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Message from the Editor



Dear Readers,

Indian Institution of Industrial Engineering is very happy to publish this issue of the Industrial Engineering Journal.

The First Paper of this issue **"INVESTIGATION OF CUTTING FLUID APPLICATION TECHNOLOGIES: A REVIEW"** has been authored by **Dr. Nilesh Ghuge, Dr. Dattatraya Palande, Dr. Pramod Belkhode & Dr. Rakesh Shriwastava.** This paper reviews the cooling and lubrication systems and provides their effect on performance parameters like surface superiority, tool wear, temperature, machining forces, etc.

The Second Paper of this issue **"PROGRESSIVE COLLAPSE ANALYSIS OF AN INDUSTRIAL RC BUILDING USING P-M INTERACTION: AN ANALYTICAL STUDY"** has been authored by **Fahad Bin Khurshid, Dr. Mohd. Umair & Nazish Shamim.** This paper provides a progressive collapse analysis using P-M interaction.

The Third Paper of this issue **"IOT BASED 4 WAY PATIENT MONITORING BAND WITH INTEGRATED GPS"** has been authored by **N. Divya Deepika, Dr. Uttam Mande, N. Sahithi & V. Vineetha**. This paper provides an innovative IOT based patient monitoring technique with integrated GPS.

The Fourth Paper of this issue **"GETTING DIVIDEND FROM DEMOGRAPHY: SKILL DEVELOPMENT EVIDENCE IN INDIA"** has been authored by **Dr. Mini Agrawal, Dr. Hephzibah Beula John, Dr. Arif Hasan & Prof. K. S. Thakur.** In this paper, the authors have empirically investigated the effect of skill development programmes on the youth productivity and performance outcomes.

The Fifth Paper of this issue **"SUSTAINABILITY DRIVERS AND APPLICATIVE CASE STUDY WITH INDUSTRY4.0 IN A COMMERCIAL VEHICLE INDUSTRY"** has been authored by **Dr. Arvind A R, Ravi Shankar, Sridharan A P, Nagamanikkam & Dinu Davis**. In this paper, the authors have presented sustainability drivers for a commercial vehicle industry.

The Sixth Paper of this issue **"COMPARATIVE ANALYSIS OF NATURAL FREQUENCY OF TRANSVERSE VIBRATION OF A CANTILEVER BEAM BY ANALYTICAL AND EXPERIMENTAL METHODS"** has been authored by **Dr. R. J. Patil, Prof. S. V. Tawade & Prof. A. S. Kale. T**his paper shows a procedure for the determination of natural frequency of vibration of a cantilever beam by analytical and experimental methods by using FFT analyzer.

I express a deep sense of gratitude to all those who have been involved directly and indirectly in bringing out this issue in its present form. We are grateful to all the members of the Editorial Board for giving useful suggestions for improving the content of the Journal. Our thanks are due to all reviewers for sparing their valuable time to review the manuscripts of these papers. The authors who have contributed their papers to this issue deserve special thanks.

We expect to receive continued support from our esteemed readers, reviewers, and authors.

Prof. (Dr.) Kuldip Singh Sangwan,
Editor-in-Chief

OBITUARY



Professor K. C. Sahu: a great teacher, researcher, consultant, guru

Each of these words describes **K C SAHU**, who made immense contributions to the field of knowledge in Industrial Engineering, Work Systems Design and Operations Research. Over the course of Sahu's remarkable 90 year life, whatever he discovered along the way, he wanted to share with an overarching intention to develop professionalism and community of Industrial & System Engineers.

He was a brilliant student all along, starting from his village school Tangi in Cuttack District of Odisha and Ravenshaw College in Cuttack, was a top ten rank holder of the State of Odisha. Then he was admitted to the first IIT of the country at Kharagpur from where he graduated in Mechanical Engineering with honours and served for a brief period in GKW Calcutta. Then he worked as a lecturer in Mechanical Engineering in the famous University College of Engineering Burla, Odisha.

Being motivated by our most revered GURU Late Professor R. MISHRA of IIT Kharagpur; Professor Sahu joined his Almamater in the Department of Mechanical Engineering. He did his M.Tech and Ph D in Industrial Engineering from IIT Kharagpur under the supervision of Professor R MISHRA. At that time, Industrial Engineering was a part of Mechanical Engineering. He was sent to Stanford University in USA to attend a program in Engineering Economy directed by the originator of the subject Professor GRANT IRESON. After his return from USA, Prof Sahu introduced the subject in IIT. I am fortunate enough to be trained by him on the subject. I still remember at that time the printed book of the author was not available. Prof Sahu taught us from the Professor GRANT IRESON'S hand written copy. The same hand written cyclostyled note was circulated to us.

As a pioneer, he established the Industrial Management Centre in Indian Institute of Technology along with Professor Mishra. Now the same is known as the Department of Industrial and Systems Engineering. His profound contributions to the evolutionary growth of Industrial Engineering Education in India are always remembered by the professionals. Professor Sahu touched every one of us in the Industrial Engineering and Operations Research community with his theories and practices. He connected with so many people across the world by his loving touch on a personal level. He was a typical professor with remarkable graciousness and profound compassion for the students. He was the first recipient of the Lillian Gilbreth Award of our IIIE.

When, I was the Editor –in –Chief of our IE Journal he served as an important member of the Editorial Board and also when I was the National Chairman of the IIIE (1985-86) he served as the President of IIIE. He also served as the President of Operational Research Society of India. Professional community and all the members of the IIIE and ORSI will definitely miss him. The excellent knowledge base which he has created and left for all of us will never die. We will certainly be inspired by his ever illuminating contributions.

Professor R. P. Mohanty
Former President of IIIE

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INVESTIGATION OF CUTTING FLUID APPLICATION TECHNOLOGIES: A REVIEW

Dr. Nilesh Ghuge
Dr. Dattatray Palande
Dr. Pramod Belkhode
Dr. Rakesh Shriwastava

Abstract

Health problems, higher costs, environmental concerns, and stringent environmental regulatory standards all necessitate limiting the operator's exposure to mineral oil-based cutting fluid. In industries, an incalculable amount of coolant is used every day, increasing the risk of respiratory and skin disorders. However, the usage of coolant is unavoidable due to the increasing need for productivity and job necessities. Many efforts are being undertaken to improve machining performance. Various cooling strategies are utilized in machining processes. Diverse sustainable solutions are developed in an effort to get the highest possible cutting fluid efficiency with the smallest possible amount. Among these are MQL, vegetable oils, nanofluid, iconic liquid, vapor coating, cryogenic machining, air cooling, heat pipe etc. This paper gives an in-depth look at all of the cooling and lubrication systems that are currently used and how they affect performance parameters like the surface superiority, tool wear, temperature, machining forces, etc. In addition, the research needs for future studies are identified. It is evident from the study that cooling procedures and coolant types have a considerable impact on machine performance.

Keywords: Cutting fluid, MQL, Vegetable oil, Nanofluid, Cryogenic cooling

1. INTRODUCTION

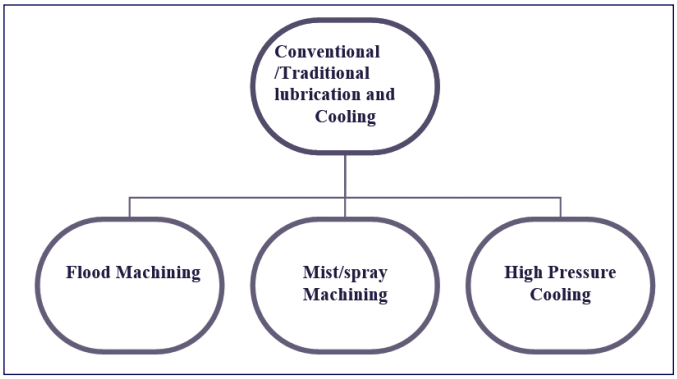
Cutting fluids are used to reduce friction and temperature throughout all machining operations. All of the coolants are responsible for getting rid of the chips. Friction reduction decreases cutting forces. Reduced cutting forces and temperatures result in decreased power usage and tool wear in all industrial processes. This improves machining outcomes in terms of higher surface quality, reduces rejection, and hence increases process productivity. It will also lower the total cost of the manufacturing process. Cutting fluids on the market are environmentally destructive and contain carcinogenic toxins. They endanger the operator. Excessive exposure to these substances might lead to life-threatening disorders. Dumping cutting fluid waste is particularly challenging since it may pollute the soil. Various regulatory bodies have established severe guidelines for the use of mineral-based cutting fluid. Efforts are being made to identify alternatives to cutting fluids. Using the developing MQL as a lubricant consumption limiter is one method. Various studies are now being conducted to examine the efficacy of different machining fluids in various machining operations. This review study outlines the various cutting fluids, the technology used to apply cutting fluid, and the impact of several alternatives on machining process performance [1].

2. LITERATURE REVIEW

2.1. Traditional Cooling/Lubrication Approaches

Cutting fluid improves machining performance. Different techniques of cooling and lubricating are used to apply cutting fluids to the cutting zone. The most widely used techniques are flood lubrication, spray or mist cooling, and high pressure cooling. These are detailed in the following section. Figure 1 shows the layout of some of the traditional techniques used during the machining process [2].

Figure 1. Traditional methods of cooling/lubrication



Flood cooling is also known as wet cooling. This method utilizes approximately 20 to 30 l/min of cutting fluids. It has been observed that due to direct contact with cutting fluid, most of the operators suffer from respiratory issues and other illnesses. The cutting fluid is circulated and then dumped into the soil. This is harmful to the environment as well as waste management of the used fluid also creates problems [3]. Oil mist is an aerosol mix of very small droplets suspended in the air and resembling fog. This mist is produced by forcing compressed air through a venturi, or vortex. Since mist cooling needs less coolant flow, it is more eco-friendly and efficient

than flood cooling. Presently, scientists are attempting to develop different forms of mist cooling by nitrogen oil spray and cold compression cooling using nitrogen spray [4].

Senthil Kumar et al. (2002) conducted an experiment to compare the effects of high-pressure coolant on workpiece hardness vs dry cutting. The high-pressure coolant's ability to improve surface smoothness, reduce tool wear and cutting forces, and regulate chip form was examined. Cutting forces were lowered, surface quality was improved, and chip width was reduced when high-pressure coolant was used [5].

Zhenghui Lu et al.(2020) examined the effects of high-pressure coolant (HPC) on the cutting capabilities of HUVC titanium alloy, particularly tool life, wear mechanism, surface quality, cutting temperature, and thrust force, in high-speed ultrasonic vibration cutting. The tool life in HUVC at 200 bar HPC was 7.3 times that of the conventional cutting (CC) technique when the cutting speed was 400 m/min. Furthermore, using HPC increased the quality of the machined surface in a later HUVC cutting operation significantly. Furthermore, when compared to CC, the temperature in HUVC was reduced by 55% at 300 m/min [6]. According to Alexander et al. (1998), HPC saves cutting fluid usage by 50% and simultaneously reduces cutting temperature and force. [7].

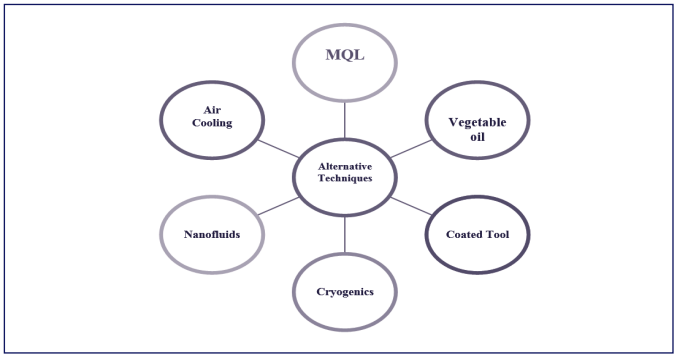
Bonney et al.(2003), machined Inconel 718 using SiC-whiskers reinforced ceramic tools at a pressure between 11 and 20 MPa. According to the findings, HPC was accountable for severe edge notching, a shorter tool life, and an increase in cutting force with an improvement in chip [8].

Srby et al.(2018) asserted that the HPC cooling technique was incapable of increasing tool life, minimizing notch wear and edge chipping, and reducing cutting force while machining Inconel 625 with a ceramic insert under 5–15 MPa coolant pressure and 200–300 m/min cutting speed. They came to the conclusion that the HPC approach is incompatible with ceramic tool machining [9].

2.2. Alternative Cooling/Lubrication Techniques

This section addresses the evolution and significance of various cooling and lubrication solutions to conventional cooling, including air cooling, coated tools, minimum amount of lubrication, vegetable oil as a cutting fluid, nanofluids, cryogenics, and others. Figure 2 gives the layout of the few alternative techniques.

Figure 2. Alternative Cooling/lubrication Techniques



Because of technological advancements in tool materials and machine tools, the use of minimal mist lubrication (a mix of air and oil) in machining production processes has become an industry need. D.U. Braga et al.(2003) evaluated the MQL (10 ml/h of oil) with air during the drilling of an Aluminum silicon alloy using a solid carbide drill (K10). The author observed that smaller holes yielded better results when roughness differences were taken into account. When drilling Aluminum silicon alloys, it was not required to use a cooling fluid because the cutting area temperature was not high enough to cause tool damage. This prevents the chip from sticking to the tool and so makes the cut easier [10]. According to Sanjeev Kumar et al.(2018), one of the solutions is to employ cooled air generated by a vortex tube. In this work, trials were performed to investigate the effectiveness of cooling air generated by a vortex tube during turning of AISI 4340 steel. The wear rate, surface finish, and thrust force were used to evaluate the machining's performance. The usage of cooling air generated by a vortex tube considerably improved tool life, lowered cutting force, and surface quality as compared to conventional operation conditions. [11].

T. Ueda et al.(2005) used experimental data to explore the effect of oil dew on tool temperature during cutting. A carbon steel tool coated with oil vapor was used for intermittent turning. The temperature of the tool during engagement was assessed using a two-color measuring instrument. The blade temperature reached 1060 °C while cutting dry at a speed of 300 m/min, but dropped to 1000 °C when lubricated vapor was delivered. According to the investigation, the tool heats up to 1060 °C while cutting dry at 300 m/min, but only to 1000 °C when using oil mist. A 60 °C temperature difference corresponds to a 50 m/min variance in cutting speed. When cutting intermittently, such as end milling, oil mist has a greater impact on tool temperature than when cutting continuously [12]. According to A.K. Sahoo et al. (2012), the three major wear processes encountered during milling are abrasion, chipping, and catastrophic failure. When cutting strong steel, an uncoated carbide insert shattered early. Under harsh cutting circumstances, tool life was predicted to be roughly 19 minutes for TiN inserts with a ZrCN coating and 8 minutes for carbide inserts with a ZrCN coating. Multilayered TiN covered inserts cost 93.4 percent less than uncovered Carbide inserts and 40% less than Zr CN coated Carbide inserts in abrasive machining with a 0.3 mm flank wear requirement. A multilayered TiN coated carbide insert offered a substantially longer tool life of roughly 19 minutes, compared to 8 minutes for a ZrCN coated insert and less than one minute for an uncoated carbide insert. The higher thrust force recorded during strong turning within the prescribed parametric range has resulted in chipping and catastrophic failure. Multilayer-coated carbide inserts done effectively at a variety of cutting speeds and cut depths. TiN coated carbides with many layers outperformed Zr CN coated carbides [13].

Micro lubrication is a viable option for environmentally friendly cutting, but there are a number of process issues to address before implementation. The researchers compared

micro lubrication to dry machining and air cooling. The primary features of the MQL, such as the amount of oil, air pressure, and target distance, have been investigated in a series of tests carried out by Ling Chen et al.(2021) at the University of Illinois at Urbana-Champagne. The MQL process provided improved milling characteristics. Tool wear and cutting force were decreased, air quality was improved, and roughness was equivalent to the four processes [14].

According to Richard R. Kibbe et al.(2015), the MQL system could save a great deal of money by replacing the flood cooling strategy. The conventional approach involves costs such as water usage, a chiller, filtration equipment, a pump, and pipelines, as well as sewage treatment. In the case of MQL, this cost can be minimized. The high-pressure delivery system raises both the initial cost and the cost of keeping it running [15].

N.Dhar et al. (2006) conducted an extensive study to find out the impact of the MQL on the performance of the machining parameters. The author promoted MQL as a method for lowering environmental intrusiveness and occupational dangers.MQL's improved heat management almost eliminated notches and grooved erosion on the primary cutting edge [16].

According to J.P. Davim et al.(2006), MQL is a feasible alternative to flood lubrication systems. This article described a practical investigation that was carried out on brasses that were turned with varying levels of MQL. Turning on brass specimens was done using K10 inserts under a range of lubrication conditions. It was investigated how feed rate and speed affected cutting power, cutting force, surface irregularity, and chip shape. Furthermore, turning with and without flood lubrication was investigated. It was revealed that by employing a little amount of lubricant, performance conditions equivalent to or better than those created by flood lubrication were achieved. In all instances, the surface roughness value rose with feed rate. Ra levels in MQL rose when cutting rates increased to 200 ml/h. MQL lubrication produced equivalent or better results than flood lubrication [17].

According to N.B.Borkar et al.(2011), the metal cutting industry, which uses cutting fluid, has become more and more unsafe and polluting. As a consequence, many alternatives were studied to eradicate the usage of lubricating oil in production operations. The ideal solution to the current task is to use as little oil as possible. They chose mild steel as the work piece to investigate the issue. The author has determined three major conditions for coolant fluid: dry, wet, and MQL. They have defined four control parameters: cutting speed, feed rate, depth of cut, and tool wear. They used a bar chart and a line plot to compare the results for surface roughness and tool wear. They recommended "ANOVA" and "S/N plot" for parameter tuning. According to the author, MQL is the most important advancement in machining made by the H.S.S tool. MQL produced an improved surface quality, which subsequently boosted dimensional accuracy; this was owing to the substantial decrease in tool wear. MQL processing surpasses traditional production with flood cutting fluid supply in terms of cutting performance [18].

Ali S.M et al.(2011) validated the impact of MQL and dry cutting by comparing them to different outputs such as surface roughness, force, tool wear, chip thickness ratio, and temperature. For this experiment, medium carbon steel was used. Cutting speed and feed force are control parameters. The author examined the control parameter and the output to see whether there was a meaningful influence. By doing this experimental inquiry, the author discovered that the mean temperature of the chip tool contact could be minimized while utilizing MQL by adopting a visual method based on the work materials, tool shape, and cutting conditions. The cutting force was also lowered by MQL. The uncoated insert SNMG-120408 has reduced flank wear in MQL jet machining of steel, prolonging tool life and enhancing productivity at higher cutting speeds and feed rates.MQL improved dimensional accuracy and surface superiority by reducing tool tip wear and damage, as well as the mean temperature of the chip interface [19].

K. Abou-El-Hossein et al. (2014) used the MQL concept to create a steel specimen. The results of the MQL surface finisher were compared to those of flood coolant and dry procedures. According to the data, MQL produced a very high-quality surface. As a consequence, it was highly recommended that MQL be used instead of flood cooling for changing steel grades. According to the author, MQL outperforms flood cooling when milling steel grades with carbide inserts [20].

A. Saini et al.(2014) investigated how cutting pressures and tool tip temperature were impacted by approach angle, feed, speed, and depth of cut. 64 experiments on AISI-4340 were conducted using two different coated carbide inserts (PVD and CVD). Thus, when cutting forces and temperature are taken into account, the author concludes that MQL machining outperforms dry machining. The thin TiAIN coating on the insert generates a fine surface, which is highly advantageous for avoiding built-up edges. MQL machining generates minimal waste and uses less cutting fluid, hence reducing environmental and health risks. Furthermore, it reduces machining costs by reducing the rate of cutting fluid consumption as well as the time necessary to clean and manage wet chips [21].

2.2.1 Vegetable oil and Nanofluid

MQL significantly reduces the amount of coolant needed; however the endeavor to totally eliminate mineral-based cutting fluid results in the emergence of vegetable oil-based cutting fluid. Researchers have made use of several vegetable oils. These oils are used in conjunction with the MQL system. MQL-vegetable oil was considered to produce promising outcomes in surface roughness, temperature, cutting force, and tool life.

E. Kuram et al. (2010) used vegetable cutting oils to minimize thrust force and increase surface smoothness when drilling at a variety of spindle speeds and feed rates. Three different food cutting fluids were evaluated utilizing an HSSE tool on AISI 304 austenitic stainless steel. One was made from refined sunflower oil, while the other two were cutting fluids that were readily available. Spindle speed, feed rate, and drilling depth

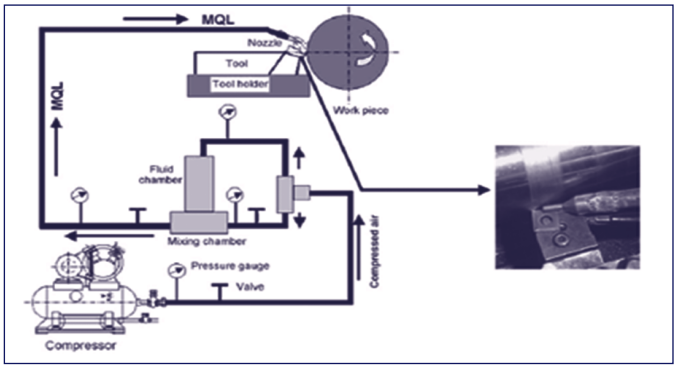
were all evaluated during the machining process. Drilling AISI 304 at a feed rate of 0.12 mm/rev and a drilling depth of 21 mm with the SCF-I resulted in the highest reduction in thrust force. SCF-II has the worst surface qualities at rates of less than 0.08 mm/rev. With increasing spindle speed, the thrust force decreased. With any cutting fluid, there was no tool wear [22].

Li Benkai et al.(2016) compared MQL grinding performance to that of base oils such as castor oil, soybean oil, rapeseed oil, maize oil, sunflower oil, peanut oil, and palm oil. Higher viscosity vegetable oil gives greater lubrication and needs less grinding effort. Castor oil has the lowest crushing power of the seven vegetable oils but the greatest crushing coefficient in terms of thermal and power ratio. Palm oil, on the other hand, grinds readily and has a low viscosity. Higher viscosity vegetable oils provided a higher lubricating effect and much lower grinding forces. The findings showed that the length of the carbon chain has no effect on the capacity of vegetable oils to conduct heat. Heat transfer was higher when the carbon chain was shorter [23]. The performance of various vegetable oils to be utilised as cutting fluid was tested by Ghuge et al.(2016) They revealed that soybean oil and ground nut oil performed better than blassocut oil. The practicality of optimization is also determined by calculating desirability [24].

Putu Hadi Setyarini, et al.(2021) used rubber seed oil is as a cutting fluid in their study, which employs the minimum drop lubrication approach. Carbide inserts and varied flow rates are used in the turning process. The results revealed that the higher the cutting fluid flow rate, lower the surface roughness [25].

According to Lizhi Tang et al(2022)., the biological stability of vegetable-based cutting fluids is a problem that needs to be addressed in order to achieve optimal performance. This research focused on the development of biologically stable cutting fluids. The bactericidal performance, toxicity, degradation rate, and economics of several sterilizing procedures were analyzed in depth, and a prospective development path for increasing the biological stability of cutting fluid was suggested [26].

Figure 3. Schematic view of the MQL (27)



M.M.A. Khan et al. (2009) investigated the effects of MQL and cooking oil on AISI 9310 machining performance in terms of chip–tool input transformation, chip formation mode, tool wear, and surface polish during both dry and wet machining. A lathe machine was used to carry out the experiment. Figure 3 shows the schematic of the MQL setup. The cut depth was kept constant throughout this method at 1.0 mm. The control parameters were cutting velocity and feed rate. Over the range of cutting velocity and feed rate tested, MQL showed predicted benefits in chip formation patterns, tool wear, and surface polish, and lower average chip–tool contact temperature. Wet cooling with a lubricant with low solubility had little influence on cutting temperature and became less effective as cutting velocity and feed rate rose. The MQL approach reduced total chip–tool contact temperature by up to 10% as compared to wet machining. The MQL jet significantly reduced flank wear while cutting low alloy steel with a carbide insert. Minimal lubrication precludes deep grooving, resulting in cutting tool failure that is both early and catastrophic. Surface finishes are enhanced as tool tip wear is reduced [27].

Gyanandra S Goindi et al. (2018) compared regular vegetable oil with hydrophilic vegetable oil and found that hydrophilic vegetable oil has a lower cutting force at a higher cutting speed and a smaller cutting condition at a slower cutting speed. Hydrophilic materials are thought to be good for better manufacturing because the fluorine in the ionic liquid can easily escape at higher cutting temperatures and stick to the chip's surface [28].

Figure 4. Vegetable oil as cutting fluid [29]

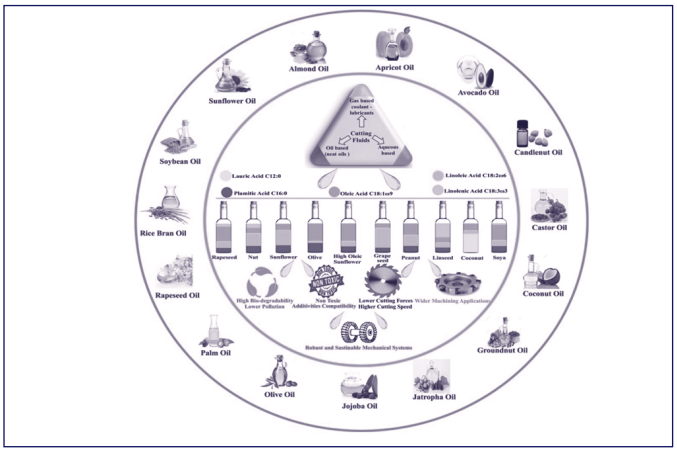
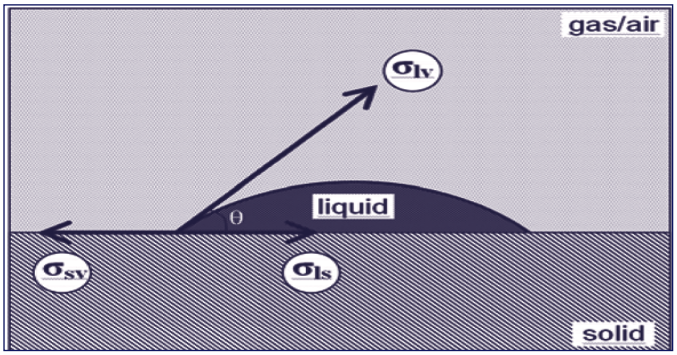


Figure 5. Schematic showing a droplet of liquid on a solid surface (30)



Sankaranarayanan R et al. (2021) explored into the possibilities of using environmentally friendly vegetable oil-based cutting fluids to achieve long-term green manufacturing. Figure 4 depicts the vegetable oils under investigation. The suitability

of many vegetable oils for various metal-cutting applications was assessed and compared. Vegetable oils can substitute synthetic cutting fluids, according to this review of a study article, and this option could contribute to green machining in a cost-effective and efficient manner [29]. The performance of vegetable oil as a cutting fluid can be improved by inserting additive to improve oil properties. Many researchers are now working on examining the proportions of the different nanofulid and its impact on the machining performance.

S. Khandekar et al. (2012) provided a qualitative performance comparison of regular and nano fluids during machining. Furthermore, the influence of nanoparticles on the wettability properties of base fluids was examined. It was revealed that adding 1% Al_2O_3 a nanoparticle to standard cutting fluid enhances its wettability substantially. Figure 5 shows the schematic of a droplet of liquid on a solid surface. The remarkable reduction in crater and flank erosion was due to improved thermophysical behavior and lubricating properties [30].

R.R. Srikant et al.(2013) examined several studies conducted to reduce heat produced during the machining process. As per the study, cutting fluids remain the favored approach, but their limitations do limit their usefulness. Machining is a high-heat, high-friction operation. As compared to standard cutting fluids, a coolant must have improved cooling and lubricating capabilities. The advantages of nanofluid include higher heat conductivity and viscosity. Because of these features, they are suited for use in the metal-cutting industry [31].

Hegab et al. (2018) covered a study of all the topics related to nano-cutting fluids and their applications, including nano-fluid preparation methods, nano-fluid stabilization, the thermal and physico-mechanical properties of the nano-fluid, nano-fluid impacts on cutting performance metrics, and nano-fluid issues [32].

Li et al. (2018) used minimum quantity lubrication (MQL) with a cutting fluid based on vegetable oil in TC4 milling. Graphene nanoparticles were mixed into a vegetable oil-based cutting solution to increase cooling and lubrication. To assess the performance of the four cooling/lubrication settings, a number of milling experiments were carried out (dry, gas, pure MQL, and graphene MQL). In terms of milling force, milling temperature, tool wear, and surface integrity, the milling parameters of TC4 were investigated. The use of graphene improved milling characteristics significantly. Overall, the findings suggested that adding graphene to the milling zone oil coating would improve cooling and lubrication [33].

As per the research of Chatha S.S et al.(2016), C140H42O20 nanoparticles reduced thrust force (27.34%), torque (64.9%), Ra (33.8%), and friction coefficient (51.7%) in the 30th hole as compared to the natural MQL condition. Sufficient C140H42O20 nanoparticles in nano-fluids MQL drilling improved film lubricants and dependability, resulting in improved drilling quality. Food oil nanofluids were a novel type of cutting fluid that could be used in drilling applications instead of traditional oil-based MQL. This was due to the fact that a sufficiently high concentration of nanoparticles in base oil stimulates the creation of a thick lubricating layer, which increases heat transfer. C140H42O20 mixed vegetable oil is a novel form of cutting fluid for drilling applications that uses nanoparticles to increase drilling process sustainability and cooling capabilities to replace standard rock oil-based cutting fluids. When graphene nonmaterial was added to foundation oil, erosion was reduced and drill bit life was increased when compared to the pure MQL approach. The high concentration of nanoparticles in the oil enhanced its viscosity [34].

P.B. Patole et al. (2018) used the MQL approach to perform research on surface quality. They used a CNC lathe. The effect of MQL settings on the Ra of AISI 4340 was investigated using MWCNT nanofluids. They investigated this experiment using three control parameters: pressure, flow rate, and coolant type. Coolant was a mixture of MQL 1 C2H6O2 combined with a nanofluid and MQL2 H2O combined with a nanofluid. They planned their experiment on an L16 OA. The data was evaluated using an ANOVA. According to the results, the most important factors influencing Ra decrease were cutting fluid, flow rate, and pressure, with pressure having the least impact on surface texture becoming excellent under MQL employing nano coolant. The variation in surface roughness between experimental and predicted values is less than 10%. Inserts coated with WC, class K10, and standard CCMT 090308 were utilised to improve the machining characteristics of AISI 4340 during the MQL process. When compared to H2O, $C_2H_6O_2$ as a working fluid mixed with nano fluid yields better results [35].

Shokrani et al. (2021) evaluated the influence of several contaminants on convective heat transfer and machinability in Ti6Al4V end milling, including Al2O3, polycrystalline diamond (PCD), and graphite, as well as water in MQL oil. When compared to normal MQL, eliminating PCD from oil improved heat transfer by 43%, according to the trial. This might result in a 1.6-fold improvement in tool life while cutting titanium alloy at high speeds. The effect of floating various additives in MQL oil on Ti6Al4V titanium alloy high-speed end milling is examined. The study revealed that Al2O3, PCD, and graphite suspended in oil increased the rate of heat transmission. Increased cooling capabilities have been found in machining experiments to greatly extend tool life. This was also apparent in case of power usage and the bending moment of the tool assembly [36]. Figures 6 and 7 shows the convective heat transfer coefficient for the various combinations.

Figure 6. Convective heat transfer coefficient for various MQL CL (36)

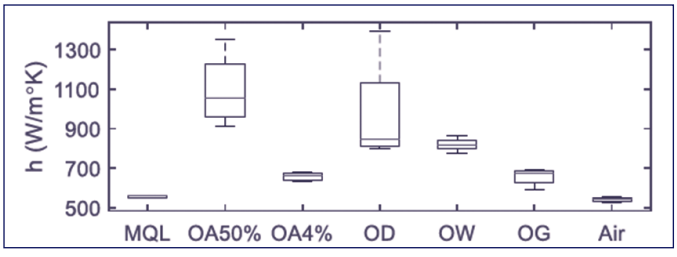
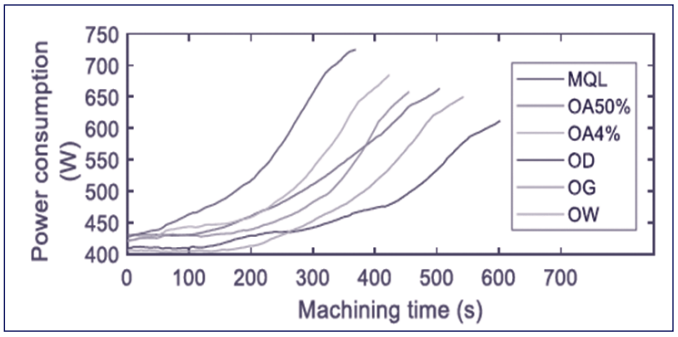


Figure 7. Power consumptions for various MQL CL (36)



2.2.2. Cryogenic cooling

Y. Yildiz et al.(2012) gave overview of cryogenic cooling. Cryogenic cooling with liquid nitrogen is a technique that does not pollute the environment in any way. Liquid nitrogen captivates heat from the manufacturing process and rapidly evaporated. The fluid evaporated during cryogenic freezing by carbon dioxide, and while the concentration of carbon dioxide evaporated was small. Cutting fluid residues were removed from machine parts and chips as a result of machining, lowering treatment costs. Furthermore, the compounds employed are non-toxic and therefore do not cause fog [37].

According to H.Chetan(2016) and his colleagues, gaseous cooling has the same advantages as cryogenic cooling because both are considered to be some of the most environmentally friendly and clean ways to mill various technological alloys after dry machining [38].

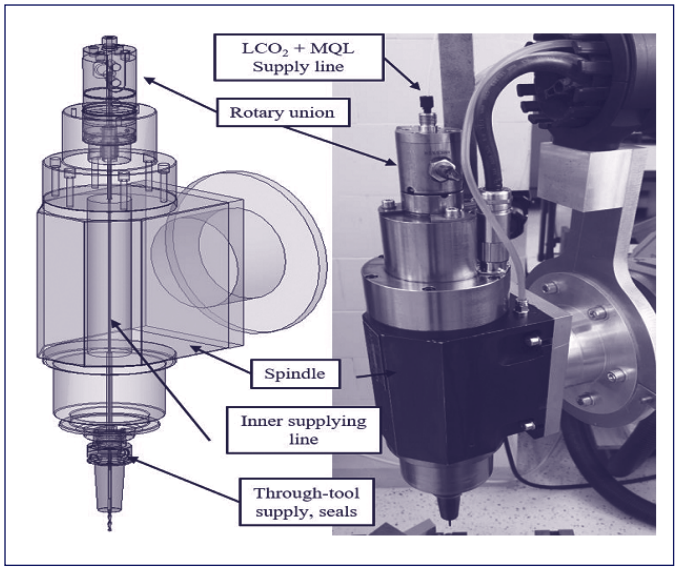
D.A. Stephenson et al.(2014) collected preliminary data on the use of super - critical CO2 MQL as a flood coolant in an outward CNC lathe with an Inconel 750 spindle. ScCO2 MQL improved the tool's life or rate of material removal when machining Inconel 750 and related nickel alloys by enhancing lubricity and altering the principal wear process away from fast notch wear and toward slow crater erosion and chip smashing. Notch wear was greatly reduced in the presence of ScCO2 MQL, although craters and hammering were much more obvious. This study showed that MQL processing can be utilized to manufacture a difficult-to-machine metallic alloy. As a result, the author determined that when hard turning Inconel 750 at 48.7 SMM and 0.20 mm/rev, CO2 MQL gave a longer tool life than soluble flood coolant. Under these circumstances, a CO2 air flow rate of roughly 70 g/min is enough. When used in combination with carbide tools for fuzzy turning, Inconel 750, Inconel's supercritical CO2 milling machine (SCCO2 MQL) boosts material removal rates by 25–40%. CO2 MQL increased flow ability and shifted the wear mechanism away from rapid groove erosion and toward gradual crater wear and chip hammering [39].

T. Bergs et al. (2019) mentioned how cryo chilling in combination with MQL is simply a dependable approach to boost efficiency when cutting difficult metals. The high-tech approach was a single-channel method that makes use of oil solvation in supercritical CO2. Fluid carbon dioxide (LCO2) was easier to handle and more widely available. For the purpose of machining Ti6Al4V, a one-of-a-kind single channel system capable of linking LCO2 and MQL has been created and tested. Rhenus LA722139 was discovered to be more CO2 solvent than Rother lubricant c-ti. The two-channel technique resulted in a reduced tool life when compared to flood lubrication [40].

According to D. Grguras et al (2019), the physiochemical properties of oil have a substantial influence on its absorption in LCO2. The development of a single-channel, pre-mixed LCO_2 and oil delivered by MQL represented a significant advancement in cryo metalworking methods. The rate of evaporation influenced the size and circulation of the oil phase as well as the tool's life. A revolutionary technique for mixing any liquid lubricant into a fluid CO_2 flowing without the need for extra CO2 has been developed. Solvated oils are highly soluble in LCO_2, allowing for smaller droplet sizes and more even dispersion, which results in better lubrication [41].

Using CO2 – MQL cool lubricated, a novel method for monitoring heat and cooling fluxes during the milling process has been developed by T. Augspurger et al.(2019) The device included a monitoring system to relay the temperature sensed by a thermocouple placed on the tool. Additional data analysis was utilized to determine heat transfer into the device by comparing observed temperatures to analytically anticipated transient temperatures [42].

Figure 8. Spindle adaptation for through-tool LCO2 + MQL supply (43)



L. Sterle et al. (2021) investigated the effects of LCO_2 cooling, MQL and cutting speed on drilling as shown in figure 8. Torque, thrust force, and temperature are measured under a range of manufacturing and operating conditions. The experimental simulation experiments were used to assess the different influences of each of these factors. The drilling of 42CrMo4 steel with the help of LCO_2 and MQL was studied. The author examined and tweaked the cooling, lubrication, and cutting conditions. LCO_2 cooling improved chip evacuation by increasing pressure. By minimizing friction between chips, drill flutes/hole walls, and at the cutting edge, MQL greatly increased torque reduction and stability. LCO_2 flow rate must

be tuned for the cutting circumstances and MQL scenario utilized to attain the greatest performance [43].

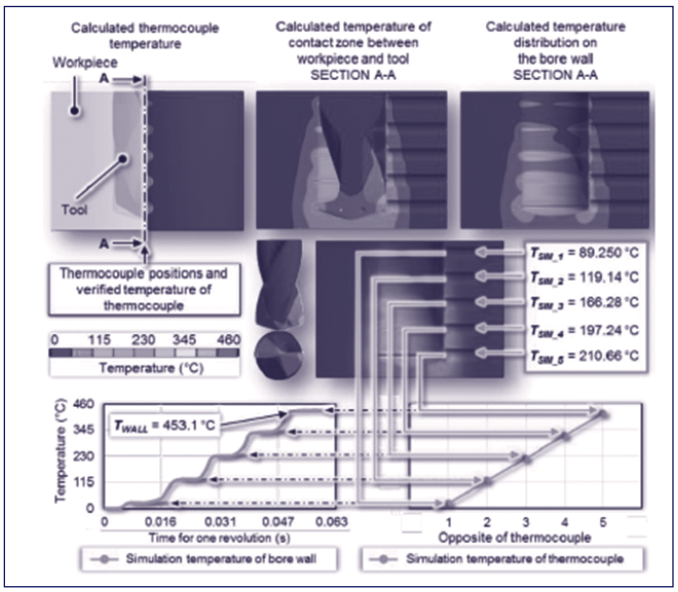
Y. Kaynak et al. (2015).investigated the lubricating technique with time intervals ranging from 1 to 4 minutes. They looked at the effects of manufacturing (vacuum arc remelting against vacuum induction melting (VIM +VAR)), processing (hot rolled + totally annealed versus cold worked + super elastic anneals), and machining conditions (dry, cryo, and MQL). Cryogenic machining greatly improved cutting tool performance by minimizing progressive tool wear during room-temperature processing of austenitic NiTi alloys. As stated by the author, MQL and dry machining were not superior to cryogenic machining since the cutting and tool wear processes in dry and MQL were quicker than in cryogenic machining. Cryogenic machining resulted in more homogeneous and smooth surface feed marks. According to the study, NiTi alloys containing TiC particles had significantly poorer tool life than alloys without these particles. According to the findings of this research, using carbon-free NiTi alloys gives an advantage in terms of machinability. According to recent research, cryo processing is the best way for boosting the processability of this alloy since it reduces tool wear significantly. However, after four minutes, all three machining processes produced surface roughness that was essentially equivalent [44].

Liew P et al. (2021) provided a critical assessment of the literature on cutting fluids and cooling techniques for hardened steel turning. The author focuses on wet cutting, high-pressure cutting, MQL dry cutting, and cryo cutting as well as other technologies. They also suggested that hybrid technology be investigated further [45].

3. MODERN WAY OF LUBRICATION/COOLING

E.Oezkaya et al. (2019) examined the impact of fluid flow and channel diameter on the fluid channel. To augment the studies, CFD experiments were employed.

Figure 9. Tool Temperature Simulations (46)



CFD and FSI are appropriate approaches for conducting a comprehensive analysis of the drilling process. Increased channel widths have little effect on lessening the high heat loads associated with Inconel 718 drilling because the increased coolant flow supplied by a bigger refrigeration system is largely centered in the groove and dead zones at the sharp end still persist. Raising the pressure on either side led to greater flow rates, which resulted in an increased rate of heat transfer, resulting in a prolonged tool life owing to improved internal cooling conditions as shown in figure 9 [46].

Recep Demirsöz et al.(2020) investigated the tribological behavior of 316 L stainless steel versus 100 Cr6 alloy under different cooling conditions. A ball-on-flat tribometer was used to conduct tribological testing on additively manufactured 316 stainless steel under dry, MQL, cryogenic, and hybrid cryo+MQL conditions. Following that, the most essential tribological characteristics, such as friction forces, volume loss, wear depth, and micrographs, were examined. Combining cryo and MQL cooling settings increases tribological performance while controlling material volume loss and wear rates, according to the research. MQL, cryo, and dry conditions were outperformed by the cryo+MQL condition [47].

According to R.L. Javaroni et al.(2022), the MQL approach's application is still limited due to the repeated incidence of overheating and disc obstruction during grinding. MQL needs to be improved before it can be utilised in a variety of grinding operations. The purpose of study was to investigate the effectiveness of a cooled wheel cleaning jet (CWCJ) combined with the MQL while cutting AISI 4340 hardened steel. Trials employing the usual MQL+WCJ technique were undertaken as a comparative. The MQL+CWCJ technique surpassed the standard MQL method in all parameters studied, decreasing wheel wear by up to 98 percent, surface roughness by 70%, roundness deviation by 81%, and grinding power by 30%. The MQL technique worked poorly because of insufficient cooling and a restricted chip removal capability, resulting in increased wheel obstruction [48].

Franci Pusavec et al.(2020) revealed that solid-lubricated LCO_2 surpasses other types of lubrication. Tribological measurements were used to evaluate the coefficient of friction between an uncoated carbide implant and the substrate. The topography of the final surface was examined using an elevated scanning electron microscope, which revealed no adhering solid particles on the workpiece's surface. When compared to emulsion, the friction coefficient between both the cutting work piece and the breakthrough solid-lubricated LCO_2 technology is lowered by 0.25 to 0.09. (64 percent reduction). Machining using solid lube produced a dry method that eliminated the need to clean and/or deep clean machined surfaces. MoS_2 solid particles showed the ability to form tribofilms in the contact zone [49].

A.N. Mohd Khalil et al.(2021)explored the influence of different MQL combinations on NiTi alloys using aluminium oxide particles in SolCut oil. As per data, combining nano MQL with cold compressed air reduced tool wear and cutting force significantly. But, the cutting force generated by this hybrid state was far greater than that generated by micro MQL, especially at speed of up to 25 m/min. However, in terms of

reducing heat just at the cutting area, this combination surpasses micro MQL [50].

I. Kantharaj et al. (2021) invented a novel technology for removing heat from the manufacturing process. Heat pipes inserted in cutting tools are used to dispel the extra heat generated at the tool-workpiece interface. The machining that is done with these tools is done in a dry environment. This method of using heat pipe-embedded tools has been designed, built, and tested for a range of machining techniques, and it has proved suitable for industrial applications. It was also explored how to increase the surface quality of the manufactured items as well as the tool life. Interesting effects, such as a decrease in cutting force while utilizing such instruments, are also mentioned. [51].

Wu X et al.(2021) conducted a thorough examination and evaluation of various cutting fluid technologies as well as the evolution of green manufacturing technology. The author concentrated on the technological challenge in the research accomplishments of eco-friendly cutting fluid and waste fluid management. The author concentrated on the technological challenge in the research accomplishments of eco-friendly cutting fluid and waste fluid management. Production of an amino acid additive, a self-adapting jet parameter supply system, and a fitting technique among processing conditions and cutting fluid were suggested, laying the groundwork and offering aid for cutting fluid research and innovation [52].

X. Li et al. (2014) designed a self-inhaling cup segmentation disc that reduces grind heat by about 50%. According to the research, reducing the polishing surface temperature by 30% or more improves grind effectiveness. The use of self-inhaling wheels improves grinding performance while reducing surface burn. When combined with external and internal cooling, a segment disc with a self-inhaling structural cup form has the ability to significantly lower temperatures. The temperature drop caused by the use of a water-based semi-synthetic fluid may help to reduce grind heat and increase machining efficiency, lowering the risk of surface grinding burn. A segment disc with a self-inhaling structural cup form, when combined with external and internal cooling, has the ability to significantly lower temperature [53].

V. S. Sharma et al.(2009) gave an overview of the major advancements in methodologies like minimum quantity lubrication (MQL)/near dry machining (NDM), pressurized coolant (HPC), cryo cooling, compressed air cooling, and the use of solid lubricants/coolants. These processes reduced friction and heat in the cutting area, increasing process productivity [54].

Pralhad B. Patole et al. (2021) offered a complete evaluation of the research on cutting fluids and cooling procedures for hardened steel turning.. The author mainly focuses on the different technologies like wet cutting, high pressure cutting, MQL dry cutting and cryogenic cutting. They also recommended the hybrid technology for further research [55].

CONCLUSION

This research article provides a brief overview of significant research efforts to discover a solution for the replacement of mineral-based cutting fluid. This analysis also includes an examination of the various technologies employed to remove the harmful cutting fluid. It also highlights the research conducted by many writers to assess the performance of machining operations employing various cutting fluids. The primary goal was to decrease cutting fluid exposure. Based on this need, many methods utilizing less cutting fluid than flood cutting are being developed. Minimum Quantity lubrication has been shown to be the most effective strategy for reducing operator contact with cutting fluid. Many studies employed mineral-based cutting fluid with MQL and demonstrated a significant increase in machining parameters as well as cost savings. Considering environmental standards, attempts were made to replace harmful cutting fluid with vegetable oils such as soyabean, sunflower oil, and so on. Rubber seed oil is also being considered as a feasible option. In terms of temperature, surface roughness, and cutting forces, the use of vegetable oil as a cutting fluid in a MQL system produced promising results. The use of nanofluids, non-edible oil, and solid-lubricated LCO2 improved work piece qualities as well. Using heat pipes also showed improvement in heat rejection. Cutting fluid stability and purification are the main concerns, and many researchers have given solutions for them. Multinational companies use MQL technology with bio lubricant in the majority of developing nations. On the other hand, small businesses are unaware or reluctant to use the different technologies available in the manufacturing field. The greatest impediments to the industry's expansion are illiteracy and a cavalier attitude toward employee health. The MQL systems on the market are expensive. There is a need for MQL systems and cutting fluids that aren't too expensive and can be bought by small manufacturing units.

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PROGRESSIVE COLLAPSE ANALYSIS OF AN INDUSTRIAL RC BUILDING USING P-M INTERACTION: AN ANALYTICAL STUDY

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Abstract:

Progressive collapse is the eventual failure or proportionately substantial failure of a part of a structure caused by the propagation of a local failure from element to element across the system. This might be viewed as the ultimate failure of the structure or the failure of a substantial component of it. The progression of such a collapse may be precipitated by manmade, natural, intentional, or unintentional factors. During this phase, the system in the process of collapse redistributes the loads to prevent the loss of vital structural elements. In this study, SAP2000 was used to examine a reinforced concrete building. The recommendations of the General Services Administration (GSA) and the Department of Defence (DoD) were adopted to anticipate the total amount of collapse. The notion of the study is to take into account the most adverse scenario and suggest the best approach amongst the two, which may help in performing future studies in less time.

Keywords: Progressive Collapse, Linear Dynamic Analysis, Non-Linear Static Analysis, Non-Linear Dynamic Analysis, Bresler method, Demand Capacity Ratio (DCR).

INTRODUCTION

Progressive collapse is the spread of an initial local failure from element to element, resulting, eventually, in the collapse of an entire structure or a significant large part of it (ASCE_07-02, 2007). This can be stimulated by natural or manmade activities like earthquakes and explosions. To make the structure stable enough to withstand such a loss, beam-column joints shall be designed in such a way that they shall reciprocate under the bridging effect of large stresses and negative bending moment (Zhao, 2019)such as explosions or impacts, during their service life. It is, therefore, necessary not only to evaluate their safety under traditional loads and seismic action. The structural performances related to progressive collapse scenarios need to be investigated. The study of progressive collapse involves a dynamic problem, but unfortunately dynamic experiments on the behavior of the civil engineering structures under dynamic conditions are rare. In this research, beam-column sub-assemblage specimens were tested under dynamic load. The loading program consists in placing a large mass, as a dead load, on the top of the middle column of a beam-column sub-assemblage. The support under the middle column is suddenly removed for simulating the sudden loss of a column and the damage that will result in the structure. The loading system and supporting devices were specially designed for this test. The upper dead load can be changed by increasing or decreasing the applied mass to different specimens. The supports for the side column have a controlled rigidity in the horizontal direction and are designed to restrain rotation of the side-column. Thus, the boundary conditions are supposed to be similar to real situations. During the test, a laser was installed under the middle pillar to collect the falling velocity and a high-speed camera was used to visualize the whole process of failure. The images obtained from the camera were processed by Digital Image Correlation (DIC. Some of the famous examples of this phenomena are the collapse of the World Trade Towers in 2001, the collapse of the Murrah Federal Building in 1995, Oklahoma City, U.S.A., because of intentional manmade activities. And an unintentional manmade activity, gas cylinder blast, became a cause of collapse of Ronan Point Building in 1968, London, Britain (Abdelwahed, 2019).

The research has scope for the non-frequent progressive collapse phenomenon, the effect of which can be adverse based on the errors of both design method and specification in reciprocating the spread of damage in the subject project. The progress in this field of study may lead to minimizing damage during the flow of events. Secondly it shall favour superior structure against natural disasters. From the safety point of view more the life saved, the better it is. After initial damage, it will help insure the building does not give-in at others positions. Upon threat due to combatian scenario or assault intended to harm. In all situations the research shall favour better method of both design and specifications. In available literatures, it has been observed that the most appropriate guidelines are provided by the two agencies, GSA (2016) and DoD (2016) and the difference in recommendations are summarized and used for this study. Further, it has been observed that most of the researchers generally use guidelines of both the agencies to perform their studies. Hence, the need to perform such a study which may conclude the best guidelines is very high and the findings may reduce the time to perform future studies on progressive collapse.

LITERATURE REVIEW

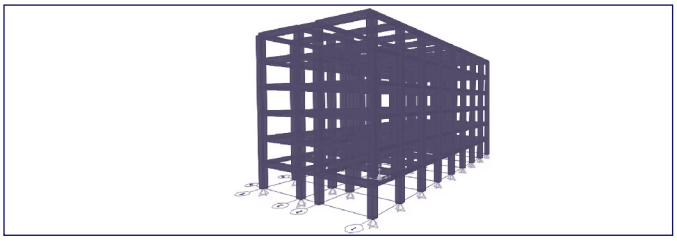
Progressive collapse comes with great non-linear problems like large rotations, displacements and collision between specimens. The damage is irreversible thus, the model to

be analysed must consider the said above problems. There are two types of models, finite element model (FEM) and discrete element model (DEM). Three types of modeling falls under FEM to study progressive collapse which are Fine model, Simplified model and Multi-scale model. Fine model generates various elements respective to mechanical behaviour of structural members. This method is little bit complicated because it requires large calculation and thus, the use is restricted to sub-structure and specimens only. Luccioni et al. studied progressive collapse of a fine element RC structure for blast loads (Luccioni et al., 2004). The fine element is time consuming and laborious. Therefore, researchers prefer using simplified model over fine model for research. This method includes ultimate mechanical behaviour by using corrected structure or mechanical parameters. In a study (Zhang and Liu, 2008), authors have developed a model which can define the accumulated large deformation upto some extend. A deferent study (Lu et al., 2010) was performed to simulate failure or facture by using an element deactivation method on two models, fiber beam model and layered shell model. Lastly, for a multi-scale model all the structural members are modelled as a simplified model except those which are under complex stage. To simulate a structure member under complex stress stage preference is to use fine model. Hence, a multi-scale can be said as a combination of fine and simplified model. The authors (Khandelwal et al., 2008) have studied a high rise steel frame by using macro model. A macro model is used to describe material non-linearity and geological behaviour of the specimen. Similar researches using macro model was performed by many researchers (Bao et al., 2008; Talaat and Mosalam, 2007). On the other hand, another method i.e. DEM is similar to FEM in terms of mechanical behaviours. But simulation procedure is different. The method use rigid bodies connected to springs to reciprocate the mechanical behaviour of a structure. Movements of rigid bodies are determined by using Newton's Laws of motion whereas; internal forces are given by spring relationships. Authors (Munjiza et al., 2004) have created a method which uses both DEM and FEM and by comparing the results concludes that the proposed method replicate the progressive collapse more accurately and also simplifies the calculations and establishment of model. Sun et al. have studied progressive collapse of RC bridge under seismic effect using DEM (Sun et al., 2003). On the basis of available literature this may be said that the DEM gives unsatisfactory result before the occurrence of failure whereas; the FEM gives accurate result for the same stage. As the collapse occurs, FEM fails to account some major parameters like movement of ridged bodies and their collision. To account such parameters experimental studies were performed. In a study (Qian and Li, 2012a), authors have performed experiment on realistic beam-column concrete structures providing different spacing between stirrups and reinforcement ratios and concluded the mechanism of collapse, development of cracks and the load- displacement curves. The authors further performed a study (Qian and Li, 2012b) in which the dynamic collapse mechanism was studied on six structural models of 1/3 scale. Authors concluded that collapse can be decreased by keeping small span length. Different experimental study (Sadek et al., 2011)simulating a column removal scenario. The assemblies represent portions of structural framing systems designed as intermediate moment frames (IMFs was performed on the four frames, two of concrete and two of steel, to assess how seismic design affects the progressive collapse resistance of the frames. Wei-Jian et al. performed progressive collapse analysis on concrete frame beams and studied the mechanism and collapse resisting capacity of the modelled beams (Wei-Jian et al., 2008). Destruction of un-operational building by blasting can give better data to study progressive collapse. Hence, a study (Song and Sezen, 2009) was performed on Student Union Building of Ohio State University to calculated the DCR for different members at different locations. In different studies (Sasani et al., 2011, 2007; Sasani and Sagiroglu, 2010, 2008) multiple experiments were performed on real structures, without considering any live load for safety point of view. Experiments were performed by removing some structural components and the findings were in terms of internal force distribution and deformation time-history. Matthews *et al.* performed column removal experiment on a two floor RC frame structure. The column was removed by blasting and redistribution of gravity loads was studied by using dynamic amplification factor. Finding states that the whole structure was in elastic state even after the removal of column (Matthews et al., 2007). To assess robustness and progressive collapse resistance demand of a structure, theoretical studies were performed by many researchers. These two parameters must be considered apart from conventional design method to enhance performance of significant structures. The main focus of researchers is to study the non-linear dynamic effects on the structural capacity during collapse process. A parameter called Dynamic Amplification Factor (DAF) can be used with linear static method as a simplified design methodology to prevent progressive collapse. A study (Marjanishvili and Agnew, 2006) concluded that dynamic analysis is a better approach to study progressive collapse of structures by analysing a nine-storey steel moment resistant frame. In a different study, authors (Joshi et al., 2010) have compared the DCR values obtained from numerical analysis performed for both linear and non-linear cases and studied progression of collapse in a multi-storeyed RCC building. The researchers have concluded that the plastic hinges are initially developed on members with maximum DCR value.

METHODOLOGY

The study is performed using finite element modelling. A space frame of six storeys was modelled in SAP2000. The frame is 32m x 14.5m in plan. It has eight bays of 4m each along the longitudinal direction and two bays of 6m and one of 2.5m along the transverse direction, as shown in figure (1).

Figure 1 SAP2000 Model



All the columns are square in cross-section with same dimension whereas, the beams are rectangular in cross-section with different dimensions. For the calculation of superimposed dead loads, thickness of the exterior walls is considered as 230mm, thickness of partition walls and depth of all the slabs are considered as 150mm. All the dead and live loads are as per the Indian codal provision (Bureau of Indian Standards, 2016). Following the general construction practice of India, the columns are designed for M40 grade of concrete whereas, the beams are made-up of M25 grade of concrete. Grade of steel, Fe415 (HYSD bars), is same for beams and columns. The details of the structure are presented in table (1).

Table 1. Details of building parameters

Items		Description
Storey Height		3m
Column cross-section		600mm x 600mm
Beam cross-section	At all the floors except the roof level	300mm x 450mm for beams spanning 2.5m and 4m
		400mm x 600mm for the beams spanning 6m
	At roof level	250mm x 450mm

The model was first analysed and the base shear correction was done as per Bureau of Indian Standards (2002, 2016). For the analysis, only gravity loads are considered because the probability of occurrence of an earthquake or any other event at the same time of failure of a structural member is too low. Hence, the model is analysed for (DL+0.25LL) load case only and the forces in all the members were noted as the capacity of the members for the calculation of the Demand Capacity Ratio (DCR) as per equation (1).

$$DCR = M_P / M_{max} \quad (1)$$

Where, Mmax is the bending moment of the member (capacity) and MP is the expected ultimate moment capacity of the member. After noting the capacity of the members, the model is designed following the Bureau of Indian Standards (2002, 2016). All the supports were kept fixed for this analysis and designing, after which, the supports were changed to pinned for the study on progressive collapse. The building with pinned supports will experience significantly large bending moment because, the bending moment will not carry over to the support ends and hence provide the worst case scenario. The model is analysed for both linear and non-linear cases. The Linear Dynamic Analysis (LDA) was performed following the recommendations of GSA (2016) whereas, the Non-Linear Static Analysis (NLSA) and Non-Linear Dynamic Analysis (NLDA) were performed as per the recommendations of GSA (2016) and DoD (2016). The static cases accounts a sudden column loss whereas, the dynamic effect can only be seen if the failure of structural member is gradual. For the linear case, the amount of collapse was obtained by calculating the DCR. The members for which the calculated values of DCR is greater than or equals to 2 are said as collapsed because the structure is symmetrical in plan as well as in elevation (GSA, 2016). The guidelines of the agencies (DoD, 2016; GSA, 2016) used for the analyses are summarized in the table (2).

Table 2 Guidelines of GSA (2016) and DoD (2016)

Agency	Load case(s) for analysis	Location of column removal
Linear Dynamic		
(GSA, 2016)	2(DL+0.25LL) on the entire structure	Outer middle column about longer and shorter bay and one corner column upto three floors
Non-Linear Static		
(GSA, 2016)	2(DL+0.25LL) on the whole structure	Outer middle column about longer and shorter bay and one corner column upto three floors
(DoD, 2016)	2(1.2DL+0.5LL) on the adjacent bays and floors above the removed column (1.2DL+0.5LL) on the rest part of the building	Outer middle column about shorter and longer bay, at ground floor, intermediate floor and at the top floor
Non-Linear Dynamic		
(GSA, 2016)	(DL+0.25LL) on the whole structure	Outer middle column about longer and shorter bay and one corner column upto three floors
(DoD, 2016)	(1.2DL+0.5LL) on the whole structure	Outer middle column about shorter and longer bay, at ground floor, intermediate floor and at the top floor

Whereas, for the non-linear cases, the amount of collapse was obtained by the chord rotation criterion (FEMA-356, 2000) as tabulated in table (3). To check the rotation, hinges are assigned in the model.

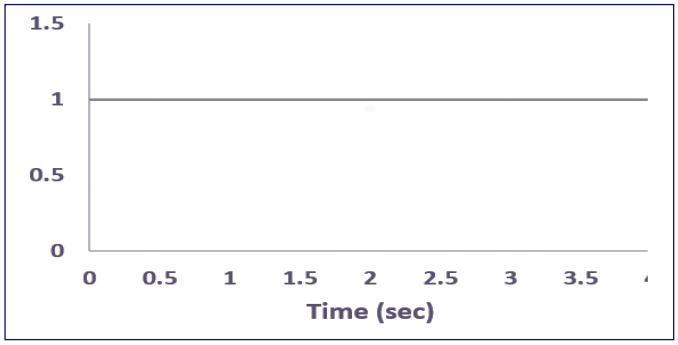
Table 3. Chord rotation capacity (FEMA-356, 2000)

State of Damage	Chord Rotation Capacity
Immediate Occupancy (IO)	$\theta_y + 10\% \text{ of } (\theta_u - \theta_y)$
Life Safety (LS)	$\theta_y + 60\% \text{ of } (\theta_u - \theta_y)$
Collapse Prevention (CP)	$\theta_y + 90\% \text{ of } (\theta_u - \theta_y)$

For the LDA, columns were removed from the recommended locations and the nodes above and below the removed columns were assigned with the same magnitude of forces, which were obtained as the forces due to gravity load in the structure without column removal. These assigned forces acts in the opposite direction and therefore, portray the same stable condition of the model as it was before the removal of column. Subsequently, two functions are defined to perform this analysis which will demonstrate the structural behaviour upto four seconds. First function is a constant function with magnitude 1 which begins with the initial time i.e. zero seconds and continues till four

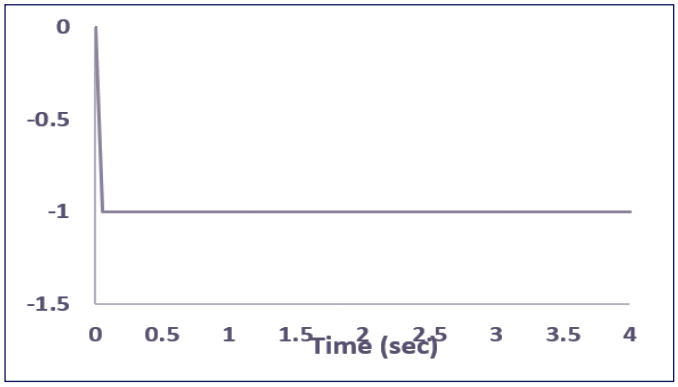
seconds as shown in Figure 2. This function is assigned to all the dead and the live loads.

Figure 2. Constant Function



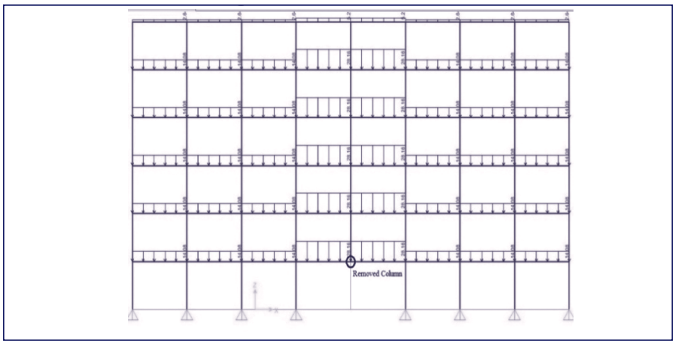
On the other hand, the second function begins with the initial time i.e. zero seconds and decreases gradually till 0.05 seconds beyond which it becomes constant upto four seconds as shown in Figure 3. This gradually decreasing function is assigned to the node(s) at the removed column locations. This function portrays gradual loss of column at the specific location after 0.05 seconds from the start time of the analysis. After completion of analysis, forces in each member were noted as demand and the DCR was calculated.

Figure 3. Gradual Function



The NLSA can be performed by two methods; displacement controlled method and load controlled method. This study uses the second method of performing NLSA by considering an immediate loss of column which begins with a zero initial condition. As per the guidelines of GSA (GSA, 2016), this analysis shall be performed considering a load case (DL+0.25LL) with a DAF on the entire structure. Therefore, the whole structure was analyzed for 2(DL+0.25LL), where 2 is the DAF and the amount of collapse was noted by referring to the rotation criteria (FEMA-356, 2000). Whereas, as per the guidelines of DoD (DoD, 2016), the NLSA shall be performed in such a way that the DAF is not applied on the entire structure and its use is restricted to the adjacent bays and floors above the removed column. Therefore, the analysis is done for two load combinations, 2(1.2DL+0.5LL) on the adjacent bays and the floors above the removed column and (1.2DL+0.5LL) on the rest of the structure. In SAP2000, it is not possible to perform an analysis by using two different load cases at the same time. Hence, to take into account the two independent scenarios, the density of the material and dead loads are increased by 20% and the live loads are reduced to 50% of the initial magnitude. Thereafter, for the adjacent bays and floors above the removed column, the DAF was used as shown in Figure 4. Subsequently, the NLSA was performed by making a new load case as (DL+LL) which accounts the DoD (DoD, 2016) guidelines.

Figure 4. Distribution of loads for NLSA following the DoD (DoD, 2016) guidelines



The approach of performing NLDA is a bit similar to that of the LDA. The forces obtained as the design forces of the members are assigned to the nodes above and below to the removed column because, these forces will keep the structure in equilibrium, as it was before the loss of column. To incorporate the dynamic effect, the gradually decreasing function explained in the LDA part and shown in Figure 2b, was assigned to column removal location. As a limitation of the software, the NLDA must began with another NLA which may be dynamic or static. Therefore, the analysis which follows the guidelines of GSA (GSA, 2016), began with a non-linear static case of (DL+0.25LL) and for DoD (DoD, 2016), it began with a non-linear static case of (1.2DL+0.5LL). The amount of collapse was noted as per the rotation criteria (FEMA-356, 2000).

RESULTS AND DISCUSSION

The model comprises of 216 columns and 354 beams which makes a total of 570 structural members. In the LDA, after calculating the DCR from Equation 1 and referring to the Figure 5, it has been found that when the corner column was removed then 12 beams which were supporting the corner side of the building just above the removed column got collapsed along with the 5 columns which were supporting those beams.

Figure 5. DCR for corner column removal at the ground floor

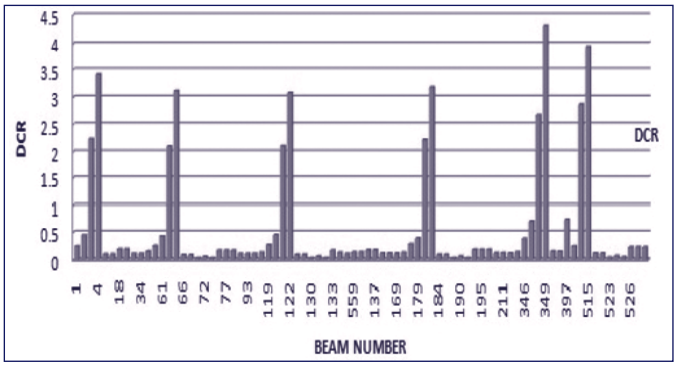


Figure 6 shows the ground floor corner column removal case and Figure 7 is for removal of middle column along the longitudinal bay. The column shown in red color is the corner column which is removed and the members which are shown in red color are the failed members whereas, the members shown in black color are safe even after the stress reversal.

The calculation process of DCR is very tedious as it requires deep attention and takes long time in noting the capacity as well as the demand of the structural members. Hence, the need of the hour is to propose an alternative of DCR with the same accuracy and precision. Bresler (Bresler, 1960) has presented a framework to plot interaction curves for columns subjected to uni-axial and bi-axial moments which states that a column is safe for every value of P-M interaction which lies within the interaction curve.

Figure 6. Collapsed members when corner column at ground floor was removed

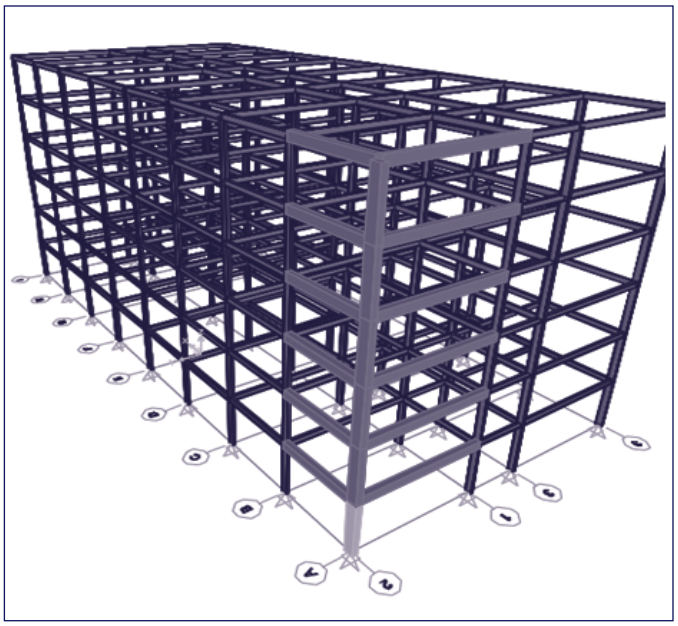
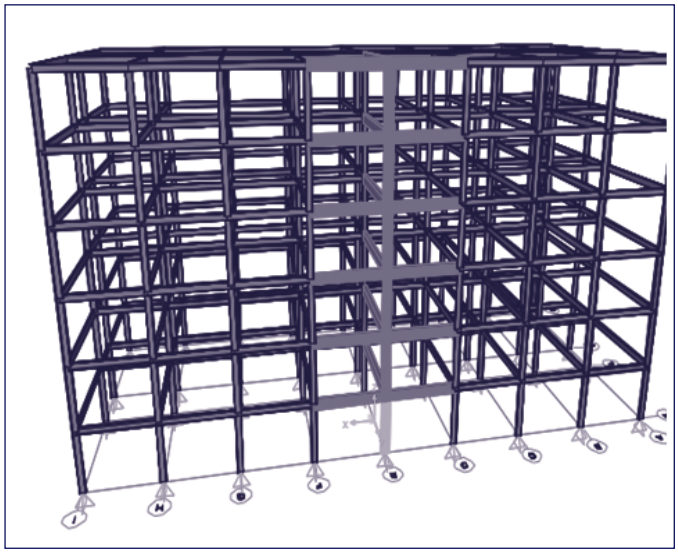


Figure 7. Collapsed members when corner column at ground floor was removed



Therefore, the interaction curves for columns of the model after column loss were plotted and the amount of collapse was observed. In Figure 8 and Figure 9, the interaction curves are shown for the ground floor corner column removal case. The curve shown in Figure 8 is for the column which is at the floor above to the removed column and the curve shown in Figure 9 is for the column at the top floor. The demand for P-M_2 in both the cases are falling outside the interaction curve whereas, the demand for P-M_3 is lying within the curve. Hence, these columns are failed in the P-M_2 interaction. These curves are plotted for each column of the model and it was found that the amount of collapse obtained from the DCR and the interaction curves came exactly the same.

Figure 8. Interaction curve for corner column at the first floor

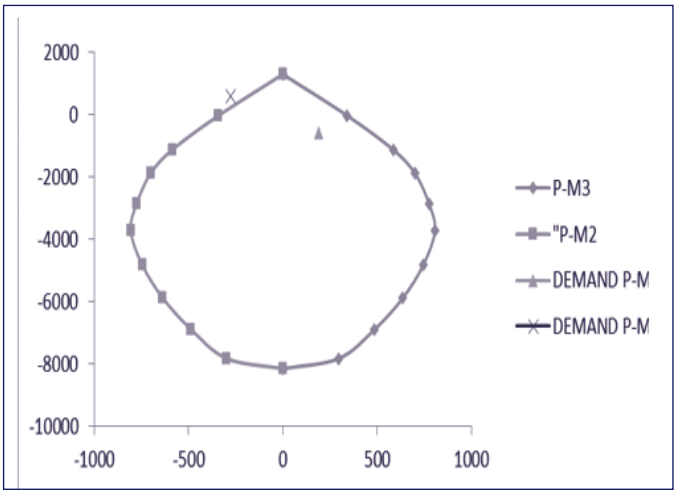
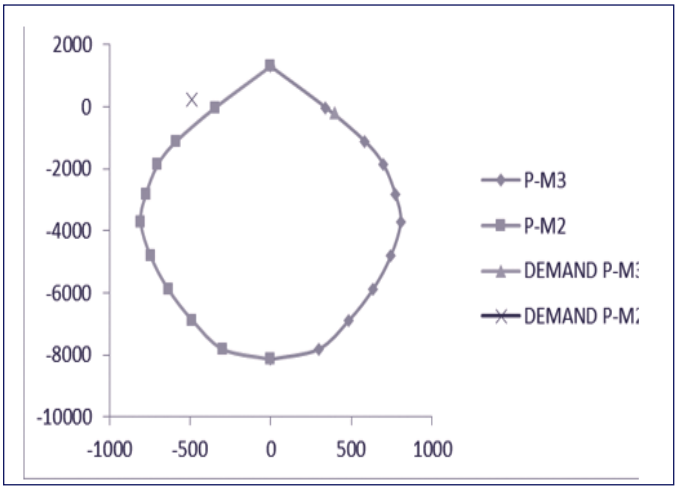


Figure 9. Interaction curve for corner column at the top floor



Therefore, finding the amount of collapse by plotting interaction curves may be considered as an alternative to the DCR calculation which is accurate and comparatively less time taking. The amount of collapse occurred in the structure from the LDA performed by following the GSA (GSA, 2016) for removal of column at different locations is summarized in Table 4.

Table 4. Results of LDA following GSA (GSA, 2016) guidelines

Column Removal Location		No. of Members Collapsed	%age of Collapse	Floor Area Collapsed (m^2)
G.F.	Corner Column	17	2.98	26
	Longer Face Column	23	4.04	52
	Shorter Face Column	6	1.10	10
F.F.	Corner Column	9	1.57	26
	Longer Face Column	12	2.11	52
	Shorter Face Column	5	0.89	10
S.F.	Corner Column	11	1.93	26
	Longer Face Column	8	1.40	52
	Shorter Face Column	4	0.70	10

The comparison between the results obtained from the NLSA and NLDA by following the guidelines of both the agencies (DoD, 2016; GSA, 2016) are presented in Table 5 and Table 6 respectively. The comparison is done only for the column removal locations at the ground floor (G.F.) and second floor (S.F.), which is the intermediate floors (I.F.), because these floors are common in both the agencies (DoD, 2016; GSA, 2016).

The results presented in Table 5 indicates that the collapsed area is same for both the standards despite of the huge difference in load case criteria. At the ground floor, when the corner column is removed, 2.98% of the total built-up area got collapsed whereas, 4.04% of the built-up area got collapsed when the middle column was removed about the longer and shorter bay. Subsequently, for the second/intermediate floor, when the corner column was removed, total collapse was 1.93% of the built-up area whereas, the collapsed area increases to 2.63% for the middle corner removal cases about the shorter and the longer bay.

Table 5. Comparison between the results of NLSA following GSA and DoD guidelines (DoD, 2016; GSA, 2016)

COLUMN REMOVAL LOCATION No. of Members Collapsed		GSA (2016) and DoD (2016)		
		%age of Collapse	Floor Area Collapsed (m^2)	
G.F.	CORNER	17	2.98	26
	LONGER FACE	23	4.04	52
	SHORTER FACE	23	4.04	36
S.F.	CORNER	11	1.93	26
	LONGER FACE	15	2.63	52
	SHORTER FACE	15	2.63	36

Likewise, the results presented in Table 6 shows the comparison of results for the NLDA. Similar to the case of NLSA, the comparison is done for the common locations of column removal. At the ground floor, when the corner column and middle column about longer bay is removed, the amount of collapse came equal following the guidelines of both the agencies (DoD, 2016; GSA, 2016). For the corner removal case at the ground floor, the collapsed area is 26 m2 and it increases to 52 m2 for the case of middle column removal about the longer bay. Whereas, at the same floor level, when the middle column about the shorter bay was removed, there was no collapse observed following the GSA (GSA, 2016) guidelines, eighteen members which were attached to the removed column or supporting the floors above are reaching to their plastic moment capacity only.

Table 6. Comparison between the results of NLDA following GSA and DoD guidelines (DoD, 2016; GSA, 2016)

COLUMN REMOVAL LOCATION No. of Members Collapsed		GSA (2016)	DoD (2016)
		No. of Members Collapsed	No. of Members Collapsed
G.F.	CORNER	17	17
	LONGER FACE	23	23
	SHORTER FACE	18 MEMERS REACHING TO PLASTIC MOMENT CAPACITY ONLY	23
S.F.	CORNER	11	11
	LONGER FACE	15	15
	SHORTER FACE	18 MEMERS REACHING TO PLASTIC MOMENT CAPACITY ONLY	15

whereas, 23 structural members collapsed for the analysis performed following the DoD (DoD, 2016) guidelines. Similarly, at the second/intermediate floor, the results obtained by removing the corner column and middle column about the longer bay are same for both the agencies (DoD, 2016; GSA, 2016) i.e. 1.93% and 2.63% respectively is the percentage of area collapsed and when the middle column about the shorter bay was removed, 12 members reaches to their plastic moment capacity by GSA (GSA, 2016) and no member was collapsed whereas, by DoD (DoD, 2016), 52 m2 area got collapsed.

CONCLUSIONS

The phenomena of progressive collapse may be trigged by any natural or manmade activity. Earthquakes, tsunamis, tornados and landslides are few amongst the natural activities whereas, fire, blast or any other type of manmade impact may initiate such phenomena of progressive collapse. Blast or any other type of strong impact has a tendency for sudden loss of a structural member whilst, majority of the natural as well as the manmade activities will account the gradual loss of the members. Hence, studies which are based on the blast or any other type of impact

may be restricted to perform the NLSA only as it accounts the sudden loss of structural member(s) and those studies which are based on the other type of triggering events such as earthquakes, fire etc. which are generally responsible for gradual loss of the member(s), may perform the NLDA only.

Referring to the results obtained from the NLSA, the amount of collapse by following the guidelines of both the agencies (DoD, 2016; GSA, 2016) is coming exactly the same, even when the structure is analyzed for different load combinations i.e. 2(DL+0.25LL) and 2(1.2DL+0.5LL). Hence, this may be concluded that there is a scope to revise the DAF or the load combinations or both because even with this notable difference in the present load cases the amount of collapse was not affected. Additionally, this may also be concluded from the results of the NLDA that the guidelines of DoD (DoD, 2016) are more suitable to perform the study of NLDA as the number of collapsed members are more which makes it the worst case scenario for the modelled structure.

Furthermore, as discussed earlier, the calculation process of DCR is very tedious, hence the proposed approach of plotting interaction curves for column to check its status may be used as an alternate to the DCR calculation. The Eq. 1 consider bending alone as a parameter to calculate the DCR. As per the matter of fact that a column shall be analyzed for the combination of load and moments (P-M2 and P-M3) instead of analyzing it individually for load and for moments. Hence, using the Eq. 1 to calculate the value of DCR becomes obsolete for the case of columns and it shall only be used for the beams. The proposed approach will significantly reduce the time to perform the LDA for the reason that the number of columns will be comparatively less to the number of beams and once a column is found to be failed in P-M combination, the beams attached to it will also be considered as failed.

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IOT BASED 4 WAY PATIENT MONITORING BAND WITH INTEGRATED GPS

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V. Vineetha

Abstract

The latest technology continues to face a great difficulty when it comes to managing and monitoring potentially contaminated patients. This project uses an IoT-based wearable monitor to track several vital indicators. Additionally, the system promptly alerts concerned medical authorities about any breaches for potentially infected patients by tracking real-time GPS data. The wearable sensor is linked to an edge node in the IoT cloud, which processes and analyses the data to identify the patient's current state of health. The proposed system consists of three layers: an Android web layer for mobile phones, a wearable Internet of Things sensor layer, and a cloud layer with Application Peripheral Interface (API). Every layer has a specific function; for instance, information from the IoT sensor layer is used to define health Vitals. In the following tier, the data is kept in a cloud database for quick decisions, alerts, and precautionary steps. Notifications and alarms will be sent to impacted patients' families using the Android mobile application layer. For forecasting and warning items, the integrated system has both an API and a mobile application that are synchronised. For monitoring, therapy, and analytical purposes, the design must specify the measured readings of the patient's condition. The investigation also shows how digital remote platforms and wearable technology are frequently utilised as a monitor to track a patient's health and recovery.

Keywords: ***Patient monitor, Android Application, Tracking, Alarms and Alerts.***

1. INTRODUCTION

The number of scenarios in which we use the Internet has been growing in recent years, expanding from static to social, transactional, and mobile. This progression has spawned a new concept: The Internet of Things (IoT) is described as any everyday device (or group of devices) connecting to the Internet from anywhere and at any time. Wearable technology, such as watches and phones running the Android operating system, is used in this project. The goal is to collect and interpret data from sensors put in individuals Vitals to detect. A suggestion for a smart health support system for monitoring isolated patients from a far. Implementation of an Internet of Things-based smart home healthcare support architecture capable of decreasing avoidable hospital loads caused by regular outbreaks. Specifically, the new system, which can also supply vital comforts using only IoT-enabled household appliances, encourages people with severe and chronic illnesses. Internet of Things-enabled devices make remote monitoring in the healthcare industry possible. These devices have the potential to keep patients safe and healthy while also enabling physicians to deliver excellent care. Patient engagement and satisfaction have increased as interactions with doctors have become simpler and more effective. Additionally, the amount of time spent in the hospital is cut down, and readmissions are prevented. IoT has a significant impact on reducing healthcare costs and improving treatment results. Without a doubt, IoT is revolutionizing the healthcare sector by changing how devices and people interact while providing healthcare solutions. Applications of the internet of things in healthcare can benefit patients, families, hospitals, and insurance providers. This will be the project's future architecture. In this project the real-time scenario is taken into consideration. The patient is monitored time to time through an android application with the iot wearable device on the patient. In this application the caretaker can visualize the readings of the patient irrespective of age can notice the changes shown in the app and can act accordingly. Everything is displayed in number formats, mentioning the minimum and maximum.

2. SCOPE OF THE WORK

IoT describes a scenario in which every element of our immediate surroundings is made capable of autonomously connecting with one another without the need for human to human or machine to machine communication. In addition to being a ground-breaking discovery, it has the potential to significantly improve our quality of life. The scope of this project includes researching an IoT application and related hardware. With the aid of this application, patients in hospitals are continuously checked for health conditions. When any patient's health is in an abnormal condition, the doctor and nurse are promptly notified via alarm or message. Due of this, they frequently react fast and cater to patients.

3. EXISTING SYSTEM

There are currently systems that fall under the category of non-IoT technologies, such as BPM metres and thermometers, where we must use human labour to examine a person's results and there is no specific alert mechanism to notify a doctor when the doctor is located remotely. Before choosing one over the other, you should be informed of the specific advantages

and disadvantages that each has to offer. The patient's heart rate and blood pressure measurements are shown on the bpm metre itself. Values cannot be checked when we are in a remote place. The thermometer is the same. But in this case, using sensors and smart health care, anyone with authorised access can view the patient's values. The current technologies are too complicated for typical use, without any prior knowledge of them.

4. PROPOSED SYSTEM

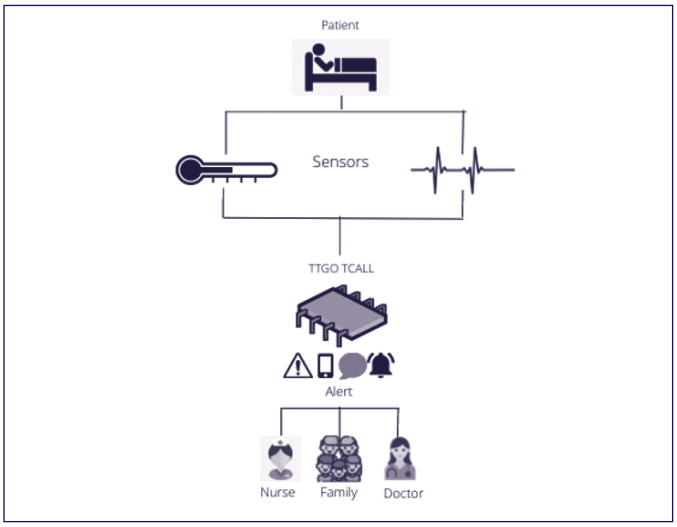
Smart Health Care is the idea to calculate a person heartbeat and temperature levels with the use of sensors and analysing the results to alert the doctor about patient condition via message. To talk about the system, it's an smart health care using sensors. Here to make patient monitoring easier. This idea combines the internet of things (IoT) and medicine, allowing for extensive instrumentation of the healthcare experience regardless of the patient's and provider's locations. With the use of Data Science, the quality of care is increased. When necessary, timely and appropriate medical care can be obtained, and the services' content will be more individualized. Alarms assist in preventing patient harm by enabling quick notice of and response to life-threatening circumstances. And with these alarms and notifications from an application brings out the aim of this project including patient tracking.

5. PROBLEM ANALYSIS

RPM (Remote patient monitoring) has the ability to significantly alter how patients are treated. If widely adopted, it will drastically alter the patient experience and make it possible for healthcare providers to manage their resources significantly more effectively than they presently are, reducing pressure on healthcare systems around the world.. The patients admitted in hospitals are monitored by the nurses and are timely noted and reported to the doctor. In order to reduce manpower we need specific devices that gives us an accurate measure of the patient's heart rate, temperature and etc. this brings out the idea of Quarantined patient monitor. The patient's complete report in displayed in the cloud server where the data is stored and linked to the application. Anyone can access the application through an authorized access to check the patient reports and monitor them from any remote location. When the patient's condition is critical the person who wish to monitor can get a message to phone number which is set for sending the alert notifications and alarms. And even the patient's location is tracked using GPS. And also, the patient can communicate with the microphone, as and when required. Smart health care is advantageous as the include efficient time usage, improves communication and better extended care. Through apps and a health information platform, patients can manage their condition on their own. Smart healthcare can help individuals better manage their own health.

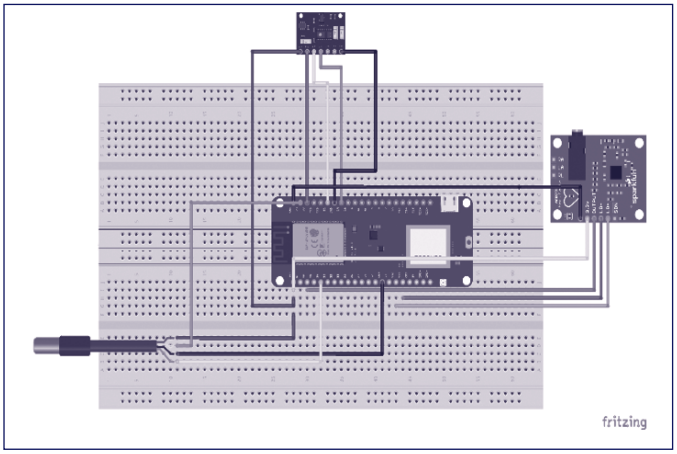
6. ARCHITECTURE

The medical industry and healthcare are heavily reliant on technology. Many technological tools and pieces of equipment have been developed for human health care. The patient monitoring system is portable, low cost, the user interface is so friendly anyone who wishes to monitor can access easily. The patient is monitored through the band which consists of the sensors and all the readings from the sensors are stored and displayed in the app. When the readings are out of the range then the doctor/nurse/the family member who wish to monitor is notified, if in case the readings are abnormal then an alert is given. The patient's location is tracked and displayed.



7. METHODOLOGY

Patient monitor band is a clinically accurate, wearable device. This keeps the track of heart, temperature, blood oxygen level and pulse data. The way the physicians can access that data is regular, when the patient brings the gadget, which links to the android application and transfers the recorded information through the cloud. After conducting preliminary research on the many types of devices accessible and their programmability for usage with a custom app, the lack of an intuitive technological answer became the driving force behind this project. The band is designed in such a way that the patient doesn't find it uncomfortable to wear it.

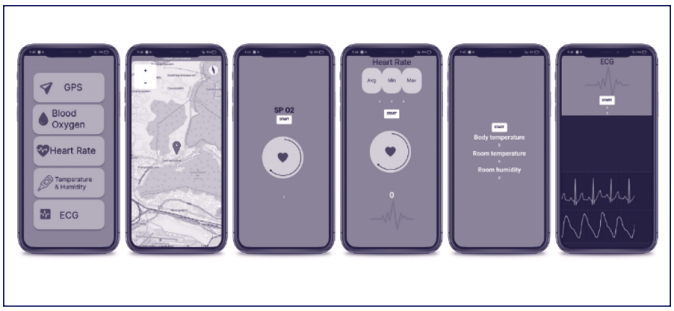


In this the temperature, heart rate, pulse is displayed and the patients live location is tracked. The google fire base is used as a data base hosting and integrating is done in fire base. To create an interface android studio is used. All the predictions whether the condition is normal or abnormal everything is displayed in the app created using the android studio.

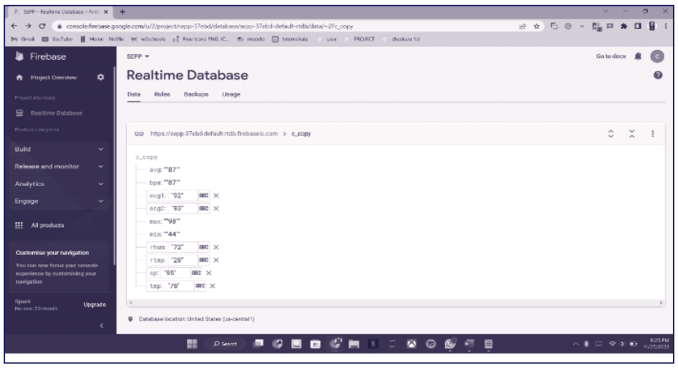


8. RESULTS AND DISCUSSION

The data is monitored through fire base. The various sensor data are displayed. Each sensor data is displayed in a separate field. And that data is sent to the customised application.



The normal human body temperature would range between 92.7-99.5 °F in an average. The temperature is normal and updated in the log continuously is the patient puts the iot wearable device. The normal heart rate of a person varies from 50-90 bpm as in case of adults it may vary from 60-100 bpm. In the same way ECG and Blood oxygen levels are also detected with the sensors. If the values are abnormal, the alarm buzzes as a way of alerting the caretaker.



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GETTING DIVIDEND FROM DEMOGRAPHY: SKILL DEVELOPMENT EVIDENCE IN INDIA

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Dr. Arif Hasan
Prof. K. S. Thakur

Abstract

India has placed a strong emphasis on skill growth as a result of the country's shifting demographics, rising desires of young people for improved employment opportunities, and rising employer expectations of a workforce that is well-trained and productive. In order to reap the benefits of these generational dividends, Prime Minister Narendra Modi launched the Skill India initiative on July 15, 2015. The campaign's objective is to train more than 40 crore candidates in India in various skills by 2022. Numerous government initiatives are included, such as the Pradhan Mantri Kaushal Vikas Yojana, National Skill Development Mission, National Policy for Skill Development and Entrepreneurship, and the Skill Loan Program. In order to provide skill-based training to the youth and allowing them to gain and support in country's anti-poverty programmes, the skill acquisition initiative was developed. The Indian government has launched a number of large-scale national programmes for technical education, training, and skill development over the past 20 years to increase opportunities for young people in terms of employment and income. In light of the aforementioned, it is crucial to establish if a skill development programme contributes to a rise in youth productivity and performance outcomes. Current research sheds insight on recent evidence of skill development in India.

Keywords: Skill Development, Demographic Dividend, Asian Countries Skills Development Initiatives, Skill Development Training, Unemployment Problem, National Skill Development Mission, Skill Development Policy, Training & Development.

INTRODUCTION

India has a significant demographic asset that could be turned into a dividend by making a positive contribution to economic development. The National Skill Development Initiative will empower all humans to attain access to jobs and assurance the competitiveness of India on the worldwide market thru more desirable abilities, expertise, and nationally and globally acknowledged qualifications. The National Skill Strategy identifies specific focus classes for skill growth inclusion in the context of improving infrastructure and a better job agenda to understand their future competitiveness and lead to social and economic progress. Previously few numbers of Indian employees had any organized skill training. So it is not shocking that many segments of the country's economy are facing a lack of qualified workers and are dazed by low productivity rates owing to poor quality of the workforce. At the same time wide numbers of the country's youth are searching for economic and livelihood opportunities. In this sense, capability creation has become an important goal for the region. Not only is this important to sustainable growth, but will also help meet the desires of young people for high quality, well-paying careers and self-employment opportunities. This would also encourage the country to take advantage of its favorable demographic profile. India has the chance to become a worldwide supplier of skills with a large pool of skilled people, particularly the aging developed world.

The primary goal of the professional acquisition program is to build awareness, uplifting skills, creating work openings and entrepreneurship. Professional training system would improve the competitiveness of the country's workforce by allowing them to get high-quality professional training through a range of industries. This would also bring about a structural shift in the world from input-based skill training to magnitude-based skill training. This also seeks to dramatically increase the nation's skill training operations and allow skill training to take place at a rapid pace, without losing efficiency.

LITERATURE REVIEW

Compare Indian skills development initiative with other Asian countries skills development initiative. India acquires wonderful opportunity of the demographic dividend (Palit, D. A., 2009). Desai et al., (2010) Growth, poverty, inequality, and human development are always concern in India. After the liberalization, rapid economic growth has stimulated further global interest. Indian MNCs witnessed a turbulent era in the form of hyper competition. Misra (2015), skill development in India is as an Influence of the demographic dividend and upgrade skill to entrée in global market and increase productivity of both sector organized and unorganized. The existing policy of skill development needs modification according to the requirement of industry and global market. Misra (2015), suggest private participation and skill development university establishment in every state can be useful to achieve target of training people by 2022. Even after the Government investing a lot in training costs and infrastructure, creation of vigorous workforce for the industry is still a fantasy. As a world's fastest growing economies, India needs Gray collar (knowledge employees),

Pink collar (waiters, vendors, salespeople) and Rust Belt (construction) jobs complement white and blue collars (Prasad & Purohit ,2017). Students need to be made industry prepared through making the curriculum for professional courses in a way that offers complete on the job education and the high-quality standard of training needs to be upgraded. After substantial development in literacy, very high incidence of illiteracy causes the Indian workforce even today. Thus, need for increasing capability of skill development programs (Saini, V., 2015). Srija, A. & Sanghi, S. (2018), Productivity is more important among them, and it has different measurement for individuals. (Agrawal & Thakur, 2019) sates after the completion of training there is a remarkable change in trainee productivity. Availability of skilled manpower, innovative practices and technological upgradation can increase the productivity. Improved productivity reflects in improvement of GDP, increased enterprise profit and worker with high wages. Improving the production of management skills is the best direction and the growth policies will be a necessary step. The development policies must be according to the requirement of various sectors also focusing on quality and relevance of the training. The Developing Countries show that innovation in professional growth contributes to global change and low pay breaks. In many areas of the globe, short-term training programs have been commonly used as a strategy tool to boost the employability of specific population communities. The results of Indian studies also seem to be consistent with earlier assessments that the impact of education on development countries is more positive than in the EU or the US (Betcherman et al. 2004).

STATEMENT OF THE PROBLEM

A skilled workforce is vital in order to make India globally competitive and further enhance its economic growth. As a knowledge-based economy, India has progressively progressed due to the abundance of competent, versatile and skilled human resources. With the growing encouragement of globalization, India has enormous opportunities to create its distinguishing position in the world due to Skill capacity available. Knowledge and skills are important grounds of macroeconomic development and socioeconomic stabilization. Developing skills can be described as skills obtained or evolved through training or knowledge. It enhances people's capacity to adapt to altering business requirements and helps to profit from innovation and business operations. At national level, any country's future prosperity eventually relies on how many people are employed and how efficient they are at job. For inclusive growth, skilled human resources are crucial. In order to reap the advantages of our country's demographic dividend, the development of skills can therefore be linked to a wider growth, employment and development that include government interventions.

In current scenario educated youth of India are facing severe unemployment problem, due to lack of skills and technical knowledge. Most of them are unaware about the developments taking place in the modern world. India's government is working hard to accomplish the target mentioned, which has positive impacts on youth as well.

- **H_1:** There is significant role of skill development training program acquisition, upskilling and change in working methodology on productivity of youth.
- **H_2:** There is significant impact of skill development training program acquisition, upskilling and change in working methodology on performance of youth.

Probably the biggest issue is to ensure that skill policy is implemented at ground level at an alarming rate due to absence of consciousness. In addition, convincing blue chip businesses to appoint the qualified workforce is another bottleneck due to the problem of stability and outdated curriculum that does not meet industry standards. Therefore, instead of sticking to local demands, we need to generate employment throughout the world. The toughest job is to source and create a pool of skilled, knowledgeable, and certified trainers who are ahead of time and understand the strategy, individuals, and media feelings.

OBJECTIVES OF THE STUDY

The Skill Development program is associated to the increase in productivity and performance outcomes or evidence. Where person can shift his or her ability by learning. Skill Development Trainee productivity and performance directly depends upon the training attributes includes training acquisition which transfers to upskilling and work methodology. The objective of the study is to assess the role of skill development program in improving the productivity and performance improvement of trainees.

METHOD

A Descriptive research design as well as exploratory research design is employed for present research. Result generalization of study is on group of trainee who were trained at training center of skill development program. Both primary and secondary data was collected and a convenience, non-probability sampling. Data for this study was collected by survey conducted at training centers. The sample of this study consist of youth who were trained at skill development training center in India. A closed ended limited questionnaire is used to collect relevant knowledge and evidence on the categorical scoring scale of Likert five points. A thorough interpretation of the element by these experts aided in establishing the face-validity of the questionnaire and its objects. The questionnaire was seen and shared with teacher and psychologist at the counseling centre. These individuals first shared their opinions on the questionnaire and suggested the necessary change. Collected data wrangled through editing and codding. Every gathered questionnaire was checked for culmination and cleans for more deep and extensive treatment of response. However, 65 questionnaires were removed, as not fit for final analysis. Therefore, remaining 1193 questionnaires were used for further data analysis. Wrangled data were imported into SPSS 24 for analysis. Analysis were Categorized into descriptive analysis and statistical analysis. To visualize the data, descriptive analysis were used to analysis demographic information. First, reliability measurement scale was examined to find the appropriateness of data for research.

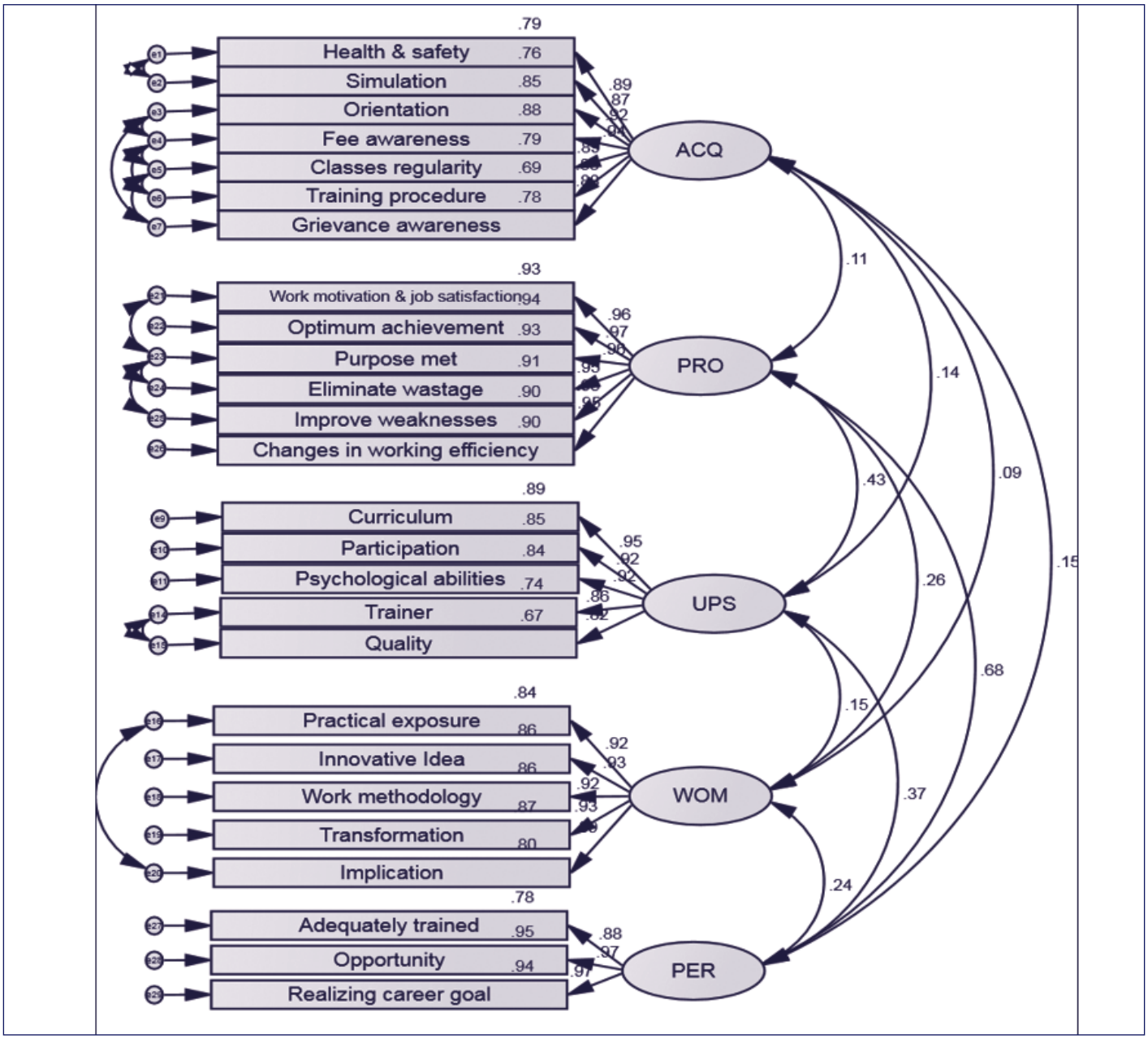
This is a test of the consistency of the respondent's answers to all the items in the measure. The obtained value of the overall measure is 0.931 Cronbach's alpha which is greater than the 0.70 and indicates the excellent consistency and acceptable for research. Descriptive study showed the plurality of respondents were 64.91 percent male and 35.09 percent female out of 1193 respondents in all. And male respondents dominate the survey. Most of the respondents are Senior Secondary 67.34 percent of total sample. The results clearly indicate that big parts if India are on the verge of seeking career possibilities for economic and livelihoods.

RESULTS

Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis is a method of quantitative data analysis and belongs to structural equation modeling techniques (Mueller & Hancock, 2001). Confirmatory factor analysis commonly uses structural equation modeling approaches and carried out by using analysis of a moment structures. Structural equation modeling (SEM) tests unintended relationships with linear equation model and assumes a relationship between variables and factors. AMOS.24 program has been used in the present analysis for modeling structural equations. Modeling of structural equations is a technique which examined the suggested relationship between independent and dependent variables. Modeling of structural equations is a two-stage method. Stage one involves developing a model for confirmatory factor analysis, and then evaluating validity questions. Phase two includes planned testing of the model. In other words, after the validity test of the measurement model, the adjustment is based on the program Adjustment Indices (MI) recommendation and developed modified model in Figure 1.

Figure 1. CFA Model Fit



Validity and Reliability Check

For CFA convergent validity, discriminant validity and reliability check is absolutely necessary (Hair et al., 2006). Validity is the amount of the accurateness of an item used in a study (Linn, R.L, 2000). The following are measures to check convergent Validity and discriminant Validity. Table 1 shows the summary of Validity and Reliability check of CFA model. All the construct values are acceptable for further analysis.

Table 1. Summary of Validity and Reliability check

Factor	CR	AVE	MSV	MaxR(H)	WOM	ACQ	PRO	UPS	PER
WOM	0.966	0.852	0.068	0.967	**0.923**				
ACQ	0.964	0.769	0.030	0.965	0.105	**0.877**			
PRO	0.986	0.919	0.479	0.986	0.261	0.127	**0.959**		
UPS	0.958	0.767	0.186	0.963	0.155	0.162	0.431	**0.876**	
PER	0.961	0.860	0.479	0.976	0.244	0.174	0.692	0.368	**0.928**

Note:

- Diagonal value of factor > Non diagonal value for discriminant validity (Kesharwani & Tiwari, 2011)
- CR: Composite Reliability should be CR > 0.7
- CR: Composite Reliability > AVE: Average Variance Extracted
- AVE: Average Variance Extracted should be AVE > 0.5
- MSV : Maximum Shared Variance should be MSV < AVE
- MaxR (H): Maximal Reliability should be H > CR

Common Method Bias (CMB)

Common method bias denotes a bias of dataset apart from the measures (Podsakoff, et al., 2003). A common method bias represents influenced responses and majority of the variance is described by a single factor. Common latent factor (CLF) method captures the common variance between the all observed variables. In this method, add another latent factor in the CFA measurement model. After adding and connecting the common latent factor (CLF) all observed variable standardized regression weights is compared of both the models (with and without CLF). The difference between both the standardized regression weights should not be more than 0.200. Analysis show difference of both the models (with and without CLF) is <0.200 which reflects the data is free from bias.

CFA Measurement Model fit

After evaluating model validation and biasness check, the fitness of CFA measurement model was analyzed by using AMOS 24. The appropriateness of the model was scrutinized before scan the hypothesis and the assessed structure relationship. For this, various model fit indices or measures were used to confirm the model structure. The appropriateness of the model was scrutinized and various model fit indices or measures were used to assess structure relationship. According to Table 2, all Confirmatory factor analysis model fit indices are within the acceptance level and demonstrate good fit model.

Table 2. CFA Model Fit Indices

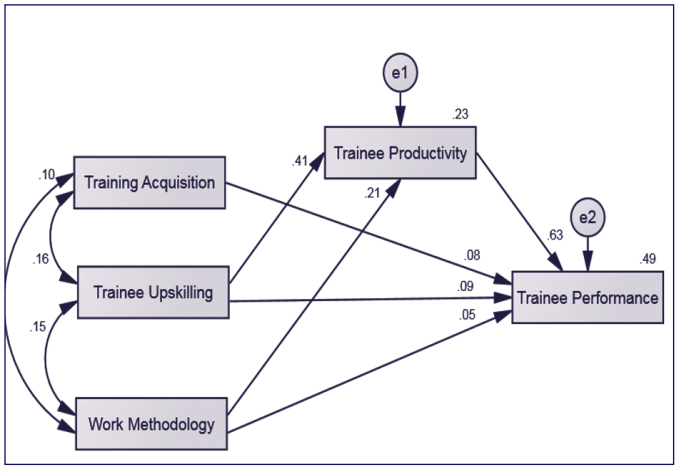
Acceptance Level	Actual Value	
P-value >0.05 (Not Ap-(plicable for sample >200	0.000	Not Appropriate for this study as sample size is 1193
Chi-Square/ df < 3.0 and should be less than < 5.0	4.276	Within Acceptance limit
GFI >0.90	0.930	Within Acceptance limit
NFI > 0.90	0.972	Within Acceptance limit
CFI > 0.90	0.979	Within Acceptance limit
RMSEA <0.08	0.052	Within Acceptance limit

Source: Author's Calculation

LATENT VARIABLES MODEL

Latent Variables model is prepared with imputed score considering the pattern and estimated parameter of CFA Model. This model is design according to the predetermine attributes of skill development training program. A skill development training program is claimed to be effective only when training outcome matches with its objective that is trainee productivity and performance outcomes. Trainee productivity and performance directly depends upon the training attributes. Figure 2 shows the path diagram model constructed on training attributes of Skill Development with standardized parameter estimate.

Figure 2. Latent Variables Model



In this latent variable path diagram there are five confirming factor that is training acquisition, upskilling, work methodology, productivity and performance. These factors affect the influences of skill development training depends on variable. In this model, independent variables include training acquisition, upskilling and work methodology while dependent variable includes productivity of trainee and performance. Intervening

variables includes in training acquisition such as the structure and formality of the educational environment or trainer's ability to engage trainee with stated curriculum or contextual attributes which directly affect the trainee performance. For testing hypothesis the relationship between independent variable and dependent variable were analyzed. Significant p value less than 0.05 shows that independent variable have a significant impact on dependent variable. Significant p value is depending on the critical ratio, when the it is greater than 1.96 for a regression weight, then the significant p values is significant. In Table 3 p-value column *** indicate significance less than .001.

Table 3. Latent Variables Relationship

Relationship			Estimate	S.E.	C.R.	P-values	Label
PRO	<---	UPS	0.811	0.051	15.936	***	Significant
PRO	<---	WOM	0.239	0.03	8.046	***	Significant
PER	<---	UPS	0.106	0.028	3.760	***	Significant
PER	<---	ACQ	0.084	0.023	3.601	***	Significant
PER	<---	WOM	0.039	0.015	2.562	0.01	Significant
PER	<---	PRO	0.388	0.014	26.868	***	Significant

Source: Author's Calculation

Note: *** shows p value is <0.001

Result of tested hypothesis on the basis of p value obtains in Table 3, which is less than 0.05. All result is significant and hypothesis is accepted. Hence independent variables training acquisition, upskilling and work methodology is directly influence the dependent variable trainee productivity and performance. Therefore both Hypotheses are accepted, there is a significant role and impact of skill development training acquisition, upskilling and change in working methodology on productivity and performance of youth.

DISCUSSION

Findings of this study supporting that skill development training has positive relationship and strong positive impact on trainee productivity and performance as a evidence. Training also promotes self-employment among unemployed youth. Training programs are very important for achieving excellence and skills in knowledge, skills, ability, potential, attitude and behavior in order to meet rapid technological changes and changes in work practices.

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SUSTAINABILITY DRIVERS AND APPLICATIVE CASE STUDY WITH INDUSTRY4.0 IN A COMMERCIAL VEHICLE INDUSTRY

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Nagamanikkam
Dinu Davis

Abstract

Industry 4.0 spans the entire gamut from automation to digitalization up to smart factory inclusive of sustainable measures. This paper details few of the sustainable development specific to commercial vehicle manufacturing with key focus on in-house facility development for mitigating product defects, an overview of progressive transformation of facilities and support mechanisms like energy management in a sustainable manner as well as the future course of sustainability on similar areas. The authors further provide practical approaches with examples in each area and the benefits observed.

Keywords – Industry 4.0, Sustainable facilities development, Energy management, Engine facilities transformation.

INTRODUCTION

Industry 4.0 being multifaceted spans the entire spectrum in manufacturing industry with multiple use cases and user stories. It is the springboard into the future of manufacturing wherein dependence on digital data based decision making approach is observed ie decision based on actual facts and numbers. As a start Manufacturing industries requires energy and in particular Electrical energy for its various energy needs like heating, ventilation, cooling, lighting, running mechanical devices through electric motors and drives. In this backdrop Commercial Vehicle(CV) manufacturing is no exception, as electricity is the primary requirement in CV industry to function. Additionally CV industry are continually evolving from mechanical to digital to smart across a time period in a progressive manner due to multiple factors like Capex(cost), technology, scale of adoption, resource constraints and methods. This paper explores with case studies on the nuances of adoption of industry 4.0 across the CV industry taking into consideration sustainability, Self-reliance and adoption of made in India products.

REVIEW OF LITERATURE

To start with a systematic review of literature was conducted to understand research already done, captured as below:

Claude et.al [1] conducted an empirical research in a south African multinational engineering company and the challenges faced by experienced area managers. Further deep dives into the meaning of organizational change and transformation applicable in South African business environment,also themes like speed, effectivity, and Broad-Based Black Economic Empowerment (BBBEE) are discussed. Julian et.al [2] examines i4.0 industrial relevance and related opportunities including challenges as drivers for implementation under sustainability. the study takes different perspective considering company sizes, industry sectors, and the company's role across nearly 746 German manufacturing companies spread across five industry sectors giving a positive outlook from strategic, operational, as well as environmental and social opportunities for i4.0 implementation, whereas challenges with regard to competitiveness and future viability as well as organizational and production fit impede its progress.

Mirjam et.al [3] has compiled the relation between i4.0 and sustainability based on descriptive and content analysis and presents a theoretical framework. Specific questions of "How does Industry 4.0 affect company sustainability practices and performance? How do sustainability goals affect Industry 4.0 adoption?" are analyzed. Further the impetus on positive aspects over negative aspects of i4.0 are discussed.

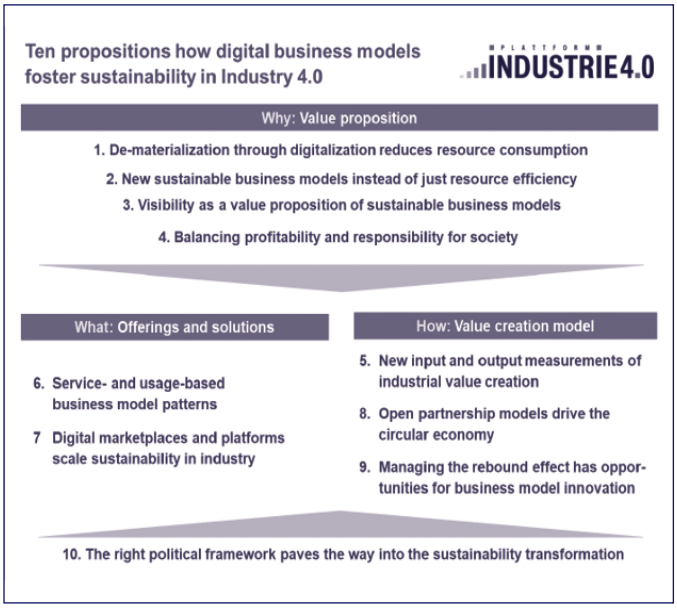
Judit et.al [4] discusses on 4 scenarios ie deployment, operation, integration and compliance with sustainable development goals in the long term. Negative relationship observed between production process flow , raw materials, different energy needs, information flow and disposal of waste and the environmental impact. Integrating i4.0 enhances environmental sustainability by creating ecological support system thereby ensuring higher environmental performance. LEONARDO et.al [5] observes an increasing trend between i4.0 and sustainability with its adoption as a pillar under the smart factories umbrella established via bibliometric performance and network analysis (BPNA) treated with Science Mapping Analysis Software Tool (SciMAT) resulting in 12 network structure clusters with patterns in a theoretical mode. Bhaveshkumar et.al [6] explores i4.0 understanding among the Indian manufacturing industries for finding out the motivating factor towards its implementation, assessing their sustainability and its impact on sustainability pillars. Krzysztof et.al [7] evaluates relation between i4.0 and

sustainability through review of literatures using systematic literature network analysis and constructed a sustainable i4.0 depiction framework on SLNA. Neaga Irina [8] emphasizes the circular economy approach on sustainable usage of resources and energy. Additionally, advices to enhance the circularity or recycle of the resources and energy within industries based on the actuals with an understanding on the scarcity of natural resources and the waste at the end of life of products may retain some value. Ivic et.al [9] analyses and observes mining companies in Europe on their positive engagement on health, safety, air and water areas while an absence in utilization of renewable energy and waste recycling including gender diversity. Björn et.al[10] analyses the transformative change in accordance with Paris agreement 2030 and presents a comprehensive analysis of literature survey and deliberates on the transformations observed including sustainability. Breno et.al[11] studies the business strategic environmental decisions in a of a luxury car manufacturer based out of United kingdom and understands the basis of green adoption and further shares the benefits attained through green initiatives. Nabila et.al[12] presents a Life Cycle Costing method using different scales for comparing design options and materials used in automotive vehicle. Various Life Cycle Costs considerations were analyzed like environmental damage costs, fuel expenses and materials costs as well as brining in socio-technical vision for a French car manufacturing company. Hab et.al[13] using Lowell Center for Sustainable Production (LCSP) modelled towards analysis of sustainable production and assess automotive manufacturing companies in the European union for crucial key aspects. Empirical studies undertaken based on Corporate Social Responsibility/ Sustainability reports of car manufacturing companies and analyzed and observed that most of the sustainable production practices focusses on sustainability from environment perspective, the employee and social aspects are also present. Wanja et.al[14] focuses on interior development of premium automotive car manufacturers from lightweight construction and CO2 emission reduction and the influence of economical, ecological and social issues from sustainability based on quantitative study considering customer expectation. Caroline et.al[15] conducted a bibliometric analysis in Industrial engineering domain on Automotive sectors sustainability and innovation. The study concludes stating the need for radical innovations for conforming to existing environmental standards like reduction in greenhouse gas emission, life cycle assessment, reverse logistics and ecological innovation emphasizing the need for further empirical studies. Lucian et.al[16] presents a different automotive business model considering three dimensions of organizational sustainability such as Economic, social and environment and validates fifteen principles fo sustainability. The review of literature also observes the applicability in CV manufacturing industries is very limited and present tremendous scope for enhancements.

SUSTAINABILITY

Sustainability as per UN [a] is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Present generation engineers are accountable for sustainability as they engineer the tomorrow. Therefore, the impetus on the engineers are way much more in terms of bringing in efficiency into operations, planning of new / upgrading existing facilities thereby protecting the future generation from deprivation. Engineers in manufacturing industries tend to adopt industry 4.0 towards achieving sustainability as stated by Pillar et.al[17] in figure 1.

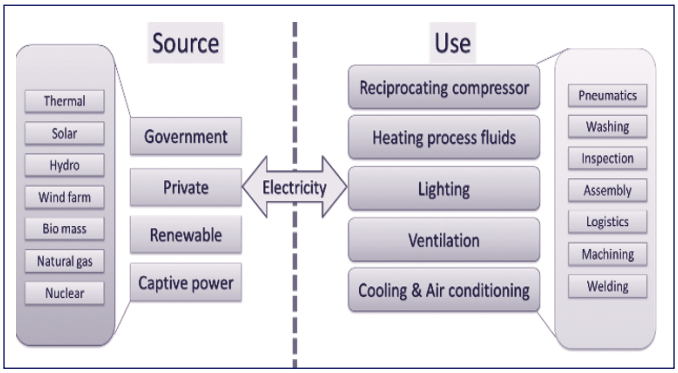
Figure 1: Ten propositions how digital business models foster sustainability in industry 4.0



Manufacturing industries of which CV also forms a part use many forms of resources of which Electricity (power) forms a major one.

Power in Manufacturing Industries:

Figure 2: Electricity source and use



Manufacturing industries rely heavily on usage of Electrical power (nearly 55% of operating expenses) for its various manufacturing requirements. Details are broadly summarized in Figure 1.

The usage of electrical power in CV industries especially in assembly lines are mostly towards compressed air generation which are used for operating pneumatic tightening tools used in assembly processes.

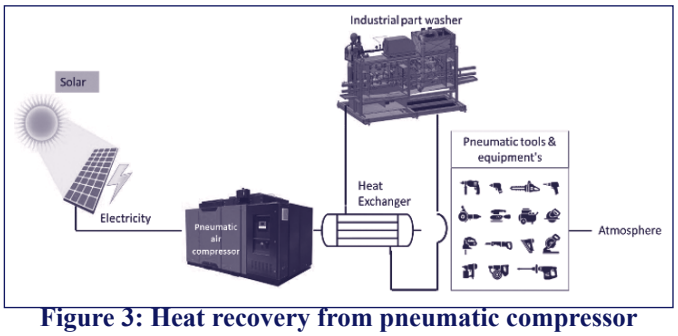


Figure 3: Heat recovery from pneumatic compressor

Case study 1:

The pneumatic compressors in addition to providing compressed air output also produces lots of heat which are vented to the open atmosphere as tabulated in table1. It can be observed that nearly 85% of input power get transformed into recoverable heat while 10% are un-recoverable and only 4% get converted into compressed air.

Table 1: Conversion of input power to compressed air

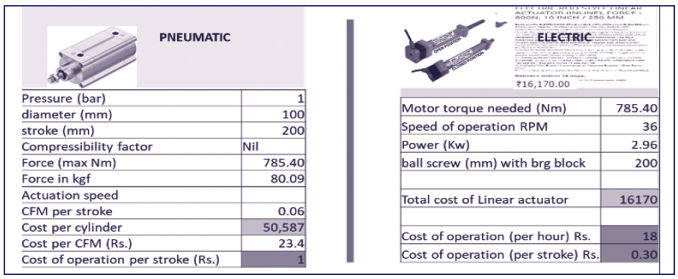
Electrical power 100%	Motor Losses – 8%	Compressed air – 4%
		Unrecoverable heat – 10%
	Hot air – 25%	Recoverable heat – 85%
	Hot Oil – 67%	

Through the usage of thermic fluid based heat recovery system given in Figure 2, the waste heat are captured and used for heating industrial part washers installed in machine shops, thereby the usage of heavy duty industrial grade dip type heaters needed for heating the alkaline degreasing solution in the bath of industrial part washers and the corresponding energy consumption reduced by 50Kw per air compressor of Atlas copco GA 90 model (reference data).

Case Study 2:

Compressed air is also used for operating multiple pneumatic devices like cylinders and actuators which are used in machine tools for operating doors, slides and multiple machine elements. Also pneumatic hoists are in use for material handling purposes. A theoretical study undertaken for one case of converting a pneumatic cylinder based application with electric slide equivalent is presented in Figure 3.

Figure 4: Substitution analysis of pneumatic cylinder with electric slide



It can be observed that the running cost per stroke of electric slide is 33% that of made in India Pneumatic slide which interprets in a savings of 67% of running cost for power alone. This switch / change in technology has enormous potential in reducing the variable manufacturing cost of the product being produced. Also the fixed cost of electric slide is less than 50% the total cost of pneumatic circuity, this has potential for CAPEX (Capital expenditure) reduction thereby potential for reduction in fixed cost of manufacturing. Engineers in manufacturing locations have the skill set needed to identify such cases and bring about savings and benefits to manufacturing organizations in a more sustainable manner.

Case study 3:

As stated in the beginning, nearly 55% of total operating cost is towards power. Therefore, adopting of renewable energy sources in manufacturing organizations have large benefits to the business operations and profitability. A south indian large CV manufacturing company have reported that the usage of Wind energy has reduced external power demand upto 23%. Similarly, Solar source of electricity generation has saved the company 37% of total energy consumption. In all about 60% of power consumption is met by renewable sources thereby paving way for more sustainable operations. Other sustainability initiatives like wood free operation (reduction by 15%), Carbon neutrality through tree plantation (~ 96,000 trees), Water conservation being water positive and recycling 60% of water needs also contribute to the company's profitability. These are being monitored through industry 4.0 tools. Additionally, various energy conservation measures like LED fication, optimization of cooling towers, usage of Energy efficient motors (EE3 classification), Interlocking hydraulic pump operations based on hibernation mode of main systems, Dust collection system interlock with main machines, Diesel to LPG conversion of ovens in foundry application are some of the initiatives taken up towards reduction of consumption and are also being monitored through IOT devices.

Case study 4:

Since CV manufacturing involves large manufacturing facilities due to the size of the product under manufacture, lots of components and sub assemblies needs to be aggregated and assembled in the right order with the right torque to specification. Operator errors results in high severity needing product recalls [b][c]. These were planned to be mitigated by engineers working in the manufacturing lines through a concept called 'Interlocking' wherein feedback based tools were interlocked with the assembly conveyor in such a manner that without operation completion the product does not index to the next stage of assembly. While the concept is fairly simple at the face of it, multiple challenges exists starting from the need for facility upgradation, procurement of feedback based tools, providing error proofing devices, establishing Communication with legacy systems, availability of budget and times. These were planned to be mitigated through a phased and frugal approach by engineers through enabling feedback from existing electric tools, upgrading selective pneumatic tools with feedback mechanism, upgrading the programmable logic controllers in the existing manufacturing

setup and usage of Supervisory Control and Data Acquisition system at less than 10% the cost of new systems. Through the usage of such systems costly product recalls were reduced and products were produced in a more sustainable manner. ECRSO (Eliminate, Combine, Reduce, Simplify & Optimize) method were exclusively used for the above project towards bringing in frugality and cost savings for the company.

CONCLUSION

The paper can be taken as a reference for manufacturing industries on their journey towards reaching sustainable industry 4.0 in manufacturing. The case studies presented provide good references towards easy adoption in sustainability and ideation for more applicative developments across the manufacturing industry in a progressive manner.

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COMPARATIVE ANALYSIS OF NATURAL FREQUENCY OF TRANSVERSE VIBRATION OF A CANTILEVER BEAM BY ANALYTICAL AND EXPERIMENTAL METHODS

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Abstract

Vibration analysis of any mechanical systems is very important since excess vibrations leads to failure of the mechanical systems. There are many methods and instruments available in the engineering field for measuring the mechanical vibrations in mechanical systems. In this present work transverse vibrations of a cantilever beam are analyzed analytically and experimentally. In our present work FFT analyzer is used to measure the natural frequency of vibration of a cantilever beam. Initially the natural frequency of the cantilever beam is calculated analytically and then natural frequency was found out by experimentally by using FFT and the results were compared. Both analytical and experimental results were found to be almost the same. The present work shows a standard procedure for the determination of natural frequency of vibration of a cantilever beam by analytical and experimental methods by using FFT analyzer.

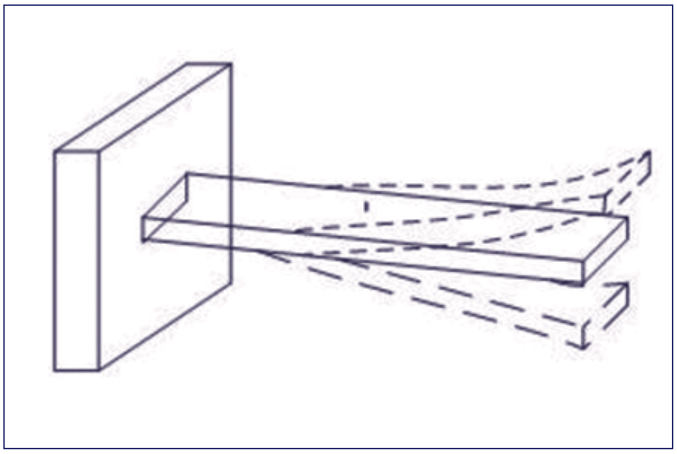
Key Words: Cantilever beam, Natural frequency

1. INTRODUCTION

A straight, horizontal cantilever beam is deformed into curve when it is subjected to a vertical load. After the removal of Load, the beam regains its original shape as it was prior before subjected to load, but due to inertia the beam stays in motion. Which results in vibration of beam at characteristic frequency [6]. In this paper a cantilever beam with rectangular cross section for transverse vibration is investigated. Device used are Accelerometer and Fast Fourier Transform Analyzer. Most extensively studied among structural elements are beam as it finds many engineering applications. Structure like Long span bridges, robot arm and tall buildings are modeled with beam like element, beams as well as the presence of cracks affects the dynamic response of the structure significantly. It can result into failure of structure in a very extreme way. To predict the failure, vibration monitoring can be used to detect changes in the dynamic responses and/or dynamic characteristics of the structure [7]. One of the most important tasks in designing of mechanical system is Vibration Analysis. Design engineer has to take into consideration information like dynamic behaviour of structure of machine tool, effect of vibration absorber on rotating machineries. This information helps to design system to control the excessive amplitude of the vibration [2]. Before the advent of computers, seeking the analytical solution was one of the most popular ways to solve an engineering problem. In comparison with numerical methods, the analytical solutions have the advantage of elegance and are time-saving. However, for most practical engineering problems no analytical solutions can be found, unless they are significantly simplified. Because of this drawback of the analytical method, it has gradually been replaced by numerical methods after the invention of computer, particularly in recent years. One of the greatest shortcomings of the numerical approach is that it is time-consuming, but because of its powerful ability for solving the practical problems this drawback seems allowable [1]. An intelligent FFT analyser is capable of adapting its operating parameters on the basis of the signal spectrum set up and characters. The realised instrument is equipped with auto configuration capability. The experimental tests carried out on a large number of signals highlight the instrument capability of correctly detecting a good frequency resolution for any signal spectrum type [3]. In this paper a straight horizontal cantilever beam is subjected to free vibration due to which it will vibrate at its natural frequency. The aim is to study the vibration of thin film cantilever beam. The frequency equations are solved to show the output frequencies and the mode shapes related to each frequency [4]

2. THE CANTILEVER BEAM

Figure No. 1: The beam under free vibration



A Cantilever beam is a beam whose one end is fixed and another end is free. When a beam is subjected to load it withstands

the load by resisting against bending. Bending moment is the reaction of the beam, when a beam is subjected to bending force due to its own weight, external load, etc. When a straight horizontal cantilever beam is exposed to vertical load, it will bend downwards and after removal of load will regain its original shape but will vibrate at natural frequency due to inertia. Most fundamental structure of any structure from decades is cantilever beam. The cantilever beam is much greater in length as compared to width and depth. In addition, cantilever beams may be straight or curved, with rectangular or circular cross sections. Figure 1 shows a cantilever beam with a rectangular cross section. The design and shape of cantilever beam is application specific, its weight, size, shape all parameters changes based on application. For example, one of the most common applications of a cantilever beam can be the "fixed wing" in meters is designed as a beam for some preliminary analysis to help lift the plane and make it fly. In Micro Electrical Mechanical Systems (MEMS), micro cantilever beams are used in radio frequency filters and resonator [4].

3. NATURAL FREQUENCY FROM ANALYTICAL CALCULATION

Beam's Specifications: L = 0.3 m, b = 0.019 m, t = 0.002 m

M. I. of cantilever beam (I) = $(1/12)xbt^3$

$= (1/12)x0.019 \times (0.002)^3 = 1.267 \times 10^{-11}\ m^4$

Area of cross section of cantilever beam (A)

$= b \times t = 0.019 \times 0.002 = 3.8 \times 10^{-5}\ m^2$

$E = 210GPa$ ($210x10^9\ N/m^2$) ---For steel.

$\rho = 7800\ kg/m^3$ ---For steel.

For 1st mode

$$\omega = 1.875^2\sqrt{\frac{EI}{\rho AL^4}} = 1.875^2\sqrt{\frac{210*10^9*1.267*10^{-11}}{7800*3.8*10^{-5}*0.3^4}}$$

$$= 117.03 \text{rad/sec}, \quad \& \quad f_n = \frac{\omega}{2*\pi} = 18.62 \text{Hz}$$

For 2nd mode

$$\omega = 4.694^2\sqrt{\frac{EI}{\rho AL^4}} = 4.694^2\sqrt{\frac{210*10^9*1.267*10^{-11}}{7800*3.8*10^{-5}*0.3^4}}$$

$$= 733.5 \text{rad/sec}, \quad \& \quad f_n = \frac{\omega}{2*\pi} = 116.74 \text{ Hz}$$

For 3rd mode

$$\omega = 7.855^2\sqrt{\frac{EI}{\rho AL^4}} = 7.855^2\sqrt{\frac{210*10^9*1.267*10^{-11}}{7800*3.8*10^{-5}*0.3^4}}$$

$$= 2054.03 \text{rad/sec}, \quad \& \quad f_n = \frac{\omega}{2*\pi} = 326.9 \text{Hz}$$

4. THE FFT ANALYZER

In FFT spectrum analyzer, the input signal is digitized and that to at high sampling rate which is similar to oscilloscope. The digital time record obtained as a result is then transformed using a algorithm known as Fast Fourier transform algorithm, into a Frequency Spectrum. The function of the signal analyzer is to measure the magnitude of an input signal compared frequency with the maximum frequency range of instrument. The amplitude of vibration is recorded on the basis of its evolution versus the frequency at that the signal appears. The original time domain signal is converted into Frequency domain view. Single Channel FFT and Multichannel type is specially used for determining Single vibration parameter from one or more sources.

4.1. Benefits of FFT analyzer:

4.1.1. Quick capture of waveform: In view of the very fact that the waveform is analyzed digitally, the waveform can be captured in a comparatively very short time, and then the afterwards analyzed. This short capture time will have many advantages – it will afford the capture of transients or short-lived waveforms.

4.1.2. Able to capture non-repetitive events: The short capture time implies that the FFT analyzer will capture non-repetitive waveforms, giving them a capability, which will be not possible with other spectrum analyzers.

4.1.3. Able to analyze signal phase: As part of the signal capture method, information is gained which might be processed to reveal the phase of signals.

4.1.4. Waveforms can be stored using FFT technology: It will be possible to capture the waveform and analyze it later and this should this be required.

4.2. Disadvantages of the FFT analyzer:

4.2.1. Frequency limitations: The important limitation of the frequency and bandwidth of FFT spectrum analyzers is that the analogue to digital converter, ADC that is used to convert the analogue signal into a digital format. Whereas technology is raising this component is still places a serious limitation on the higher frequency limits or the bandwidth if a down-conversion stage is employed.

4.2.2. Cost: The high level of performance needed by the ADC implies that, this item could be a terribly very high-cost item. Additionally, to all the other processing and display circuitry required, this leads to the prices rising for this stuff.

5. EQUIPMENT USED FOR EXPERIMENTATION

Apparatus used to perform the real experiment are Impact Hammer, Accelerometer, Multi-channel Vibration Analyzer (DEWESoft-DEWE-43), A computer or a laptop loaded with software for modal analysis. Test-specimen that is a cantilever beam which is held in a fixture, power supply to be given to the computer and the vibration analyzer, connecting cables for the impact hammer and the accelerometer, fasteners and spanner to assemble rigidly the specimen in the fixture, adhesive wax to fix the accelerometer.

5.1. Impact Hammer: This seems like an ordinary hammer however its head is fitted with a load cell and contains electronic circuitry and an output cable that will be connected to vibration analyzer. On hitting the impact hammer on any structure an impulsive force is applied to the structure which is a cantilever beam in our present work. An equal and opposite force is detected by the load cell fitted within the head of the hammer. This generates an electrical signal that is given to vibration analyzer that analyzes the signal, compares with the signal received from accelerometer connected to the structure, and this information is used to develop FRF (Frequency Response Function) and finally the natural frequencies of the structure are found out.

5.2. Accelerometer: An accelerometer is a device (a transducer) which when attached to a vibrating structure gives out the electric signals which are proportional to the acceleration. This signal is given to a vibration analyzer that processes and analyzes the signal. Just in case of our experiment, the signal coming from accelerometer fitted to the cantilever is analyzed with respect to the one received from the impact hammer in order to search out the natural frequencies of the cantilever.

5.3. Vibration Analyzer: Vibration Analyzer is an electronic equipment that processes and analyzes the signals received from transducers used in vibration measurement such as impact hammer, accelerometer, digital tachometer and many more. It has various channels that is it can receive number of electric signals at same time. The vibration analyzer has terribly refined electronic circuits and works along with with a computer. Fast Fourier Transform (FFT) is an algorithm often used for analysis of the electric signals which gives frequency components and their corresponding amplitudes present in the signals.

5.4. A Computer or a Laptop loaded with software for modal analysis: Additionally, to the software used together with the vibration analyzer, the software are available now-a-days devoted exclusively to the modal analysis. Such software helps inputting data to the computer related to geometry of the structure, location of placing of the accelerometer on the structure as well as points of hitting of the impact hammer and their directions and so on. Also, there are facilities to choose different type of analysis required, ranges of various parameters of interest. Such software essentially processes the signals received from the impact hammer and accelerometer, carrying out their FFTs, finding FRF, getting Mode Indicator Function, carrying out curve fitting over a selected range of frequencies, and finally providing the natural frequencies, mod shapes, and modal damping factors.

5.5. Fixture and Test-Specimen: A fixture holds the steel bar of rectangular cross section firmly at one end so that the specimen can be considered as a cantilever beam. The cross-sectional dimensions of the cantilever beam used are 19mm x 2 mm and length 300 mm. The fixture holds the cantilever bar firmly at one end and the fixture is assembled to a table. A small accelerometer is attached at the middle of the cantilever beam using an adhesive like loctite.

6. NATURAL FREQUENCY FROM EXPERIMENTATION

Figure No. 2: Experimental Setup

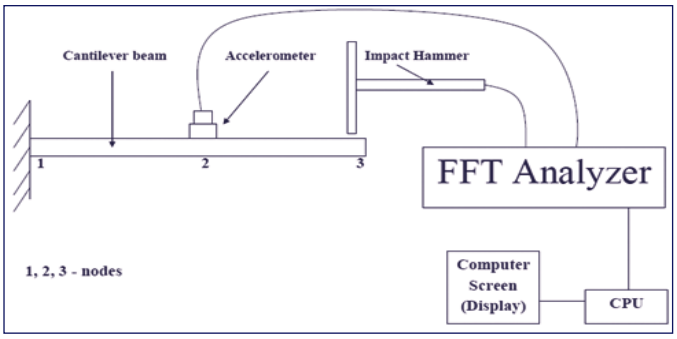


Figure No. 3: Actual Photograph of Experimental Setup



Prepare the cantilever beam. Measure the length on the fixture that holds the steel cantilever beam and leave a margin of that length on the steel cantilever beam. Divide the remaining length of the steel cantilever beam into 2 parts and mark node numbers at each division from 1 to 3. Let node 3 be the free end and node 1 the fixed one. Fix the accelerometer to the steel cantilever beam at the middle of the beam. Make sure that the face of the cantilever beam with markings and node numbers up, fix the beam into the slot on the fixture so that a cantilever is formed. Connect all the wires and cables properly. Make connections of the vibration analyzer, computer or laptop, accelerometer and the impact hammer. Switch on the power supply. Open the software of vibration analysis and experimental modal analysis installed on the computer/laptop. Provide necessary inputs and make necessary settings in the software. Ensure that there is proper supply and communication between the devices connected. Now we shall provide impacts by the impact hammer on the nodes marked on the cantilever beam one by one. Impacts will be given on nodes 2, 3; node 1 is fixed. Accelerometer is connected at node 2. Signals from the impact hammer and the accelerometer will be received by the vibration analyzer for each impact provided one by one and will be compared and analyzed by the software. Curve known as Frequency Response Function (FRF) will be generated by the software that is used to find the natural frequencies of the cantilever beam. Observe the curve and read frequencies that correspond to peaks of the FRF.

7. OBSERVATION GRAPHS FROM FFT ANALYZER

Figure No. 4: The first mode undamped natural frequency of cantilever beam

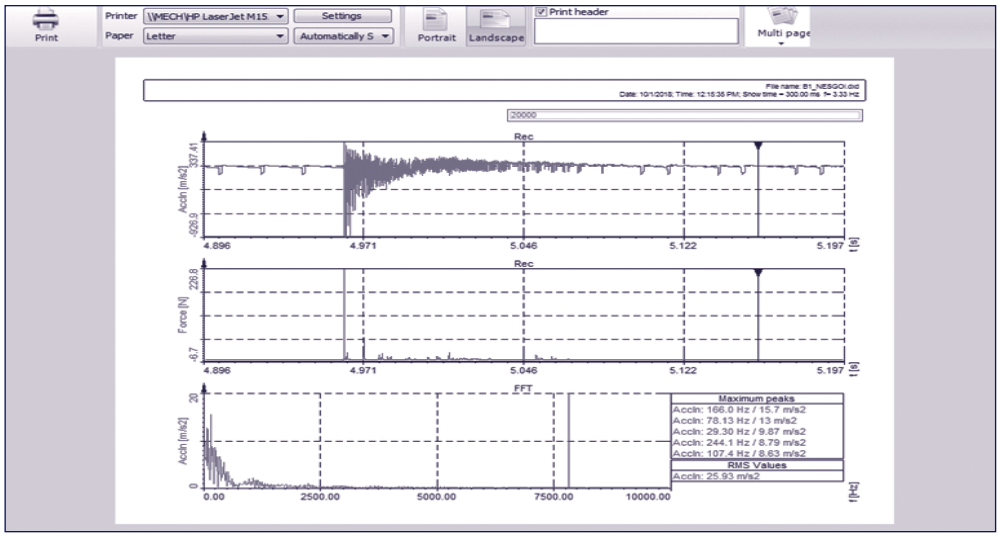


Figure No. 5: The second mode undamped natural frequency of cantilever beam

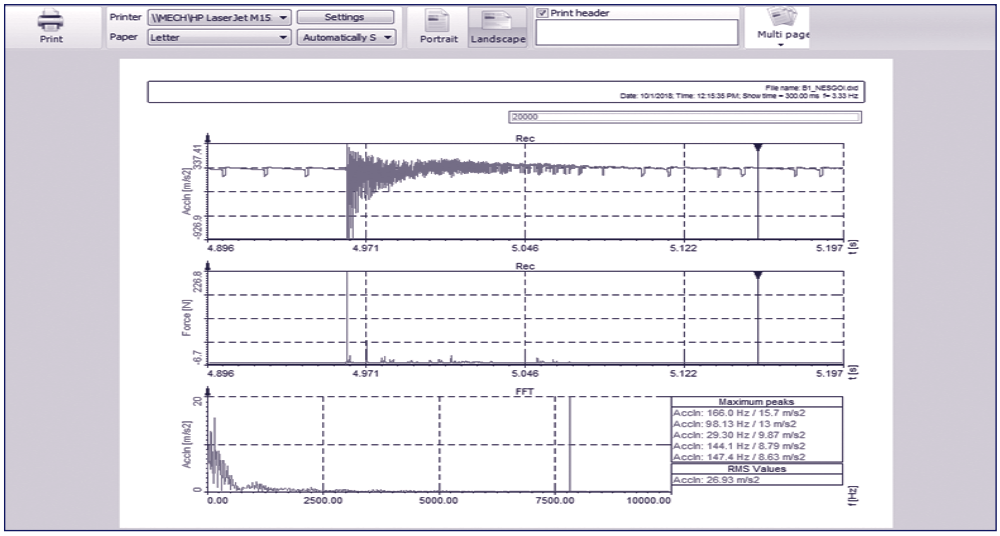
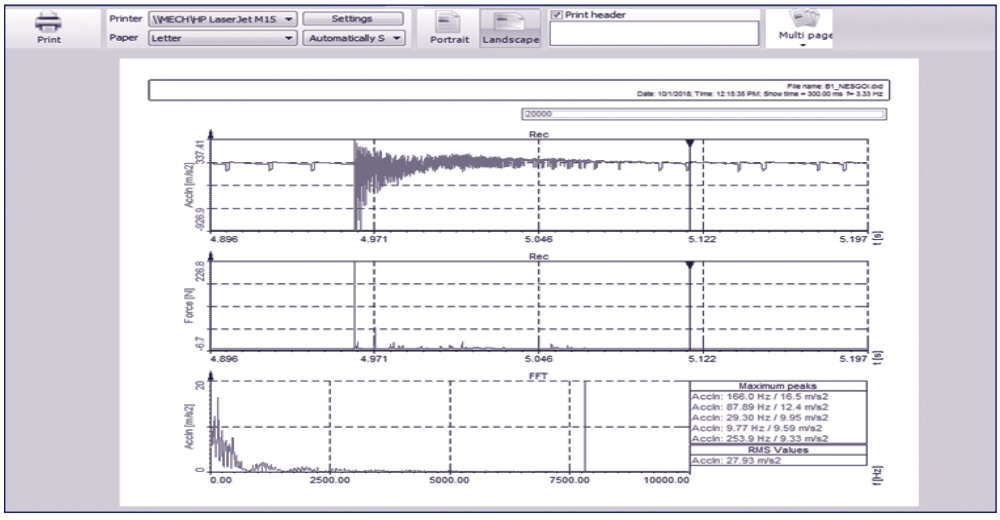


Figure No. 6: The third mode undamped natural frequency of cantilever beam



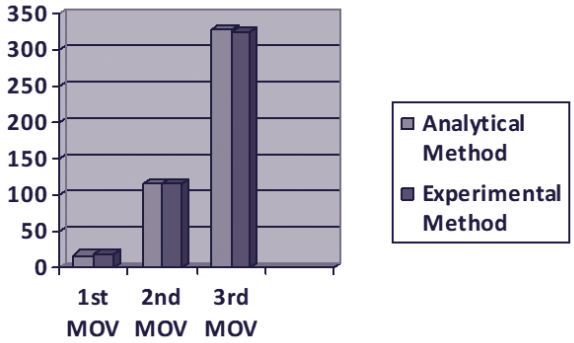
Observed the FRF (Mode Identification Function). The frequencies that correspond to the peaks of amplitude are noted. These corresponds to the natural frequencies of the cantilever beam. In fact, they correspond to the natural frequencies of the principal modes of the cantilever beam that were excited, or participated in vibration of the cantilever beam due to impacts. Compared these values with those obtained from formulae. Comparative analysis is done on the difference in values obtained from these two methods experimental and the analytical.

8. ANALYTICAL AND EXPERIMENTAL RESULTS

Table 1: Analytical and experimental results

Mode of vibration	Natural frequency by Analytical Calculation (Hz) (Analytical Method)	Natural frequency by FFT Analyzer (Hz) (Experimental Method)
1st	18.62 Hz	19.77Hz
2nd	116.74Hz	116.0 Hz
3rd	326.9Hz	324.0Hz

Figure No. 7: Analytical and experimental results



9. CONCLUSIONS

Vibration analysis is one of the most important processes in the field of mechanical engineering. Cantilever beam vibration study is very important. It helps to determine the durability concerns. This information from this work can be is used to reduce the discomfort and excessive stresses in different applications in which beams are essential components. Beams are exposed to different dynamic loads in different applications. When a cantilever beam is Subjected to a dynamic load, the beam will vibrate at its natural frequencies. The natural frequency of vibration of cantilever beam is analyzed by both analytical and experimental methods and both the results were compared. From result table it can be concluded that Natural frequency obtained by FFT Analyzer i.e., by experimental method is matching with natural frequency by analytical calculation. The dimensions of the cantilever beam are length L = 0.3 m, breadth b = 0.019 m and thickness t = 0.002 m. Natural frequency obtained by analytical calculation for 1st mode, 2nd mode and 3rd mode of vibrations are 18.62 Hz, 116.74Hz and 326.9Hz respectively. The natural frequency obtained by experimental method by using FFT for 1st mode, 2nd mode and 3rd mode of vibrations are 19.77Hz, 116.0 Hz and 324.0Hz.

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