International Journal of Latest Engineering Science (IJLES) E-ISSN: 2581-6659

DOI: 10.51386/25816659/ijles-v5i2p102

Volume: 05 Issue: 02 **March to April 2022** **www.ijlesjournal.org**

Evidence of Manufacturing Productivity using TPM in Indian industry: a survey

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Abstract

An industrial survey was carried out to explore the potential use of total productive maintenance (TPM) for the performance monitoring and improvement within the Indian manufacturing firms. Based on survey response and newsletter, analyses were performed on popularly used TPM metrics, its present status and expectation by the manufacturing firms. It has also been found that many of the companies have not implemented TPM but they use overall equipment effectiveness (OEE) for the manufacturing performance monitoring and diagnostics purpose. Further analysis showed that a majority of companies has not only successfully implemented TPM but they have achieved high manufacturing productivity. Correlation analysis showed a strong positive relationship between degrees of satisfaction of management with the increasing value of OEE& OPE. The result indicates some ineffectiveness of the companies having no performance monitoring tool like OEE impact negatively on their performance.

Key Words: *TPM, Manufacturing performance, OEE*

1. Introduction

Due to intense global competition and increasing demand of quality product at lower cost companies are striving to improve and optimize their manufacturing productivity in order to stay competitive. TPM is a plan, which concentrates on total involvement of everyone from top management to all employees for all equipment throughout its life resulting in maximum effectiveness of equipment, tidier, neat and clean work place and boosted employees (Ljungberg 1998 and Campbel 2006). In other words TPM is a methodology that aims to increase the availability of existing equipment, hence reducing the need for further capital investment and maximum utilization of available resources [Chan (2005) and Ahuja (2008)]. Currently, the concept of TPM in Indian manufacturing firms is the critical missing concepts in successfully achieving not only world class equipment performance, but also it is a powerful new means in improving overall company performance. As the global competition characterized by the rapid technological innovation and ever changing market demands is putting enormous pressure on manufacturing organizations hence, to ensure the plant achieves the desired performance at an optimal operating cost, managers need to keep continuous tracking of effective utilization of resources and opportunities for the improvement.

TPM is designed to maximize the overall equipment effectiveness. The concept of OEE and focused improvement were found to be quite encouraging for success of TPM (Suzuki, 1994). In other words OEE is a quantitative metric widely used within TPM environment for the measurement of TPM success. Therefore OEE is vital for continuous performance improvement of a production plant.A monitoring system is necessary to ensure the optimum equipment availability producing the high quality of product with the designed speed of machine.

The purpose & objective of this paper is to present the understanding of TPM by the management and its outcome within the Indian manufacturing firms. For this purpose the relevant data have been gathered only from the larger group of industries having the employees size more than thousands. The second point of interest is to investigate how the TPM element influences the manufacturing performance. This has been done by establishing the

DOI: 10.51386/25816659/ijles-v5i2p102

Volume: 05 Issue: 02 March to April 2022 www.ijlesjournal.org

correlation between TPM element and factors measuring the manufacturing performance. Finally, the effective use of OEE within TPM environment and degree of satisfaction of management through increasing values of OEE has been established.

2.0 Literature review

2.1 TPM environment

TPM is a production-driven improvement methodology that is designed to optimize equipment reliability and ensure efficient plant utilization through the use of employee involvement and empowerment, by linking manufacturing, maintenance and engineering function. It has been developed by the Japan Institute of Plant maintenance (JIPM) as a very important tool for equipment intensive manufacturing sectors; it is a key means for increasing machine availability (Suzuki, 1994). The value of deploying TPM has been worldwide recognized, particularly in the customer driven market, demand of high quality of product at low cost and profit to the company. The central thrust of the TPM programme was to the complete elimination of the "six major equipment losses" (Nakajima 1988). The key concept behind effective improvements was autonomous maintenance. The concept of overall equipment effectiveness (OEE) and focused improvement were found to be quite encouraging for success of TPM [Suzuki, 1994]. TPM does not provide a quick or easy solution. It usually requires changes in employee's attitudes and values, which takes time to imbibe. Quick and company-wide performance gains should not be expected too much during the initial phase. While top management commitment and leadership is essential for TPM success, it is not sufficient on its own. TPM embraces empowerment to production operators establishing a sense of ownership in their daily operating equipment (Tsang & Chan, 2000). This sense of ownership is an important factor that underpins TPM to its continual success with every operator being responsible to ensure her own machine is well maintained for the maximum utilization.

Positive strategic outcome of TPM implementations is the reduced occurrence of unexpected machine breakdowns, which ultimately results in enhanced profits in the organization [Gosavi, 2006]. The results of the analyses indicate that TPM controls productivity, cost, quality, delivery time, safety and morale of the employees (Johnson, 1996). TPM can be a strong contributor to the strength of the organization and has the ability to improve Manufacturing performance (Gosavi, 2006). At large it has been found that the six TPM elements are widely used in the Indian manufacturing industry as shown in Fig. 1 to improve the performance of company.

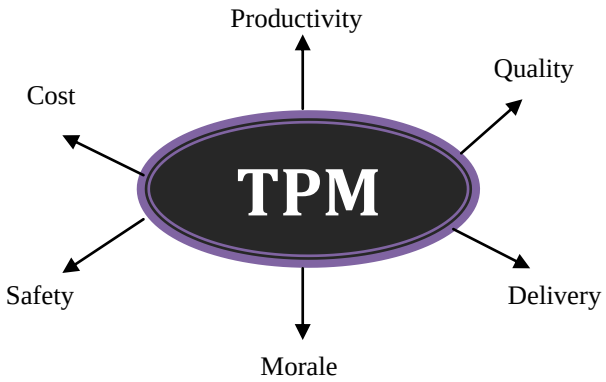

Figure 1: TPM Elements described by Johnsson (1996)

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2.2 TPM elements

Nakajima (1988), often regarded as the originator of TPM, states that the goal of TPM is to enhance equipment effectiveness and maximize equipment output. It seeks to achieve this by striving to attain and maintain optimal equipment conditions in order to prevent unexpected breakdowns, speed losses, and quality defects at the product, process and system level (Bamber, Sharp and Hides, 1999).

A number of organizations have claimed improvements in equipment availability, reliability and a reduction on maintenance costs when implementing TPM (Blanchard, 1997; Cooke, 2000). The benefits of TPM are often quoted as increase in product quality, equipment availability, and a reduction in operating costs (Cholasuke, Bhardwa and Jiju, 2004; Bohoris et al., 1995; Al-Najjar, 1996).Through TPM, it should also be possible to increase employee morale and job satisfaction by allowing the workers to be involved with every aspect of TPM. Most of the universally accepted definitions of TPM, by Barnes (2002), Baglee, Trimble and MacIntyre (2003), Hansson and Backlund (2002), and Kardon and Fredendall (2002) build upon the basic five pillars outlined by Nakajima: Improve (OEE), autonomous maintenance, planned maintenance, training to operators, early equipment management. TPM also facilitate the organisation to achieve higher levels of productivity, improved customer service, morale and profits. Japan Institute of Plant Maintenance (JIPM) provides eight pillar of TPM implementation plan that results in substantial increase in labour productivity through controlled maintenance, reduction in waste, and reduced production stoppages and downtimes.

2.3 Manufacturing performance measurement within TPM environment

There are various ways of measuring manufacturing performance. The measurement of manufacturing performance remains unsettled subject due to the diverse and multidimensional nature of manufacturing. However, the most predominant approach in the literature is to use cost, overall equipment effectiveness, quality, delivery and customer satisfaction as the basic dimension within Indian context. Mckone et al (2001) have found that TPM has a strong and positive relationship with low cost, high levels of quality and strong delivery performance. Sharma and Trikha (2011) have discussed frequent machine breakdown, low plant availability and increased overtime as the great threat to a manufacturing plant in the context of India.

The concept of total productive maintenance (TPM) launched in 1980s, provided a quantitative metric called overall equipment effectiveness (OEE) for measuring the productivity of manufacturing equipment's (Nakajima 1988). OEE identifies and measures the losses of important aspects of manufacturing namely availability, performance and rate of quality. Performance measures are indispensable of for management to understand the state of manufacturing system and to take appropriate action for maintaining competitiveness and profitability. The generic function of the manufacturing performance measures are summarized in the Figure 2 (Hon, 2001).

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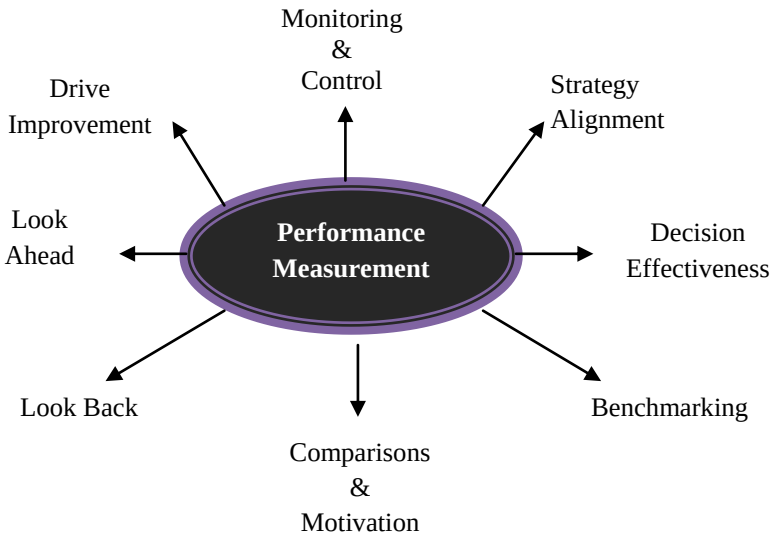

Figure 2: Functions of the performance measurement

3. Research Methodology

A Sample of 400 companies has been identified using online newsletter published by consultancy and TPM club which works only for the implementation and promotion of TPM. A structured survey approach has also been used as the research strategy in this study for the authentication of newsletter in the sample companies. The data used for empirical analysis of the TPM were collected as part of TPM club India newsletter. The companies targeted throughout the India and deals with the manufacture of automotive components; pulp and paper products; petroleum products; chemical products; fabricating metal products; machinery and equipment (Table 1).

Through the all sources relevant data and information such as company profile, TPM background, expectation from the TPM, success of TPM and relevant data has been captured. This research can be classified as an exploratory study, where information is collected using literature; newsletter and surveys to find out what is happening, seek new insights into and assess the whole phenomena in the present scenario (Robson, 2002). Survey research strategy was chosen as it provides collection of large amount of data from a sizeable population through the administered questionnaire (Saunders, 2007). Since the data is standardized, it allows easy comparison and quantitative analysis using descriptive and inferential statistics.

Table 1: The profile of respondent companies

Manufacturing Sector of Respondents	Respondent (Percent)	Cumulative Percent
Automotive Industry	38.6	38.6
Manufacturing of Machinery	13.6	52.1
Chemicals	11.4	63.6
Metal Industry	8.6	72.1

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Food & beverage	5.7	77.9
Petroleum Industry	5.7	83.6
Metal & Fabrication Industry	4.3	87.9
Textile	3.6	91.4
Tyre Industry	3.6	95.0
Pulp & Paper Product	2.9	97.9
others	2.1	100.0
Total	**100.0**	

4. Result & Discussion

4.1 TPM environment and expectation

To gain insight into TPM environment and the common expectation after TPM implementation has been critically examined throughout the entire sector. The factors and the measuring units which influence the performance of company may vary sector to sector and factory to factory. Also the importance of the common factor varies company to company for the calculation of performance. The importance of the factors has been listed from all the companies and has been asked to rate the factor according to their company needs.

From the result (Figure 3), it is shown that machine availability, breakdown occurrence, machine performance, quality defect and delivery are perceived the highest impact on plant operation and hence company performance. On the other hand, machine changeover, maintenance cost, TPM cost, customer complaint, and morale of the employee have something lesser impact on the company performance. This indicates that machine availability still leads the highest impact on manufacturing performance. To get high plant availability with no frequent breakdown occurrence, during the availability of machine its performance should be satisfactory. The working of equipment should be defect free for the high quality rate. During analysis it has been found that some of the company does not include the rework product into the quality rate. On the production part machine changeover and maintenance are highly frequent problem which affect the performance of company. Accident within the company and moral of employees also affect the production. On time delivery of product and the customer complaint too affect the company performance. In many companies TPM cost is also calculated and due to huge investment company discards the TPM program.

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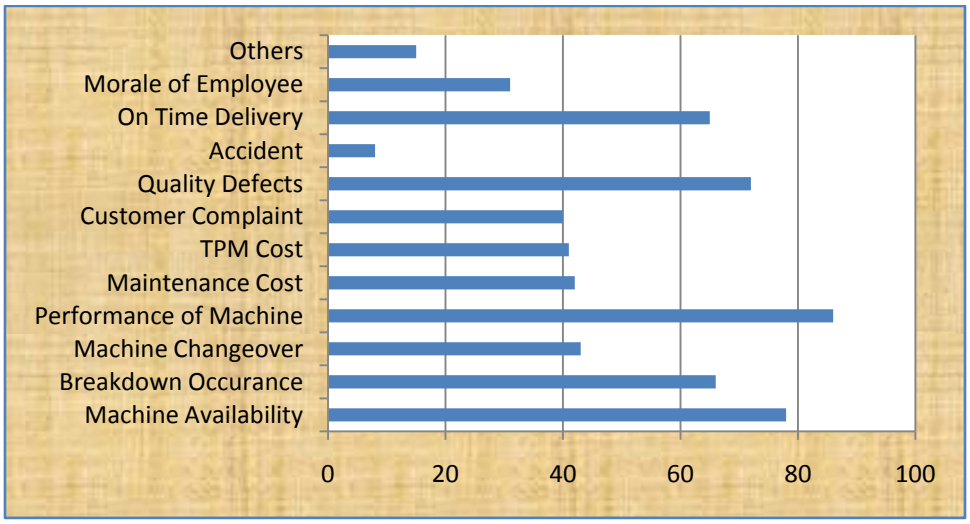

Figure 3: The important factors hampering net production

To check the TPM objectives pursued by the various companies, the data collected and rank the importance of the various elements in their companies. The average percentage of the result is shown in Figure 4. It has been found that quality rate, productivity and cost effectiveness are highly rated TPM elements. It was also found that on time delivery, safety and moral of the employee are the important element of the TPM for the indian manufacturing firms. Results also indicate that 28% of respondent use other factors within TPM environment to achieve their expectation while TPM programm.

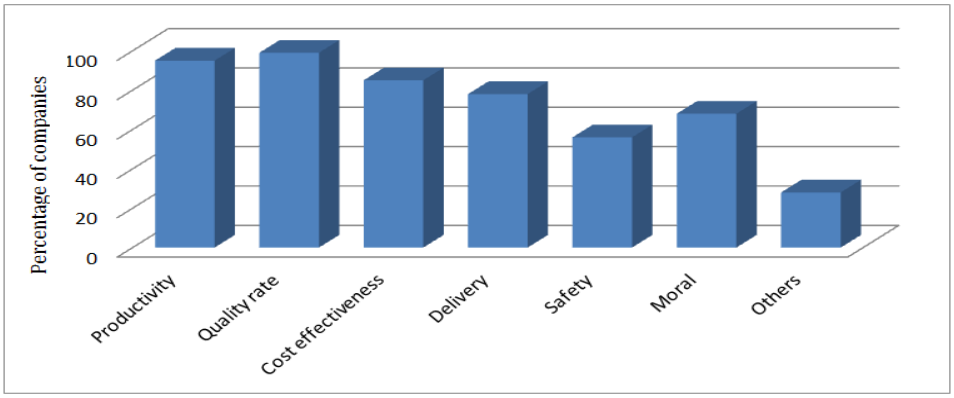

Figure 4: The TPM elements pursued by different companies

During the collection of data the respondent are asked about the TPM expectation. It has also seen that many companies calculate the TPM cost against their benefit. Prior to TPM implementation management expects something and if their expectation fulfills the company continues the TPM program otherwise it has been observed that a few company kick off the TPM program in their middle. The various expectations of the companies have been listed in the table 3.

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Table 3: The Important expectation through TPM program within India	
1. Reduce production cost	2. Setup times for faster model changeover
3. Zero downtime	4. Reduce frequent breakdown
5. Zero accident	6. Employee motivation
7. Zero loss	8. Long term and sustainable competitive edge
9. Highest quality	10. Development of technical know-how in house
11. Optimum productivity level	12. Clean, green and happy work environment
13. Reduce lead times	14. Effective and efficient working method
15. Energy conservation	16. Strong pollution mechanism
17. Customer delight	18. Best work culture
19. Robust system in place	20. Dynamic leadership

4.2 Influences of TPM elements on manufacturing performance

The result of analyses indicates that TPM controls manufacturing cost, quality and delivery time. TPM can be strong contributor to the strength of organisation and has the ability to improve Manufacturing performance (McKone 2001). The success of TPM is measured through various indicators as shown in table 1. As it is not feasible to include all such measure in this paper, only representative salient measure and most widely used metrics are collected and its influences on manufacturing performance have been checked through the correlation analysis.

To check the influence of TPM environment on the manufacturing performance, the Pearson correlation analysis was done among the different and important TPM element as shown in Table 4, It showed that plant availability has a high correlation with overall equipment effectiveness (with $p = 0.002$) as expected at the 0.01 significant level. Since the data has only for the six consecutive years and the parameter having the average values of 57 manufacturing firms. This is an indication that companies pursing high OEE value are interested in the plant availability. OEE is also correlated with quality rate (with $p = 0.044$) at the 0.05 significant value. When production rate increase OEE also show increasing trends and that show with correlation between production rate and OEE (with $p = 0.004$). OEE also shows the correlation with customer complaint (with $p = 0.004$) it gives indication that quality rate has impact on OEE and hence the OEE value increases and customer complaint decreases. Production rate also shows the correlation with customer complaint (with $p < 0.001$) that indicates if customer complaint has to be minimized the production process should execute carefully and it may impact on production rate. In this analysis on time delivery does not show any strong correlation with other measuring element and this outcome was unexpected. However manufacturing firms strongly accept that increasing value of OEE also improve the delivery. The major accident show relation only with the quality rate (with $p = 0.022$). Here, accident is directly related with the safety and environmental issue. It also indicates that safety and environmental issue are more concerned with managerial rather than technical details of manufacturing performance.

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Table 4: Correlation between the TPM elements factors measuring manufacturing performance

Pearson Correlation Coefficient, N=57 **. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed).							
TPM Element used for the manufacturing performance measurement	Overall Equipment Effectiveness	Plant Availability	Quality Rate	Production Rate	On Time Delivery	Customer Complaint	Major Accident
Overall Equipment Effectiveness	1	.477** **.002**	.646* **.044**	.949** **.004**	-.426 .400	-.947** **.004**	-.348 .500
Plant Availability	.477** **.002**	1	-.010 .985	.383 .453	.567 .240	-.449 .372	.039 .942
Quality Rate	.646* **.044**	-.010 .985	1	.824* **.044**	-.734 .097	-.781 .067	-.877* .022
Production Rate	.949** **.004**	.383 .453	.824* .044	1	-.535 .274	-.985** **.000**	-.610 .198
On Time Delivery	-.426 .400	.567 .240	-.734 .097	-.535 .274	1	.473 .343	.552 .256
Customer Complaint	-.947** **.004**	-.449 .372	-.781 .067	-.985** **.000**	.473 .343	1	.608 .201
Major Accident	-.348 .500	.039 .942	-.877* **.022**	-.610 .198	.552 .256	.608 .201	1

4.3 Overall equipment effectiveness (OEE)

TPM is a production driven improvement methodology designed to maximize the overall equipment effectiveness (Robinson and Ginder, 1995). The concept of OEE and focused improvement were found to be quite encouraging for success of TPM (Suzuki 1994). TPM employs OEE as a quantitative metric for measuring the performance of a production system. OEE is the core metric for measuring the success of TPM implementation program (Jeong and Philips, 2001). The metric has become widely accepted as a quantitative tool essential for measurement of productivity in manufacturing operations (Huang et al., 2002). Even though many of the ancillary companies in India is widely using OEE as a powerful TPM metric (Kumar et al., 2011) to measure and monitor manufacturing performance. It provides a systematic method for establishing production target and incorporates practical management tools and technique in order to achieve a balanced view of process availability, performance efficiency and rate of quality (Bulent et al., 2000). OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and rate of quality of product.

OEE = Availability x Performance Rate x Quality Rate

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TPM seeks to improve the OEE, which is an important indicator, deployed to measure success of TPM program. TPM has the standard of 90 percent availability, 95 percent performance and 99 percent rate of quality (Levitt, 1996). An overall 85 percent benchmark OEE is considered as world class performance (Blanchard, 1997; McKone et al., 1999). As shown in Figure 4, the average of OEE and overall plant effectiveness (OPE) is increasing and it is almost towards the world class performance.

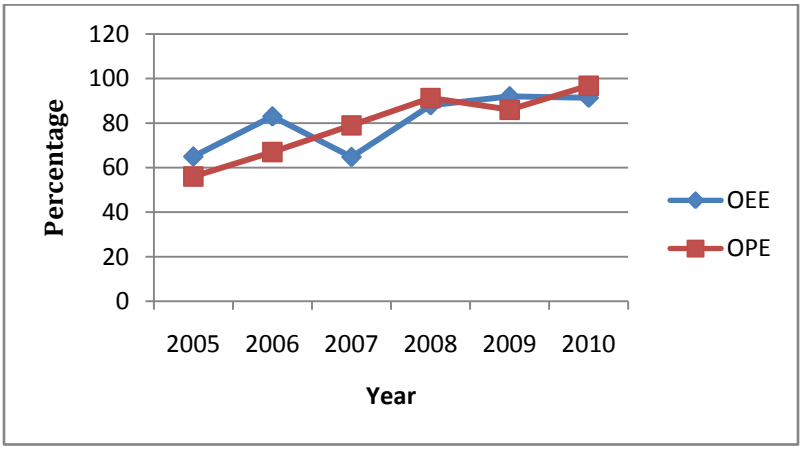

Figure 4: Trends of OEE and OPE during the year 2005 to 2010.

The interest was also to analyze the effective use of increasing values of OEE by checking how OEE support the management and what factors and how much are expected by the respondent. As shown in Figure 5, 92% of the respondent uses OEE for the effective resource utilization. OEE is also considered as useful indicator in monitoring and controlling equipment effectiveness (with 89% response rate); to identify bottlenecks (with 72% response rate); to identify hidden capacity (with response rate 78%); decision support (with 68% response rate); overall performance improvement (with 66% response rate); opportunities for improvement (with 62% response rate); safety improvement (with 58% response rate) and others (with 18% response rate).

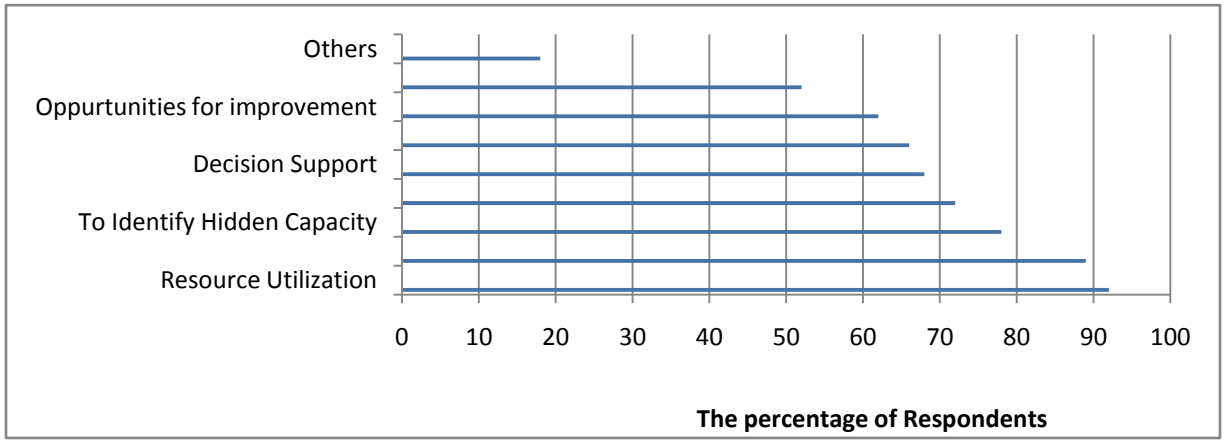

Figure 5: Controlling factors supported by overall equipment effectiveness

In addition, the respondents were asked to indicate the degree of satisfaction with their increasing value of OEE. As shown in Figure 11, 63.5% respondent is strongly agreed and 27.9% of respondent agree that the increasing value of

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OEE is the indicator management satisfaction. While 3.8% respondent are neutral and only a few percentage approx.

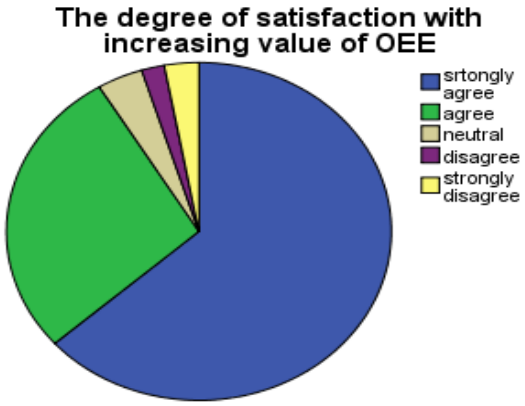

Figure 6: Degree of satisfaction with OEE

2% only is out of this category. It is very clear indication that the successful implementation of TPM increases the value of OEE and the expectation of company as mentioned above in Figure 6 is being fulfilled.

These significant result on TPM implementation and the expectation of management personal, coupled with their degree of satisfaction raise a question on the effectiveness of performance measurement system in their practice. A better performance measurement model explores the opportunity to identify the bottleneck and potential improvement.

5. CONCLUSION

This paper highlights the long term effects of TPM on organizational performance within the Indian manufacturing firms. The TPM deployment has significantly contributed towards improving the manufacturing performance, quality, safety, morale and besides ensuring the cost effectiveness of the manufacturing function within the organisation. The relevant data has been gathered only for six years starting from year 2005 to 2010. The most widely used performance indicator and their measurement units used in TPM environment has been identified; the management expectation while TPM implementation have gathered; the influence of TPM element on the manufacturing performance has been checked through correlation analysis; and finally, the effective use of OEE as a powerful TPM metric have been explored and the degree of satisfaction of the management with increasing value of OEE has been shown.

The main research finding can be summarized as follows:

(a) First, literature review showed that the different categories of TPM pillar or element have been proposed by various authors. However, it was observed that TPM elements described by Johansson (1996) have been widely accepted within the Indian manufacturing firms.

(b) The important factors that affect the performance of production have been summarized and the machine availability and performance of machine has identified as most critical factor.

(c) To counter the production disruption, management prefers performance improvement of the existing resources.

(d) Analyses reveal that safety and morale of employee is the key area on which more attention is still required.

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(e) Correlation analysis shows that TPM elements influence the manufacturing performance with strong – positive correlation coefficient.

(f) It is observed that OEE metric and its parameter are found to be most relevant equipment performance indicator, capable of measuring and monitoring the resource utilization and production losses.

(g) It has been noticed that many companies don't have implemented TPM program even though they use OEE for the performance monitoring purpose.

The success of TPM program and overall performance improvement of the selected companies may be an eye opener for those companies that have not initiated on it and their performance is also not up to the mark. The degree of satisfaction of the management with the increasing values of OEE shows that high value of OEE gives satisfaction to the management and hence the employee.

Scope for future research:

(a) TPM program and its implementation can be further extended to sector specific or in the context of medium scale and small scale industries in India.

(b) Almost all the companies calculate simple OEE but it has many critiques (Kumar et al., 2012). Further research can be extended to the development of methodological approach for the OEE calculation.

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