Chapter 6

Impact Analysis of TPM on (PQCDSM) Indicators

6.1 Introduction

It had been discussed in previous chapters that TPM implementation in two wheeler automobile sector was very successful in improving organization’s competitiveness and manufacturing performance. The objective of this chapter is to highlight the significant improvements of operational efficiency regarding TPM key performance indicators known as PQCDSM. The company has successfully implemented TPM initiatives and achieved the TPM Excellence award in 2012. This implementation has made the organization globally competitive and world class manufacturing industry. It is quite important to measure each indicator because it keeps everyone involved in monitoring and improving these indicators. The objective of TPM designed cross-functional team is to work on each and every aspect of performance indicators and coming up with improvement suggestions. Every organization has to define and set targets in all areas in terms of PQCDSM by considering all losses and bottlenecks which affect the plant performance. The meaning and significance of each indicator as per TPM guidelines are explained as follows:

- **Productivity (P):** Lost production output due to material productivity, manpower productivity, and tools productivity. According to standard TPM guidelines, minimum 85% OEE must be achieved.

- **Quality (Q):** To reach zero customer complaints. This can be done by eliminating rejection/rework, by avoiding mistakes in the preparation of cheques, bills, invoices.
In broader times, it means by meeting customer expectations so that there should be no return of customer.

- **Cost (C):** To reduce the manufacturing cost by 30% by reducing operational and maintenance cost, inventory carrying cost and cost of communication, etc.

- **Delivery (D):** To deliver 100% goods on time to the customer. It can be achieved by minimizing the delay in logistic losses, delay in delivery to any of the support functions.

- **Safety (S):** To create zero accident-free zone area by ensuring safety while working on machines, safety in material handling, safety in packaging, etc.

- **Morale (M):** To boost up the employees of the organization by making them participate in contributing a number of kaizens, one point lesson (OPL). The sample of OPL is shown in Appendix X. It also includes the establishment of autonomous maintenance teams so that better communication and teamwork should be promoted.

TPM concept is highly appreciated because its benefits can be seen in both tangible and intangible. Hence, measuring TPM effectiveness is essential for keeping the organization’s TPM efforts on the track. It should be measured periodically during complete TPM development program, and the findings can further be used to work out new strategies for meeting the goals.

This chapter focuses on tangible benefits gained in terms of TPM key performance indicators PQCDSM and its implementation. It helped the selected case of industry/plant
significantly to achieve higher productivity, customer satisfaction, morale and profits besides other benefits.

6.2 Impact of TPM on various indicators

This section elaborates the impact analysis of TPM on various indicators such as productivity (P), quality (Q), cost (C), delivery (D), safety (S) and morale (M).

6.2.1 Impact of TPM on productivity

In the preceding chapters, it was clearly seen that TPM methodology is a very effective strategy for improving overall plant efficiency. The present study discussed the impact of TPM on PQCDSM indicators which were carried out in a two wheeler automobile manufacturing sector. The main objective of the presented case was to improve the overall productivity of the plant. Therefore, the autonomous maintenance groups were formed to increase the maintainability of the equipment. Secondly, the selected plant was put under observation to track OEE of the overall plant so that the massive losses could be identified and eliminated throughout the organization and office areas. Initially, OEE of TPM manager model machine in machining section was evaluated but later on slowly it was being replicated in other parts of the plant. The benefits of measuring OEE has benefitted to identify the six big losses, and focused improvement TPM cross-functional teams has contributed to eliminating these losses. 5S implementation in offices and shop floor has also played a significant role in improving the manpower productivity. It helped to motivate the employees to participate actively and contribute to production and maintenance related task so as to increase the overall productivity of the plant.
There was a massive increase in production of two wheeler over the benchmark year. The Figure 6.1 shows that in the year 2008, the average monthly production was only 78442 units but after TPM initiatives, there was an enhancement of productivity and overall production volume got increased to 232200 units in the year 2012.

![Average Monthly Production Volume Trend](image)

**Figure 6.1: Average monthly production volume trend during the period (2008-2012)**

6.2.2 Impact of TPM on quality

Quality has been considered as one of the most promising parameters for making the brand image. Customer rejections, defects, and re-work, have a significant impact on the quality indicator. It has been seen that the customer complaints were reduced significantly after the implementation of TPM initiatives. This has been achieved by regularly doing monitoring and resolving the customer oriented issues. The methodology of refining the processes from the beginning has also been carried out so that no defective items were manufactured. The Hero MotoCorp Ltd. has successfully organized the training of the employees, who were involved in quality control. The quality assurance department has emphasized the
importance of implementation of TPM in their concerned area of work, which has ultimately reduced the customer complaints and process rejection was found to be zero.

The implementation of 5S approach and office TPM pillar has automatically increased the productivity of manpower in support functions such as preparation of cheques, bills, invoices, etc which resulted in a reduction of customer complaints. It was again necessary for the selected automobile manufacturing plant to improve the overall production rate and quality of the product. To achieve this aspect, the maintainability, and reliability of the equipment by measuring OEE was considerably improved with small machine breakdown lowering and eliminating the losses and by involving the highly motivated entire workforce to increase the customer satisfaction level.

A significant improvement in customer complaints has been obtained as shown in Figure 6.2. It has been significantly reduced from benchmark 64 in 2008 to 10 by 2012. This reduction in customer complaints signifies that the quality of the product (raw material, semi-finished or finished product) has been improved subsequently during the above said period due to the promotion of TPM activities in the organization.

![Customer complaints trend](image)

Figure 6.2: Customer complaints trend during the period of (2008-2012)
6.2.3 Impact of TPM on cost

TPM has been a very successful in terms of improving operating performance of the organizations. TPM claims to have a positive influence on cost indicator. *(Feigenbaum, 1991)* Clearly indicated that a TPM program resulted in improved product quality, improved production flow, and reduction in operating expenses and losses etc. TPM also aims at continuous and long-term improvements in performance and therefore it results in improving the financial output of organizations in terms of market share and profits. *(Nakajima, 1988)* the father of TPM considered it as “profitable TPM” as decreasing the cost of maintenance provides automatic improvements in profits. *(Yamashina, 2000)* Concluded that TPM could be a primary source of profitability of manufacturing organizations. The author discussed that it is possible through efficient management of equipment, machines, and support services. It has been observed by the management of the selected automobile industry that maintenance cost has been increased by 30%-40% of the production costs and emergency repairs were very much found to be expensive. Therefore, the need of introducing an efficient TPM implementation program was felt fundamentally necessary.

The following Figure 6.3 represents the graphical representation of the cost of operations trend. This figure signifies that cost of operations in the year 2008 was 62 million and during successful implementation of TPM, the cost has been drastically reduced to 50 million. It is because all six big losses were monitored rigorously to enhance the OEE and this significantly increases the production yield in the same time span. Also, the average cost of operations came down with higher production yield with same inputs.
6.2.4 Impact of TPM on delay in delivery

Delay or inaccurate deliveries will have an adverse impact on customer satisfaction and organization brand image. The customer always expects the fast and timely delivery of their product. There are various other reasons for the delay such as delay in payments to suppliers, vendor inconsistencies, delay in information, delay in packaging, delay in the long procurement process, which ultimately caused the delay in logistics. Other contributors to delay were external delays like government inspections, customs formalities, and system failure among others.

Figure 6.4 represents the adherence delivery trend of the organization. There was a massive increase in delivery adherence from 75% to 96%. The figure shows that in the year 2008, the delivery adherence percentage was only 75% but after TPM initiatives, improvements have been made in logistics section related to loading and unloading issues, resolving the shortage of labor or raw material and transportation issues, which made it possible to increase the delivery adherence up to 96% in the year 2012.
Figure 6.4:- Delivery adherence trend during the period of (2008-2012)

6.2.5 Impact of TPM on safety

The workplace is composed of the following elements consisting Manpower, materials, and machinery. To succeed in safety, health, and environment, the most important element needed to take care is human in the workplace (Borris, 2006), (Waeyenbergh and Pintelon, 2009) and (Mcbride, 2010). The human elements are the most challenging and complicated factor. That is why equipment and materials can be made safer to a favorable extent. In this part, the human factor must be reputed in the incident prevention. Operator training must be done simultaneously along with the other training for incident prevention to be more efficient. Ensuring equipment reliability, maintainability, preventing human and eliminating accidents and pollution are the fundamental principle of TPM. That is why; safety health and environment pillar is a major component in any TPM development program. Following ways are adopted so that TPM can improve safety:
• Through the implementation of 5S concept, one can make the workplace clean, tidy and well-organized.

• Autonomous maintenance and focused improvements eliminate hazardous areas.

• Autonomous maintenance trained operators look after their equipment and are better able to detect abnormalities early and deal promptly.

• Operators take responsibility of their own health and safety.

Practicing TPM builds healthy, safe and clean working environment. Environmental cleaning, repairing, and safety are the essential manufacturing requirements. But in spite of this, there is always a possibility of plant or equipment causing accidents and pollution. In manufacturing organizations, the unfortunate incidents and accidents occur due to the following unsafe conditions such as incorrect design of workplace, inappropriate design of the equipment and tooling, lack of operator’s carelessness, damaged instruments, due to lack of effective protection shields for the equipment, lack of fire and explosion preventive system, unfavorable working conditions such as noise and air pollution (Brah & Chong, 2004), (Chan et al., 2005), (Dossenbach, 2006). Wear (corrosion) in equipment parts sometimes, cause vibration, noise, and loose fitting bolts.

Hence during the implementation of TPM, in the selected organization, it was necessary to consider the required and standard safety predictions in every stage. If all the employees use TPM with safety standards, the organization will achieve drastic development and improvements in production and safety. Following Figure 6.5 signifies the four-year trends of accidents during TPM implementation in Hero MotoCorp Ltd., which finally highlights the importance of safety and hazards control.
6.2.6 Impact of TPM on Motivation

It has been found in TPM implementation that many kaizens and absenteeism are a good indicator of employee morale. If a workforce is highly motivated and satisfied with the work culture, they are more participative and productive. If they are not motivated, they usually tend not to be productive in the organization. For encouragement and maintaining the enthusiasm with positive focus over the period, motivation is an important TPM indicator. Banners, signs, flags, notice boards, publishing TPM newsletters, putting up TPM posters at strategic locations, designing TPM slogans were displayed to create a positive environment and promote healthy workforce culture (Lazim and Ramayah, 2010). (Graisa and Al-Habaibeh, 2011) have observed that motivation awards to contributing employees and to shifts were given in the office meetings or organization events. There should be a management support system in the form of motivation and incentive compensation system that recognizes and reward employee based on merit. A good human resource management practice affects the employee motivation by encouraging them to
work both harder and smarter. Hence, highly motivated and well-trained people with skills contribute to organizational performance to achieve a high level of TPM.

Figure 6.6 represents the number of kaizens received, which indicates the overwhelming participation and well recognized during the monthly communication meeting conducted by Plant Head in the selected automobile plant. The sample of kaizen record sheet is shown in Appendix VII. During the quarterly communications gathering, consistent participants were recognized and honored in the function. The trend of absenteeism during TPM implementation was found to be in decreasing order in the Hero MotoCorp Ltd.

Figure 6.7 signifies the absenteeism trend. The downward trend of absenteeism was a result of an increase in ownership level among the associates, who were enjoying the daily routine as a unit. Another initiative by the selected plant management was the introduction of advanced leave management system which was taking care of the interest of their associates as well countering the unplanned absenteeism.

![Kaizens Trend](image)

Figure 6.6: Trend of number of kaizens received (2008-2012)
6.3 Discussions and analysis of PQCDSM indicators

TPM journey was started in Hero MotoCorp Ltd. in 2008 in an energetic and positive way with the selection of manager model machines under the guidance of Mr. Osamu Yoshioka, who was appointed as a TPM consultant by the organization. After successful implementation of autonomous maintenance on selected manager model machines, during 2009 TPM was kicked off. The outcomes and expectations out of TPM were likely to improve productivity, quality, safety and increase employees and customer satisfaction.

The equipment breakdowns and defects were minimized resulting improvement in productivity. There is a relationship between input and output in a manufacturing environment. Input variables consist of labor, material, and machines, while output comprises “PQCDSM” (Nakajima, 1988). The present study reveals the measurement and analysis of TPM effectiveness in terms of Productivity (P), Quality (Q), Cost (C), Delivery (D), Safety (S) and Morale (M) indicators i.e. “PQCDSM”. It has been observed that...
successful implementation of TPM initiatives can be rationally actualized in selected automobile plant through a complete cultural change and a strong commitment by the top management. The tangible benefits gained from each indicator are very much significant and helpful to understand the impact of TPM on the organization. The real life improvement in TPM effectiveness indicators (PQCDSM) highlights the positive impact of TPM implementation in the automobile industry.

The results have been discussed concerning tangible benefits under each category of the indicator. It has been shown in Figure 6.1 that the benchmark of monthly production volume in 2008, which was found to be 78442 units and after implementation of TPM initiatives, the production got increased to 232200 units in the year 2012. It has been evident from Figure 6.2 concludes that the customer complaints have been reduced to one tenth against zero complaints. Moreover, the operational cost has been drastically reduced as considerably from 62 million in 2008 to 50 million in 2012 as shown in Figure 6.3. All other factors such as delivery rate, no. of accidents and improvements in no. of kaizens have been improved significantly as depicted from Figures 6.4, 6.5, 6.6 and 6.7. Table 6.1 illustrates the improvements in key performance indicators (PQCDSM) after the successful implementation of TPM in Hero MotoCorp Ltd. It has been proved finally, that TPM helped the organization significantly to gain and achieve high productivity, morale, customer satisfaction and profits.
Table 6.1: Benchmark and targets of TPM performance indicators (PQCDSM)

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<tr>
<td>Productivity (P)</td>
<td>OEE</td>
<td>%</td>
<td>63%</td>
<td>70%</td>
<td>75%</td>
<td>80%</td>
<td>85%</td>
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<td>Quality (Q)</td>
<td>Customer complaint</td>
<td>Nos.</td>
<td>64 Nos.</td>
<td>45</td>
<td>30</td>
<td>20</td>
<td>Zero</td>
<td>10</td>
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<tr>
<td>Cost (C)</td>
<td>Cost of operations</td>
<td>Million rupees</td>
<td>62</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Delay in delivery (D)</td>
<td>Delivery Adherence trend</td>
<td>%</td>
<td>75%</td>
<td>85%</td>
<td>95%</td>
<td>100%</td>
<td>100%</td>
<td>96%</td>
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<tr>
<td>Safety (S)</td>
<td>No. of Accidents</td>
<td>Nos.</td>
<td>2</td>
<td>Zero</td>
<td>Zero</td>
<td>Zero</td>
<td>Zero</td>
<td>Zero</td>
</tr>
<tr>
<td>Morale (M)</td>
<td>No. of Kaizens</td>
<td>Nos.</td>
<td>320</td>
<td>2000</td>
<td>4000</td>
<td>5500</td>
<td>6500</td>
<td>6042</td>
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6.4 Summary of the chapter

TPM strives to achieve overall plant efficiency by maximizing output regarding (PQCDSM) by minimizing input (*Nakajima, 1988*). As illustrated in Figures (6.1-6.7) and results discussed in above section, there were significant improvements in productivity, quality, cost, delivery, safety and morale indicators under “PQCDSM”.
With the successful implementation of TPM, the chosen automobile plant has finally achieved reduce downtime of machines, increase production, a decrease in re-work, rejection and increase motivational parameter among the entire workforce, which automatically resulted in excellence quality of products. TPM methodology not only enhances the effectiveness of the manufacturing system but also increases the efficiency of the entire organization through mandatory participation and continuously improvement in TPM key performance indicators.

The conclusions, recommendation, and scope for future work are finally summarized in the next chapter.
Chapter 7

Conclusions, Recommendations and Scope for Future Work

7.1 Introduction

The primary motivation for the thesis was to study the implementation of TPM in a flexible manufacturing environment within the context of Indian industries. The findings have indicated that total productive maintenance (TPM) not only leads to increasing efficiency and effectiveness of manufacturing systems, measured in terms of OEE index and PQCDSM indicators but also prepared the plant to meet the challenges put forward by globally competing for economies to achieve world class manufacturing (WCM) status. The study has dealt with the examination and needs analysis of maintenance practice such as TPM in a flexible manufacturing environment, which not only increased the overall maintainability and reliability of the equipment in the semi-automated cell but also reduced the operational and maintenance cost. The industry selected for the present research work was country’s largest manufacturer of motorbikes (Hero MotoCorp Ltd.,) by explaining the preparedness and initiatives taken for TPM in a flexible manufacturing environment. The management of the organization felt that the maintenance costs were 30-40 percent higher than the production costs and also emergency repairs were more expensive if the same job was done in a pre-planned manner. Hence, TPM practice was felt necessary to implement in two wheeler automobile industry. It is assumed that the management of selected automobile two wheeler plant wished to adopt the total productive maintenance philosophy as part of their future strategic objectives. The study has illustrated the improvement of office efficiency through the implementation of 5S technique in selected office zone areas.