad whereas just in case of harshness, speak is slower with lower pitch run. Thusly, feeling recognizable proof within the talk is nice in numerous applications.

## II. LITERATURE SURVEY

A system that is employed to examine human emotions from sound fastens created by speaker. During this system we have used 2 correct models, for example, SVM and HMM to portray sentiments. In solicitation to examine emotions we tend to isolated four acoustic options, for example, supernatural center of mass, spread, equality and projection. this method is separated in to 5 clear stages-sound pre-processing, incorporate extraction, division, model preparing and gathering. Sound pre-processing is employed to oust upheaval gift within the sign. within the element extraction half, we tend to expel four acoustic options. Division is employed to phase sound catches in to voiced and unvoiced grouping. [1]

Sentiments settle for a motivating activity in our regular daily existence. Sentiments are the trademark physiological response of the figure which might be seen by the outward look. within the projected structure analysis has been exhausted the sector of Human laptop Interaction (HCI). the whole endeavour is split into 3 important advances for example Face revelation, facial half extraction and gathering. within the chief stage face space has been done victimization Haar Cascaded frontal face problem solving [2]

Feeling affirmation could be a speedily making examination area beginning late. instead of people, machines do not have the skills to examine and show emotions. Regardless, human-PC collaboration is often improved by suggests that of motorized emotions affirmation, per se decreasing the necessity of human intervention. Four central sentiments (Anger, Happy, worry and Neutral) are bankrupt down from energetic speak signals. Sign addressing systems are used for procuring the age options from these signs. Supply feature the speedy vital repeat (F0), system incorporates the formants and overwhelming frequencies, zero-crossing purpose rate (ZCR), and therefore the incorporate options signal imperativeness is used for the examinations [3].

Talk is AN free instrument of seeing emotions that offer all around info associated with completely different abstract states of a private. during this explicit state of affairs, we tend to gift a unique strategy employing a mixture of prosody options (for instance pitch, imperativeness, Zero convergence rate), quality options (for instance Formant Frequencies, Spectral options, etc.), gathered options ((i.e.) Mel-Frequency Cepstral constant (MFCC), Linear prophetical cryptography Coefficients (LPCC)) and dynamic element (Mel-Energy extend dynamic Coefficients (MEDC)) for energetic tailored affirmation of speaker's eager states. Shocked SVM classifier is employed for recognizing confirmation of seven distinct evangelistic states to be specific umbrageous, dismay, fear, happy, impartial, and hopeless and stun [4]. during this endeavour feeling from Hindi speak is formed. The information used was assembled from varied speakers having a spot with completely different sexual directions and age gathering. This work primarily turned around eight sentiments which has a mix of head emotions with some improvement emotions and are recorded as: Happy, Angry, Sad, Depressed, Bored, Anxiety, worry and Nervous. These signs were pre-processed, and dismembered victimization varied systems like cepstral, direct need constant, etc [5]

The specific challenges in vocal inclination affirmation in human machine interfaces that consolidates sound pre-taking care of, extraction of inclination crucial options and portrayal of it. Feeling affirmation is that the most contestable and fascinating purpose of analysis that is to date is overseen disengaged progression. Paper shows the various problems associated with electronic taking care of, information standing, options dominancy per feeling and mental changes throughout the inclination age. the final focus of this paper is to assist the peruser with about to the quality of human computer Interaction [6]

The pitch structure could be a hero among the premier enormous properties of talk, that is tormented by the energetic state. essentially contribute choices are regularly utilized frameworks for changed tendency space. during this work totally various powers of suppositions and their effect on pitch

alternatives are broke down. This comprehension is fundamental to turn out to be such a structure. Powers of assessments are appeared on Plutchik's cone-surrounded 3D model. [7]

This paper demonstrates a unique system for picture brimfull with inclination scene gathering that yields the inclination (as names) that the scene is presumptively attending to energize in watchers. Since the loaded with inclination tendencies of shoppers expect a crucial activity in picture call, aroused scene portrayal will develop more and more partaking client driven film request and examining applications. 2 principal problems in organizing film brimfull with inclination scene request are thought of. One is "the means by that to suppose incorporates that are vehemently associated with the watcher's emotions", and therefore the alternative is "the means by that to stipulate removed options to the inclination classes" [8]

An inclination acknowledgment structure with facial expression employing a Bayesian framework. In certifiable correspondence, it's doable that one or two of bits of the face are going to be blocked by upgrades, for example, glasses or a prime. In past examinations on facial affirmation, these examinations are had the tactic to fill within the openings of blocked options within the wake of obtaining facial expression from every image. In any case, just one out of each odd single blocked element will for the foremost half be crammed within the openings fully. Thusly, it is troublesome for robots to understand sentiments fully persistently correspondence [9]

Researches procedures for tailored request of spoken explanations dependent on the eager state of the speaker. The instructive list used for the examination starts from a corpus of human-machine trades recorded from a business application passed on by Speech works. Straight discriminant request with Gaussian class-. prohibitive likelihood transport and k nearest neighbourhood procedures are accustomed portray articulations into 2 basic inclination states, negative and non-negative [10]

### III. PROPOSED SYSTEM

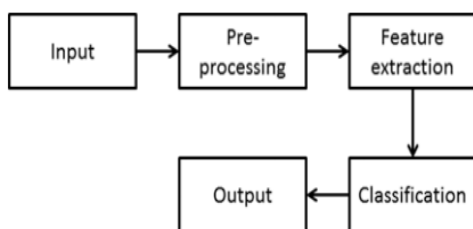


Fig.1 Block diagram of Proposed System

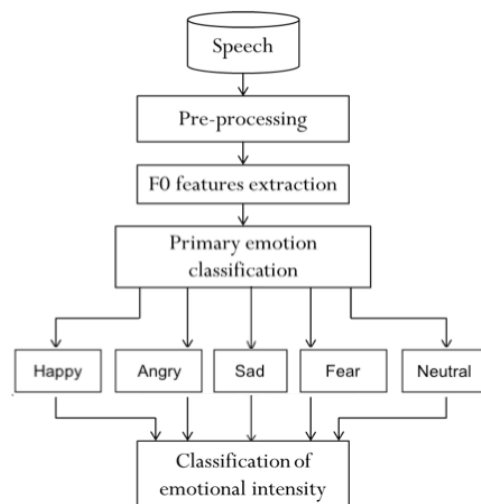


Fig.2 Algorithm for Audio signal processing

The pitch contour is one of the most significant properties of speech, which is affected by the emotional state. Therefore, pitch features have been commonly used in systems for automatic emotion detection. Fig shows algorithm for audio signal processing used in this system.

**Speech:** Speech is an audio signal. It is input from user

**Pre-processing:** Pre-processing images commonly involves removing low-frequency background



noise, normalizing the intensity of the individual particles images, removing reflections, and masking portions of images. Image pre-processing is the technique of enhancing data images prior to computational processing. Pre-processing of audio signal is divided in two parts:

- 1) The first stage being the pre-edit and processing of raw audio, to a common standard, before applying FX processing. This typically involves the removal of unwanted sections, such as chatter between takes, coughs, sneezes and any aberrant peaks, such as clicks, thumps, paper rustling, to leave a clean audio file, and then measuring the RMS level and normalising the audio to a predetermined RMS level so that the audio files are at the same RMS level prior to any FX processing.
- 2) The second stage is the use of FX to remove unwanted noise, rumble and hum and tonal and overall levelling, using Noise reduction, EQ, harmonic enhancement, dynamics etc., to provide a set of clean, leveled audio assets.

Every gathered articulation may contain foundation and amplifier clamor. Wavelet thresholding was utilized to the de-noising recorded articulations. In addition, for additional examination, every single gathered expression has been divided into 20 ms outlines utilizing Hamming window with half cover.

### Features extraction

Feature extraction is the estimation of factors, called an element vector, from another arrangement of factors (e.g., a watched discourse signal time arrangement). Highlight choice is the change of these perception vectors to include vectors. The objective of highlight choice is to discover a change to a moderately low-dimensional component space that jelly the data appropriate to the application while empowering important correlations with be performed utilizing basic proportions of likeness. Determination of productive acoustic highlights is a basic point. It is very hard to make a non-various vector, which portrays the object of examination well. In this paper the impact of exhibited passionate states on F0 shape has been displayed. Following are run of the mill F0 shapes for four fundamental feelings and their powers.

- 1) There are three resentment powers: wrath, outrage and disturbance. For rage F0 increments recognizably according to nonpartisan discourse and furthermore to its forces. This feeling seems to advance on a more significant level in voice pitch. The most reduced qualities were gotten for inconvenience. Alongside increment of feeling power the pitch run turns out to be a lot more extensive and its ascents have a more noteworthy steepness.
- 2) According Plutchik's model delight has three powers: bliss, satisfaction and quietness. These vocal enthusiastic states (comparable with fierceness, outrage and inconvenience) described by increments in F0 mean, range and inconstancy. Be that as it may, pitch changes are smoother contrasted with the past gathering. In spite of the fact that, increments are as yet corresponding to the force of explained feeling.
- 3) Grief, bitterness and contemplation have fundamentally the same as F0 shapes, likewise comparative with the unbiased discourse. There is general diminishing in F0 mean, range and changeability and furthermore descending coordinated sound form. Every one of them are spoken with a limited quantity of progress, F0 is practically consistent. As in past cases increments are corresponding to the force of feeling.
- 4) The last gathering of feeling comprises of dread, dread and trepidation. During the assessment higher F0 mean and more extensive F0 territory were found in correlation with impartial discourse form.

The impact of the power for the essential recurrence is equivalent to in other enthusiastic gatherings.

**Classification**

Right off the bat, all feelings were allocated to four gatherings speaking to essential feelings: outrage, dread, bitterness, and satisfaction. It is hard to precisely perceive feeling putting together just with respect to F0 includes even with such a little arrangement of feelings. Best outcomes were acquired, just as in numerous different scientists, for outrage. We are utilizing Vokaturi calculation for feeling acknowledgment. Vokaturi, established in 2016 and situated in Amsterdam, creates programming which mirrors the best in class in feeling acknowledgment from the human voice. They have built up a few libraries, in C and Python, so engineers can coordinate feeling identification from discourse in their applications. The OpenVokaturi form was the one checked for similar purposes. One the one hand, it works on the PC where it is being utilized, so it needn't bother with access to the Internet. Then again, it's not as incredible as different administrations that arrival us the outcomes determined by a ground-breaking net of PCs.

**IV. RESULTS**

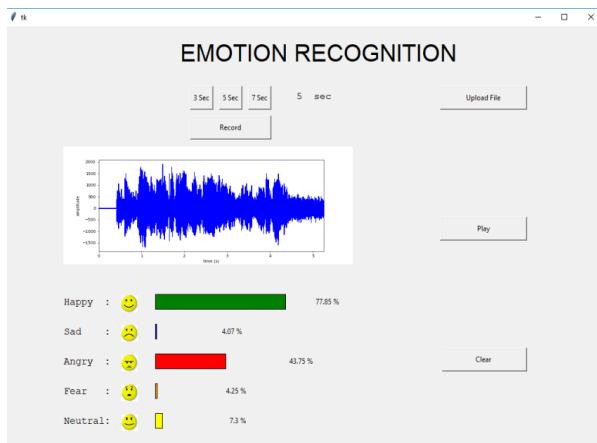


Fig.3 Emotion recognize: Happy, Angry and Neutral emotion

```
## File Emo pitAve pitDir pitDyn pitJit intAve intDyn intJit spcSlo spcJit
## 1 03a01Fa Hap 7.843 0.069 47.044 225.261 70.152 123.866 124.783 -24.761 291.425
## 2 03a01Nc Neu 3.106 -1.481 34.479 81.602 77.124 119.133 135.310 -23.003 279.199
## 3 03a01Na Ang 11.538 -0.748 39.850 239.541 74.989 119.830 125.678 -11.895 236.128
## 4 03a02Fc Hap 14.277 -0.144 40.608 49.205 74.946 139.700 116.640 -21.835 260.228
## 5 03a02Nc Neu 2.779 -0.088 36.414 35.817 78.388 136.579 98.402 -23.546 228.249
## 6 03a02Ta Sad 0.952 -0.552 32.832 49.909 78.794 68.814 84.168 -26.579 231.741
## 7 03a02Nb Ang 10.099 0.255 53.830 255.318 71.987 122.662 126.559 -14.212 199.145
## 8 03a02Mc Ang 14.640 -0.849 55.092 304.520 70.945 147.799 187.774 -7.266 225.950
## 9 03a04Ad Fea 14.507 -2.025 62.848 312.140 75.534 138.105 161.663 -17.021 320.762
## 10 03a04Fd Hap 10.980 -1.137 46.569 34.599 72.555 102.452 138.891 -19.524 353.262
## 11 03a04Lc Bor 1.092 -0.188 24.335 128.274 74.766 64.655 49.590 -20.210 140.245
## 12 03a04Mc Neu 1.666 -0.263 40.141 45.790 74.118 147.766 132.240 -18.446 345.596
## 13 03a04Ta Sad -1.136 -0.789 30.915 45.678 77.867 55.959 46.787 -21.876 268.835
## 14 03a04Mc Ang 15.530 -0.337 49.928 241.626 74.898 139.191 167.740 -10.842 260.153
## 15 03a05Aa Fea 14.007 -0.706 85.523 363.118 75.201 193.033 187.700 -19.254 309.852
## 16 03a05Fc Hap 11.662 -1.508 50.947 324.113 75.728 161.582 138.468 -23.989 312.993
## 17 03a05Nd Neu 3.480 -0.702 46.805 86.754 77.140 158.367 128.839 -25.468 326.156
## 18 03a05Tc Sad 0.329 -0.502 44.231 65.730 77.487 114.261 108.254 -29.039 393.742
## 19 03a05Na Ang 11.195 0.835 48.116 504.413 73.774 146.226 168.905 -17.978 272.416
## 20 03a05Nb Ang 16.536 0.858 70.195 161.294 73.372 207.033 241.235 -14.027 363.438
```

Fig.4 Different Parameters according to

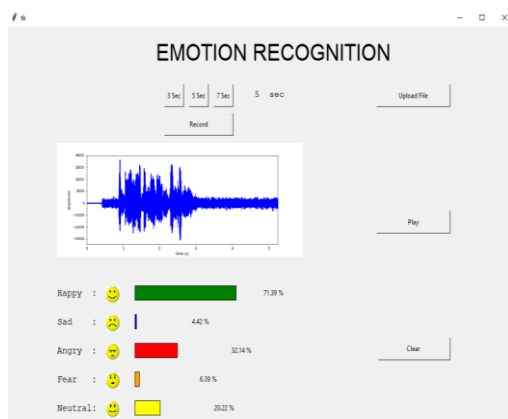


Fig.5 Emotion recognize: Happy, Angry, Fear and Neutral and Angry

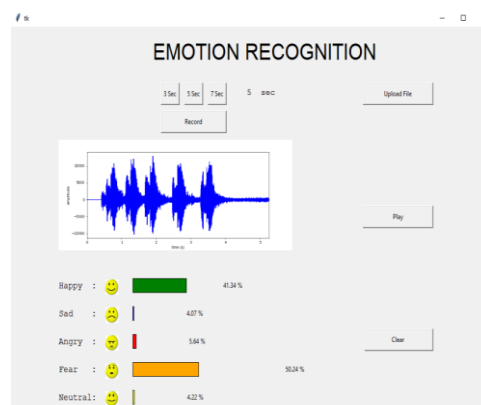


Fig.6 Emotion recognize: Happy, Fear and Angry

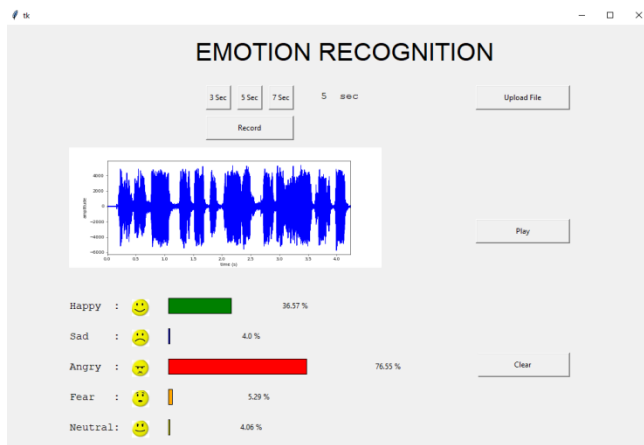


Fig. 7 Emotion recognize: Happy, Angry and Fear

## V. CONCLUSION

Another methodology from discourse signal is going after perceiving feelings has been anticipated. The consequences of this examination show that the outflow of feeling influences F0 form. In any case, the utilization of choices associated alone to F0 doesn't give good outcomes. The regular precision of acknowledgment feeling bunch is concerning five hundredths. For acknowledgment of feeling forces in an exceedingly explicit group exactness execution enormously improves. One will watch some normality for each group of feelings: best outcomes were accomplished for the most vulnerable and most grounded forces, the most exceedingly terrible outcomes for essential feelings. In addition, an examination of perplexity lattice shows that if the arrangement is erroneous, results in reason at the neighbouring sentiment of a comparable gathering.

## REFERENCES

- [1] Recognition of Emotions from Audio Signals Swapnali Tandell<sup>1</sup>, Shital Patil<sup>2</sup>, Vikrant Kadam<sup>3</sup>, Srijita bhattacharjee International Journal Of Current Engineering And Scientific Research (IJCESR) Volume-5, Issue-2, 2018
- [2] Prof. V.D. Bharate<sup>1</sup>, Shubham Sunil Phadatare<sup>2</sup>, Suhas Panchbhai<sup>3</sup>, Vishal Pawar, "Emotion Detection using Raspberry Pi", International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 05 | May -2017 Page 780
- [3] Esther Ramdinmawii<sup>1</sup>, Abhijit Mohanta<sup>2</sup> and Vinay Kumar Mittal "Emotion Recognition from Speech Signal", Proc. of the 2017 IEEE Region 10 Conference (TENCON), Malaysia, November 5-8, 2017
- [4] Emotion Recognition in Speech by MFCC and SVM Akhilesh Watile, Vilas Alagdeve, Swapnil Jain International Journal of Science, Engineering and Technology Research (IJSETR) Volume 6, Issue 3, March 2017, ISSN: 2278 -7798

- [5] Rajni, Dr..Nripendra Narayan Das Emotion Recognition from Audio Signal International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 5, Issue 6, June 2016
- [6] Development in Emotion Recognition in Human Speech: A Review Prof. Sandeep Khanna Mr.Vipin J. Gawande, International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 4, April - 2014
- [7] Recognition of Human Emotion from a Speech Signal Based on Plutchik's Model INTL JOURNAL OF ELECTRONICS AND TELECOMMUNICATIONS, 2012, VOL. 58, NO. 2, PP. 165–170 August 24, 2011; revised May 2012
- [8] Miyakoshi, Y., & Kato, S. (2011). Facial emotion detection considering partial occlusion of face using Bayesian network. 2011 IEEE Symposium on Computers & Informatics.
- [9] Irie, G., Satou, T., Kojima, A., Yamasaki, T., & Aizawa, K. (2010). Affective Audio-Visual Words and Latent Topic Driving Model for Realizing Movie Affective Scene Classification. IEEE Transactions on Multimedia, 12(6), 523–535.
- [10] C. M. Lee', S. Narayanan'. R. Pieraccini, "Recognition of Negative Emotions from the Speech Signal", 0-7803-7343-X/02/\$17.00 Q 2002 IEEE



## M-COMMERCE ANALYTICAL STUDY: A LAST DECADE PERIOD AND POST COVID-19 PANDEMIC SITUATION

□ Prof. Archana Memane-Gaikwad\*  
Dr. Roop Kishore Singhal\*\*

### ABSTRACT

*To highlight to major points which are the real incident once which is belong to our country India's. Major breakthrough economic decisions of demonetization in 2016, November and second out of India to such a small African country. So here it is to start with highlighting first second point about that a small under developed African country KENYA which was just some time back was regarded as no one in the world in terms of M-Payments. Second point that almost more than last three decades the breakthrough and biggest economic decision taken by our Honorable Prime Minister Shri. Narendra Modi Ji in November 2016. They demonization that 500 Rs note and 1000 Rs note to be taken out circulation from the economy justifiable of this landmark decision was given that time to make the economy paperless economy & stop the circulation of fake currency. All the corruption available in the system of our country to be removed after highlighting this two points. One major points during post demonetization time it was also well known allegation across all type of media. Which was made available that a company overnight with the decision of demonetization got usually benefited by increasing this volume from say 100% to 1 million % rise and today that company its and well known and alternate to and payment apps that is Paytm. Now from there on it is seen in current economy that NPS (Net Payment System) and several M-Payments apps especially government app BHIM, Google pay, Phone Pay etc. Our countries major straight is middle class society with the world top in rate using Internet access 7.75 billion with using Smartphones, IPAD etc. Authors objective through this study with considering just mention earlier matter and during and post COVID-19 situation in connection with stopping spared of a COVID-19 by exchanging currencies so M-Payment and M-Commerce issues its current status and rise in the future application are made some such outcomes of this study. Wherein extensive used of secondary data collection. In form of Daily newspaper, COVID-19 related information, articles and research paper, several research report and books available. Work used in our research methodology which was a part of research design. Author attention is also to be altered from the study to find out some important useful suggestions that can be made possible to the union government to enhance the used of M-Commerce and M-Payments. Through this paper identify the issues of the future growth of M-commerce and boosting factors of M-commerce. Even the application providers have to think taking into considerations the needs and type of users. Government should take necessary steps to enhance growth factors like building off infrastructure to internet connectivity, provide awareness and literate more people for English language and M-Commerce usage.*

**Keywords:** M-Commerce, WAP (wireless application protocol), Mobile services, M-Payments, Demonetization

\*Assistant Professor, Department of MBA, R.M.Dhariwal Sinhgad, Management School, Pune

\*\*Assistant Professor, Department of MBA, NBN Sinhgad School of Management Studies, Pune

## INTRODUCTION

M-commerce is sale and purchase of goods over the internet by the use of mobile phones. It refers to WAP enabled smartphones equipped with Bluetooth technology provides users the facility to conduct business transactions. Handy devices are Wireless like cellular phone or tablets. It is known as next generation M-commerce. Users to access the internet without requiring a place to plug in. This technology is called wireless application protocol (WAP).

M-commerce is fast gaining prominence as it is very easy and convenient. Applications of M-commerce like M-banking, M-shopping, and M-entertainment also saves a lot of time which is boon for modern people who are so busy in their fast pacing lives. M-commerce was born in the city of Helsinki. Mobile commerce was first introduced in Helsinki when a coca cola vending machine operated through mobile phone was set up. First phone based banking service was launched in Marita bank in 1997, which later on enabled payment through text message and thereby paved the way for m-commerce. In the 2000 commerce related services spread rapidly. Norway launched mobile parking payment.

Austria offered train ticketing through mobile device. Japan offered mobile purchased of airline tickets. The potential mobile commerce market, mobile phone manufactures such as Samsung, Sony, Blackberry and iPhone are working with carriers such as AT and T wireless, Verizon wireless, Vodafone, Telenor, NTT DoCoMo, Bharti Airtel, Sprint Nextel corporation and Reliance Communications are developing WAP enabled smart phone and offer complete range of telecom service. There are new trends reshaping the world. Mobile commerce is sometimes described as a wireless

extension which is easily accessible anytime from anywhere. Products and services like M-shopping, M-ticketing, Mobile money transfer, Mobile banking, Mobile ATM, Location based services etc; are the factors which are making M-commerce so popular day by day. Which includes all e-commerce transactions, carried out using a mobile (hand held) device. M-commerce is the way of doing business in a flexible way, by making the transaction anytime from anywhere. M-commerce depends on the availability of mobile connectivity. We have become used to making mobile phone calls anywhere, at any time in the same way consumers are able to shop using a hand held device, PDA, mobile and Tablet, wearable computer or smart wireless devices. There are many ways in which consumers of India can be benefited from advancement of M-commerce.

Buying and selling of goods and making mobile payment over internet, booking online tickets, downloading games, audios and videos, using unlimited online software, getting mobile tickets and many more are part of mobile commerce. Day by day many peoples are transferring to M-Commerce to attain good and fast transaction into market. Due to large number of mobile application, growth rate in mobile penetration in India is increasing day by day. The users has intensely increased on mobile phone and consuming bandwidth of internet providers. We can say that people are becoming "Mobify".

## REVIEW OF LITERATURE

- **Gupta, Chandhok and Manu Gupta (2016)**

The article entitled "Hardship of M-commerce in India: Problems, Issues and challenges" In this paper presents M-commerce problems and issues with M-commerce in India. The study found that, the increasing the demand

of the M-commerce applications and services. Have been discussed in paper.

- **Manpreet Kaur (2015)**

The article entitled “M-commerce: SWOT Analysis”. This paper is intended to bring out the facts about the feasibility of M-commerce today, its growth and the strength and opportunities, the weaknesses and threats lying ahead. The study found that, many companies in India started using mobile for doing Business, Financial sector, Telecom sector & Banking are some of the sectors using mobile commerce.

- **Dr. Gupta and Mr. Vyas (2014)**

In this article entitled “Promises and Problem of M-Commerce in India”. Have been discussed in the in this research paper. How M-Commerce is developing in India. The study found that, there is lot of work, which is to be done for M-Commerce.

- **Khawar, Kamran and Weijun (2010)**

In this article entitled “Mobile Commerce and Applications: An Exploratory Study and Review”. This paper presents a review of mobile commerce business models and their importance of the creation of mobile commerce solutions. Have been discussed in the paper.

- **Tandon, Mandal, & Saha (2017)**

The articles entitled possible issues in mobile e commerce. He had tried to bring out the potential benefits and challenges associated with the technology. Many wireless technology protocols like GPRS, WAP, UMTS, and GSM etc.

## OBJECTIVES

1. To study the factors and issues of M-commerce.

2. To study the services and applications of M-Commerce.

## I. Boosting factor of M-Commerce

**Ubiquity:** Ubiquity means usage of online services and carrying of online transactions is not affected by the user’s geographical location.

**Wide reach:** Wide reach is also one of reasons of boosting factor of Mobile commerce in India. People of all levels and categories are using mobile phones and availing mobiles services nowadays.

**Fast connectivity:** Feature of GPRS mobile devices is offering connectivity and services, which help people to remain always connected with others. This feature brings consistent connectivity and services, which help people to remain always connected with others.

**Real Time Service:** It is the possibility of real time of services. Under which time and quickness matters a lot. For example in case of stock market a broker need a real time data in a very fast manner.

**Localization:** Mobile positioning technologies, such as GPS, enable companies to offer services and goods to the user based on the current location. Tracking and reaching to user has become so easy.

**Personalization:** Mobile devices are carried for personal use by an individual, that’s why they are ideal for personal information. Mobile technology provides the benefits to send personalized messages to different people and various groups. Mobile database have become a primary requirement for providing personalized services and compiling personalized information.

**Easy access to Smartphone:** The Smartphone are not at all expensive and common people can easily afford it. With the



advancement of technology and cut throat competition amongst the mobile companies customer and getting best quality, highly featured smart phone on a very reasonable and affordable price.

#### **Low rate of mobile internet services:**

The mobile internet packs are now available at cheap rates unlike the past times when they were so expensive that only affluent people could afford them, 4G, 3G and 2G services are available at cheap rates which are within the reach of common people; this is also a major factor for the growth of M-commerce in India. Major network providers like Vodafone, Airtel and Idea bring new schemes of mobile internet to attract consumers. As Jio and Airtel are offering very attractive and tempting 4G internet plans for the consumers at very low rates.

## **II. Issues in M-Commerce**

**Regulatory Issues:** There are many regulatory issues as far as banks, telecom and third party processors are concerned.

#### **Issues for Banks:-**

- Anti Money laundering and Know Your Customer (KYC) controls,
- Cash payment and cash handling infrastructure,
- Transaction capability,
- Bank account opening and maintenance,
- Tie-up with merchants etc.

#### **Issues for Telecom companies-**

- Anti Money Laundering laws, KYC regulations,
- Fraud management / reporting, etc.
- Transaction monitoring Issues for Third party payments processors
- Regulatory controls, Application hosting and Network infrastructure,
- Transaction capability and monitoring,

- Centralized cross bank settlement mechanism etc.

**Lack of awareness:** Most of the people even does not know what they have with them and how to make the best use of it. Even some of the users is feeling insecure while doing online transaction through mobile phone.

**Lake of easy, standardized payment:** Some process via like ATM, credit card there is no other mode of payment is become popular.

## **III. Applications of M-commerce**

**M-Shopping:** Mobile shopping is the process of purchasing goods and services through mobile devices. Almost all big retailers offer online shopping options to their customers. Presently the highest boom is in this sector. People spend more time on mobile phones that computers main reason is its mobility. Best quality, trendy, reasonable products are easily available through M-shopping on mobile with secured mobile wallet payment system.

**Entertainment:** Entertainment is also one of the important features of Mobile commerce. Playing online games, watching online videos and listening songs on smart phone devices played an important role in development not only for entertainment industry but also for M-commerce industry.

**Education:** One can access lot of contents without any time and location constraint anytime anywhere using hand held devices. Many of the online journals, books, research papers and articles have their dedicated application help the students in their education and learning.

**Travel and Ticketing:** With the introduction of internet enabled fast speed smart phones, mobile users have started booking online tickets easily. Be it for railways, road or air



travelling through mobile ticketing apps tickets for any medium of transport can easily be booked. Indian Railways launched official mobile application which helps consumers to check train, schedule, availability, booking, cancellation and other related functions. There are many apps for road transport booking like Ola cab, Uber, Jugnoo etc.

**Banking Apps:** Mobile banking is an integral part of mobile commerce. Many banks provide online banking facility. Online facilities like Fund transfer, Micro payment, Bill payment, Tax payment, Request for check, Request for mini statement, various statements etc. Facility can be availed. Mobile banking services are provided by all leading banks.

#### IV. M-Commerce services:

M-commerce services and applications	
Mobile Banking	Mobile Accounting Mobile Brokerage Mobile Financial Information
Mobile Entertainment	Mobile Gaming Download of Music and Ring tones Download of Video and Digital Images
Mobile Information Services	Current affairs (financial, sport and other news) Travel information Tracking services
Mobile Marketing	Direct Marketing Organization of Mobile Events Mobile newsletters
Mobile Shopping	Mobile purchasing of goods and services
Mobile Ticketing	Public Transport booking Sports and cultural Events tickets Air and rail Traffic
Telematics Services	Remote diagnosis and maintenance of vehicles Navigation services Vehicle tracking and theft protection

#### RESEARCH METHODOLOGY

Secondary data collection research methodology is used in this study. Our secondary data collection is mostly internet based study combined with few articles, management journals, online research reports and books on M-commerce.

#### Limitation of M-commerce

**1. Security:** The main issue related to M-commerce is security. Users have doubt in mind

while making online payment as they need to share the information related to debit/credit card over the internet. Another threat is of hacking and virus. Hackers may hack the device and steal all personal and important information from mobile. Viruses also damage the handset if the security measures are not proper.

**2. Language barrier:** In India most of people are not well versed with English language, so for them it is not possible to do transactions through

mobile due to this language barrier. This is also one of the major issues.

**3. Lack of awareness:** M-commerce is popular in city. Not in rural areas because villagers people are illiterate people. Even today many people in India are not are aware of mobile phones and internet. Those who are aware are still hesitant regarding buying online, making payment online, how to return if not satisfied with delivered one.

**4. Data transmission rate:** Speed is one of the biggest issues of M-commerce. Common users still get the speed of 2mbps for 3G and 4G network mobile phones, although data transfer at 14.5mbps can be attained but the charges for such service are very high.

**5. Lack of network coverage:** Many time customers don't get connectivity at geographical locations so without coverage using M-commerce is not possible.

### THE NEW BUSINESS MODEL OF MOBILE COMMERCE

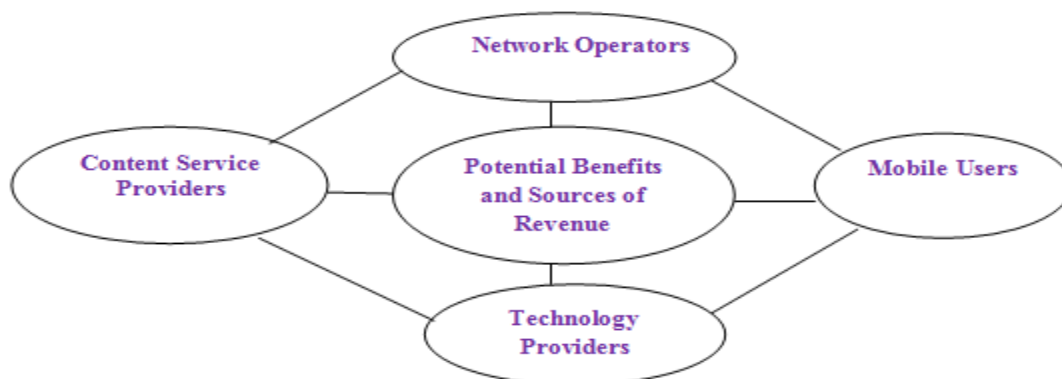


Figure: New Business Model of M-Commerce

As shown in figure Network operators is provide of wireless communication services, Content service providers, Mobile users, Technology Providers in an increasingly competitive market and to support business planning and potential benefits and sources of revenue comprise the essential structure and basis of interaction for the new business model of mobile commerce.

### MOBILE INTERNET USERS IN INDIA

**Table No 1: Mobile Internet Users in India (Figures in Million)**

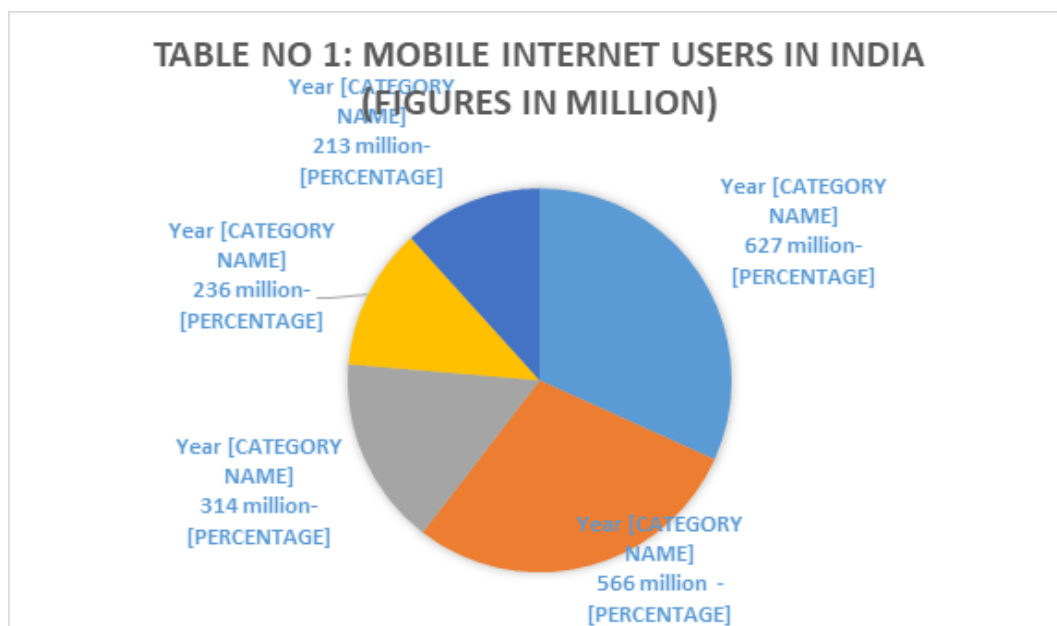
Year	Mobile Internet Users In India
2015	213
2016	236
2017	314
2018	566
2019	627

Source: IAMAI

As the number of mobile internet users is increasing day by day. In COVID -19 situation changes can be attributed to with the improving mobile infrastructure. The availability of

improved high speed of 3G and 4G network connectivity, so people are shifting to apps and internet for most of their activities. In COVID - 19 situation all are using by online platform like

ZOOM, YouTube, Twitter. Most of the people they are working at home. In the current situation there is also lack of internet connectivity access.



## SUGGESTIONS

1. Indian government should take necessary steps to enhance these growth factors like building off infrastructure to internet connectivity, provide awareness and literate more people for English language and M-Commerce usage.
2. The government should take the necessary action for improvement in mobile internet connectivity, mobile payments, security, proper government policies.
3. Government had to start campaigns for rural people provide knowledge of mobile commerce.

## CONCLUSION

The companies by adopting M-commerce can transform the business completely but the opportunity is yet to be tapped due to many constraints. As illiteracy and low speed of internet are the major constraints which need to be resolved fast to make optimum use of this

technology. M-commerce has made the online trading and shopping so easy and fast like never before. People can access their bank accounts, book tickets and do other stuff and manage their uncountable work easily. M-commerce is a real revolution in Indian business sector. These factors have increased the strength for M-Commerce in India; it has led to newer opportunities for the businesses to grow. Mobile commerce is going to play a major role in conducting business in future.

## REFERENCE

- Kaur (May, 2015). "M-commerce: SWOT Analysis", Sai Om Journal of Commerce and Management, A peer reviewed National Journal.
- Kaur (December, 2015). "Transformation from E-commerce to M-commerce in India" Sai Om Journal of Commerce and Management, A peer reviewed National Journal.

- Bhardwaj and Aggarawl (March-April, 2015). "M-commerce", International Journal of Engineering Research and General Science.
- Khawar, Kamran and Yang (April. 2010). "Mobile Commerce and Applications: An Exploratory Study and Review" Journal of computing.
- Gupta, Chandhok and Manu Gupta (January, 2016). "Hardship of M-commerce in India: Problems, Issues and challenges" IOSR Journal of Business and Management.
- Dr. Gupta and Mr. Vyas (April, 2014). "Benefits and Drawbacks of M-Commerce in India: A review", International Journal of Advanced Research in Computer and Communication Engineering.
- Satinder and Niharika (September, 2015). "The Impact of Mobile Commerce in India: A SWOT Analysis", 2nd International Conference on Science, Technology and Management, New Delhi.
- Dr. Batra and Dr. Juneja (February, 2013). "M-Commerce in India: Emerging issues", International journal of Advanced Research in IT and Engineering.
- Dr. Shettar (November 2016)." SERVICES AND APPLICATIONS OF MOBILE COMMERCE IN INDIA: AN EMPIRICAL STUDY", Quest Journals Journal of Research in Humanities and Social Science.
- Tandon , Mandal and Saha (2013). "M-Commerce-Issues and Challenges".
- [http://www.academia.edu/5379833/MCOMMERCE\\_IN\\_INDIA\\_EMERGING\\_ISSUES](http://www.academia.edu/5379833/MCOMMERCE_IN_INDIA_EMERGING_ISSUES)
- [http://www.academia.edu/1470067/FROM\\_MOBILE\\_TO\\_MOBILE\\_COMMERCE\\_AN\\_OVERVIEW\\_IN\\_THE\\_INDIAN\\_PERSPECTIVE](http://www.academia.edu/1470067/FROM_MOBILE_TO_MOBILE_COMMERCE_AN_OVERVIEW_IN_THE_INDIAN_PERSPECTIVE)
- [https://en.wikipedia.org/wiki/Global\\_Internet\\_usage](https://en.wikipedia.org/wiki/Global_Internet_usage)



# ANNAPURNA: Diet Recommender System

Aditya Nimbalkar  
Bachelor of Engineering  
Information Technology  
STES's NBSSOE, Ambegaon  
(BK)

Rahul Samant  
Assistant Professor  
Information Technology  
STES's NBSSOE, Ambegaon  
(BK)

Shreyash Mahajan  
Bachelor of Engineering  
Information Technology  
STES's NBSSOE, Ambegaon  
(BK)

Rajat Tapdiya  
Bachelor of Engineering  
Information Technology  
STES's NBSSOE, Ambegaon (BK)

Pranita Dapke  
Bachelor of Engineering  
Information Technology  
STES's NBSSOE,  
Ambegaon (BK)

## ABSTRACT

Grains, non-veg protein sources, vegetables, and fruits are key parts of a good varied diet. They are emphasized in this guideline because they provide vitamins, minerals, complex carbohydrates, proteins, fats, and other substances that are important for good health. They are also generally low in fat (good fats), depending on how they are prepared and what is added to them at the table [2]. Thus a recommender system that recommends a good and balanced diet for achieving fitness goals like weight gain or muscle gaining, say fat burning and weight maintenance

## General Terms

Diet recommendation, Data mining, Customized meals, Ketogenic diet, Target caloric intake, Current caloric intake.

## Keywords

Diet recommendation, Data mining, Artificial Intelligence basic methodologies, Machine Learning, Decision Tree, Customized meals, Keto diet, BMI.

## 1. INTRODUCTION

A clean balanced diet plays an important role when considered an individual's life. A balanced meal plan is beneficial for having good health as well as the prevention of various diseases [1]. A person who takes a balanced diet seems to be fit all the time. Nonetheless, what actually is a balanced diet? A balanced diet includes an appropriate amount of all nutritional groups, such as carbohydrates, minerals, proteins, fats, and sugar (through natural sources) for maintaining health. All the issues related to the health of a person are related to the diet [1]. The tripod stand consists of three major pillars namely diet, exercise, and proper sleep.

So the whole fitness goal revolves around these three factors which are mainly weight maintenance, fat loss programs, and weight gain. People being aware of the importance of diet still can't manage due to their hectic schedules to get their dietary system on point. Thus a diet recommendation application which is portable, user-friendly, easily accessible provides individual plan considering the goals. The key point to be mentioned diet may vary as per the goals and basic aspects considered like weight, height, work ethic, age, gender and history of diseases.

Thus considering the goals, we display the calorie count to be maintained for routine life. Also, a meal plan consisting of

five to six precise meals that can be customized and will be targeting the calorie count required using machine learning.

Considering the daily corporate life, it becomes difficult for people to have a clean diet plan and that to follow it precisely. The bad eating habits lead to a variety of diseases [1].

To help a person for scheduling a daily plan, BMI stands for Body Mass Index which indicates whether the person is obese or under-fit or ideal. BMI helps for maintaining healthy structure day to day life. The scope of this system can be cost-effective. It consists of an application recommending people meal plans according to the veg, & non-veg or both. A budget-friendly diet plan that is accessible from anywhere. No appointment system as readily available for all age groups so we can provide a meal plan as per their dietician choice. BMI or Calories will be calculated daily.

The traditional diet system consists of appointment booking then sharing personal details varies from person to person and then suggesting a diet, which is time-consuming. The "Dietician Application" reduces the time span and skips the appointment procedure. The product is cost-effective, optimizes the time factor and readily available.

## 2. RELATED WORK

There are a variety of different applications with work related to dietary foods and supplements.

An application like My Fitness Pal contains a huge database with covering over variety of foods and their key parameters like calories, proteins, carbohydrates, fats, potassium, and sodium, which gives a general idea about the daily intake of these parameters considering feasible goals [1].

There are other applications that track our calories and give us an oriented approach to the calories burned, My fitness pal is one of the widely used applications [6]. There are different approaches like the fuzzy approach which is been used for diet prediction. Suggestion applications based on ontology and fuzzy approach.

Special cases like users with a medical history, considering their health condition providing a customized diet plan according to the goals. Ketogenic diets which have been a trend in a fitness industry that involves more caloric intake from proteins, fats and less preferred from carbohydrates, here there are few applications which are best for a ketogenic diet like "Carb-Manager", it is an application which involves all

the steps required for a perfect ketogenic diet for losing fat like caloric intake calculation, insulin and many more [4]. Thus there is another application which focuses on customizing meals and providing a better insight into the macros being consumed throughout the day like PlateJoy, It focuses on customized meals thus giving detailed information about the nutrients being consumed [5].

### 3. DATASET

Dataset is prepared by taking all the aspects of various people who have successfully transformed themselves into their desired goal. Nutritionists have played a major role in helping creating datasets. Dataset is made by surveying local gyms. Trainers of these gyms have shared information including the diet plan of all the clients. The dataset consists of a variety of nutritious food which is extremely healthy for humans. Food which is taken into consideration is easily available in the market. They are extremely cheap as well. For example, seasonal fruit that is grown on motherland is healthier than the fruits which are imported. Once the BMI is calculated, the next step is to select a goal. Users can select their goal as weight gain, weight maintenance or weight loss. Once the current calories are known, target calories can be calculated. Target calories is given by,

$$\text{Target calories} = (\text{Height (cm)} - 100) * 33$$

Once the target calories are known, next step determines the diet plan.

**Table 1: Dataset**

Total number of Records	Attributes	Diet Plans
163	BMI, Current Calorie, Target Calorie, Diet Plan	12

### 4. PROPOSED FRAMEWORK

The system uses a MYSQL database for containing all the information of the user. The database contains all the structured data about user profiles, goals, and parameter like calorie count [3]. The basics of an individual like weight, height, work schedule, age, and gender are considered. BMI calculation indicates a person's body mass index which identifies the current fitness state. According to the BMI results like under-fit, over fit and fit; the goals are selected

and then calorie count is displayed. Considering the target calories with the help of machine learning, a customized diet plan is generated. The main aspect of the application is providing an option for veg or non-veg combined with veg sources. A generic diet plan will be displayed to the user.

**Table 2: Diet plan for calories ranging from 1000-1200**

Meals	Food Items	Calories
1	One whole egg one egg Omelette, One Chapati	200
2	One apple	100
3	Rice(1/2 cup),Dal(1/2cup), Ghee(1 tspn) Oil(15ml)	478
4	Oats(40gm),Almonds(3),Honey(2tspn)	Total calories=1110

#### 4.1 BMI

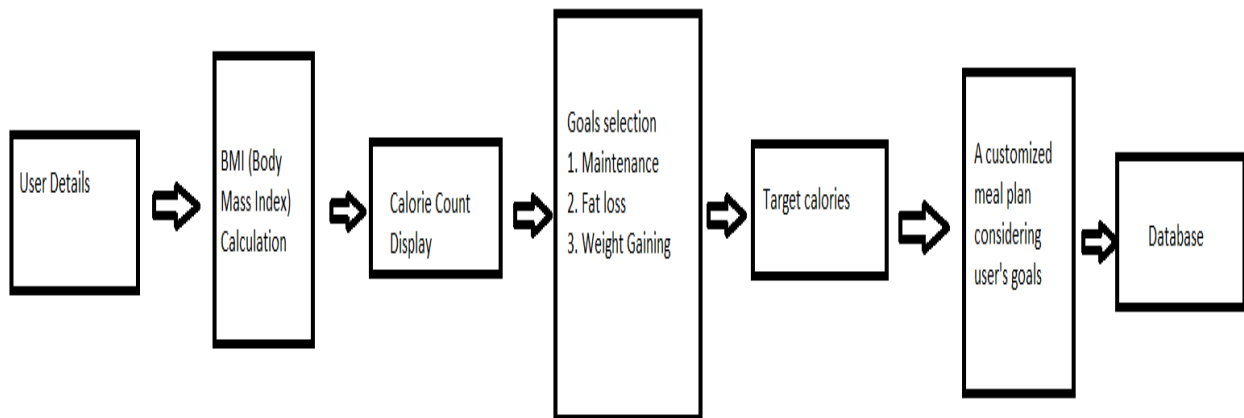
BMI stands for body mass index. BMI is determined by weight in kilograms divided by square of height in meters. BMI is used to measure the leanness of a person based on height and weight. It determines whether the person has appropriate body weight with respect to their height. BMI is used to calculate tissue mass. The value of BMI determines whether the person is normal weight, underweight, or overweight.

BMI is given by,

$$\text{BMI} = \text{Mass (kg)} / \text{Height}^2 \text{ (m)}$$

**Table3: Different Range of BMI for adults**

BMI range	Category
Below 18.5	Under weight
18.5-24.9	Normal Weight
25.0-29.9	Over weight
30.0 -35.0	Obese class 1
35.0-40.0	Obese class 2
>40.0	Obese class 3



**Fig 1: System Flow Diagram**

## 4.2 Algorithm

Regression Tree is used in order to measure how effective the 'target caloric intake' of a person has to be to maintain one's 'weight' and as such provide a suitable diet plan. The attribute such as 'height' and 'weight' are used to calculate BMI (Body Mass Index), suggests in which range (Under-weight, Ideal, Over-weight) a person belongs to.

Regression Trees are a type of Decision Tree and follow an upside-down schema. In a Regression Tree, each leaf represents a numeric value. It is used to determine how to divide the observations by trying different 'thresholds' and calculating the Sum of Squared Residuals (SSR) at each step. The step with the smallest sum of squared residuals becomes a candidate for the root of the tree. If there is more than one predictor, first find the optimal threshold for each one and pick the candidate with the smallest sum of squared residuals to be the root. When there are fewer than some minimum number of observations in a node, then that node becomes a leaf node otherwise repeat the process to split the remaining observations until no observations can further be split into smaller groups.

### Mathematical Model

Set Theory  $S = \{s, e, X, Y, \phi\}$

Where,  $s$  = Start of the program.

1. Log in with username and passcode.

2. Submitting personal details like height and weight.

3. Calculation of BMI.

4. Select a goal.

5. Calculation of current caloric intake and target caloric intake.

6. Displaying the diet plan.

$e$  = End of the program.

$X = \{\text{BMI, goal, current calorie, target calorie}\}$

$X$  = Input of the program.

Goals = weight loss, weight gain, weight maintenance.

$Y$  = Output of the program (diet plan).

Basic steps include the calculation of BMI, current caloric intake and target caloric intake. The features are provided as an input to the Decision tree Regression Model and then the resultant output is a diet plan.

$X, Y \in U$

Let  $U$  be the Set of System.  $S = \{A, U\}$ ,

Where,

Admin and User are the elements of the set.

$A = \text{Admin}$   $U = \text{User}$

## 5. RESULT

### 5.1 Comparison Report

The initial task in research was to compare different machine learning models. The figure below represents comparison in terms of accuracy metrics when trained and tested on datasets. Random splitting was performed on the datasets thus training and testing of the algorithm leads to enhancement of model performance. It was observed that machine learning

algorithms/models such as Naive Bayes and KNN performed fairly well but Decision Tree outperformed all the other models. Decision Tree provides better results in comparison to other models as it divides the dataset into subsets so as to provide better results.

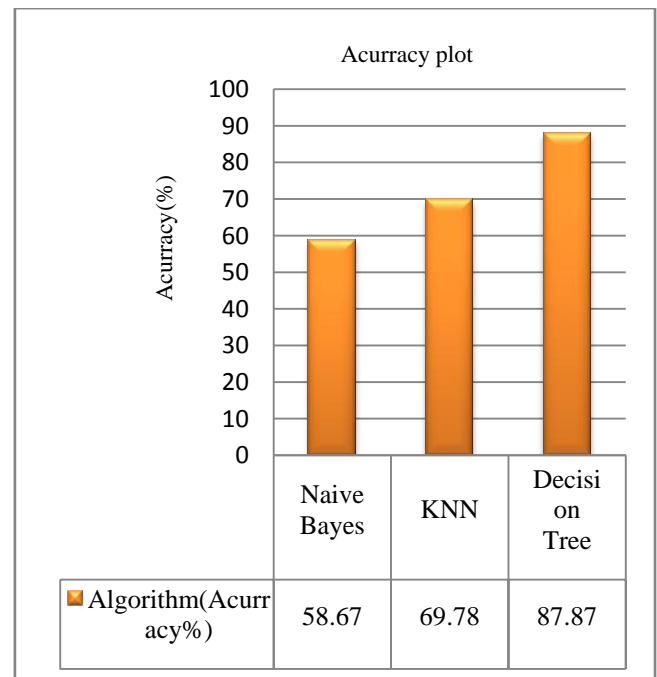


Fig2. Comparison of Algorithms

## 6. CONCLUSION

The proposed framework performs accurately and gives a diet plan which is user convenient. The Regression Decision tree provides an accuracy of 87.87%. The system consists of an application recommending people, meal plans according to veg, non-veg, or both included and provides a budget-friendly diet plan that is accessible from anywhere. No appointment system as it is readily available for all age groups so we can provide a meal plan.

## 7. REFERENCES

- [1] A. Singh, N. Kashyap and R. Garg, "Fuzzy based approach for diet prediction," 2019 9th International Conference on Cloud Computing, Data Science & Engineering (Confluence), Noida, India, 2019, pp. 377-381.
- [2] [www.vepachedu.org](http://www.vepachedu.org)
- [3] R. Sookrah, J. D. Dhowtal and S. Devi Nagowah, "A DASH Diet Recommendation System for Hypertensive Patients Using Machine Learning," 2019 7th International Conference on Information and Communication Technology (ICoICT), Kuala Lumpur, Malaysia, 2019, pp. 1-6.
- [4] "Keto made easy" by Carb manager, <https://www.carbmanager.com/>
- [5] "Plate joy: Custom meal plans and custom recipes", <https://www.platejoy.com/>
- [6] My fitness pal: Free online calorie counter, <https://www.myfitnesspal.com/> [https://play.google.com/store/apps/details?id=com.myfitnesspal.android&hl=en\\_IN](https://play.google.com/store/apps/details?id=com.myfitnesspal.android&hl=en_IN)
- [7] Chavan, S. V., Sambare, S. S., & Joshi, A. (2016),

- August). Diet recommendation based on prakriti and season using fuzzy ontology and type-2 fuzzy logic. In *Computing Communication Control and automation (ICCUBEA)*, 2016 International Conference on (pp. 1-6). IEEE.
- [8] Bhushan, P., Kalpana, J., & Arvind, C. (2005). Classification of human population based on HLA gene polymorphism and the concept of Prakriti in Ayurveda. *Journal of Alternative & Complementary Medicine*, 11(2), 349-353.
- [9] Kaur, S., & Bharti, G. (2012). Two inputs, two output fuzzy controller system design using MATLAB. *Int. J. Adv. Eng. Sci. Technol. (IJAEEST)*, 2(3).
- [10] Lee, C. S., Wang, M. H., & Hagrais, H. (2010). A type-2 fuzzy ontology and its application to personal diabetic-diet recommendation. *IEEE Transactions on Fuzzy Systems*
- [11] T.Y Wong and P. Mitchell, "Hypertensive retinopathy", *New England Journal of Medicine*, 351(22), pp.2310-2317, 2004.



# Sherlock: An Ensemble based Deep Learning Framework for Fake News Detection

Sameer Kulkarni  
Department of Information  
Technology  
NBN Sinhgad School of  
Engineering, Pune, India

R. M. Samant  
Department of Information  
Technology  
NBN Sinhgad School of  
Engineering, Pune, India

Atharva Bhusari  
Department of Information  
Technology  
NBN Sinhgad School of  
Engineering, Pune, India

## ABSTRACT

Fake news is impacting societal harmony and peace. Considering the magnitude of this harmful impact, there is a need to find a solution to curb the online spread of fake news. Detection of fake news is being tackled with various approaches like manual checks, statistical based classification algorithms and deep learning techniques in recent times. This task however, becomes tricky due to the non-binary (entirely true of false) nature of news reporting. Results reported in existing research work require deeper investigation such as classification on a scale of entirely true to entirely false rather than binary classification of news articles. In this paper, a novel ensemble-based framework – Sherlock, to detect fake news articles using natural language processing (NLP) and deep learning techniques is proposed. Due to unsatisfactory results of using a single approach, this framework consists of three distinct tasks of classification based on the article's semantic structure, source credibility and sentiment of the news. The technique of using pre-trained word vectors as word embeddings for semantic analysis has shown performance boost by 2-4%. Additionally, a scale for measuring fakeness of news is proposed. Sherlock classifies a given news article into one of the four degrees of fakeness- "true", "mostly-fake", "entirely-fake" or "uncertain". A comparison of the performance of text classification task using various statistical based machine learning algorithms and deep neural networks are also reported based on two publicly available benchmark datasets. The best test accuracies of 94% for binary classification and 65.5% for multiclass classification were obtained for a GRU (Gated Recurrent Unit) based deep neural network model which has been incorporated in the proposed framework. Sherlock uses a browser plugin to accept news for detection via web-scraping technique and consequently, the training dataset is updated in order to establish context for current affairs. An indigenous dataset which is frequently updated with Indian news context is introduced for the first time to the best of our knowledge. The overall product experience using Sherlock largely intervenes the impulsive behavior of forwarding news, and thereby provides the solution to curb rampant spread of fake news.

## General Terms

Fake News Detection, Machine Learning, Natural Language Processing, Data Mining.

## Keywords

Fake News, Natural Language Processing, Deep Learning, Semantic Analysis, Sentiment Analysis, Pre-trained Vectors, Gated Recurrent Unit.

## 1. INTRODUCTION

Fake news analysis and detection has become an emerging field of research due its effect on the socio-economic and political factors of the world. Impact of fake news ranges from causing political unrest and hampering public administration to spreading social deceptiveness and religious hatred. Existing solutions are less effective in giving precise statistical rating for news articles. One of the reasons is the challenges in natural language processing since natural language can be ambiguous, where a word can have different meaning and interpretations based on the context it is being used in. The proposed framework *SHERLOCK*, comes up with a human-like approach of detecting whether a news article is fake i.e. by considering the semantic style of the news report, checking if the source is reliable and whether the news expresses unrealistically extreme positive or negative sentiments. The basic idea behind the approach is to identify deceptiveness and minimize ambiguity in an intentionally crafted piece of misinformation. Gated recurrent unit is used in the deep neural network architecture which is a variant of Recurrent neural network introduced by Kyunghyun cho et al [1]. The semantic model of the framework has been trained on a dataset of over 45,000 English news articles for multiclass classification which gives an accuracy of over 65%. The source reliability model performs better given its binary nature, and gives an accuracy of 94%. Subsequently the models are retrained with updated data (Headline, news article, source and date), as the semantics and vocabulary changes with time. This also helps with updating a bag-of-words (BOW) model of sources/authors that are linked with producing fake news. This is done by regularly scraping latest articles from news websites.

The paper is organized as follows. Previous related work done on fake news detection is discussed in Section 2. The datasets used are briefly described in Section 3, followed by a detailed methodology of the proposed framework and neural network architecture used for the models in Section 4. Results of experimented algorithms/neural networks along with performance of the models used in the framework are discussed in Section 5 and finally Section 1 concludes the paper.

## 2. RELATED WORK

Fact checking websites such as BOOM, AltNews.in, PolitiFact.com and Factly.com tackle fake news by employing experts and journalists which is an inefficient approach as manual individual checking of news articles will take up non-deterministic amount of time and may still yield inaccurate and biased results. There has been extensive research carried out with regards to detecting fake news from social media

using data such as tweets and posts or images ([2], [3], [4], [5]). However, fake news articles spreading through news websites which can be considered to be a more believable source is not much explored. Also, lack of manually labelled fake news dataset is a challenge mentioned in the paper [6] and it introduces a fine-grained dataset containing short statements and their attributes which got an accuracy of 27.4% using hybrid CNN. It also proved that using metadata associated with news can give improved performance for fake news detection. Literatures [6] and [7] report results for multiclass datasets while all other mentioned work focuses on binary classification which might not be an efficient form of detection considering that news articles can partially contain true information along with false, misleading information and hence classifying them as completely true or false can be inconclusive. [8] proposed hand-crafted features to be used in machine learning classifiers. Another literature introduces a form of query matching system using online fact-checkers and trusted news website [9]. This however, may create a dependency on the efficiency of the third-party fact-checkers and availability of news content on those websites.

### 3. DATASET

**Table 1. Summary statistics of datasets used for experimentation and model training**

Dataset	Total no. of articles	Attributes	Classes
DoF	45000	Title, Text, Author, Label	4
FNC	20800	Id, Title, Author, Text, Label	2
SR	604	Text, Author, Label	2
SST	10300	Sentence, Label	2

Train, validation and test samples are split as 70%, 10% and 20% respectively except for SST, where standard train test split is given.

- **DOF:** Degree of Fakeness dataset that is an amalgamation of datasets “Getting Real about fake news”, “Liar, Liar pants on fire”, “Fake news challenge dataset” ([6], [10], [11]) and 302 manually scraped true news articles focusing on Indian news. The datasets commonly contain title, text author and label of news articles and statements. The datasets have been relabelled into 4 labels as – 0: True, 0.5: uncertain, 0.75: mostly-fake, 1.0: fake.
- **FNC:** Fake News Challenge dataset [10] contains news articles, attributes and their binary labels as

reliable and unreliable. It is used for comparison of accuracies of different algorithms/neural networks with the model architecture used in the framework.

- **SR:** Source reliability dataset that is a subset of the DoF dataset with only a selected number of international authors and labelled as trusted for true and not-trusted for mostly-fake and fake news articles. The labels are as – 0: unreliable, 1: reliable.
- **SST:** Stanford sentiment treebank which includes movie reviews and the fine-grained labels converted to binary as – 0: normal (positive/negative) and 1: extreme (extremely positive/negative) and neutral values discarded [12].

### 4. PROPOSED FRAMEWORK

The task is to detect the degree of fakeness of news articles by considering the output of three ensemble models discussed in detail in further subsections. To do this, a rule based-decision system is used as shown in Table 2. The basic idea behind designing the rules is a higher priority to the semantic analysis model as it extracts better features from the whole news article and gives a fine-grained output in terms of degrees of fakeness as described in Section 3. Furthermore, the sentiment and source models give leverage to the semantic model by giving information about the degree of sentiment (normal or extreme) of the article and whether the source is reliable, based on a BOW model.

**Table 2. Rules for the decision system based on output of three models as semantic-sentiment-score**

Condition	Decision
(T-N-R)   (T-N-U)   (T-E-T)   (H-N-T)	TRUE
(H-N-U)   (H-E-U)   (M-N-U)   (M-E-R)	MOSTLY-FAKE
(M-E-U)   (F-N-U)   (F-E-R)   (F-E-U)	ENTIRELY-FAKE
(T-E-U)   (H-E-R)   (M-N-R)   (F-N-R)	UNCERTAIN

Table 2 contains the combination of possible results and the corresponding decision based on those results where, [T: true; H: half-true; M: mostly-fake; F: fake], [N: normal; E: extreme], [R: reliable, U: unreliable]. Fig 1 represents the process flow for a new article to be detected for fakeness. Data regarding news content and its attributes like date of publishing and author is scraped from online news websites using web-scraping technique and preprocessed before feeding respective data to the models and giving result based on the rule-based decision as shown in Table 2. The process ensures total automation from data gathering to displaying output on a user-interface.

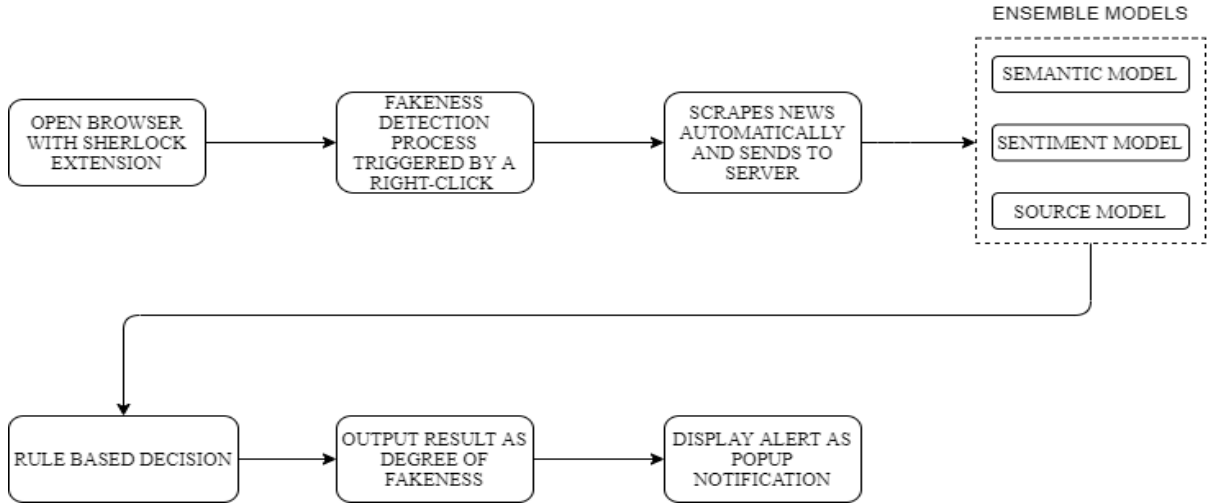


Fig 1: System flow diagram

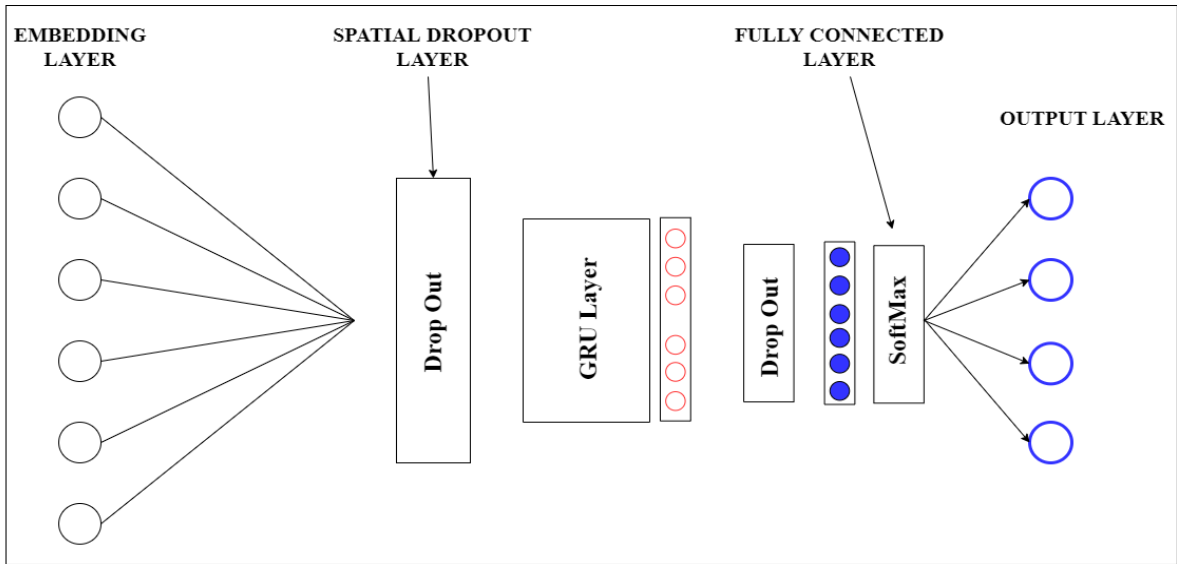


Fig 2: Model Architecture

#### 4.1 Model Architecture

Recurrent Neural Networks (RNN) are specially used for text-based classification problems and in theory, can backpropagate through time to calculate the gradients. Gated recurrent unit is a variation of recurrent neural networks that solves the vanishing or exploding gradient problem typically found in vanilla RNNs. [13] shows that, as the gap grows between an input  $x_t$  and another output  $h_{t+n}$ , RNN does not tend to learn or connect to the information. This led to the development of Long short-term memory [14] and GRU which are similar to RNNs but with gates to improve long term dependencies. GRU is similar to LSTM network in controlling information flow mechanism, without using the memory unit. Hence clearly, without memory unit, GRU has better computational efficiency. The GRU model has two gates as update gate and the reset gate which control the flow of amount of information from one unit to the next. The mechanism of an update gate  $z_t$  at a time step  $t$  for an input  $x_t$  can be represented mathematically as:

$$z_t = \sigma(W^{(z)}x_t + U^{(z)}h_{t-1}) \quad (1)$$

Where,  $h_{t-1}$  is output of a previous unit and  $W^{(z)}$ ,  $U^{(z)}$  are the weights for update gate  $z_t$  associated with the current input  $x_t$

and previous unit output respectively. The sum of these results is regulated using an activation function  $\sigma$  (Gate activation), typically Tanh or ReLU. Thus, it controls the amount of information to be passed ahead from the previous time steps. Similarly, a reset gate  $r_t$  can be represented as:

$$r_t = \sigma(W^{(r)}x_t + U^{(r)}h_{t-1}) \quad (2)$$

The difference from update gate lies in the value of wights. Specifically, the reset gate controls the amount of information to forget from the previous time steps. The content of current unit stored in  $h_t$  is calculated as sum of current input with its weight and Hadamard product of reset gate and previous information with its weight and finally, this result is multiplied by an activation function (Unit activation) to regulate the output as shown in (3) The collective final information  $h_t$  to be passed on to the next unit calculates the sum of Hadamard product of update gate with previous input and  $(1-z_t)$  with content of current unit as shown in (4).

$$h'_t = \sigma(Wx_t + r_t \Theta Uh_{t-1}) \quad (3)$$

$$h_t = z_t \Theta h_{t-1} + (1 - z_t) \Theta h'_t \quad (4)$$

A simplified model architecture as shown in Fig 2 is common for all the three models used in the framework but with different characteristics such as hyperparameter values and training rate suitable for the specific task of each model as described in Table 1 with detailed discussion in Section 5.2.

## 4.2 Semantic Model

The semantic model uses news articles to extract semantic features using static pre-trained word embeddings. A popular method to improve performance of network models is to initialize word vectors with those obtained from an unsupervised neural language model [15]. Word2vec is a predictive modeling algorithm by Tomas Mikolov used to predict the context words based on target words or vice-versa using either skip-gram or a continuous bag-of-words model (CBOW) [16]. However, skip-gram has proved to perform better with long length corpuses by producing 2 vectors for each word; one vector considering the word as center word and another considering it as a context word to predict another center word. Hence, skip-gram is better for the scope of this framework as data is in the form of long-length news articles.

The skip-gram model will define a probability distribution to predict context words  $w_c$  (words around target word  $w_o$ ). It will adjust the vectors such that to maximize the probability of predictions such as:

$$P(O|C) = \frac{\exp(\vec{U}_o + V_c)}{\sum_{w=1} \exp(\vec{U}_w + V_c)} \quad (5)$$

Where, O is the output word index; C is the center word index;  $V_c$  and  $V_o$  are center and outside vectors associated with indices c and o. Sherlock uses the transfer-learning to create word-embeddings and transfer these embeddings to the framework model architecture to extract semantic-based features.

The word2vec vectors are trained on the same dataset used to train the model and this dataset is continuously updated to include latest vocabulary used in news articles. This approach performs exceptionally better when compared to training the vectors at embedding layer in the network architecture.

**Table 3. Network Model characteristics**

Model	Units	Gate Activation	Activation	Loss	Dropout	Optimizer	Batch Size	Epochs
Semantic	200	Tanh	ReLU	Cross Entropy	0.4	Adam	128	5
Sentiment	100	Tanh	Sigmoid	Cross Entropy	0.2	Adam	128	5
Source	50	Tanh	Sigmoid	Cross Entropy	0.2	Adagrad	256	5

## 4.3 Source and Semantic Model

While analyzing fakeness in a news articles, information regarding the source reliability is identified using the frequently updated BOW model. Each time a common source associated with fake news, their frequency count in the unreliable class increases. The model is built on the idea that news articles from reliable sources increases the probability of the article being true and in contrast, unreliable sources increase the probability of the news being fake. For example, the results can be observed to be highly manipulated by the output of source model when a news article is classified as “uncertain” (0.5) by the semantic model. In cases where the author is anonymous, the model would not be part of the decision-making process as clearly, it’s prediction would not be correct regardless of the result. Similar action takes place for cases where author is not a part of the current BOW. However, in this case, the article along with the author and its result predicted by the framework will be saved into the dataset for inclusion in future training process. Thus, the sentiment model needs to be trained frequently with updated dataset as reliability of sources depend upon the number of true/fake news articles published by them. The sentiment model detects whether the positive and negative sentiments in the article are normal or extreme. It should be noted the labels of dataset [SST] are divided such that the values from 0 to 0.2 and from 0.81 to 1.0 are considered as “extreme” and the values from 0.21 to 0.4 and from 0.61 to 0.8 as “normal” unlike for example in [15], [17] and [18] where values are divided as “positive” and “negative” on either side of the

neutral values (from 0.41 to 0.6). The basic hypothesis is that the probability of a news being fake increases when news text is carrying extremely negative or positive sentiment coupled with an unreliable source/author. For example, by adding extremely negative sentiments in a religion-based news, an author can create a sense of hatred among readers. Significant features like adjectives, adverbs, etc. are selected as features for sentiment classifier to be classified into normal or extreme sentiment.

## 5. RESULTS

### 5.1 Comparison Report

Initial task in the research was to compare statistical machine learning algorithms and deep neural networks. Fig 1 represents comparison in terms of accuracy metrics when trained and tested on binary and multiclass datasets. All the algorithms/models were trained using the same random split for both datasets to maintain fairness in comparison. It was observed that while the machine learning algorithms performed fairly good in terms of binary classification, they overfit the training samples and gave poor test results for multiclass classification. This was not the case with neural networks where only a minor difference was observed in training and testing results. The GRU-based neural network outperformed all the other models. The performance was further also compared in terms of precision, recall and F1 score. Results in similar proportions were observed with a few exceptions, more precisely in multiclass classification but the GRU based network was fairly ahead in those metrics as well.

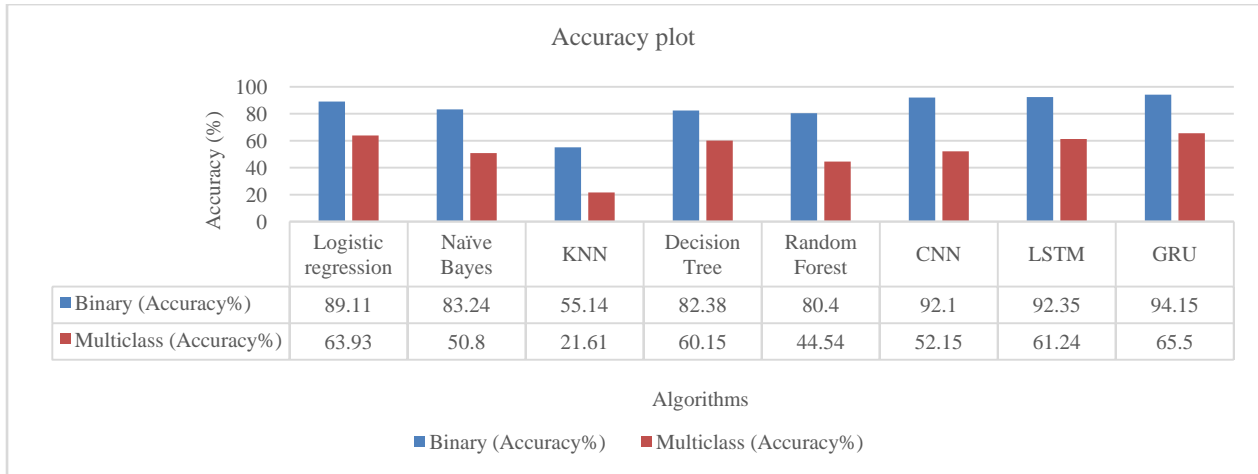


Fig 1: Results (Test Accuracy) for Binary and Multiclass classification

### 5.2 Performance of Framework Models

Table 3 gives information about the model characteristics. There are different hyperparameters and batch settings for each model. The best settings have been selected via a grid search on respective models. However, it was observed that change in dropout layer values for regularization proved to be ineffective for the source model. It is set at a standard value of 20% and can be adjusted in the future when an increased dataset is available through frequent web scraping of news content as mentioned above. Semantic model uses categorical cross-entropy as loss function for multiclass classification as opposed to binary cross-entropy for the other 2 models as they are assigned for binary classification. Learning rate has not been explicitly set for the models as Adam optimizer is used which is an adaptive algorithm and would compute individual

learning rates for various parameters [19]. The results for all the ensemble models are reported in Table 3. The source model performed fairly good despite being trained on a small dataset. It is to be seen whether the model performs consistently with a continuously increasing training data size. Semantic model is the same as used for comparison in Fig 3 and has been reported in terms of the other parameters as well in Table 4. The sentiment model gives a lesser accuracy than expected for a binary classification but it is understood that the reason is due to there being less distinction between extremely positive/negative and normal positive/negative sentiments as compared to the higher distinction between positive (extreme and normal) and negative (extreme and normal) sent

Table 3. Model metrics of Proposed Framework

Models	Class	Precision	Recall	F1 Score	Accuracy
Semantic Model	TRUE	0.88	0.68	0.77	0.655
	Mostly-fake	0.59	0.5	0.54	
	Fake	0.63	0.66	0.65	
	Uncertain	0.51	0.84	0.63	
Sentiment model	Normal	0.62	0.6	0.61	0.628
	Extreme	0.58	0.68	0.66	
Source Model	Reliable	0.86	0.98	0.92	0.917
	unreliable	0.9	0.82	0.9	

### 6. CONCLUSION

The proposed framework performs fairly well on the parameters of response time and classification accuracy. The reported accuracy of 94% for binary and 65.5% for multiclass classification is satisfactorily higher than the current reported ones. The features of news like semantic, sentiment and source play a major part in boosting the overall performance of the framework. The GRU-based deep learning model performs much better than the earlier reported techniques. Ensemble based framework approach widens the scope for detecting fakeness from different dimensions of news content. Sherlock is implemented as a tool for detection and intervention of fake news articles on the internet in order to curb its spreading and consequently create a culture of fact checking and control on impulsive forwarding of such articles

through social media platforms. Future scope is to incorporate a model in the framework to predict reliability based on images available with the news.

### 7. REFERENCES

- [1] K. Cho, B. v. Merriënboer, C. Gulcehre, D. Bahdanau, F. Bougares, H. Schwenk and Y. Bengio, "Learning Phrase Representations using RNN Encoder-Decoder," arXiv:1406.1078, 2014.
- [2] S. Helmstetter and H. Paulheim, "Weakly Supervised Learning for Fake News Detection on Twitter," IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM) , 2018, pp. 274-277.
- [3] S. Krishnan and M. Chen, "Identifying Tweets with Fake

- News,” IEEE International Conference on Information Reuse and Integration for Data Science, 2018, pp. 460-464.
- [4] A. Sen, K. Rudra and S. Ghosh, “Extracting Situational Awareness from Microblogs during Disaster Events,” Social Networking Workshop, COMSNETS 2015 , 2015.
- [5] T. Traylor , J. Straub, Gurmeet and N. Snell, “Classifying Fake News Articles Using Natural Language Processing to Identify In-Article Attribution as a Supervised Learning Estimator,” IEEE 13th International Conference on Semantic Computing (ICSC), 2019, pp. 445-449.
- [6] W. Y. Wang, “Liar, liar pants on fire: A new benchmark dataset for fake news detection,” arXiv:1705.00648v1 [cs.CL], 2017, p. 422–426.
- [7] S. Saad, W. Nicholas, S. Mei-Ling and F. Daniel, “High Dimensional Latent Space Variational Auto Encoders for Fake News Detection,” IEEE Conference on Multimedia Information Processing and Retrieval (MIPR), 2019, pp. 437-442.
- [8] J. Reis, A. Correia, F. Murai, A. Veloso and F. Benevenuto, “Supervised Learning for Fake News Detection,” IEEE Computer Society, 2019, pp. 76-81.
- [9] S. Sudarshan, S. Seth, K. Chebrolu, S. Chakrabarti, M. Agarwal, A. Pale and A. Bagade, “The Kauwa-Kaate Fake News Detection System: Demo,” ACM India Joint International Conference on Data Science and Management of Data (CoDS-COMAD) , 2020.
- [10] “Fake News Challenge,” [Online]. Available: <http://www.fakenewschallenge.org/>.
- [11] M. Risdal, “Kaggle.com,” [Online]. Available: <https://www.kaggle.com/mrisdal/fake-news>.
- [12] R. Socher, A. Perelygin, J. Y. Wu, J. Chuang, C. D. Manning, A. Y. Ng and C. Potts, “Recursive Deep Models for Semantic Compositionality Over a Sentiment Treebank,” In Proceedings of EMNLP, 2013.
- [13] Y. Bengio, P. Simrad and P. Franconi, “Learning Long-Term Dependencies with Gradient Descent is Difficult,” IEEE Transactions on Neural Networks , Vol 5, No. 2, 1994, pp. 157-166.
- [14] S. Hochreiter and J. Schmidhuber, “Long Short-Term Memory,” in *Neural Computation Vol. 9,8*, <https://doi.org/10.1162/neco.1997.9.8.1735>, 1997, pp. 1735-1780.
- [15] Y. Kim, “Convolutional Neural Networks for Sentence Classification,” Conference on Empirical Methods in Natural Language Processing (EMNLP), 2014, pp. 1746-1751.
- [16] T. Mikolov, I. Sutskever, K. Chen, G. Corrado and J. Dean, “Distributed Representations of Words and Phrases and their Compositionality,” 2013, pp. 1-9.
- [17] R. Socher, J. Pennington, E. H. Huang, A. Y. Ng and C. D. Manning, “Semi-Supervised Recursive Autoencoders,” EMNLP '11: Proceedings of the Conference on Empirical Methods in Natural Language Processing, 2011, pp. 151-161.
- [18] N. Kalchbrenner, E. Grefenstette and P. Blunsom, “A Convolutional Neural Network for Modelling Sentences,” arXiv:1404.2188v1 [cs.CL] , 2014.
- [19] D. P. Kingma and J. L. Ba, “ADAM: A METHOD FOR STOCHASTIC OPTIMIZATION,” 3rd International Conference for Learning Representations, San Diego arXiv:1412.6980, 2015.

# Vibration Analysis of Disc Brake by Using FEA and FFT Analyzer

<sup>1</sup>Pradnya Dhainje, <sup>2</sup>S.M. Jadhav

<sup>1</sup>PG Student, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Pune, Maharashtra, India, 411041

<sup>2</sup>Assistant Professor, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Pune, Maharashtra, India, 411041

\*\*\*

**Abstract** – A disc brake is a type of brake that uses calipers to squeeze pairs of pads against a disc or rotor to create friction. This action retards the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. The energy of motion is converted into waste heat which must be dispersed. The disc brake is a device for slowing or stopping the rotation of a wheel. Repetitive braking of the vehicle leads to heat generation during each braking event. In our project topology optimization and modal analysis of existing 2-wheeler disc brake is performed. The 3D model will be drawn with the help of CATIA software. In modal analysis disc brake with three different shape holes are performed namely original, elliptical and larger circular hole. Hence, modal analysis is performed on three different shapes to evaluate mode shapes and natural frequency. So, optimum model is selected from these analyses. Also, experimental analysis using FFT technique (impact hammer test along with accelerometer) to determine mode shapes and natural frequency and comparison with FEA results are performed. Modal Analysis and of the Rotor Disc of Disk Brake is aimed at evaluating the performance of disc brake rotor of a car under severe braking conditions and there by assist in disc rotor design and analysis. Similar testing will be done using FFT analyzer method for experimental stress analysis.

**Key Words:** Repetitive Braking, Vibration, FEA, ANSYS.

## 1. INTRODUCTION

In today's growing automotive market, the competition for better performance vehicle is growing enormously. The racing fans involved will surely know the importance of a good brake system not only for safety but also for staying competitive. The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc usually made of cast iron or ceramic composites includes carbon, Kevlar and silica, is connected to the wheel and the axle, to stop the wheel. A friction material in the form of brake pads is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. This friction causes the disc and attached wheel to slow or stop. Generally, the methodologies like regenerative braking and friction braking system are used in a vehicle. A friction brake generates frictional forces as two or more surfaces rub against each other, to reduce movement. Based on the design configurations, vehicle friction brakes can be grouped into drum and disc brakes. If brake disc is in solid body the heat

transfer rate is low. Time taken for cooling the disc is low. If brake disc is in solid body, the area of contact between disc and pads are more. In disc brake system a ventilated disc is widely used in automobile braking system for improved cooling during braking in which the area of contact between disc and pads remains same.

## 2. LITERATURE REVIEW

Khaled R.M. Mahmoud et al. [1] mathematical models to study the dynamic behavior of a wedge disc brake are presented in this article. The friction coefficient has a significant role in the brake system dynamics especially, self-energized. A set of experiments have been conducted to formulate mathematical equations relating the friction coefficient, normal force and sliding speed. The effect of main operational parameters of a wedge disc brake such as normal force, sliding speed and wedge angle on the dynamic behavior and their comparisons with conventional disc brake system are investigated. Setting time and frequency response are the main performance indicators to investigate the dynamic behavior of a disc brake. The results indicate that friction coefficient significantly influence the resonance frequency and setting time of wedge disc brake shoe factor. However, the coefficient of friction has a negligible effect on setting time or resonance frequency of conventional disc brake. The effect of sliding speed on a wedge disc brake dynamic is somewhat considerable but it has a little effect on the dynamics of a classical disc brake.

Daanvir Karan Dhir et al. [2] the kinetic energy of the vehicle is converted into mechanical energy while braking which leads to heat dissipation and temperature rise of the disc and the disc-pads. The aim of this investigation was to study the rise in temperature of an automotive disc brake at the time of braking and its effect on disc durability using finite element method. Application of a specified braking torque on the rotor led to generation of heat flux. The heat flux generated and the heat transfer coefficient taken into consideration were numerically analyzed, which were then used to calculate the rotor rigidity, maximum temperature rise on the disc rotor. The rotor was further loaded with thermo-mechanical cyclic stresses which were used to analyze the durability and fatigue factor of safety of disc. The influence of variations in disc rotor geometry i.e. holes and airfoil vents in comparison to a simple flange type disc were studied and their effect on maximum temperature rise and disc durability has been investigated by modeling and



conducting FEM techniques in Solid works and ANSYS respectively.

Xingwei Zhao et al. [3] creep groan in automotive disk brakes is a prevalent low frequency vibration phenomenon. It may occur when a car accelerates slowly from standstill with slightly operating brake as it might be the case for cars with automatic transmission or at slopes. The origin of creep groan is friction-induced vibrations from the pad-disk contact in the brake resulting in stick-slip limit cycles. These stick-slip limit cycles may excite comprehensive structural vibrations in the car leading to structure-borne sound and passengers' discomfort. The investigations in the present paper focus on the origin of this phenomenon - by considering set-ups concentrating on the pad-disk contact - and the possibility of suppressing the stick-slip limit cycle vibrations by excitation with piezoceramic actuators. Therefore, two test set-ups are investigated. The simpler one just uses disk, brake pads and caliper from an industrial brake, while carrier and suspension are replaced. The other one considers a complete brake including serial carrier and suspension. Low frequency stick-slip limit cycles could be observed in both test set-ups and a corresponding nonlinear model including the bristle friction law is developed for both systems.

Chin An Tan et al. [4] this paper presents a dynamic stability study of a novel brake disc design consisting of periodic lattice truss substructures. An integrated approach of theoretical modeling, experimental modal analysis, and finite elements methods is employed in this investigation to understand the squeal characteristics. The brake system is analytically modeled by a rotating annular disc subjected to in plane frictional loads. Natural frequencies and forced response of the brake disc are obtained and validated by finite elements results. Experimental modal analysis of the lattice brake rotor/pad system with free-free boundary conditions is performed to obtain the modal properties of the brake rotor as inputs to the finite elements model.

Yan Shui et al. et al. [5] the ventilated disc brake of vehicles was selected as the objective of this study, which was built on 3D modeling technology. Through establishing thermo-structural coupling model, this study analyzed the transient temperature field of automobile brake under the condition of hard braking. Meanwhile, the test of hard braking was carried out on professional platform of vehicle test bench in this paper, and temperature curves of brake disc in radial and circumferential directions were obtained. By comparison, the experimental values and simulation values were basically equal. The rationality of the selected finite element analysis (FEA) was attributed, which provided a better theoretical basis for further experimental analysis.

### 3. EXPERIMENTATION

#### 3.1 Problem Statement

High stresses are seen in brake disk due to friction & also the vibrations will be increased so to reduce the vibrations,

optimization & modal analysis will be carried out. So, in current study modal analysis of disc brake with different shape is performed to obtain optimized model without disturbing its existing natural frequency. Hence, FEA analysis results are compared with experimental results using FFT analyzer technique.

#### 3.2 Objectives

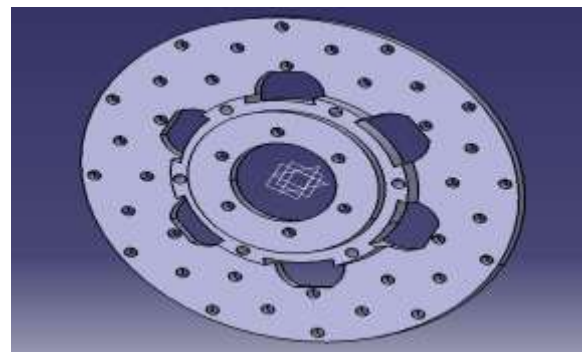
- ❖ To prepare CAD design of existing disc brake using CATIA V5 software.
- ❖ To obtain optimized model of existing disk brake (by making larger holes and elliptical) shape and comparing with original model.
- ❖ To determine mode shapes, natural frequency, deformation in disc brake through finite element analysis by modal analysis.
- ❖ Experimental analysis of disc brake to obtain mode shapes and natural frequency by modal analysis using FFT analyzer technique.
- ❖ Validation of experimental and analytical results.

#### 3.3 Methodology

1. The CAD model is prepared in CATIA V5 R20.
2. The modal analysis is performed in ANSYS 19.0. Modal analysis is performed to determine mode shapes, natural frequency, deformation of all models (by large holes and elliptical) shape to get optimized models.
3. The best optimized is to be obtained and compared to the existing model.
4. Experimental analysis of the disc brake rotor will be performed by fixing one side to determine mode shape and natural frequency using FFT analyser technique.
5. Comparison of experimental and numerical results.

#### 3.4 FEA Analysis

**Material selection for disc brake:** Grey cast iron



**Fig -1:** Catia model of disc.

Solid model of the disc brake assembly is shown in fig.1, consisting of brake pad along with arrangement of circular holes.



Property	Value	Unit
Material Field Variables	Table	
Density	7200	kg m <sup>-3</sup>
Isotropic Secant Coefficient of Thermal Expansion		
Coefficient of Thermal Expansion	1.1E-05	C <sup>-1</sup>
Isotropic Elasticity		
Derive from	Young's Modu...	
Young's Modulus	1.1E+11	Pa
Poisson's Ratio	0.28	
Bulk Modulus	8.335E+10	Pa
Shear Modulus	4.296E+10	Pa

Fig -2: Engineering Materials Properties in ANSYS.

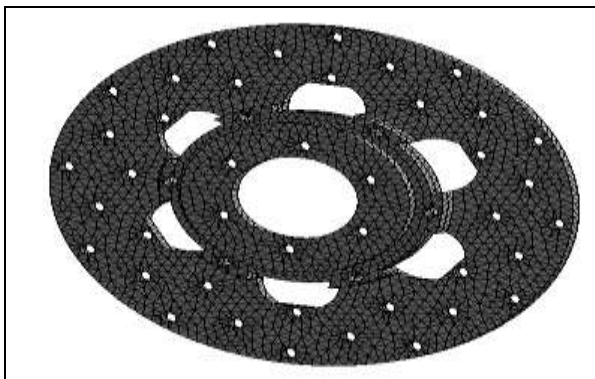


Fig -3: Meshing of Disc Brake.

In meshing of disc brake geometry, we used tetrahedral element type and get 37787 nodes and 19740 elements.

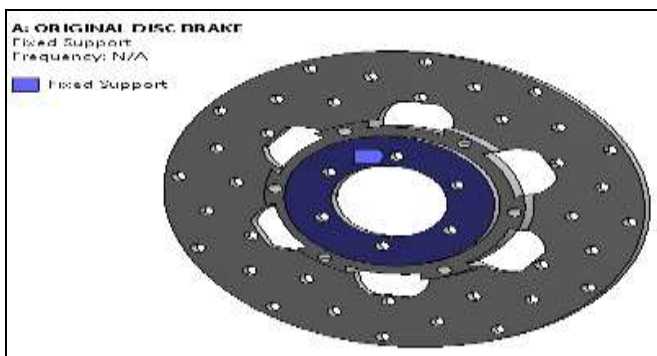


Fig -4: Boundary Conditions.

#### 4. RESULTS AND DISCUSSION

Results for Different mode shapes

At mode 1

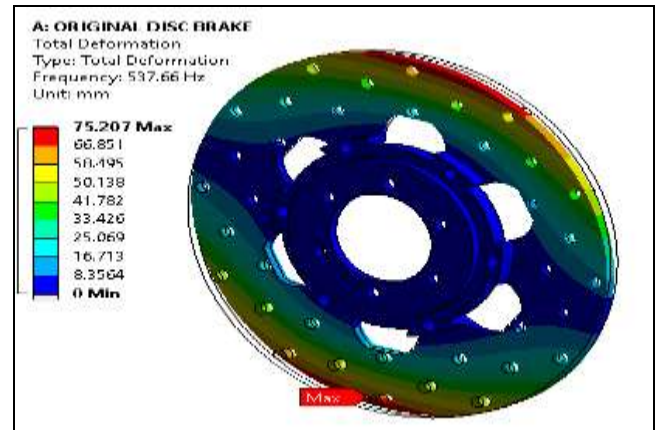


Fig -5: Natural Frequency at Mode 1.

At mode 2

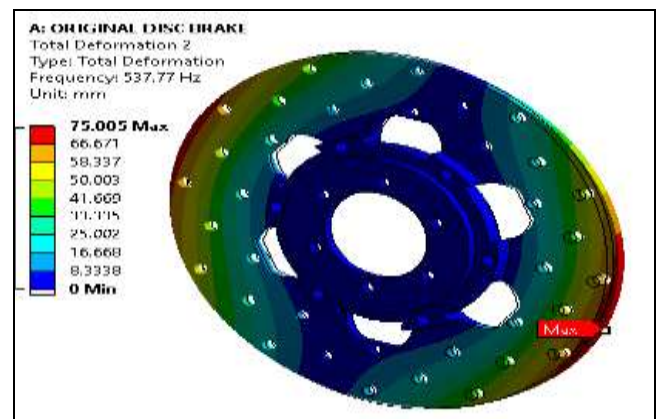


Fig -6: Natural Frequency at Mode 2.

At mode 3

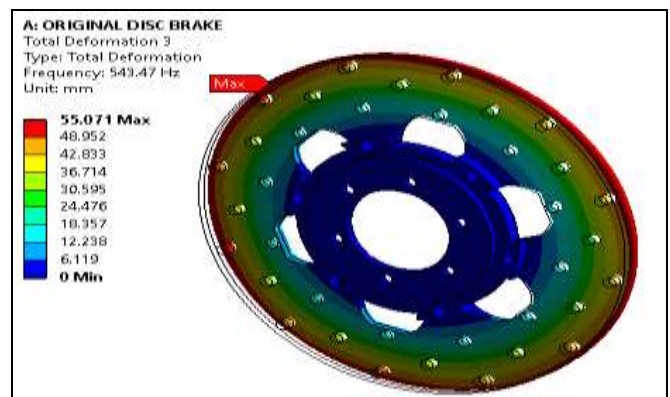


Fig -7: Natural Frequency at Mode 3.

At mode 4

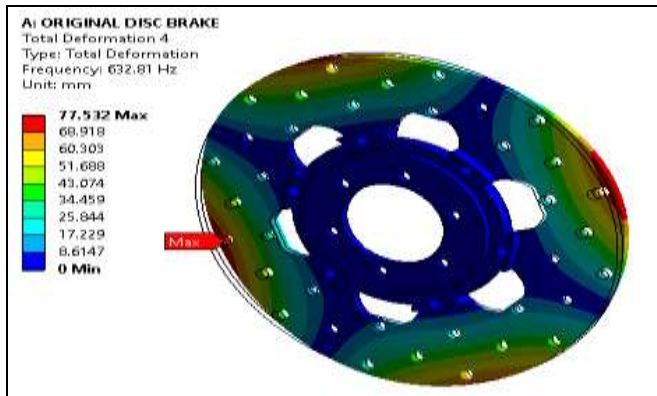


Fig -8: Natural Frequency at Mode 4.

At mode 5

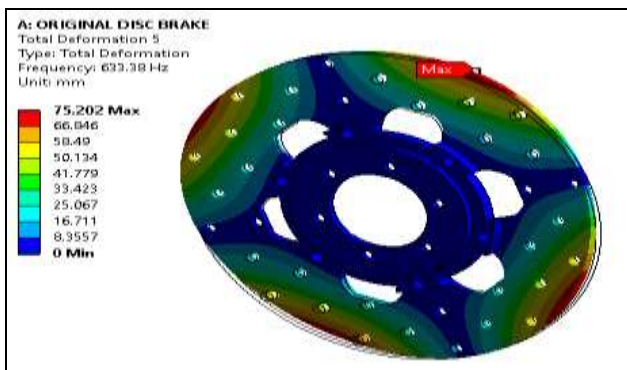


Fig -9: Natural Frequency at Mode 5.

Table -1: Natural frequency reading for 5 mode shape For Disc Brake with Elliptical Hole.

Tabular Data		
	Mode	Frequency [Hz]
1	1.	540.48
2	2.	540.72
3	3.	544.36
4	4.	631.64
5	5.	632.11

Table -2: Natural frequency reading for 5 mode shape For Disc Brake with Large Circular Hole.

Tabular Data		
	Mode	Frequency [Hz]
1	1.	539.14
2	2.	539.63
3	3.	543.92
4	4.	634.38
5	5.	634.82

### Experimental Testing

Experimental modal analysis is performed on disc brake with elliptical shape holes to determine natural frequency and mode shapes. It is observed from above graph obtained by Fast Fourier transform (FFT) technique that maximum frequency is about 556 Hz and from ANSYS it is observed around 544.6 Hz.



Fig -10: Experimental Setup



Fig -11: FFT Analyzer Results

### 5. CONCLUSION

By comparing the different results obtained from FEA and experimental setup, it can be concluded that,

1. Modal analysis of disc brake is performed to obtain optimized model for existing disc brake. It is concluded that after performing analysis on three different shapes (original, large circular holes and elliptical shape) holes the best optimized results are obtained with elliptical shape holes.
2. Disc brake with elliptical shape hole has more weight loss (5%) without disturbing its existing natural frequency compared to original disc, hence heat dissipation is increased and cooling effect is improved.
3. Experimental modal analysis of disc brake provided natural frequency around 556 Hz and ANSYS around 543.6 Hz. So, both frequencies are nearly same. Also, mode shape 3 frequency is observed to be severe as 50 % mass is participated in vibration.

## REFERENCES

- [1] [AleskanderYevtushkendo, Michal Kuciej, "Temperature and thermal Stresses in a pad/disc during braking", Elsevier, Applied Thermal Engineering 30 (2010) 354-359,2011, doi:10.1016/j.applthermaleng.2009.09.015
- [2] Ali Belhocine, Mostefa Bouchetara, "Thermal analysis of solid brake disc", Elsevier, Applied Thermal Engineering 32 (2012) 59-67, 2012, doi: 10.1016/j.applthermaleng.2011.08.029
- [3] Fred Puhn, "Brake Handbook" (HP Books, U.S.A., 1985), ISBN: 0-89586-232-8.
- [4] F. Talati, S. Jalalifar, "Investigation of heat transfer phenomenon in a ventilated disc brake rotor with straight radial rounded vanes", Journal of Applied Sciences, 8:3583-3592, 2008, doi: 10.3923/jas.2008.3583.3592
- [5] Guru Murthy Nathi, T N Charyulu, K.Gowtham, P. Satish Reddy, "Coupled Structural/ Thermal Analysis of Disc Brake", IJERT: 539-553, 2012, doi.org/10.15623/ijret.2012.0104004
- [6] Giancarlo Genta, Lorenzo Morello, "The Automotive Chassis (Volume 1), Springer, 2009", ISBN: 978-1-4020-8674-8.
- [7] Rudolf Limpert, "Brake Design and Safety" (S.A.E. International, U.S.A., 1999), ISBN: 1-56091-915-9
- [8] ANSYS (Version 15.0), ANSYS Meshing User's Guide, Computer Software, ANSYS Inc., Houston, USA, 2015.
- [9] M. Boniardi, F. D' Errico, C. Tagliabue, G. Gotti, G. Perricone, "Failure analysis of motorcycle brake disc", Engineering Failure Analysis, 13 (2006) 933-945, doi: 10.1016/j.engfailanal.2005.04.01.
- [10] Roger Rabb, "Fatigue life evaluation of Grey Cast Iron Machine Components under variable amplitude loading" Fatigue Design and Reliability (ESIS Publication 23), Elsevier Science Ltd., 1999, ISBN:0080433294
- [11] Brake disc modal behavior, A IORDACHE, G ANGHELACHE and R MOISESCU, International congress of automotive and transport engineering
- [12] Modal Analysis of Automobile Brake Disc, Dong Xiaowei, Zhang Bojun, Meng Dejian, International Journal of Engineering Research & Technology (IJERT)
- [13] Investigation of Natural Frequency and Modal Analysis of Brake Rotor Using FEA and EMA, Nilesh K. Kharate, Dr. Sharad S. Chaudhari International Journal of Innovative Research in Science ,Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 10, October 2014
- [14] Finite Element Analysis of Brake Disc of Motorcycle, Mr. Nilesh R. Farande Mr. Chetan D. Patil, Prof. R. D. Patil, International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE)
- [15] Vibrational Analysis of Disc Brake Rotor of a Two-Wheeler to find the defect using FEA D. Bhadgaonkar, A. Singh, S. S. Jadhav, S. S. Jadhav
- [16] Mahle Metal Leve S/A, Mahle International GmbH, "Cylinder Line and Cast-Iron Alloy", U.S. Patent 14/239,240, Oct 30, 2014.



# A Review Paper on: Containment Test and Impeller Burst Simulation using Explicit Dynamics

Priti Sawaikar<sup>1</sup>, Digvijay Mahajan<sup>2</sup>, Hemanth K Gopalakrishnan<sup>3</sup>

<sup>1</sup>(PG Student, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon Bk., Pune, India)

<sup>2</sup>(Asst. Professor, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon Bk., Pune, India)

<sup>3</sup>(Applied Mechanics, Cummins Turbo Technologies, Pune, India)

**Abstract:** *Containment test is done for ensuring the safety of turbocharger by checking the ability of the turbine and compressor housing to retain all the fragments within it, in case of wheel burst. For inducing impeller burst, an impeller with purposely provided slot on the back face of the impeller is assembled in turbocharger and operated at target speed. Experimental testing involves various iterations to be performed for successful burst to occur i.e. to obtain correct slot dimensions of the impeller to burst at target speed, resulting in expensive and time consuming test. Thus, to avoid the experimental iterations of containment testing, Finite Element simulation method can be used. This paper presents the literature survey on containment testing, methodology used for simulating containment test and impeller burst. Based on literature survey, various parameters can be considered to develop a methodology to simulate impeller burst.*

**Keywords:** *Containment testing, Impeller burst, Weakening slot, Successful burst, Explicit Dynamics*

## I. INTRODUCTION

### A. Containment Test

Various tests are performed on turbocharger to check its capability for usage before it is delivered to the customer. Containment test is used for checking the ability of the compressor and turbine housing individually for containing the debris within it, if wheel burst occurs.

Pranita Kesare et.al. [1] explains certain operating conditions that may lead to the failure of turbocharger and its components. High pressure turbine disk failure of CF6-80A engine at Los Angeles International airport in 2006 and turbine disk incident at Qantas A3380 engine are few of the examples illustrated.

Burst and Containment by Garrett et.al. [2] explains the wheel burst as the failure of turbine or compressor wheel when they are unable to hold as a single piece against the centrifugal forces. Wheel burst can occur in two ways: 1. Blade burst – where the blades get detached from the wheel 2. Hub burst – the extreme case where hub region reaches beyond its ultimate limit and bursts into pieces. This phenomenon occurs at very high temperature and high-speed range. Containment test is described as an ability of the turbine and compressor housing to absorb the energy released during burst and contains all the debris within it. Impellers have higher probability to fail through burst as the material used for manufacturing impeller is Aluminium, which has lower strength than the Inconel material used for turbine wheels. Some of the other factors are low cycle fatigue, foreign object damage etc. For validating a new wheel or impeller design, tests are carried out with the turbocharger assembled with speed and temperature sensors. After this, the instrumented turbocharger is installed on containment stand where hot air fuel gas mixture is introduced on turbine wheel to drive the test according to actual operating conditions. After dwelling the turbocharger at some speed and temperature, its speed is intentionally increased and operated at speed more than design speed.

Simon Barrans et.al. [3] explains the use of turbochargers in engine to meet the Euro VI norms. Development in turbocharging technology, its methods and limitations for future development are also proposed in this paper. In most of the countries, the taxes on passenger cars are linked with the amount of carbon dioxide that is generated in standard duty cycle, therefore demanding the turbochargers to reduce the emissions of carbon dioxide. The turbochargers are also expected to deliver various peak powers, help in downsizing the engine etc. This increases various structural problems in turbocharger. There are several other reasons contributing to turbocharger failure such as external load on turbine side (thermal expansion and vibration of components) and compressor side (vibration load due to air filter etc.), internal load due to rotating systems and high temperatures on turbine side. The highest load that turbine housing or compressor housing will be experiencing are those resulting from the failure of turbine wheel and impeller through burst. The reason for turbine wheel or an impeller to burst is low cycle and high cycle fatigue. Low cycle fatigue (LCF) is seen when the material is loaded beyond its elastic limit. To avoid this, author concludes with a suggestion to manufacture by

milling the compressor wheel from strong aluminium billet and not by casting. High cycle fatigue is observed when material is subjected to cyclic loading within the material's elastic limit. To safeguard the turbocharger and other components around, from the damage due to turbine or impeller burst, manufacturers design the turbocharger such that they contain all the burst fragments and validate the same by carrying out containments tests. For containment testing the turbocharger wheels are purposely induced to burst at speed higher than maximum design speed. Two types of tests are performed to depict wheel burst are 1. Hub burst 2. Blade off. Work is further required to relate the actual material properties of wheel to predict the turbine wheel or impeller burst using Finite Element Analysis.

### B. Explicit Dynamics

Ashish Jaiswal et.al. [4] explains the capabilities of ANSYS to solve structural dynamics problems. Various disciplines available and their algorithms available in ANSYS are explained. Transient dynamics analysis is used for determining the time response of structure for forces varying with time. To solve these problems, time integration is performed. Implicit and Explicit are the time integration methods available. Implicit uses Newmark method, it is unconditionally stable. This method solves linear equation for each time step and the stiffness matrix is inverted for each increment, which is computationally expensive. Explicit method used Central Difference method which is conditionally stable. It also solves linear equations for each time step but it does not perform any inversion. Thus, Explicit method is preferred to provide solution for nonlinear problems involving large deformation, impact problems, short duration problems etc.

Czeslaw Bajer et.al. [5] describes various types of time integration methods used through this paper. Newmark and Central Difference method are most commonly used for structural dynamics analysis problems. Various other methods such as the Bossak and Hilber Hughes Taylor methods are also studied, which are considered as an alternative to Newmark method. Implicit methods provide infinite speed of information which is considered to be very important for wave propagation problem. But, in Explicit methods, the speed of information flow is limited to diagonal of mesh.

Pranita Kesare et.al. [1] studied the steps followed for solving problems using Explicit method. The state of system at later time is calculated using state of system at current time in Explicit method. Smaller time steps are used which ensures proper stability and accuracy of solution. No convergence check is needed as the equations are uncoupled. No inversion of stiffness matrix is needed to avoid iterations. They have considered wheel burst analysis for light duty turbine wheel application, for the speed varying from 150 krpm to 200 krpm. ANSYS AUTODYN has been used for simulating wheel burst.

Suman Anand et.al. [6] states that Explicit Dynamics is used to model high velocity impact problems. Explicit Dynamics makes it easy to simulate highly non-linear problems involving high strain rate, material failure, large deformation etc. Explicit Dynamics is used to simulate problems which last for few milliseconds or less than that. To solve Finite Element problems, user starts with discretising the model after the addition of material properties defined by material models. Further, the application of loads and constraints are provided for solving.

L Wang et.al. [7] explains the reason to use Explicit Dynamics for simulating wheel burst. Finite Element (FE) methods are resolved into Implicit and Explicit method. The Implicit method performs iterations to find approximate static equilibrium after each loading increments. It uses convergence condition for controlling the increment. For problem involving high non-linearity, many iterations are performed to find the equilibrium. Hence, this method is expensive and requires high memory. The Explicit method solves the problem by advancing the state from one to next time increment without performing iterations. It does not require any convergence criteria, thus solves nonlinear, complex problems efficiently. Thus, Explicit FE Analysis is selected to simulate wheel burst and containment test.

Badita et.al. [8] explains the Explicit Dynamics solution strategy. Dynamic response of any structure or nonlinear problems can be determined by using Explicit Dynamics. Various steps are followed while solving problems using Explicit Dynamics like discretising the model, assigning material properties, meshing, providing initial boundary conditions and loadings. After this, pre-processing the time will be integrated which will produce motion at node points in mesh. This motion produces deformation in elements which results in change in volume. The strain rate is derived with the help of rate of deformation using various elemental formulations. External forces are calculated from the given boundary conditions, loads and contacts. For calculating nodal acceleration, nodal forces are divided by nodal mass. The accelerations are integrated in time to determine nodal velocities and the velocities are further integrated in time to calculate new nodal positions. The advantage of using Explicit Dynamics for nonlinear is, no iterations are required while performing time integration. No convergence criteria and no inversion of stiffness matrix are required. There was also a car crash test simulated using the same. The Model is prepared in ANSA and simulation is done using ANSYS Explicit Dynamics. Thus, car crash simulation results are determined without any actual hardware destruction.

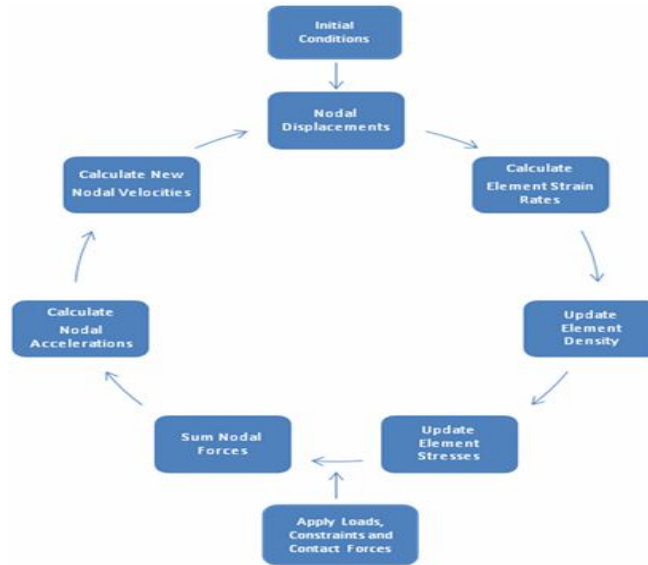


Fig 1: Explicit Dynamics methodology [8]

J S Sun et.al. [9] explained a performance comparison between Implicit and Explicit methods for impact test of an elastic bar and cylindrical disk on rigid wall. The author has described Implicit method to be unconditionally stable but faces issue while solving complex problems. The reason is that, for complicated problems the time increment reduces, the computational cost of tangent stiffness matrix increases and equilibrium is difficult to achieve.

### C. Material Models For Ductile Materials

There are various material models used for defining the behaviour of ductile material under dynamic loadings. Johnson Cook is one of the material model which covers strain rate effect, high temperature and thermal softening effects.

Ying Li et.al. [10] studied different strength and fracture models used for simulation of ductile material. To validate these models Taylor test is performed in which the flat nosed cylinder is impacted against fixed wall. Finite Element Analysis software AUTODYN is used for predicting the failure modes of the test through simulation. Maximum principal stress, equivalent plastic strain, maximum principal strain, Johnson Cook fracture model's parameters are obtained by conducting tensile test at high temperature. Johnson Cook material model is selected to reduce the complexity. According to the results of the test conducted, it is concluded that Johnson Cook fracture criteria is accurate for ductile fracture in dynamics problems.

Len Schwer et.al. [11] differentiated the Johnson Cook (JC) model from traditional plastic models. JC model can model material responses such as strain hardening, strain rate effect and thermal softening effect. According to the author JC model is considered as linear in logarithm of strain rate. JC constitutive model is given as below. Johnson Cook later expanded the idea of this model for fracture criteria.

$$\sigma_Y = \left[ A + B \left( \varepsilon_{eff}^p \right)^N \right] (1 + C \ln \dot{\varepsilon}) \left[ 1 - \left( T_H \right)^M \right]$$

Fig 2: Johnson Cook material model equation [11]

A V Sobolev et.al. [12] studied difference observed in the results calculated with plasticity given by Johnson Cook material model. Most of the models do not consider the phenomena of kinematic strength and effect of strain intensity on yield strength. Johnson Cook material model is mostly used as it considers both kinematic strength phenomenon and adiabatic heating of the material which is under strain. The equation of Johnson Cook material model shown in fig 2, defines a material's strain curve. The A parameter is the yield strength of material for low stress rate. Parameter B and n represent isotropic strengthening during the strains. C considers the kinematic strengthening. Plastic properties of materials are tabulated. Simulation is run using LS Dyna and Johnson Cook material model. Test and analysis results are compared, and it is seen that plastic strain tabulated model disagree with the test data with 20% indent depth and 13% indent diameter. It is assumed that the disagreement may be because of the test data that doesn't include any description of how indent diameter and depth are measured.

Michal Grazka et.al. [13] presents how laboratory experiments and numerical simulation results are connected. Taylor impact test is used for calculating the dynamic parameters of a material. Johnson Cook model is used for simulation as it shows relation of deformation with strain rate. The A, B, C, n, and m constant in the equation of Johnson Cook model shown in fig 2, are used to calculate dynamics response of material undergoing plastic deformation. This material model is used as it is easy to apply and only 5 constants are required to describe it. For simulation, speed of sample hitting the wall is considered as  $130\text{ms}^{-1}$ . For Taylor impact test, impact velocity and final shape of the sample after its deformation on rigid wall is used for determining the dynamic properties of material. Copper Cu-ETP samples has been used. Coordinate measuring technique is used to measure the shape after the test. The fault value after comparing the curves obtained is about 3.8%. Thus, it's concluded that the method followed (Taylor test) can be used as an alternative to Hopkinson pressure bar test for calculating the Johnson Cook parameters.

I S Boldyrev et.al. [14] studied the effect of material model parameters and the failure criteria on cutting forces that arise during the Finite Element simulation of the cutting process of Al 6061-T6. Finite Element method is chosen for analysis using Langrangian approach and element erosion with 0.5 failure strain. For analysis, isotropic, kinematic hardening and Johnson Cook material models are selected. The developed model predicts the cutting forces, continuous chip morphology in accordance with experimental data. From the simulation results, it is observed that Johnson-Cook constitutive model and the failure criteria used gives more accurate results as compared to kinematic and isotropic hardening.

#### D. Containment Simulation

Experimental containment testing involves number of iterations to be performed for successful burst to occur i.e. to achieve impeller burst at target speed. To avoid the iterations in testing, containment test is simulated using Explicit Dynamics. Simulation provides an initial guess of weakening slot that is required for successful burst to occur, thus saving time and with minimum cost.

L Wang et.al. [7] used ANSYS Autodyn method to simulate the containment test. During simulation, steady state thermal analysis, in which the temperature effects are considered first then Transient Explicit Dynamics analysis, where wheel burst and turbine housing containment simulation is performed. Later, the target speed is applied to the weakened wheel. To model the plastic behaviour of housing material, Johnson Cook strength model is used as it models high temperature, large strain and high strain rate. For ductile failure of wheel burst and housing simulation, plastic strain is applied as material failure criterion. This simulation is applied to other case studies and good correlation between test and simulation results is observed. Also, this simulation technique of wheel burst is used for simulating impeller burst and it shows good results. Thus, this paper presents the methodology to optimize the design of weakening slot for bursting turbine wheel at any specific speed.

J M Ramamoorthy et.al. [15] performed the simulation of containment test of both the compressor and turbine housing and validated it with the test results. Wheel burst occurs when the centrifugal forces exceeds the internal binding forces. Hub burst condition is considered, where the hoop stress is a major concern. Burst speed of wheel is estimated using area weighted mean hoop stress (AWMHS) method. The containment test has been simulated by defining the strength and damage model. For impeller burst no temperature effects are considered. The duration of simulation showed considerable reduction in kinetic energy of impeller. For wheel burst, steady state thermal analysis has performed considering the thermal effects. Simulation results have been validated with several rig tests and they show less than 2% deviation in burst speed.

Thomas Winter et.al. [16] described the containment test as the ability of turbocharger housing to contain the fractures of rotating parts inside the housing during wheel burst. The containment test is expensive and time consuming. Therefore, the author has suggested to simulate the test using Explicit Finite Element method.

#### E. Meshing algorithms/Mesh sensitivity

Meshing is an important factor affecting the simulation results. Use of different meshing algorithms, mesh sizes leads to variation in result. Thus, mesh sensitivity study is required before running the simulation.

Maruti BH et.al. [17] developed a Finite Element method to predict the burst margin limit. The parameters used for meshing the model are stated in this paper. The Finite Element model developed consists of 12,534 nodes of PLANE 42 type of elements. The mesh model has around 1000 first order elements for one half of disc thickness. 4 noded axis symmetric PLANE 42 elements have been chosen as they possessed the capability of modelling plasticity and large strain effects. Each node has 2 degrees of freedom (DOF) along x and y axis accordingly and the angular velocity is given about y axis.

Pranita Kesare et.al. [1] studied the impact force generated by turbine wheel blade detachment. The author has used Johnson Cook material model for modelling the ductile INCONEL turbine wheel material. For meshing, they have used linear tetrahedral elements



to capture the geometry accurately. Also, the critical regions have been meshed finely based on mesh sensitivity study. Around 1 lakh elements and 2 lakh nodes are generated on the wheel model.

L Wang et.al. [7] simulated the turbine housing containment. Due to geometry complexity, tetrahedral elements of first order have been used for meshing. About 1.8 million elements are generated after meshing.

S S Borikar et.al. [18] stated that at high temperature and high velocity of exhaust gases, internal bonds of the materials start breaking w.r.t. high centrifugal forces. Wheel burst can occur in two failure modes, hub burst and wheel detachment. Explicit Dynamics has been used for simulation. To model the ductile behaviour of turbine wheel material, Johnson Cook model has been used. Circumferential groove has been considered for blade detachment. In simulations, wheel burst resulted in an unequal number of fragments due to non-uniform mesh density over the regions of the turbine wheel. Hence, the turbine model is meshed with different type of meshing algorithms, mesh sizes such as Tet mesh, Hex dominant, pattern meshing etc. Using the Pugh matrix, pattern instance method is selected for meshing.

Thomas Winter et.al. [16] used axial flow turbocharger of 5100 kW consisting of radial compressor. The compressor wheel sample is notched at three positions with 120 deg apart. For simulation, the model consisted of brick, shell and beam elements are used. Shell elements are used in regions of less importance. Beam elements are used at the connection of two different parts. The body of compressor wheel had three parts, which consisted hexahedron elements mostly and pentahedron elements in small number. MAT\_PIECEWISE\_LINEAR\_PLASTICITY material type is used in model. Plastic strain of 35% to 40% is considered for realistic failure. The simulation lasted about 2 to 2.5 milliseconds. Using LINUX-cluster with four CPUs, simulation ran for about 20 hours. The parts of compressor wheel are on the shaft at beginning of simulation, later the fragments intruded the housing within 1.2 milliseconds. For validation, test is carried out. High stressed region and cracks seen on the compressor wheel during the test are well predicted by simulation. Good correlation is identified between test and simulation.

D Ruta et.al. [19] presented the mesh sensitivity study that is carried out on compact tension specimen which is dynamically loaded. In experimental testing, it's observed that the resistance increases as the loading rate increases. And the crack tends to incline with respect to the loading direction. To validate the experiment results, analysis with three different mesh sizes are done with  $h = 5, 10, 15$ mm. 8 noded linear strain elements and 4 noded constant strain elements are used for meshing the model. It is observed that even though the mesh and finite elements are different, there is no significant difference on response. The crack propagation is observed to be perpendicular to loading direction as expected from experiment.

R A Claudio et.al. [20] performed analysis on gas turbine disk. For meshing the sector model, 20 node isoparametric elements are used, as they showed good results. Different types of mesh are used for analysis: coarse mesh with 11886 DOF, medium mesh size with 20387 DOF and fine mesh with 67938 DOF. The simulated results predicted the life of the component.

#### *F. Burst Margin Determination Using Static Analysis*

Simulating containment testing or burst phenomenon using Explicit Dynamics involves high run time. Even simulation requires a good guess of slot depth value to be provided in order to avoid many iterations and achieve burst at target in few instances. To reduce the time involved for simulation using Explicit Dynamics and provide right guess of slot depth value for simulation, static analysis has been proposed as one of the method.

Hasan Calhoglu et.al. [21] investigated analytically the elastic plastic stress analysis of curvilinear orthotropic rotating disc for strain hardening material. The disc has been produced by compression moulding of aluminium metal which has matrix reinforced curvilinear steel fibers. From the solution, it is seen that radial stress component is always tension and along the radial section it is zero. Also, the circumferential stress component is highest at inner surface and low at outer surface. The circumferential stress magnitude is found to be higher than the radial stress component.

Masahiro Shikida et.al. [22] studied spin tests for both the notched and unnotched disks made of the mild steel under simple loading test. Bursting of disk has been achieved by air turbine which provides high speed rotation. Vacuum pump maintains the test chamber's pressure less than 5mmHg. Digital tachometer is used for recording the rotating speed of air turbine. SS41 mild steel has been used as spin burst test material. The notched length on notched disk varies from 5 to 40mm in 5 intervals. One side of the surface is polished with emery paper. The strain components in disk include radial, tangential and axial stresses. The Tangential strain affects the fracture mostly. In experimentation it is seen that, deformation started at 26000 rpm and later the tangential strain reached 17% on the inner diameter before it finally burst. And the deformation at outer side is not more than 1.5%. The difference between the x and y component of tangential strains are small, hence no deformation of anisotropy material was tested. In unnotched disk it was seen that a warp of 3.8mm on edge of the bore at 28000rpm and gradually decreases to plane surface before it burst. The warp is due to severe strain concentration around bore.



Nelli N Alexandrova et.al. [23] studied the plane state of stress in an elastic perfectly plastic isotropic rotating annular disk mounted on a rigid shaft. The analysis is based on Mises yield criterion and its flow rule. Analytical method is used for solving the plane stress conditions as much as possible and further solving them numerically. The plastic deformation is seen near disk's inner radius and the outer radius is never seen to be plastic completely.

Maruti B H et.al. [17] performed thermal and mechanical analysis on high speed aero-engine turbine wheel for determining the over speed and limit for burst. They developed a parametric model as per the real object. The combinations of thermal and centrifugal loads are calculated by FE calculation after knowing the axis of symmetry, speed and blade material and disc. For analysis, 10000 to 22000 rpm is applied as turbine speed. Thermal load of 450 deg at bore and 600 deg at rim of disc is considered. The blade load is distributed on nodes. INCONEL 718 is used as turbine disc material. Bilinear material parameters are considered for temperature variation from the bore to rim. To understand the effect of various load acting on the disc, individual sensitivity analysis is done. The results showed hoop stress distribution is a function of disc radius. It is maximum on inner rim side and minimum on outer surface. Experimental test is simulated for the burst margin on the disc and for all the loading conditions. After the finding the stress for each radial station, the burst margin is calculated using empirical formula. It is concluded that, all the three loads (thermal load, centrifugal load and blade load) together affect the stresses and burst margin.

Sai Prashanth R C et.al. [24] described that amount of stress acting on compressor disc which is necessary to prevent the failure of an aero engine's compressor. Rotating components release energy on bursting. 2D model of compressor disc is created and used for analysing over speed burst margin. Titanium Ti 6Al 4V is considered as compressor disc material. Disc rotational velocity of 14000 and 15000 rpm is applied. For simulation, and the body motion is constrained in y direction. Snippet commands are used for calculating hoop stress e.g. SSUM. The average hoop stress values are obtained for 14000 and 15000 rpm cases. Case 7 of both 14000rpm and for 15000 rpm gave best results in terms of burst margin. It is seen that burst margin increases with decrease of average mean hoop stress.

Rudresh et.al. [25] in this paper established the failure analysis of turbine disk for an air engine. To determine the stresses on the turbine disc, a model is developed with the help of CATIA software. Model is meshed using hypermesh tool. INCONEL 718 is used as turbine disk material. It is observed that using 18000rpm as angular velocity, the hoop stress and von misses stress increase and the radial stress decrease as a result of increase in radial distance from bore to outer rim.

Harinath SP et.al. [26] carried out a methodology for the estimation of aero engine disc's safety margin and LCF number of duty cycles. According to ASTM INCONEL 718 material is considered for aero engine disc. ANSYS software is used for simulation, as experimental way for obtaining safety margin is time consuming and expensive. The geometry is optimized considering the design, behavioural and topological constraints using a design of experiments (DOE) approach. Later static analysis is performed on the optimized geometry on which various loads act such as centrifugal, thermal loads. It is seen that the hoop stress which is maximum at bore decreases as the length of the disc increases from the bore region to rim. The radial stresses are minimum at bore portion. As hoop stress is dominant at bore portion, which is a major factor for disc failure.

Harinath SP et.al. [26] also performed static analysis for evaluating safety margin and LCF life. They obtained the radial and hoop stress from the analysis performed. Several criteria and theories state the procedure to obtain the rotational speed at which the disc will fail. Robinson and Hallinan's criteria are used as these are widely used theories for finding burst margin of rotating disc. Using linear approach for evaluating safety margin, it assumes ultimate stress to be within the elastic limit region and the yield is not there. But this assumption is not real thus they concluded it as invalid. Later isotropic hardening is also considered but they concluded it to be unacceptable as real material behaviour i.e. stress in tension and compression loading not same. Finally, kinematic approach is selected as it modelled the material behaviour as it behaves during testing. The burst margin is evaluated using Robinson's and Hallinan criteria for 3 different cases.

R A Claudio et.al. [20] explained the procedure followed for predicting fatigue life of a gas turbine disk. Sector model is used for finite element analysis. Nickel alloy IN718 is defined as turbine disk material. Null displacement is given in Z direction of the mounting flange and  $\theta$  direction. Temperature of 600 deg and speed of 15,000rpm is given as loading conditions. 3D as well as 2D analysis is performed with and without crack on turbine disk. Initially stress analysis is performed. The stress results has good conformance in simulation and analytically results. In 3D analysis, it is observed that maximum principal stress value is close to tangential stress value.

Srinivas Murthy et.al. [27] illustrated how the gas turbine disc is designed at speed of 12000rpm and operating temperature of 500 degC. Centrifugal loads and thermo mechanical loads are major loads which act on turbine blades. A sector model of cyclic symmetry for an integrated disk assembly is considered. The model having 3 blades with 18 deg disk sector. For analysis, higher order elements are considered. They have also considered three loading conditions: centrifugal force only, combination of

centrifugal and blade pressure, and at last considering all three loads. It is observed, that hoop stress is maximum at disc bore and it decreases as length of the disc increases from the bore region to rim. As a part of over burst evaluation, two criteria are used: Robinson's criteria and Hallinan's Criteria.

Ranjan Kumar et.al. [28] explained, how they found the burst margin for a gas turbine disc using finite element method for different wheel speeds. They have also explained the burst margin as safety limits of speed within that region are no failure of disc will be seen. 2D model of the disc is considered due to complex geometry. IN718 is used as turbine disc material. A temperature of 481.5deg at bore and 510deg at rim of disc is applied. Static analysis is run for uniform thickness of the disc and the results are compared with the analytical results. Hoop stress is determined to calculate the burst margin. For burst margin of 122%, the allowable speed is 18000rpm for disc with variable thickness and 17800rpm for disc with uniform thickness.

Anton N Servetnik et.al. [29] studied methods used for determining limiting burst speed of disks of gas turbine engine (GTE). Limit equation method is the traditional method used for assessing the disk load carrying capacity. In this equation stress concentration effect is not considered and also the effect of mating part and thermal field of the disk. The calculative values and the experimental data are distinct by 20% in some of the cases. Further finite element method is used as it takes into account the structural and loading peculiarities. For this, energy based fracture criterion is selected which states that fracture will occur at instant when the strain energy density reaches its critical value in most stresses point of the disk. To determine the plastic strain distribution on disk during loading, incremental plasticity theory with isotropic hardening is used. The simulation and experimental results using energy fracture criterion fit within less than 2%. The Tresca yield condition proved to be more reliable than the Von Mises yield condition.

## II. CONCLUSIONS

Based on the literature survey done, it can be concluded that there are various methods to solve dynamic problems but Explicit Dynamics analysis seems to be widely used to solve such problems. To carry out impeller burst simulation, various parameters are to be considered important. As per literature survey carried out, some of the important parameters used in different research for containment test simulation can be considered to be standard. Such as for defining ductile behavior of the impeller material, Johnson Cook material model can be selected. Uniform meshing option can be selected to capture results accurately in the slot region. Equivalent plastic strain can be selected as failure criteria. Also, burst margin criteria can be studied for providing initial guess for slot depth during testing.

## III. ACKNOWLEDGMENT

The author thanks Prof. Sainand Jadhav and Prof. Digvijay Mahajan for their support. The author is thankful to Mr. Hemanth Kumar Gopalakrishnan for his constant support throughout the project.

## REFERENCES

- [1] P. Y. Kesare, Sai Pavan Kumar, N K Chhapkhane, "Determination of Impact Force for Turbine Housing Containment", International Journal of Engineering Research & Technology, Vol. 5, issue no. 05, pp. 612-616, 2016
- [2] Garrett, "Burst & Containment: Ensuring Turbocharger Safety." [Online]. Available: [https://www.turbosbytm.com/download/TMS&R013\\_en.pdf](https://www.turbosbytm.com/download/TMS&R013_en.pdf)
- [3] Simon Barrans, John Allport, Goodarz Khodabakhshi, "Turbocharger Structural Integrity", Journal of Manufacturing and Industrial Engineering, 15 September 2014
- [4] Ashish Jaiswal, "ANSYS Explicit Dynamics and AUTODYN Applications", 2011
- [5] Czeslaw Bajer, "Time Integration Methods, Theoretical Foundation of Civil Engineering", Vol., 2002
- [6] Suman Anand and Kunal Sharma, "High Velocity Impact Analysis on 'Composite Material Block ' Using FEM Approach", International Journal of Engineering Research and Development, Vol. 7, no. 11, pp. 75-82, 2013
- [7] L. Wang and C. Mimeche, "Explicit Dynamic Finite Element Simulation of Turbocharger Containment and Wheel Burst", no. May, 2016
- [8] BADITA Oana-Georgiana si RAUTESCU Diana-Iulia, "Crash Simulation using ANSYS Explicit Dynamics", 2016
- [9] J. S. Sun, K. H. Lee, and H. P. Lee, "Comparison of Implicit and Explicit Finite Element Methods for Dynamic Problems", Journal of Material Processing Technology, Vol. 105, no. 1, pp. 110-118, 2000
- [10] Y. Li, X. Li, X. Kong, and X.-X. Wu, "Evaluation of Ductile Fracture Models in High Velocity Impact Problems", ICF 2013, Vol. 2, pp. 4-9, 2013
- [11] L. Schwer, S. Engineering, and C. Services, "Optical Strain Rate Forms for the Johnson Cook Constitutive Material Model and the Role the Parameter Epsilon", pp. 1-14, 2007
- [12] A V Sobolev, M V Radchenko, "Use of Johnson Cook Plasticity Model for Numerical Simulation of the SNF Shipping Cask Drop Test", Nuclear Energy and Technology, 2016
- [13] Michl Grazka, Jacok Janiszewski, "Identification of Johnson Cook Equation Constants Using Finite Element Method", 2012
- [14] I S Boldyrev, I. A. Shchurov, and A. V. Nikonov, "Numerical Simulation of the Aluminum 6061-T6 Cutting and the Effect of the Constitutive Material Model and Failure Criteria on Cutting Forces' Prediction", International Conference on Industrial Engineering, Vol. 150, pp. 866-870, 2016
- [15] J. M. Ramamoorthy, S. S. Parikh, S. Pandian, and P. S. Kasthuri Rangan, "Containment Simulation and Validation of Turbocharger Housing Design", 11th International Conference Turbochargers Turbocharging, pp. 281-288, 2014



- [16] T. Winter, A. Huss, and H. Beck, "Simulation of Containment-Tests of Fast-Spinning Rotors by Explicit FEM", 6th European LS-DYNA Users' Conference, pp. 147–158, 2006
- [17] B. H. Maruthi, M. V. Reddy, and K. Channakeshavalu, "Finite Element Formulation for Prediction of Over-speed and burst-margin limits in Aero-engine disc", International Journal of Soft Computing and Engineering (IJSCE), Vol. 1, no. 3, pp. 172–176, July 2012
- [18] S. S. Borikar, K.A.Mahajan, G. Hemanth Kumar, "Mesh Sensitivity Study of Turbine Wheel Burst Analysis using Explicit Dynamics", Journal of Mechanical and Civil Engineering (IOSR-JMCE), 6th National Conference RDME 2017, Vol. 17, no. 10, pp. 25–32, March 2017
- [19] D. Ruta, J. Ozbolt, "Dynamic Fracture of Concrete Compact Tension Specimen: Mesh Sensitivity Study", 9th International Conference on Fracture Mechanics of Concrete and Concrete Structures, 2016
- [20] R. A. Cláudio, C. M. Branco, E. C. Gomes, and J. Byrne, "Life Prediction of a Gas Turbine Disc using the Finite Element Method", 8as Jornadas Fractura, pp. 131–144, 2002
- [21] Hasan Calhoglu, Muzaffer Topcu, Ali Riza Tarakcilar, "Elastic–Plastic Stress Analysis of an Orthotropic Rotating Disc", International Journal of Mechanical Sciences, 2006
- [22] Masahiro Shikida, Yukio Kanayama, Masateru Ohnami, "A Study on High Speed Disk Bursting Speed", JSME, Vol. 23, issue no. 181, July 1980
- [23] Nelli N. Alexandrova, Sergei Alexandrov, Paulo M. M. Vila Real, "Analysis of Stress and Strain in a Rotating Disk Mounted on a Rigid Shaft", Theoretical Applied Mechanics, Vol.33, issue no. 1, 2006
- [24] Sai Prashanth R , Dr. Yogananda, "Weight Optimisation and Burst Margin of Aero Engine Compressor Disc", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Vol. 5. Issue VI, June 2017
- [25] Rudresh M, Nitesh Karbari and Maruthi B.H, "Investigation of Stresses in Turbine Engine Disc", International Journal of Advances in Scientific Research and Engineering, Vol. 3, issue no. 7 August 2017
- [26] Harinath SP, Sharath Chandra GV , Shreyas PM , Kumar Gowda, "Evaluation of Over-speed, Burst Margin and Estimation of Low-cycle Fatigue Life of an Aero Engine Disc", International Journal of Innovative Research in Advanced Engineering (IJIRAE), Vol. 4, issue no. 4, April 2017
- [27] Srinivas Murthy, Shivarudraiah, "Verification of Over-Speed and Burst Margin Limits Inaero Engine Rotor Coupling Along with Estimation of Low Cycle Fatigue Life", International Journal of Applied Engineering Research, 2018
- [28] Ranjan Kumar, Vinayak Ranjan, Bipin Kumar, Sanjoy K. Ghoshal, "Finite Element Modelling and Analysis of the Burst Margin of a Gas Turbine Disc using an Area Weighted Mean Hoop Stress Method", Engineering Failure Analysis, 2018
- [29] Anton N. Servetnik, "Energy Based Method for Gas Turbine Engine Disk Burst Speed Calculation", 28th International Congress of the Aeronautical Science, 2012

# Design and FEA Analysis of Boiler Chimney against Fouling

Priyanka Thigale<sup>1</sup>, Prof. R. K. Nanwatkar<sup>2</sup>

<sup>1</sup>PG Student, <sup>2</sup>Asst Professor, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon (Bk), Pune, India.

**Abstract:** Chimney plays very important role in the exhaust of flue gases from boiler to the atmosphere. An initial design of chimney heat recovery heat exchanger was provided. Generally, boiler is a closed vessel in which fluid (water) is heated. A chimney is nothing but a simple structure used for carrying hot flue gases from stove, furnace to the atmosphere. It causes heat losses in many ways in such a way that the discharge of hot combustion gases to the atmosphere through chimneys. This Paper focuses on an initial design of chimney for 15 TPH boiler, 15 bar pressure is provided. Design against Fouling is mainly Focused in this work for reducing discharge of hot combustion gases and an attempt is made to improve the Efficiency of Boiler. The main objective of this project is to redesign the chimney to reduce the formation of fouling which drastically affects the efficiency of boiler. An experimental analysis using FEA is done by using ANSYS and same is validated with actual solution by customer end.

**Keywords:** FEA, boiler, chimney, fouling, cyclic loads, creosote

## I. INTRODUCTION

At the point when hot vent gases goes from a flame through cylinders then this sort of heater are called as flame tube boilers. In this sort warmth is moved from the dividers of the cylinders by methods for conduction mode, accordingly when water is warmed it is changed over to the steam. The benefits of this sort of evaporator is, there are numerous little cylinders or pipes henceforth it offer huge warming surface territory.

A fireplace is basic structure where hot vent gases are conveyed to the environment from heater. Along these lines it results heat misfortunes with the end goal that fireplace conveys hot pipe gases to climate. By and large vertical fireplaces are utilized, with the goal that progression of gases should take easily, and to draw the air into the burning is known as smokestack impact. The space inside the fireplace is called as vent. By and large fireplaces are situated in structures, s trains and ships as well. Alluding to train stacks or ship fireplaces, the term smokestack is utilized. The capacity to move pipe gases to the environment because of smokestack impact is know as fireplace impacts. Fouling is only the affidavit of undesirable material on surfaces because of this aggravation happens in capacity of part. Fouling material additionally comprise of inorganic or non-natural substance . Fouling is normally not quite the same as surface-development wonders, in this it can happen on a surface of a segment, framework which plays out the capacity. Because of vaporization of inorganic components like coal during burning can cause fouling. At the point when the components stored on the outside of part because of warmth is consumed and temperatures decline in the convection zone of the heater, and in this way mixes shaped from this.

Store development, encrustation, crudding, statement, scaling, scale arrangement, slagging, and muck development are different terms which can be utilized to portray fouling . This Fouling are normally found in ship frames and so forth. In warmth move parts fouling happens because of salts present in the cooling water or gases, and in this way the math is create on teeth . There are two fundamental sorts of fouling full scale fouling and small scale fouling which are utilized in the cooling innovation and other specialized fields. In this way Micro fouling is increasingly hard to counteract.

Types of Fouling

- A. Crystallization fouling.
- B. Particulate fouling.
- C. Biological fouling.
- D. Reaction fouling.
- E. Freezing fouling.
- F. Corrosion fouling.

## II. LITERATURE SURVEY

Ulrich Kleinhansa, Christoph Wielanda, Flemming J. Frandsen, Hartmut Spliethoffa,b in *ELSAVIER journal of Progress in Energy and Combustion Science*, in paper entitled (4 February 2018), "Ash formation and deposition in coal and biomass fired combustion systems: Progress and challenges in the field of ash particle sticking and rebound behavior" survey the present learning on powder development, fiery remains molecule transport and statement during strong fuel ignition, with accentuation on molecule staying and bounce back conduct. A piece of the fuel can be inorganic, this structures inorganic vapors and fiery debris particles. The impaction of strong, liquid or mostly liquid particles on surfaces is subject to the molecule and surface qualities. For example, a particulate store may catch approaching particles or be evacuated because of disintegration, while liquid layer will gather all affecting particles, regardless of in the event that they are sticky or not. The fundamental properties influencing the molecule stickiness are the consistency and surface strain for silicate-rich fiery remains. On other hand, the stickiness of salt-rich slag for herbaceous biomass and wood-or waste-based fills is regularly portray by utilizing the fluid soften part. The critical parameters, for example, the molecule motor vitality and the edge of impaction. In the event that all active vitality is dispersed during the effect, the molecule will stay superficially. This audit exhibits a review of significant cinder shaping components found in biomass and coal, and talks about the heterogeneity of particles' inorganic structure. Systems, for example, Ash transportation and affidavit likewise their scientific depiction are talked about. Likewise arrangement and temperature-dependended models are given for the estimation of fiery debris molecule and store properties. These properties are basic so as to portray the molecule staying and bounce back conduct. Fiery remains molecule staying and bounce back criteria can be isolated into three fundamental gatherings, they are as per the following:

- A. The particle melt fraction,
- B. The particle viscosity, or
- C. The energy dissipation of a particle

Staying criteria are displayed, their required parameters are talked about and normal molecule and surface properties found in burning frameworks are outlined. Eight diverse staying criteria are executed in a computational liquid elements code and calculations are analyzed against estimations from an entrained stream reactor. Uniform estimated soft drink lime glass particles are connected rather than inhomogeneous fly powder particles, since soft drink lime glass is known to carry on like coal fly slag. By utilizing a foundation dependent on crafted by Srinivasachar et al best understanding for the affidavit rates on a perfect cylinder is accomplished. In this model, the staying and bounce back limit is a component of the molecule dynamic vitality, the edge of impaction, and, the molecule consistency. Hence, the parameter, for example, silicate-rich fiery debris are utilized to affirmed the molecule consistency. It ought to be determined utilizing temperature-and sythesis subordinate connections, staying alert that there is a huge dispersing in the outcomes from such models and that the models are regularly just substantial in restricted compositional ranges, and can't be utilized outside these. An unthinking model is utilized to clarify results from glass molecule tests and their reliance on the molecule motor vitality. Accordingly, the impaction procedure is subdivided in four stages, and the vitality dispersal of each progression is determined. These hypothetical contemplations demonstrate that the contact edge of a liquid bead with the substrate is of minor significance, and that most of saving particles are commanded by crafted by disfigurement against thickness. This audit passes on the its exact forecast for silicate-rich fiery debris and significance of the molecule consistency. The proposed standard can anticipate the staying of little, strong particles underneath 10 mm distance across, as it is frequently seen in writing. Additionally, it is urgent to think about the surface structure and stickiness, so as to foresee testimony rates in strong fuel-terminated frameworks. Because of various fiery remains molecule science, biomass cinders and their stickiness are progressively troublesome, when contrasted with coal powder. And furthermore salt-rich particles and their stickiness are control. Here, a connection between the consistency and measure of fluid stage is a promising methodology, and ought to be tended to in future work. Moreover, the thickness of various cinder particles silicate-, salt-or Ca-rich ought to specially be demonstrated from the concoction and physical structure rather than an exact fitting strategy between fuel science and consistency estimations:<sup>[1]</sup>

Akash Singh, Vivek Sharma, Siddhant Mittal, Gopesh Pandey, Deepa Mudgal, Pallav Gupta in *Springer International Journal of Industrial Chemistry* (2018) in paper entitled, "An overview of problems and solutions for components subjected to freside of boilers" examined different reports including issues, (for example, agglomeration, slagging, fouling, burning embrittlement, weariness disappointment and high temperature erosion) identified with boilers and their potential arrangements. Likewise a portion of the controlling parameters for high temperature erosion has additionally been examined. For the improvement in surface Thermal splashing is utilized as a primary device. By utilizing diverse covering systems and materials issue of erosion, wear opposition,



electrical or warm protection can be changed. What's more, consequently because of testimony of fiery remains in biomass-terminated boilers additionally causes serious issues of agglomeration. By utilizing kaolin or  $\text{NH}_3$  in the bed of boilers this issue of agglomeration can be comprehended. Heartbeat explosion wave innovation, savvy ash blower, and synthetic treatment innovation are some significant procedures which can be utilized to limit the impacts of fouling. They found that Corrosion hindrance is one of the strategies that have been utilized to secure and build the life of metallic social legacy. Sol-gel defensive coatings on the metal and combinations surfaces can diminish the rate of consumption in different destructive mediums. [2]

Ming-Jia Li, Song-Zhen Tang, Fei-long Wang, Qin-Xin Zhao, Wen-Quan Tao, in ELSEVIER journal, (2017) titled, "Gas-side fouling, erosion and corrosion of heat exchangers for middle/low temperature waste heat utilization: A review on simulation and experiment" condensed the trial studies, improvement and incitement for the fouling, disintegration and erosion of warmth exchangers. The key instruments, the forecast models and techniques, important examinations of fouling, disintegration and erosion the reproductions with these models were presented. Furthermore, the expectation procedures of the fouling, disintegration and erosion rate were presented by accepting creators' examinations as delineations among them. At long last, it ought to be noticed that for the fouling, disintegration and consumption issues, there are still some key attempts to be improved comprehend the fouling, disintegration and erosion components, and propose the novel warmth exchangers for hostile to fouling, against disintegration and hostile to consumption. In future warmth exchanger structures can beat the issues. Hence This will advance the advancement of advances which can proficiently recuperate the hot pipe gas waste warmth and therefore by and large vitality use productivity is improved.

### III. PROBLEM IDENTIFICATION

The need to make proficient boilers in heater industry is significant in view of up and coming new innovations. Various parameters ought to be chosen for proficient working for kettle. Because of various warmth misfortune happening in the evaporator the exhibition of heater gets influenced. The unburnt pipe gases get aggregated on the smokestack surface and this structures a layer of on surface, this is called as fouling and this issue accompanies organization. Subsequently, in view of fouling on surface its warmth move rate diminishes and accordingly the effectiveness of evaporator changes. So to beat this issue we have make a unique arrangement with the goal that warmth lost through vent gases while leaving stack stage may produce a thought of fouling results. Consequently by expanding the speed of the vent gases this issue can be diminished. So we have to make an arrangement for expanding the speed of pipe gases

#### A. Objectives

- 1) The main objective of this project is redesigning and testing of boiler chimney to reduce fouling but also not to affect efficiency.
- 2) An attempt is made by material modification and by introducing flappers in the fifth section of the chimney. Flappers were properly installed at various angles like  $10^\circ$ ,  $12^\circ$ ,  $15^\circ$  and results analyzed by comparing all of them.
- 3) Material modification by selecting material which can reduce the chances of fouling.
- 4) Design modification of chimney by introducing the flappers and verification of the same through FEA and validating it with actual results given by customer end.

#### B. Scope

- 1) In this project, an initial design of chimney for 15 TPH boiler, 16 bar pressure is provided.
- 2) This project is based on the work undertaken to redesign the flue gas duct in chimney to reduce the formation of fouling which affect the efficiency of the boiler.
- 3) This system was specifically designed for boiler chimney. In the completion of the design, the flappers are provides in the flue gas duct (segment V).
- 4) The attempt of project is to reduce the cross section area in that particular segment to increase the flow of flue gases.

#### C. Methodology

- 1) The project is proposed to be done in the following manner.
- 2) Compiling the problems, difficulties arise in boiler system which causes reduction in boiler efficiency.
- 3) Research on fouling in boilers & its effect on boiler efficiency.
- 4) Research on ways of minimizing fouling.
- 5) Finding out the best way to change the design to reduce fouling problems.



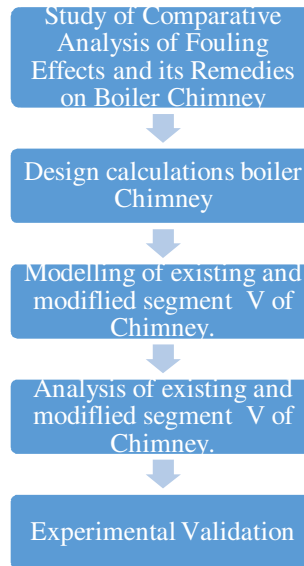


Fig. No. 1: Flowchart of methodology

#### IV. DESIGN AGAINST FOULING

It was our duty to consider the effect of fouling upon the component performance during the specific operation lifetime and make provisions in our design for sufficient extra capacity to ensure that the exchange will meet process specifications up-to shut down for cleaning. We were also to consider the mechanical arrangements that are necessary to permit easy cleaning. In our design, the following measures have been taken to reduce the rate of fouling.

- A. Provision for particulate filters.
- B. Introduction of turbulent flow upstream of the exchanger core

#### V. BOILER SPECIFICATION

Boiler steam capacity	15 TPH
Working steam pressure	15 bar
Fuel	Coal
Fuel firing rate	2023 kg/hr
Steam generation rate	8954 kg/hr
Steam pressure	14 bar
Feed water temperature	90°C
% Of co <sub>2</sub> in flue gases	8%
% Of co in flue gases	167
Average flue gas temperature	210 °C
Ambient temperature	027 °C
Humidity in ambient air	0.018kj/kg of dry air
Surface temp of boiler	65 °C
Wind velocity around boiler	4 m/sec
Total surface area of boiler	118 mm <sup>2</sup>
G cv of bottom ash	700 K.cal/kg
G cv of fly ash	395 k.cal/kg
Ratio of b. A/ f.a	90;10
Fuel analysis in %	
Ash content in fuel	7.80%
moisture in coal	29%
carbon content	38%

Table No. 1 : Boiler Specification

### VI. DESIGN CALCULATION

#### A. Data Required For Design Calculation

	Top diameter (in mm)	Bottom diameter (in mm)	Height (in mm)	Shell thickness (in mm)	Avg. diameter (in mm)
Seg 1	900	900	5000	6	900
Seg 2	900	900	5000	6	900
Seg 3	900	900	5000	6	900
Seg 4	900	900	5000	8	900
Seg 5	900	1575	5000	10	1237.5
Seg 6	1575	2250	5000	10	1912.5

Table No. 2 : Data required for design calculation

#### B. Basic Dimensions of Chimney

Total height of chimney = 30m

Height of flare =  $H = 1/3(30) = 10\text{ m}$

Diameter of the flare =  $1.6 \times 0.9 = 1.44\text{m}$ .

Computation of wind pressure:

The design wind speed at any height z is given by

$$V_z = V_b \cdot k_1 \cdot k_2 \cdot k_3$$

Where,

$V_b$  = basic wind speed at the site =  $37\text{m/s}$  for Pune.

$k_1$  = probability factor (risk coefficient) = 1.0 for general buildings and structures.

$k_3$  = topography factor = 1.0 for flat topography

$k_2$  = terrain, height and structure size factor

$$V_z = 37 \times 1 \times 1 \times k_2$$

Now design wind pressure  $P_z = 0.6V_z^2$

$$= 0.6 \times (37 \times k_2)^2 \times 10^{-3} \text{ kN/m}^2$$

$$= 22.2 k_2 \text{ KN/m}^2$$

For chimney, adopting a shape factor of 0.7,  $f_z = (P_z \cdot D \cdot \Delta_z) 0.7$ .

#### C. Calculation Of Wind Speed Pressure and Force For Each Segment

Segment	H(m)	$k_2$	D (m)	$\Delta_z$	$P_z = 1.3245 k_2^2 (\text{kN/m}^2)$	$f_z = (p_z \cdot D \cdot \Delta_z) 0.7 (\text{KN})$
Seg 1	30	1.10	0.9	5	1.6037	5.0517
Seg 2	25	1.062	0.9	5	1.4962	4.1713
Seg 3	20	1.05	0.9	5	1.4612	4.6029
Seg 4	15	1.02	0.9	5	1.3789	4.3468
Seg 5	10	0.98	1.2375	5	1.2729	5.5132
Seg 6	5	0.98	1.9125	5	1.2729	8.5205

Table No. 3 : Calculation of wind speed pressure and force for each segment

**D. Moment at Each Section**

Moment at segment 1=(5.0517 x 2.5)  
=12.6292 KN-m

Moment at segment 2=(5.0517 x 7.5)+(4.1731x2.5)  
=49.6705 KN-m

Moment at segment 3=(5.0517 x 12.5)+(4.1731x7.5)+ (4.6029x2.5)  
=110.0017 KN-m

Moment at segment 4=(5.0517 x 17.5)+(4.1731x12.5)+ (4.6029x7.5)+(4.3436x2.5)  
=192.6992 KN-m

Moment at segment 5=(5.0517 x 22.5)+(4.1731x17.5)+ (4.6029x12.5)+(4.3436x7.5)+(5.5132x2.5)  
=300.0387 KN-m

Moment at segment 6=(5.0517 x 27.5)+(4.1731x22.5)+ (4.6029x17.5)+(4.3436x12.5)+(5.5132x7.5)+(8.5205x2.5)  
= 442.4625 KN-m

**E. Design of Chimney Shell**

Stress due to chimney weight,  
 $f_s=0.0785h \text{ N/mm}^2$

Stress due to weight of lining,  
 $f_l=0.002h/t \text{ N/mm}^2$

Stress due to wind,  
 $f_w=(0.004M_wxx)/(\pi D^2 t) \text{ N/mm}^2$

Minimum thickness of shell from stability point of view= $D/500$   
 $=900/500 =1.8 \text{ mm}$ .

It is assumed that the design life of steel chimney shell will be 20 years and coal is used for boiler. Hence add additional 4mm Thickness to account for corrosion, Hence total minimum thickness of plate= $6+4=10\text{mm}$ .

Effective thickness = $10-4=6\text{mm}$

$f_c$  = the maximum compressive force per unit length

$f_t$  = Maximum uplift force per unit length of circumference

**F. Determination of Stress**

Seg	h(m)	D(m)	T(mm)	D/t(mm)	h/D	$f_c \text{ (N/mm}^2\text{)}$	$f_t \text{ (N/mm}^2\text{)}$
1	5	0.9	6	150	5.55	124	105
2	10	0.9	6	150	11.11	124	105
3	15	0.9	6	150	16.66	124	105
4	20	0.9	8	112.5	22.22	108	105
5	25	1.2375	10	123.75	20.20	108	105
6	30	1.9125	10	191.25	25.1572	97	105

Stress due to chimney weight (fs)	Stress due to weight of lining (fl)	Stress due to wind (fw)	Fc max	Ft max	Stability check
0.3925	1.666	3.308	5.366	2.9155	stable
0.785	3.333	13.102	17.130	12.227	stable
1.1775	5	28.818	34.996	27.641	stable
1.57	5	37.86	44.43	36.29	stable
1.9625	5	24.94	31.908	22.977	stable
2.355	6	15.4022	23.757	13.047	stable

Table No. 4 : Determination of stress

### G. Computation of Actual Weight

Self Weight of chimney

$W_s = \text{Density of steel (78.5kN/m}^3) \times \text{Volume of steel in chimney}$

$$W_s = 3(78.5 \times \pi \times 0.9 \times 0.006 \times 5) + (78.5 \times \pi \times 0.9 \times 0.008 \times 5) + 2(78.5 \times \pi \times (0.9+2.250/2) \times 0.010 \times 5) = 67.6949 \text{ KN}$$

$W_l = \text{Weight density for brickwork} = 20 \text{ KN/m}^3$

$$= (20 \times 0.8 \times \pi \times 0.1 \times 20) + (20 \times \pi \times (0.8+2.150/2) \times 0.1 \times 10) = 193.207 \text{ KN}$$

$$\text{Total } W = 67.6949 + 193.207 = 241.482 \text{ KN}$$

Increase the weight by 5% to account for lap, stiffeners, platforms, ladder etc.

$$\text{Total } W = (241.482 + 12.074) = 253.556 \text{ KN}$$

### H. Design of Base Plate

The maximum compressive force per unit length

$$F_c = \frac{W_s + W_l}{\pi d} + \frac{4M_w}{\pi d^2 \cdot 2} = \left[ \frac{253.5568}{\pi \times 2.250} + \frac{4(442.4625)}{\pi \times 2.250^2} \right]$$

$$= 147.1520 \text{ KN/m}$$

$$= 147.1520 \text{ N/mm}$$

Allowable bearing pressure,  $\sigma_c = 4 \text{ N/mm}^2$

$$\therefore \text{Width} = 147.1520 / 4$$

$$= 36.788 \text{ mm}$$

Provide 37 mm wide base plate.

### I. Design of Anchor Bolts

Maximum uplift force per unit length of circumference

$$F_t = \frac{4M_w}{\pi d^2} - \frac{W_s}{\pi d}$$

As per IS 6533 (part 2): 1989, the overturning moment  $M_w$  should be increased to 1.5 times from stability consideration

$$F_t = \frac{4(442.4325 \times 1.5)}{\pi \times 2.250^2} - \frac{67.6949}{\pi \times 2.250}$$

$$= 365.99 \text{ KN/m}$$

Let us provide 39mm dia. ISO fine threaded bolts having effective area =  $1028 \text{ mm}^2$ , at root of thread. Taking permissible tensile strength of  $120 \text{ N/mm}^2$  at the root of thread.

$$\text{Strength of each bolt} = 1028 \times 120 \times 10^{-3} = 123.36 \text{ KN.}$$

No increase in stress is recommended since wind is the major load in the case of chimneys.

$$\text{Spacing of bolts} = \frac{123.36}{67.6949} \times 1000 = 1822.2 \text{ mm}$$

$$\text{No. of bolts} = \frac{\pi \times 2.250 \times 1000}{1822.2} = 3.8791$$

However, provide 4 bolts of 39mm nominal diameter on a circle diameter.

### VII. FINITE ELEMENT ANALYSIS OF EXISTING MODEL OF SEGMENT V OF CHIMNEY

#### A. Reverse Engineering of Existing Model of Segment II of Chimney

The below CATIA diagram represents segment II of the chimney which we have taken into consideration. The section V is of 5000mm high with base diameter of 1572mm and outer diameter of 900mm.

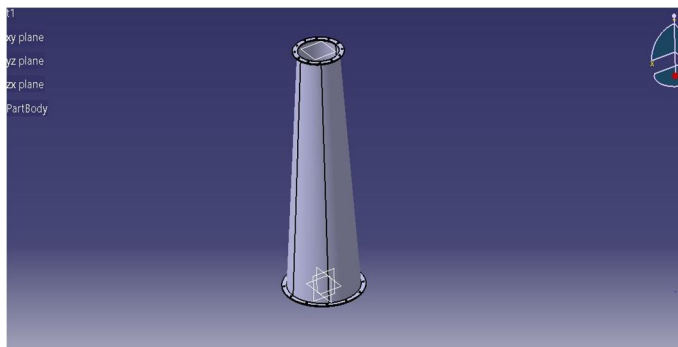


Fig. No. 2: CAD model of segment V

#### B. Finite Element Analysis Of Existing Model Of Segment V Of Chimney

1) *Mesh Model:* A structure or component consists of infinite number of particles or points hence they must be divided in to some finite number of parts. Meshing is nothing but dividing a component into finite numbers. Dividing components helps us to carry out calculations on the meshed part. We divide the component by nodes and elements. We are going to mesh the components using 3D element. Number of nodes and elements are formed respectively. After meshing elements are to be checked for Quality i.e. elements have a definite quality criterion and this criterion should be met by all elements.

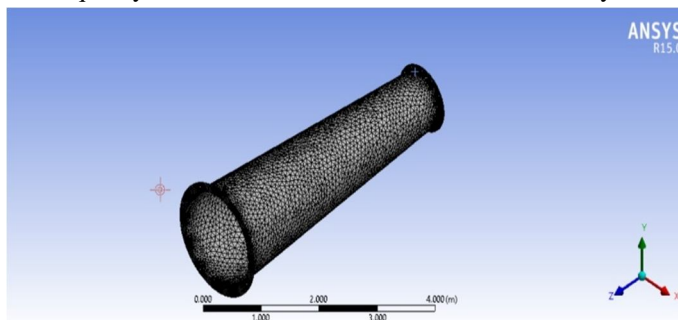


Fig. No 3: Meshed model of segment V of chimney

### VIII. INTRODUCTION TO FLAPPERS

Flappers is the metal material with reducing cross section of area. This reducing cross sectional area increases the pressure energy of the outgoing gases into kinetic energy. Due to increase in velocity of the gases, a turbulent flow is formed and due to this the gas does not stick to the chimney surface. Instead, this gas is flown upwards and outside the chimney. Hence we can reduce the fouling. In our project, we have attached flappers in the second section of the chimney. In our project, we have attached the flappers at different angles ranging from 10°, 12° and 15° and got the results. We did the comparison of various angles and the respective results and computed them with various softwares like ANSYS and CATIA.

The flappers in are used to reduce the fouling effect at different angles. CAD model of flappers is shown in fig 4, 5, 6.

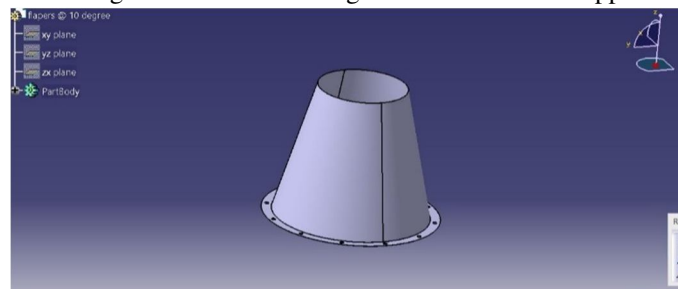


Fig. No 4: Flapper at angle 10°

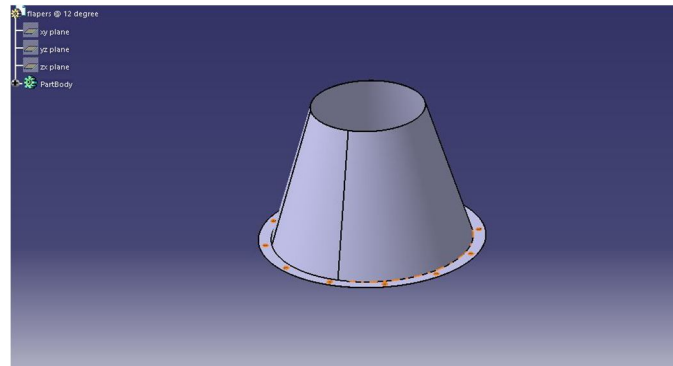


Fig. No 5: Flapper at angle 12°

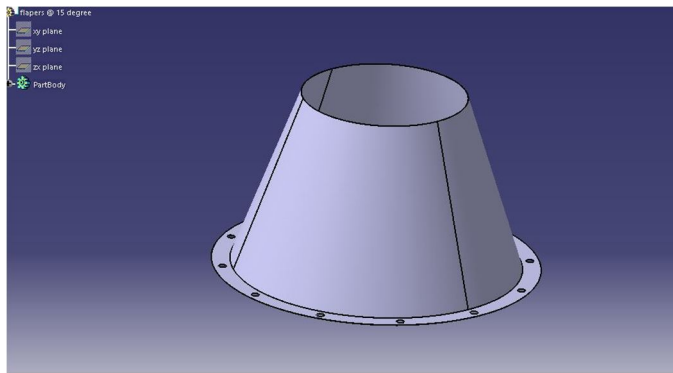


Fig. No 6 : Flapper at angle 15°

CAD model of flappers inserted in segment II of chimney is shown in fig 7, 8, 9.

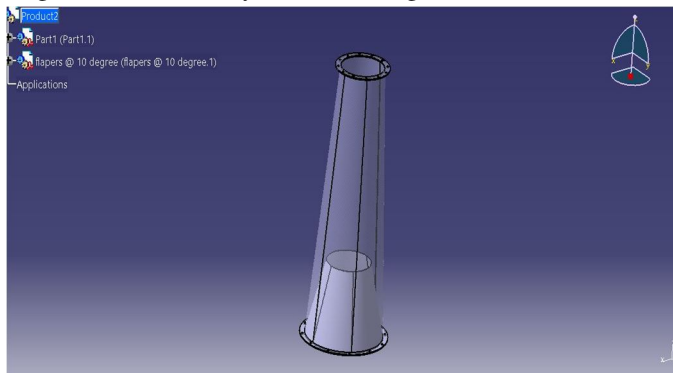


Fig. No 7 : Chimney segment II with Flapper at 10°

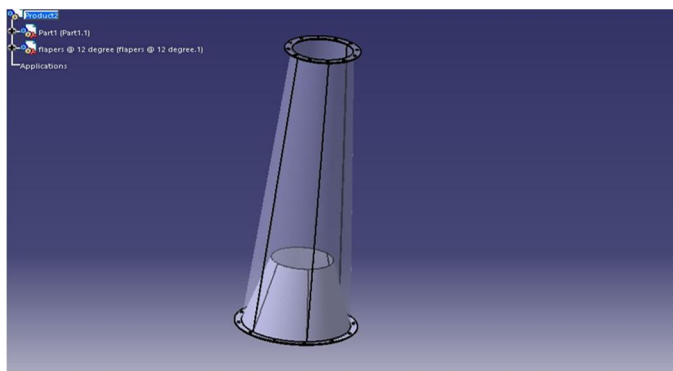


Fig. No 8 : Chimney segment II with Flapper at 12°



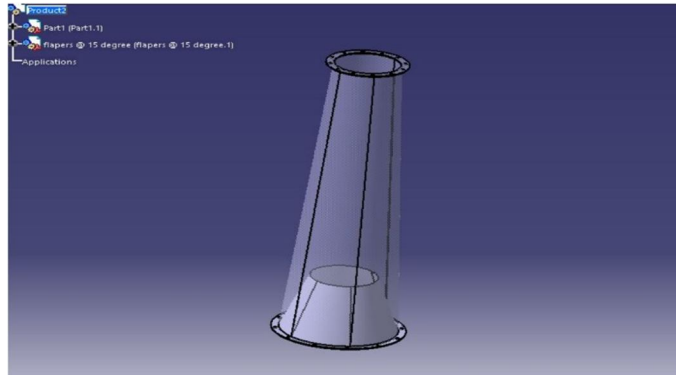


Fig. No 9: Chimney segment II with Flapper at 15°

### IX. DESIGN CONSIDERATIONS AND OPTIMIZATION OF EXISTING DESIGN AND MODIFIED DESIGN

In the designing of the exchanger following factors were put to consideration.

- 1) The surface has to be the most efficient and suitable.
- 2) The design has to consider the fouling effect of the flue gases.
- 3) The design has to allow for quick maintenance without interfering with the boiler operations.
- 4) The ducting design has to conform to the boiler chimney design.

Based on the above points, flapper provided at various angles in chimney convergent duct to check the velocity increase of flue gases in chimney area.

#### A. Change In Velocity of Existing Model And Modified Model

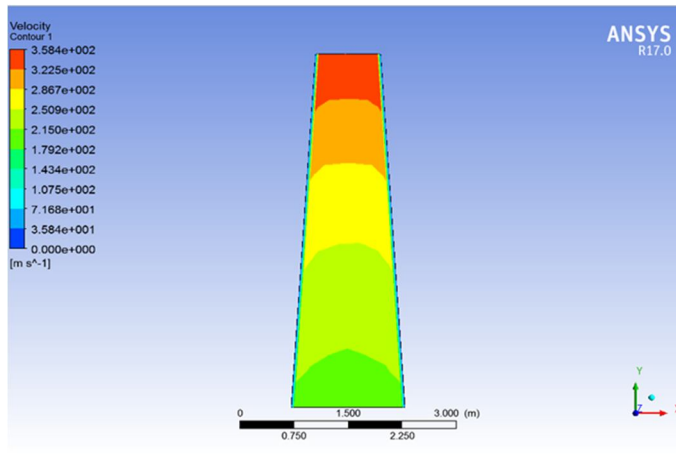


Fig. No 10 : Velocity obtained in without modification.

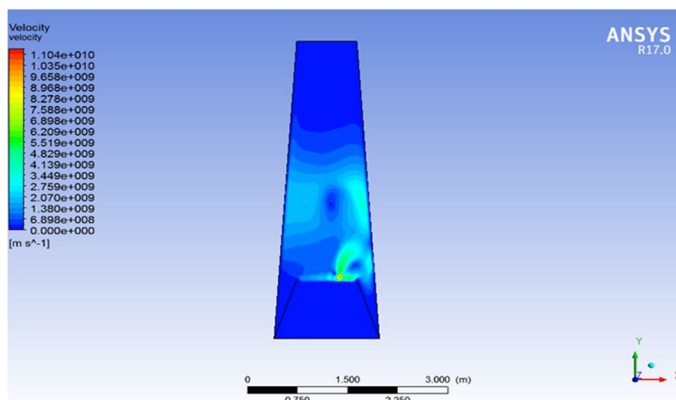


Fig. No 11 : Velocity obtained in with modification.

**B. Change In Pressure Of Existing Model And Modified Model**

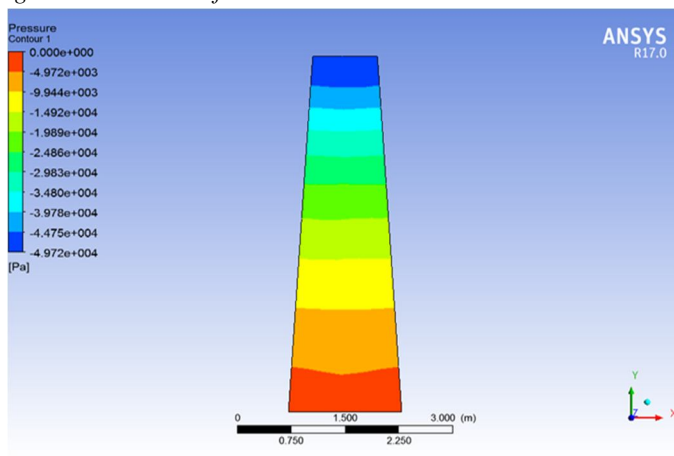


Fig. No 12: Pressure obtained in without modification.

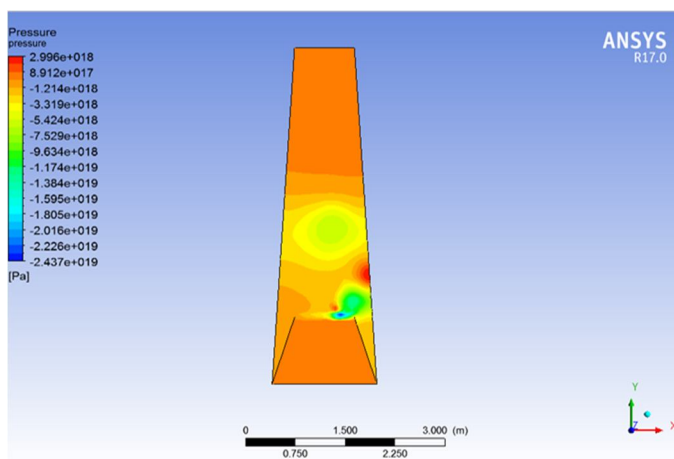


Fig. No 13: Pressure obtained in with modification.

**X. RESULTS**

From above modification we have use convergent on the diverse aspects of the operation of boiler efficiently. In upcoming years to come Efficient operation of boiler is likely to play a very big role in following years, Industries all over the world are going through increased and powerful competition and increased automation of plants. To get away with this challenge, it is clearer by this paper. By using this technology, we have obtained change in velocity and pressure. In other word we can say that, velocity increases and pressure decreases due to modification. The difference between velocity and pressure of existing and modified design is as shown below graph.

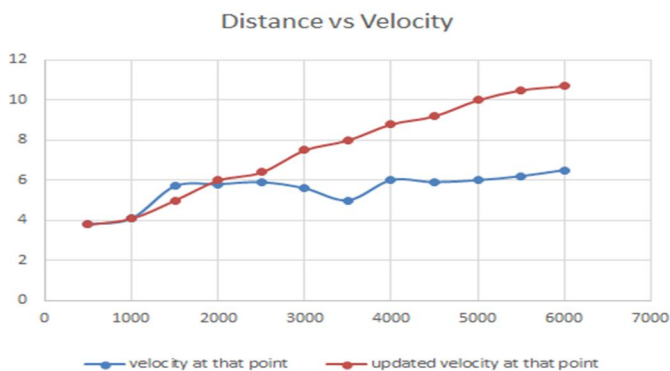


Fig. No 14 : Graph 1- Distance vs Velocity.

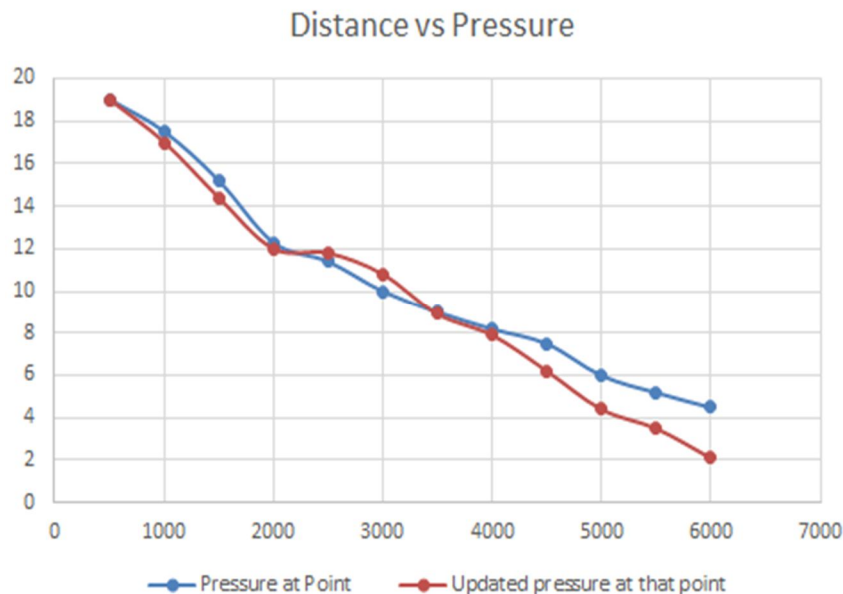


Fig. No 15 : Graph - Distance vs Pressure.

### XI. CONCLUSION

- A. The objective of this project was completion and testing of boiler chimney heat recovery heat exchanger system that could be used to recover heat lost through flue gases and reduces the effects of fouling.
- B. Design calculation with specified working parameters in order to reduce the fouling on boiler chimney surface were validated and implemented successfully.
- C. Attempts were made to reduce fouling by introducing flappers in the fifth section of the chimney. Flappers were installed at various angles like 10°, 12°, 15° and analysis is done on the results by comparing all of them.
- D. Analysis results showed that, the flappers installed at 15° is the best choice to reduce soot formation i.e., fouling which eventually increases the efficiency of the chimney and also the life of chimney.
- E. The effects of pressure and velocities of flue gases on the boiler chimney surface are analyzed through finite element method, the results of which were validated with the actual with satisfactory results.

### XII. FUTURE SCOPE

- A. The exchanger core plate spacing should be increased to improve on air flow.
- B. An allowance for expansion of the plates should be provided at the ends of the plates.
- C. The height of segment should be optimized, to increase the time for the flue gases to exchange heat with air.
- D. Similar work can be done different heat exchanger surface which are affected by fouling or clogging on the heat transfer surface.
- E. In this project Finite element analysis method were used to check the effect of pressure and velocities of flue gases due to design modifications. Computational Fluid dynamics can be applied to check the effects of flue gases due to shape optimization performed due to design modifications.

### XIII. ACKNOWLEDGMENT

The author is indeed a great pleasure and moment of immense satisfaction. I take the opportunity to thanks those who gave us their indebted assistance. I wish to extend my cordial gratitude with profound thanks to our internal guide Prof. R. K. Nanwatkar. It was his inspiration and encouragement which helped us in completing my work. I am also thankful to Prof. S. M. Jadhav, PG Co-ordinator for his overwhelming support and invaluable guidance. My sincere thanks and deep gratitude to Head of Department, Prof. D. H. Burande and other faculty members. At last but not least I express my sincere thanks to the Institute's Principal Dr. Y. P. Reddy, for providing us infrastructure and technical environment.

## REFERANCES

- [1] Ulrich Kleinhansa, Christoph Wielanda, Flemming J. Frandsenc, Hartmut Spliethoffa,b in ELSAVIER journal of Progress in Energy and Combustion Science, in paper entitled(4 February 2018) , “Ash formation and deposition in coal and biomass fired combustion systems: Progress and challenges in the field of ash particle sticking and rebound behavior”.
- [2] Akash Singh, Vivek Sharma, Siddhant Mittal , Gopesh Pandey, Deepa Mudgal, Pallav Gupta in Springer International Journal of Industrial Chemistry (2018) in paper entitled, “An overview of problems and solutions for components subjected to freside of boilers”.
- [3] Ming-Jia Li, Song-Zhen Tang, Fei-long Wang, Qin-Xin Zhao, Wen-Quan Tao, in ELSEVIER journal, (2017) titled, “Gas-side fouling, erosion and corrosion of heat exchangers for middle/low temperature waste heat utilization: A review on simulation and experiment”.
- [4] Sagar Kafle a, Seung Hee Euh a, Lahoon Cho a, Yun Seong Nam a, Kwang Cheol Oh a, Yun Sung Choi a, c, Jae-Heun Oh c, Dae Hyun Kim a, in ELSEVIER Energy Journal, (2017) “Tar fouling reduction in wood pellet boiler using additives and study the effects of additives on the characteristics of pellets”.
- [5] R. K. Mishra, in Springer journal technical article, “Fouling and Corrosion in an Aero Gas Turbine Compressor”, (2015).
- [6] Suhas R Bamrotwar, Dr. V.S.Deshpande, in journal (2014) IOSR-JMCE, named “Root Cause Analysis and Economic Implication of Boiler Tube Failures in 210 MW Thermal Power Plant”.
- [7] K.T. Ajayi and A. A. Akande, in JETEAS (2012) paper published “Effect of Fouling on Heat Transfer Surfaces in Boilers”.
- [8] Kilkovský B, Turek V, Jegla Z. and Stehlík P, in 8th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics 11 – 13 July 2011, in paper published “Aspects Of Fouling In Case Of Heat Exchangers With Polluted Gas”.
- [9] Mostafa M. Awad Mansoura University, Faculty of Engineering, Mech. Power Eng. Dept., Egypt(2011), in “Fouling of Heat Transfer Surfaces”.
- [10] Panayiotis Andreou, in his master thesis on “Behavior, Analysis and Design of Steel Chimneys” (Oct 2011).
- [11] Aleksandar M. Simonovic, Slobodan N. Stupa, Ognjen M. Pekovic, in FME Transactions (2008) 36, 119-125, in paper published, “Stress Distribution as a Cause of Industrial Steel Chimney Root Section Failure”.
- [12] Mathew A. Eaton in 15th North American Waste to Energy Conference May 21-23, 2007 “Analysis of Boiler Fouling and Boiler Cleaning Methods at the Commerce Refuse-To-Energy Facility”.
- [13] K B MCINTYRE, Proc S Afr Sug Technol Ass (2002), “A Review of the Common Causes of Boiler Failure in the Sugar Industry”.
- [14] Yimin Zeng, Kaiyang Li, Robin Hughes and Jing-Li Luo, in I&EC Research journal in paper, (2018) “Corrosion Mechanisms and Materials Selection for the Construction of Flue Gas Component in Advanced Heat and Power Systems”.

# Design Manufacturing and Vibration Analysis of Worm and Worm Wheel Gear Box

Sushmita Kamble<sup>1</sup>, Prof. R. K. Nanwatkar<sup>2</sup>

<sup>1</sup>PG Student, <sup>2</sup>Asst Professor, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon (BK), Pune, India.

**Abstract:** Gears are important element in a variety of industrial applications such as machine tool and gearboxes. An unexpected failure of the gear may cause significant economic losses. For that reason, fault diagnosis in gears has been the subject of intensive research. Vibration signal analysis has been widely used in the fault detection of rotation machinery. In this dissertation vibration analysis of worm and worm wheel gear box is done by FEA and experimental method. Design of worm and worm wheel gear box is done on basis of given working parameters using SI units and design data book and same design parameters is used for fabrication. The performance of gear box is tested at 0 kg, 3kg, 6kg, 9kg and speed for 1425 rpm. Frequency measurement at working loading condition is performed using FFT analyzer. Natural frequencies at different loading condition are determined by using FFT analyzer. The experimental results obtained by above testing is validated with finite element analysis and the results found satisfactory and within the range.

**Keywords:** Vibration, fault diagnosis, condition monitoring, gearbox.

## I. INTRODUCTION

Gears are critical components of industrial gearbox and are critical to running the company. It is vital that they work as intended or entire operation could come to a halt. Gearboxes, while tough, are sensitive machines prone to failure if not properly maintained. These machines are constantly under extreme stress and high temperatures. Accordingly, even the smallest misalignment caused by vibration issues could be catastrophic. Vibration analysis has grown in importance recently when it comes to industrial gearboxes. This type of maintenance is one of the most widely used gear fault analysis techniques. It aids in early fault detection, enabling users to prevent breakdowns. Vibration analysis involves listening to the vibration in the gearbox. An industrial gearbox is composed of a variety of components, and each of them vibrates on a unique frequency. If your gearbox has suffered damage, the noise patterns will change. The sound you hear can help you diagnose the type of the damage, and even its source. Vibration analysis is a process of looking for anomalies and monitoring change from the established vibration signature of a system. The vibration of any object in motion is characterized by variations of amplitude, intensity, and frequency. These can correlate to physical phenomena, making it possible to use vibration data to gain insights into the health of equipment. Vibration analysis can be used to:

- 1) Find a developing problem that can be repaired to increase machine lifetime.
- 2) Detect and monitor a chronic problem that cannot be repaired and will only get worse
- 3) Establish acceptance testing criteria to ensure that installation/repairs are properly conducted.

## II. LITERATURE SURVEY

Elasha, F. , Ruiz-Cárcel, C. , Mba, D. , Kiat, G. , Nze, I. and Yebra, G., Engineering Failure Analysis, volume 42 : 366-376. (2015) in paper entitled, "Pitting detection in worm gearboxes with vibration analysis", this paper aimed to apply various vibration analysis techniques to diagnose the presence of naturally developed faults within worm gearboxes. The condition of three different worm gearboxes was assessed using various vibration signal analysis techniques including a few statistical measures, Spectral Kurtosis and enveloping. This was undertaken in an attempt to identify the presence of defects within the worm gearboxes. [1]

Vikram A. Jagtap, Prof. Pavankumar R. Sonawane (2017), in International Journal of Innovative Research in Science, Engineering and Technology, paper entitled "A Review on Fault Detection of Gearbox by using Vibration Analysis" reviewed on various techniques used for analyzing the faults of gearbox based on vibration analysis method with small insight on new approach used for diagnosis of gearbox such as Artificial Neural Network, fuzzy sets and some emerging technology in gear fault analysis. [2]

G.S. Lamani<sup>1</sup> , Prashant S.Pawar<sup>2</sup>,Nikhil G.Ranalkar<sup>3</sup>,Omkar P.Pawar<sup>4</sup>,Suyog V.Patil in IOSR Journal of Mechanical and Civil Engineering(2018) in paper entitled, "Vibration analysis of worm and worm wheel gear box" Reviewed is made of some current vibration analysis techniques used for condition monitoring in gear fault. Each unit of mechanical equipment has a different

signature in the frequency spectrum. The vibration spectrum shows the areas of stress and undue energy. Vibration measurements trend changes at different locations along the units to predict the problems. [3]

Ganesh Survase<sup>1</sup>, Suraj Sutar<sup>2</sup>, Tushar Pawar<sup>3</sup>, Akshay Rajmane<sup>4</sup> in International Journal of Mechanical, Robotics and Production Engineering in paper (2018), “Study & Vibration analysis of worm and worm wheel gear box by using FFT Analyzer” Reviewed some of current vibration analysis techniques used for condition monitoring in gear fault. Each unit of mechanical equipment has a different signature in the frequency spectrum. The vibration spectrum shows the areas of stress and undue energy. The key benefits include: - Monitoring equipment life, increasing equipment uptime, managing and scheduling maintenance work. Vibration analysis can determine misalignment unbalanced, mechanical losses, eccentric shafts, gear wear, broken teeth & bearing wear. As load increase there is initial decrease in acceleration to its minimum and then again starts increasing with same behaviors in trends of corresponding maximum frequency value. [4]

Miss. Radhika Laxman Patil<sup>1</sup> Mr. Ravindra D. Patil<sup>2</sup> Mr. Sandesh S. Awati<sup>3</sup> Mr. Suhas N. Ankalkhope<sup>4</sup>, (2017) International Journal for Scientific Research & Development in paper entitled “A Review Paper on Design, Optimization and Testing of Special Purpose Worm and Worm Wheel Gearbox for Butterfly Valve Operation” used higher standard output torque gearboxes which are uneconomical, heavy as well as large in size. Also quarter turn worm and worm wheel gearboxes for opening and closing of butterfly valves gives better performance, because butterfly valves rotate only in 90°. This paper represents design, optimization and testing of special purpose worm and worm wheel gearbox for butterfly valve operation [5]

### III. PROBLEM STATEMENT

As the company's profile, the company manufactures gears & gear boxes as per customer's requirement. The one customer wants a worm & worm wheel gear box for 0.5HP motor. Then after the design & manufacturing of gear box. The company should check the vibration that occurs in the gear box, it should be as minimum as possible. It is very important as per the quality aspect. Therefore to find the vibration that occurs in the gear box we are using the FFT analyser and validate with the help of finite element analysis.

#### A. Objectives

- 1) To design worm and worm wheel gear box.
  - a) To understand design of worm and worm wheel gear box.
  - 2) To evaluate the performance of gear box for various loading and speed conditions.
    - a) Evaluate the performance of worm and worm wheel gear box for different loading conditions.
    - b) Evaluate the performance of worm and worm wheel gear box for different speed conditions
    - c) Calculate both the values.
  - 3) To determine natural frequencies at different loading conditions.
  - 4) To validate the design experimentally and by FEA.
    - a) Calculate the results experimentally by FFT analyser.
    - b) Calculate the results by using Finite element analysis.
    - c) Validate the design by comparing the FFT and FEA results.

#### B. Scope

- 1) Similar work can be performed on different types of other gear and gear boxes for reduction in vibration caused by rotating machinery parts.
- 2) Observation results obtained by FFT can be validated with mode shape analysis using various Finite element software like ANSYS to get more accurate results.
- 3) This kind of project work proves to be the best suited method in the field of NVH Analysis in various automobile sectors

#### C. Methodology

- 1) Design of worm and worm wheel gear box
- 2) Manufacturing of worm and worm wheel gear box.
- 3) Selecting Vibration techniques to determine the fault in worm and worm wheel gear box.
- 4) Vibration analysis using Fast Fourier Transform (FFT) analyser.
- 5) Vibration analysis at different load and different speed conditions.
- 6) Finite Element analysis for results obtained by FFT analyser.



- 7) Results and Discussion.
- 8) Validation of design using FEA.
- 9) Conclusion

#### IV. DESIGN

Computer Aided Design software uses either vector-based graphics to represent the objects of traditional drafting, or may also produce raster graphics which show the overall appearance of designed models for mechanical design. Similar to the manual drafting of the engineering and technical drawings, the CAD output must convey information, such as materials taken, processes, dimensions of the component, and tolerances, according to the application-specific conventions.

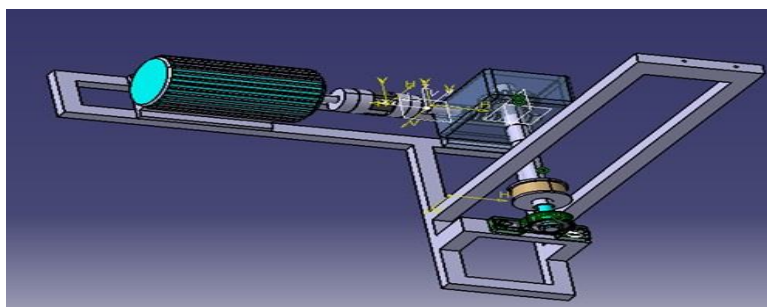


Fig. No. 1: CAD model of assembly.

##### A. Worm Wheel

- 1) No. of teeth ( $Z_2$ ) = 21
- 2) Module ( $m$ ) = 3mm
- 3) PCD ( $d_2$ ) = 63mm
- 4) Outer Dia. = 72mm

##### B. Worm

- 1) No. of threads = 6
- 2) PCD ( $d_1$ ) = 26.6mm
- 3) Outer Dia. = 32.6mm
- 4) Centre Distance = 44.45m
- 5) Worm Wheel Bearing = 30205×2
- 6) Worm Bearing = 30204×2
- 7) A pair of worm gears is specified and designated by four quantities in the following Manner,

$$z_1 / z_2 / q / m$$

- 8) Dimensions of worm and worm wheel
- 9)  $l = 3.14 \times \text{no. of threads in worm diametric pitch}$

$$l = 3.14 \times 6 = 18.84\text{mm}$$

- 10)  $P_x = p \times m$

$$= p \times 3$$

$$= 9.425\text{mm}$$

- 11)  $l = P_x \times Z_1 = 18.84$

$$Z_1 = 1.99 = 2$$

- 12) Lead angle of worm:

$$\tan g = l / (p \times d_1)$$

- 13)  $g = 12.71^\circ$   $g + y = 90^\circ$

- 14)  $y = 77.30^\circ$

$$= \text{helix angle of worm tang} = Z_1 / q$$

$$q = 8.86$$

- 15) Speed Ratio =  $Z_2 / Z_1 = 21 / 2 = 10.5$

**V. MANUFACTURING OF WORM AND WORM WHEEL GEAR BOX**

Sr. No.	Part Name	Material	Machine	Operation	Quantity
1	Worm Gear	SS	Hobbing & Shaping Mc	Hobbing & Shaping	1
2	Worm Wheel	SS	Sawing	Sawing	1
3	casing	MS	Casting	Casting	1
4	Stand	MS	Welding	Cutting Mc/welding	1
5	AC Motor				1
6	Shaft	MS	Lathe Mc	Turning/Facing	1
7	coupling	MS			1
8	key	MS			2
9	Pulley	MS	Lathe Mc	Turning/Facing	1
10	Bearing				1
11	Rope	Resin			1

*A. Vibration Analysis USING FFT Analyser.*

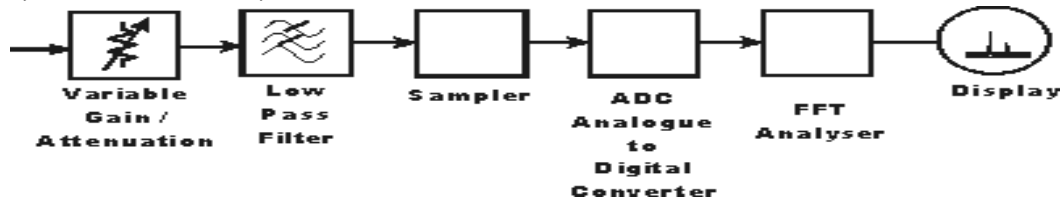


Fig. No. 2: FFT Analyser.



Node Description



Experimental set up

**VI. RESULTS OBTAINED BY FFT ANALYSER.**

**A. 0 Kg load**

- 1) *Axial*: Maximum deviation is in range of 4200-6300Hz and maximum value of deviation is at 5439.45Hz with value of 0.74g.

Graph1

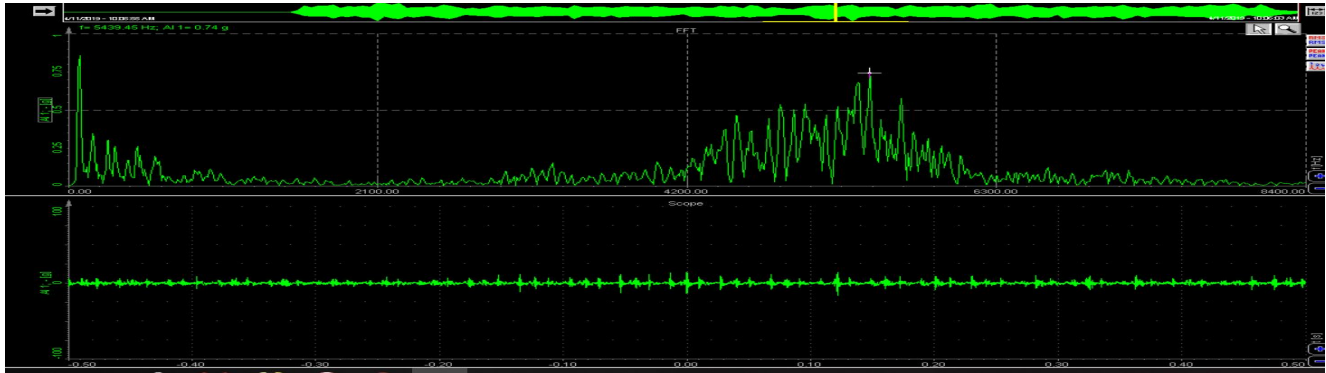


Fig. No. 3

- 2) *Horizontal*: Maximum deviation is in range of 4200-6300Hz and maximum value of deviation is at 4292.88Hz with value of 0.96g.

Graph2

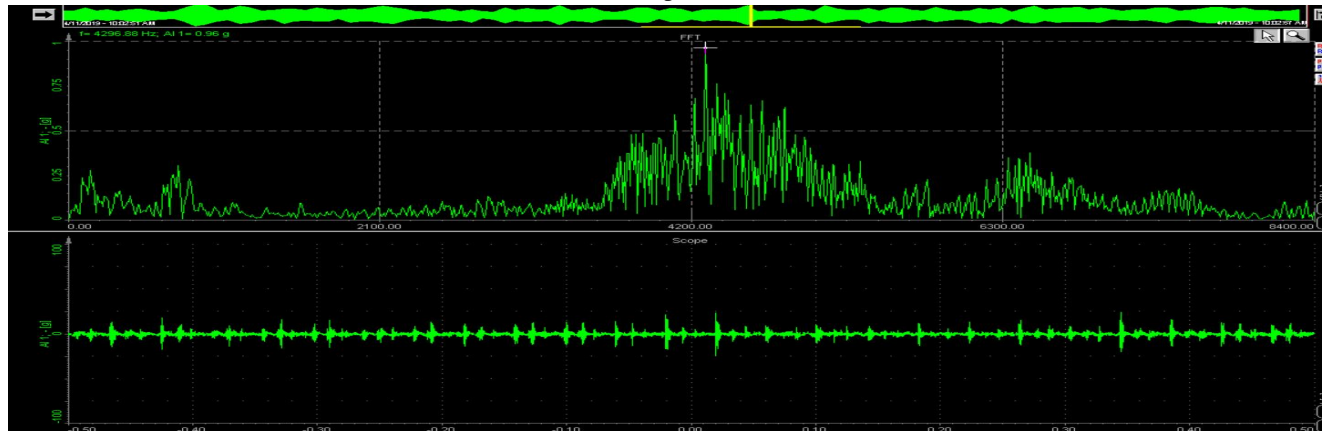


Fig. No. 4

- 3) *Vertical*: Maximum deviation is in range of 4500-6300Hz and maximum value of deviation is at 5429.69Hz with value of 1.05g. ( $g=9.81\text{m/s}^2$ )

Graph3

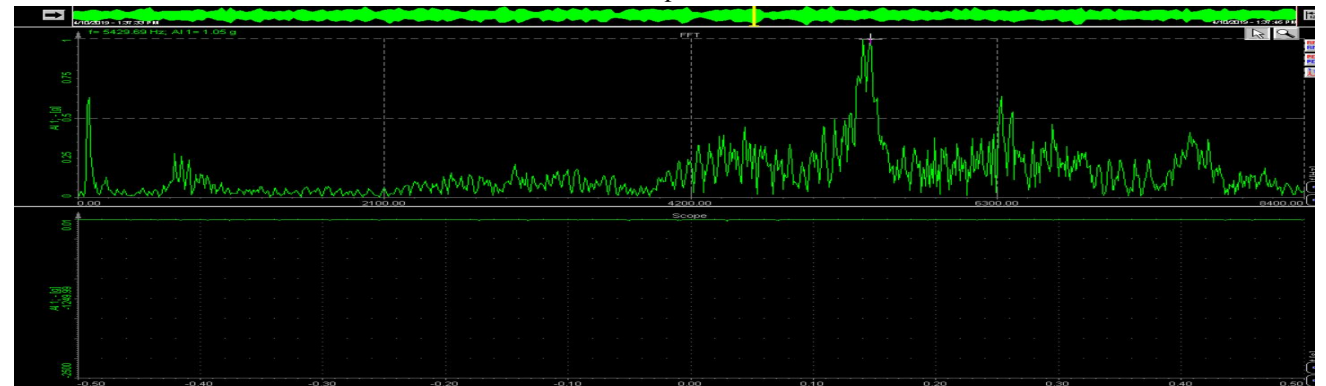


Fig. No. 5

**B. 3 Kg Load**

- 1) *Axial*: Maximum deviation is in range of 4200-6300Hz and maximum value of deviation is at 5410.16Hz with value of 0.55g. ( $g=9.81\text{m/s}^2$ )

Graph4

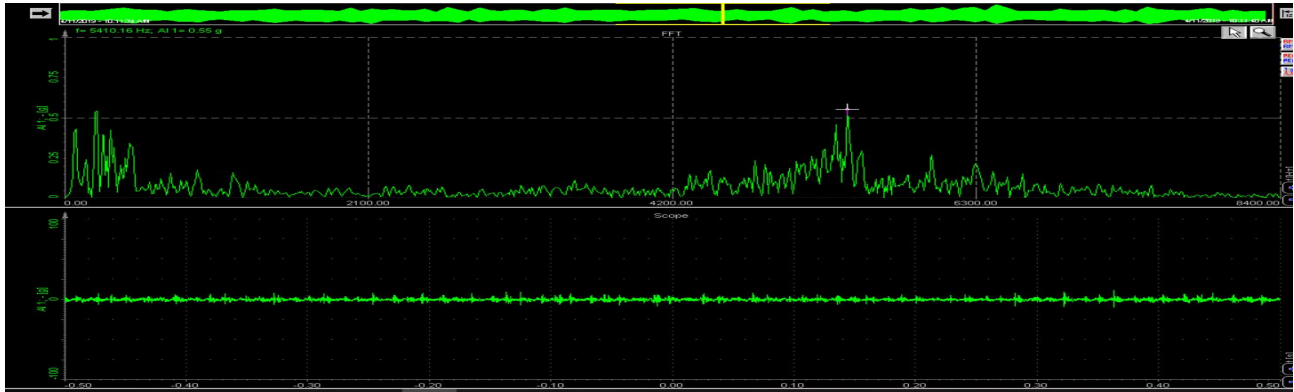


Fig. No. 6

- 2) *Horizontal*: Maximum deviation is in range of 4200-6300Hz and maximum value of deviation is at 5312.50Hz with value of 0.80g. ( $g=9.81\text{m/s}^2$ )

Graph5

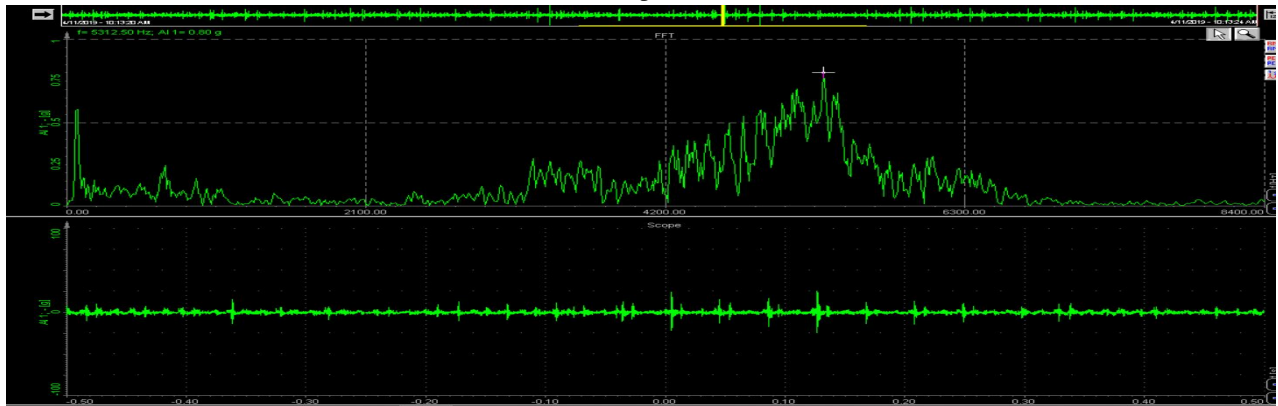


Fig. No. 7

- 3) *Vertical*: Maximum deviation is in range of 5000-7500Hz and maximum value of deviation is at 5332.03Hz with value of 0.92g. ( $g=9.81\text{m/s}^2$ )

Graph6

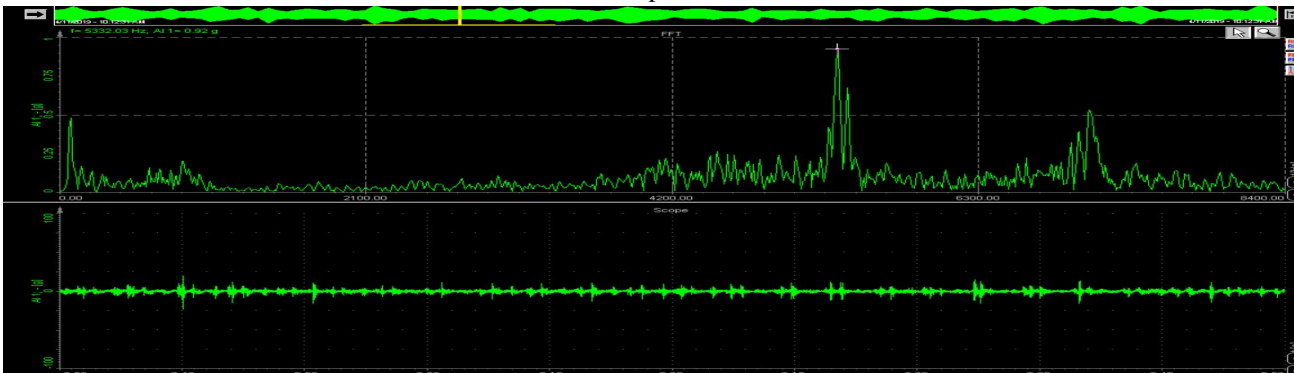


Fig. No. 8

C. 6 kg Load

- 1) *Axial*: Maximum deviation is in range of 4200-6300Hz and maximum value of deviation is at 4521.48Hz with value of 1.03g. ( $g=9.81\text{m/s}^2$ )

Graph7

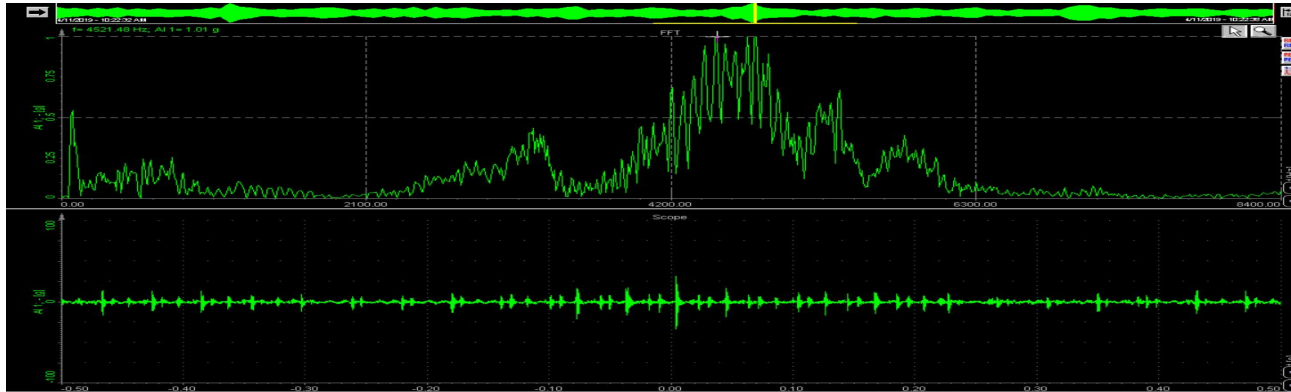


Fig. No. 9

- 2) *Horizontal*: Maximum deviation is in range of 4200-6300Hz and maximum value of deviation is at 4824.22Hz with value of 1.10g. ( $g=9.81\text{m/s}^2$ )

Graph8

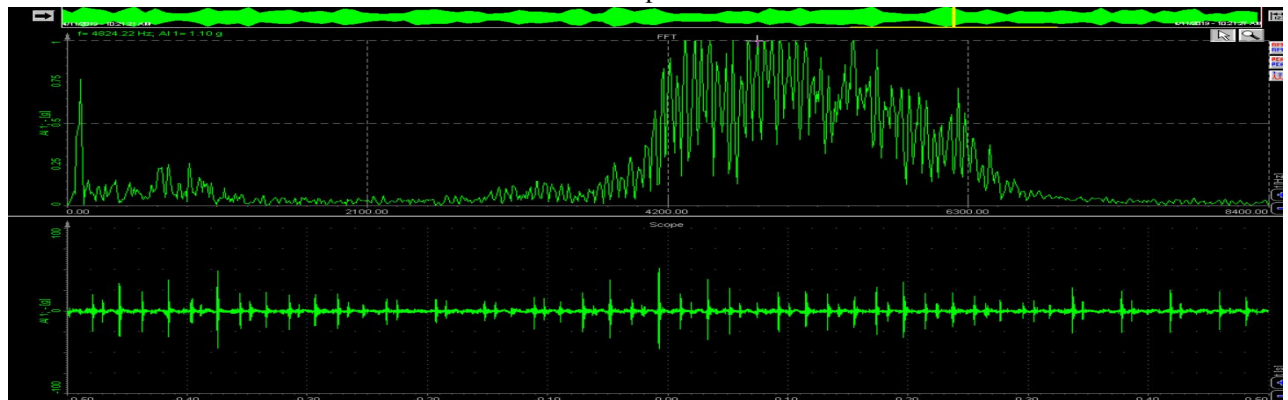


Fig. No. 10

- 3) *Vertical*: Maximum deviation is in range of 4200-6000Hz and maximum value of deviation is at 4492.19Hz with value of 0.80g. ( $g=9.81\text{m/s}^2$ )

Graph9

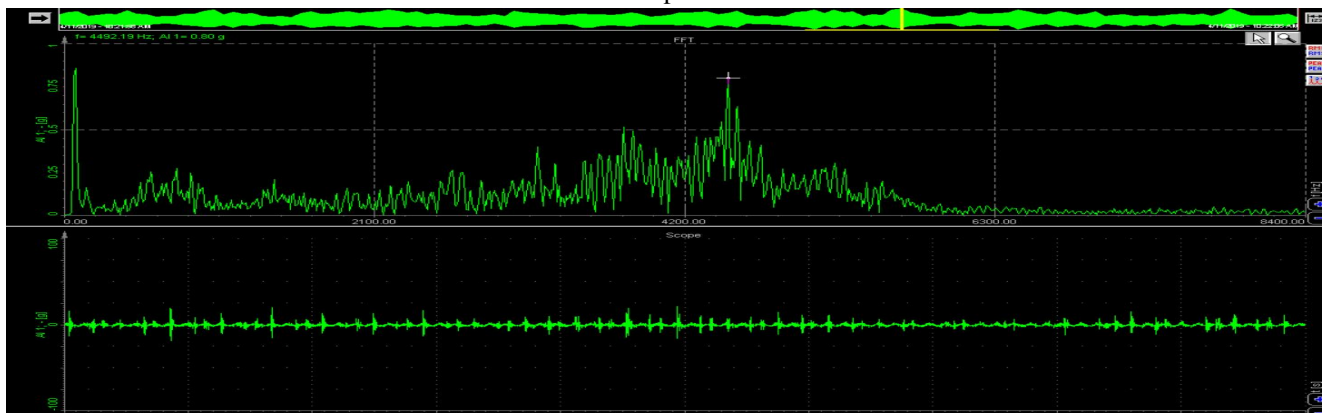


Fig. No. 11



D. 9 Kg load

- 1) *Axial*: Maximum deviation is in range of 4200-6300Hz and maximum value of deviation is at 5322.27Hz with value of 1.42g. (g=9.81m/s<sup>2</sup>)

Graph10

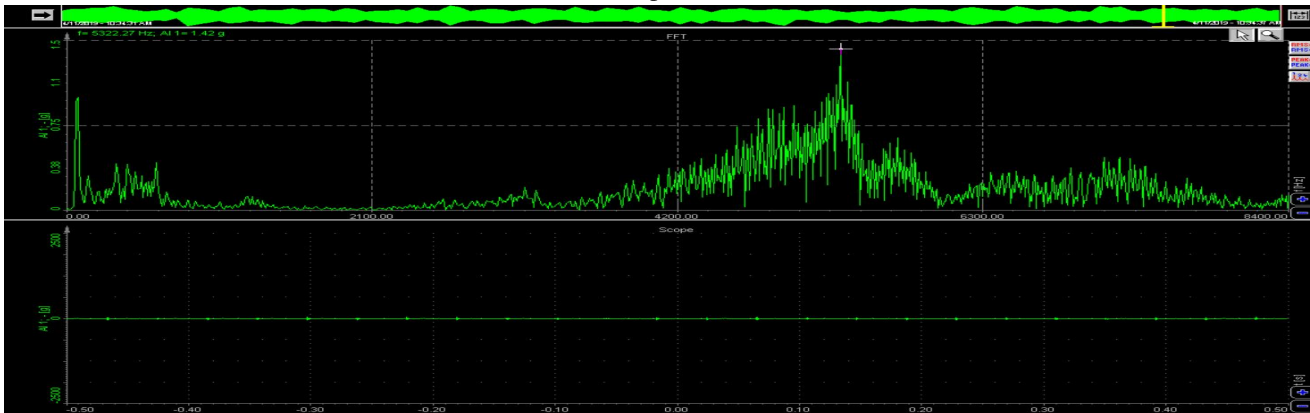


Fig. No. 12

- 2) *Horizontal*: Maximum deviation is in range of 2100-4200Hz and maximum value of deviation is at 2382.8Hz with value of 0.253g. (g=9.81m/s<sup>2</sup>)

Graph11

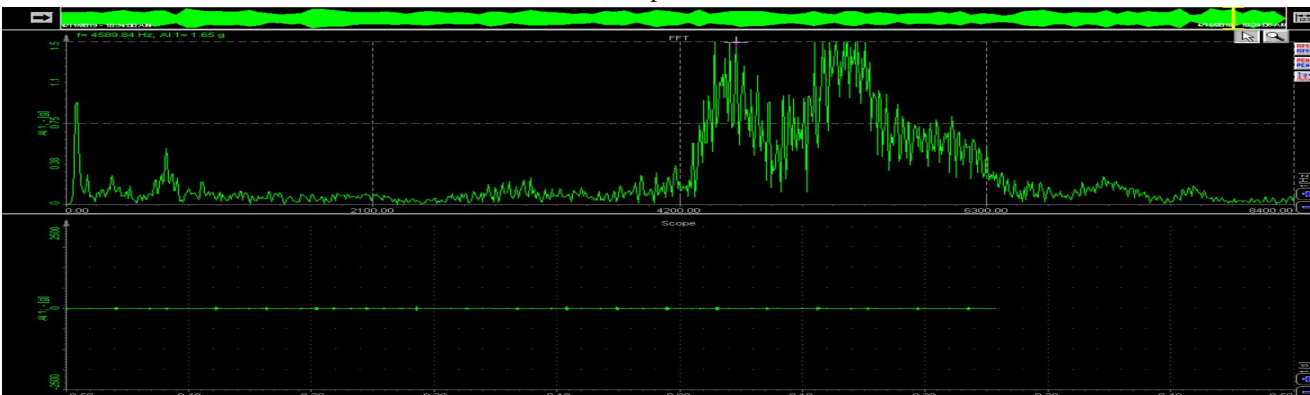


Fig. No. 13

- 3) *Vertical*: Maximum deviation is in range of 4200-6300Hz and maximum value of deviation is at 5332.03Hz with value of 1.52g. (g=9.81m/s<sup>2</sup>)

Graph12

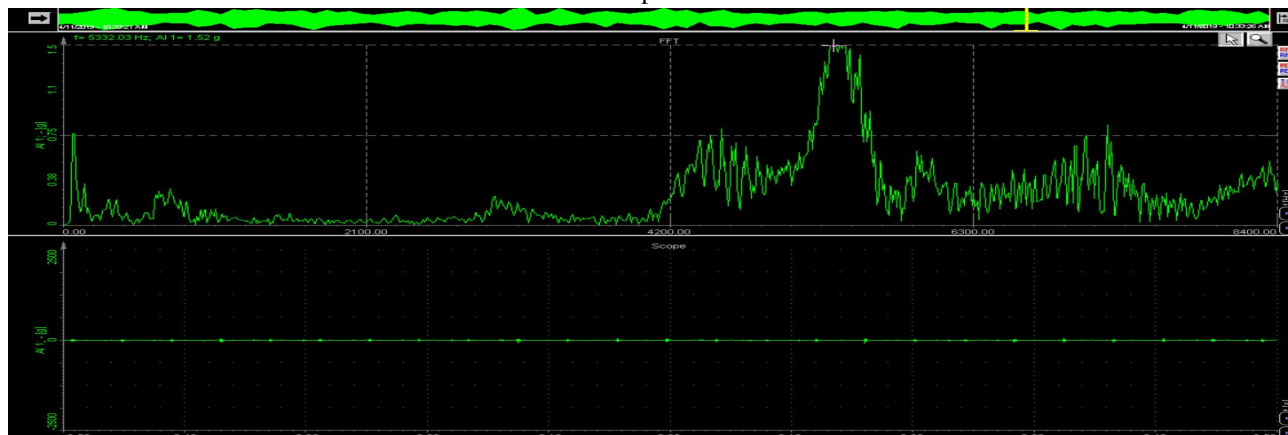
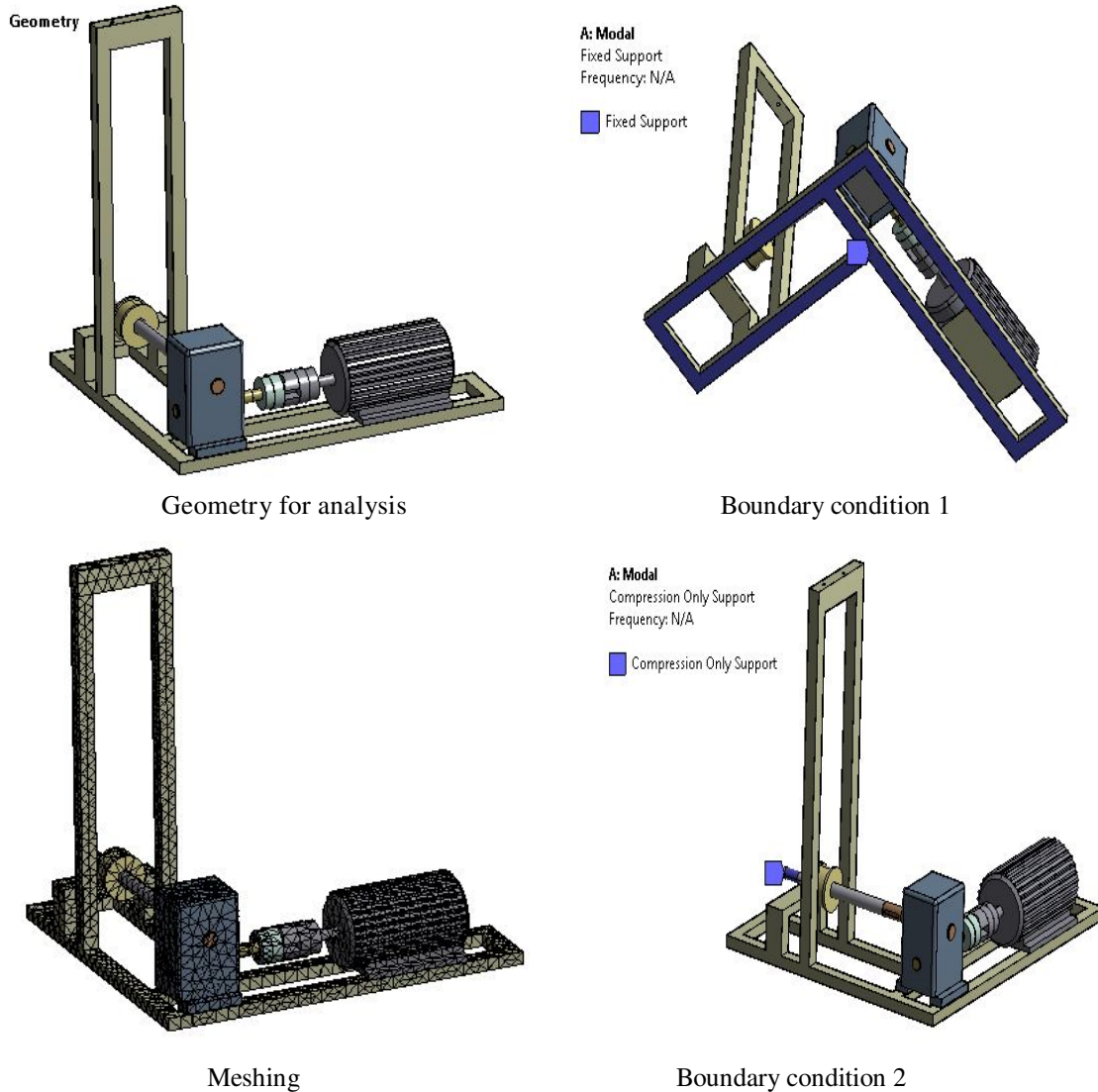


Fig. No. 14



## VII. FINITE ELEMENT ANALYSIS

### A. Results Obtained by Using Fea.



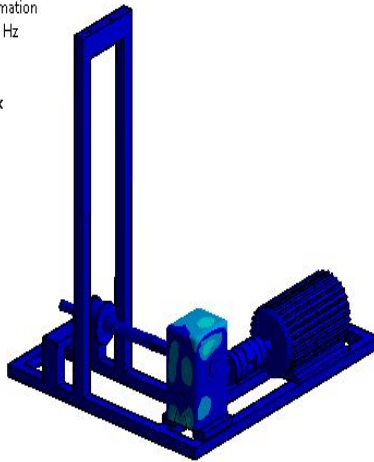
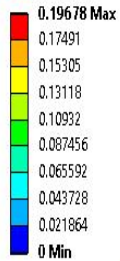
Details of "Analysis Settings"	
[-] <b>Options</b>	
Max Modes to Find	30
Limit Search to Range	Yes
Range Minimum	4000. Hz
Range Maximum	6000. Hz
[-] <b>Solver Controls</b>	
Damped	No
Solver Type	Program Controlled
[+] <b>Rotordynamics Controls</b>	
[+] <b>Output Controls</b>	
[+] <b>Analysis Data Management</b>	

Fig. No. 15

B. 30 Natural frequencies were extracted in range between 4000Hz to 6000Hz

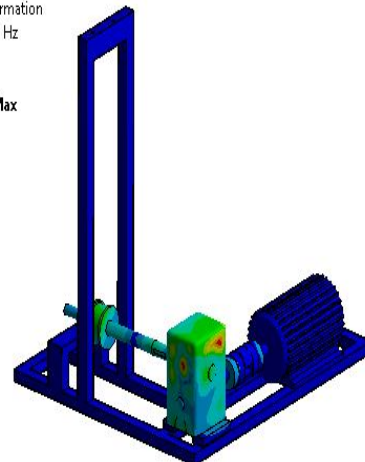
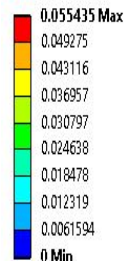
C. Above frequency range was chosen from testing frequency values

Type: Total Deformation  
Frequency: 4233.4 Hz  
Unit: m



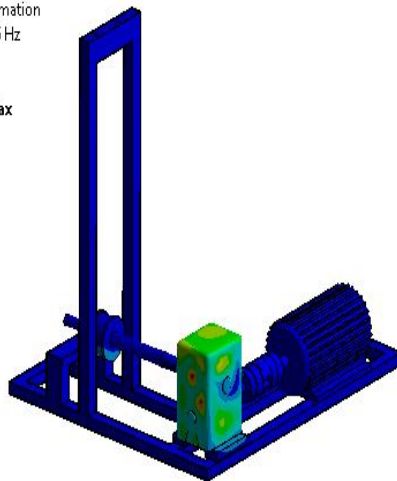
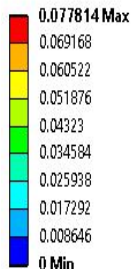
FEA result at 4233.4Hz

Type: Total Deformation  
Frequency: 4469. Hz  
Unit: m



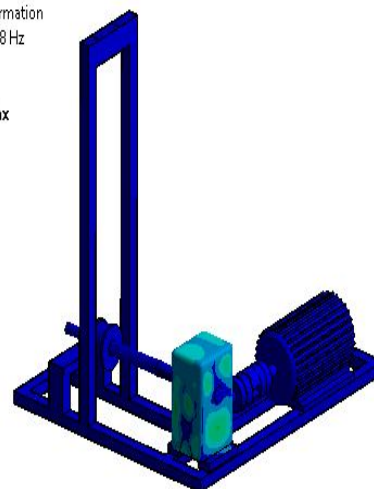
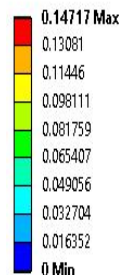
FEA result at 4469 Hz

Type: Total Deformation  
Frequency: 4541.6 Hz  
Unit: m



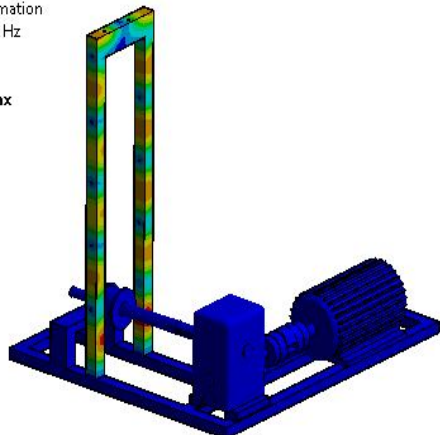
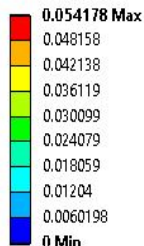
FEA result at 4541.6Hz

Type: Total Deformation  
Frequency: 4806.8 Hz  
Unit: m



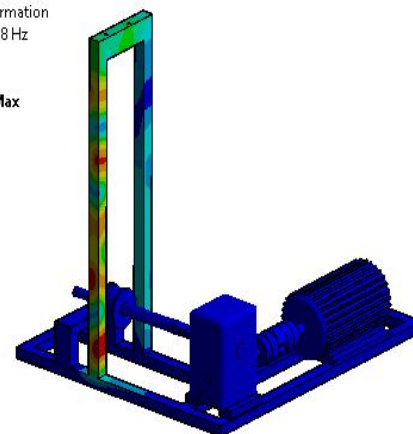
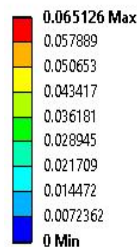
FEA result at 4807.8 Hz

Type: Total Deformation  
Frequency: 5355.1 Hz  
Unit: m



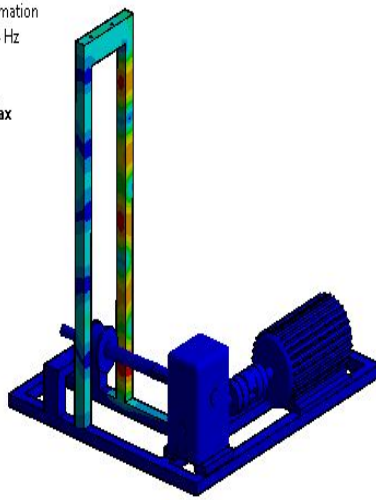
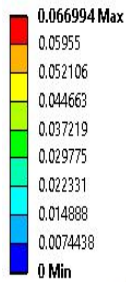
FEA result at 5355.1 Hz

Total Deformation 22  
Type: Total Deformation  
Frequency: 5397.8 Hz  
Unit: m



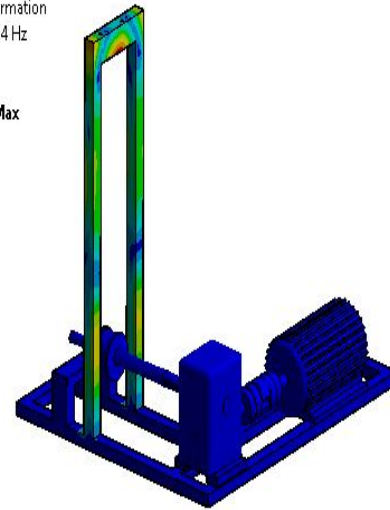
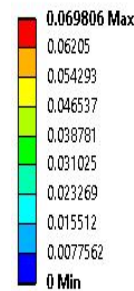
FEA result at 5397.8 Hz

Type: Total Deformation  
Frequency: 5409.4 Hz  
Unit: m



FEA result at 5409.4 Hz

Type: Total Deformation  
Frequency: 5442.4 Hz  
Unit: m

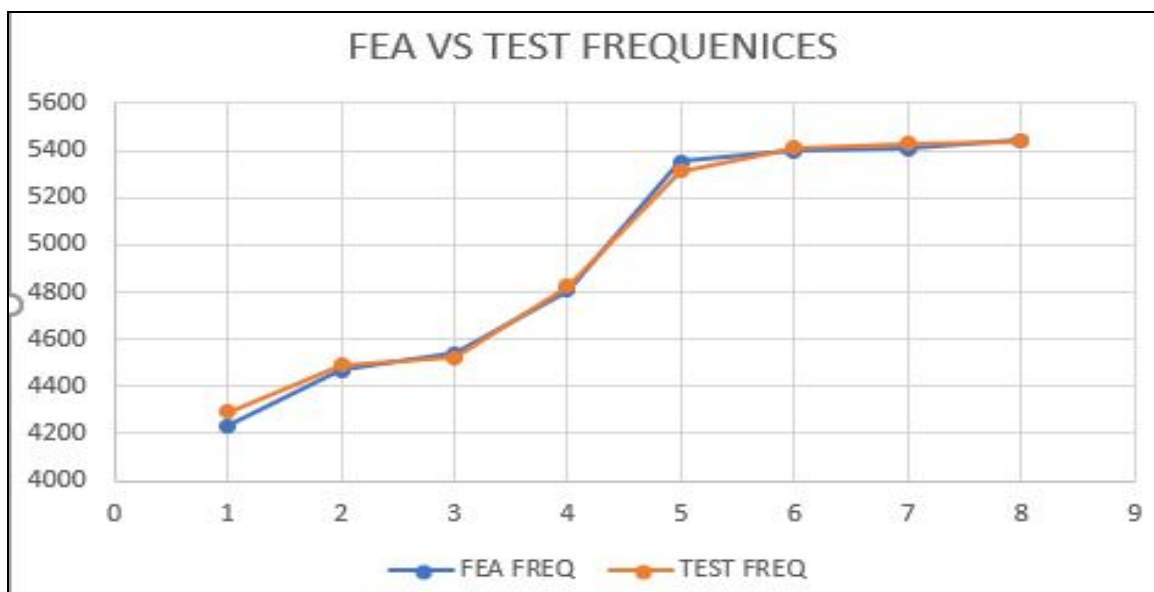


FEA result at 5442.4 Hz

### VIII. OBSERVATIONS

Comparative Analysis of FEA and Test Results.

MODE NO	FEA Frequency (Hz)	TEST Frequency (Hz)	Error %
1	4233.4	4292.88	-0.5948
2	4469	4492.19	-0.2319
3	4541.6	4521.48	0.2021
4	4806.8	4824.22	-0.1742
5	5355.1	5312.5	0.426
6	5397.8	5410.16	-0.1236
7	5409.4	5429.69	-0.2069
8	5442.4	5439.45	0.0295



Graph of Test frequencies vs FEA results.

### VIII. CONCLUSION

- A. Axial Direction: For node 1,2,3,4 as load increases there is decrease in acceleration with decrease in value if maximum frequency attained for corresponding Maximum acceleration.
- B. Horizontal Direction: For node 1,2,3,4 as load increase there is initial decrease in Acceleration to its minimum and then again starts increasing with same behaviours in trends of corresponding maximum frequency value.
- C. Vertical Direction: For node 1,2,3,4 as load increase there is initial decrease in Acceleration to its minimum and then again starts increasing with same behaviours in trends of corresponding maximum frequency value.
- D. Vertical Direction: For node 5, 6 as load increase there is initial decrease in acceleration to its minimum and then again starts increasing with same behaviours in trends of corresponding maximum frequency value.
- E. From the test result and FEA results it is observed that the results are found satisfactory and within the range.

### IX. FUTURE SCOPE

- A. Similar work can be performed on different types of other gear and gear boxes for reduction in vibration caused by rotating machinery parts.
- B. Observation results obtained by FFT can be validated with mode shape analysis using various Finite element software like ANSYS to get more accurate results.
- C. Various metrological methods can be implemented for online inspection of rotating machines on basis of results obtained by above experimental work, for suitability to low skilled workers.
- D. This kind of project work proves to best suited method in field of NVH Analysis in various automobile sectors

### X. ACKNOWLEDGMENT

The author would like to take the opportunity to thank who gave us their indebted assistance. I wish to extend my cordial gratitude with profound thanks to our internal guide Prof. R.K. Nanwatkar. I am also thankful to Prof. S. M. Jadhav, PG Co-ordinator for his overwhelming support and invaluable guidance. My sincere thanks and deep gratitude to Head of Department, Prof. D. H. Burande and other faculty members. At last but not least I express my sincere thanks to the Institute's Principal , for providing us infrastructure and technical environment.



# Weight Optimization and Manufacturing of Composite Leaf Spring

Yash A. Jaiswal<sup>1</sup> Amit G. Rakhonde<sup>2</sup> Shubham V. Jaiswal<sup>3</sup> Sarvesh C. Mane<sup>4</sup> Arun S. Thakare<sup>5</sup>

<sup>1,2,3,4</sup>Student <sup>5</sup>Professor

<sup>1,2,3,4,5</sup>Department of Mechanical Engineering

<sup>1,2,3,4,5</sup>NBN Sinhgad School of engineering, Pune, India

**Abstract**— The main use of Leaf springs is in suspension system to absorb shock loads due to road irregularities in automobiles like light motor vehicles, heavy duty trucks and in rail systems. Leaf springs carry lateral loads, brake torque, vibrations in addition to shock absorbing. The benefit of leaf spring over helical spring is that the ends of the spring can be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. The suspension leaf spring is one of the potential items for weight reduction in automobiles unsprung weight. The main aim of our research is to study and analyze the leaf spring of a vehicle which is made up of E-glass epoxy material. Experimental testing will be carried out on UTM and analysis with the help of ANSYS-Workbench software. The comparative analysis will be carried out between the analytical and experimental results.

**Keywords:** Leaf Spring, Steel, Epoxy, ANSYS, UTM

## I. INTRODUCTION

In automobile industry increasing innovations and development of the product tend to replace material, optimize design & better manufacturing process. Due to advancement in technology in the automobile industry, new components need to be added in the vehicle. This increases the weight of the vehicle which in turn increases fuel consumption. Hence, it has now become necessary to reduce the weight of the vehicle. Also, it is desired to keep the unsprung weight at its minimum. Suspension system of a vehicle falls under the category of unsprung weight. Study also says that almost 20% of the total weight of the vehicle lies in its suspension [2]. So suspension system has become a potential component in which weight reduction can be achieved. Currently the leaf spring suspension system is made from steel, but it is possible to replace it by composite material to have desired material property. The leaf springs absorb all the bumps and dips in the road, thus providing a more comfortable ride for the vehicle's occupants. But steel leaf springs have unsprung weight. So we have developed E-glass/epoxy mono composite leaf spring to reduce weight up to 80% with increase driving reliability come greater suspension.

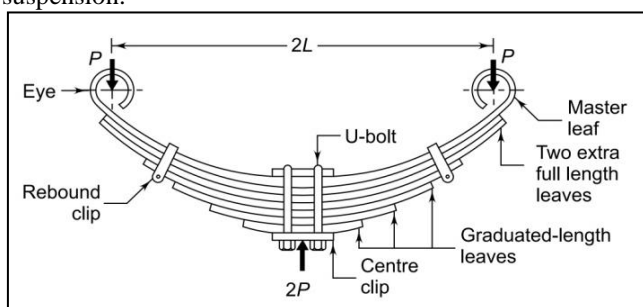


Fig. 1 : Semi elliptical leaf spring [6]

## II. PROBLEM STATEMENT

The Automobile Industry has shown keen interest for replacement of steel leaf spring with that of glass fibre composite leaf spring, since the composite material has high strength to weight ratio, good corrosion resistance and tailor-made properties. The present study is focused to search the new material for leaf spring.

## III. PROPERTIES OF MATERIALS

The materials used in the steel leaf spring are plain carbon steel, chromium-vanadium steel, chromium-nickel molybdenum steel, silicon-manganese steel, etc are materials used in design of steel leaf spring. The type of steel used in conventional leaf spring of light motor vehicles is 55Si2Mn90 i.e. silicon manganese steel. The properties of 55Si2Mn90 are given in table no. 1.

Parameter	Value
Material selected – Steel	55Si2Mn90
Tensile strength (N/mm <sup>2</sup> )	1962
Yield strength (N/mm <sup>2</sup> )	1470
Young's modulus <i>E</i> (N/mm <sup>2</sup> )	2.1·10 <sup>5</sup>
Normal static loading (N)	10750
Spring weight (kg)	20
Width of the leaves (mm)	63
Thickness of leaves (mm)	8

Table 1 : Properties of steel [1]

In this work, we are using a mono leaf spring made of composite material. Various cross sections for the leaf springs are used as follows:

- 1) Constant thickness, constant width design.
- 2) Constant thickness, varying width design.
- 3) Varying width, varying thickness design.

Here, in this work we are using the simplest form of cross section i.e. constant thickness and constant width. The properties of E-glass fibre composite are given in the table no. 2.

Properties	Value
Tensile modulus along X-direction (Ex), MPa	34000
Tensile modulus along Y-direction (Ey), Mpa	6530
Tensile modulus along Z-direction (Ez), Mpa	6530
Tensile strength of the material, Mpa	900
Compressive strength of the material, Mpa	450
Shear modulus along XY-direction (Gxy), Mpa	2433
Shear modulus along YZ-direction (Gyz), Mpa	1698
Shear modulus along ZX-direction (Gzx), Mpa	2433
Poisson ratio along XY-direction (Nuxy)	0.217
Poisson ratio along YZ-direction (Nuyz)	0.366
Poisson ratio along ZX-direction (Nuzx)	0.217
Mass density of the material, kg/mm <sup>3</sup>	2.6e-6

Flexural modulus of the material, Mpa	40000
Flexural strength of the material, Mpa	1200

Table 2 : Properties of E-glass fibre <sup>[1]</sup>

IV. DESIGN CALCULATIONS

A. Weight calculations

Weight of vehicle = 1615 Kg  
 Maximum load carrying capacity = 535 Kg (8 persons)  
 Total weight = 1615 + 535 = 2150 Kg  
 Taking F.S. = 2 & Acceleration due to gravity = g = 10 m/s<sup>2</sup>  
 Total weight = W = 2150\*2\*10 = 43000N  
 Since the vehicle is 4-wheeler a single leaf spring corresponding to one of the wheels takes up ¼ th of the total weight.  
 F = 43000/4 = 10750 N

B. Design calculations

Theoretical calculations are done by using following formulas:

$$\text{Deflection } (\delta) = \frac{4*F*L^3}{E*b*t^3} \dots\dots(i)$$

$$\text{Stress } (\sigma) = \frac{6*F*L}{b*t^2} \dots\dots(ii)$$

Where, F = load applied  
 L = half length between eyes  
 b = width of leaf spring  
 t = thickness of leaf spring  
 E = Young’s modulus

By solving equations (i) & (ii) the dimensions of mono leaf spring were obtained.

V. MODELLING AND FEA ANALYSIS

A. Modelling

The figures below, Fig. 2 & Fig. 3 are the 3D models of the steel and composite mono leaf spring respectively, they were modelled using “CATIA V5”. The dimensions for the model were calculated analytically considering the load which will act on the leaf spring when it will be mounted in the vehicle. Standard dimensions were used for the steel leaf spring as provided by the manufacturer while that of the composite leaf spring were calculated according to the load.

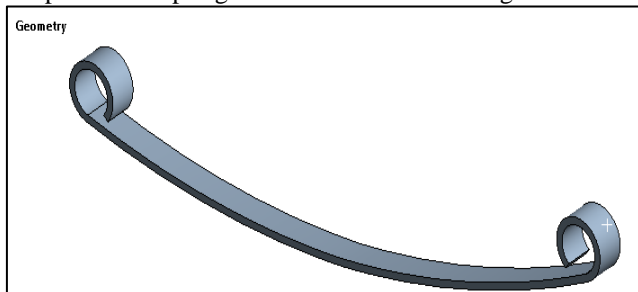


Fig. 2 : 3D model of steel leaf spring

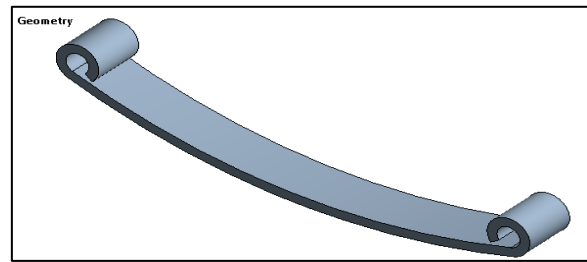


Fig. 3 3D model of composite leaf spring

B. FEA analysis

The analysis of the 3D models of the leaf springs was carried out using “ANSYS WORKBENCH-19”. The material properties like young’s modulus, Poisson’s ratio; density, type of properties, etc were defined for both the materials. Meshing of the model was done using brick elements. After the mesh, proper boundary conditions were applied. The results of stress and deflection were obtained for both the leaf springs (i.e. steel and composite leaf spring).

1) Meshing

ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient solutions. Element type used is solid brick 8 node 185<sup>[4]</sup>. Mesh size is manually controlled. After meshing contact pair is create lower and upper surface. For the leaf springs, the mesh was created using hex/brick elements as this is a simple model. The number of nodes and elements created for steel leaf spring was 26,703 and 4,545 respectively, while that for the composite leaf spring was 1, 11, 042 and 22, 747 respectively. Fig. 4 & Fig. 5 show the meshed model of both the springs <sup>[5]</sup>.

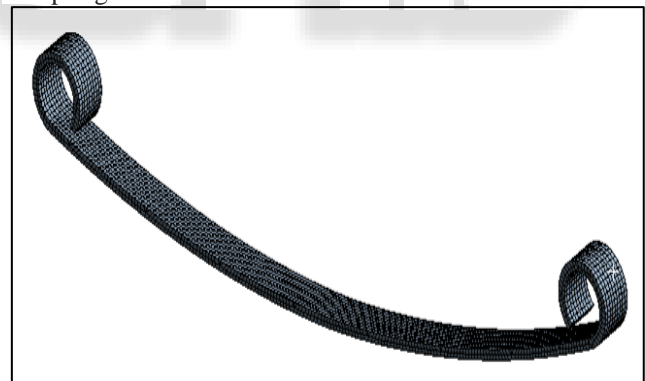


Fig. 4 : Meshing of steel leaf spring

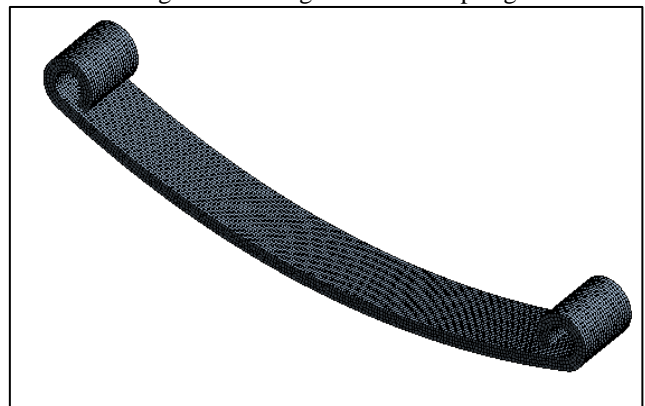


Fig. 5 : Meshing of composite leaf spring



2) *Boundary conditions*

A boundary condition for the model is the setting of a known value for a displacement or an associated load. For a particular node you can set either the load or the displacement but not both. The main types of loading available in FEA include force, pressure and temperature. These can be applied to points, surfaces, edges, nodes and elements or remotely offset from a feature. The way that the model is constrained can significantly affect the results and requires special consideration. As for the leaf spring, the ends are fixed while the load acts at the centre of the curved body of the leaf spring. Similar constraints and loads were applied to the mesh of the spring to obtain the results. Same boundary conditions were applied to both the leaf springs. Fig. 6 & Fig.7 shows the boundary conditions used which are similar to the actual mounting of the leaf spring.

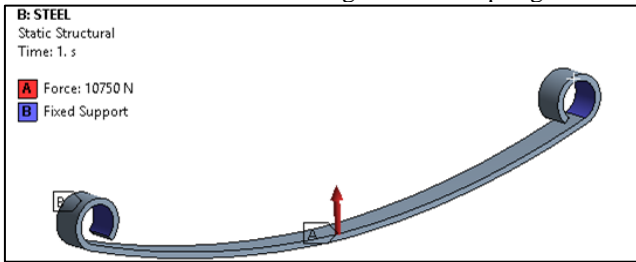


Fig. 6 : Boundary conditions of steel leaf spring

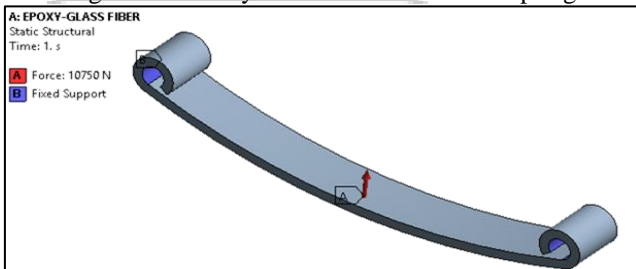


Fig. 7 : Boundary conditions of composite leaf spring

C. *Analytical Results*

1) *Total Deformation*

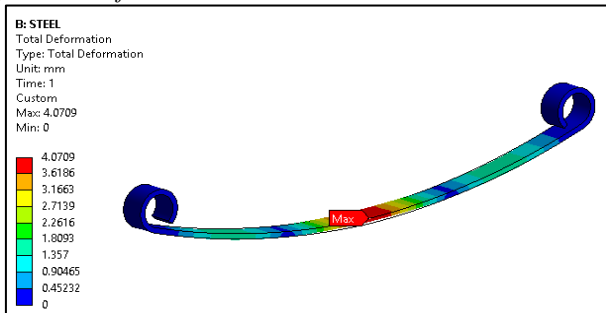


Fig. 8 : Deformation in steel leaf spring

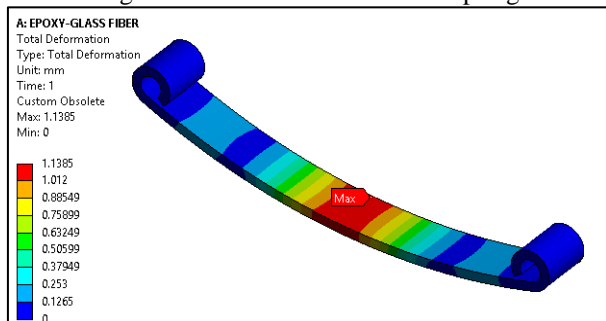


Fig. 9 : Deformation in composite leaf spring

2) *Equivalent Stress*

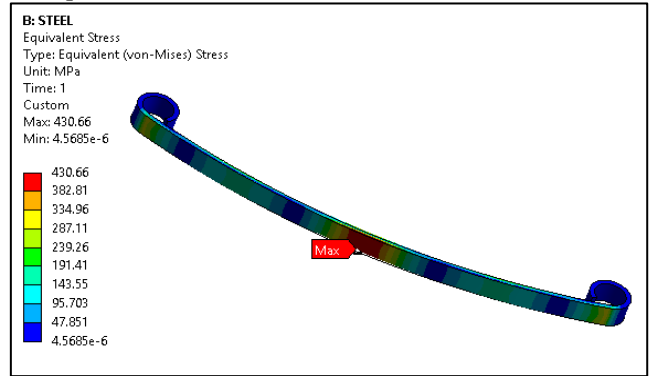


Fig. 10 : Equivalent stresses in steel leaf spring

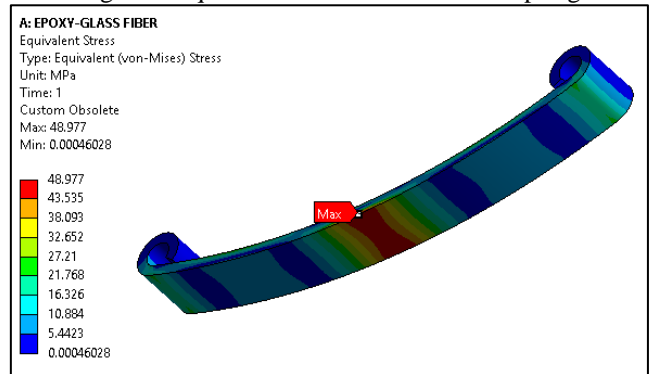


Fig. 11 : Equivalent stresses in composite leaf spring

VI. *MANUFACTURING*

A. *Prerequisite:*

- 1) Pre-cut glass fibre sheets of slightly oversized dimensions.
- 2) Mixture of epoxy resin and hardener.

Hand layup method was used to manufacture the composite leaf spring. It is an open mould process which progresses at a slow pace but helps to produce economical quantity of components [3]. It is a fast process as compared to the other processes. The manufacturing requires E-glass fibre sheets & epoxy resin as the main constituents. Other than this, it requires simple tools like roller/brush, wax, hardener and gloves for safety purpose.

As the curved length and camber length of composite leaf spring are similar, it was suitable to use the master steel leaf spring to generate the required curved shape to obtain the mono leaf spring. Over the top curved surface, a piece of sheet metal was stuck on which the sheets of glass fibre will be placed. To facilitate easy removal of the mono leaf spring a layer of wax was applied on the sheet metal. Over the layer of wax, resin mixture was poured in order to make the glass fibre sheet adhered to the die. After applying the wax and epoxy resin onto the sheet metal surface, place a piece of glass fibre sheet on the wax layer. Pour the epoxy resin and hardener mixture on the glass fibre sheet and spread the mixture evenly over the entire surface of the glass fibre sheet using a roller or a brush. As soon as the resin was spread evenly on the sheet, second sheet was placed on top of it and again the resin was poured and spread evenly over the glass fibre sheet. This process was followed until the required thickness was achieved. After the

leaf spring has solidified, wax applied below the first layer will help in easy removal of the leaf spring from the die. As oversized sheets has been used, there was need to cut the spring up to the required dimensions, hence machining was needed to be done.



Fig. 12: Manufacturing process of composite leaf spring

### VII. EXPERIMENTAL TESTING

The steel and composite leaf springs were tested by using hydraulic UTM. The experimental set up is shown in Fig. 13. The leaf springs to be tested were examined for defects. The load was applied from zero to the prescribed maximum load and back to zero. The spring was supported at centre and hydraulic pressure was given from bottom to the spring. This test is called as the “3 point bending test”.



Fig. 13: 3-point bending test on UTM

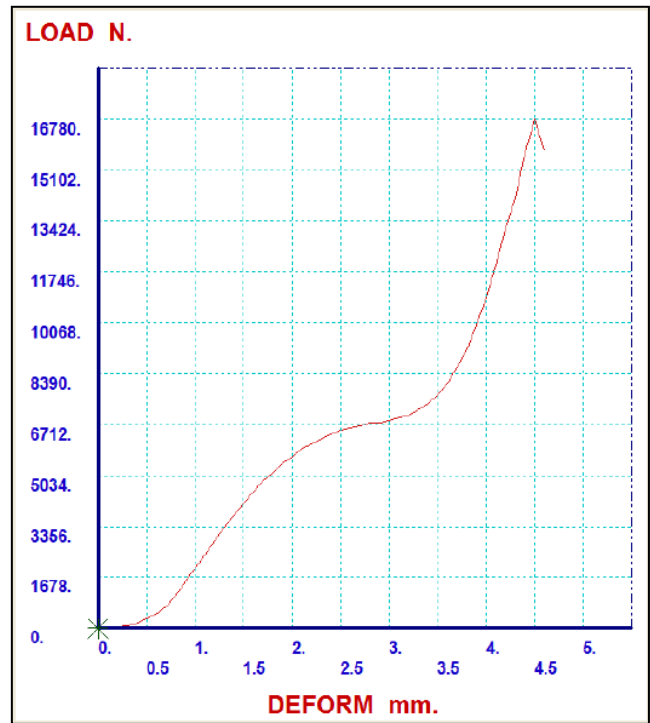


Fig. 14: Results obtained from UTM

Sr. No	Parameter	Analytical	Experimental
1.	Stress (MPa)	430	473.15
2.	Deformation (mm)	1.138	4

Table no. 3 Comparison Table

### VIII. TYPES OF JOINTS

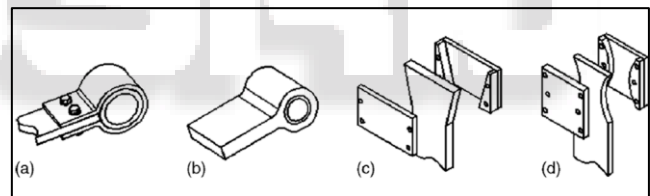


Fig. 15: Types of joints

To provide a proper and reliable suspension system, joints are necessary to be fixed to the axel and the vehicle body. Four types of joints shown in Fig.15 can be used as the joint of composite leaf springs. The joint type (a) consists of a steel eye that can be bolted to the spring body. This type of joint has lower manufacturing cost and simple structure, but needs to be drilled on the spring, which may result into stress concentration, which is unfavourable to the reliability of composite leaf spring. In joint type (b) the eye and spring are manufactured simultaneously from the same material. Although there is no stress concentration in this type of joint, the reinforcement of composite at the junction of eye and spring is necessary to avoid the splitting of unidirectional fibres. The disadvantage of this type of joint is that it is difficult to manufacture. In joint types (c) and (d) the spring end has a conical or concave width profile so that the steel eye fittings with the same conical or concave profile can be mounted easily and reliably, together with rubber pads. There is no stress concentration due to the drilling in joint types (c) and (d). But the angle of conical parts should be selected great enough to avoid squashing the composites in the available space. At the same time, it will

also affect the installation space of composite leaf spring and the machining requirement of the conical or concave profile is much higher, resulting in the higher manufacturing cost for those types of joints [2].

#### IX. CONCLUSION

- Weight of conventional steel leaf spring - 20kg
- Weight of composite mono leaf spring – 3.9kg (without joints)

Experimental results from testing under the static loading conditions containing strength and deflection were obtained. These results were also compared with FEA results. From this it was concluded that the composite leaf spring will perform satisfactorily as observed from the strength point of view, and can be replaced with the conventional leaf spring. As the spring was designed from the same stiffness as that of steel leaf spring, both the springs are considered to provide equal vehicle stability. The main purpose of our research was to optimize the weight of the conventional steel leaf spring suspension system used in the automobiles. As observed, the composite leaf spring shows less deflection for the same weight and also less stresses are induced in it as compared to the steel leaf spring. In addition to this, the weight reduction achieved was up to 80%.

#### REFERENCES

- [1] G.J. Shiva Shankar, S. Vijayarangan, “Mono Composite Leaf Spring for Light Weight Vehicle – Design, End Joint Analysis and Testing”, Vol. 12, No. 3. 2006.
- [2] Jun K., Zhenyu W., Zhiping C.X.Y., “A review on material selection, design method and performance investigation of composite leaf springs”, Composite Structures, PII - S0263-8223(19)30567-7, 2019.
- [3] T. Keerthi vasan, S. M. Shibi and C. K. Tamilselvan, “Fabrication and testing of composite leaf spring using carbon, glass and aramid fiber”, Materials Today, 2019
- [4] A.J. Pawar, S.N. Bansode, “Weight Optimization of Mono Leaf Spring Used for Light Passenger Vehicle”, Volume 3, issue 3, 2015.
- [5] B.B.Deshmukh, S.B.Jaju, “Design and Analysis of Glass Fiber Reinforced Polymer (GFRP) Leaf Spring”, 2011.
- [6] V. B. Bhandari, Design of machine elements, McGraw Hill, page no. 437, 1994.

# Design and Analysis of Filter Tube Sheet of Pressure Vessel Against Fatigue and Fouling

Mr. Vaibhav A. Sapate<sup>1</sup>, Prof. Ravikant K. Nanwatkar<sup>2</sup>, Prof. Sainand M. Jadhav<sup>3</sup>

<sup>1</sup>PG Student, Department of Mechanical Engineering, NBSSOE, SPPU, Pune, Maharashtra.

<sup>2,3</sup>Assistant Professor, Department of Mechanical Engineering, NBSSOE, SPPU, Pune, Maharashtra.

**Abstract** - Many Petroleum industries use Filter sheet vessel for various applications. It generally deals with filtering the Natural gas immediately after it is mined. During these operations, natural gas contains common but serious contaminant e.g. sulphur in the form of H<sub>2</sub>S, SO<sub>2</sub>, CH<sub>4</sub>S, OCS and CS<sub>2</sub>. Of these sulphur combines with sand to create a rough particulate impurity like slogging, clogging, fouling etc. Filter tubes in pressure vessels provides a large surface for filtration. These tubes are made up of ceramics, steel etc and provide filtration up to 0.1 micro mm. But due to continuous use, these filter tubes gets layer of clog on surface which raises the overall pressure in the vessel. This pressure rise has some limits which cant exceeds beyond certain limits because of stability issues. Due to this reason the filter tubes are cleaned once a month/ week. This causes shut down of whole plant during cleaning which affects the economic costs due to loss of production. This problem can be reduced by designing a self cleaning filter unit which is divided into two sections and after every 4 to 5 seconds one of the compartments receives a reverse pressure of 1 sec and washes out the filter tubes. This system of cleaning of tubes without stopping the plant gives good results without reduction in production and since it is a regular cycle so its needs to be shut down the plant once a year for full clean-up. However, due to reverse pressure, the stress profile in the filter changes from tensile to compressive, creating possibility of fatigue. The main aim of this project work is to design of filter tube sheet on basis of working parameters, analyze the fatigue variation with modified concept using finite element analysis method to avoid fouling, slog and fatigue.

**Key Words:** FEA, tube sheet, fatigue, cyclic loads, de-clogging, Fouling.

## 1. INTRODUCTION

The present work predicting the fatigue life of the tube sheets (used as main supporting element in large filter vessels), by design modification using proposed working cycle and transient analysis of the same. The application of the filters which is considered in this project is of petro chemical industries. This analysis finds application in natural gas filtering when it is immediately mined from the ores.

A tube sheet can be defined as perforated circular sheet or a plate with a pattern of holes (triangular / rectangular) specially designed to accept pipes or tubes. These tubesheet facilitate the smooth flow of fluid inside the tubes and also

support and isolate the boilers, heat exchangers and other types of filter elements. The variety of material use to make tube sheet ranges from different types of metal, resin composites, ceramics or plastic. Cladding / insulating material / sacrificial /galvanic anode method is used as a corrosion barrier and insulator and may also be fitted with a galvanic anode which covers the tubesheet during its manufacturing.

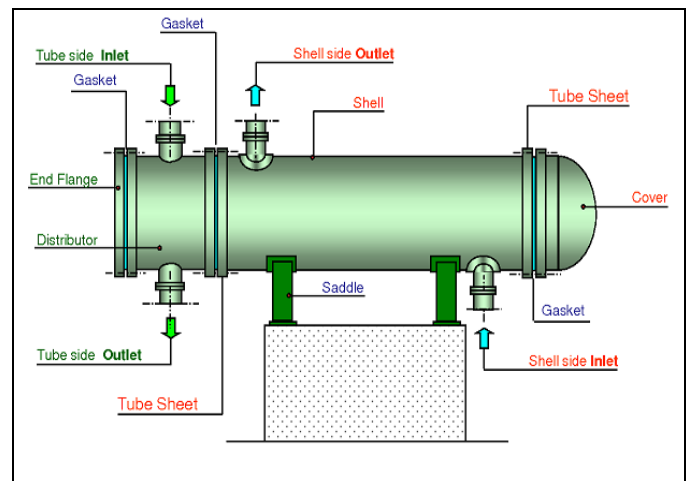


Figure 1: Assembly of Pressure Vessel & tube sheet

Generally tubesheet are used in bundles in filters, boilers and heat exchangers with thin walled dense arrangements. These Tubes are supported on either end or in between according to specified design by sheets which drilled in specific pattern, generally triangular or rectangular to allow the tube ends to pass through the sheet. The ends of the tubes which are fixed in the tube sheet are expanded by means of flowing fluid and getting fixed in closed chamber to form a seal and makes a complete unit between the tube sheets. Flanges and tubesheet are bolted to make rigid unit to avoid any further design issues. The shell of heat exchanger extends beyond the end of tube sheet and is sealed, to form two closed chambers on the non-tube ends. An arrangement is formed where the heat exchanger / boiler consists of different chambers joined by tubes. Heated fluid generally in gaseous or liquid forms including other foreign materials from ore i.e. minerals etc. is then passed from one end to the other end of chamber through the tubes using various metallurgical processes like hydrometallurgy, pyrometallurgy or electrometallurgy. Generally these flowing fluid are high in temperature which creates to increase in temperature of tubesheet. Attempt can be made



to increase the velocities of these fluids which otherwise can create fouling and creating cloggy surface on the tubesheet or on the surface of tubes. Also this fouling can be reduced by analysing the fatigue life behaviour of the tubesheet by transient analysis. Design calculation of tubesheet and its pattern to fixe tubes is somewhat complex process. These patterns include triangular or rectangular holes to have maximum tubes on the tubesheet with reduction in fouling and fatigue. Many computer aided technologies like CAD, CAM, and FEA are used now a day for safer design and analysis of the tubes and tubesheet. Tube sheets have pattern of holes with designed diameter and pitch. The portion between these holes is called ligament and the cross sectional area of the ligament w.r.to the area in a normal unpierced cross section of width is called ligament efficiency. The Stress Concentration Factor (SCF) is defined as the ratio of maximum principal stress in the stressed model to the nominal stress applied at the boundary of the plate. As tubesheet plays a vital role in design and analysis of the pressure vessel it should be carefully studied for various loads and working conditions. The thickness of the tubesheet varies directly to the costing and procurement of various component of pressure vessel. Thicker tubesheet results in longer tube length inside the tubesheet that do not take part during working operations. The primary aim of this project is to evaluate the fatigue life design of tubesheet by determining and analysing the effects of instant back pressure for cyclic loadings using Finite Element Analysis. The diameter, thickness and other design parameters are studied for given mechanical and working parameters for efficient and safe performance of the pressure vessel. Also various possible causes of fouling and clogging are theoretically analysed to find out suitable solution to avoid risk of fluing in tubesheet. This Research paper includes various design calculations using standard ASME codes for pressure vessel tubesheet. A mathematical modelling has been prepared by considering tubesheet as a flat plate with center hole, for verifying the designed and FEA solution. Further dynamic and transient analysis has been done with FEA software ANSYS for evaluating the fatigue life of the tube sheet.

### 1.1 Problem Definition

Tube Sheet filters is cleaned by applying back pressure, and the pollutants are then collected at the opposite end of the vessel. Industrial filters do this operation once a month. However in a Coal gas plant, the level of impurities is high, and this results in dense clogging of the filters within 5 days, and severe damage is caused to the filter and assembly due to the heavy built up of pressure as the tube get clogged. To tackle this problem, an instantaneous back pressure mechanism has been developed, which delivers 5 seconds of back pressure after 14 seconds of front pressure. This declogs the filters and reduces chances of pressure built up. However, due to back pressure, the stress profile in the filter changes from tensile to compressive, creating possibility of fatigue.

### 1.2 Objectives

- 1) To analyse the filter sheet for the load cycle specified.
- 2) To Study the possible causes and remedial measure of fouling on tube sheet surface.
- 3) To Study the effect of variation of parameters on the performance of the system. Since Flammable gases are involved in the process, safety is of prime importance.
- 4) To perform an ideal case analysis to benchmark the normal stresses during operation.
- 5) To conduct Transient analysis to check performance under a single cycle operation.
- 6) To perform Fatigue analysis to be undertaken to check the life of the component.
- 7) To modify the design if the fatigue life is not up to requirements.
- 8) To perform Tests will be to benchmark the modifications.

### 1.3 Scope

- 1) Three dimensional modeling of the tube sheet using any suitable CAD modeler, Viz. CATIA /ANSYS Workbench.
- 2) Finite element analysis (dynamic and transient) using suitable solver viz. ANSYS14.0.
- 3) Load cycle analysis by graphical methods using MS Office Excel and word.
- 4) Determination of fatigue and the stress profile on the filter due to pressure variation from tensile to compressive.
- 5) Comparative analysis with existing results of similar products.
- 6) Cost estimation for optimized solution.

### 1.4 Methodology

During normal operation, air flows inward through the intake duct and passes through the filter elements. Duct is collected on the outside surfaces of the elements. Clean air flows through the center of the elements into the clean air storage elements.

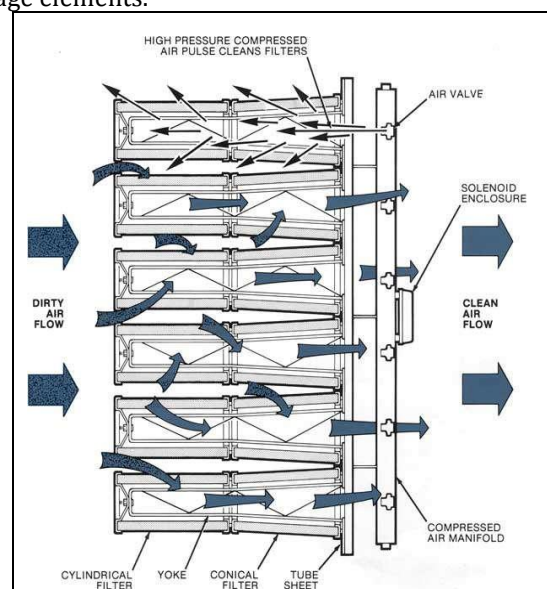


Figure 2: Basic operation of filter tube sheet

## 2. LITERATURE REVIEW

Title of Publication	Author and Publisher	Findings / Concluding remarks	Work to be completed / scope
Design of Perforated Plates	W.J. O'Donnell, B.F. Langer; JEIT, ASME; Volume 84. (2019)	Analysis of the stresses and deflection in the perforated plates with a triangular penetration pattern.	Fatigue and transient analysis with rectangular pattern. Fouling analysis by increasing the velocity of flowing fluid in tubes.
A finite element Benchmark for the Dynamic Analysis of Perforated Plates with a Square Penetration Pattern	D.L. Kaap, M.A. Sprague, R.L.Engelstad (2018)	for the dynamic analysis of perforated plates with a square penetration pattern	Effect of reduction in thickness of the tubesheet and its result on tubesheet stresses and design modification considering this changes.
Gas-side fouling, erosion and corrosion of heat exchangers for middle/low temperature waste heat utilization: A review on simulation and experiment.	Ming-jia Li, Song-Zhen Tang, et.al. in ELSEVIER (2017)	The simulations and experimental studies for the fouling, erosion and corrosion of heat exchangers.	Fatigue and transient analysis with effect to reduce the fouling. Design modifications to reduce the stresses due to variation in thickness of tubesheet.
Strength Analysis of Tube to Tubesheet joint in Shell and Tube Heat Exchanger"	Kotcherla Sriharsha, Venkata Ramesh Mamilla and M.V. Mallikarjun in (IJSETR),	The strength analysis of a typical tube to tube sheet joint in shell and tube heat exchanger.	Fatigue and fouling behavior with design modifications and FEA analysis through transient and dynamic approach.
Analysis of the Tubesheet Cracking in Slurry Oil Steam Generators.	L.K. Zhu,L.J. Qiao, X.Y. Li, B.Z. Xu, W. Pan, L. Wang, Alex A. Volinsky;in ELSEVIER.	Analysis of the tube sheet cracking in slurry oil steam generators Tubesheet to increase the service life.	Same as above with further work related to tubesheet in pressure vessel.

### Conventional and Proposed Filtration Process

When natural gas is mined it contains contaminants. The most common and serious contaminants is sulphur, usually in the form of oxides, these sulphur at times combines with sand to create a rough particulate impurity. The gas is usually considered sour if the hydrogen sulphide content exceeds 5.7 milligrams of H<sub>2</sub>S per cubic meter of natural gas. Filter tubes are the most commonly used filter options as they provide a large surface for filtration. They are typically made of ceramic and provide filtration up to 0.1 micro mm. However these filters do get clogged over a period of time. Once they get clogged they obstruct the flow of flow of gases,

creating pressure rises. Once the allowable value is reached it need to shut down the plant and apply back pressure to clean the filter tubes. However when the filter tubes are being cleaned, the entire plant line has to be shut down. This comes with economic costs as the production of the pant reduces. Furthermore after restarting the system takes 30 mins to reach full capacity which further augments the production losses. Furthermore this cleaning is needed every month creating schedule losses.

To reduce the production losses and scheduled losses in the system a new system has been incorporated which reduces the compulsion of shut down of entire plant line for cleaning of filter tubes and also increases the overall productivity of the plant. The newly designed compartments are divided into two compartments as shown in figure after every 5 seconds one of the compartments receives a back pressure of 1 second, and cleans the filter tubes. This ensures cleaning without stopping the plant, plus since this is in regular cycles, plant shutdowns for full clean up are needed only once a year. During filtration process the compressed gas is passed through the gas inlet chamber to the Filter elements. This gas is collected at the top of the filter compartment. Blow pipes with nozzles are provided for providing the back pressure and clean the filter elements. A compressed air supply is provided for creating a high intensity back pressure. The process of creating back pressure is divided into number of cycles for cleaning number of chambers.

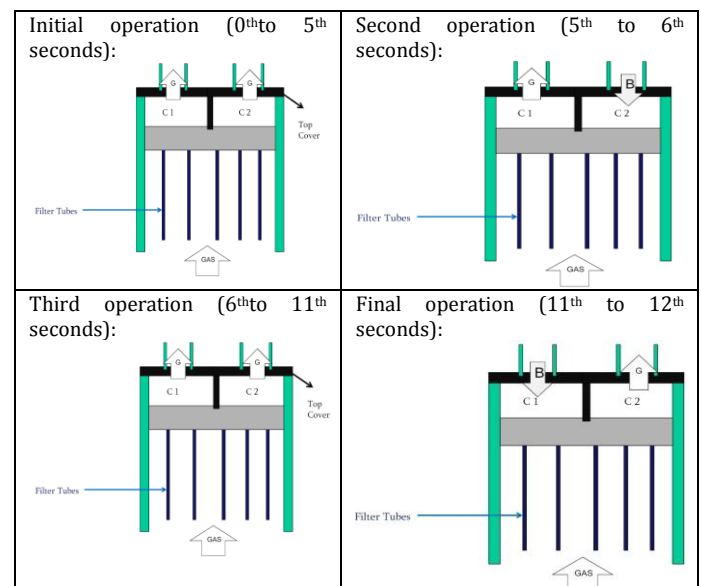


Figure 3: The proposed filtration process

The process repeats itself over and over again. However one of the crucial components is the filter sheet itself. This sheet stress reversals from positive to negative and is susceptible to fatigue.



### 3. DESIGN AND MATERIAL SELECTION

#### 3.1 Material Selection

Materials are selected according to the following criteria.

- 1) Corrosive or noncorrosive service
- 2) Contents and its special chemical/physical effects
- 3) Design condition (temperature)
- 4) Design life and fatigue affected during the plant life
- 5) Referenced codes and standards
- 6) Low temperature service
- 7) Wear and abrasion resistance
- 8) Welding and other fabrication processes

During analysis and testing of tubesheet of pressure vessel in this case the material used is SA 516 GR70 having following properties,

Table1: Properties of the tubesheet material

Requirement	Grade 55	Grade 60	Grade 65	Grade 70
Carbon, max 0.5" and under	0.18%	0.21%	0.24%	0.27%
Manganese 0.5" and under	0.60-0.90%	0.60-0.90%	0.85-1.20%	0.85-1.20%
Tensile strength in ksi	55-75	60-80	65-85	70-90
Yield strength in ksi	30	32	35	38

Careful examination reveals that a material with maximum carbon content of 0.18%, manganese content of 0.90%, 70 ksi tensile strength and yield strength of 38 ksi will satisfy the requirements for all grades of SA-516. If the material also meets all other requirements of the specification, then it may be marked for all four grades of SA-516. The material taken for tubesheet is SGR 590, as per the specifications of ASME codes.

#### 3.2 Design Calculation

For design calculations, ASMEVIII, Div 1, TEMA codes and UHX of ASME BPVC part VIII-1 is used.

All necessary design values for the calculation are listed.

Table 2: Tubesheet Parameters for Design Calculations (Instant Back Pressure)

Sr. No.	Parameter Description	Notations	Given Value
1	Internal Pressure	P	0.14 MPa
2	External Pressure	P <sub>0</sub>	Atmospheric
3	Process Volume	V <sub>p</sub>	126 cu m
4	Expected Stagnant Volume	V <sub>s</sub>	Not Specified
5	Buffer Volume Requirement	V <sub>b</sub>	Not Specified
6	Tube Porosity Volume	T <sub>p</sub>	70
7	Tube Length	T <sub>L</sub>	5.5m
8	Radius of tube sheet	r	2m
9	Tube Diameter	d	0.15m

A 5% Gap will be maintained on the Tube Sheet radius to allow for welding. Tubes shall be spaced in a manner such that they form a 60 deg Equilateral Triangle.

#### Calculations for unknown parameters:

Total volume = Pressure Volume + Expected Stagnant Volume + Buffer Volume

$$V = V_p + V_s + V_b \dots \dots \dots (1)$$

$$V = V_p + 0.1V + 0.01V \dots \dots \dots (2)$$

$$V(1 - 0.1 - 0.01) = V_p$$

$$V(0.89) = 126 \times 109.$$

$$V = 1.415730 \times 1011 \text{mm}^3$$

$$\text{Buffer Volume} = V_b = 0.01V = 1.415730 \times 109 \text{mm}^3$$

$$\text{Stagnant Volume} = V_s = 0.1V = 1.415730 \times 1010 \text{mm}^3$$

Here, V<sub>s</sub> > 0.1V<sub>p</sub>

Hence, the vessel is characterized as a full process reactionary vessel.

Referring A2209, for full process reactionary vessel,

$$V_p = (0.90 \text{NTD}) \times (\pi r^2) \quad (\text{NTD is nozzle to nozzle distance in meters}).$$

$$126 \times 109 = 0.90 \times \text{NTD} \times \pi \times (2000)^2$$

$$\text{NTD} = 11146.4968 \text{ mm}$$

$$\text{i.e. NTD} = 11.146 \text{ metres}$$

$$\text{Now, } V_s + V_b = (0.82L_1) \times (\pi r^2)$$

Here, V<sub>s</sub> > V<sub>b</sub>, hence considering V<sub>b</sub> = V<sub>s</sub>

$$2 \times 1.415730 \times 1010 = (0.82L_1) \times (\pi \times 2000^2)$$

$$\text{Gives, } L_1 = 2749.203 \text{ mm.}$$

$$\text{i.e. NTD} = 2.7492 \text{ metres}$$

#### Calculations for Tube sheet volume (Tv):

$$T_v = \frac{\pi}{4} (3800)^2 \times T_t$$

Assuming T<sub>t</sub> = 1mm

$$T_v = 11341.1494 \times 103$$

The above volume is reduced value of actual tube sheet volume by 5% for welding space).

#### Calculation for tube volume:

$$\text{Total volume} = \frac{\pi}{4} T_d^2 \times T_L \quad \dots \dots T_L = T_t$$

$$T_v = 17671.458 \text{mm}^3$$

#### Calculations for 'n' no of holes,

$$T / T_v = 0.3$$

$$0.3 = 1 - \frac{\text{Tube volume}}{\text{Tube sheet volume}} = 0.7$$

$$0.7 = \frac{\text{Tube volume}}{\text{Tube sheet volume}}$$

$$11341.1494 \times 103 \times 0.7 = 17671.458 \times n$$

$$n = 449.244 \text{ nos} \cong 450 \text{ number of holes.}$$

#### Calculations for ligament efficiency,

$$\frac{\text{Area remaining after drilling holes}}{\text{area before drilling the holes}} = \frac{D - nd}{D}$$

$$= \frac{4000 - (22 \times 150)}{4000} = 0.175.$$

#### Calculations for Tubesheet thickness,

Referring ASME section VIII, div-I, page no. 34.

$$t = d \sqrt{\frac{C.P}{S.E}}$$

For, 1000C i.e. SA516 GR70

S = 20.0KSi

S = 137.895 N/mm<sup>2</sup>

$$t = 4000 \sqrt{\frac{0.2 \times 0.14}{137.895 \times 0.175}} = 136.253 \text{ mm} = 137 \text{ mm}$$

Recalculation of volumes considering tube sheet thickness,

$$V_p = 1.1 (V_p' + Tr) + 1.2 (P_i * T_d * T_d) * (T_p/400)N$$

But  $Tr/T_v = 0.3$

$$Tr = 5301.43 \text{ mm}^3$$

$T_d = 150 \text{ mm}$  (Tube Diameter)

$T_p = 70$  (Tube Porosity Volume)

N = 450 nos. (No of tubes)

$$V_p = 1.14191781 \times 1011 \text{ mm}^3$$

For full process reactionary vessel,

$$V_p = (0.90 \text{ NTD}) \times (\pi r^2)$$

$$1.41 \times 1011 = (0.90 \times \text{NTD}) \times (\pi \times 20002)$$

$$\text{NTD} = 12548.290 \text{ mm}$$

i.e. NTD = 12.54m.

Now Total volume,  $V = V_p + V_b + V_s$

Where,  $V_b = 0.01V$  and  $V_s = 0.1V$

$$V = 1.41 \times 1011 + 0.01V + 0.1V$$

$$V = 159.44943 \times 109 \text{ mm}^3$$

$$V_b = 0.01V = 1594.4943 \times 106 \text{ mm}^3$$

$$V_s = 0.1V = 15944.943 \times 106 \text{ mm}^3$$

Now,  $V_s + V_b = (0.82 \times L_1) \times (\pi r^2)$

Here,  $V_s > V_b$ ,

Hence considering  $V_b = V_s$

$$2V_s = (0.82 \times L_1) \times (\pi \times 20002)$$

$$L_1 = 3094.776 \text{ mm} = L_1 = 3.094776 \text{ m}$$

#### Design of Shell:

According to ASME Section-VIII, Division-I, UG27,

$$\text{Thickness of Shell (tshell)} = \frac{P.R}{SE - 0.6P}$$

$$t_{shell} = \frac{0.14 \times 2000}{137.895 - (0.6 \times 0.14)} = 2 \text{ mm}$$

According to ASME Section-VIII, Division-I, UG32,

$$\text{Thickness of ellipsoidal head (thead)} = \frac{P.D}{2SE - 0.2P}$$

$$thead = \frac{0.14 \times 4000}{2 \times 137.895 - (0.2 \times 0.14)} = 2.029 \text{ mm}$$

But according to According to ASME Section-VIII, Division-I, the thickness of shell as well as ellipsoidal head should be taken minimum 6mm.

#### Design of Nozzle:

According to ASME Section-VIII, Division-I, UG36,

$$t_m = \frac{P_i d_i}{2\alpha J - P_i} = \frac{0.14 \times 300}{(2 \times 137.85 \times 0.6) - 0.14}$$

$$t_m = 0.154 \text{ mm}$$

Similarly,

$$t_r = \frac{P_i d_{ishell}}{2\alpha J - P_i} = \frac{0.14 \times 2000}{(2 \times 137.85 \times 0.6) - 0.14}$$

$$t_r = 3.388 \text{ mm}$$

But as per ASME codes minimum thickness should be taken as 6mm.

$$h = 2.5(tr - CA) = 2.5(6 - 3) = 7.5 \text{ mm}$$

OR

$$h = 2.5(trn - CA) = 2.5(6 - 3) = 7.5 \text{ mm}$$

$$d = d_i + 2CA = 300 + (2 \times 3) = 306 \text{ mm.}$$

$x = d$  or whichever is maximum

$$x = 306 \text{ mm}$$

OR

$$x = \frac{d_i}{2} + t + t_n - 3CA$$

$$x = 153 \text{ mm}$$

Therefore, taking maximum value as, 306mm

#### Area calculation,

Area pertaining to material removed

$$\text{i.e. } A = d.tr = 306 \times 3.388 = 1036 \text{ mm}^2$$

Excess area in the shell,

$$A_1 = (2x - d)(t - tr - CA) = [(2 \times 306) - 306][6 - 3.388 - 3] = 0$$

Excess area in the nozzle,

$$A_2 = 2h_1(tn - trn - CA) = 2 \times 7.5(6 - 0.154 - 3) = 42.69 \text{ mm}^2$$

Excess area in the nozzle inside the shell,

$$A_3 = 2h_2(tn - 2.CA) = 2 \times 7.5[6 - (2 \times 3)] = 0.$$

Therefore required area,

$$A_r = A - (A_1 + A_2 + A_3) = 1036 - (0 + 42.69 + 0)$$

$$A_r = 993.31 \text{ mm}^2$$

#### Design of Reinforcement pad,

dip = internal diameter of RF pad

dop = external diameter of RF pad

t = thickness of RF pad

$$dip = d_i + 2t_n = 300 + (2 \times 6) \text{ dip} = 312 \text{ mm.}$$

$$dop = \frac{A_r}{t_p} + d_{ip} = \frac{993.31}{6} + 312 \text{ dop} = 477.55 \text{ mm } 478 \text{ mm.}$$

#### Design of flange,

(Referring PV Engineering design calculation as per ASME standards)

Load on projected area = pressure x projected area.

$$P = (0.14 \times 4000) \text{ i.e. } P = 560 \text{ N.}$$

Nomenclature,

A = Flange overall diameter = 162"

Bn = Flange internal diameter = 157.5"

Tflange = Flange thickness = 0.5"

Rf = Hub corner radius = Tflange/2 = 0.25"

Gof = Hub thickness = 6mm = 0.25"

G1 = Hub base thickness = 6mm = 0.25"

m = gasket factor

Referring PV Engineering Data sheet,

$$B = B_n + 2CA = 157.5 + (2 \times 0) = 157.5"$$

$$\text{VarR} = [(\text{VarC} - \text{VarB})/2] - g_1$$

$$\text{VarC} = \text{Bolt circle diameter} = (\text{PCD}) \text{ bolt} = 162 - 2 = 160"$$

$$\text{VarB} = 157.5"$$

$$\text{VarR} = [(160 - 157.5)/2] - 0.25 = 1"$$

$$\text{GID} = 157.5 + (G_0/2) = 157.5 + (0.25/2) = 157.625"$$

$$\text{GOD} = 159"$$

$$\text{VarN} = \frac{G_{OD} - G_{ID}}{2} = \frac{159 - 157.625}{2} = 0.687"$$

$$G_0 = N/2 = 0.687/2 = 0.3437"$$

b = if (b0 > 0.25 then, , b0)

Here, b0 > 0.25

VarB = 0.293"  
 VarG = if [b0 > 0.25, GOD - (2 VarB)] = 159 - (2 0.293)  
 VarG = 158.414"  
 Hub corner radius = Rf = Length of hub = 0.12"

**Design of bolt**

H = 0.785 (VarG)<sup>2</sup> Pr  
 = 0.785 (158.414)<sup>2</sup> 20.305  
 H = 399.99 103Pounds.....end load  
 He to be considered wind pressure here,  
 He = [0.785 (VarG)<sup>2</sup> 0.0265] < H  
 Hp = 2 VarB 3.14 VarG m P  
 = 2 0.293 3.14 158.414 3 20.305  
 = 17755.9974 Pounds.....contact load  
 Wm1 = H + Hp = (399.99 103) + 17755.9974  
 Wm1 = 417745.99 Pounds.....bolt load.

**Bolt area required,**

$A_m = \frac{W_{ml}}{\text{Allowable Load}} = \frac{417745.99}{20000} = 20.887 \text{ in}^2$  .....bolt area.

Now, Am = 0.87" .....for bolt area.

No. of bolts =  $\frac{A_m}{\text{Bolt root area}} = \frac{20.887}{0.87} = 24 \text{ nos.}$

**Total length of the shell,**

L0 = NTD + (RF Pad)OD = 12.54 + 0.3556  
 = 12895.6mm.

Reinforcement pad diameter = 14" = 355.6mm

**Approved Design Modification after Testing,**

- L1 which is currently calculated to be 3094 has been updated to 3200, as per site conditions.
- Filter Cover designers have made the following changes
- On top Side the no of nozzle required will be 4, 2 for positive pressure and 2 for negative (back) pressure.
- The back pressure nozzles are bigger than the other two nozzles, of size 700mm dia. The other two nozzles are to be made 500mm dia.
- Nozzle reinforcement pads are kept at 1400mm dia (2 x nozzle dia), the repad is kept same for all 4 nozzles.
- Previous tube SGR506, failed the back pressure tests, and it was found that larger dia filter tubes will be needed. Hence the tubes will be replaced by SGR590 tubes, of Dia 1400 mm.
- The Tube Sheet will be divided into two sections. Hence the central band of 100mm width will have no tube holes as it will be resting point for the portion.
- To compensate for this loss, the outer requirement of 5% space is reduced to 2.5% for the Tube Sheet.
- SGR 590 Tubes have the following properties, Dia 1400mm, length 4600mm, and weight 72.5kg.
- The Tube sheet will be welded to the shell from both sides.
- Top Nozzles will be at a distance of 1800mm from the Flange.
- NTD will be maintained at 12550 mm, therefore the bottom nozzles will be shifted and overall length of the vessel will increase by about 1100mm (approx. value, calculate exact value for modelling).

- Bottom Nozzle size will be increase to 700mm and there will be 2 nozzles at 180 degree orientation.
- Nozzle on the dish end will also be upgraded to 500mm dia; this is because SGR 590 has tendency of coagulating impurities into larger blocks.

**Pressure Cycle**

For SGR 590 the following pressure cycle is present for one chamber of the sheet.

0 - 5 sec 0.14 MPa (Up) A  
 5 - 6 sec 0 MPa  
 6 - 10 sec 0.145 MPa (Back) B  
 10 -11 sec 0 MPa

When chamber 1 is at cycle A, chamber 2 will be at cycle B. Both will be shut off at the same time.

During Shutoff the accumulation of gas will increase the upward pressure up to 0.143 MPa.

Since the entire process is working at differential of 0.005 MPa, Max upward pressure will be 0.145 MPa.

Design Pressure is hence considered to be 1.2 x 0.145 = 0.174 MPa which will be the test pressure.

Corrosion allowance is considered to be 3mm.

**Modified design calculations:**

Calculation for tubesheet thickness,

Referring ASME codes section VIII, division-I, UG 34, t = d

Where, C = factor considering the method of attachment (0.20 for fillet welding).

d = diameter of vessel

P = internal pressure

S = Allowable stress

E = efficiency (summation of ligament and joint efficiency).

For given material, i.e.SA516GR70, allowable stress = S = 20.0ksi = 137.895 N/mm<sup>2</sup>.

**Volume of tubesheet (Tv),**

$Tv = (\pi/4)d^2 Tt$

Where, Tt = tubesheet thickness

Tv = total volume of the tubesheet

TL = tube length.

$Tv = (\pi/4) (4000)^2 Tt$

Considering, Tt = 1mm

Tv = 12566.37 103mm<sup>3</sup>.

Reducing 2.5% space for welding, i.e. taking diameter = 3900 mm.

$Tv = (\pi/4) (3900)^2 Tt$

**Volume of tube (Tv),**

Now tube diameter = 0.14 m = 140mm

Considering length of the tube = length of tube sheet,

Tubesheet volume =  $\frac{\pi}{4} T_D^2 \times T_L$  .....(TL = Tt)

Tube volume =  $\frac{\pi}{4} (140)^2 \times 1$

Tube volume = 15393.804 mm<sup>3</sup>.

**Calculation for no. of holes on tubesheet,**

Volume of holes = 15393.804 n

Residual volume = tubesheet volume - tube volume

TR = TV - TT

But TR/TV = 0.3



$$i.e. 0.3 = 1 - \frac{Tube\ volume}{Tube\ sheet\ volume} = \frac{15393.804 \times n}{11945.906 \times 10^3}$$

n = 543.214 544 holes.

Total pitch = total diameter - (2.5% diameter) - diameter of hole = Total pitch = 3900 - 140 = 3760mm.

for locating the holes,

Considering pitch as 1.1d, we get,

$$Pitch = 1.1 \times 140 = 154mm.$$

$$i.e. 2b = 154mm$$

$$b = 77mm$$

$$a = b (\tan 60)$$

$$a = 77 (\tan 60)$$

$$a = 133.3679mm.$$

Number of holes arranged = 509

$$Ligament\ efficiency, \eta = \frac{D - nd_h}{D} = \frac{4000 - (24 \times 140)}{4000}$$

$$\eta = 0.16$$

$$Now, thickness\ of\ tubesheet, \sqrt{\frac{0.2 \times 0.14}{137.895 \times 0.16}}$$

$$t = 4000$$

t = 142.49 150mm (minimum to be taken for tubesheet design as per ASME code).

#### 4. EXPERIMENTAL ANALYSIS

##### 4.1 FEA Analysis

Filter sheet bending failure usually follows a path from the center of filter holes pattern to outside surface of filter sheet. Fractures are usually asymmetric and it is often possible to decide whether the bending loads leading to fracture are the results of gas loads. High gas loads induce tensile stresses in the filter sheets.

In the project four different cases of loadings on tubesheet has been considered, to analyze the effects of cyclic loadings on tubesheet as follows, CAD Model of Tubesheet using CAD Modeler. Import this model in ANSYS workbench for Meshing. Mesh generation has been done using HEX and TET element of ANSYS 14.5. Results has been tabulated for both elements considering different load conditions to evaluate the convergence factor and nature of curve between number of nodes vs deformation & stress value. Thus Fatigue life has been evaluated using transient analysis in ANSYS 14.5 solver. Various testing results have been compared with FEA solution to determine infinite fatigue life behavior.

##### Case I: Self Weight and Gravity Load (TET element)

No. of Nodes	Element Size	Max Deformation (mm)	Max Stress (Mpa)
110850	95	0.77228	38.015
149744	64	0.80331	38.231
222416	54.5	0.81815	38.352
250544	50	0.82115	38.361
298837	37.5	0.82449	38.36

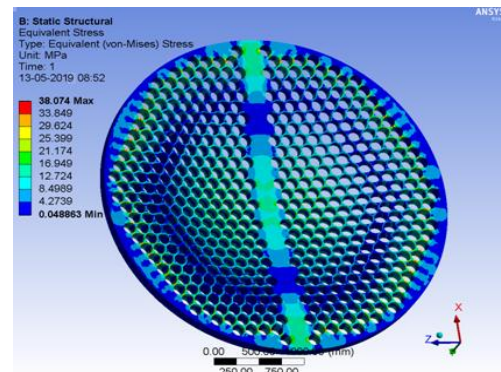


Figure4: Maximum stress in MPa (meshing with 2.5L nodes)

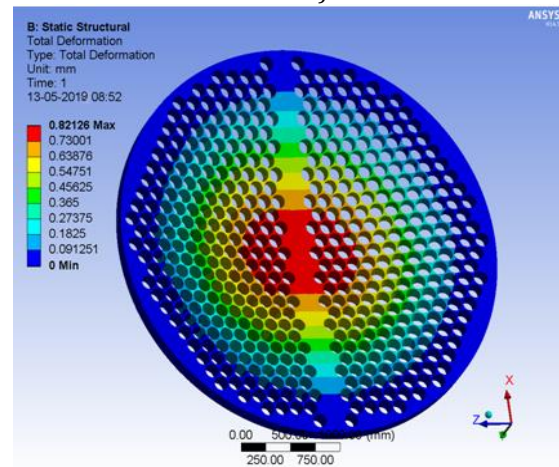


Figure 5: Maximum Deformation in MPa (with 2.5L nodes)

##### Case II: Gravity with Design Loads in opposite direction of gravity (TET element)

No. of Nodes	Element Size	Max Deformation (mm)	Max Stress (Mpa)
110814	95	0.67284	34.065
150019	64	0.70022	34.037
222053	54.5	0.71235	35.264
250225	50	0.71512	35.013
297126	37.5	0.71817	35.94
355759	35	0.71837	35.148

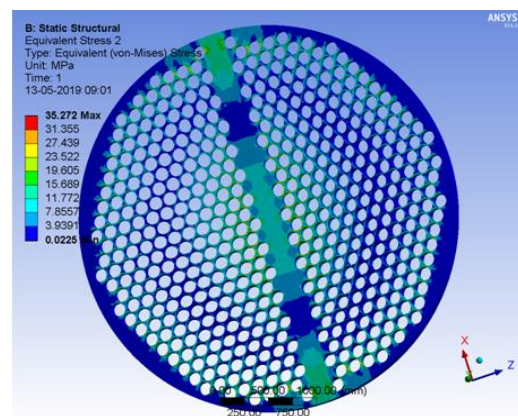


Figure 6: Maximum stress in MPa (meshing with 2.5L nodes)

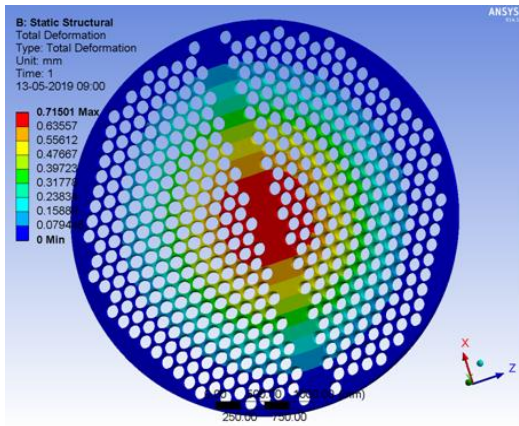


Figure 7: Maximum Deformation in MPa (meshing with 2.5L nodes)

**Case III: Gravity with Back Pressure in the direction of gravity (TET element)**

No. of Nodes	Element Size	Max Deformation (mm)	Max Stress (Mpa)
110814	95	1.9762	97.342
150019	64	2.0559	96.735
222053	54.5	2.029	97.457
250225	50	2.1	99.829
297126	37.5	2.1083	98.742
355759	35	2.1091	98.327

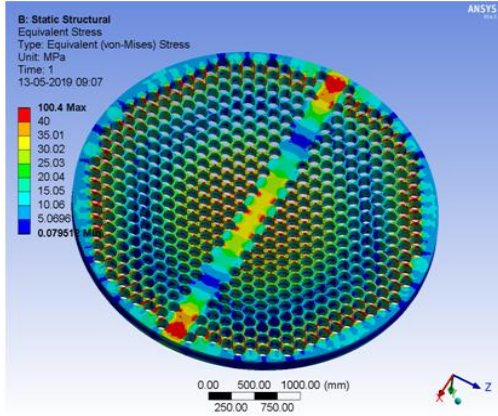


Figure8: Maximum stress in MPa (meshing with 2.5L nodes)

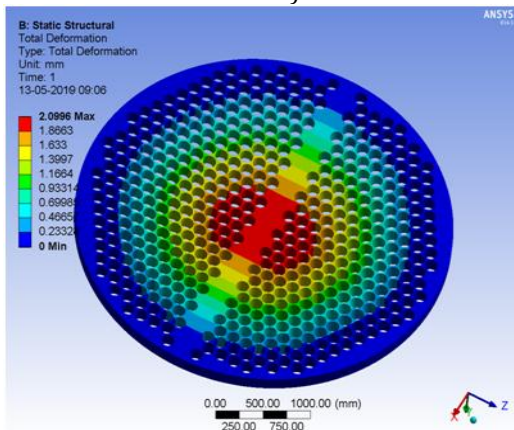


Figure 9: Maximum deformation in MPa (with 2.5L nodes)

**Case IV: Positive and Negative Pressure both at a Time (TET element)**

No. of Nodes	Element Size	Max Deformation (mm)	Max Stress (Mpa)
110853	95	0.9539	58.766
149744	64	0.99743	60.717
222416	54.5	1.0172	61.575
250544	50	1.0212	62.146
298837	37.5	1.0255	62.056
355381	35	1.0256	62.101

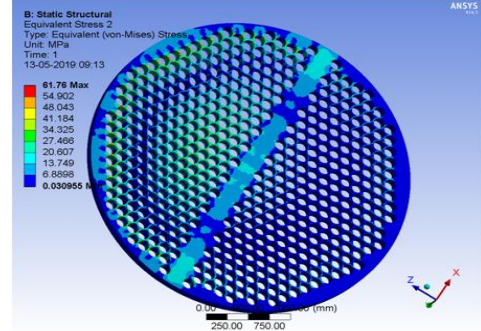


Figure 10: Maximum stress in MPa (with 2.5L nodes)

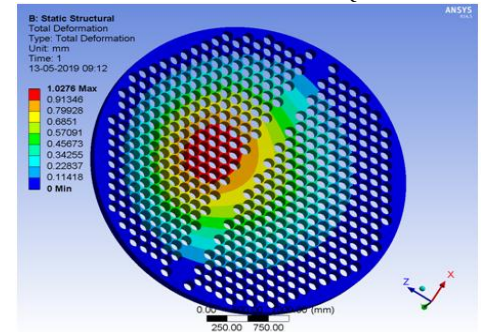


Figure 11: Maximum deformation in MPa (2.5L nodes)

Similar results were obtained for the same case (1 to 4) with "Hex" element for comparative analysis.

**4.2 Transient Analysis**

**CASE I: (Without gravity)**

Time	Wmax	Max Stress	Time	Wmax	Max Stress
0.2	1.15E-02	1.1286	6.2	1.32E-02	1.2333
0.4	2.31E-02	2.2638	6.4	2.17E-02	2.0087
0.6	3.34E-02	3.2746	6.6	3.52E-02	3.2843
0.8	4.50E-02	4.4112	6.8	4.44E-02	4.13
1	5.64E-02	5.5351	7	5.84E-02	5.4384
1.2	6.80E-02	6.6711	7.2	6.80E-02	6.3314
1.4	7.95E-02	7.7958	7.4	8.15E-02	7.5926
1.6	9.11E-02	8.9308	7.6	9.17E-02	8.5312
1.8	0.10254	10.056	7.8	0.10471	9.7498
2	0.1141	11.19	8	0.11524	10.728
2.2	0.12559	12.317	8.2	0.12793	11.911
2.4	0.13715	13.45	8.4	0.13878	12.92
2.6	0.14864	14.577	8.6	0.15119	14.076
2.8	0.16019	15.709	8.8	0.16228	15.11
3	0.17169	16.837	9	0.17447	16.244
3.2	0.18323	17.968	9.2	0.18576	17.296
3.4	0.19474	19.097	9.4	0.19779	18.416
3.6	0.20628	20.228	9.6	0.20921	19.48



3.8	0.21779	21.357	9.8	0.22112	20.589
4	0.22932	22.487	10	0.23264	21.662
4.2	0.24084	23.616	10.2	0.24448	22.764
4.4	0.25237	24.746	10.4	0.25606	23.843
4.6	0.26389	25.875	10.6	0.26784	24.94
4.8	0.27542	27.005	10.8	0.27947	26.024
5	0.28694	28.134	11	0.29121	27.118
5.2	4.91E-04	4.38E-	11.2	4.98E-04	4.18E-
5.4	1.27E-03	0.1135	11.4	1.32E-03	0.11098
5.6	1.74E-03	0.15567	11.6	1.82E-03	0.15286
5.8	2.40E-03	0.21472	11.8	2.51E-03	0.21115
6	2.56E-03	0.2296	12	2.68E-03	0.22592

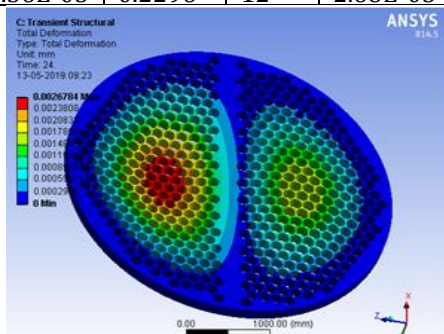


Figure 12: Maximum deformation in mm(Transient)

**CASE II: Considering Positive and Negative Pressure both at a Time (HEX Element)**

Time	Deforn	Stress	Time	Deforn	Stres s
0.2	0.8152	43.661	6.2	0.82089	43.108
0.4	0.8338	45.269	6.4	0.82521	43.789
0.6	0.8169	45.389	6.6	0.83221	45.082
0.8	0.8510	47.759	6.8	0.83748	45.906
1	0.8269	47.556	7	0.84438	47.155
1.2	0.8629	50.014	7.2	0.84982	48.025
1.4	0.8411	49.885	7.4	0.85773	49.229
1.6	0.8746	52.164	7.6	0.86535	50.141
1.8	0.8606	52.276	7.8	0.87481	51.306
2	0.8885	54.284	8	0.88272	52.254
2.2	0.8807	54.672	8.2	0.89195	53.386
2.4	0.9026	56.414	8.4	0.90006	54.363
2.6	0.9003	57.048	8.6	0.90912	55.47
2.8	0.9174	58.57	8.8	0.91754	56.468
3	0.9196	59.396	9	0.9267	57.557
3.2	0.9332	60.754	9.2	0.93527	58.571
3.4	0.9384	61.717	9.4	0.94432	59.646
3.6	0.9496	62.963	9.6	0.95297	60.672
3.8	0.9567	64.015	9.8	0.96196	61.737
4	0.9664	65.192	10	0.97093	62.77
4.2	0.9750	66.296	10.2	0.98036	63.869
4.4	0.9844	67.434	10.4	0.98997	64.949
4.6	0.9938	68.565	10.6	1	66.046
4.8	1.0035	69.685	10.8	1.0101	67.13
5	1.014	70.828	11	1.0206	68.223
5.2	0.8142	42.737	11.2	0.81481	42.725
5.4	0.8149	42.699	11.4	0.81379	42.784
5.6	0.8140	42.842	11.6	0.81555	42.709
5.8	0.8150	42.675	11.8	0.81347	42.836
6	0.8141	42.874	12	0.81574	42.704

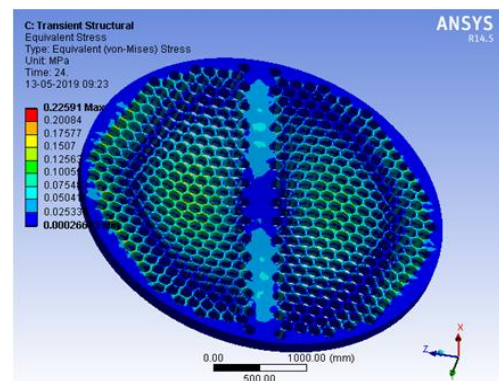


Figure 13: Maximum stress in MPa (Transient)

**4.3 Experimental validation**

- 1) All new product equipments were be tested at 2.5 times the operating pressure using Hydro test.
- 2) The Hydro test has slow built up of pressure, from base pressure to test pressure over a period of 120 min.
- 3) The equipment is maintained at test pressure of 30 min.
- 4) The pressure gradually reduced to base pressure within a period of 45 min.
- 5) After test, all components subjected to NDT as below,
  - a) No surface irregularities must be present.
  - b) Pre Dyed components should have no loss of dye due to leakage.
  - c) Ultra Sonic Testing – Post Test, internal damage shall get amplified if any, and shall be recorded in an Ultra Sonic Test.
- 6) The test performance of the assembly should be completely elastic; this shall be verified by checking the dimensions of product for any permanent yield.

**Hydro Test Condition**

Working fluid : Water with Anti Scaling Additives  
 Test Pressure : 2.5 x 0.07 MPa  
 Leak Inspection : Sensors (LDR) on the top side of Filter assembly.  
 Method : Visual Inspection on top side after completion of test.  
 Remark : Simultaneous testing of all 7 chambers was done. Filter holes were plugged with caps of SA 204.

**Test Execution Details**

- Begin Time : 09.00 hrs
- Base Pressure : 0 MPa (Empty vessel)
- Peak Pressure Time : 11.00 hrs
- Peak Pressure : 0.175 MPa
- Pressure relief begins Time : 11.30 hrs

**Visual Inspection Details**

- No leak observed on Top Side of Assembly
- No visible damage observed after test.
- Plug Adhesion intact after test.

**Auditors Remarks:**

- Code requirements have been met by the analysis.
- The Mesh is satisfactorily fine enough to generate accurate results with considering boundary conditions.



- The maximum Stress in Filter sheet is 32 MPa, however nominal value if calculated is much lower, it satisfy FOS is 5.
- Gasket plate shows peak pressure of 34 MPa. However it is observed to significant stress raiser due to vicinity of contact and relatively less thickness of the plate compared to the other components.
- Material Non Linearity may not be modeled in future analysis as it will have negligible effect on accuracy and unnecessary increases solution time.
- FEA processing has been done in line with requirements of SA 516 GR70, FEA and the component maintains a FOS greater than 5 for the current boundary conditions.

## 5. CONCLUSION AND FUTURE SCOPE

### 5.1 Conclusions

- The filter tube sheet is analyzed for proposed load cycle of four stages compared to conventional and found satisfactory results with FEA and transient analysis to reduce fatigue.
- Theoretical approach of studying possible causes and remedial measure of fouling on tube sheet surface conclude that fouling can be reducing by design modification and implementing the mechanism by increasing the velocity of flue gases.
- Modified design calculations shows acceptable effect of variation of parameters on the performance of the system.
- Analysis results are reliable as seen in Mesh Sensitivity convergence and actual Testing.
- Concerned with FEA analysis more accurate results are achieved using HEX element compared to TET element with fine meshing but increased time.
- FEA Validation shows we can increase efficiency of Filter sheet by increasing number of tubes and maintaining Factor of Safety 5, to benchmark the normal stresses during operation.
- Transient analysis done for predicating the fatigue life shows satisfactory results.
- Transient analysis illustrates the scope for enhancement of infinite fatigue life of the tubesheet which will increase the overall efficiency.

### 5.2 Future Scope

- Further analysis can be done for different components of the pressure vessel such as shell, flange, support etc for evaluating the results to improve efficiency and life of the pressure vessel.
- Similar transient and dynamic analysis can be performed for thickness optimization of tubes as well as tubesheet.
- Design modification and its FEA analysis can be performed for different patterns of tubesheet hole and insertion in between the tube pathways to support the tubes with different materials, distances and thickness.

- Further Transient analysis can be performed for velocity and pressure calculations of flowing fluid effect on pressure vessel components using CFD analysis, so as to reduce time for fouling by the suit particles and other fouling materials.

## ACKNOWLEDGEMENT

It is indeed a great pleasure and moment of immense satisfaction for me to present a seminar report on **"Design and Analysis of Pressure Vessel Filter Tube Sheet against Fouling and Fatigue"** amongst a wide panorama that provided us inspiring guidance and encouragement, I take the opportunity to thanks to thanks those who gave us their indebted assistance. I wish to extend my cordial gratitude with profound thanks to our internal guide **Prof. R. K. Nanwatkar and Prof. S. M. Jadhav**. It was their inspiration and encouragement which helped me in completing my work. My sincere thanks and deep gratitude to Head of Department, **Prof. D. H. Burande** and other faculty member; but also to all those individuals involved both directly and indirectly for their help in all aspect of the project.

At last but not least I express my sincere thanks to the Institute's Principal **Dr. S. D. Markande**, for providing us infrastructure and technical environment.

## REFERENCES

- [1] "Design of Perforated Plates" W.J. O'Donnell, B.F. Langer; Journal of Engineering for Industry; Trans. ASME; Volume 84 (August 1962); Paper no.61-WA-115.
- [2] "A finite element Benchmark for the Dynamic Analysis of Perforated Plates with a Square Penetration Pattern", D.L. Kaap, M.A. Sprague, R.L. Engelstad; Fusion Technology Institute University of Wisconsin; UWFDM-1034 May 1997.
- [3] "Comparisen and Design and Analysis of Tubesheet Thickness by using UHX code of ASME and TEMA standerds", Kalepesh D. Shirode, Dr. S.B. Rane, Mr. Yashawant Naik international journal of mechanical engineering and technology (IJMET), ISSN 0976-6359, volume-4, issue-4, july-august 2013, pp 105-117.
- [4] "Strength Analysis of Tube to Tubesheet Joint in Shell and Tube Heat Exchanger" Kotcherla Sriharsha, Venkata Ramesh Mamilla and M.V. Mallikarjun in International Journal of Science, Engineering and Technology Research (IJSETR), Volume 1, Issue 4, October 2012, ISSN: 2278-7798.
- [5] "Finite Element Analysis of a Tubesheet with considering effective geometric properties through design methodology validated by Experiment", Ravivarma. R, Azhagiri. Pon, International Journal of Computational Engineering Research (IJCER), ISSN (e):2250-3005, volume-4, Issue-4, April 2014.
- [6] "An Approach to Finite element Analysis of Boiler Tubesheet" R.D. Patil, Dr. Bimlesh Kumar, American Journal Of Engineering Research (AJER), e-ISSN:2320-

- 0847, p-ISSN:2320-0936,Volume-2, Issue-8, PP-8-11.
- [7] "Thickness and Shape Optimization of Filter" Naik, Shweta, Global Journal of Researches in Engineering; Mechanical and Mechanics Engineering; Volume-13; Issue-1;Version-1.0;Year-2013.
- [8] "ASME Section III Stress Analysis of a Heat Exchanger Tubesheet with a Misdrilled Hole and Irregular or thin ligaments" Dr. Enrique Gomez, Mr. Roberto Ruiz, Mr. Robert M. (CON) Wilson, proceedings of the ASME 2013 pressure vessels and piping conference PVP 2013 July 14-18, 2013 paris, France.
- [9] "Analysis of the Tubesheet Cracking in Slurry Oil Steam Generators" L.K. Zhu, L.J. Qiao, X.Y. Li, B.Z. Xu, W. Pan, L. Wang, Alex A. Volinsky; ELSEVIER science directory journal, engineering failure analysis 34(2013) 379-386.
- [10] "3-D finite element analysis of roller-expanded heat exchanger tubes in over-enlarged tubesheet holes" N. Merah, A. Al-Aboodi, A. N. Shuaib, Y. Al-Nassar in article; Appl Petrochem Res (2012) 1:45-52; DOI 10.1007/s13203-011-0005-z.
- [11] "Stress Analysis of Tubesheet in waste Heat Boiler" Minshan Liu, Qiwu Dong, Xingu, journal of pressure equipment and systems 4(2006) 48-51; Thermal Energy Engineering Research Centre of Zhengzhou University, Zhengzhou 450002, China,
- [12] "Optimization of Advanced filter system" R. A. Newby, G. J. Bruck, M. A. Alvin, T. E. Lippert, Westinghouse Science & Technology Centre; Worked Under Contract Number DE-AC26-97FT3300703 August 20, 1997 - April 1998.
- [13] "Advance Mechanics of Materials" Arthur P. Boresi, Richard J. Schmidt, John Wiley & sons, Inc; sixth edition.
- [14] "Pressure Vessel Design Manual" Dennis Moss, ELSEVIER publications, third edition.
- [15] "Pressure Vessel Design" Guides and Procedures, P.V. Engineering.
- [16] "CASTI Guidebook Series - Vol. 4 to ASME Section VIII Div. 1 for Pressure Vessels" Bruce E. Ball, Will J. Carter.



**Prof. Sainand M. Jadhav**, Faculty of Department of Mechanical Engineering, of STES's NBSSOE, Ambegaon, Pune. His area of specialization is CAD /CAM and research area is CAD/CAM, Mechatronics, Vibration.

## BIOGRAPHIES



**Prof. Vaibhav Sapate**, PG Student, Design Engineering of NBSSOE, Ambegaon, Pune and Ex-Faculty of Department of Mechanical Engineering, of Sou. Venutai Chavan Polytechnic college, Vadgon.



**Prof. Ravikant K. Nanwatkar**, Faculty of Department of Mechanical Engineering, of STES's NBSSOE, Ambegaon, Pune. His area of specialization is CAD/CAM and research area is CAD/CAM, Design, Mechanical Vibration, Material Science and Metrology.

# DESIGN FABRICATION OF E-BICYCLE AND COMPARATIVE ANALYSIS OF LEAD ACID BATTERY AND LITHIUM ION BATTERY

**ADITYA MAHAJAN, SAYALI ADHAV, ANKIT ANVEKAR**

BE Student, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Pune

**RAVIKANT NANWATKAR**

Assistant professor, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Pune

**Abstract-** As the worldwide population is growing day by day and there is increasing demand for the product from the manufacturing industry a simple, reliable, eco-friendly, safety, and less costly product. One of them is electric vehicles. One type of such an electric vehicle is the electric e-Bicycle (e-cycle). E-cycle typically incorporates a battery, which can be charged at an ordinary domestic power socket, linked to an electric motor in the bicycle transmission system. Increase in fuel price of Petrol bike along with the consideration of the environmental factors uses a bicycle over a motor vehicle for short distance traveling. The rider has the power to controls the output power from motor i.e. speed using a handlebar mounted throttle and controller. . The main aim of this paper is to present the idea of harnessing the various energy and use it in today's existence of human life .Now-a-days there are so many vehicles on road, which consumes more fuel and also hazards our environment. It is our responsibility to reduce the consumption of fuel and its hazardous emission products. Taking this into consideration it is our small step towards reducing the use of more fuel consuming vehicles and attract the eye of people towards its alternatives i.e. Electric bicycle. So we intend to design a cycle which would run on an alternative source and also reducing human efforts called as Battery Operated Cycle. In this paper we design an alternative mode of transport for betterment of social and environment.

**Keywords:** Cycle, Electric cycle, Battery, Eco-friendly, transportation, Pollution, etc.

## 1. INTRODUCTION

As worldwide population is growing day by day and there is increase in manufacturing and using of fuel powered. This vehicle require fossil fuel to run and it a limited source of energy which will be over after some period and to cop up with this need, the revolution for the eco-friendly cycles were the most depended modes of transportation, along with this the consideration of the increase in fuel price and the environmental factors we must admit that it is far more better to use a cycle over a motor vehicle for short distance travelling. Imagine how useful would the cycle be if even the small effort applied by man for riding on rough terrain. This project is based on combination of the standard geared cycle with an electric power motor. The system is modified in such a way that the rider can make choice of which mode he prefers i.e. he can either choose the cycle to be driven completely with the electric motor or he can choose it to be driven manually by himself. The idea of mounting the motor and its support assembly onto a geared cycle was to reduce the effort to-be applied for extra little weight that the rider will have to take along with the cycle. The unit has been designed in such a way that people of any age group can depend on it. Our idea of Implementation of the project was mainly biased towards providing inter college transportation. E-Bicycle Typically incorporates a battery, which can be charged at an ordinary domestic power socket, linked to an electric motor in the Bicycle transmission system. The rider have the power to controls the output power from motor i.e. speed using a handlebar mounted throttle and controller. The term 'e-bike' is generic and includes a combination of different electrically powered two-wheelers some of which function by simply turning a throttle. This Bicycle is designed and made in very less cost as compared to original cost, so any

one can afford this Bicycle. As we know that due fuel powered vehicles, the emission of toxic gases is increasing day by day, due to this 4.3 million people

### 1.1 Background

Global warming and depletion of nonrenewable resources are becoming major problems in the current scenario. People try to move towards "clean" energies. In fact, the most important invention of the last century was the invention of the petrol and diesel engine. The transportation sector has been revolutionized every bit. Speed has converted days into hours, hours into minutes and seconds. Passenger comfort and "less strain on human muscles" are guiding forces behind it. But this rapid modernization in the transportation sector guzzles a lot of fuel. Increased level of pollution and global warming are demerits of excessive usage of petrol and diesel vehicles. To overcome these problems scientists have come up with a concept of e-vehicles (i.e.) electric vehicles. The greatest advantage of e-vehicles is that they do not use fuels such as diesel and petrol and hence do not emit fuming exhausts (these exhausts are very detrimental to health). Electric Bicycles (also known as e-bikes) are the most important vehicles under the category of electric vehicles. These are very much user-friendly for commuting within city limits. These e-bikes are basically simple bicycles fitted with an electric motor which augments its speed. Worldwide there are many types of electric bicycles ranging from the ones which have a small motor which assists in easy pedaling (less exertion) to the ones having more powerful motors which resemble very closely to mopeds. However, all-electric bicycles have the ability to be pedaled by the rider in case of battery discharge or any other fault in the motor. The electric bicycle is an electrical-assisted device that is designed to deliver the electromagnetic momentums to a present bicycle therefore relieving the user of producing the energy essential to run the bicycle. It is provided with the dynamo to generate electric power from rotating wheels.

### 1.2 Motivations

The motivating factor is to identify the need of finding and modifying E-Bike is to overcome the issue of the pollution because of vehicles in metro towns & urban zones is swelling uninterruptedly. Considering the all class of society it is not reasonable for all to purchase (scooters, mopeds or motorcycles). There is also provision of solar panels to generate more electric power. The single biggest advantage of electric bicycle is that it is cost operative as it mainly only entails building cost as running cost would only require the charging of the battery. The currently existing electric scooters are far more costly and due to budgetary constraints a middle class person cannot afford such a locomotive at his place. Along with the development of technologies the theory must be also implemented to design and manufacture a product that can be sold off at a greater frequency, which has a very low production cost and one that is of good quality. In order to implement all the above ideas, we planned to make the design and product in such a manner that it can be competed with the existing "e-Bikes" in the market. The basic idea is to attach a motor to the cycle for its motion. A motor that is powered by a battery and that can be switched on during difficult terrains and switch off and pedal to get the battery re-charged during motion in a flat terrain. The fig no 1.shows the electric bicycle available in the market

### 1.3 Problem statement of this paper

The world is facing with big challenges including depletion of fossil fuels and global warming caused by exhaust emissions from conventional vehicles fuelled with gasoline or diesel. So, to overcome these challenges we are going to manufacture electric bicycle.

### 1.3 Objective of this paper

- 1 To reduce the human effort.
- 2 To increase the human comfort and Easy maintenance
- 3 To overcome the fossil fuel challenges.
- 4 To reduce the pollution.
- 5 To provide better health benefits as the bicycle can be operated manually.
- 6 To provide easy charging of the battery.



## 2. LITERATURE REVIEW

### 2.1 Research Gap

The Bicycle, in its present upright form, called a “Safety Bicycle” and introduced by the Rover model in 1885, is a relatively cheap method of extending the range, increasing the speed, and improving the energy efficiency of human powered transport. It can coast down hills, roll easily along the flat, and make use of gearing to tackle steep hills. Many Bicycle alternatives exist, ranging from recumbent models to chunky off-road machines; however the “safety Bicycle” shape remains most common. Electric Bicycles, with more than a century of commercial history (the first patents for electric Bicycles were granted in the 1890s), have long been available, and found adopted in small numbers in many countries. Their relative lack of popularity until recently may be attributed to technological or economic factors, however the fact of their existence means that they are already covered by legislation in most countries. In terms of personal electro-mobility alternatives, there are a plethora of amazing inventions ranging from the Segway, the Yike Bike, Ryno, various electric scooters, skateboards, power skates, and electric quad bikes and so on. Ignoring the fossil-fuelled variants, recent alternatives have been released which are powered by compressed air, flywheel, fuel cell and probably other unusual power sources. However the vast majority of experimental machines use a combination of electrical motor and battery. Battery solutions tend to be limited to the robust but weighty lead-acid cells in cheaper or older systems, through surprisingly few NiMH variants, to Lithium Ion (predominantly LiFePO<sub>4</sub> or LiMn<sub>2</sub>O<sub>4</sub> based cells) in more modern and expensive variants. The Segway is one of the most imaginative and innovative personal mobility solutions to have been developed in recent years, with a loyal following of users, and several niche application areas. However the Segway has not attracted widespread adoption on campus to date. General Motors have used the Segway as the foundation for their P.U.M.A. (Personal Urban Mobility & Accessibility) project which effectively adds car-like features to the Segway; a seat, roof and steering wheel. Whilst this is exciting and extremely attractive from a technological point of view, it leads to a very expensive transport solution, requires significant thoroughfare space, and may require licensing for use in certain locations (for example, even the basic Segway is not currently legal for use in public areas within Singapore). Electric quad bikes are likewise expensive, bulky to park and have few advantages over an electric Bicycle. In fact, all of the devices mentioned are expensive, certainly significantly more so than a standard Bicycle, and most work on the premise of simply adding a motive power source to a Bicycle- type system (or scooter/skateboard/skates). However it is by no means certain that lack of such power assistance is the main reason why Bicycles may not have been more widely adopted in many campus environments. Thus, adding motive power alone may not lead to the more widespread adoption of electric Bicycle-type transport.

### 2.2 Review of Literature

#### 1. The German Naturalistic Cycling Study – Comparing cycling speed of riders of different e-bikes and conventional bicycles [1]

Objective of this paper was to explore the acceleration and speed of orthodox and electrically powered bicycles under truthful statuses. Authors distinguished between electric bicycles which deliver provision up to 45 km/h (as known as S-pedelects) and 25 km/h (speed of pedelecs). Additionally, as speed limits of 30 km/h might influence especially on the execution of speedier cyclists (e.g. Spedelec rider), the potential mean speed might be even advanced under various situations. Authors also found noteworthy variances in numerous measures between pedelecs and orthodox bicycles, although less noticeable. This might be interpreted as a symptom that, when accelerating from standstill, the assistance provided from motor used by the pedelec riders to reach their preferred speed easier, not earlier. Authors also given the variance in the user population, it is not irrational to admit that at present, e-bikes do not cause any revolution in cycling mean speed at all. The growth of e-bikes in younger cyclists is still there. It has even been embraced that the e-bicycle is going from being a "recovery vehicle" to a stylish frill. By this authors gave the vision that this will change two wheeled activity and street security in the center and long stretch.

#### 2. Urban Electric Bike [2]

In this paper, authors considered importance of easy vehicle mobility and compactness. In which they revealed that folding is the strategic feature of the e-bike which would not have been probable devoid of the folding arms. For the ease of sliding of the arms a bolt is provided. In order to provide rigidity to the bike a guide has been provided on the main frame



About other components, both the plates are welded on front arm of the bike and a constraint is established on the back arm to confine the angle between the two arms to  $50^\circ$ . Furthermore, in paper the specifications and functionalities regarding components of e-bike were discussed. At initially, fundamental driving component about Hub Motor that Regular electric motors utilize a mechanical gadget called a commutator and two contacts named carbon brushes to switch the electric current periodically and affirm the pivot continues handing over the comparative bearing. Hub motors are characteristically brushless motors (See fig. 4) which replaces the commutator and brushes with planetary gears and an electronic circuit. The Hall Effect Sensors help to locate the position of the permanent magnets and which coils to activate to keep the motor spinning. Then about the accelerator or say throttle, author discussed below working. Working of a Twist throttle is based on the principle of potentiometer which is also called variable resistor. It is used to fluctuate the voltage passing through the throttle. In order to pass more through the throttle, the more twist should be provided as a result less is the resistance. Therefore twist throttle offers the signal to the BLDC hub motor controller to increase or decrease the current passed to the motor.

### 3. Campus Mobility For The Future: The Electric Bicycle [3]

This paper presents the various outcomes and results of the study containing visions into the scheme. Electric bikes, of much sort have been surveyed by and by in a semi-open contract conspire on the Nanyang Technological University campus in Singapore. According to this campus, it is a famous and helpful administration, with a few models of electric bike being exceptionally very much utilized. Riders contemplate the premier of the electric bikes to be both agreeable and engaging while at the same time utilizing it, and extremely suitable for campus travel. Understudies and general society alike view the plan unhesitatingly, and creators have seen a lessening in the quantity of miles driven via auto inside the grounds for the dominant part of clients who are additionally drivers. In this paper, authors have sensibly inspected the utilization of bikes on campus, displaying and investigating review results that endeavor to clarify blocks to bigger acknowledgment of the bike. Authors likewise bolster the general public by giving arrangement that if this information is coordinates with a portion of the qualities of the campus encompassing, it is conceivable to suggest specialized, arranging and reasonable arrangements that together should help the more prominent acknowledgment of bike transport. This is the concentration of the rest of the paper.

### 4. Design And Fabrication Of Dual Chargeable Bicycle[4]

In this paper, authors discussed about the crucial components and its experiments of e- bike, alternator and batteries. First, alternator which is an electromechanical device that transforms mechanical energy to electrical energy in the form of alternating current. The brushes of a DC generator carries a small fraction of the current, which carry the generator's whole output. A set of rectifiers (Diode Bridge) is essential to alter AC to DC. To provide direct current with low ripple, authors used a three-phase winding and the pole pieces of the rotor are shaped (claw-pole) to produce a waveform similar to a square wave as an alternative of a sinusoid. Author used alternator of Yamaha bike which workings are done at high RPM since authors' electric bicycle is restricted to low RPM so they changed the windings of alternator and upsurge e the drive ratio. Hence, it can function at low RPM.

### 5. An Improved & Efficient Electric Bicycle System With The Power Of Real-time Information Sharing[5]

Firstly they are using the sun based board as a hotspot for E-bicycle. In that they utilized the 20 KW sunlight based board and it is associated with the 12 v battery. So the sun powered board is utilized to charge the battery. Here basic concept they applied that the solar energy is converted into electric energy by using photovoltaic effect. The second source of energy is that they are convert the mechanical energy into electrical energy by using dynamo. Dynamo is a electric device which generate the power with the help of commulatur. In this paper they mentioned the procedure of how mechanical energy is converted into electrical energy and it will utilized for run the electrical bike. They connect the dynamo in the front wheel of E-bike. As the wheel of bike is run along the wheel commulatur also rotate and it will generate the power. So the mechanical energy gets converted into electrical energy and it will store in dynamo whenever it will be required, it will supply the energy to E-bike.

## 6. Design Of Electric Bike With Higher Efficiency[6]

From this paper it can be found that they are focused on the improvement of efficiency of E-bike. Generally the speed of E-bike is in the range of 40-45 km/hr at maximum. So there they increase the speed of E-bike and design the aerodynamic shape in such a way that the efficiency of E-bike is improved. For the increasing the speed they are done the comparison of power transmission system. In that they found four power transmission system. Based on Application the out of four any one of them power transmission system is used in E-bike. Generally the chain drive is used for transmitting the power. Along with that there are three different types of motor is also used like Gear hub motors, Crank drive motors and direct drive motors. So after completing experimental study it can be found that due to the specifications like light weight, inexpensive, compact, offering non-slip the chain drive is more efficient as compared to belts or gears.

## 7. Design And Development Of Solar Assisted Bicycle[7]

In this paper, study on alteration of present bicycle in form of solar assisted which is energized by solar energy is carried out. For both city and nation streets that are made of bond, black-top, or mud, this bike is fitting, It is reasonable, unobtrusive in development and can be widely utilized for short separation voyaging especially by school youngsters, understudies, office goers, villagers, postmen and so forth. It is especially reasonable for youthful, matured, disable individuals and provides food the need of financially poor class of society. The best critical component of this bike is that it doesn't expend important petroleum products along these lines sparing crore of outside trades.

## 8. Design, Fabrication And Performance Analysis Of Solar Power Bicycle[8]

In this paper, authors carried the selections of different components of E-bike. Determination of Battery: Two Li-ion Battery storing with 12 V and 12 amp-hour rating are kept in use. The variety of battery relies upon its voltage, ampere and wattage rating and so forth. The whole energy of totally charged battery in two hours is 288 Watt-hours. Choice of Motor: A Brushless D C Motor (BLDC) for 300 Watts control with electronic compensation framework is painstakingly picked. Brushless DC Motors (BLDC) have many favored contrasted with mechanically moved DC motors in light of the fact that BLDC engines have permanent(long enduring) magnet , electronically drove, No twisting on rotors, frictionless operation, not so much commotion but rather more undeviating(uniform) torque..

## 9. Design, Development And Performance Evaluation Of Solar Power Assisted Tricycle[9]

In this paper, the solar powered tricycle as an auxiliary for auto rickshaw is carried out by authors. Authors mentioned key relevant features of the solar power assisted tricycle in this paper.

- a. For higher power, motor of higher capacity can be used.
- b. It works with a reasonable speed with less fatigue to the rider.
- c. Source of power and shade utility by mounting solar panel..
- d. The tricycle is steadier contrasted with a two wheel bike.
- e. The parking place for solar powered vehicle does not involve a shed.
- f. The battery can be charged even while riding the tricycle. This guarantees unremitting vitality contribution to the tricycle with no extra cost.

## 10. A Dynamic Model For The Performance And Environmental Analysis Of An Innovative E-Bike[10]

The authors have directed an ecological investigation of the considered vehicle, especially contrasting the e-bicycle and a thermal moped, as far as ecological effect. This paper spoke to the natural examination of an electrically supported bike under genuine driving circumstances of mimicked speed-time profiles. In think about, trial results of roller test seat estimations completed on a warm moped utilized so as to assemble the apropos emissive information amid genuine driving circumstances. The ecological appraisal was performed considering an examination with the emissive execution of this moped by utilizing kinematic parameters that assign the reenacted driving elements; an unmistakable advantage of e-bicycle likened to thermal mopeds was appeared and figured as far as emanations spared of CO, HC and NOX, which was a general report finding of this paper.

### **11. The Copenhagen Wheel: An Innovative Electric Bicycle System That Harnesses The Power Of Real-Time Information And Crowd Sourcing[11]**

In this paper authors deliberate innovative bicycle wheel concept which is used for comfortable ride of e-bike. The name of that wheel is known as Copenhagen wheel. The Copenhagen wheel is a bike wheel that can be effortlessly retrofitted into any normal bicycle. It look for red center point not just contains engine , batteries and inward apparatus framework yet in addition incorporates ecological and area sensors which are controlled by the batteries in the hagggle information for cycling related versatile application.

### **12. Parametric Finite Element Analysis Of Steel Bicycle Frames: The Influence Of Tube Selection On Frame Stiffness[12]**

Authors presented a parametric Finite Element model of road bicycle frames using beam elements with wavering tube profiles in this paper. In order to observe the impact of tube profiles on lateral stiffness and vertical compliance of the frames, wide range of current frame geometries had been subjected to several in plane and out of plane loading situations. This was postponement of preceding effort which considered the influence of overall frame geometries (tube lengths and angles) on the stiffness characteristics of frames. For a subset range of frame sizes (with seat tube lengths varying from 490-630mm), parameters were utilized to characterize measurements for roundabout tube profile shapes, shifting divider thicknesses related with butted tubes.

### **13. Parametric Finite Element Analysis Of Bicycle Frame Geometries[13]**

This paper has outlined by respective authors which includes a Finite Element model by means of beam elements to signify a customary road bicycle frame. The model simulation carries two standard loading constraints to undergo the vertical compliance and a lateral stiffness characteristic of 82 existing bicycle frames from the bicycle geometry project and compares these characteristics to an improved solution in these circumstances. Maybe obviously littler edges (490mm seat tube) act the most thoughtfully as far as both vertical consistence and horizontal solidness, while the shorter best tube length (525mm) and bigger head tube edge (74.5°) brings about an along the side stiffer edge which relates with discoveries from literature outcomes. The upgraded esteems demonstrate an extensive improvement over the best of the current casings, with a 13% expansion in vertical dislodging and 15% decline in horizontal relocation when identified with the best of the dissected edges. Here general stacking conditions for frame structure and other auxiliary parts (rear dropouts, sections, handlebar, situate tube) are appeared in Figure-9 and 10.

### **14. Numerical Study On Materials And Design Optimization Of A Bicycle Frame[14]**

In this paper the procedure of selecting a material for robust frame structure is approached by authors Author has taken- materials like composites (HT Graphite epoxy and S-Glass Epoxy) and Aluminium Alloy 6061-T6 for Circular and Elliptical cross section. From ANSYS 14.5 simulation results it is determined that composites (HT Graphite epoxy and S-Glass Epoxy) can be used as bicycle frame material due to its better results (stress, strain & displacement) when compared with Aluminium Alloy 6061-T6. Also, for the bicycle frame the Circular cross section is more preferable than Elliptical cross-section because of high strength withstanding ability. Then in the two composite materials (HT Graphite epoxy and S Glass Epoxy) Due to less cost and reasonably high strength S-Glass Epoxy can be preferred when compared to HT Graphite Epoxy Figure-11 and Figure-12 shows the stress, strain values and deformation values for circular cross section frames and elliptical cross section frames respectively.

### **15. Performance Evaluation Of Electric Bicycles[15]**

In this paper authors discuss the configuration and overview of E-bike. In this they have classified the various possible components used to build an e-bike. As per shown In the figure 13, the fundamental design of an electric bicycle drive comprise of a controller that controls control stream the battery to the electric engine. It implies the power provided from electric engine is utilized to run e-bicycle. The power act parallel along the power delivered by rider via pedal on the bike. The specifications regarding E-bike

### 3. DESIGN CALCULATIONS

#### 3.1 Transmission -

The Motor used in the electric bicycle is self-generating motor with power and speed of 350 watt and 2750 rpm respectively. The motor runs on 24 volts and full load current of  $\leq 19.20A$ .

$$P = 2 * 3.14 * 2750 * T/60$$

$$T = 1215 \text{ N.mm}$$

Reduction in chain drive

$$R_{\text{chain}} = 66/11 = 6:1$$

$$\text{Torque at wheel shaft} = T * R_{\text{chain}} = 1215 * 6 = 7291.8 \text{ N.mm}$$

$$\text{Speed at wheel shaft} = 2750/6 = 458.33 \text{ rpm} = 57.0554 \text{ km/hr.}$$

#### 3.2 Shaft design:

$$\sigma_s = 16T_w / (3.14 * D^3)$$

Assuming, diameter of shaft = 10 mm

$$\sigma_s = 37.155 \text{ N/mm}^2$$

Where,  $T_w$  = Torque at wheel shaft

$D$  = Diameter of shaft

$\sigma_s$  = working stress.

Material to be used = 30C8 Plain carbon steel

Material  $\sigma_s = 66.67 \text{ N/mm}^2$  (F.O.S = 3 and  $\sigma_{UT} = 400 \text{ N/mm}^2$ )

Therefore, design of shaft is safe.

Design of Sprocket and Chain for Electric Bike

We know,

$$\text{TRANSMISSION RATIO} = Z_2 / Z_1 = 66/11 = 6$$

For the above transmission ratio number of teeth on pinion and the number of teeth sprocket is in the range of 21 to 10, so we have to select number of teeth on pinion sprocket as 11 teeth.

So,  $Z_1 = 11$  teeth

The outer diameter is decided on the basis of driving chain sprocket number i.e #25 and driven chain sprocket i.e #40.

CALCULATION OF MINIMUM CENTER DISTANCE BETWEEN SPROCKETS

$$D_{c1} = 25.45$$

$$D_{c2} = 274.21 \text{ mm}$$

The minimum centre distance between the two sprocket =  $C' + (80 \text{ to } 150 \text{ mm})$

$$\text{Where } C' = D_{c1} + D_{c2}$$

$$C' = 25.45 + 274.21$$

$$C' = 299.66 \text{ mm}$$

MINIMUM CENTER DISTANCE =  $299.66 + (80 \text{ to } 150 \text{ mm})$  MINIMUM CENTER DISTANCE = 380mm to 450mm.

#### 3.3 Brakes:

Basic input values

Max. Weight of bicycle = 100kg

1. Brake Pedal

$F_{bp}$  = Force output of brake assembly

$F_b$  = Force applied by driver = 3kg

$P_r$  = Pedal ratio.

$$F_{bp} = F_b \times P_r$$

$$30 \times 5 = 150 \text{ N}$$

2. Brake pads

By assumption

$$F_{bp} = F_{clamp}$$

$F_{clamp}$  = clamping force by brake pads to rim

$$F_{clamp} = 150 \text{ N}$$

$F_{friction}$  = frictional force generated by brake pads

$F_{bp}$  = coefficient of friction between brake pad & rotor

$$F_{friction} = F_{clamp} \times F_{bp}$$

$$= 150 \times 0.4 \text{ (dry condition)}$$

$$= 60 \text{ N}$$

$$\text{Friction} = 150 \times 0.1 \text{ (wet condition)}$$

$$= 15 \text{ N}$$

Torque generated by the  
The brake pads at the rim.

$$T_r = F_{friction} \times \text{Radius of rim}$$

$$= F_{friction} \times 0.645$$

$$T_r = 9.675 \text{ Nm}$$

Torque of wheel generated by motor

$$T_w = 0.72918 \text{ Nm}$$

Since,  $T_r > T_w$

The force generated by the rim is more than torque at wheel vehicle decelerate and wheel will lock.

### 3.4 Frame:

According to the ergonomics and the market survey the frame geometry of the bicycle is designed by considering the parameters like riders' height, wheel diameter etc. The frame geometry is as follows:

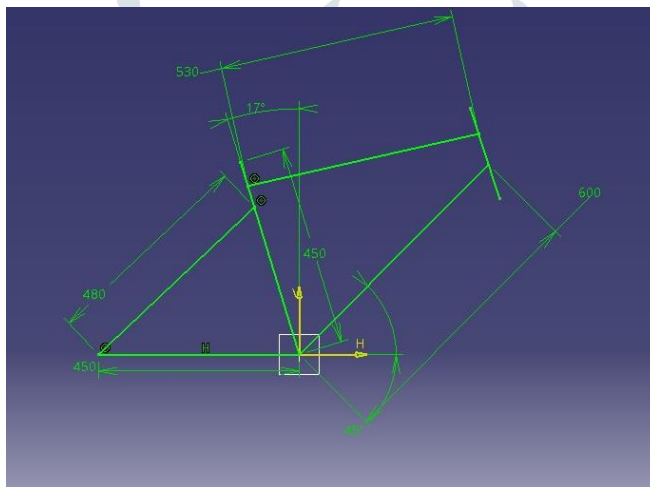


Figure No. 01. Frame Geometry of E- Bicycle-1

The Material for the frame is selected according to the parameters like tensile strength, Elongation, density, hardness, etc.

Table No 1. Properties of material

Material	Yield strength (MPa)	Tensile strength (MPa)	Density (kg/cm <sup>3</sup> )	Hardness (BHN)
Aluminium	240	290	2.7	95
Mild steel	250	345-525	7.85	130

According to the table mentioned above we can conclude that mild steel can be used for manufacturing of



frame. Mild steel has been used from past years because of its properties. Aluminum can also be used for frame in the form of alloy by changing its properties.

#### 4. CONCEPTUAL CAD MODELS

##### 4.1 Cad model of bicycle frame

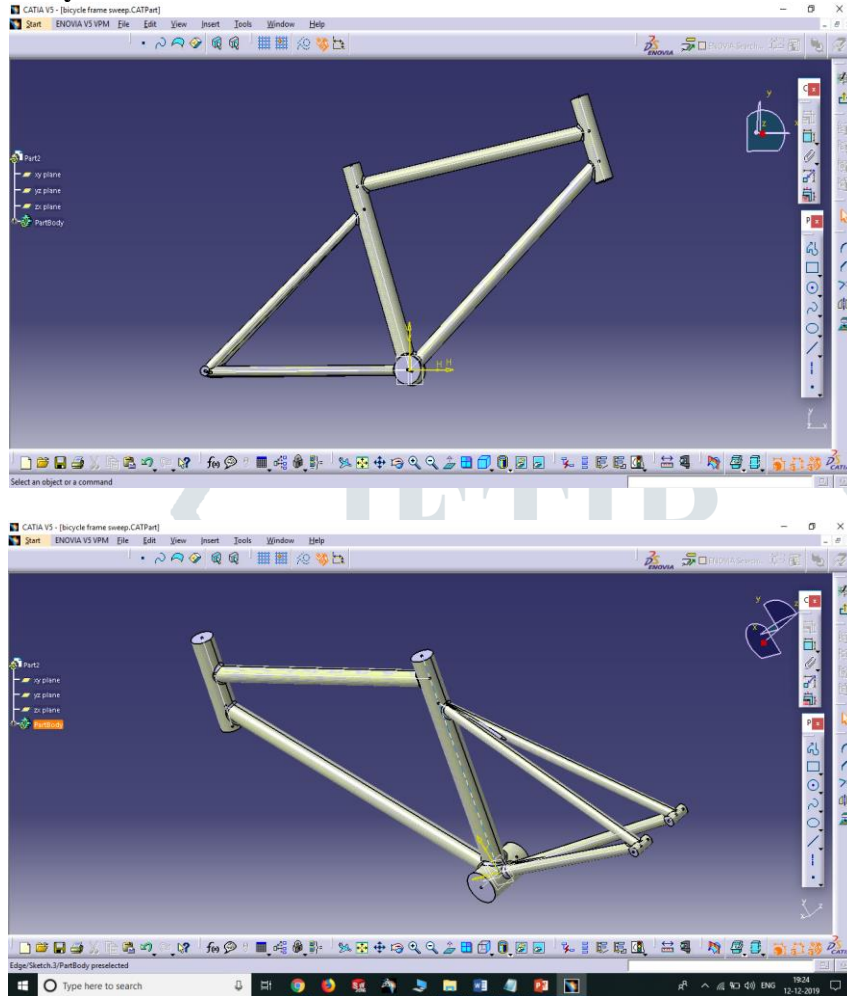


Figure No. 02. Frame Geometry of E- Bicycle-2

All the components of the Bicycle are assembled in such a way that, the Bicycle will not look messy and the weight of components does not affect to the Design of Bicycle. Key port is given in middle of handle bar which controls all the electrical circuits as shown in shows the fully assembled Bicycle which is actually an Electric Bicycle.

##### 4.2 Complete Fabricated Electric Cycle



Figure No. 03 Complete Fabricated Electric Cycle

## 5. COMPARATIVE ANALYSIS OF LITHIUM ION BATTERY AND LEAD ACID BATTERY

### 5.1 INTRODUCTION

#### 5.1.1 LEAD ACID BASICS

Lead acid has been around for over 100 years and will be a market force for the foreseeable future due to its low cost and established manufacturing base. The two types are identical in their internal chemistry. The most significant differences between the two types are the system level design considerations. Flooded lead acid batteries require three things that VRLA don't: upright orientation to prevent electrolyte leakage, ventilated environment to diffuse gases created during cycling, routine maintenance of electrolyte. Due to these differences, the lower cost of flooded lead acid must be balanced against the added complexity and secondary costs.

“Deep cycle” and “shallow cycle” lead acid batteries can be found in both the VRLA and flooded classes. Shallow cycle VRLA batteries are commonly used for automotive start, light, ignition (“SLI”) batteries that must deliver high power pulses for short durations. The stationary power market uses deep cycle since the batteries will often discharge at a low rate over the course of multiple hours.

#### 5.1.2 LITHIUM ION BASICS

The concept of a lithium-ion battery was initially conceived in the 1970's and began to see widespread adoption by the 1990's. All lithium-ion cells are “deep cycle” meaning that they have the ability to be fully charged and discharged. The life of the battery will significantly increase if the depth of each discharge is limited to 80% of the rated capacity.

### 5.2 LIFE CYCLE AND PERFORMANCE

Lithium-ion has significantly higher cycle life than lead acid in deep discharge applications. The disparity is further increased as ambient temperatures increase. The cycle life of each chemistry can be increased by limiting the depth of discharge (DoD), discharge rate, and temperature, but lead acid is generally much more sensitive to each of these factors.

In the figures below, AGM refers to a lead acid battery.

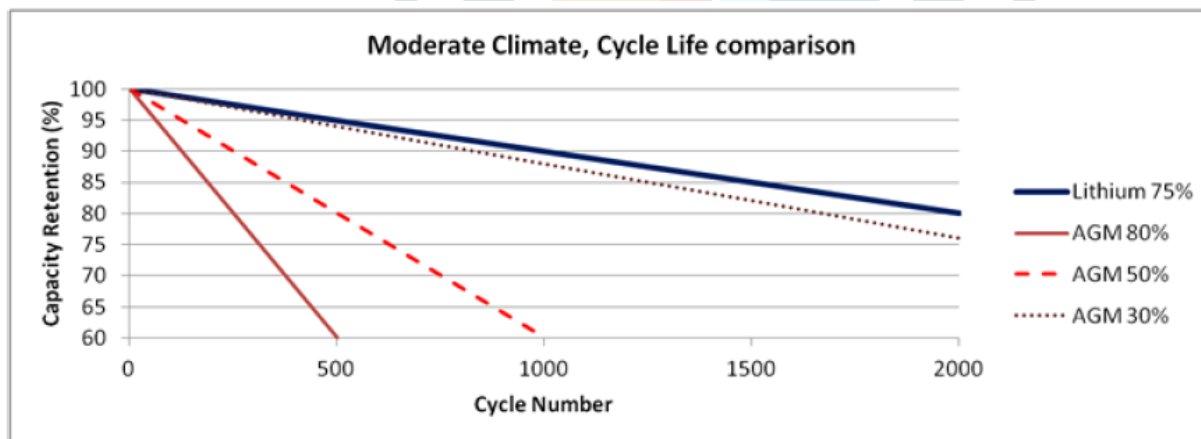


Figure No. 04 Moderate Climate Cycle Life Comparison

In hot climates where the average temperature is 33°C, the disparity between lithium-ion and lead acid is further exacerbated. The cycle life for lead acid (flooded and VRLA) drops to 50% of its moderate climate rating while lithium-ion will remain stable until temperatures routinely exceed 49°C.

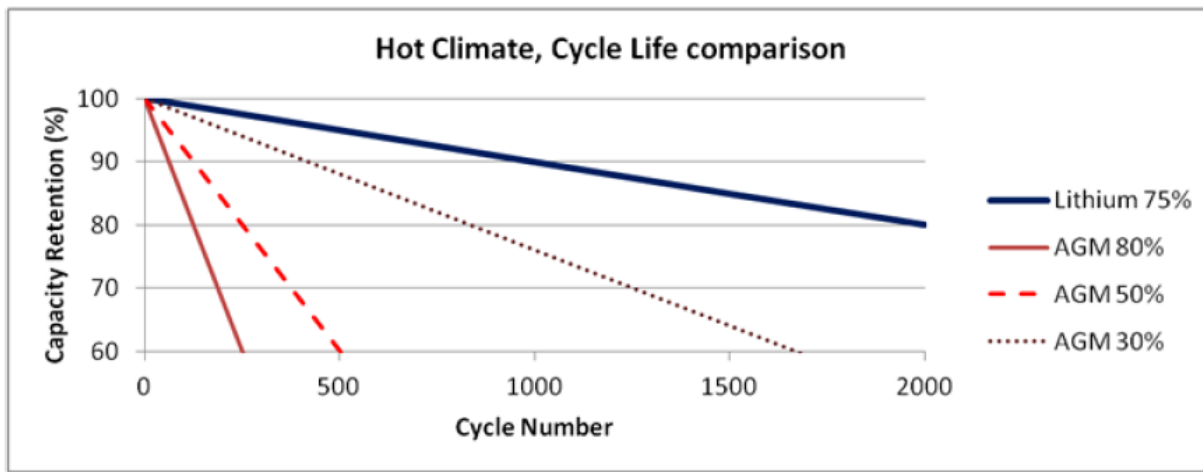


Figure No. 05 Hot Climate Cycle Life Comparison

Analyses indicate that lithium-ion has an 18% higher lifetime cost when compared to lead acid in moderate climates, but is much more cost effective in hot climates. There is a significant area of the world that sees average temperatures high enough to decrease the life of lead acid batteries. A factor not represented in the figure is that the battery systems are often housed in enclosures that see internal temperatures 10°C higher than the air temperature due to solar insolation, which would further decrease the performance of lead acid. The average temperature is also not completely representative of how much time is spent at extreme temperatures where the degradation accelerates in lead acid systems (e.g. one hour spent at 40°C and one hour spent at 20°C has a worse impact on the battery compared to two hours spend at 30°C). Another critical consideration for lead acid is how long the system will take to discharge. The shorter the discharge period, the less capacity is available from the lead acid battery. A 100Ah VRLA battery will only deliver 80Ah if discharged over a four hour period. In contrast, a 100Ah lithium-ion system will achieve over 92Ah even during a 30 minute discharge. As shown in the figure below, this condition makes lithium-ion very well suited for applications where full discharge occurs in less than eight hours.

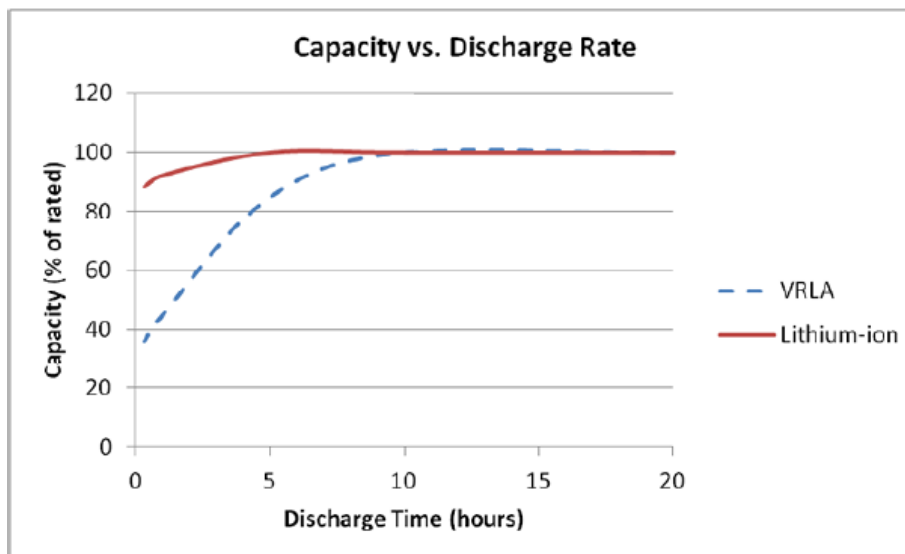


Figure No. 06 Capacity vs. Discharge Rate

### 5.3 ENVIRONMENTAL IMPACT

Lead acid batteries compare poorly to lithium-ion with regards to environmental friendliness. Lead acid batteries require many times more raw material than lithium-ion to achieve the same energy storage, making a much larger impact on the environment during the mining process. The lead processing industry is also very energy intensive, leading to large amounts of pollution. Although lead is highly hazardous to human health, the manufacturing methods and battery packaging make the human risk negligible.

Lithium is not without its own environmental problems. The major components of a lithium-ion cell require the mining of lithium carbonate, copper, aluminium, and iron ore. Lithium mining specifically is resource intensive, but lithium is only a minor portion of the battery cell by mass, so the aluminium and copper environmental impacts are much more significant. The lithium-ion recycling industry is only in its infancy

right now, but the cell materials have shown high ability for recovery and recyclability, so it is expected that lithium-ion recycling rates will rival lead acid.

#### 5.4 SAFETY

Lead acid and lithium-ion cells are both capable of going into “thermal runaway” in which the cell rapidly heats and can emit electrolyte, flames, and dangerous fumes. The likelihood and consequences of an event are higher for lithium-ion as it has a higher amount of energy in a smaller volume. Multiple cell and pack safety precautions are taken to prevent trigger events, such as short circuits and overheating.

**Table No 2. Comparison of batteries and solar panels.**

Sr. No	Parameters	Lithium ion battery	Lead Acid Battery
1	Weight	Light in weight	3 times weight of li-on battery
2	Resilience / discharge	Less vulnerable to high discharge and climate change	Damages through excessive discharge and extreme temperature
3	Life	Excellent	Good
4	Efficiency	High	Low
5	Replacement	6-7 years	1.5-2 years
6	Cost	Very High	Average
7	Power density	125 W/Kg	40 W/kg
8	Usable Energy	80%	50%
9	Voltage per cell	3.2 V	2 V
10	Maintenance	Basic annual Maintenance	Regular Maintenance every 3 months

#### CONCLUSION

With increasing prizes of fuel and pollution alternative choice can be available which is traditional but in new modify version of cycle. In this research paper we are able to design and modify an e-bike which may be the solution to our problems which we are experience now a days like traffic congestion, parking difficulties and pollution from fossil fueled vehicles. We have modify and assembled the devices required the cycle and make the less prize Electric cycle compared to market. It has been noted that the electric bicycle is not only an alternative for transportation, but also a way of practicing daily sports to promote healthy living. After completing the analysis on e-cycle; it is observed that the life of people is very fast so no one can purchase e-cycle. Only the countries with a large number of inhabitants are interested in electric bicycles because they are a sustainable form of mobility, transport, and countries with high environmental awareness. Now the data analyzed related to the electric bicycle shows an increase in scientific and technological interest in this subject because people promoted by the attraction caused by the price, much less than a scooter, and by its speed and lightness in use, in addition to having a simple and inexpensive recharge. Researcher modify an idea to develop an e-bike which is manually operated as well as automatic on electric battery. This paper presents the less costly, light in weight, pedal can be used when power not in use and effectively use of e-cycle. This paper identifies potential barriers of electric bicycle. This project is designed to improve the normal bicycle and make it extra efficient. The electric bicycle is hybrid and so it can run by electrical energy, solar energy, and dynamo and can also be pedalled thereby still retaining the exercise people drive from riding bicycle. As EVs are becoming more widely accepted, consumers will be able to save money, be energy independent, have a lower impact on the environment, pollution, and greenhouse Gases etc. Lithium mining specifically is resource intensive, but lithium is only a minor portion of the battery cell by mass, so the aluminium and copper environmental impacts are much more significant. The lithium-ion recycling industry is only in its infancy right now, but the cell materials have shown high ability for recovery and recyclability, so it is expected that lithium-ion recycling rates will rival lead acid.



## FUTURE SCOPE

Future research and development is needed to continue improving the specific energy and energy density of batteries being used by vehicles, while at the same time reducing the cost of the technology. Infrastructure to support widespread adoption of electric vehicles will also need further development and implementation. Efforts, such as those noted above, can add to alleviating range anxiety for consumers and potentially change overall perceptions of electric vehicles, and as a result, EVs will have better market penetration leading to a dramatic change in the automobile industries.

## REFERENCES

- [1] [1] K. Schleinitz , T. Petzoldt , L. Franke-Bartholdt , J. Krems , T. Gehlert, The German Naturalistic Cycling Study – Comparing cycling speed of riders of different e-bikes and conventional bicycles, ScienceDirect- Ekseveir July- 2015
- [2] Ajinkya Parab, Ankit Kamath, SatwantSingh Rajpurohit, Zeeshan Mulla , Urban Electric Bike , IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 02, 2015 ISSN (online): 2321-0613
- [3] Ian Vince McLoughlin, Komang Narendra, Leong Hai Koh, Quang Huy Nguyen, Bharath Seshadri, Wei Zeng, Chang Yao , Campus Mobility for the Future: The Electric Bicycle , Journal of Transportation Technologies, 2012, 2, 1-12
- [4] R.S Jadoun , Sushil Kumar Choudhary , Design And Fabrication Of Dual Chargeable Bicycle, Innovative Systems Design and Engineering, www.iiste.org ISSN2222-1727 (Paper) ISSN 2222-2871 (Online) Vol.5, No.8, 2014
- [5] Chetan Mahadik , Sumit Mahindrakar , Prof. Jayshree Deka , An Improved & Efficient Electric Bicycle System With The Power Of Real-time Information Sharing, Multidisciplinary Journal of Research in Engineering and Technology, www.mjret.in ,ISSN:2348-6953 , M15-1-2-7-2014
- [6] Rahul Sindhvani , Punj L. Singh , Anjum Badar , Ankur Rathi , Design Of Electric Bike With Higher Efficiency , International Journal of Advance Research and Innovation Volume 2, Issue 1 (2014) 247-251 ISSN 2347 - 3258
- [7] M. Reddi Sankar, T. Pushpaveni, V. Bhanu Prakash Reddy, Design and Development of Solar Assisted Bicycle , International Journal of Scientific and Research Publications, Volume 3, Issue 3, March 2013 ISSN 2250-3153
- [8] Rajendra Beedu, Ankit, Mohmed Asif Shaik, Sushant Jain, Design, Fabrication And Performance Analysis Of Solar Power Bicycle, International Journal of Renewable Energy and Environmental Engineering ISSN 2348-0157, Vol. 02, No. 03, July, 2014
- [9] Rajendra Beedu , Performance Evaluation Of Electric Bicycles, IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308 July-2015
- [10] Carmelina Abagnale, Massimo Cardone , A dynamic model for the performance and environmental analysis of an innovative e-bike, ScienceDirect Energy Procedia 81 ( 2015 ) 618 – 627
- [11] Christine Outram, Carlo Ratti, Assaf Biderman , The Copenhagen Wheel: An Innovative Electric Bicycle System That Harnesses The Power Of Real-Time Information And Crowd Sourcing ScienceDirect Energy Procedia 81 ( 2015 ) 618 – 627
- [12] Derek Covill, Alex Blayden, Daniel Coren , Parametric finite element analysis of steel bicycle frames: the influence of tube selection on frame stiffness , ScienceDirect
- [13] Derek Covilla, Steven Begga, Eddy Eltona, Mark Milnea, Richard Morrissa, Tim Katza , Parametric Finite Element Analysis Of Bicycle Frame Geometries , ScienceDirect- Ekseveir Procedia Engineering 72 ( 2014 ) 441 – 4
- [14] V. Sarath Teja, D.V.S.S.S.V. Prasad, K.S.B.S.V.S. Sastry, Numerical Study on Materials and Design Optimization of a Bicycle Frame
- [15] Akshay, N. Khonde, Aditya R. Ughade, Kapil D. Warghane, Rajat R. Vidhale Students, Performance Evaluation of Electric Bicycles, IARJSET ISSN (Online) 2393-8021 ISSN (Print) 2394-1588 International Advanced Research Journal in Science, Engineering and Technology, Agni-Pankh 16-Jawaharlal Darda Institute of Engineering and Technology, Yavatmal-Vol. 4, Special Issue 3, January 2017



## A Study of Quality Services provided by MSRTC with Special Reference to Pune Division

Dr. Prakash Vishnu Pise  
Assistant Professor  
NBN Sinhgad School of Management Studies,  
Ambegaon Bk Pune

**Abstract:** In India, the passenger transport is divided in to public and private transport. Public transport i.e. government operated transport provide scheduled services while private transport provide ad-hoc services at the riders' desire.

Maharashtra State Road Transport Corporation (MSRTC) is state owned corporation which provides transport services to the remote or unreached rural areas in Maharashtra; but still it is known as provider of poor quality service and it is not meeting the expectations of the passengers. There are number of private transport services which are providing comfortable services to the passengers; and therefore most of the passengers are attracted towards these private transport services. So many efforts have been taken by MSRTC to attract the passengers, programs, discounts etc. have been implemented but there is no expected response from the passengers. The present study would help to get feedback on efforts taken by the management of state transport corporation for implementing the various profit oriented schemes. This study is also important to examine the values of such schemes from the passengers point of view in the light of the information collected from them. Apart from this, the present study would be also significant to know whether the methods of implementing the schemes, its objectives are approximate and whether the procedure employed is effective and producing desired results and its impact on the profitability of MSRTC. The present study is significant to understand the nature of barriers in the management of finance and to know the measures for removing these barriers for smooth management of finance.

Satisfaction of passengers is an ambiguous and abstract concept and the actual manifestation of the state of satisfaction vary from person to person and service to service. The state of satisfaction depends on number of psychological and physical variables. The present study examines the public and private transportation services in terms of passenger's satisfaction and find out the reasons of passenger dissatisfaction in case of MSRTC

## **Introduction**

Mobility of human beings is an important behavioural trait of modern age. Provision for a continuous and uninterrupted mobility of man and materials is a basic necessity of the society. Thus, road transport service provides both- time and place utilities. Transportation and Communication accelerate the economic and commercial growth of a nation and reduce the global radius to bring the countries closer to achieve the concept of global village. It links up villages, towns, countries and continents and broadens the market, fosters, greater factor utilization, promote greater methods of outsourcing, recreations, civilization etc. the State Road Transport sector of a country's economy. Thus an efficient transport system is the Yardstick of an economy.

In India, growth of population advent of large manufacturing industries, imbalanced regional developments have all contributed to the development of different modes of transport of all the various modes of transport, road transport is the most popular because of its ready availability, flexibility of operations, and adaptability to individual needs, door-to-door service and reliability. Road transport generally acts as a feeder service to rail, marine and air traffic. The Government of India recognized in its planned development programmes that roads are an inevitable infrastructure of the socio-economic development of the country.

## **Historical Perspective of Maharashtra State Road Transport Corporation**

The process of nationalization of the road passenger transport sector started immediately after independence; when the central government introduced the legislation for the purpose sometime in 1948, which resulted in bringing on the statute book in 1950 – the Road Transport Corporation Act. In December 1949, Bombay State decided to set up a single corporation for the whole state under the Road Transport Corporation Act 1950. Nationalization of passenger road transport services in Maharashtra started in June 1948, initially as a departmental undertaking with a fleet of 35 buses operating on the Pune Ahmednagar and allied routes, which later were handed over to the statutory corporation viz, Bombay State Road Transport Corporation. This corporation in 1961 emerged as the Maharashtra State Road Transport Corporation, which is today the second largest, after Andhra Pradesh State Road Transport Corporation, passenger road transport organization in India.<sup>1</sup>

## **Evaluation of Passenger Satisfaction**

The state road transport services play a predominant role among the services extended to the citizen. Today, service quality has become very important than ever before in any area; because service providers have realized that, they have to provide customer perceived values. As competition increases, customers have more options to choose from and of course, service quality will become their priority when spending their money; especially as they try to maximize the value in return as well as satisfaction for every unit of money spent. For this reason, the customers' perception on the services used is necessary because service quality can be approached only from the consumer point of view. It is absolutely necessary to correlate the expectations of

customers with perceptions regarding the transplantation services, making the outcome essential in evaluating the quality of service.

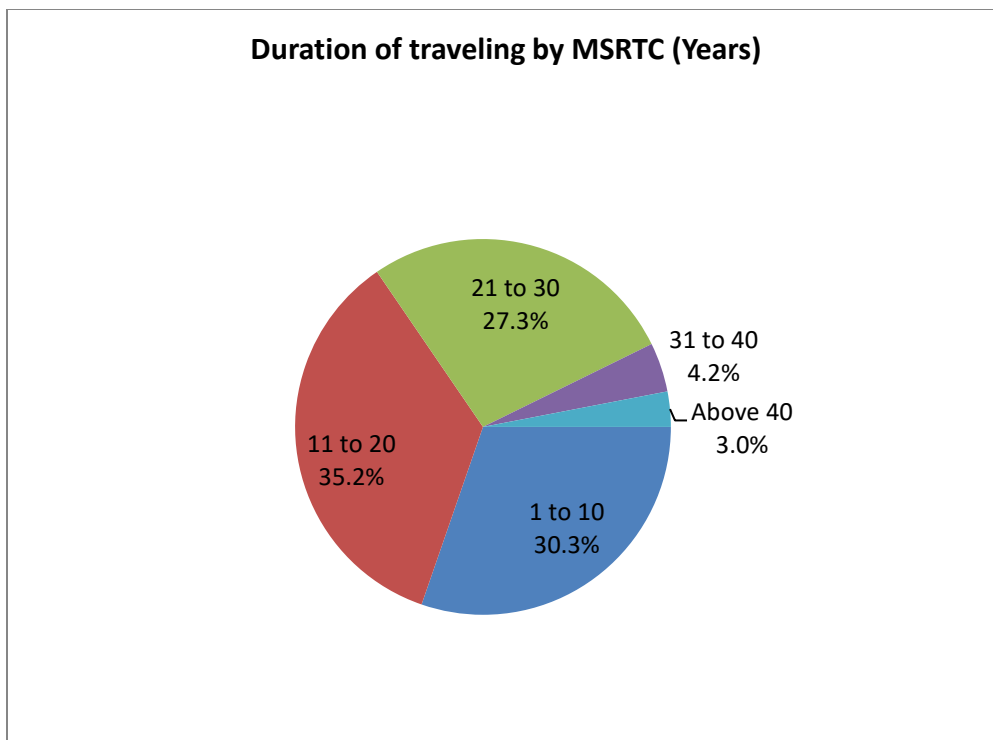
In bus operation of state road transport corporation there are performance parameters which are directly and easily amenable to measurement and evaluation and those which are not. Many state road transport corporations assures to their passengers about adequate, effective, efficient, safe, reliable, clean and friendly bus service throughout the year. This could be an objective. It lacks its ingredients – parameters, performance standards, measuring mechanism and promised performance targets.

From the passengers' point of view, the most important expectations could be – punctuality, cleanliness, safety. Alternative arrangements for uncertain case, assurance, passenger information service and easy access for reservations etc.

In the following tables, researcher has evaluated the satisfaction of passengers on the basis of these parameters. In total 165 passengers have been interviewed for this purpose.

Duration of traveling by MSRTC

Sr. No.	Years	Frequency	Percent
1	1 to 10	50	30.3
2	11 to 20	58	35.2
3	21 to 30	45	27.3
4	31 to 40	7	4.2
5	Above 40	5	3
	Total	165	100

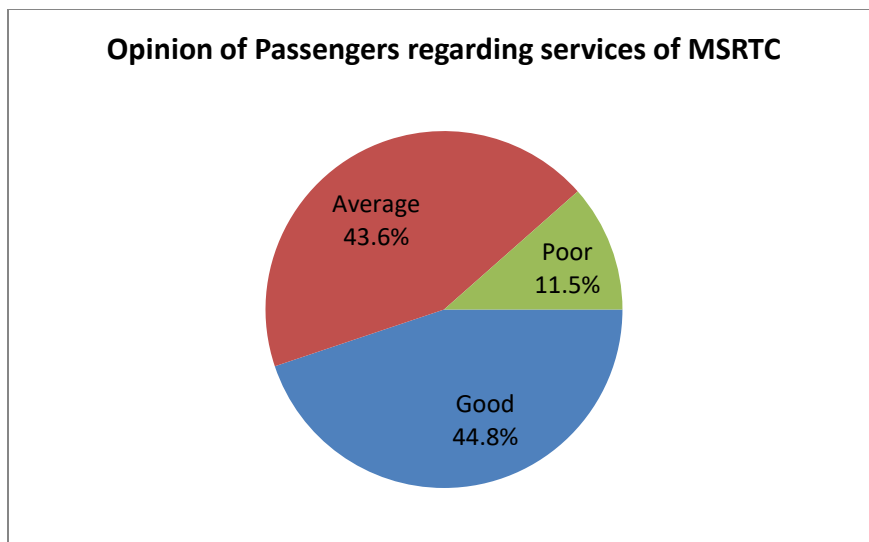


From the above table we come to know that, majority of passengers (35.2%) are travelling through Maharashtra State Road Transport Corporation since 11 year to 20 years. 30.3 percent passengers are travelling since 1 to 10 years. 27.3 percent passengers are travelling since 21 to 30 years. Only 3.0 percent passengers are travelling through MSRTC since 40 years and above.

In the following table the opinions of passengers regarding services provided by Maharashtra State Road Transport Corporation have been indicated.

Opinion of Passengers regarding services of MSRTC

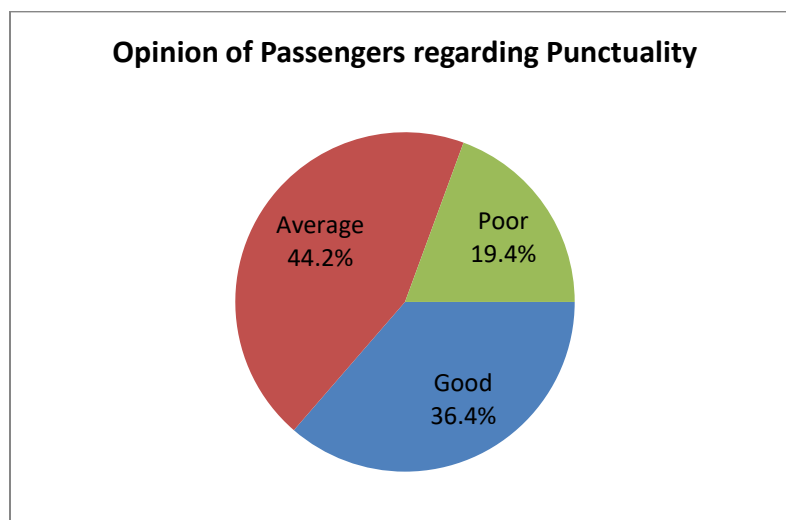
Sr. No.	Opinion	Frequency	Percent
1	Good	74	44.8
2	Average	72	43.6
3	Poor	19	11.5
	Total	165	100



44.8 percent passengers have opined that, the service provided by Maharashtra State Road Transport Corporation is good. According to 43.6 passengers it is at average level, and only 11.45 percent passengers have opined that the service rendered by the Maharashtra State Road Transport Corporation is poor.

**Opinion of Passengers regarding Punctuality**

Sr. No.	Opinion	Frequency	Percent
1	Good	60	36.4
2	Average	73	44.3
3	Poor	32	19.3
	Total	165	100

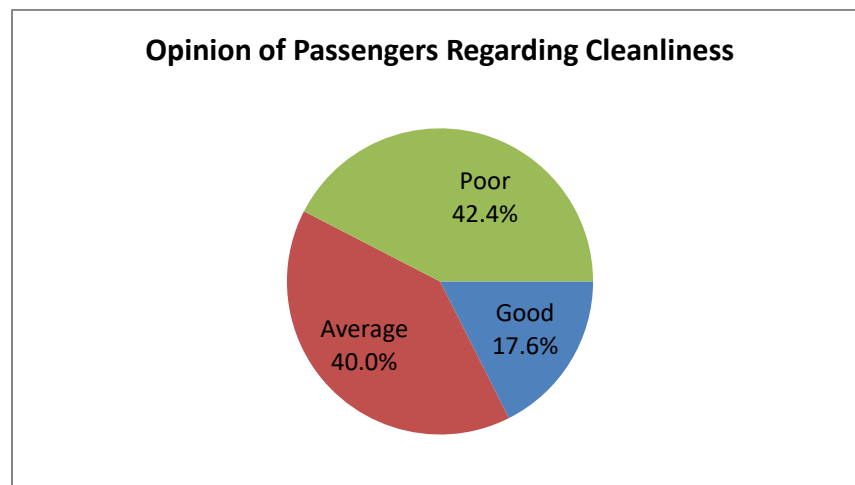




In the opinion of 19.3 percent passengers, punctuality of Maharashtra State Road Transport Corporation is very poor. According to 36.4 percent and 44.3 percent passengers, the punctuality of corporation is good and average respectively.

#### Opinion of Passengers Regarding Cleanliness

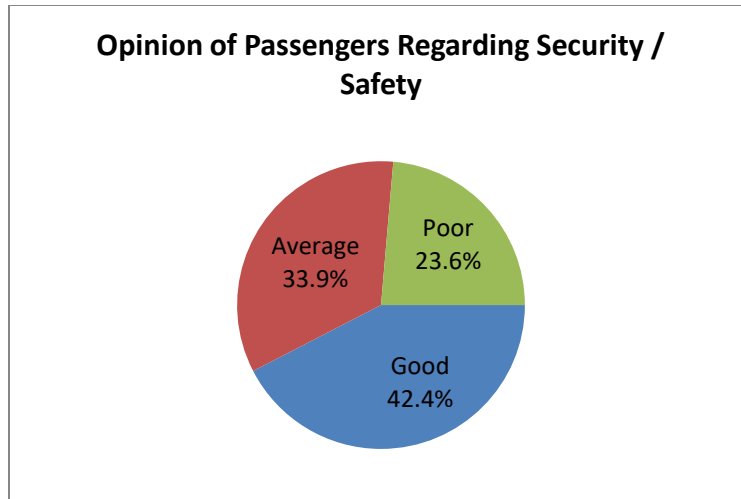
Sr. No.	Opinion	Frequency	Percent
1	Good	29	17.5
2	Average	66	40.1
3	Poor	70	42.4
	Total	165	100



According to 17.5 percent passengers cleanliness of buses and bus stations is good, 40.1 percent passengers have opined that it is at average level and 42.4 percent passengers have stated that, the cleanliness of buses and bus stations are very poor.

#### Opinion of Passengers Regarding Security / Safety

Sr. No.	Opinion	Frequency	Percent
1	Good	70	42.4
2	Average	56	33.9
3	Poor	39	23.6
	Total	165	100

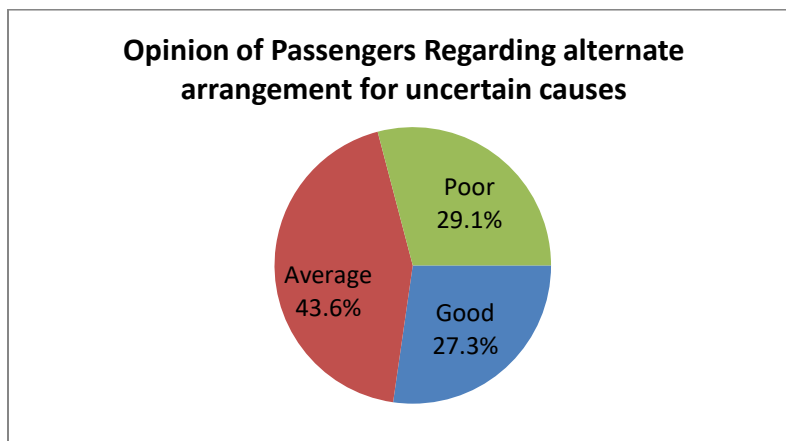


Majority of passengers (42.4 percent) have stated that level of travel safety is very good. 33.9 percent passengers have been stated that, level of safety during travel is poor.

In the following table the opinions of passengers regarding the alternative arrangements for uncertain cause.

Opinion of Passengers Regarding alternate arrangement for uncertain causes

Sr. No.	Opinion	Frequency	Percent
1	Good	45	27.3
2	Average	72	43.7
3	Poor	48	29.0
	Total	165	100

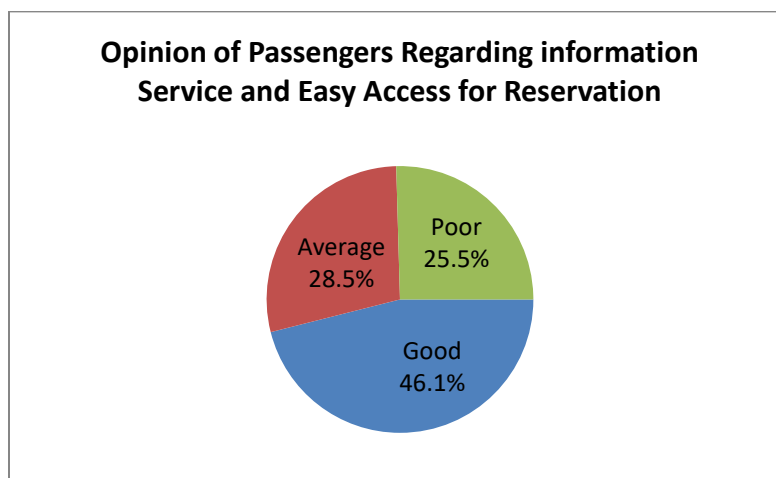


27.3 percent passengers have opined that the alternative arrangement made by Maharashtra State Road Transport Corporation, for uncertain cause is good. According to 43.7 percent have been

opined that the alternative arrangement made corporation for uncertain cause is good. According to 43.7 percent passengers it is at average level and 29 percent passengers have stated that the alternative arrangement made by corporations for understanding cause is poor.

#### Opinion of Passengers Regarding information Service and Easy Access for Reservation

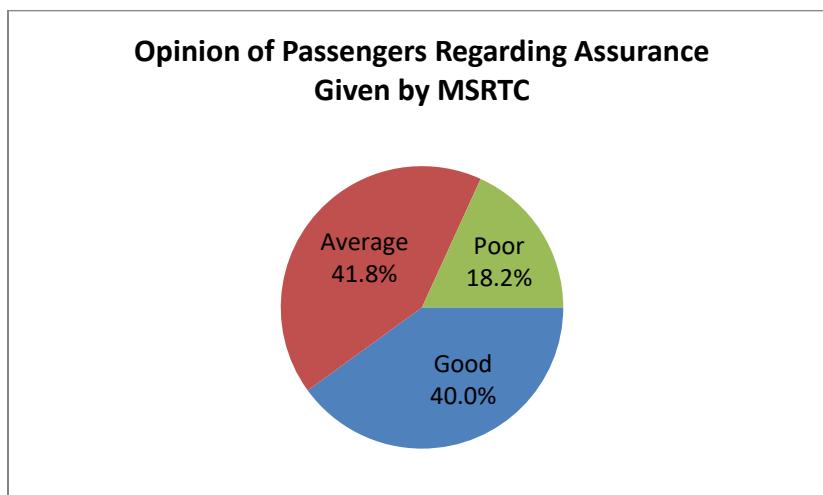
Sr. No.	Opinion	Frequency	Percent
1	Good	76	46.0
2	Average	47	28.5
3	Poor	42	25.5
	Total	165	100



The passenger information service and accessibility of reservation is good, opined 46 percent passengers. 28.5 percent opined that it is at average level and 25.5 percent passengers have opined it is poor.

#### Opinion of Passengers Regarding Assurance Given by MSRTC

Sr. No.	Opinion	Frequency	Percent
1	Good	66	40.0
2	Average	69	41.8
3	Poor	30	18.2
	Total	165	100

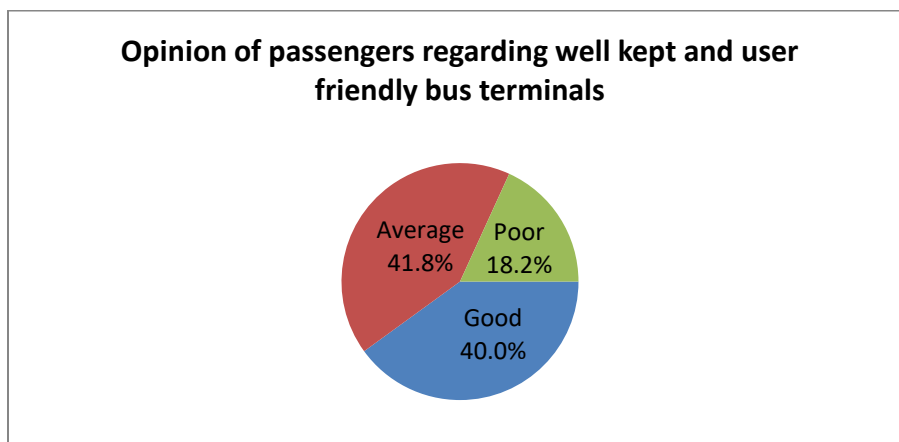


40 percent passengers have opined that the assurance given by Maharashtra State Road Transport Corporation is at good level. According to 41.8 percent passengers assurances is at average level and only 18.2 percent passengers have opined that it is at poor level.

The following table indicates the opinions of passengers regarding well kept and user friendly bus terminals of Maharashtra State Road Transport Corporation.

Opinion of passengers regarding well kept and user friendly bus terminals

Sr. No.	Opinion	Frequency	Percent
1	Good	66	40.0
2	Average	69	41.8
3	Poor	30	18.2
	Total	165	100

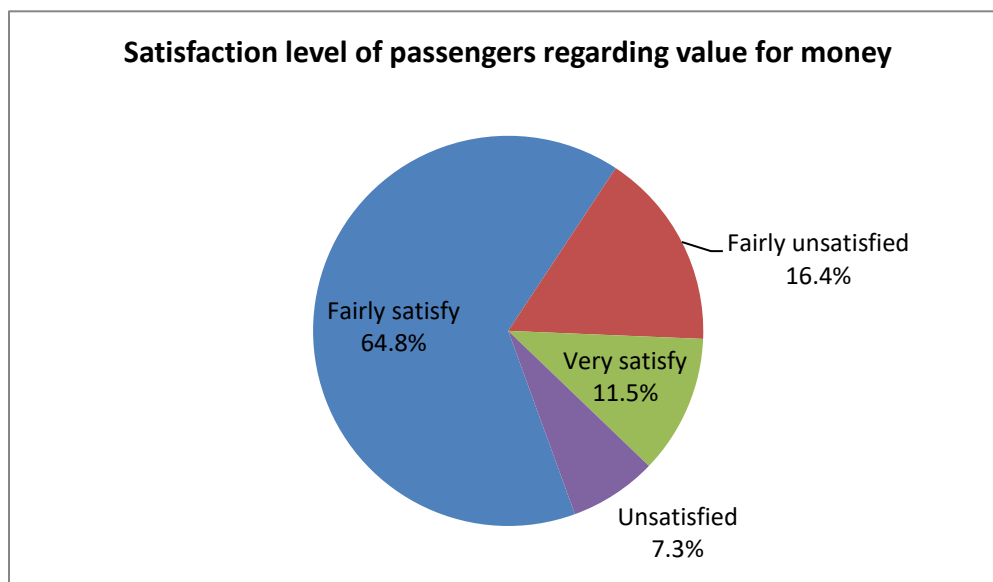


According to 29 percent passengers the bus terminals maintained are at average level. In the opinion of 36.3 percent passengers the bus terminals of Maharashtra State Road Transport Corporation are well kept and they are use friendly. 35 percent passengers have opined that the bus terminals are not well kept and are not user friendly, they are poor in maintenance.

The following table indicates the satisfaction level of passengers in the context of their value for money.

Satisfaction level of passengers regarding value for money

Sr. No.	Satisfaction Level	Frequency	Percent
1	Fairly satisfy	107	64.8
2	Fairly unsatisfied	27	16.4
3	Very satisfy	19	11.5
4	Unsatisfied	12	7.3
	Total	165	100

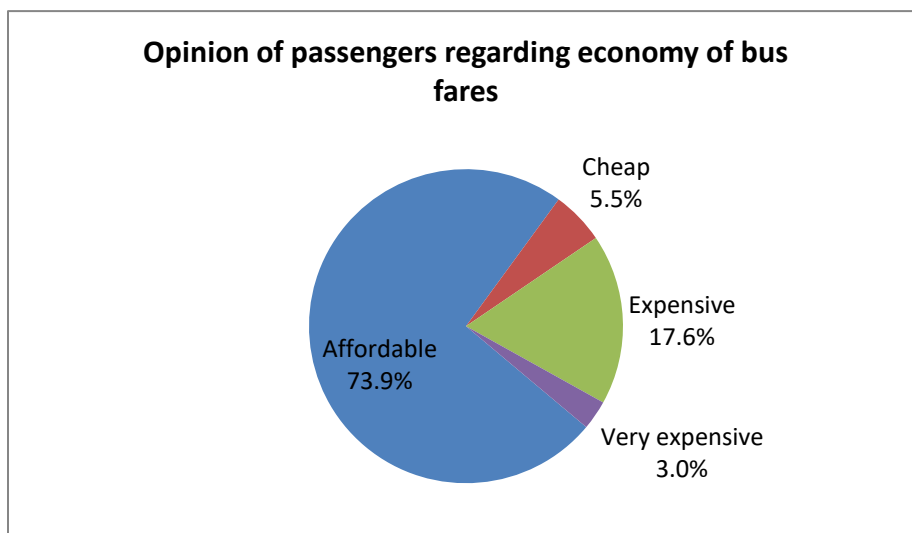


The above table indicates that, 64.8 percent passengers are fairly satisfied for their value for money paid to Maharashtra State Road Transport Corporation. 16.4 percent passengers are fairly unsatisfied, 11.5 percent passengers are very satisfied and only 7.3 percent passengers have expressed dissatisfaction regarding the value of their money paid to Maharashtra State Road Transport Corporation.

Opinion of passengers regarding economy of bus fares



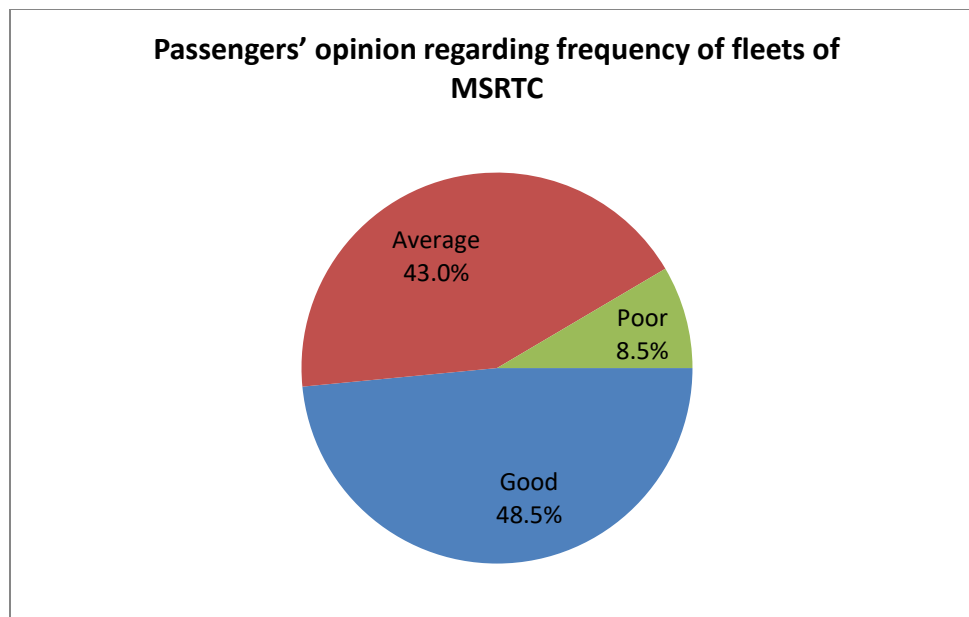
Sr. No.	Opinion	Frequency	Percent
1	Affordable	122	73.9
2	Cheap	9	5.5
3	Expensive	29	17.6
4	Very expensive	5	3
	Total	165	100



Majority of passengers (i.e. 74 percent) have opined that the bus fare charged by Maharashtra State Road Transport Corporation is expensive. 5.5 percent passengers opined that it is cheap and 21 percent passengers have opined that the bus fare charged by Maharashtra State Road Transport Corporation is affordable.

Passengers’ opinion regarding frequency of fleets of MSRTC

Sr. No.	Opinion	Frequency	Percent
1	Good	80	48.4
2	Average	71	43.0
3	Poor	14	8.4
	Total	165	100

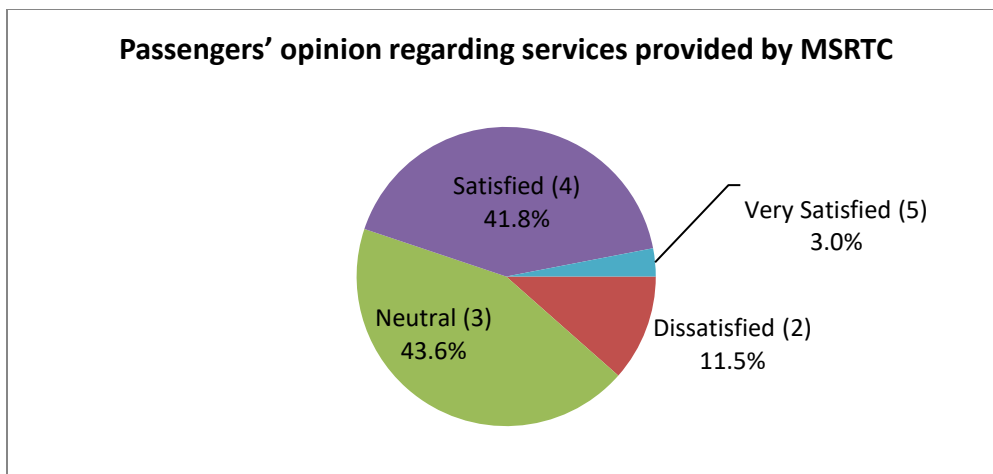


In the opinion of 48.4 percent passengers the fleet frequency is good. 43 percent passengers have stated that the frequency of fleet is at average level and only 8.4 percent passengers have stated that fleet frequency is poor.

The following table indicates the general opinions passengers about services provided by Maharashtra State Road Transport Corporation.

Level of Customer Satisfaction about services provided by MSRTC

Sr. No.	Level of Satisfaction (Scale)	Frequency	Percent	Cumulative Percent
1	Very Dissatisfied (1)	0	0	0
2	Dissatisfied (2)	19	11.5	11.5
3	Neutral (3)	72	43.6	55.2
4	Satisfied (4)	69	41.8	97.0
5	Very Satisfied (5)	5	3.0	100.0
	Total	165	100.0	



43.8% Passengers have generally opined that the services of Maharashtra State Road Transport Corporation are either satisfied or very satisfied. Almost same number of passengers (46.8%) opined satisfaction level as neutral and only 11.5% percent passengers opined that services are dissatisfactory.

### Testing of Hypothesis

#### 1) Hypothesis 1

**Customers are satisfied about the services provided by MSRTC.**

Researcher has a question in survey questionnaire about the satisfaction level of MSRTC service rated on 1 to 5 scale Following table explains the scenario.

Table No. 5.70

Level of Customer Satisfaction about services provided by MSRTC

Sr. No.	Level of Satisfaction (Scale)	Frequency	Percent	Cumulative Percent
1	Very Dissatisfied (1)	0	0	0
2	Dissatisfied (2)	19	11.5	11.5
3	Neutral (3)	72	43.6	55.2
4	Satisfied (4)	69	41.8	97.0
5	Very Satisfied (5)	5	3.0	100.0
	Total	165	100.0	

The null hypothesis is **H<sub>0</sub>: Customers are satisfied about the services provided by MSRTC.**

**H<sub>0</sub>:  $\mu \geq 4$**

The alternative hypothesis is **H<sub>a</sub>: Customers are not satisfied about the services provided by MSRTC.**

**H<sub>0</sub>:  $\mu < 4$**

If level of satisfaction of customers is equal or above 4 then we can say that customers are satisfied. Hence one sample ‘T’ test was used to analyse customer opinion. One sample T test shows whether a mean of single variable differs from a specified constant (here 4).

One-Sample Statistics					
Variable	N	Mean	Std. Deviation	Std. Error Mean	
Level of Satisfaction	165	3.36	0.725	0.056	

The one-sample statistics table shows the mean, the standard deviation, and the number of respondents.

**One-Sample Test**

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
level of satisfaction (Rating)	-11.276	164	.000	-.636	-.75	-.52

As shown in above table, service scores has negative value, which means that service quality was not close to the service quality that satisfies customers. Therefore, the null hypothesis was rejected, that means that customers were not satisfied with service quality. Above table also

indicates that the p-value .000 is lower than the significant level .05, denoting that there is a significant difference between customer satisfaction with service quality,

Therefore, we reject the hypothesis “**Customers are satisfied with service provided by MSRTC**”

## 2) Hypothesis 2

**There is a positive relationship between bus maintenance and expenses.**

Researcher has selected five years (2008-09 to 2012-13) bus maintenance and expenses records from balance sheets of Maharashtra State Road Transport Corporation, Pune division to test this hypothesis.

Since we have two scale type variables, this hypothesis test is a nonparametric test. Thus the statement of the hypotheses does not concern population parameters, but instead are statements concerning the variables themselves.

The hypotheses are as follows:

The null hypothesis is **H<sub>0</sub>: There is no positive relationship between bus maintenance and total expenses.**

**H<sub>0</sub>:  $p > 0.05$**

The alternative hypothesis is **H<sub>a</sub>: There is positive relationship between bus maintenance and total expenses.**

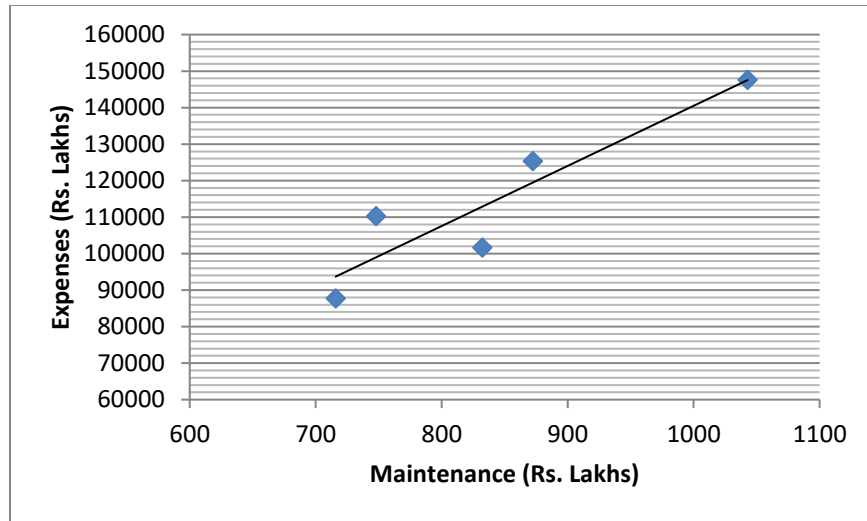
**H<sub>a</sub>:  $p < 0.05$**

Researcher has tried to find the relationship or association between the expenses and maintenance. As per the balance sheet of MSRTC, maintenance and expenses figures for five years (2008 to 2013) are as follows.

Year →	2008-09	2009-10	2010-11	2011-12	2012-13
Maintenance (Rs. Lakhs)	715.84	832.37	747.83	872.30	1042.73
Expenses (Rs. Lakhs)	87707.59	101672.88	110218.43	125356.25	147613.08

The scatter diagram for this data is as follows. The linear trend line has been included which seems to best match the data.





Descriptive Statistics		
	Mean	Std. Deviation
Maintenance	842.21	128.54
Expenses	114513.65	22994.75

Correlations			
		Maintenance	Expenses
Maintenance	Pearson Correlation	1	0.920
	Sig. (2-tailed)		0.027
	N	5	5
Expenses	Pearson Correlation	0.920	1
	Sig. (2-tailed)	0.027	
	N	5	5

$p\text{-value} = 0.027 < \alpha = 0.05$

As derived p value is less than the alpha (0.05) we can reject the null hypothesis.

We can see here correlation is significant at the 0.05 confidence level. As we increase the value of maintenance variable, value of expenses variable also increase positively.

Hence we, accept the alternate hypothesis “**There is positive relationship between bus maintenance and total expenses**”

In survey questionnaire, researcher has asked question regarding the hygiene and maintenance of MSRTC buses. Following opinions were given by the passengers regarding the same.

### **Opinion of passengers regarding the Hygiene and maintenance of Buses**

Sr. No.	Opinion	Frequency	Percent
1	Clean and well maintained	46	27.9
2	Unhygienic and well maintained	86	52.1
3	Very clean and well maintained	2	1.2
4	Very unhygienic and well maintained	31	18.8
	Total	165	100

Above table confirms that though buses are unhygienic (opinion by 70.9% passengers) but still they are well maintained as opined by almost all (100%) passengers.

Thus increase in maintenance increased the expenses on buses, this supports researcher’s testing of hypothesis “There is positive relationship between bus maintenance and total expenses”

### **3) Hypothesis 3**

**There is a positive correlation between revenue from passengers and working expenses.**

Researcher has selected five years (2008-09 to 2012-13) revenue from passengers and working expenses records from balance sheets of Maharashtra State Road Transport Corporation, Pune division to test this hypothesis.

Since we have two scale type variables, this hypothesis test is a nonparametric test. Thus the statement of the hypotheses does not concern population parameters, but instead are statements concerning the variables themselves. The hypotheses are as follows:

The null hypothesis is **H<sub>0</sub>: There is a no positive correlation between revenue from passengers and working expenses.**

**H<sub>0</sub>:  $p > 0.01$**

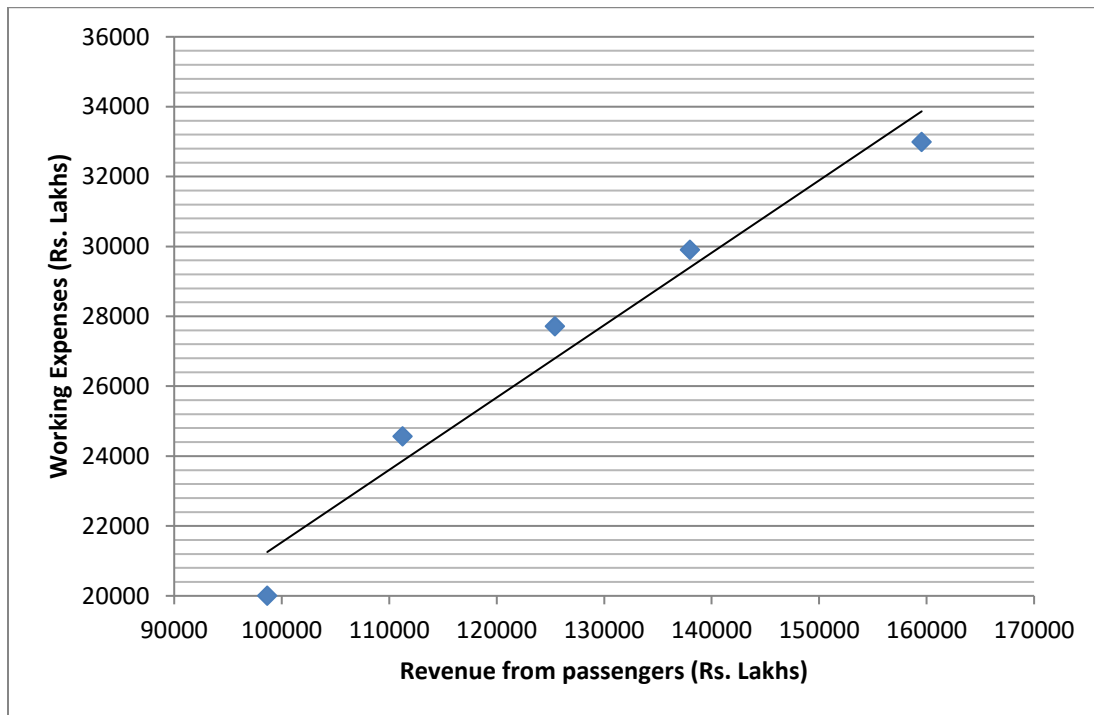
The alternative hypothesis is **H<sub>a</sub>: There is a positive correlation between revenue from passengers and working expenses.**

**H<sub>a</sub>:  $p < 0.01$**

Researcher has tried to find the relationship between the revenue from passengers and working expenses of MSRTC. As per the balance sheet of MSRTC, revenue from passengers and working expenses figures for five years (2008 to 2013) are as follows.

Year →	2008-09	2009-10	2010-11	2011-12	2012-13
Revenue from Passengers (Rs. in lakhs)	98659.7	111264	125417	137979	159540
Working Expenses (Rs. in lakhs)	20007.5	24565.3	27716.1	29909.5	32990.2

The scatter diagram for this data is as follows. The linear trend line has been included which seems to best match the data.



Descriptive Statistics		
	Mean	Std. Deviation
Revenue from passengers	126571.92	23620.84
Working Expenses	27037.71	4991.91

Correlations			
		Revenue from passengers	Working Expenses
Revenue from passengers	Pearson Correlation	1	0.980
	Sig. (2-tailed)		0.003
	N	5	5
Working Expenses	Pearson Correlation	0.980	1
	Sig. (2-tailed)	0.003	
	N	5	5

$p$ -value = 0.003 < alpha = 0.01

As derived  $p$  value is less than the alpha (0.01) we can reject the null hypothesis.

We can see here correlation is significant at the 0.01 confidence level. As we increase the value of revenue from passengers variable, value of working expenses variable also increase positively, which proves that both variables have positive relationship.

Hence we, accept the alternate hypothesis **“There is a positive correlation between revenue from passengers and working expenses.”**

### **Research Design and Methodology**

#### **Introduction**

Research in common parlance refers to a search for knowledge. The advanced Learner’s Dictionary of current English lays down the meaning of research as “a careful investigation or inquiry especially through the search for new facts in any branch of knowledge.” Redman and Mory<sup>1</sup> define research as a “systematized effort to gain new knowledge” Some people consider research as a movement, a movement from known to unknown. It is actually a voyage of discovery. We all possess the vital instinct of inquisitiveness for, when the unknown confronts us, we wonder and our inquisitiveness makes us probe and attain full and fuller understanding of the unknown.

In the present chapter researcher explains the research design overall plan for the study.

#### **Rational and Significance of the study**

In a simple language, transportation is the movement of people, cattle or goods from one place to

another. Air, road, rail and water are the major modes of transportation and are playing vital role in the economic development of the country.

In India, the passenger transport is divided in to public and private transport. Public transport i.e. government operated transport provide scheduled services while private transport provide ad-hoc services at the riders' desire.

Maharashtra State Road Transport Corporation (MSRTC) is state owned corporation which provides transport services to the remote or unreached rural areas in Maharashtra; but still it is known as provider of poor quality service and it is not meeting the expectations of the passengers. There are number of private transport services which are providing comfortable services to the passengers; and therefore most of the passengers are attracted towards these private transport services. So many efforts have been taken by MSRTC to attract the passengers, programmes, discounts etc. have been implemented but there is no expected response from the passengers. Every year the balance sheet of MSRTC indicates tremendous losses. MSRTC find itself plagued by several problems, partly external but largely self inflicted. With dedicating financial support from both central and state government after liberalization and in the wake of intense competition from private operators, MSRTC has had to largely fend for itself. A popularly held hypothesis has been that MSRTC is oversized and hence splitting of this organization into smaller organizations could vastly improve its financial management process. This idea has gained further ground after the dramatic turnaround of Karnataka State Road Transport Corporation (KSRTC) after it had been split into the smaller organizations.

The present study would help to get feedback on efforts taken by the management of state transport corporation for implementing the various profit oriented schemes. This study is also important to examine the values of such schemes from the passengers point of view in the light of the information collected from them. Apart from this, the present study would be also significant to know whether the methods of implementing the schemes, its objectives are approximate and whether the procedure employed is effective and producing desired results and its impact on the profitability of MSRTC. The present study is significant to understand the nature of barriers in the management of finance and to know the measures for removing these barriers for smooth management of finance.

Satisfaction of passengers is an ambiguous and abstract concept and the actual manifestation of



the state of satisfaction vary from person to person and service to service. The state of satisfaction depends on number of psychological and physical variables. The present study examines the public and private transportation services in terms of passenger's satisfaction and find out the reasons of passenger dissatisfaction in case of MSRTC. With the increasing demand fro transportation services, speed, service quality and passenger satisfaction are going to be key differentiators for state transport corporation to get useful feedback on their actual response time and passenger service quality aspects; which in turn will help to the state transport corporation to take positive steps to maintain a competitive edge. The present study would be useful to the MSRTC in this regards. The present study may provide required feedback regarding expenditure incurred on implementing various schemes for passenger's satisfaction and their expectations from MSRTC.

The present study would be useful to get feedback regarding capital structure, investment made by MSRTC, sources of funds and also management of earning of MSRTC. Through the present study researcher has analysed the procedure of financial management on the basis of receipt and payment and other financial statements. Such type of analysis may be very useful for the management to take necessary actions to overcome the future challenges and this would be help to recognize the need to make changes in working capital structure, fixed assets utilization and other financial aspects, to create improvements and determine if these changes after implementation, have led to increased profitability of MSRTC.

Through this present study, researcher has found out apportionment of the capital from state and central government and also examined the organizations like MSRTC (Pune Division) would actually lead to improve financial management. The utility of the present study could be appreciated with reference to the point such as , the study could be useful addition to the literature on the topic which is particularly scarce. The information and analysis presented on the related topic too are likely to be useful, to MSRTC.

### **Objectives of the study**

In the past, various studies were made on State Transport Corporation in India. These studies were mainly concerned with overall performance of state transport corporations, its role in economy, passengers satisfaction etc. and its several other aspects were covered by different researchers and experts. However, no attempt was made in the past to study the financial aspect s

of state transport corporations. Taking into consideration the significance of the present study, the following objectives are formulated by the researcher.

- 1) To analyse the financial management on the basis of Receipt and Payment and other financial statements.
- 2) To find out the opinions of passengers regarding services provided by MSRTC.

### **Formulation of Hypothesis**

With a view to conducting research study toward above objectives, the hypothesis to be tested was formulated as follows-

- 1) Customers are satisfied about services provided by MSRTC.
- 2) There is a positive relationship between bus maintenance and expenses.
- 3) There is a positive correlation between revenue from passengers and working expenses.

### **Scope and limitations of the study**

A study regarding Maharashtra State Road Transport Corporation is very vast and to study its other aspects of management is also very comprehensive and can be studied from different angles. Maharashtra State Road Transport Corporation has altogether 29 divisions in the state. At Ph.D. level and in short span of time it was very difficult for researcher to cover all the divisions for the study purpose, therefore, the present study is restricted to Pune division of MSRTC.

The present study is comprehensively covering finance and accounts departments of MSRTC's Pune division. All other divisions and other aspects of management other than financial management were beyond the scope of this study.

### **Limitations of the study**

The researcher has come across the following limitations while conducting study survey.

- i) It was quite difficult to study the all road transport corporations of all the states; therefore researcher has selected Maharashtra State Road Transport Corporation for the study purpose.
- ii) It was difficult to cover all divisions of MSRTC, researcher has intended to study only one division i.e. Pune.

iii) The evolution of financial management is investigated for the period of 2008 to 2013 only.

### **Statement of the study**

The need and significance of the present study has left the researcher to state the undertaken research study as follows –

### **“A Study of Quality Services provided by MSRTC with Special Reference to Pune Division”**

### **Research Design and Methodology:**

Research is undertaken in most of professions. More than a set of skill, it is a way of thinking, examining critical the various aspects of professional works. It is a habit of questioning, what you do and a systematic examination of the observed information to find answers with a view to instituting appropriate changes for a more effective professional service. Research is a process of collecting, analyzing and interpreting information to answers the questions. But to qualify as a research, the process must have certain characteristics. It must as far as possible be controlled, rigorous, systematic, valid and verifiable, empirical and critical.

For a present study purpose, descriptive research has been designed to fulfill the objectives with data collection from different sources and to know balance sheet, profit and loss statement and other financial statements in the context of Maharashtra State Road Transport Corporation. The questions have been developed as to get responses specific to objectives that are proposed to fulfill.

For the purpose of the analysis, primary data was collected directly from the passengers. The collected primary data was analysed using percentile method.

### **Selection of Sample**

Considering the nature of study the unit of population and different constraints in data collection, the researcher has selected a sample which benefits the requirements of the of the proposed study. The sample selection will be on the following parameters-

- a) Nature of the study.
- b) Possibility of accessing the data; and ;

c) Willingness of respondents.

For the purpose of the study researcher has selected 150 passengers who are traveling in the buses of MSRTC. To identify their opinions regarding services provided and various schemes implemented by MSRTC. A random sample method has been followed for selection of sample.

### **Sources of Data Collection**

Broadly researcher has relied on two sources of information for the present study that is primary and secondary sources of information. The literature on financial management in state transport corporation is scarcity and only in the form of articles or research. Unfortunately, researcher did not come across sufficient literature in the present context. Consequently, researcher has relied mostly on research papers and study articles published in the various journals and information available on the internet. Secondary data has been collected from the many administrative officers of MSRTC. This information has been classified by using various techniques of analysis.

Primary data has been collected with the help of structured questionnaire for passengers. The main purpose of these questionnaires was to get feedback about services provided by MSRTC.

In brief, for the study purpose, survey method was used for the collection of primary data with the help of a questionnaire. The questionnaire was administered to the individual of the selected sample and their responses about themselves have been recorded.

### **Details of questionnaire**

A structured questionnaire was designed to extract information about the objectives. A questionnaire was developed on the basis of literature review and objectives of the study. The questionnaire consists questions with multiple choice answers and open ended questions based on the different criteria such as how long using MSRTC travelling services, level of satisfaction regarding services, rating the MSRTCS services (punctuality, cleanliness, security/ safety, alternate arrangement for uncertain causes, assurance), satisfaction about value for money, fare, frequency of buses, overall experience etc.

### **Data Analysis**

The filled questionnaires were numbered serially and checked for the consistency of the data and any inconsistent data. The questions and responses were codified to represent the data in a tabular and graphical form wherever appropriate. Researcher has used SPSS software for data

processing.

### **Literature Review related to Maharashtra State studies, articles etc.**

1) A study paper titled, "Analysis of productivity and efficiency in MSRTC" by Manisha Karne and Venkatesh Anand (2003). Through this study authors have examined the issue of splitting financial recovery. They have also examine the possibility of improvement in financial profitability by means of enhanced input productivity. While discussing on the financial conditions of MSRTC, authors have stated that, even though MSRTC operates along 100% nationalized routes in Maharashtra state, it faces competition from private bus and maxi cab operators who operate stage carriage services in a clandestine manner posing as contract carriage operators. Authors have further stated that, since these operators compete with MSRTC only along its high density routes, MSRTCs load factors have fallen along these routes there by affecting its financial performance.

2) A study article titled, "Total Factor Productivity, Total Price Performance and Economic Profitability : A Case study of BEST," (2009) by S. K. Singh, published in the Indian Journal of Transport Management, Vol.33 No.1. In this article author has examines changes in economic profitability, total factor productivity and total price performance of India's largest municipal transport undertaking- BEST From 1990-91 to 2005-06. Analysis shows that, contrary to usual perception, BEST increased its output price at greater rate than that of input factor prices. However, it also faced decline in its total factor productivity. As result, it could not improve its economic profitability from 1990-91 to 2005-06. Author has stated that, although there is virtually no change in BEST's economic profitability from 1990-91 to 2005-06, there is a significant difference in the trend between first and second half of the sample period, From 1991 to 1997, both TFP and TPP (Total Price Performance) declined but decline in TPP was more than that in the TFP (Total Factor Productivity). As a result, BEST's economic profitability improved during 191 to 1998. Author has observed that, from 1998 to 2006 TPP and TFP improved but improvement in TFP was less than that in the TPP. As a result BEST's economic profitability deteriorated during 1998-2006. Author has stated that although, there is a clear distinction in growth rate of TFP, TPP and Economic profitability between first and second half of the sample period, it appears that these parameters follow a cyclical pattern where they go up and down for two to three years. It is important to note that economic profitability of BEST worsened for those periods when TPP growth exceeded TFP growth.



3) A study article titled, “ Operation G-2 in Nashik District: A viable marketing strategy,” (2003) by S. H. Gawhane & D. M. Kawathekar published in the Indian journal of transport management, Vol 27 No. 1 Saptashrunji Devi temple is an important holy place in Nashik, Maharashtra. Millions of devotees are visiting this temple for worship of goddess every year. Authors have informed that the District Collector & the Divisional Controller of Maharashtra State Road Transport Corporation at Nasik took a decision that during the festival only MSRTC buses will ply from the village Nanduri to Saptashrunji Temple. Authors have further informed that, on this basis of this decision MSRTC made rigorous financial planning for the operation of its buses during the festival period. Authors have observed that, with the financial planning & operation strategy, the MSRTC’s Nasik division could increase its revenue from the festival during the nine days period from Rs. 33.92 lakh in the year 2000-2001 to Rs. 7053 lakh in 2001-2002.

4) A study article titled, “A Study of Service Quality of MSRTC as perceived by passengers in & around Pune,” (2001), by V. Nambiar published in the Indian journal of Transport management Vol. 25 No. 3. In the opinion of author, in the liberalised competitive environment, Maharashtra state road Transport Corporation is continuously in the process of becoming a dynamic business organization. The views of the passengers are crucial in this regard while finalising any strategy. This study was conducted during August- December 1997 to find out as to whether the passengers in & around Pune perceived the quality of the services rendered by MSRTC as matching to their expectations. A tool called ‘Service Quality Questionnaire’, was used for the study. Through this questionnaire author has focussed on five general dimensions of service quality viz., Tangibles, Reliability, Responsiveness, Assurance and Empathy. The study showed that in a scale of 7 there is a gap of 1.45 between the perception score of 4.00 and passengers expectation of 5.45. The highest gap of 2.32 was found in responsiveness while the lowest gap was in tangibles passengers gave first importance to the reliability dimension followed by responsiveness while assurance was given least importance.

5) A study paper titled, “Social Objectives and Finances of STUs. The case of APSRTC” (1999) by RVS Reddy published in International Journal of Transport Economics vol 36 No. 2 the light of analytical study revealing the inevitable presence of social obligations on the finances and financial performance of APSRTC, author has stated that, there is a strong case for subsidizing the losses suffered by the corporation on account of such social obligations.

Alternatively at least the amount of financial implications should be quantified to facilitate an objective study of the corporation's financial performance and contribution to the society. Author has concluded that participating governments have converted their contributions (which were hitherto treated as loans and the corporation is obliged to pay interest on them) into equity thus relieving the Corporation of the burden of interest.

6) A study article titled "Financing State Transport Undertakings" (1999) by L. G. Agashe, published in the Indian journal of transport management vol 23 No. 2. In this article author has highlighted the funds required and the resources from which the funds are to be raised. In this context author has opined that the cost reduction programme will reduce the amount to be raised by increasing revenue. Author has further stated that the net amount of revenue increase should be come by revision of fares, rationalization of fares, seasonal variations in fares, by introducing better quality services at higher fares and by employing new marketing techniques for raising occupancy rations. Author has further suggested that state transport Corporation should with draw from uneconomic operations if government does not subsidies such operations. Boards of state transport undertaking must exercise its autonomy government should refrain from interference in day do day working of state transport undertakings.

7) A study article titled, "Economic survey gives MSRTC Points to Mull," by Manish Umbrajkar, Published in the Times of India' April 2011. This economic survey has brought to the fore a few points of concern related to the financial performance of the Maharashtra state Road Transport Corporation. Of the issues prominent are the decreasing number of passengers and increase in the bus, staff ratio. Author has stated that, the MSRTC has been able to reduce the expenditure incurred on the overtime that was being paid to employees according to the information provided by officials of MSRTC, until last year, the MSRTC was spending a whopping Rs. 60 Corer as overtimes salary for its employees. The officials pointed out that, there has been an increase in the overage effective kilometers operated per day only because the MSRTC made optimum use of its existing fleet.

8) A book titled, "Financial Management of MSRTC In India" (1998) by Akbar Ali Khan, Published by Anmol Publisher. The subject of financial management of State Road Transport Corporation is a very important one in the context on the role of public undertakings in development as well as in achieving of the objectives of the planning. At a time when passenger

road transport undertakings are being criticized for the heavy losses due to unprecedented constraints and crisis in managing their financial problems; it is necessary to have analytical studies about the financial performance of these undertakings. Therefore, author has evaluated the financial performance of state transport corporations by according various tools of analysis such as financial ratios, funds flow statements, cost of capital, capital structures, cost effectiveness, cost fare inter relationship etc. In this book author has highlighted the various factors affecting the financial performance such as capital structure, material efficiency, tax burden, physical and operations performance, profitability etc. author has also dealt with the inter firm comparison of financial performance of MSRTC, APSRTC and GSRTC. Author has stated that, conclusions drawn will have optional utility for the SRTC Government planners and policy makers.

9) A study article titled, "MSRTC remains one of the best in the country" by Ranjan Dasgupta, Published in Sakal Times May 16, 2014. Author has opined that, MSRTC is among the top five performers both on financial and physical parameters. As per the statistical information provided by author, in 2011-12 it had earned a net profit of Rs. 30 crore. MSRTC are Karnataka state transport corporation topping the list by making a net profit of Rs. 60 crore. As per the opinion of author these two state transport corporations (MSRTC & KSRTC) have done well during the financial year 2011-12. The other state transport corporations are the Punjab state transport corporation with a net profit for Rs. 7 crore and Orissa state Transport Corporation with a net profit of Rs. 2 Crore. Author has further stated that, in the last five years or so, the MSRTC's performance has been remarkable. In fact, the average financial performance of most of the state transport corporations including that of MSRTC has showed remarkable improvements. In matters related to fuel efficiency, fleet utilization etc. these state transport corporations have done pretty well. However, author has sounded a note of caution for the state government and the management of Maharashtra state road transport corporation that some of its buses need to be replaced as soon as possible.

### **In Conclusion**

In spite of the fact that public transportation plays an important role in the economic, cultural, social and industrial development of any nation, transport sector has not received due consideration of the researchers in the past. However, at present universities, various research institutes of road transport, Association of State Road Transport Corporation, special division of planning commission and ministry of surface Transport etc. have taken special interest for the

researches in this sector several international levels. National level and state level studies have paid attention to the transport sector, today. The existing literature related to the present topic can be viewed from the different perspectives as review of literature in the context of international, national and state level.

The present study report endeavours to review briefly the related published literature in the forms of books study articles, researches etc to substantiate the views of various economists, management experts, in transportation sector. Researcher does not claim to review all the related literature in the context of the topic selected for the study. It is just an attempt to take a glance at some important works alone in the context of public transportation, passenger satisfaction, and financial problems facing by State Road Transport Corporations in India etc.

### **Major Observations and Suggestions**

#### **Major Observations Regarding Financial & Physical Performance**

1) It is observed that the efficient operations of Maharashtra State Road Transport Corporation is different owing to many legal constraints. Researcher has informed that, the motor vehicle act imposes many administrative procedures to get permit for route of the bus services. In case of Maharashtra State Road Transport Corporation, the demand pattern for passenger travel is also uneven and some time more random in nature than generally observed in the case of other productive enterprises.

2) It is observed that, the rising cost of many inputs required for bus operations is uncontrollable cost component as the operations have no influence to control the prices of fuel and spare parts, The economic rationale demands the immediate upward change in the fare structures based on the cost of the operations, but owing to legal and administrative procedure the various steps needed appear to be highly time consuming, more over resistance from public and political authorities are also creating problems even for justified increase in fare. The lag in increase in fare and high cost of operations owing to non-controllable cost component creates the long term problem of financial viability of the Maharashtra State Road Transport Corporation.

3) It is observed that, increasing taxation (passengers and motor vehicle taxes) on Maharashtra State Road Transport Corporation is highly burdensome. The fixed component of taxation which is independent of vehicle utilization per day creates fixed liabilities on Maharashtra State Road Transport Corporation. When the prices of inputs affecting variable cost

components are rising the fare is not flexible as needed, the burden of taxation is to be reduced so that the financial viability would be possible.

4) How the nationalization is being implemented in a particular state is also very much significant for economic operation of State Road Transport Corporation. Through, there is a fully nationalization of road transportation of Maharashtra, it compelling MSRTC to compete with private bus transport operators, many problems would crop up as private operators are having special advantages which may creates the problems for highly legalized and accountable organization like Maharashtra State Road Transport Corporation.

5) Inability (due to political Compulsions) to link the price of the service to the increase in the inputs cost due to fuel, spare parts, depreciation and wages. The price of diesel has increased year after year but the fare structure has not changed with the similar pattern. Today not only the cost of diesel and fuel has gone up but the cost of diesel and fuel has increased but the cost of salary and wages has also increased. So naturally there is an imbalance between the cost incurred and the revenue generated

6) The Road Transport Corporation Act (1950) stipulates that Road Transport Corporation function as commercial undertakings. At the same time it stipulates that they function in public interest as well. This inherent dichotomy in the act has led to a lot of ambiguity and confusion in interpreting the roles and functions of Maharashtra State Road Transport Corporation. Maharashtra State Road Transport Corporation, in particular has to offer concessional fare to various underprivileged section of the society and also operate along uneconomic routes.

7) Maharashtra State Road Transport Corporation provides an alternative mode of transportation. Today corporation competes with alternate modes as well as private bus operators of similar services. Maharashtra State Road Transport Corporation is operating in a highly competitive market but at the same time has to discharge public sector obligations like providing connectivity to locations which may not be attractive to private operators or plying on uneconomic routes, with uneconomic fares, delay in revision of fares, burden of concessional travel, high level of taxation under motor vehicle tax and passenger tax, higher fixed costs and limited flexibility as regards manpower.

8) It is observed that, like most of the others road transport corporations. Maharashtra State Road Transport Corporation chose to operate as a vertically integrated enterprise by owing and

managing all allied activities apart from its core activity of providing public passenger bus transportation. Researcher has found that, over a period of time it owned and operated a large number of depots, workshops, terminals, bus body building units at Pune, Aurangabad etc, tyre retreading plants and so forth. Researcher has informed that, the weak financial situation of Maharashtra State Road Transport Corporation made the maintenance of these assets all the more difficult.

9) It is also observed that, running and operating the allied activities, which had been justified on the backgrounds of lack specialization no longer has any economic rationale in the post liberalization and globalization era of specialization. However, the strong labour unions of Maharashtra State Road Transport Corporation, apart from a general reluctance to outsourcing has resulted in Maharashtra State Road Transport Corporation concentrating its attention needlessly on activities it could have outsourced at a lower cost which constitutes a relative large share in total cost.

10) The analysis drives home the observation that the Maharashtra State Road Transport Corporation offer huge amount of fare concession to different sections of the society. As a part of corporate social responsibility and a greater proportion of total concession standing on account of students, the blind etc. But the state government fails to support the corporation through reimbursement.

11) In the last 65 years needs of passengers have changed. Comparatively passengers today are not poor as they were 65 years ago. Now, they are ready to spend for better buses and good services, passengers will not support monopoly that is indifferent to the needs of the passengers will. Maharashtra State Road Transport Corporation will have to compete with the private bus operators by innovation and by playing the game in the same manner and by meeting the needs of the passengers. In big cities like Pune, Mumbai many buses will have to go to the passengers rather than expecting them to come to the bus station. It is observed that, auto or taxi fare for going to bus station is more or double than ST bus fare, therefore to attract passengers many private bus operators pickup and drop passengers at various points in the city. There is a need for flexibility in fares to meet the demands of passengers in different situation. Maharashtra State Road Transport Corporation has the potential to bounce back, but for that it needs support of the government.



Researcher has observed the strengths and weaknesses of the Maharashtra State Road Transport Corporation during the study period; which are listed below.

### **Quality of Service: Passengers opinion**

Through the interview researcher has tried to understand the opinions of passengers about quality of service rendered by Maharashtra State Road Transport Corporation.

- i) There is thin line between the passengers who opined that the service quality is good and the passengers who opined the quality of service is average. (Ref. table no. 5.46)
- ii) Majority of passengers have opined that the time punctuality of Maharashtra State Road Transport Corporation\_ is average; cleanliness of buses and bus stations is also very poor. But for safty travelling they have given first preference to the Maharashtra State Road Transport Corporation's buses.
- iii) There is no proper alternate arrangement for uncertain causes. Majority of passengers have opined that such type of arrangement is average type. But the passenger information service is very good because of authorized agents appointed by corporation in all the big cities of Maharashtra. Therefore passengers have easy access for reservations. (Ref table no. 5.50, 5.51)
- iv) Majority of passengers opined that the bus fare charged by Maharashtra State Road Transport Corporation is very expensive as compared with railway fare for long distance. (Ref. table no. 5.55). majority of passengers opined that the service provided by the corporation is of average level.

### **Suggestions**

On the basis of observations and discussions had with some of the officials of Maharashtra State Road Transport Corporation, researcher has made some suggestions with a view to improve the financial performance, physical performance and quality of service.

- i) It is suggested that, Maharashtra State Road Transport Corporation should follow automatic fare revision mechanism. The prices of few key inputs should be monitored and changes in their prices should automatically be fed into fares. This would be preferred to keeping fare levels for three to four years and then following the same with a steep fare hike which would lead to erosion of passenger traffic. Such a mechanism needs to be worked out in detail.
- ii) There should be greater flexibility in pricing for Maharashtra State Road Transport Corporation. Having a uniform fare structure throughout the organization may not be very wise move. As commonly perceived, it may not even be equitable. Maharashtra State Road Transport

Corporation should carefully study the demand pattern for its services and price them accordingly. This kind of pricing mechanism could lead to welfare maximization at the same time proving to be financially viable.

iii) In the view of the advantages of public bus transport system it would be desirable to lessen the burden of commodity taxation. In addition, public buses are subject to motor vehicles tax and passenger tax etc., which also need to be rationalized. It is a sorrow state of affairs to note that the amount of motor vehicle taxes is almost engulfing the total revenue of Maharashtra State Road Transport Corporation leaving no surplus. This needs the consideration of the policy makers to reduce the burden of taxes so as to provide a scope for corporation to stand financially.

iv) It is proposed to reduce the normal depreciation fund and spend it to reduce loans and current liabilities. The Maharashtra State Road Transport Corporation should aim to build up a corpus fund over a period of five years to help to increase the revenue and to undertake capital investment. The state government must enable the corporation to raise additional funds by giving guarantee to debentures and in return it will help in lowering the interest rate.

v) The Maharashtra State Road Transport Corporation depends more upon loans and revenue liabilities. Increasing loans and liabilities are creating obstacles in the financial improvement and growth of organization. To avoid this situation the state government of Maharashtra need to make different groups like students, physically handicapped people, journalists, freedom fighters, senior citizen etc. It is the mere political interest of government that has to be implemented by corporation as a compulsion. The government always agrees to reimburse the total concession cost to Maharashtra State Road Transport Corporation and hardly succeeds. The government never reimburses the subsidy properly. This is major obstacle in the financial growth of corporation. It is suggested that, the state government should reimburse concessions, subsidy total amount in two or three phases in a year. So as to meet operating cost to reduce the huge cost burden. It is also suggested that, proper steps should be taken by the government to pay the subsidy amount to Maharashtra State Road Transport Corporation otherwise it is suggested to cancel these concessions.

vi) It is suggested that, the government must play a strict and impartial role of regulator to rectify defects in transport act. The state government may take effective steps to control illegal operations of private bus companies and regulate the operation of private buses as well.

vii) It is suggested that, there is a large scope to improve non-traffic revenue in corporation through launching of major advertising campaign. It should implement some measures to improve luggage revenue, introduction of parcel services and transport corporation can introduce postal services, produce high security number plates, pay and park and commercial complexes in vacant land of corporation in the city to have a additional revenue.

viii) It is recommended that, tendering for purchase of diesel and by ensuring supply of certain important input HSD oil at controlled process is to be implemented. Corporation can establish petrol bunks in vacant places of corporation so as to raise income sources.

ix) It is advised that, as a part of calculating service wise profitability, corporation has to identify the loss gaining routes and they must stop these routes or these routes must be redesigned with a view to getting profits.

x) It is also suggested that, the government of Maharashtra is giving subsidy for motor vehicle tax to the other organization and subsidy is being paid by the government. It has to end its discriminatory tax policy by bringing down motor vehicle tax to a uniform percent of the traffic revenue, as prevalent in the neighboring states. The government should reduce value added tax, motor vehicle tax, passenger tax and sales tax on Maharashtra State Road Transport Corporation. This will result in reducing losses.

xi) It is proposed that, the Maharashtra State Road Transport Corporation should impose severe cases on activists who is responsible for damage of buses at the time of bandhs or agitations, Corporation should not provide buses for political parties, government activities or meetings without receiving total amount or sufficient advances for bookings.

## **BIBLIOGRAPHY**

1. Report of the Committee on Transport Policy and Co-ordination, Planning Commission, Govt. of India, 1966.
2. Report of the National Transport Policy Committee, Planning Commission, Govt, of India, 1980.
3. Study on Modal Cost and Traffic Flows, Rail India Technical and Economic Services, New Delhi, 1980.
4. Report of the Planning Group on Road Transport, Planning Commission, Govt, of India, 1987.
5. Patankar, P. G., 1994, Policy Reforms for Road Development, Seminar on 'Privatization of Roads', Indian Merchants' Chamber, Mumbai, March.

6. Kadiyali, L. R., 1986, Estimation of Total Freight and Passenger Movements in India, Report by Engineering Consultants, New Delhi.
7. Sriraman, S., 1987, "Road Transport Industry in India", Economic Times.
8. Sriraman, S., 1977, "Road User Cost Study" Asian Transport J.
9. Road User Cost Study, 1982, Central Road Research Institute, New Delhi.
10. Road Deterioration in Developing Countries, World Bank, Washington DC, 1989.
11. A Study of the Performance of State Road Transport Undertakings, Planning Commission, Govt, of India. 1955.
12. Study on Modal Cost and Traffic Flows, Rail India Technical and Economic Services, New Delhi, 1980.
13. Dalvi, M. Q., 1992, Policy in India, Mimeograph.
14. Mishra, R. K. and Nandagopal, R., 1991, Efficiency Through Competition in Public Utilities, The Journal of Institute of Public Enterprise, Vol. 14, Issue-2.
15. Meyer, J. R. and Gomez, I, "The Impact of Public Transport on Us Metropolitan Wage Inequality", International Journal of Transport Economics. J. Transport Econ, No. 3.
16. Road Transport Industry in India, National Council of Applied Economic Research, New Delhi, 1978, Central Institute of Road Transport.
17. Road Goods Transport in India, Central Institute of Road Transport, Pune, 1994.
18. Small, K. et al., 1989, Road Work. A New Highway Pricing and Investment Policy, Brookings Institution, Washington.
19. Vehicle Modernization and Road User Study, World Bank, 1987, Kathuria, S., Competing Through Technology And Manufacturing, Oxford University Press.
20. Biswanath Chakrobarthy, (2007): Is it Meaningful to Measure Performance of Government Sector, Journal of Commerce, Vidyasagar University, Vol.12 pp.32-42.
21. John Pucher and Nisha Korattyswaroopam, (2004): The Croresis of Public Transport in India: Overwhelming Needs But Limited Resources, Journal of Public Transportation, Vol. 7, No. 4, pp. 1-20.
22. Annual Report of GSRTC from 2001 -02 to 2006-07.
23. Operational Result of GSRTC from 2001-02 to 2008-09.
24. Cumulative Costing Result of GSRTC from 2001 -02 to 2008-09.
25. Statement for target and achievements of GSRTC from 2001-02 to 2008-09.
26. Circulars of GSRTC from 2001-02 to 2006-07.
27. Information Statement for State Government -Ministry for Transport.
28. GSRTC website [www.gujaratstc.com](http://www.gujaratstc.com)-referred on December 2009.
29. Tanmay Desai, Sanjay Parmer, 2009, GIDC Rajju Shroff Rofel Institute of Management Studies, Vapi, Summer Internship Project, "Study of GSRTC".
30. N. Ravichandran and Surya Prasad, (2007), Reviving Gujarat State Road Transport Corporation: An Agenda For Action. Report submitted at IIM-Ahmedabad, [linkww.iimahd.emet.in/publications/data/2007-03-05\\_NRavichandran.pdf](http://linkww.iimahd.emet.in/publications/data/2007-03-05_NRavichandran.pdf).

31. Report Of The Planning Commission. 11th Plan Period, Govt., Of India. New Delhi. 2010  
Report on SRTUs - Twelfth Five Year Plan, RBI, Mumbai. 2012-17.
32. Profile & Performance of STUs, CIRT, Pune. 2009-10
33. Report On Road Transport Sector , World Bank, 2008.
34. Rajindar K.Koshal., 1970, Economies of Scale In Bus Transport - II - Some Indian Experience. Journal of Transport Economics and Policy, Vol. IV, No. 1, Jan, 1970, p.p.29-36.
35. Profile & Performance of STUs, CIRT, Pune, 2009-10.
36. P. Jegadish Gandhi., , 1994, Indian Transport System: An Appraisal of Nationalised Bus Services, Mittal Publications, New Delhi, p. 110.
37. Review On Performance Of SRTUs, Ministry Of Road Transport and Highways (MORTH), New Delhi. 2010.
38. Anderson.S.C and Fielding G.J., 1982, Comparative Analysis of Transport Performance, Journal of Transport Performance, Irvine, CA.
39. Fujii, Satoshi and Ryuichi Kitamura., 2003, What Does a One-Month Free Bus Ticket do to Habitual Drivers? An Experimental Analysis of Habit and Attitude Change, Transportation, Vol. 30, p.p. 81-95.
40. G. Ramesh and T.V. Ramanayya, 2007, Economic Contribution Of Public Passenger Transport / Organisations—An Application Of EVA Methodology, Vision, The Journal of Business Perspective, Vol. 11, No. 3 1, July-September, 2007, p.p.25-36.
41. Dr. R.K.Agarwal and Pramod Bhargava., 1965, Profitability Analysis Of State Road Transport Undertakings : A Case Study Of RSRTC and UPSRTC, Asian and Pacific Accountant, New Delhi, p.p. 143-168.
42. Financing Transport Infrastructure and Services in India, RBI, Mumbai, 2009.
43. John Puchera, Nisha Korattyswaropama, Neha Mittala, Neenu Ittyerahb (2005). Urban Transport Crisis in India, Transport Policy, Vol. 12 , p.p. 185-198.
44. J. Mahalingu & J.Madegowda (2011), Impact of Motor Vehicle Taxation Policy on the Financial Viability of STUs in India Indian Journal of Transport Management, Jan-March,p.p.32-43.
45. S.John Manohar and P.Gurunathan. , 2010, Application of Balanced Score Card Method for Measuring Service Productivity in Passenger Transport Industry: Empirical Evidence, Journal Of Transport Management, Vol.34, No.4, Oct-Dec, 2010, p.p.285-311.
46. Keck.C. A And N.R.Schneidr., 1979, Economist Efficiency And Effectiveness: The Development and Application Of Multimodal Performance Measures For Transport Systems In New York State, Presented At The 59 Annual Meeting Of The Transportation Research Board, Washington D C.
47. Farrell M.J., 1957, The Measurement of Productive Efficiency, Journal of Royal Statistical Society. Series A, CXX,No.3, 1957, p.p.253-290.
48. Anderson S. C and Fielding G.J., 1982, Comparative Analysis Of Transport Performance, Journal Of Transport Performance, Irvine, CA.

49. Jagdish Gandhi., 2004, Indian Transport System: An Appraisal of Nationalised Bus Services, Concept Publishing House, New Delhi, p.31.
50. Research Paper on The Effectiveness of Undertakings in the Bus Industry, National Economic Research Associates, 2004
51. F.C. Kulshrestha., 1989, Management Of State Road Transports in India, Mittal Publications, New Delhi.
52. John Pucher, Nisha Korattyswaroopam, Neenu Ittyerah., 2004, The Crisis of Public Transport in India: Overwhelming Needs but Limited Resources, Journal Of Public Transportation, Vol.7, No.3, p.p. 1-20.



## **Study the relationship between Employee value proposition and employee turnover in Management Institutes with reference to Pune (India)**

Dr. Reshma Ramnath Kabugade (Associate Professor, NBN Sinhgad School of Management studies ambegaon bk Pune)

Mr. Rohan Ramnath Kabugade. (Assistant Professor, Jaywant College of Engineering & Management, Tal-Karad

### **Abstract:**

As compare to the other Sectors, education Sector plays an important role in the Development of the country. Based on financial support getting from the government, the education sector has been divided into the two-part first is granted colleges and the second one is non granted colleges in Maharashtra, India. Management institutes belong to non granted institutes in Maharashtra, so most of the institutes are treated as private Institutes hence respective private organization management is responsible to provide all the benefits and facilities for employees in the education sector. Nowadays the faculty turnover rate increases in Management institutes which leads to decreases the quality of education.

This Research Article focuses on the correlation between employees value proposition and employees turnover, which would help to understand the relationship between getting benefits to the employees and their turnover.

### **Introduction:**

In today's array Employment seekers are required to congregate their Physiological, Safety, social, self esteem and achievement needs. If they fail to meet their requirement, they would start to search new job opportunities. Management institutes are facing significant difficulties in employee attraction and maintenance, at the time of joining as a faculty staffs in management Institutes candidates are facing self evaluated questions like

What's in it for me?"

“What more can you offer?

Can I upgrade myself?

All these questions are associated with various levels of human needs. Every layer of HR facets is required to work on employees need in provisions of employee's value proposition.

Minchington (2005) defines an Employee Value Proposition (EVP) as a set of associations and offerings provided by an organisation in return for the skills, capabilities and experiences an employee brings to the organisation. It is an employee-centred approach that is aligned to existing, integrated workforce planning strategies as it has been informed by existing employees and the external target audience.

### **Review of Literature:**

The trouble of examining this subject showed up in the irregularity in the measure of writing. For this situation, the creator could locate an endless measure of writing and research on staff turnover beginning from as right on time as the 1950s (March and Simon, 1958).

However, employer branding is a somewhat new idea very little scholarly writing can be found. The principle research and hypothetical examination are produced by Richard Mosley (1990), who initially made the idea. Moreover, a large portion of the research concentrating on employer branding depends on the work of Backhaus and Tikoo (2004),

Barrow and Mosley (2005) and Moroko and Uncles (2008; 2009). The creator found that the writing is fairly oversimplified in its perspectives all writing and contextual investigations found to have one and only message: "employer branding is great". Henceforth the creator has not possessed the capacity to discover much writing on negative effects or research demonstrating something else.

### **Objectives:**

1. To identify statutory benefits getting to faculty staff members of Management
2. To identify non-statutory benefits getting to faculty staff of Management
3. To understand the reasons behind the turnover of employees in Management Institutes
4. To study the correlation between employee benefits and employee turnover.

### **Research Methodology**

#### **1.2. Problem Statement**

Every employee working in any organization wants to pull off their needs at various level. To study the correlation between employee value proposition and employee's turnover is necessary.

#### **1.3. Research Objectives**

This study is designed to test how employee benefits can concern the turn over the intention of faculty members.

#### **1.4. Hypothesis**

The review of literature of this study has helped to develop the following hypothesis:

Ho: There would be no relationship between employee benefits and turnover intention among employees

#### **1.5. Research Methodology**

##### **1.5.1. Sampling**

This research study has been carried out in different Management Institutes of Pune , who are providing

master levels education, convenient sampling methods have been used due to the financial and time limits for the collection of the data. The sample size is 70 faculty

members from four colleges including, assistant professor, associate professor , Professors, and directors.

The ages of participants were from 25 to 60 years having Masters in PhD qualification.

### 1.5.2. Data Collection Method

The respondents were informed about the objectives of the research study. Once the communication with the respondent established, the personal information sheet was worked out which focused on the respondent's work experience, age, marital status, gender, education, an order of current job, and main reasons for leaving the last job.

Also, statements were asked in a questionnaire to check an employee's turnover intention. Participants responded on a five-point Likert Scale. To study the collected data statistically,

help was taken by Ms-Excel for statistical analysis. In order to address the analytical framework of the study, a structured questionnaire was developed based on the literature Review

### Data Analysis :

<b>1. Gender</b>	<b>No. of Respondents</b>
Female	43
Male	27
	70
<b>2. Age</b>	
Less than 30 years	17
30 to less than 40	36
40 to less than 50	7
50 years or more	3
<b>3. Educational Qualifications:</b>	
Diploma or less	0
Bachelor	0
Master	46
Doctorate	24
<b>4. Years of Service</b>	
Less than 5 Years	22
5 to less than 10	31
10 to less than 15	17

5. Job Category	
Assistant Professor	33
Associate Professor	27
Profesor	7
Director	3
<b>7. Contract Type</b>	
Full-Time permanent Approval	34
temporary 1 Year Approval	17
Fixed-Term Contract	19
Part-Time contract Group	0

<b>A. Reward</b>	
1	The competitiveness of the job’s financial compensation package
2	The comprehensiveness of the organization’s health benefits
3	The comprehensiveness of the organization’s retirement benefits
4	The amount of holiday/vacation time that employees earn annually

<b>A. Reward</b>	<i>Column 1</i>	<i>Column 2</i>	<i>Column 3</i>	<i>Column 4</i>	Turnover
<i>Column 1</i>	1				
<i>Column 2</i>	1	1			
<i>Column 3</i>	0.561535	0.561535	1		
<i>Column 4</i>	0.115865	0.115865	0.206716	1	
Turnover	0.76337	0.76337	0.667206	0.703377	1

Interpretation:

The above table shows that,1. There is significant correlation between, The comprehensiveness of the organization’s health benefits. 2. the comprehensiveness of the organization’s retirement benefits 4. the amount of holiday/vacation time that employees earn annually and Turnover.

<b>B. Career Opportunity</b>	
1	The developmental/ educational opportunities provided by the job and organization
2	The future career opportunities provided by organization
3	The growth rate of the organization's business is high
4	Here employees are rewarded and promoted based on their achievements
5	Good level of stability of the organization

<b>Career Opportunity</b>	<i>Column 1</i>	<i>Column 2</i>	<i>Column 3</i>	<i>Column 4</i>	<i>Column 5</i>	Turnover
<i>Column 1</i>	1					
<i>Column 2</i>	0.959235	1				
<i>Column 3</i>	0.262203	0.309235	1			
<i>Column 4</i>	0.185969	0.240056	0.847432	1		
<i>Column 5</i>	-0.09093	-0.05493	0.417466	0.462939	1	
Turnover	0.153312	0.207342	0.907974	0.918022	0.712639	1

Interpretation:

The above table shows that there is significant correlation between,

- 1.The growth rate of the organization's business is high 2. employees are rewarded and promoted based on their achievements and employees turnover 3.Good level of stability of the organization and turnover.
- 1. The developmental/ educational opportunities provided by the job and organization, 2. The future career opportunities provided by organization are depicts weak correlation with turnover.

<b>C The Organization</b>	
1	The organization’s reputation as an employer has been recognized by a third-party organization
2	The reputation of Students served in performing the job
3	The organization’s level of commitment to having a diverse workforce



4	The level of involvement employees have in decisions that affect their job and career
5	Whether the work environment is formal
6	The competitive position the organization holds in its market(s)
7	The degree of respect that the organization shows employees
8	High amount of risk that the organization encourages employees to take
9	The extent to which the organization invests in modern technology and equipment

<b>C The Organization</b>	<i>Column 1</i>	<i>Column 2</i>	<i>Column 3</i>	<i>Column 4</i>	<i>Column 5</i>	<i>Column 6</i>	<i>Column 7</i>	<i>Column 8</i>	<i>Column 9</i>	Turnover
<i>Column 1</i>	1									
<i>Column 2</i>	0.7185 16	1								
<i>Column 3</i>	1	0.7185 16	1							
<i>Column 4</i>	1	0.7185 16	1	1						
<i>Column 5</i>	0.8893 35	0.7367 65	0.8893 35	0.8893 35	1					
<i>Column 6</i>	0.7185 16	1	0.7185 16	0.7185 16	0.7367 65	1				
<i>Column 7</i>	0.7555 5	0.6360 53	0.7555 5	0.7555 5	0.7386 54	0.6360 53	1			
<i>Column 8</i>	0.7555 5	0.6360 53	0.7555 5	0.7555 5	0.7386 54	0.6360 53	1	1		
<i>Column 9</i>	1	0.7185 16	1	1	0.8893 35	0.7185 16	0.7555 5	0.7555 5	1	
Turnover	0.9076 25	0.7118 51	0.9076 25	0.9076 25	0.8507 07	0.7118 51	0.9607 52	0.9607 52	0.9076 25	1

Interpretation:

From above table it shows that, there are strong positive correlations between 1. The organization’s reputation as an employer has been recognized by a third-party organization 2. The reputation of students served in performing the job 3. The organization’s level of commitment to having a diverse workforce 4. The level of involvement employees have in decisions that affect their job and career 5. the work environment is formal 6. The competitive

position the organization holds in its market(s) 7. The degree of respect that the organization shows employees 8.High amount of risk that the organization encourages employees to take 9. The extent to which the organization invests in modern technology and equipment and Employee turnover

<b>D Work</b>	
1	The opportunity provided by the job task to work on innovative and “leading edge” projects
2	The level of impact the job has on outcomes
3	Whether the job responsibilities match your interests
4	The location of the jobs the organization offers
5	The recognition provided to employees by the organization
6	The extent to which the job allows you to balance our work and your other interests

	<i>Column 1</i>	<i>Column 2</i>	<i>Column 3</i>	<i>Column 4</i>	<i>Column 5</i>	<i>Column 6</i>	Turnover
Column 1	1						
Column 2	0.737385	1					
Column 3	0.737385	1	1				
Column 4	1	0.737385	0.737385	1			
Column 5	1	0.737385	0.737385	1	1		
Column 6	0.737385	1	1	0.737385	0.737385	1	
Turnover	0.970747	0.877999	0.877999	0.970747	0.970747	0.877999	1

**Interpretation:**

From above table it shows that there are strong positive correlations between 1.The opportunities provided by the job to work on innovative, “leading edge” projects 2. The level of impact the job has on outcomes 3.Whether the job responsibilities match your interests .4. The location of the

jobs the organization offers 5. The recognition provided to employees by the organization 6. The extent to which the job allows Employees to balance our work and their other interests and Employees turnover.

<b>E. Monetary and non monetary benefits</b>	
1	Getting pay scale as the Government norms
2	Getting salary on time
3	Getting incentives for qualification upgrade
4	Getting incentives for good performance

	<i>Column 1</i>	<i>Column 2</i>	<i>Column 3</i>	<i>Column 4</i>	Turnover
Column 1	1				
Column 2	0.547658	1			
Column 3	0.547658	1	1		
Column 4	0.286074	0.41953	0.41953	1	
Turnover	0.525881	0.914372	0.914372	0.751129	1

Interpretation:

From above table it shows that 1.Getting salary on time, 2.Getting incentives for qualification upgrade, these two parameters are showing Strong correlation with employees turnover.

1.Getting pay scale as the Government norms, 2.Getting incentives for good performance are showing moderate positive correlation with employee turnover.

<b>Turnover</b>		<b>Mean</b>	<b>SD</b>
1	How likely is that you will actively look for a new job in the next year?	16	3.60
2	I often think about quitting.	19.6	2.8
3	I will possibly look for a new job next year.	11	4.61

**Interpretation:**

Respondents are having majority reposes towards frequently looking for job.

**Findings:**

**Following are the Findings**

- organization's health benefits retirement benefits holiday/vacation time that employees earn annually

Findings:

1. The Comprehensiveness of the organization's health benefits, organization's retirement benefits, and the amount of holiday/vacation time that employees earn annually are having an association with employee's turnover in the institute.
2. The growth rate of the organization's business , employees are rewarded and promoted based on their achievements are having strong relationship with employees turnover wherein weak relationship with the aspect of " good level of stability of the organization"
3. The developmental/ educational opportunities provided by the job and organization shown strong relationship with employees turnover where the future career opportunities provided by organization are depicts weak correlation with turnover.
4. The organization's reputation as an employer has been recognized by a third-party organization, the reputation of students served in performing the job, the organization's level of commitment to having a diverse workforce, the level of involvement employees have in decisions that affect their job and career, formal work environment, the competitive position the organization holds in its market, the degree of respect that the organization shows employees, risk of organization to encouragement of employees and the organization invests in modern technology and equipment and Employee turnover
5. A Strong relationship between the opportunities provided by the job to work on innovative, "leading edge" projects, the level of impact, the job has on outcomes, whether the job

responsibilities match their interests, The location of the jobs the organization offers 5. The recognition provided to employees by the organization helping to manage work-life and Employee turnover.

6. From above table, it shows that getting salary on time, incentives for qualification upgrade, these two parameters are showing Strong correlation with employees turnover, pay scale as the Government norms, incentives for good performance are showing moderate positive correlation with employee turnover.
7. Faculty members are having majority responses towards frequently looking for jobs.

### **Conclusion**

Employee turnover refers to the number or percentage of workers who leave an organization and are replaced by new employees. There are several reasons in the management institute responsible for employee turnover. Following is the list of determinants in management institutions that are showing a strong correlation with faculty's turnover.

### **References**

- [1] Aaker DA. *Managing Brand Equity: Capitalizing on the Value of a Brand Name*. The Free Press, New York, NY, 1991.
- [2] Peters T. *The Brand You 50: Fifty Ways to Transform Yourself from an Employee into a Brand that Shouts Distinction*, Knopf Publishers", New York, NY, 1999.
- [3] Barrow S, Richard M. *The Employer Brand: Bring the Best of Brand Management to People at Work*, John Wiley & Sons, Ltd. UK, 2005.
- [4] Sutherland MM, Torricelli DG, Karg RF. Employer of choice branding for knowledge workers. *South African Journal of Business Management* 2002; 33(4): 1320.
- [5] Keller KL. Conceptualizing, measuring, and managing customer based Brand equity. *Journal of Marketing* 1993; 57: 122.

[6] Dawn SK, Biswas S. Employer branding: A new strategic dimension of Indian corporation. Asian Journal of Management Research 2007; 21.

[7] Heger BK. Linking Employment Value Proposition (EVP) to Employee Engagement and Business Outcomes: Preliminary Findings from a Linkage Research Pilot Study. Organizational Development Journal 2007; 25(2): 21-33.

[8] Kucherov D, Zavyalova E. HRD practices and talent management n the companies with the employer brand. European Journal of Training and Development 2012; 36.

[9] Bergstrom K, Anderson M. Delivering on promises to the marketplace: using employment branding to build employee satisfaction. Journal of Integrated Communications, 2001.

[10] <http://www.greateplacetowork.in>

[11] <http://www.hrmguide.net/buscon1.html>

[12] <http://www.wikipedia.org/wiki/employer-branding>

[13] <http://www.employmentbrand.com>

[14] <http://www.humanresources.about.com>

15

[https://iugspace.iugaza.edu.ps/bitstream/handle/20.500.12358/19570/file\\_1.pdf?sequence=1&isAllowed=](https://iugspace.iugaza.edu.ps/bitstream/handle/20.500.12358/19570/file_1.pdf?sequence=1&isAllowed=)

y



## “Study the Consumer Interaction in FMCG product through the Voice Search Technology”

*Author1 :Dr. Reshma R. Kabugade*

(Associate Professor , NBN Sinhgad School of Management Studies, Ambegaon BK ), Pune.

*Author2: Dr.Santosh Gore*

(Assistant Professor,NBN Sinhgad School of Management Studies, Ambegaon Bk), Pune.

*Author3:Prof.Avinash Dandvate*

(Assistant Professor,NBN Sinhgad School of Management Studies, Ambegaon Bk), Pune

E-mail Id- [avinash.dandvate.nbnssoms@sinhgad.edu](mailto:avinash.dandvate.nbnssoms@sinhgad.edu)

### **To Cite this Article**

Dr. Reshma R. Kabugade , Dr.Santosh Gore, Prof.Avinash Dandvate, “Study the Consumer Interaction in FMCG product through the Voice Search Technology”, Journal of science and Technology , vol.4, issue 04, July-August 2019, Pp

### **Article Info**

Received: 25-06-2019

Revised: 10-06-2019

Accepted: 14-06-2019

Published: 18-06-2019

### **Abstract:**

Research article name is “study the consumer interaction in FMCG product through the voice search technology” the aim was to understand the voice search technology and know the various types of the voice search technology even to know the types of store where this kind of technology is used. The main objectives of the study is to see the effects of voice search technology in order to identify the customer interaction with the FMCG product, to know what exactly stores opinion about this type of marketing technology. This research article focused on the voice search technology used for consumer interaction, identify various ways to interact with customer through voice search technology, To know the advantages and disadvantages of V.S.T. (voices search technology) while doing consumer interaction. The data collection was done by primary and observation method was the first method and second was questioner method was used the area sampling method was use to see the v.s.t. impact on the different stores and to check which type of voice search technology they use to see the customer interactions with the FMCG product.

**Key Words:** Consumer Interaction, Voice-search Technology, FMCG Product, Stores etc.

## **I. Introduction**

Fast-Moving Consumer Goods (FMCG) or Consumer Packaged Goods (CPG) are the products that sold on daily basis & under whatever circumstances. Some FMCG goods deteriorate within short span of time hence to be consumed immediately, viz. meats, fruits, vegetables, dairy products, and baked goods which are highly perishable. Others, such as pre-packaged foods, soft drinks, candies, and toiletries have high turnover ratios. Sales of FMCG goods are sometimes influenced by holidays and/ or seasonal periods and the discounts offered. As every single interaction with consumer can be an opportunity for your business to satisfy & retain them for future transactions.

Interaction is a basic form of communication between the company and the customer. Customer service has always been considered a circular process in consumer interaction. Customers complain the company about the value, quality, after sales service sometimes and the company tries to solve the customer’s

problem. However, platform of interaction has changed more to a proactive role with the introduction of social media and e-resources. A customer who experiences substandard customer service will spread negative word of mouth about the company in the environment.

Voice search technology include things like CCTV, Real-Time Shelf Monitoring, Digital Receipts, direct interaction with the customers, interaction through loud speaker in each and every store, superstore, grocery etc. Use this type of technology to see the consumer interaction with the FMCG products normal they keep the tract of the entire products track by the same technology this helpful to see the customers interaction with the FMCG product and their buying behavior of the fast moving consumer goods.

This Technology is used in Stores, Super stores, grocery shops to manage the supply and to understand the most demanded FMCG products. This can be help full for customers also to get the help they required to get the idea about particular goods and help them with the assistance for example in every super store there is one help desk to solve customer’s queries.

The growth of the internet over the past quarter century and the rise of the brand community phenomenon have contributed immensely to the demand for FMCGs. For example, according to German research group AGOF's research about internet facts, 73% of Germany's population is online. Additionally, 83.7% of internet users claimed use of the web to search for information and 68.3% to shop online. However, most consumers preferred nearby brick and mortar stores over the online platform in this category.

**Literature Review:**

An empirical study on voice assistants on consumer engagement and loyalty, E-commerce shopping has gradually become consumers' choice of shopping process and part of this shopping is helped by advanced technologies including voice assistants (VA). Presently, there is a variety of artificial intelligence tools that are being developed in the market, and VA has gradually gained its presence or information acquisition. In this paper, we propose a model that investigates the technology acceptance model constructs (perceived ease of use and usefulness) and its effect on the engagement and loyalty between VA and consumers. Our model also investigates the moderating role of localizing VA between transactional and non-transactional online activities. This study highlights the implication of technological integration in an e-commerce environment.

For decades, advertising represented the primary tool to generate brand awareness, for improving recall and recognition. With the rise of the Internet, the concept of advertising transmuted to search engines where advertisers buy promotional spaces in response to a set of keywords searched by the user. Within digital advertising, “search advertising” represents the most successful format, accounting for 45% of the total spending (IAB & PWC, 2018). Advertisers face an overall cost increase of search ads with a particular impact on highly competitive consumer products. For instance, the cost per click on the search term “laundrydetergentliquid” reached \$17 on Amazon.

Although brands are generally positive towards this new form of investment, the peculiarities of the voice channel also induced concerns. Compared to web browser navigation where search engines can display ten results per page and up to five advertisements, VAs can only suggest a few results with limited space for sponsored messages. This scarcity of space increased intense competition among advertisers with arises in advertising budgets.

“How voice Technology is connecting brands and customers” written by web strategist Zach Aaronson. As voices were becoming powerful instruments of change, with emerging voice technology. Voice technology is making an impact across the digital landscape, including the ways consumers compose searches on Google, how we purchase toilet paper, and even how we sign up for health insurance policies. This emerging mode of digital communication is disrupting our most fundamental notions of human-machine interaction.

As voice technology continues to grow at a rate comparable to the internet in the 90's and smart phones in the 2010's, naturally, brands want in on the action.

### **Objectives**

1. To understand the voice search technology used for consumer interaction
2. To identify various ways to interact with customer through voice search technology
3. To know the advantages and disadvantages of V.S.T.(voice search technology) while doing consumer interaction
4. To invite valuable inputs from consumer related voice-search technology up-gradation.

### **Voice-search technology tools:**

- CCTV,
- Real-Time Shelf Monitoring
- Digital Receipts
- Direct interaction with the customers,
- Interaction through loudspeaker each and every store, superstore, grocery etc.
- Product Labeling(barcode)

### **Research Methodology:**

For this study the area of project is Pune, the goals of project (objectives) was to see the customer's interaction with the FMCG products through voice search technology. In super stores, stores and grocery shopping, Pune city.

Sampling size has been selected from the universe to constitute the sample of uses of voice-search technology. In this study, 10% of sample has been taken from the population.

For this research area random sampling method was used i.e. including Shops, Superstore, general store, every single place where FMCG products get sell and maintaining about consumer interaction data. The research has been conducted on primary data, which was collected by using questionnaire and secondary data.

**Selection of Sample:** Estimated Sample size is 66. Purposive Sampling Method is used for the study. Total 70 Questionnaire circulated to different retail shops, grocery shops, malls, supermarket etc. out of that 57 respondents were taken for data analysis as 13 responses are irrelevant were taken from Sinhgad road, Pune city.

$$N = Z^2 \times (P)(1-P) / D^2$$

Where N=Sample Size

Z=Standard Deviation at 95% confidence level (1.96)

P=Expected population proportion (0.5)

D=Desired Precision (0.05)

$$N=1.96^2 \times 0.5 \times (1-0.5) / (0.05)^2$$

$$N = 66$$

**Data-analysis:**

**1. Table No.1: What type of store you run ?**

Type of store	Responses in Percentage
Grocery store	40
Superstore	10
General store	50
Small shop	0
<b>Total</b>	100

**2. Table No.2 Do you know the use of any kind of Voice Search Technology?**

Uses of Voice Search Technology	Responses in Percentage
Yes	20
No	10
Maybe	0
No Idea	90
<b>Total</b>	100

This table shows that the from the 100% , 20% have idea about of voicesearchtechnology,10% don't know the about this technology, 20% have some sort of knowledge and ,90% have no idea if this type of technology exist

**3) Table No.3: What type of V.S.T.do you use to keep the track of FMCG Product?**

<b>Type of VAST</b>	<b>Responses in Percentage</b>
keeping a record	30
Labeling products	20
Through CCTV	20
Digital records	30
<b>Total</b>	<b>100</b>

From the above chart 30%, keep there recording their books, 20% labeling products, 20% use the CCTV for VST, 30% use the digital records as a voice-search technology.

**4) Table No. 4: How will you can use the V.S.T.**

<b>Particulars</b>	<b>Responses in Percentage</b>
To lead the customers to- Words product	20
To understand and complete the customers Requirement	10
To tack the feedback of Customers	20
All of the Above	50
<b>Total</b>	<b>100</b>

From the above chart it shows that 20% to lead the customers to words product, 10% to understand and complete the customers requirement, 20% to tack the feedback of customers, 50% use as all of the above.

**5) Table No.5: Either V.S.T. helps you in your Business?**

<b>Either V.S.T. helps you in your Business?</b>	<b>Responses in Percentage</b>
Yes	80



No	20
Total	100

From the above chart it shows that 80% have positive impact on their business that V.S.T helps their business and, for 20% V.S.T is not helpful for their business.

**6) Table No.6: How does the V.S.T. help with your Business?**

Particular	Response in Percentage
Helps to understand customer demand	10
Helps customer to attract to-words Product	20
Helps to maintain records	20
All of the above	50
Total	100

From the above chart 10% helps to understand customer demand, 20% helps customer to attract to-words product, 20% helps to maintain records, 50% use as all of the above

**7) Table No.7: What is your opinion about VST accuracy?**

Particulars	Response in percentage
Very accurate	50
Neutral	30
Not so accurate	20
Total	100

From the above chart 50% opinion about V.S.T. is very accurate, 30% opinion is natural, 20% says not so accurate

**8) Table No.8: Do you tack any further action on the result of your V.S.T.?**

Action	Response
Yes	70
No	30
Total	100

From the above chart it shows that 70% use V.S.T. results for further action, 30% have no use V.S.T. results in further action.

### ***FINDING, SUGGESTION AND CONCLUSION***

From the responses it shows that majority of their store have no idea about this voice search technology ,even they are using it. Different store have different type of voice search technology as per there store size and capacity & uses.

- Majority of retailers are not aware about Voice-search technology
- Most of the respondent keeps recording in their books; some of them are using VST to labeling products, some of using the CCTV and use the digital records as a voice-search technology.
- Half of the respondents are agree that VST is useful to lead the customers to-words product, understand and complete the customers requirement and also tack the feedback of customers.
- Majority respondents have positive impact on their business that V.S.T helps their business.
- Half of the respondents depicted that V.S.T. is very accurate,
- Majority of respondents opinioned that VST should be results in further action.

Types of voice-search technology are as follows

- 1) Monitor the customer action through CCTV
- 2) Digital record maintain of the FMCG product
- 3) Labeling product
- 4) Loud speaker to direct/attract the customer towards FMCG product
- 5) Keeping the records in books

### **Conclusion:**

Voice search technology helps to understand customer demand from the FMCG product that help shop keeper to understand most demanded product, their requirement or any issues related with the product. Voice-search technology also helps to get the right feedback from the customers forex. Help desk at super store like D-mart and big-bazaar. Voice search technology is most accurate technology to identify the customer's interaction and the re-demand for the FMCG product.

### **References:**

- Philip Kotler “marketing management” defining new product launching. Part 1, Chapter 2 page 32- developing market strategies and plans. Part 2, chapter 3,4 page 66 to 96 collection information and forecasting demand and conducting marketing research
- Koksai, I. (2018, December 11). How Alexa Is Changing The Future Of Advertising. Forbes. Retrieved June 7,2019, from <https://www.forbes.com/sites/ilkerkoksai/2018/12/11/how-alexa-is-changing-the-future-of-advertising/#693c38221d4d>
- [www.ameyo.com/blog/customer-interaction-management-the-definitive-guide-to-contact-center-cim](http://www.ameyo.com/blog/customer-interaction-management-the-definitive-guide-to-contact-center-cim)
- [https://en.wikipedia.org/wiki/Fast-moving\\_consumer\\_goods#Fast-moving\\_consumer\\_electronics](https://en.wikipedia.org/wiki/Fast-moving_consumer_goods#Fast-moving_consumer_electronics)