

# Implementation of Total Productive Maintenance for Reducing Losses and Improving Productivity of Slotting and Honing Machine

Thorat Swapnil V<sup>1</sup>, Patil Rajkumar<sup>2</sup>

<sup>1</sup>Shivaji University, Government College of Engineering Karad, Vidyanagar, Karad, Satara, Maharashtra, India, 412124

<sup>2</sup>Government college of Engineering and Research Avasari, Pune University, Avasari (Kd), Tal- Ambegaon, Dist-Pune, 412405

**Abstract:** Every company emphasizes on productivity of the company which is measure of the rate at which outputs of goods and services are produced per unit of input (labour, capital, raw materials, etc.). productivity is used to find out the efficiency of the firm or industry. Hence there is need to adopt such technique which increases the efficiency of production. TPM is a tool which improves manufacturing efficiency. The TPM program is adopted in industry not only to increase the productivity but to increase the quality of product also. TPM affects on manufacturing processes along with the employee morale and job satisfaction. This paper emphasizes on effect of TPM on efficacy of slotting and honing machine. The research was carried in machining division of company. Concept is implemented in the machine shop having CNC machines, honing machines of different capacity. And its effect on overall equipment effectiveness is calculated. As overall equipment effectiveness (OEE) gives us performance, availability and quality efficiencies. The losses associated with equipment effectiveness are identified. Pillars of TPM are implemented and its effect pillarwise is observed. There was much increase in availability, performance and quality efficiencies of machines, with the reduction in losses.

**Keywords:** TPM, OEE, Quality, Availability, Performance

## 1. Introduction

Tremendous improvements have occurred in the maintenance management of physical assets of company and production systems; thus, less wastages of resources and energy occur. The requirement for optimal preventive maintenance, using, for instance, just-in-time (JIT) and total quality-management (TQM) techniques, has given rise to what has been called the total productive-maintenance (TPM) approach. Maintenance is undertaken for preserving the proper functioning of a mechanical system, so that it will serves its function. Its function and performance characteristics not only take account of output, unit costs and effectiveness of using energy, but also such factors as end-product quality, process control, achieved comfort and protection of the employed personnel, compliance with environmental-protection regulations, structural integrity and even the physical appearance of the productive system. The quality of maintenance significantly affects profit of any firm. Increased downtime affects adversely the process capability of any machines by reducing their average rate of output, so it increases the operating costs and lower the average customer's satisfaction with the service.

Today's world is one of growing expectations, increasingly onerous regulatory constraints, shifting technological paradigms and apparently endless and urgent reorganizations. Just as each major corporation has evolved a mission statement to help maintain a unified approach despite varying distractions, it is also desirable to develop a mission philosophy and statement to help maintenance staff do likewise. Maintenance serves three distinct sets: - the owners, the users of the system, and society as a whole. Owners are usually satisfied if their system generates an adequate and continuing financial return on their capital investment. Users

want each asset to continue to do whatever it was designed to do, to a standard of performance, which they consider at least to be satisfactory. Society expect the assets, in which investments have been made, not to fail in ways that lead to threats to public health and safety as well as the environment. TPM focuses on optimizing, planning and scheduling. Availability, performance and yield (i.e. acceptable quality-rate) are other factors that affect productivity. Availability losses result from breakdowns and change-overs, Performance deteriorations arise from speed losses and small stops or idling or empty positions. In this case, the line may be running, but it is not producing the quantity it should. Yield losses consist of losses due to rejects and poor start-up behaviour in the line producing the products. These losses lead to low values of the overall equipment's effectiveness (OEE), which provides an indication of how successful the production process is. TPM helps to raise the value of the OEE by supplying a structure to facilitate the assessment of those losses, and subsequently giving priority to dealing with the more serious offenders. Application of TPM leads to both short- and long-term improvements.

## 2. Case Study: Application of Developed Model

**Table 1:** Abnormalities Identified

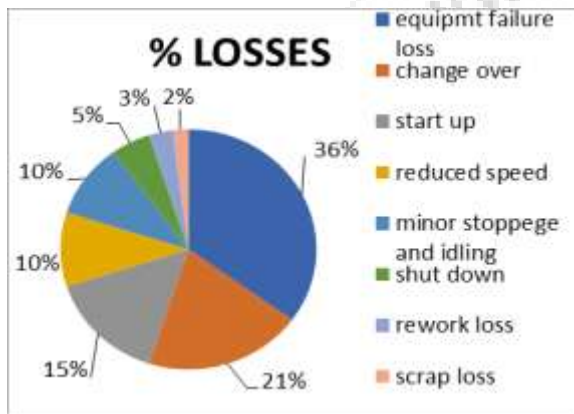
S. No.	Description of Abnormalities found on Slotting Machine
1	Accumulations of chips of machining
2	Loose control cables
3	Low production capacity
4	Oil leaking
5	Too many hand gloves found on machine

**Table 2:** Description of Abnormalities

S. No.	Description of Abnormalities found on Honing Machine
1	Insufficient supply of Honing oil
2	Variations in stroke length of honing spindle
3	Variations in spindle speed
4	Variations in cycle time
5	Erratic linear speed of honing spindle
6	No safety guard available
7	Too many hand gloves found on machine
8	Jamming of drain pipe due to accumulation of machining burr.

### 3. Stratification of losses of Slotting machine

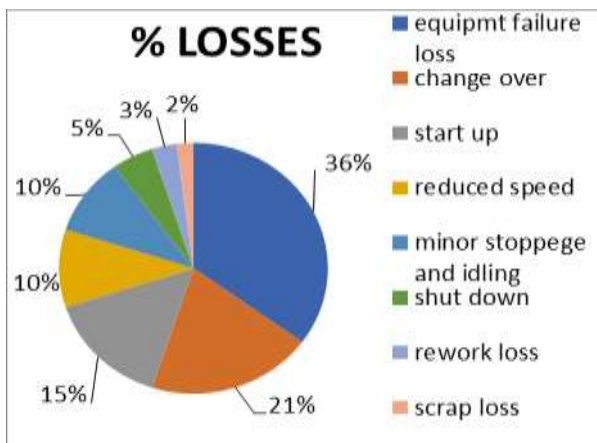
Stratification of all losses is done for getting the clear idea of contribution of each type of losses for equipment abnormal performance. Fig. shows the stratification of all the losses. Out of all these losses the failure loss is main loss. It comprises 36% of total loss, change over loss is 21%, Set up loss is 15%, reduced speed loss is 10%, minor stoppage loss is 10%, shut down loss is 5%, rework loss is 3%, scrap loss is 2%.



**Figure 1:** Stratification of losses for Slotting Machine

### 4. Stratification of losses of Honing machine

Fig. shows the stratification of all the losses. Out of all these losses the failure loss is main loss. It comprises 36% of total loss, change over loss is 21%, Set up loss is 15%, reduced speed loss is 10%, minor stoppage loss is 10%, shut down loss is 5%, rework loss is 3%, scrap loss is 2%.



**Figure 2:** Stratification of losses of Honing Machine

### 5. Pillars of TPM

The various pillars of TPM are

- 1) Focused Improvement /Kobetsu Kaizen.
- 2) Autonomous Maintenance / Jishu Hozen.
- 3) Planned Maintenance.
- 4) Quality Maintenance.
- 5) Education and Training.
- 6) Development management
- 7) Office TPM.
- 8) Safety, Health and Environment.

Out of these eight pillars we will cover first three pillars for dissertation work. These three pillars are Focused Improvement /Kobetsu Kaizen, Autonomous Maintenance / Jishu Hozen, planned maintenance, quality maintenance. These pillars are selected because they are more useful in eliminating various abnormalities that causes losses. These losses are responsible for low performance of equipment effectiveness. Table shows the classification of all losses, which are contributing in the less availability, performance efficiency and rate of quality products are as follows:

**Table 3:** Classification of all losses which affect on OEE

Factors	Losses	Pillars
Rate of availability	Equipment failure	Planned maintenance
	Change and set up	Jishu hozen
	Tool change	Kobetsu kaizen
	Start up loss	Kobetsu kaizen
Rate performance efficiency	Unavailability of man	Education and training
	Minor stoppage	Kobetsu kaizen
Rate of quality products	Reduced speed	Kobetsu kaizen/ Planned maintenance
	Scrap	Quality maintenance
	rework	Quality maintenance

### 6. Results and Discussion

The objective of this work is to see effectiveness of TPM concept. The result reveals that TPM has positive influence on various manufacturing factors such as productivity quality, cost, delivery, safety and moral. It helps in reducing various losses.

#### A. Impact of TPM on various losses

##### 1) Equipment Failure Loss

Figure 4.1 shows the reduction in equipment failure loss for both machines. Before implementation i.e. in the last period equipment failure loss of honing was 3100 minutes. This is reduced to 2380, 2200, 1670, 830, 520, 120 minutes. For slotting machine failure loss of honing was 590 minutes. This is reduced to 520, 450, 310, 160, 30, 60 minutes. For both machines Equipment failure loss is zero at the end of last month of 2016 (after implementation).



**Figure 3:** Reduction of Equipment failure loss

**2) Change and Setup cost**

Figure shows the reduction in the changes and set up loss for both machines. Before implementation i.e. in the first period change and set up loss for honing machine was 560 minutes. This is reduced to 540, 510, 480, 445, 435 Minutes. Change and set up loss is reduced to 430 Minutes at the end of april 2016. For Slotting machine was 540 minutes. This is reduced to 430, 420, 405, 350, 230, 215 Minutes. Change and set up loss is reduced to 190 Minutes at the end of april 2016. ( after implementation ).



**Figure 4:** Reduction of Change and set up cost

**3) Minor Stoppage**

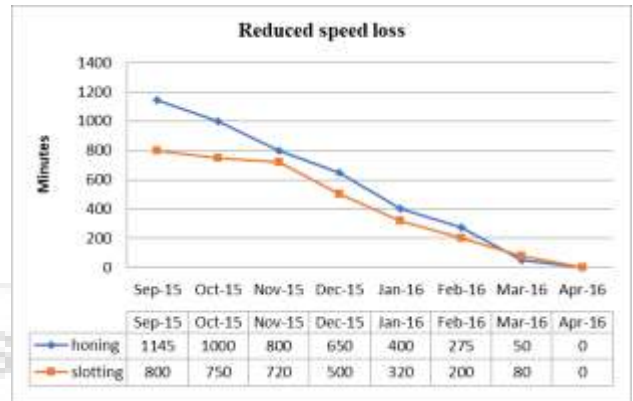
Figure shows the reduction in minor stoppage loss for both machines. before implementation implementation i.e. in the first period change and set up loss for honing machine was 1500 minutes. This is reduced to 1380, 1100, 800, 640, 400, 320 Minutes. minor stoppage loss is reduced to 200 Minutes at the end of april 2016. For slotting machine was 1048 minutes. This is reduced to 915, 800, 695, 422, 290, 250 Minutes. minor stoppage loss is reduced to 152 Minutes at the end of april 2016 (after implementation).



**Figure 5:** Reduction of Minor stoppage

**4) Reduced Speed Loss**

Figure shows the reduction in reduced speed loss for both machines. before implementation implementation i.e. in the first period change and set up loss for honing machine was 1145 minutes. This is reduced to 1000, 800, 650, 400, 275, 50 Minutes. For slotting machine was 800 minutes. This is reduced to 750, 500, 320, 200, 80, Minutes. For both machines Change and set up loss is reduced to zero Minutes at the end of april of 2016 (after implementation).



**Figure 6:** Reduction of Speed loss

**5) Scrap/Waste**

Figure 4.5 shows the reduction scrap/waste loss. before implementation implementation i.e. in the first period change and set up loss for honing machine was 180 bodies. This is reduced to 175, 150, 100, 80, 50, Bodies. scrap/waste loss is reduced to 5 Bodies at the end of april of 2016. For Slotting machine was 130 bodies. This is reduced to 120, 80, 60, 40, 35, 21 Bodies. scrap/waste loss is reduced to 11 Bodies at the end of april of 2016 ( after implementation ).



**Figure 7:** Reduction of Scrap

**B. Effect of TPM on Manufacturing Performance**

**1) Production**

Figure shows the improvement in the productivity in each period. Before implementation i.e. first period total output of honing machine was 9052 Bodies Machined. It is increased to 9752, 10787, 12012, 14052, 16725, 17645 in next periods. Productivity is improved to 18377 Bodies Machined at the end of period of April 2016. For slotting machine was 5360 Bodies Machined. It is increased to 5780, 6360, 6445, 7180, 7440, 7566 in next periods. Productivity is improved to 7720 Bodies Machined at the end of period of April 2016 ( after implementation).

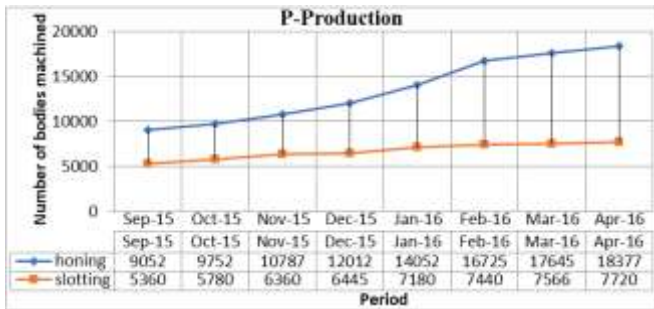


Figure 7: Increase in Production

2) Process capability

Figure shows the improvement in the process capability in each period. Before implementation i.e. first period process capability of honing machine was 0.33. It is increased to 0.4, 0.7, 0.9, 1.3, 1.7, 2.1 in next periods. Process capability is improved to 2.3 at the end of period of April 2016. For slotting machine was 1.1. It is increased to 1.15, 1.26, 1.33, 1.6, 1.7, 2.2 in next periods. Process capability is improved to 2.3 at the end of period of April 2016. (after implementation)



Figure 8: Improvement in Process Capability

3) Rework

Figure shows the reduction rework loss. Before implementation i.e. in the first period rework loss for honing machine was 330 bodies. This is reduced to 272, 248, 221, 204, 134, 56 bodies. Rework loss is reduced to 20 bodies at the end of period of April 2016. For slotting machine was 201 bodies. This is reduced to 177, 146, 112, 56, 29, bodies. Rework loss is reduced to 10 bodies at the end of period of April 2016 (after implementation).

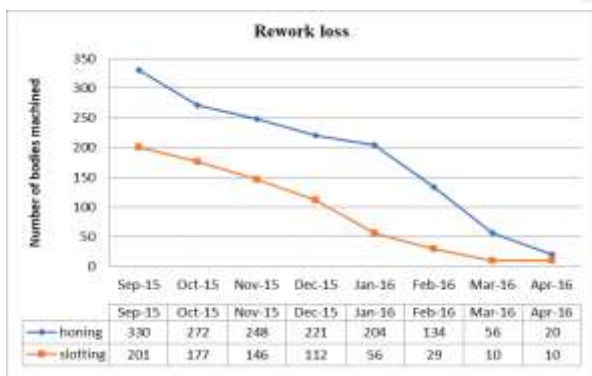


Figure 9: Reduction in Rework

4) Cost Reduced

Figure shows the reduction maintenance cost. Before implementation i.e. in the first period maintenance cost of honing machine was RS 30,000/- bodies. This is reduced to 28000, 26865, 21090, 18550, 16250, 14140, 12000 at the end of period of April 2016 (after implementation)

This is reduced to 25000, 21,000. maintenance cost is reduced to 12000 at the end of period of April 2016. For slotting machine was RS 28845/- bodies. This is reduced to 24566, 20359, 18645, 14896, 12899, 11322, 10256 at the end of period of April 2016 (after implementation)

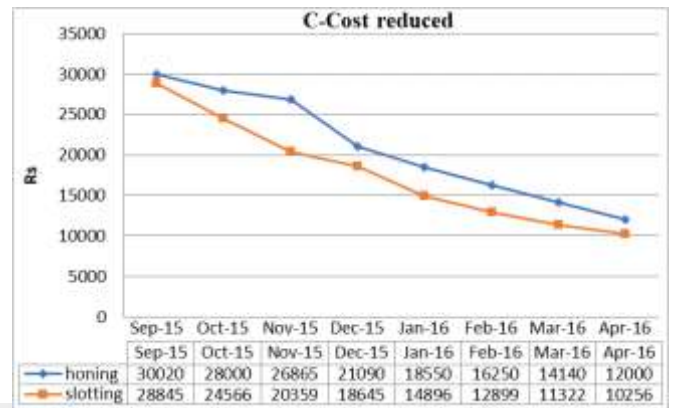


Figure 10: Cost Reduced

5) Man days lost

Figure shows the man day lost due to accidents in the plant. Before implementation i.e. in the first period for both machines day lost due to accidents was 2 days. This is reduced to zero at the end of period of April 2016 (after implementation).

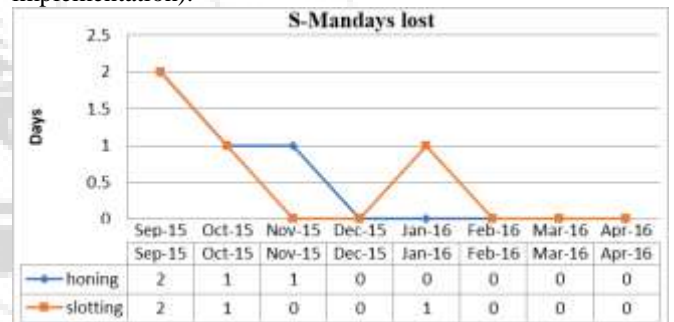


Figure 11: Man days lost

6) Morale Increment

Figure shows the improvement in the morale in each period. i.e. the improvement in no of employee suggestions. Before implementation i.e. first period total in no of employee suggestions was 3. It is increased to 5, 8, 12 in next periods. No of employee suggestions is improved to 15 for honing operator and 8 for slotting operator, at the end of period of April 2016 (after implementation).

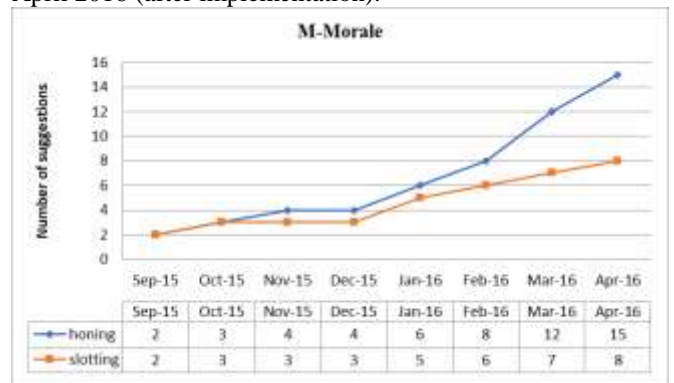


Figure 12: Increase in morale

### C. Discussions

There is 100% reduction in equipment failure achieved through TPM for both machines at the last period i.e. April 2016. Equipment failure loss is reduced to zero percent at the end of last period. i.e. after completion of TPM. Change and set up lost is reduced to 50% and 48% for slotting and honing machines through TPM. Minor stoppage loss is reduced to 65% and 70% for slotting and honing machines at the end of April 2016. Hundred percent reduction is achieved in speed loss through TPM. Workers skill gets improved with the improvement in the numbers of suggestions from the workers. For slotting machine two times and for honing machine four times improvement observed in workers suggestions. Before implementation i.e. in the last period equipment failure loss of honing was 3100 minutes. This is reduced to 2380, 2200, 1670, 830, 520, 120 minutes. For slotting machine failure loss of honing was 590 minutes. This is reduced to 520, 450, 310, 160, 30, 60 minutes. For both machines Equipment failure loss is zero at the end of last month of 2016.

Total output of both machines gets increased. Before implementation i.e. first period total output of honing machine was 9052 Bodies Machined. It is increased to 9752, 10787, 12012, 14052, 16725, 17645 in next periods. Productivity is improved to 18377 Bodies Machined at the end of period of April 2016. For slotting machine was 5360 Bodies Machined. It is increased to 5780, 6360, 6445, 7180, 7440, 7566 in next periods. Productivity is improved to 7720 Bodies Machined at the end of period of April 2016.

Accidents of both machines gets reduced. Before implementation i.e. in the first period for both machines day lost due to accidents was 2 days. This is reduced to zero at the end of period of April 2016. Before implementation i.e. in the first period rework loss for honing machine was 330 bodies. This is reduced to 272, 248, 221, 204, 134, 56 bodies. Rework loss is reduced to 20 bodies at the end of period of April 2016. For slotting machine was 201 bodies. This is reduced to 177, 146, 112, 56, 29, bodies. Rework loss is reduced to 10 bodies at the end of period of April 2016

Process capability of machine is improved. Before implementation i.e. first period process capability of honing machine was 0.33. It is increased to 0.4, 0.7, 0.9, 1.3, 1.7, 2.1 in next periods. Process capability is improved to 2.3 at the end of period of April 2016. For slotting machine was 1.1. It is increased to 1.15, 1.26, 1.33, 1.6, 1.7, 2.2 in next periods. Process capability is improved to 2.3 at the end of period of April 2016.

## 7. Conclusion

### A. Introduction

The main TPM activities have been implemented on the model machine. There is improvement seen in the rate of availability, rate of performance efficiency, rate of quality products. These three factors helps in improving overall equipment effectiveness. Productivity, quality, morale,

delivery and safety is gets improved with reduction in maintenance cost, equipment losses are also reduced.

### B. Conclusions

- 1) Productivity of slotting and honing machine is improved by 45% & 51% respectively. Quality of products also gets improved with reduction in scrape and rework also reduction in customers complaints.
- 2) Rework for slotting and honing is reduced by 78% & 80% respectively, and Maintenance cost is reduced by 50% & 48% respectively. There are zero accidents.
- 3) Workers skill gets improved with the improvement in the numbers of suggestions from the workers from 2 to 15 for slotting machine and from 2 to 8 for honing machine.

## References

- [1] A. Bonaccorsi, "On the Relationship between Firm Size and Export Intensity," *Journal of International Business Studies*, XXIII (4), pp. 605-635, 1992. (journal style)
- [2] R. Caves, *Multinational Enterprise and Economic Analysis*, Cambridge University Press, Cambridge, 1982. (book style)
- [3] M. Clerc, "The Swarm and the Queen: Towards a Deterministic and Adaptive Particle Swarm Optimization," In *Proceedings of the IEEE Congress on Evolutionary Computation (CEC)*, pp. 1951-1957, 1999. (conference style)
- [4] H.H. Crockell, "Specialization and International Competitiveness," in *Managing the Multinational Subsidiary*, H. Etemad and L. S. Sulude (eds.), Croom-Helm, London, 1986. (book chapter style)
- [5] K. Deb, S. Agrawal, A. Pratab, T. Meyarivan, "A Fast Elitist Non-dominated Sorting Genetic Algorithms for Multiobjective Optimization: NSGA II," *KanGAL report 200001*, Indian Institute of Technology, Kanpur, India, 2000. (technical report style)
- [6] J. Gerald, "Sega Ends Production of Dreamcast," *vnunet.com*, para. 2, Jan. 31, 2001. [Online]. Available: <http://nl1.vnunet.com/news/1116995>. [Accessed: Sept. 12, 2004]. (General Internet site)

## Author Profile



**Mr. Swapnil Thorat** has done his ME in Mechanical-Production Engineering from Government College of Engineering Karad in 2016. Presently he is working at same college as a lecturer.



**Mr. Rajkumar Patil** has completed his B.E. in Mechanical Engineering from Government College of Engineering and Research Avasari, affiliated to Pune University.