Enhancement of Overall Equipment Effectiveness through Implementation of Total Productive Maintenance

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Abstract
In the present competitive world most of the manufacturing industries are skirmishing by providing their best productivity. In this research article an attempt was made to analyse and implement the total productive maintenance system in a yarn manufacturing industry. At present the textile yarn manufacturing industry is incapable of supplying the product to the customer at the right time in turn to satisfy the customer to increase the productivity. This problem is occurring due to the high lead times in the regular manufacturing process. More over the frequent breakdown of machines leads to consume more cycle times for the existing process. Hence, by proper analysis and implementation of total productive maintenance system the overall efficiency of the industry may be increased and the said problems may be minimized. From the results, after implementation of total productive maintenance it was found that the overall equipment effectiveness has been increased between 5 to 8% for the various components. Similarly, the availability of the machines has also been increased up to 90%.

Keywords
TPM, OEE, Autonomous Maintenance, Availability, Unilap Machine

1. Introduction

In the current production scenario, most of the manufacturing companies are facing the recurring problems like breakdown of machines, frequent repair and quality defects. In this research, a case study has been conducted in a textile yarn manufacturing industry. Due to regular machine breakdowns, the industry currently encounters low availability and performance efficiency of the machines. Overall Equipment Effectiveness (OEE) is extensively used as a key performance indicator to measure the availability of machines. Total Productive Maintenance (TPM) eliminates breakdowns and promotes Autonomous Maintenance (AM) by operators through day to day activities involving total workforce thereby, maximizing the availability of a machine. The goal of any TPM program is to improve the overall productivity and quality along with increased employee morale and job satisfaction. Earlier, preventive maintenance was considered as a non-value added process, but currently it is an essential requirement for longer life cycle of machines in an industry to minimize the overall lead time and cycle time of the process.

2. Literature Review

Lean manufacturing is essential for small and medium enterprises (SMEs). SMEs play a very important role in the economy of any country, and it is more so in a developing country like India. SMEs contribute almost 40% of the gross industrial value added in the Indian economy. It is estimated that there are over 11 million SMEs in the country today, which comprise 90% of all industrial units Ahuja and J.S. Khamba(2008), AbhishekJainet al. (2014) and Tamizharasi and Kathiresan(2012). The SMEs alone contribute to 6% of India's gross domestic product. In Indian scenario, the government is taking lot of efforts to implement lean principles in SMEs using cluster approach. To enable systematic implementation leanness assessment needs to be done to measure level of implementation of lean in each process.In an earlier study it was reported that, the application of lean manufacturing using value stream mapping (VSM) for reducing the transportation cost of patients to get treated in an Italian hospital. This author has mentioned that VSM is the consolidated technique applying lean manufacturing in pharmization and also listed seven wastes identified in lean manufacturing arena, which are occurring in the hospital. The value stream map of patient was developed by referring to the VSM map and the actions to be taken to achieve and improvements were drawn. One of those improvements is the reduction of lead time of staying in the hospital by the patient. It is also stated that, a saving of 65 Euro per day was achieved by implementing the proposals of this research in the Italian hospital in which this research was carried out Nallusamy (2015), NazrulIdzhamKasim et al. (2015), Chiarini (2013) and Arunraj and Maran (2014).

VSM creates a common language for production processes, which facilitates more thoughtful decisions to improve the value stream of a product.VSM is a method of visually mapping a product's production path, including materials and information flow Vivek and Hemant(2014), Islam(2013), Nallusamy (2013) and Vijayakumar et al.(2014). An innovative approach was proposed using lean concept to solve the problem of cycle time reduction in local steel commercialization firm with an aim to reduce 20% of the total cycle time delivery that occurs from the time the order was placed to the time the merchandise arrived the customer plant. The methodology involved in the development of current VSM of the selected product is to identify the root cause and design a future state VSM. The result revealed a total cycle time reduction of 54% more than the 20% originally established goal Puvanasvaranet al. (2013), JitenderKumar et al. (2014), Benjamin Durakovic(2012) and Nallusamy(2015).

Integrating industrial engineering and lean techniques at a contract pharmaceutical manufacturer was proposed and in that case study on lean technique at a contract pharmaceutical industry represented a number of possible opportunities for specific areas of improvement and suggested an overall change in the manufacturing mindset. Lean manufacturing techniques were utilized in the development of new systems Shekhar(2015), Ranteshwar Singh(2013) and Chand and Shirvani (2000). The manufacturing industry has gone through significant changes in the last decade. Competition has increased dramatically. Customers focus on product quality, product delivery time and cost of product. Because of these, the organization should introduce a maintenance system to improve and increase both quality and productivity continuously. Through the case study of implementing TPM in an automobile manufacturing organization, the increase in efficiency and productivity of machines in terms of OEE are discussed GunjiVenkataPunnaRao and Nallusamy(2018), Lokeshwaran et al. (2018) and Cooke(2000).

The present scenario, the world is highly competitive. Many industries compete in this competitive world by giving their best productivity. Productivity can be improved in many ways. There is budding need for TPM execution in Indian manufacturing industries and necessitate to develop TPM implementation practice and procedures. A new definition of performance ratio was introduced to reduce the limitation of cycle time and hence the OEE has been improved. In this paper the details of application of OEE to a plastic industry are presented. Using overall equipment effectiveness calculations one can determine the present situation in the production system, effectiveness of the maintenance system, conditions of the machines, workers skill and utilization of the machines Nallusamy and Saravanan (2018), Nallusamy et al. (2018), SoraphonKigsirisin et al. (2016) and Chandrashekar and Naidu (2014). The implementation of TPM being realized and become as an essential matter to resolve maintenance issue incurred in Injection Moulding Company. The basic impact given by down time issue was manufacturer would not able to achieve the targeted production. The implementation of TPM is requiring full supporting of top management to ensure its working as well the support of all employees from all level escorting the TPM to be carried in proper way and practice Kedaria and Deshpande(2014), Rajput and Jayaswal(2012) and Afefy(2013). Based on the above literature an attempt was made to implement a lean TPM in a Yarn manufacturing industry to increase the availability and OEE.

3. Problem Statement and Objective

The selected manufacturing industry is currently facing the excess lead time and cycle time process with less availability of machines. This is mainly due to the breakdown of machines and unplanned downtime. Hence, the industry is unable to meet out the demand at the right time to satisfy the customer. The main objective of this study is to minimize the frequent machine breakdowns in the industry by implementing TPM concepts which increases the OEE. Consequently there will be a reduction in overall lead time and wastage minimization also.

4. Data Collection and Analysis

TPM is a structure of maintaining and improving the reliability of production and quality through machines, equipments, processes, and employees which adds business value to an organization. TPM focuses on keeping all equipment in top working condition to avoid frequent breakdowns and delays in manufacturing processes. OEE takes into account the various sub components of the manufacturing process such as availability, performance and quality. This percentage can be viewed as a snapshot of the current production efficiency for a machine, line or cell in the manufacturing industry. The main pillars of TPM are shown in Figure 1. The existing data was collected and the OEE value has been calculated.

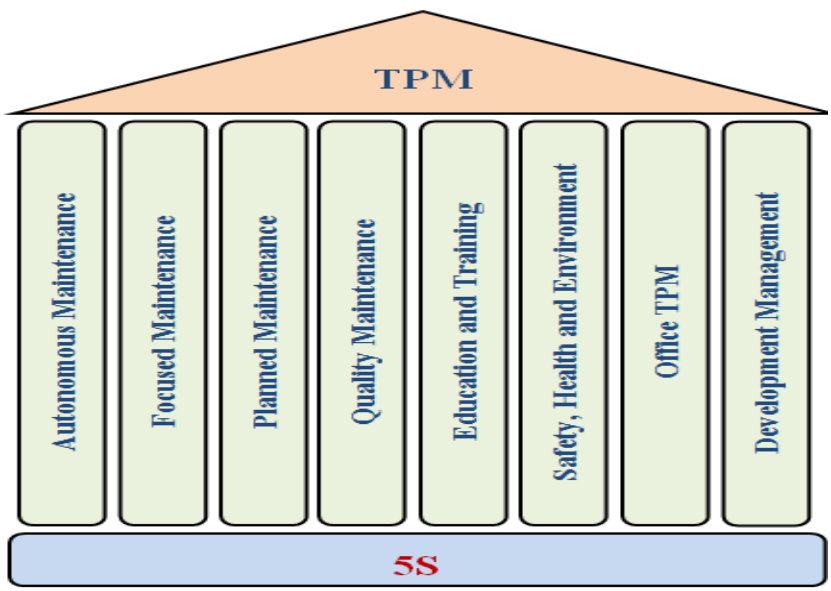

Figure 1. Pillars of TPM

4.1 Overall Equipment Effectiveness (OEE)

OEE = (Availability) × (Performance Efficiency)×(Rate of Quality)

Availability (A) = (Loading Time – Down Time) / (Loading Time)

Where,

Number of shifts = 3 shifts/day,
1 Shift = 450 minutes
Loading Time = 450 minutes,
Downtime = 120 minutes
Availability = [(450 – 120) / (450)] × 100 A = 73%

Performance Efficiency (PE) = (Ideal Cycle Time × Total Items) / (Operating Time)

PE = [(172 × 157) / (450)] = 60%

Reason:

1 lap = 260m, Machine speed = 103m/min, 1 lap completion time = 2.52 min and Idle time = 45seconds

Rate of Quality = (Total Items - Defects) / (Total Items)
Total item = 480 kg and Defects = 20 kg
R = 95.8%

Therefore, OEE = 0.73 X 0.60 X 0.955 = 41.83%

5. Results and Discussions

The machine components data was collected for Unilap E32 machine which is responsible for breakdown and number of occurrences and the results are shown in Table 1.

Table 1. Component failure in Unilap E32

Components Failure	Breakdown Time (minutes)	Occurrence
Main Motor		
Motor	120	2
V-belt	30	4
Suction Ventilator		
Motor (Bearing)	60	3
Fan (Bearing)	90	2
Shaft	60	1
V-belt	30	4
Gear Box		
Sprocket	120	1
Doffer Chain	60	2
Clutch (Bearing)	60	4
Lap Disc Spring	30	5
Suction Pipe (Valves)	15	12

Pareto Analysis: Pareto analysis is a statistical technique in decision-making used for the selection of a limited number of tasks that produce significant overall effect. It is a type of chart that contains both bars and line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The Pareto chart was developed for the failure components with number of occurrences as shown in Figure 2. From the Figure, it was found that suction ventilator and suction pipe cause a cumulative breakdown of 55%.

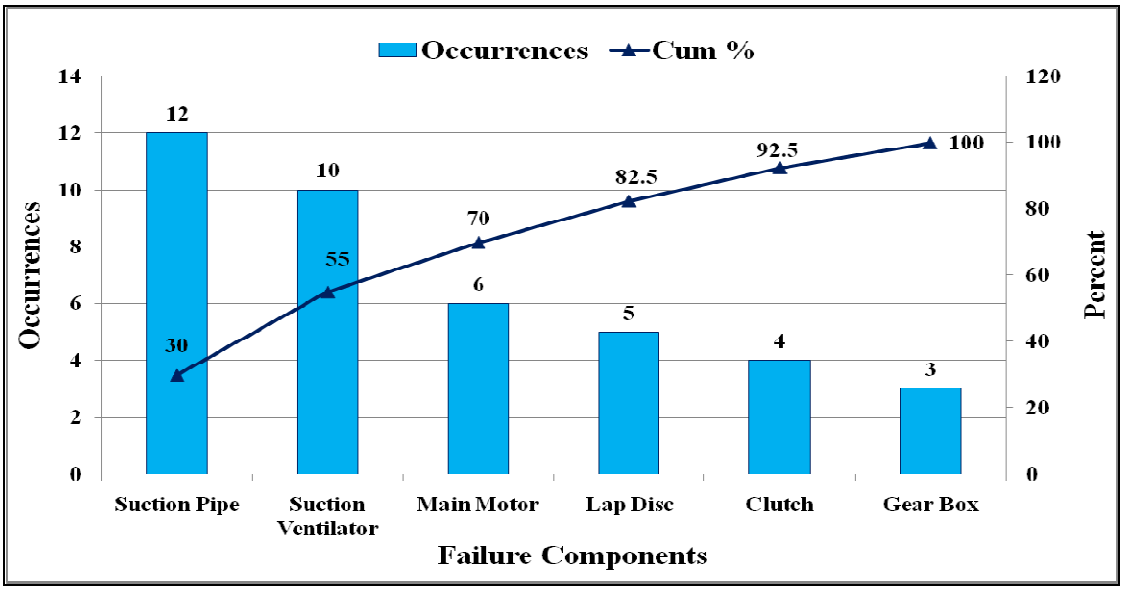

Figure 2. Pareto chart for Unilapmachine

Cause and Effect Diagram: This is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes. The cause and effect diagram for the various components with its operations are developed and as shown in Figure 3.

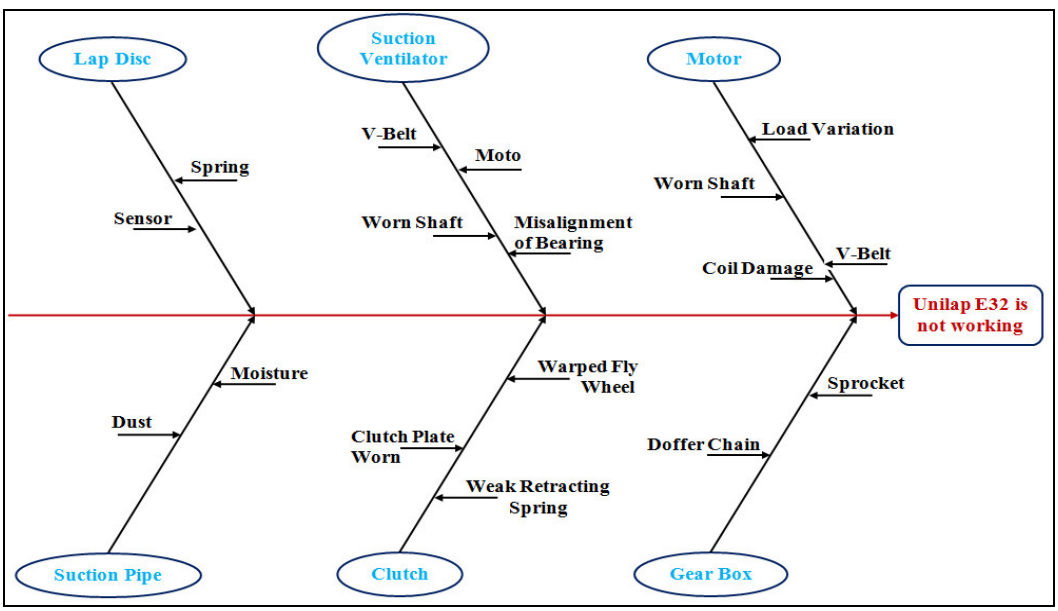

Figure 3. Cause and effect diagram for Unilapmachine E32

Availability and OEE of Unilap Machine: Availability of machine was calculated by the difference between number of working hours per shift and breakdown time of machine to the number of working hours and OEE is the product of availability, performance efficiency and rate of quality. The results of availability and OEE aregiven in Table 2.

Table 2. Availability and OEE of Unilapmachine

Components Failure	Availability (%)	OEE (%)
Main Motor		
Motor	73	41.7

V-belt	93	53.2
Suction Ventilator		
Motor (Bearing)	86	51.5
Fan (Bearing)	80	45.7
Shaft	86	51.5
V-belt	93	53.2
Gear Box		
Sprocket	73	41.7
Doffer Chain	86	51.5
Clutch (Bearing)	86	51.5
Lap Disc Spring (Sensor)	93	53.2
Suction Pipe (Valves)	97	55.5

Before Implementation of TPM Lean Tool: Availability of machines is very low before implementing TPM, due to the manufacturing firm following a breakdown maintenance schedule. Figure 4 shows the availability and OEE of Unilap machine before implementing Asset Performance Management (APM), Condition Based Maintenance (CBM) and TPM.

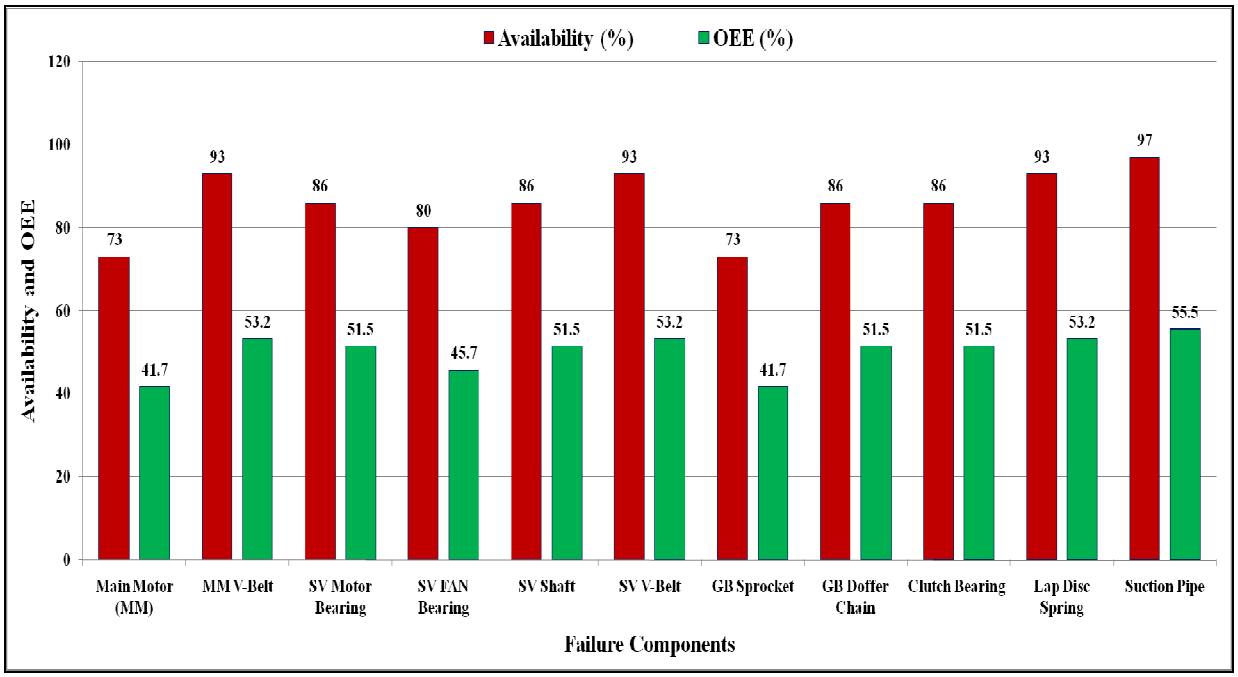

Figure 4. Availability and OEE of Unilapmachine before implementation of TPM

TPM in Process Industries: Total productive maintenance is constituted of three components such as preventive maintenance, corrective maintenance and predictive maintenance.

Preventive Maintenance: Preventive maintenance encompasses activities, including inspection and adjustments of important machine parameters cleaning and lubrication at regular interval to minimize breakdowns and ensure quality at defined level. Preventive maintenance concept had been in place in spinning industry for many years. However, preventive maintenance is a costly affair due to higher maintenance downtime and costs associated with spare parts inventories.

Condition based Maintenance: Maintenance based on condition monitoring is ideal for a spinning mill because most of the critical components (vital for quality and productivity), earmarked for planned replacement are such that, they fail gradually and progressively

To Do List: On the basis of an autonomous maintenance, checklist plays a vital role to prevent the machine breakdowns with a help of earlier inspection of machine parts and parameters. This helps in increasing the availability of machines and overall equipment effectiveness.

Comparison of Actual and Worldwide OEE of Unilap Machine: The OEE of actual selected machining process was compared with worldwide OEE and the results are shown in Figure 5.

Worldwide OEE,

Availability of machine	= 90%
Performance efficiency	= 95%
Rate of quality	= 99%
OEE	= 85 %

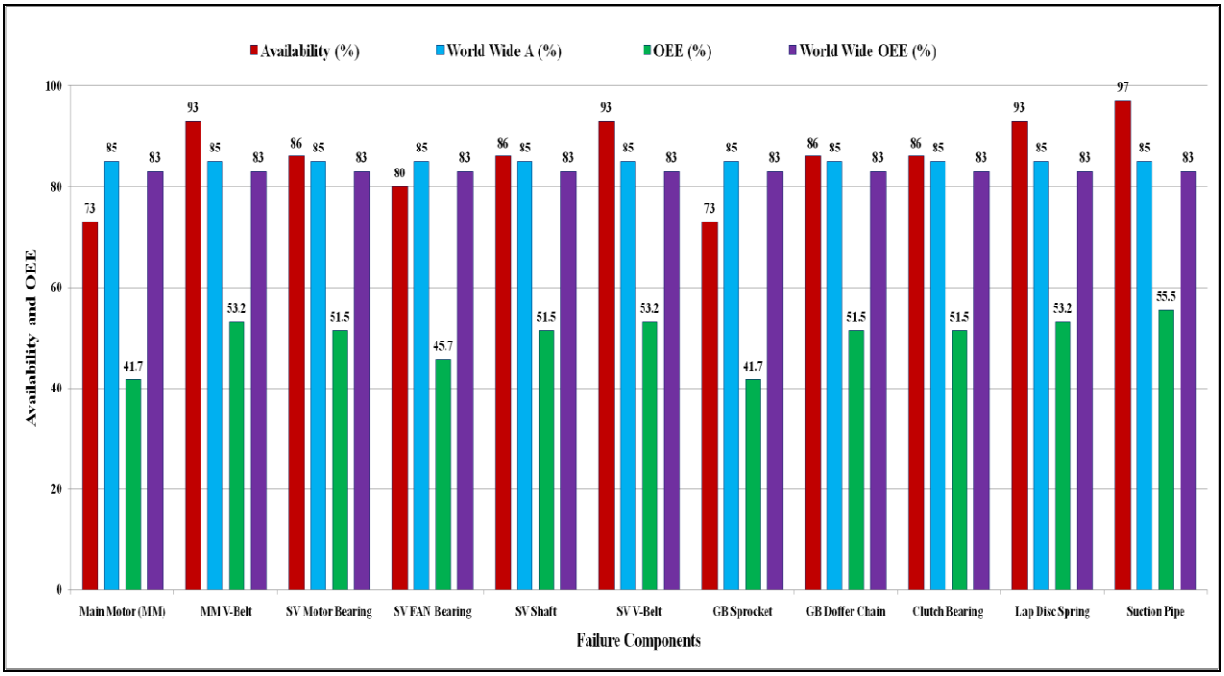

Figure 5. Comparison chart of actual and Worldwide OEE

Availability and OEE of Unilap Machine after TPM Implementation: Earlier, while comparing the scheduling activities and components responsible for Unilap machine breakdown, a complete mismatch existed between them. After TPM implementation, breakdown components were added with scheduling activities and frequency of activities were reduced. Daily checklist was introduced to reduce the machine breakdowns.After TPM implementation the OEE values for every operation was calculated similar calculation of earlier to the before implementation of TPMand given in the Figure 6. From the figure it was observed that the OEE values are increased to 53.17, 59.0, 53.17, 53.17, 53.17, 59.0, 53.17, 53.17, 53.17 and 59.0

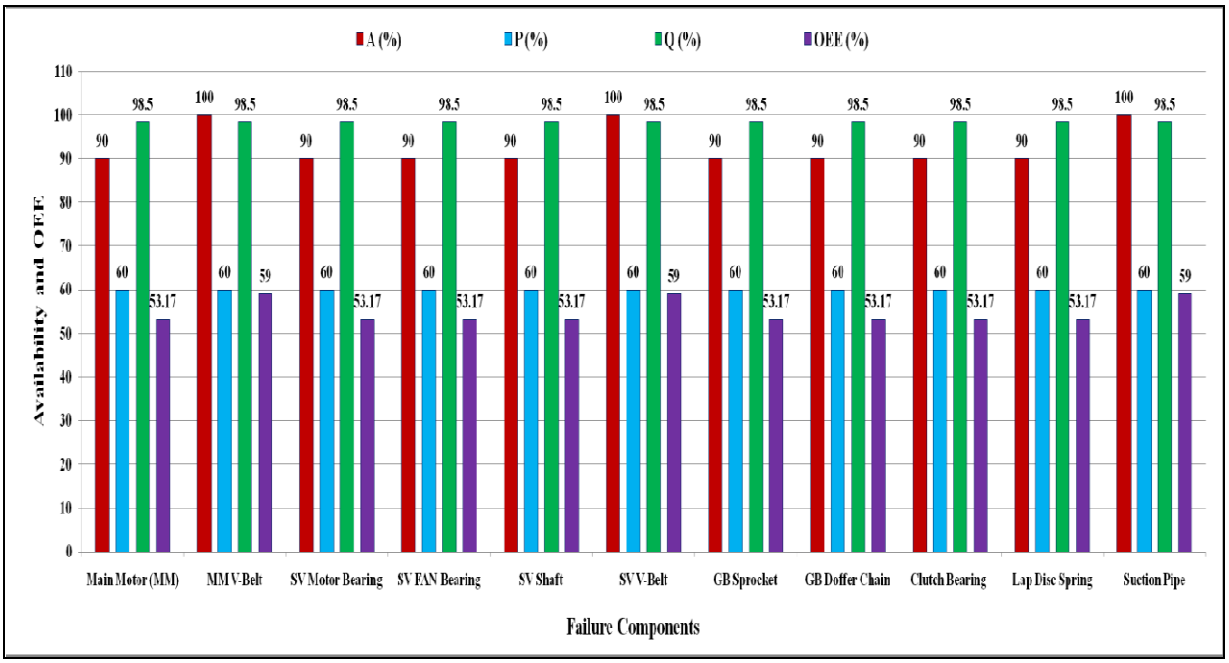

Figure 6: Availability and OEE of Unilap machine after implementation of TPM

6. Conclusion

This study was focused on evaluation and improvement of overall equipment effectiveness in a textile yarn manufacturing industry. Based on the analysis and results the following conclusions were made.

- Implementation of TPM was suggested for Unilap E32 machine in the spinning plant.
- Current values for availability and OEE for different components of the machine were calculated and tabulated.
- Based on the cause and effect analysis, the TPM lean was implemented to increase the OEE.
- After implementation of TPM, it was found that the OEE was increased between 5 to 8 % for the various components.
- Availability of the machine is also increased up to 90% and these values suggest a successful implementation of TPM in Unilap machine.

The current work was focused to find out the root causes of machine related issues and to improve the performancelevels of machines and their productivity through TPM methodology. It would bebeneficial for future projects focused toimprove the effectiveness of machines which have low OEE by implementing the TPM technique and setup time reductionby using different TPM metrics like MTBF, MTTR, etc.

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