5S TRANSFUSION TO OVERALL EQUIPMENT EFFECTIVENESS (OEE) FOR ENHANCING MANUFACTURING PRODUCTIVITY

Shekhar Sahu[1], Lakhan Patidar[2], Pradeep Kumar Soni[3]

[1]*M. Tech. Scholar, Department of Mechanical Engineering, Maulana Azad National Institute of Technology, (MANIT), Bhopal, Madhya Pradesh, India*

[2]*Ph. D. Scholar, Department of Mechanical Engineering, Maulana Azad National Institute of Technology, (MANIT), Bhopal, Madhya Pradesh, India*

[3]Assistant Professor, *Department of Mechanical Engineering, Maulana Azad National Institute of Technology, (MANIT), Bhopal, Madhya Pradesh, India*

Abstract - ***In today highly stern market, not a single concept for any industry is fit in all terms hence 5S and OEE may be adopted synergistic to improve the industrial performance. Objective of the integrated concept is to create a systematic, clean and tidy workplace and improve overall equipment effectiveness, quality, employee's satisfaction so that manufacturing productivity of industry can be improve. An analysis work has been carried out in the reviewed papers to prove that the implementation of 5S, calculation of OEE, analysis of the current status of OEE on manufacturing cells, assesses current performance of the assembly line and identify the major factors for improvement in the productivity. The main contribution of this paper is to identify the relationship among 5S, OEE and manufacturing productivity as a conceptual model. This proposed conceptual model will help industry to have better model understanding on the relationship between these techniques and step by step implementation to improve manufacturing productivity.***

Key Words: *5S, overall equipment effectiveness, hypotheses, productivity.*

1. INTRODUCTION

The 5S techniques used to establish and maintain quality environment in an organization. Origin of 5S and OEE comes from Japan on late 1980s and early 1990s by Osada [22], Hirano [24] and Nakajima [21] and it's first adopted by Toyota motor Company. 5S Concept as tools towards achieving systematic organization, productive environment, and standardization in the workplace [22]. Regarding OEE many experts have found that OEE has numerous uses and definitions which have led to considerable comparisons between equipment-to-equipment, plant-to-plant, or organization–to-organization. Overall equipment effectiveness (OEE) is a fundamental measurement method to evaluate the process. It is suggest that measurement of primary performance of process, OEE may be used as a "benchmark" [1].

1.1 5S

5S drives from five Japanese words that are Seiri, Seiton, Seiso, Seiketsu and Shitsuke [21] [30]. By introducing first 3S (Seiri, Seiton and Seiso) all non-working items are able to be removed from the workplace, only important items are place near users, machines and equipment are kept clean and shiny [10]. The main implementation 5S program comes from workers. In this respect, Shitsuke is critical to its success. Shitsuke is to train worker accordingly so that they will follow good habit.

Mahzan and Hassan [18] explained 5S as

1) Sort (Seiri) - It requires employees to sort and systematically discard items that are unnecessary in the workplace. Sorting is an important technique to transform a cluttered workplace layout into an effective area to improve efficiency and safety.
2) Set in order (Seiton) – It helps employee to organize and arrange necessary item in a neat and systematic manner so that items are use easily and return after use. The main benefit is the searching time will be reduce and there is no human energy waste or excess inventory.
3) Shine (Seiso) - It helps to keep clean and inspects the workplace thoroughly so that there is no dirt on the floor, machinery and equipment.
4) Standardize (Seiketsu) – It refers employee to maintain a high standard of organization by keeping everything clean and orderly at all times.

5) Sustain (Shitsuke) - The last step is to train people to practice the 5S system continuously so that it becomes habitual and ingrained in the culture of organization.

Further 5S practice is a well-recognized key to quality and productivity and for improving the work environment, so it becomes the starting point of a TQM or TPM program [28].

1.2 Overall Equipment Effectiveness (OEE)

The concept of OEE, introduced by Nakajima [21], is being used increasingly in most of the industries. Companies have diverse traditions of deciding their performance in order to reach and maintain a competitive edge in the market. Overall equipment effectiveness (OEE) is the consistent measure tool for evaluation the performance. It develops in industry to measure the efficiency losses that result from rework and yield losses. OEE monitors the actual performance of equipment relative to its performance capabilities under optimal behavior. In most industries several factors influence the productivity of equipment; however, some are obviously recognizable factors earlier to process, meanwhile others are unanticipated and affect equipment productivity negatively [23].

The OEE measure can be applied at numerous different levels within an operation environment to increase productivity [19]

- First, OEE can be used as a "benchmark" for measuring the initial performance of operation process in its totality. In this way the initial OEE measure can be compared with future OEE values [1].
- Second, an OEE value can be used to compare activities performance across the process, thereby highlighting any poor activities performance.
- Third, if the operation procedures work individually, an OEE measure can identify which process performance is the worst.

Thus OEE is a function of the three factors mentioned below [33]

1. Availability or uptime (downtime: planned and unplanned, tool change etc.).
2. Performance rate (actual vs. design capacity).
3. Rate of quality output (Defects and rework).

According to Nakajima [21]

OEE = Availability x Performance rate x Quality (percentage) ... (1)

Availability is proportion of time machine is actually available out of time it should be available. It express as [7]:

$$\text{Availability} = \frac{\text{planned production time} - \text{unscheduled downtime}}{\text{planned production time}}$$

... (2)

Production time = Planned production time – Downtime

Gross available hours for production include 365 days per year, 24 hours per day, and 7 days per week. However this is an ideal condition. Planned downtime includes vacation, holidays, and not enough loads. Availability losses include equipment failures and changeovers indicating situations when the line is not running.

The second category of OEE is performance. The formula can be expressed in this way:

$$\text{Performance} = \frac{(\text{cycle time} \times \text{number of product processed})}{\text{production time}}$$

... (3)

Net production time is the time during which the products are actually produced. Speed losses, small stops, idling, and empty positions in the line indicate that the line is running, but it is not providing the quantity it should.

Quality rate is the percentage of good parts out of total produced. It is sometimes called "yield". Quality losses refer to the situation when the line is producing, but there are quality losses due to in-progress production and warm up rejects. We can express a formula for quality like this:

$$\text{Quality} = \frac{(\text{No. of product processed} - \text{No. of products rejected})}{\text{No. of product processed}}$$

... (4)

OEE and six major losses lodged in one brain and intermittent disturbance in the manufacturing by the number results in diverse kind of losses. These can be defined as activities which absorb resources and create no value. The objective of OEE is to identify these losses. It is a bottom-up approach where an integrated workforce strives to achieve overall equipment effectiveness by eliminating the six big losses [21]. These six big losses are grouped into three major categories are downtime losses, speed losses, defects losses which avoid the faulty equipment and operation.

Table 1 Description of losses [21]

S. no.	Type of losses	Characteristics
1	Unexpected breakdown	Results in equipment downtime for repairs. Costs can include downtime (and lost production opportunity or yields), labor, and spare parts.
2	Setup and adjustment	Results in lost production opportunity (yields) that occurs during product changeovers, shift change or other changes in operating conditions.

S no.	Type of losses	Characteristics
3	Idling and minor stoppage	Results in frequent production downtime and that difficult to record manually. As a result, these losses are usually hidden from efficiency reports and are built into machine capabilities but can cause substantial equipment downtime and lost production opportunity.
4	Speed	Results in productivity losses when equipment must be slowed down to prevent quality defects or minor stoppages. In most cases, this loss is not recorded because the equipment continues to operation.
5	Quality defect & rework	Results in low standard production and defects due to equipment malfunction or poor performance, leading to output which must be reworked or scrapped as waste.
6	Equipment and capital investment	Results in wear and tear on equipment that reduces its durability and productive life span, leading to more frequent capital investment in replacement equipment.

1.3 Productivity

There is a need to improve the productivity of a manufacturing organization with respect to different market and product mixes [9]. Productivity alone does not depict the overall performance of a manufacturing system. Frequent changes in the design and need for continuously improving product quality require high degree of automation and flexibility of the manufacturing system [27]. The productivity improvements achieved at the equipment level are significant but insufficient because what a company really needs is a highly efficient system [12]. Productivity is the term which represents the degree of effectiveness of industrial management in utilizing facilities for production. It can also be considered as a measure of what output of goods or services is produced for a given amount of input resources (manpower, money, material, machines and methods) [29]. 5S is positively related to some operational performance measures, especially those referring to quality and productivity. Muchiri and Pintelon [20] substantiate the belief that OEE is unsuitable, because it is limited to individual equipment and no machine is in fact isolated. On the other hand, it can be argued that there is a general risk that productivity measures are influenced by external factors such as skills of operator, type of product etc., and OEE is therefore not particularly disadvantaged.

2. LITERATURE REVIEWS TO DEVELOP HYPOTHESES MODEL

The main objective of this study is establish the relationship among the 5S, OEE and manufacturing productivity by different hypothesis are follows as:

H1: Relationship between 5S and manufacturing productivity

5S system helps to organize a workplace for increasing efficiency and decrease wasting and optimize quality and productivity via monitoring an organized environment [6]. 5S is not only useful for improving the working environment but also they enhance process and product quality standards, reduce and optimize lead time, and also reduce operating costs and enhance process performance with improvement in manufacturing productivity [17]. 5S is a useful method to improve communication of an organization and help employees to decrease downtime, lead time, inventory, defect, injury, and associated costs to enhance productivity [32]. A lots of the study show a positive relationship between 5S and productivity [13] [25]. Some of the finding also partially correlated with the manufacturing productivity [11]. Therefore accordingly it proposed that:

H1: The 5S system has a direct, positive effect and leads to better manufacturing productivity.

H2: Relationship between 5S and OEE

OEE to acceptable level was endeavored utilizing TPM and 5S. To achieve overall equipment effectiveness in an industry we require proper machine environment which is made by maintaining 5S systems in the machine surrounding [2]. To increase the OEE all the three parameters availability, performance rate and quality had to be increased individually which was adopted by implementing 5S in the cell layout [10]. In pillers of TPM one of the piller is 5S. Sharma and Trikha [26], have concluded that TPM was recommended as an effective maintenance strategy to recover OEE of production machines. OEE will improve in industries through the implementation of 5S practices which improves the manufacturing productivity [13]. Researchers have concluded that availability, performance, quality rate and

OEE of the plant will increment by implementing 5S practices. Therefore accordingly it proposed that:

H2: 5S is positively correlated with OEE

H3: Relationship between OEE and manufacturing productivity

Overall equipment effectiveness (OEE) seems to be a better choice to evaluate efficiency and manufacturing productivity, for it addresses all the antecedent topics, and gives a consistent measure of the real value added production for equipment [4]. OEE was firstly proposed by Nakajima [21] as the key metric to support total productive maintenance (TPM), and is now a widely accepted way to monitor the authentic performance of equipment, in relation to its nominal capabilities under optimal operating conditions. The total productive maintenance (TPM) concept has provided a quantitative metrics of overall equipment effectiveness (OEE) for measuring the performance of individual production equipment in a factory [16].

In the highly competitive environment, to be prosperous and achieve world-class-manufacturing, organizations must possess both efficient maintenance and efficacious manufacturing strategies [3]. The lean manufacturing, OEE, TPM etc. have vital importance for any organization because these directly affect the productivity, overall operating cost, down time or in other word the overall plant performance [31]. Empirical studies substantiate the intuition that a positive effect of OEE metrics on equipment productivity subsists, but it is evident that several other aspects of manufacturing system influence the overall prosperity of company and it is therefore arduous to assess the isolated effect of OEE on productivity, that is why manufacturing productivity is discussed and a relationship is expected [14] [15]. Therefore accordingly it proposed that:

H3: OEE is positively correlated with manufacturing productivity.

The proposed hypotheses are shown in table 2.

Table 2: Hypothetical relation of 5s, OEE and manufacturing productivity

Hypothesis tools	5S	Manufacturing productivity	OEE
5S	X	H1	H2
Manufacturing productivity	-	X	H3
OEE	-	-	X

3. PROPOSED CONCEPTUAL MODEL

Based on the above review studies on 5S, OEE, and manufacturing productivity, a conceptual model has been proposed to understand the relationship as presented in figure

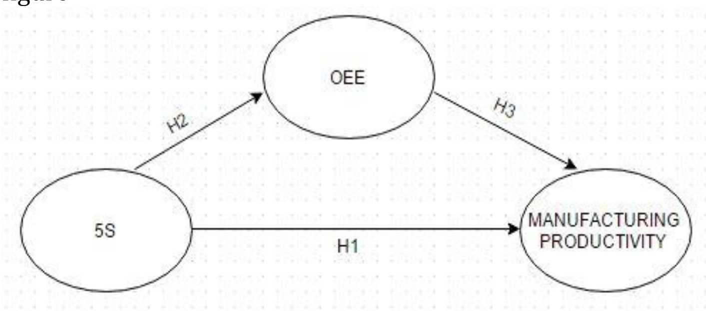

Figure 1: Proposed conceptual model of 5S, OEE and manufacturing productivity

Structural equation modelling (SEM) techniques may be used to examine the relationship between 5S, OEE and manufacturing productivity.

4. CONCLUSIONS

The main objective of this study is to establish the relationship among 5S, overall equipment effectiveness and manufacturing productivity. Three hypotheses regarding the relations among 5S, overall equipment effectiveness and manufacturing productivity has been specified and conceptual framework have been proposed for future work. It is expected that this paper will serve as a seed to investigator for successful implementation of OEE in large as well as small industries.

REFERENCES

[1] Ahmad, M., & Benson, R., “Benchmarking in the Process Industries (ISBN: 0852954115)”, IChemE, Rugby, 1999.

[2] Ahuja, I. P. S., Khamba, J. S., & Choudhary, R., “Improved organizational behavior through strategic plan implementation,” *Strategic Management Journal*, vol. 9, issue 7, pp. 167-183, 2006.

[3] Ahuja, I. P. S., & Khamba, J. S., “Strategies and success factors for overcoming challenges in TPM implementation in Indian manufacturing industry,” *Journal of Quality in Maintenance Engineering*, vol. 14 issue 2, pp. 123-147, 2008.

[4] Braglia, M., Frosolini, M., & Zammori, F., “Overall equipment effectiveness of a manufacturing line (OEEML) An integrated approach to assess systems performance,” *Journal of Manufacturing Technology Management*, vol. *20,* issue 1, pp. 8-29, 2008.

[5] Faber, J. C. J., "Evaluating the success of Total Productive Maintenance at Faurecia Interior Systems (Doctoral dissertation)," 2010.

[6] Gapp, R., Fisher, R., & Kobayashi, K., "Implementing 5S within a Japanese context: an integrated management system," *Management Decision*, vol. 46, issue 4, pp. 565-579, 2008.

[7] Gregory, A., "Number cruncher–overall equipment effectiveness and total productive maintenance," *Work Management*, vol. 59, issue 7, pp. 18-20, 2006.

[8] Hedge, H. G., Mahesh, N. S., & Doss, K., "Overall Equipment Effectiveness Improvement by TPM and 5S Techniques in a CNC Machine Shop," *SaSTech*, vol. 8, pp. 25-32, 2009.

[9] Hilmola, O. P., "Total productivity measurement and competitiveness: towards ensuring sustainable business performance in manufacturing organisations: a literature review". International Journal of Process Management and Benchmarking, 1(1), 45-62, 2005.

[10] Ho, S. K., "Integrated lean TQM model for sustainable development," *The TQM Journal*, vol. 22 issue 6, pp. 583-593, 2010.

[11] Ho, S., Mohd Hashim, A. G. B., & Mohd Idris, M. A., "Applicability of SIRIM Green 5-S Model for productivity & business growth in Malaysia," *The TQM Journal*, vol. 27, issue 2, pp. 185-196, 2015.

[12] Huang, S. H., Dismukes, J. P., Shi, J., Su, Q., Wang, G., Razzak, M. A., & Robinson, D. E., "Manufacturing system modeling for productivity improvement," Journal of Manufacturing Systems, 21(4), 249-259, 2002.

[13] Jain, A., Bhatti, R., & Singh, H., "Productivity Improvement through 5S Implementation in Indian Manufacturing Industries," *In Proceedings of the International Conference on Research and Innovations in Mechanical Engineering*, pp. 535-545, January 2014.

[14] Kumar, J., Kumar Soni, V., & Agnihotri, G., "Impact of TPM implementation on Indian manufacturing industry," *International Journal of Productivity and Performance Management*, vol. 63 issue 1, pp. 44-56, 2014.

[15] Kumar, J., Kumar Soni, V., & Agnihotri, G., "Critiques of overall equipment effectiveness (OEE): A literature review," *International Journal of Contemporary Practices*, vol. 1 issue 10, pp. 29-36.

[16] Kwon, O., & Lee, H., "Calculation methodology for contributive managerial effect by OEE as a result of TPM activities," *Journal of quality in Maintenance Engineering*, vol. 10, issue 4, pp. 263-272, 2004.

[17] Liker, J. K., & Hoseus, M., "Toyota culture," New York, McGrawHill, 2008.

[18] Mahzan, N., & Hassan, N. A. B., "Internal Audit of Quality in 5s Environment: Perception on Critical Factors, Effectiveness and Impact on Organizational Performance," *International Journal of Academic Research in Accounting, Finance and Management Sciences*, vol. 5 issue 1, pp. 92-102, 2015.

[19] Mansour, H., Ahmad, M., & Ahmed, H., "Potential using of OEE in evaluating the operational performance of work over activities. In Advances in Sustainable and Competitive Manufacturing Systems", *Springer International Publishing*, pp. 877-886, 2013.

[20] Muchiri, P., & Pintelon, L., "Performance measurement using overall equipment effectiveness (OEE): literature review and practical application discussion," International Journal of Production Research, 46(13), 3517-3535, 2008.

[21] Nakajima, S. "Introduction to TPM: Total Productive Maintenance," Cambridge, MA, *Productivity Press*, 1988.

[22] Osada, T., "*The 5S's:* five keys to a total quality environment," *Quality Resources*, 1991.

[23] Patidar, L., and Rao, K.U., "Soft foot and motor problem solved through predictive maintenance approach", *Proceedings on Recent Trends in Engineering & Sciences Conference*, pp. 10-13, 2012.

[24] Productivity Press Development Team, "5S for operators: five pillars of the visual workplace", (based on Five Pillars on the Visual Workplace: The Sourcebook for 5S Implementation by Hiroyuki Hirano), *Productivity Press,* 1999.

[25] Sánchez, P. M., Ballesteros, N. R., & Olaya, D. F., "Impact of 5S on Productivity, Quality, Organizational Climate and IS at Tecniaguas SAS," In *Enhancing Synergies in a Collaborative Environment*, 247-255, 2015.

[26] Sharma, R., & Trikha, V., "TPM Implementation in Piston Manufacturing Industry for OEE," *Current Trends in Engineering Research,* vol. 1, issue 1, 2011.

[27] Singh, S. K., & Singh, M. K., "Evaluation of Productivity, Quality and Flexibility of an Advanced Manufacturing System" Journal of The Institution of Engineers (India): Series C, 93(1), 93-101, 2012.

[28] Soni, P. K., "Total productive maintenance–An implementation experience", *International Journal of Research in Engineering and Technology*, vol. 2 issue 5, pp. 263-267, 2013.

[29] Sumanth, D. J., & Adya, B., "Impact of total productivity measurement on automation in bus transit. Journal of transportation engineering, 116(3), 377-394, 1990.

[30] Suzuki, T., "New Directions for TPM," *Productivity Press*, Cambridge, MA, 1992.

[31] Tilkar, A. K., & Nagaich, "A case study approach to productivity enhancement and calculation of Overall Equipment effectiveness".

[32] Van Patten, J., "A second look at 5S," *Quality progress*, vol. 39, issue10, 55-59, 2006.

[33] Venkatesh, J., "An introduction to total productive maintenance (TPM)," *The plant maintenance resource center*, pp. 3-20, 2007.

BIOGRAPHIES

Shekhar Sahu holds a Bachelor's Degree in Mechanical Engineering from RCET Bhilai, Chhattisgarh and pursuing M. Tech. in Mechanical engineering (Maintenance engineering and management) from Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh (India).

Lakhan Patidar holds a Bachelor's Degree in Industrial and Production Engineering from GEC (U.I.T-R.G.P.V) Bhopal, Master's Degree in Mechanical Engineering (Maintenance Engineering and Management) and pursuing a PhD in Mechanical Engineering from the Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh (India). His present area of interest includes productivity improvement in industries through modern techniques of maintenance.

Dr. Pradeep Kumar Soni holds a Bachelor's Degree in Mechanical Engineering from SATI, Vidisha, Master's Degree in Energy (Mechanical) Engineering and a PhD in Mechanical Engineering (Production Engineering) from MANIT, Bhopal, Madhya Pradesh (India). Currently, he is working as an Assistant Professor in the Department of Mechanical Engineering, MANIT, Bhopal, Madhya Pradesh (India). He has contributed a significant number of research papers at the international level.