Vol. XI & Issue No. 6 June - 2018
INDUSTRIAL ENGINEERING JOURNAL

A REVIEW OF TPM TO IMPLEMENT OEE TECHNIQUE IN MANUFACTURING INDUSTRY

Darpit N. Gandhi
Vivek Deshpande

Abstract

The exploration for improving productivity in the current competitive global environment since customers are becoming more and more quality centered and demands among customers are increased. To meet customer demand industries must work with efficiency oriented. One of the way to increase efficiency and productivity is to increase the OEE (Overall Equipment Effectiveness) of the plant or machines. OEE can be improved by continuous improvement of TPM (Total Productive Maintenance).This review study discusses an application of industrial engineering techniques such as TPM,OEE.

Total productive maintenance (TPM) is one of the most popular maintenance strategies to ensure high machine reliability, maintaining equipment in top working condition to avoid breakdowns and minimize downtimes in the manufacturing process.

Keywords-Total productive maintenance, Overall equipment effectiveness

I. Introduction

After Second World War Japanese industries realized that, industries cannot produce good quality products with the help of poor maintenance system of equipment and it cannot stay in this competitive global market. For effective maintenance system, Japanese companies adopted U.S.A. based preventive maintenance policy in 1951.

Total productive maintenance (TPM) is a Japanese philosophy, which they imported after 1951.M/s Nippon Denso Co. Ltd japan, a supplier of M/s Toyota Motor Company, in the year 1971, firstly introduced TPM concept. “Total productive maintenance is an innovative concept to maintenance that eliminates break downs, optimizes equipment effectiveness and promotes autonomous maintenance technique by operators through day to day activities involving total workforce”.

Today's competitive market huge losses occur in the manufacturing shop floor. These types of losses occurred due to inefficiency of operators, process, tooling problems and non-availability of equipment. The quality related wastes are also important, as they affect the industries in terms of time, material and reputation. There are other invisible losses occurred like material shortage, start-up loss, bottlenecks and breakdown of the machines in the process. This study reveals the effect implementing several methods.

Overall equipment effectiveness (OEE) is also one of the performance evaluation methods, which plays a major role where quality and performance of the product are important to organization. The aim of this study is to improve Overall equipment effectiveness (OEE) at a manufacturing company through the implementation of innovative maintenance strategies.The review study reveals that OEE is enhance by implementation of TPM particularly in medium scale industries.

II. LITERATURE REVIEW

This study is to identify bottleneck in three factors of Overall equipment effectiveness (OEE),

a. Availability b. Performance and c. Quality

To find the OEE of current industry and compare it with world class OEE and try to achieve excellence in the manufacturing process by implement maintenance techniques. By using these all TPM and OEE implement techniques, increase in the availability, quality as well as performance of the industries. And also reduce the rework, rejection and overall manufacturing costs. This review study ids carried out according to tools & techniques used for OEE implement .The techniques reviewed are TPM, OEE.

III. TOTAL PRODUCTIVE MAINTENANCE (TPM)

Total productive maintenance (TPM),Total means improve overall effectiveness of plants, employees and renovate overall plant effectiveness by involving all employees from bottom to top management, Productive means to produce defect free products with take care of the safety, Maintenance means to increase the lifecycle of product or production system.

Total productive maintenance is interfering between men and machine. TPM can be considered as a medical science of machines. TPM brings maintenance into key role and focus as a necessary part of the business.

The Japan institute of Plant Maintenance (JIPM) introduced the TPM is based on the implementation of series 8 pillars of TPM in a systematic manner to optimize the equipment and plant effectiveness by followed up between men and machine. The figure: 1 below shows a common structure of TPM pillars.

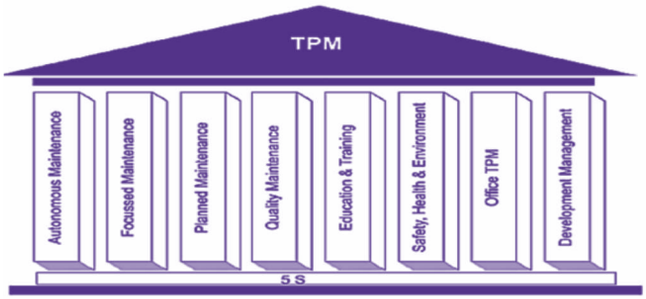

Figure: 1 Total productive maintenance pillars

Now days many industries facing trouble to implement TPM pillars because of some reasons as below

1. Inadequate information and data to implement TPM pillars
2. One of the main reasons is that TPM takes time, manpower, resources which are not afford by industries.

5S plays vital role to implement TPM pillars 5s is a base of the pillars. Further TPM pillars are described below in tabular form.

IV. TPM & OEE

Overall equipment effectiveness (OEE) is developed by Seiichi Nakajima. OEE is a way to improve the efficiency in manufacturing process .OEE has become an accepted tool to measure and evaluate plant floor performance and productivity. OEE has three factors Availability, Performance and Quality. These factors help parameters to the plant's efficiency and effectiveness. OEE highlights the actual "Hidden capacity" in an organization. Thus OEE is a function of three factors as mentioned below in Figure: 2.

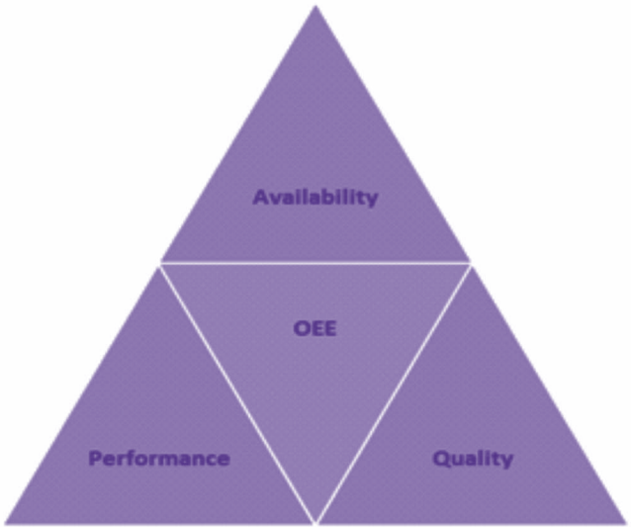

Figure: 2 Overall Equipment Effectiveness

(1) Availability: This can be defined as uptime, i.e. available time to operate equipment.

(2) Performance: This can be defined as the speed at which the manufacturing plant operates as a % term of the capacity of the plant.

(3) This is often referred as manufacturing of product at first trial with zero defects.

OEE % = Availability × Performance × Quality %

Big losses in manufacturing process as shown in below table: 1

Table: 1 big losses in manufacturing process

No.	Eight major Losses	
1.	Planned Maintenance	**Availability Efficiency** =(calendar Hours-1-2-3-4)×100/Standard Production
2.	Production Control	
3.	Equipment Breakdown	
4.	Process Breakdown	
5.	Start stop Rate Loss	**Performance Efficiency** =(Actual Production)×100/Standard Production
6.	Production Rate Loss	
7.	Quality Defect	**Quality Efficiency** =(Production-Quality Loss)×100/Production
8.	Reprocessing	
Overall Equipment Effectiveness = Availability × Performance × Quality %		

Table: 2 World Class OEE

OEE FACTOR	WORLD CLASS
AVAILABILITY	90.0 %
PERFORMANCE	95.0 %
QUALITY	99.9 %
OEE	85.0 %

OEE measurement is essential for every organization which is committed to eliminate above losses with implementation of TPM. A comparison between the expected and current OEE measures can provide the much-needed driving force for the manufacturing organizations to improve on its maintenance policy. An overall 85% benchmark OEE is considered as world-class performance which requires 90% availability, 95% performance and 99% quality to be achieved.

After reviewing the literature shows summary of various tools and technique applied for OEE and TPM implantation in table: 3.

Table: 3 Summary of Results derived from research articles

Sr. No.	Title	Author/Year	Journal/conference	Tools & Technique	Result and summary
1	Production Planning and Process Improvement in an impeller manufacturing by using Scheduling and OEE Techniques	1)S. Vijayakumar (2)V.G.S. Mani (3)N. Devraj (2014)	International Conference on Advance in manufacturing and materials engineering AMME 2014 (Elsevier)	OEE Techniques	After Implementing the new soft jaws that reduced setup time, OEE for bottle neck CNC machine 1 improved from 69% to 75% and availability increased from 85.7% to 92%. Improving delivery performance by 10.6%. OEE for bottle neck CN C machine 2 improved from 62% to 70% and availability increased from 83% to 93%.
2	Improving Overall Equipment Effectiveness by Implementing Total Productive Maintenance in Auto Industry	(1)Prof. A.Bangar, (2)Hemlatasahu , (3)Jagmohanbatham (2013)	International Journal of Emerging Technology and Advanced Engineering	OEE and Pareto Chart	TPM based corrective action plan we have reduce 80% problems analysed by P areto chart and improve OEE. TPM methodology not only increases the effectiveness of the Manufacturing system but also increase the effectiveness of the entire organization through mandatory participation and continuously improve Productivity, quality, cost, Delivery, safety health and Morale.
3	Total Productive Maintenance (TPM) Approach To Im prove Overall Equipment Efficiency	(1)Hemant Singh Rajput, (2)PrateshJayaswal (2012)	International Journal of Modern Engineering Research (IJMER) Vol.2, Issue.6, Nov-Dec. 2012 pp-4383-4386	TPM Approach for OEE	The maintenance department can plan spending requirements by using historical information to state the return on investments by contributing to the annual business plan of the company. Therefore if the world -class performance of 85%OEE was achieved then 20%increase in OEE would have represent enhance the annual earning.
4	Study of Implementation of Preventive Maintenance Programme in Nigeria Power Industry—Egbin	(1)Sunday OlayinkaOyedepo, (2)Richard OlayiwolaFagbenle (2011)	Energy and Power Engineering, 2011, 3, 207 - 220	Preventive Maintenance	As the availability of each unit varies from 28.79% to 94.53% for the five years data base considered. Also, the availability of the entire plant for the year 2009 was computed as 52.7%, while the generation utilization index is

5	Design of a total productive maintenance model for effective implementation: Case study of a chemical manufacturing company	(1)Bupe. G. Mwanza, (2)Charles Mbohwa (2015)	Industrial Engineering and Service Science 2015, IESS 2015 (Elsevier)	Effectiveness of maintenance techniques and OEE Techniques	This paper assessed the maintenance systems at a chemical manufacturing company. It identified the gaps in the maintenance system, determined the key performance indicators to be included in the TPM model for effective implementation.
6	Optimizing OEE, productivity and production cost for improving sales volume in an automobile industry through TPM: a case study	(1)Pardeep Gupta & (2)SachitVardhan (2016)	International Journal of Production Research, 2016 (Taylor & Francis)	TPM	The aim of this paper is to investigate how increase in sales volume has evolved by improving overall equipment effectiveness (OEE) of machines, plant productivity and production cost through total productive maintenance (TPM) Initiatives in a reputed tractors manufacturing industry in India. highlights the OEE improvement trend and it reveals that overall 39% improvement in OEE has taken place in about five years period Reduce the production cost by 30%. 74% in productivity Reduction in production cost 9.26 to 6.4 in six years' time.
7	Improvement of Overall Equipment Effectiveness In a Plastic Injection Moulding Industry	(1)E.Sivaselvam (2)S. Gajendran	IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e- ISSN: 2278 - 1684, p -ISSN: 2320–334X PP 12-16 (IOSR)	OEE	All industries are in the situation to improve their productivity. Every company is facing many challenging problems to produce better production rate. Manufacturers should be able to identify even the small factors affecting production growth. Clear identification of problem at the right time will help to increase quality as well as productivity rate. OEE is a known method to measure performance of production equipment in manufacturing

8	Implementation of Total Productive Maintenance on Boiler	(1)AmitBorikar, (2)Ankit P. Shingare, (3)Jay R. Sarnaik, (4)Avinash G. Bhusari	IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278 - 1684, p -ISSN: 2320-334X PP 34-38 (IOSR)	TPM	The efficiency of the thermal power plant is increased by implementing TPM. We are analyzing efficiency of a boiler during period of 4th months & we conclude that the efficiency of a boiler increases by implementing TPM on it.
9	Simultaneous consideration of TQM and TPMinfluence on production performance: Acase study on multicolor offset machineusing SD Model	(1)Nagaraj H. Kamath, (2)Lewlyn L.R. Rodrigues (2016)	Perspectives in science (Elsevier)	TQM,TPM	An attempt is made in this research to show the relevance of System Dynamics (SD) as a tool for simultaneously considering TQM and TPM environment in a offset machine of acommercial printing press. By controlling the TQM and TPM variables, this model will attempt tosimulate or predict the behavior of an efficient printing operation
10	A Case Study of Implementation of Overall Equipment Effectiveness on CNC Table type boring & milling machine of a Heavy Machinery Manufacturing Industry	(1)Vijay Lahri, (2)Dr. PramodPathak (2015)	IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 2015	OEE, Availability, Downtime, Productivity	Overall Equipment Effectiveness of CNC Table type boring & milling machine i.e. Juaristi is increased from 62% to 75%.
11	Approach for Total Productive Maintenance Evaluation in Water Productivity: A Case Study at Mahasawat Water Treatment Plant	(1)SoraphonKigsirisina, (2)SirawitPussawiro, (3)OnuraiNoohawm (2016)	12th International Conference on Hydroinformatics, HIC 2016 (Elsevier)	OEE, Profit cost, TPM, water loss	It eliminated failure rate, Increased equipment effectiveness and decreased water loss from water treatment process.
12	Total Productive Maintenance (TPM) Implementation in a Machine Shop: A Case Study	(1)Ranteshwar Singh, (2)Ashish M Gohil, (3)Dhaval B Shah, (4)Sanjay Desai (2012)	Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University International Conference on Engineering (NUiCONE 2012) (Elsevier)	Total Productive Maintenance, Total Quality Management, 5-S, Kaizen.	All the pillars of TPM are implemented in a phased manner eliminating the losses and thus improving the utilization of CNC machines.

13	Performance evaluation by using Overall equipment effectiveness (OEE)-An analyzing tool	(1)K.Mahmood, (2)T.Otto, (3)E.Shevtshenko, (4)T.Karaulova (2016)	International conference on innovative technology,intech -2016 Prague-2016	Performance evaluation,OEE,Overtime Reduction,Manufacturing Equipment	The OEE tool can help to optimize the performance of existing capacity.
14	OEE and Countermeasures: A Case Study of a Manufacturing Unit	(1)FarooqUmer, (2)Khan Umar Khatab, (3)Zahid Hassan (2017)	International Journal of Scientific & Engineering Research, Volume 8, Issue 1, January-2017	Countermeasures, Manufacturing system, OEE, Production	OEE increases from 48.4% to 50.10%, For planned downtime management, 48.49% for root cause analysis, 57.31% for management routines and 59.57% for 5S Workplace Organization.
15	Breakdown and Reliability Analysis in a Process Industry	(1)DibyojyotiDeka, (2)Dr.ThuleswarNath (2015)	International Journal of Engineering Trends and Technology (IJETT) – Volume 28	Downtime Losses, TPM, OEE, Pareto analysis, PM schedule,Weibull distribution, CDF, Distance test, K-S test	BY strictly following preventive maintenance schedule can be increase uptime of equipment and also improving the reliability of machines.
16	Analysis of OEE For TPM Implementation: Case Study.	(1)Shatrughan Tomar, (2)Arun Kumar Bhuneriya (2016)	International journal of Business Quantitative Economics and applied management research	TPM, OEE, Utilization, Availability, Quality	OEE can be implement by TPM from 27% to world class OEE
17	Lean Six Sigma Approach to Improve Overall Equipment Effectiveness Performance: A Case Study in the Indian Small Manufacturing Firm	(1)T.Varun Kumar, (2)M.Parthasarathi, (3)S.Manojkumar, (4)S.Selvaprakash (2016)	INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD	Lean Manufacturing (LM), Small Medium Enterprise (SME), Overall Equipment Effectiveness (OEE), Performance Measures	By installation of mobile maintenance increase the operating time from 71% to 78% and reduce downtime from 17% to 9%.

18	Improving efficiency of a production line by Using Overall Equipment Effectiveness: A case study	(1)ZinebAman, (2)LatifaEzzine, (3)Jamal Fattah, (4)AbdeslamLachhab (2017)	Proceedings of the International Conference on Industrial Engineering and Operations Management	Overall equipment effectiveness (OEE), Efficiency, Availability, Performance, Quality	By OEE increased the efficiency of the assembly line of 37.2% giving an efficiency of about 76.2% exceeding the 63% set by the company.
19	Productivity Improvement in Small Scale Industries.	N S B Venugopal (2015)	International Journal of Mechanical And Production Engineering, ISSN: 2320 - 2092,	Small And Medium Enterprises, Total Productivity Management, Overall Equipment Effectiveness (OEE)	By implementing TPM can increase the productivity which is beneficial to organization as well as to increase employee's income. OEEE increase from 50% to 72.8% after suggestion.
20	Total Productive Maintenance: A Case Study in Manufacturing Industry	(1)MelesseWorknehWakjira, (2)Ajit Pal Singh (2012)	Global Journal of researches in engineering Industrial engineering	Total productive maintenance, Preventive maintenance, Overall equipment efficiency,	After applying TPM total losses are decrease from 70.4hrs(Jan to March) to 32.47hrs (May –June) and OEE increase from 66.43%(Jan to March) to 75.4%(May-June).
21	Improvement of Overall Equipment Effectiveness (OEE) In Injection Molding Process Industry.	(1)S.R.Vijayakumar, (2)S.Gajendran (2014)	IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)	Focused quality improvement ,Major Losses, Maintenance, Manufacturing performance, Overall Equipment Effectiveness improvement, Planning, Training	The OEE of the injection molding process was increased from 61% to 81% through the implementation of availability, better utilization of resources, high quality products and also raised employee morale and confidence.
22	To Study and Used of Waste Material For Apply Lean Manufacturing in Industrial Work.	(1)Gajendra Singh Panwar (2016)	Vol-2 Issue -6 2016 IJARIIE - ISSN(O)-2395-4396 3289 www.ijariie.com 253	Lean	This paper has provided important insights into the current status of lean manufacturing implementation in the Silk production industry in Andhra Pradesh, as well as highlighted some associated issues.
23	A Case Study on Total Productive Maintenance in Rolling Mill	(1)Sethia, Chetan S, (2)Prof. Shende P. N., (3) Dange, (4) Swapnil S.	Journal of Emerging Technologies and Innovative Research (JETIR)	OEE,TPM	The OEE, availability, performance rate, quality rate is observed and found to be not to the level of world class measurements therefore TPM implementation is important for the rolling plant

24	Failure Mode Effect Analysis and Total Productive Maintenance: A Review	(1)S.N.Waghmare (2)Dr.D.N.Raut (3)Dr.S.K.Mahajan (4)Dr.S.S.Bhamare (2014)	International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Volume 1 Issue 6 (July 2014)	FMEA	The goal of quality and reliability systems is the same -to achieve customer satisfaction. TPM is a useful tool in Helping firm to achieve optimal manufacturing process.
25	Optimization Overall Performance of Beverage Industry by Total Productive Maintenance	(1)Shelke Pratik Bansi , (2)MadhukaraNayak, (3)U. Sai Krishna (2015)	IOSR Journal of Business and Management (IOSR-JBM) e -ISSN: 2278 -487X, p -ISSN: 2319-7668. Volume 17, Issue 5.Ver. I (May. 2015), PP 107-115	TPM,OEE	The main objective of present research is to show effect of implementing TPM in organization with system dynamic model. This objective is satisfied by analyzing data and developing model to see effectiveness of implementing TPM pillars in organization.
26	A Review on 5S Implementation in Industrial and Business Organizations	(1)RashGhodrati, (2)NorzimaZulkifli (2012)	IOSR Journal of Business and Management (IOSR-JBM) ISSN: 2278 -487X. Volume 5, Issue 3 (Nov. - Dec. 2012), PP 11-13	5S	The most important barrier for implementation of 5S effectively is poor communication.
27	Overall Equipment Effectiveness in Construction Equipment's (Implementation of OEE for Improving Performance and Quality Output of the Equipment)	(1)Prof. MilindDarade , (2)Prof. PranayKhare , (3)Mr. Pratik Desai (2017)	International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321 -9653; IC Value: 45.98; SJ Impact Factor:6.887 Volume 5 Issue VII, July 2017	OEE	Benefits of implementing Total Productive Maintenance and evaluating the overall equipment effectiveness in Construction equipment's, measuring OEE is a construction best practice.
28	Implementation of TPM to enhance in OEE in medium scale industries: A review	(1)SwapnilRaut and (2)NeatRaut (2017)	International journal of innovate science,engg. & technology Vol:4 issue 3,march 2017	TPM	By using TPM implement in OEE In medium scale industry.
29	Enhancing productivity through TPM concepts: A case study	(1)Virupakshar, (2)Ashwin B., and (3)Badiger, Anil	International Journal of Advances in Production and Mechanical Engineering (IJAPME)	TPM	Quality improvement and production improvement TPM were achieved by optimum utilization of equipment improving OEE reducing cost.

30	Effectiveness improvement of critical machines in a fabrication industry	(1)Siddharth S. Ghosh, (2)Dr. M. M. Gupta (2016)	International Journal of Scientific and Research Publications, Volume 6, Issue 2, February 2016 ISSN 2250-3153	OEE	Bending Machine and Welding Machine were identified as critical machines through grading of machines. Grading of machines was done based on the frequency of operation, volume of operation, failure, availability of alternatives and cost factor. The existing OEE level of bending machine and welding machine are 56.7 % and 59.4 %.
31	Increasing efficiency of Cupola Furnace of a Small Size Foundry: A case study	(1)Mr Sanjay Sharma, (2)MrSaurabh Singh Chandrawat	IOSR Journal of Engineering (IOSRJEN) e-ISSN: 2250 - 3021, p -ISSN: 2278-8719	TPM,KAIZEN	Significant energy savings and environment protection are realized in the foundry by applying various energy saving measures, adopting Best Operating Practices and implementing simple housekeeping measures. In general, adoption of the following measures resulted in higher energy efficiency, lower operating costs and increased profit and equipment life.
32	Lean thinking for a maintenance process	(1)SherifMostafa, (2)Sang-Heon Lee, (3)JantaneeDumrak, Nicholas (4)Chileshe& (5)Hassan Soltan (2015)	Production & Manufacturing Research: An Open Access Journal, 2015 (Taylor &Francis)	Lean ,VSM	Applying an effective maintenance strategy can ensure a high degree of utilisation, reliability, and availability of manufacturing facilities Especially in a continuous production process. This study has introduced a process to Adopt lean into maintenance activities. The process highlights types of NVA maintenance Activities, a package of VSM symbols to capture the maintenance activities.
33	Improvement of Indian SMEs through TPM Implementation – An Empirical Study	(1)Jain Abhishek, (2)BhattiRajbir (3) Singh Harwinder	Proc. of Int. Conf. on Advances in Mechanical Engineering, AETAME, (Elsevier)	TPM	Large industries take a lot of time for the complete TPM implementation but small medium enterprises can benefit by applying just few steps.

V. CONCLUSION

1. The crux of the above literature review is that, in order to improve Overall Equipment Effectiveness (OEE) in any manufacturing industries, a systematic and methodological approach is required and that is implementing pillars of TPM.

2. The three parameters of OEE viz. Availability, Performance and Quality rate needs to be taken special care off and their improvement directly contributed to improve OEE of concern machine or entire manufacturing unit.

3. It is thus observed that TPM forms the basis of OEE implement in all industries and more research work are always useful to optimize the method to improve productivity.

REFERENCES

1. *Amit Kumar Gupta,Dr. R. K. Garg., OEE Improvement by TPM Implementation: A Case Study. International Journal of IT, Engineering and Applied Sciences Research (IJIEASR) ISSN: 2319-4413 Volume 1, No. 1, October 2012, PP.115-124.*
2. *Bhupe G. Mwanza, Charles Mbohwa, Design of a total productive maintenance model for effective, Industrial Engineering and Service Science 2015, Procedia Manufacturing 4 IESS 2015, PP. 461-470.*
3. *Dibyojyoti Deka,Dr.Thuleswar Nath, Breakdown and Reliability Analysis in a Process Industry, International Journal of Engineering Trends and Technology (IJETT) - Volume 28 Number 3- October 2015, PP. 150-156.*
4. *Disha M. Nayak, Vijaya Kumar M N.,G. Sreenivasulu Naidu,Veena Shankar,Evaluation of OEE in a continuous process industry on an insulation line in a cable manufacturing unit,International journal of innovative research in science,Engineering and Technology ISSN:2319-8753 Vol. 2,Issue 5 May 2013 PP.1629-1638.*
5. *Farooq Umer,Khan Umar Khatab, Zahid Hassan, OEE and Countermeasures: A Case Study of a Manufacturing Unit. International Journal of Scientific & Engineering Research, ISSN 2229-5518 Volume 8, Issue 1, January-2017 PP.585-592.*
6. *K.Mahmood,T.Otto,E.Shevtshenko,T.Karaulova,*

   Performance Evaluation By Using Overall equipment Effectiveness (OEE)An Analyzing Tool. International Conference On Innovative Technologies,IN -TECH 2016, 6-8.9.2016 PP. 185-188
7. *Jitendra Kumar. OEE Improvement By TPM Implementation: A Case Study.International journal of Advanced Technology in Engineering and science,ISSN 2348-7550 Vol.No. 4,Issue No.07,July 2016. PP.165-170*
8. *Melesse Workneh Wakjira, Ajit Pal Singh, Total Productive Maintenance: A Case Study in Manufacturing. Global Journal of researches in engineering. Volume 12 Issue 1 Version 1.0 February 2012 Type: Double Blind Peer Reviewed International Research Journal*

   Publisher: Global Journals Inc. (USA) Online ISSN: 2249-4596 Print ISSN:0975-5861PP. 24-32.
9. *Mr. Sanjay Sharma, Mr. Saurabh Singh, Chandrawat, Increasing efficiency of Cupola Furnace of a Small Size Foundry: A case study. IOSR Journal of Engineering (IOSRJEN),e-ISSN: 2250-3021, p-ISSN: 2278-8719, www.iosrjen.org Volume 2, Issue 9 (September 2012), PP.50-57.*
10. *Papari Das, Thuleswar Nath, Root Cause Analysis of the Major Equipment Breakdown Problems of the Tube Section of a FMCG Company as an Approach to Improve OEE.InternationalJournal of Engineering Trends and Technology (IJETT) - Volume 27 Number 4 - September2015,PP.207-213.*
11. *Prof. Milind Darade, Prof.Pranay Khare,Mr. Pratik Desai. Overall Equipment Effectiveness in Construction Equipment's (Implementation of OEE for Improving Performance and Quality Output of the Equipment). International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887 Volume 5 Issue VII, July 2017 PP.1808-18011.*
12. *Raguram.R, Implementation of Overall Equipment Effectiveness (OEE),Middle-East Journal of Scientific Research 20 (5): 567-576, 201ISSN 1990-923 © IDOSI Publications, 2014*

    DOI: 10.5829/idosi.mejsr.2014.20.05.11336PP. 567-576.
13. *Swapnil Raut,Niyati Raut, Implementation of TPM to Enhance OEE in Medium Scale Industries: A Review. IJISET - International Journal of Innovative Science, Engineering & Technology*

    Vol. 4 Issue 3, March 2017 ISSN (Online) 2348 - 7968 | Impact Factor (2016) - 5.264 PP. 159-163.
14. *S.R.Vijayakumar,S.Gajendran, Improvement of Overall Equipment Effectiveness(OEE) In Injection Moulding Process Industry, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e- ISSN: 2278-1684, p-ISSN: 2320-334X PP. 47-60 .*
15. *Shatrughan Tomar, Arun Kumar Bhuneriya, Analysis of OEE for TPM Implementation: Case study, International Journal Of Business Quantitative Economics and Applied Management Research,ISSN: 2349-5677Volume 2, Issue 8, January 2016 PP. 32-40.*
16. *Siddharth S. Ghosh, Dr. M. M. Gupta. Effectiveness improvement of critical machines in a fabrication industry. International Journal of Scientific and Research Publications, ISSN 2250-3153 Volume 6, Issue 2, February 2016 , PP.174-178.*
17. *Subhankur Dutta, Ajoy Krishna Dutta, A Review on the experimental study of Overall Equipment Effectiveness of various machines and its improvement strategies through TPM implementation. In ternational Journal of Engineering Trends and Technology (IJETT) -Volume 36 Number 5- June 2016, PP. 224-232.*
18. *Vijay Lahri, Dr. Pramod Pathak ,A Case Study of Implementation of Overall Equipment Effectiveness on CNC Table type boring & milling machine of a Heavy Machinery* Manufacturing Industry,IOSR Journal of Mechanical and

Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 5 Ver. V (Sep. - Oct. 2015), PP. 63-70.

19. *Zineb Aman, Latifa Ezzine, Jamal Fattah, Abdeslam Lachhab, Improving efficiency of a production line by Using Overall Equipment Effectiveness:A case study,Proceedings of the International Conference on Industrial Engineering and Operations Management,Rabat, Morocco, April 11-13, 2017 PP.1048-1057.*

AUTHORS

Darpit N. Gandhi, M.E. (Industrial Engg.) 4th Semester Student, G H Patel Collage of Engineering & Technology, VallabhVidhyanagar, Gujarat,
E-mail : darpitngandhi1995@gmail.com

Vivek Deshpande, Assistant Professor, Dept. of Mechanical Engineering, G H Patel Collage of Engineering & Technology, VallabhVidhyanagar, Gujarat
E-mail : vivek_deshpande@yahoo.com