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Improving Equipment Effectiveness Through TPM

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Abstract: In the present high stress, turbulent business environment well run organizations strive to continually to enhance their capabilities to create excellent value for the customers by improving the cost effectiveness of the operations. Maintenance is thus a vital support function in business, especially increasingly large investments are being required in physical assets. 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 behavior in the line producing the products. These losses leads to low values of the Overal Equipment's Effectiveness (OEE) which provides a n indication of how effective 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. An application of TPM leads to both short and long term improvements. TPM seeks to encourage the setting of ambitious, but attainable goals for raising the value of the OEE and to measure any deviation in what is achieved relative to the original objective.

Key words: TPM, team working, early equipment management, planned maintanance, autonomous maintanance, training, OEE

INTRODUCTION

TPM: A dynamic, profit oriented approach to plant and equipment management, Total Productive Maintenance (TPM) combines the principles of preventive and predictive maintenance with management strategies, that increase profitability and return on assets through employees participation. TPM is a quality focused approach for asset management.

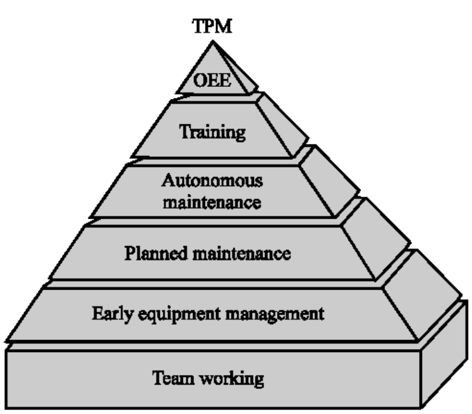

Plate 1: Schematic layout of TPM

Schematic layout of TPM: TPM is a proven and successful procedure for introducing maintenance considerations into organizational activities. It involves operational and maintenance staff working together as a team to reduce wastage, minimizes downtime and improve end product quality. It needs active well focused maintenance staff, even when the system is perceived to be working as expected. TPM builds on the concepts of Just In Time (JIT), lean management, Total Quality Management (TQM) and design to achieve minimum life cycle cost Plate 1.

TEAM WORK

Teamwork is the concept of people working together cooperatively, as in a singing group (e.g., Beatles). Projects often require that people work together to accomplish a common goal; therefore, teamwork is an important factor in most organizations. Effective collaborative skills are necessary to work well in a team environment. Many businesses attempt to enhance their employees' collaborative efforts through workshops and cross-training to help people effectively work together and accomplish shared goals.

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EARLY EQUIPMENT MANAGEMENT

Good equipment management techniques improve the use of capital assets and extend their life cycle. The objective is to maximize a company's total investment in equipment. This is accomplished by ensuring that individuals and group understand their role in equipment management. So that they know their activities improve total life cycle of the equipment. Traditionally, the equipment management function is divided in to following phases such as specifications, procurement, startup or commissioning, operation, disposal etc.,

PLANNED MAINTENANCE

Planned maintenance increases profits! The primary objective for any business is to produce profits for the owner. Profit oriented goals apply to an elderly couple operating a corner grocery store, as well as to large corporations. Even maintenance consulting firms have to operate at a profit. Maintenance control in a mine, fleet or plant can increase profits in two ways:

Increased production: Reduction of wasteful or unnecessary downtime increases production, thereby increasing profits.

Reduced costs: Higher productivity, method improvements or material changes can reduce maintenance costs, thereby increasing profits.

AUTONOMOUS MAINTENANCE

Autonomous Maintenance is a critical first step of TPM and operators must be trained to close the gap between them and the maintenance staff, making it easier for both to work as one team.

Autonomous maintenance is an especially important pillar of Total Productive Maintenance (TPM) because it enlists the intelligence and skills of the people who are most familiar with factory machines-- equipment operators. Operators learn the maintenance skills they need to know through a seven-step autonomous maintenance program:

- Initial cleaning.
- Countermeasures to sources of contamination.
- Cleaning and lubricating standards.
- Overall inspection.
- Autonomous maintenance standards.
- Process quality assurance.
- Autonomous supervision.

TRAINING

The term training refers to the acquisition of knowledge, skills and competencies as a result of the teaching of vocational or practical skills and knowledge that relate to specific useful competencies.

Kriss Precision Engineering is a strategic business unit and this unit produces jobs such as jigs and fixtures, dies and tools for assemblies of various components which are entirely based on job orders. The manager heads the unit and it has the following key performance areas (Hartmann, 1992) as follows:

- Production development.
- Quality department.
- Maintenance department.
- Supply department.

The unit has the CNC machines and special purpose machines and the unit was alienated in to cells. Each cell consists of two vertical turning centers, one horizontal turning centre, one vertical milling centre and one washing machine.

The following are identified (Tsang and Chan, 2000) to implement the TPM activities:

- Identify VW cell for demonstration
- Constitute a team comprising of manager, circle leader and members from production, quality and maintenance including operators.
- Committee with the circle leader as a chairperson
- Collect data to evaluate the overall equipment effectiveness.
- Set targets to improve the OEE by identifying and improving 6 losses.
- To create TPM awareness among operators.
- To provide training, If required on basic machine cleaning and inspection.
- Introduce autonomous maintenance by the operator
- Create and establish 5S awareness.
- Implement these activities in the other machines in the cells identified subsequently.

It was decided to implement TPM activities in the VW cell machines in the first phase and subsequently impellent parallel in the other machines with the learning.

Reasons for selection of the model cell:

- Oldest cell in the unit.
- Lowest output.
- Scrap is 1.7% in this product.

- Unsafe because of 100% air cleaning in all machines
- Lesser cycle time when compare top the other product.

To understand the current levels of performance, it was planned to calculate the OEE (Campbell and Andrew). In view of this the following data for the last 4 months was calculated and analyzed.

- Breakdown time.
- Setting time.
- Tool change time.
- No operator time.
- Now power time.
- No job time.
- No air time.

The above data for the last 4 months machine wise are given in the Table 1 and 2.

Availability: Using the breakdown, setup and tool change occurs and the percentage availability was calculated.

Availability (%) = Actual running time/planned cell production time.

Performance rate: To calculate the performance rate, the theoretical cycle time needs to be calculated. The theoretical cycle time was calculated for all the jobs run in the machine unit last four months.

Performance% = Pieces produced/the theoretical cell production rate.

The total cycle time consists of the following elements namely:

- Rapid forward time.
- Cutting time.
- Dwell time.
- Rapid time.
- Shuttle time.

The sum of all the above gives the standard cycle time under optimal conditions. Further to calculate the performance ratio, the output details in both the shifts were collected and the quantity of each part was multiplied by is optimal cycle and this was summed up for all parts to get the actual time required for production. The ratio of value to the operating time gives the availability. The production output details month wise for all the machines in the VW cell are summarized in the Table 2.

Table 1a: Down time details from Dec 07-Mar 08 for VTC 1

Month/losses	Dec	Jan	Feb	Mar
Equipment failure	40	91	92	135
Tool change	7	8	12	6
No operator	15	10	0	0
No power	22	10	12.5	8
No air	20	5	0	15

Table 1b: Down time details from Dec 07-Mar 08 for VTC 2

Month/losses	Dec	Jan	Feb	Mar
Equipment failure	90	258	34	46
Tool change	8	4	8	8
No operator	15	0	0	0
No power	26	7	8	1
No air	20	0	0	15

Table 2a: Output data with operating and cycle time Dec 07-Mar 08 for VTC 1

	Dec	Jan	Feb	Mar
Production/month (no's)	6715.00	8218	5076	8429
Operating time(min)	16041.00	19316	12435	20083
Cycle time (min)	2.28			

Table 2b: Output data with operating and cycle time Dec 07-Mar 08 for VTC 2

	Dec	Jan	Feb	Mar
Production/month (no's)	6999.00	2112	4068	5313
Operating time (min)	16543.00	4993	9758	12593
Cycle time (min)	2.28			

Table 3a: Quality rate and rate details from Dec 07-Mar 08 for VTC 1

	Dec	Jan	Feb	Mar
Quality rate	98.9	99.1	98.36	99.3
Scrap	74	74	83	64

Table 3b: Quality rate and rate details from Dec 07-Mar 08 for VTC 2

	Dec	Jan	Feb	Mar
Quality rate	99	99	99	99
Scrap	86	18	51	46

Quality rate: From the data available it was found that the quality rate is 96%. The quality rate and the scrap details are summarized in the Table 3.

Quality (%) = Good pieces/total pieces made

OVERALL EQUIPMENT EFFECTIVENESS (OEE)

It is a measure comparing how well manufacturing equipment is running compared to the ideal plant. The resulting measurement is expressed as the ratio of the actual output of the equipment divided by the maximum possible output of the equipment under ideal conditions. OEE is calculated by multiplying three independently measured values: Availability, Performance Rate and Quality Rate. In other words, OEE takes an holistic view of all losses that impact on equipment performance: not being available when needed; not running at the ideal rate and not producing first pass A1 quality output. Typical losses include:

Table 4a: Computation sheet with out shutdown and line organization losses Dec 07 – Mar 08 for VTC 1

	Dec	Jan	Feb	Mar
Operating time	16041.00	19316.00	12435.00	20086.00
Loading time	17032.00	21354.00	18124.00	21819.00
Down time	991.00	2038.00	5689.00	1733.00
Output/month	6715.00	8218.00	5076.00	8429.00
Rate of availability	94.18	90.46	68.61	92.06
Rate of performance	95.58	97.14	93.21	95.82
Rate of quality	98.90	99.10	98.36	99.24
OEE	89.03	87.08	62.90	87.54

Table 4b: Computation sheet with shutdown and line organization losses Dec 07-Mar 08 for VTC 1

	Dec	Jan	Feb	Mar
Operating time	16041.00	19316.00	12429.00	20068.00
Loading time	17745.00	22046.00	24321.00	23921.00
Down time	1704.00	2730.00	11892.00	3853.00
Output/month	6715.00	8218.00	5076.00	8429.00
Rate of availability	90.00	88.00	51.00	84.00
Rate of performance	96.00	97.00	93.00	96.00
Rate of quality	98.90	99.10	98.36	99.24
OEE	84.45	84.35	46.78	79.85

Availability:

- Planned downtime.
- Set up time.
- Unplanned recorded downtime or breakdowns.

Performance rate:

- Reduced speed.
- Minor unrecorded stoppages.

Quality rate:

- Rejects.
- Rework.
- Yield and start up losses.

Equipment effectiveness is a measure of the value added to the production through the equipment.

TPM maximizes the equipment effectiveness through two types of activities:

Quantitative: Increases the equipments total availability and improving its productivity with in a given period of operating time.

Qualitative: Reduces the number of defective products, stabilizing and improving quality.

With all the three ratios calculated the OEE was computed for the last 4 months. The computation of the overall equipment effectiveness, the availability, performance rate and the quality are given in the Table 4.

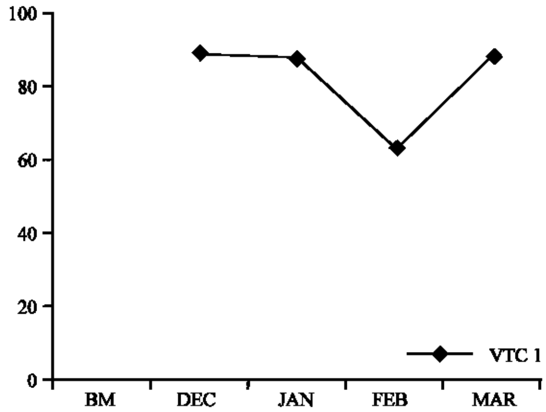

Fig. 1: OEE trend with shutdown and line organization loss from Dec 07-Mar 08 VTC 1

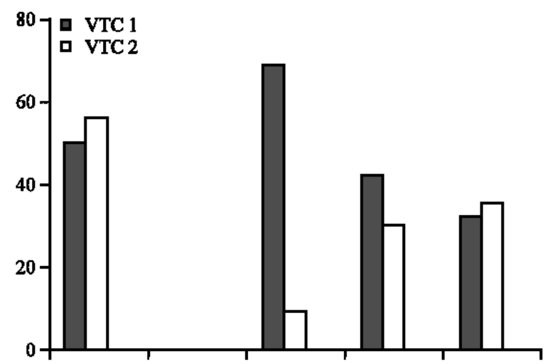

Fig. 2: Tool change loss trend in VTC 1 and VTC 2

ANALYSIS OF THE OVERALL EQUIPMENT EFFECTIVENESS

The trend of OEE is given in the Fig. 1 and 2. To improve OEE continuously a target is fixed from the benchmark value. The trend indicates that for vertical turning center including the shutdown and line organization losses the OEE varies between 77.84% (benchmark) to 80.9% and OEE reduces with 47.8%.

CORRECTIVE ACTIONS PLANNED TO IMPROVE OEE

The proportion of the three different ratios contributing to the OEE, namely availability, performance rate and the quality are found out. All possible factors are to be critically examined. The time lost due to no operator/ material is quite significant and by eliminating it, the OEE can be increased significantly. All possible losses that affect the OEE have been brain stormed with the concerned groups and corrective actions are drawn to improve OEE continuously. A specific target in the

Table 5: Phenomenon matrix

Physical phenomenon	Cause	Root cause
Z- axis abnormal encoder	Dirt's deposited in scale/sensor	Dirty environment
Tool sensor faulty alarm	Proxy switch failed	Proxy switch fouling with guard
Turret position shifted	Spindle hit with turret	Power cut
Turret limit switch fault alarm	Frequent alarm	Turret relay module life

Table 6: Activity chart

S.No	Activity	Time taken (min)
1	Searching of spanner	3
2	Searching of vernier	3
3	Bringing of tools form stores	5
4	Loosening of tool	1
5	Cleaning of tool holder	0.5
6	Mounting of tool	1
7	Measuring tool offset	1
8	Offset entering	0.5
	Total time consumed	15

increase of OEE should be ser. For example a target of 2% increase every month could be a good starting point (Kumar *et al*., 2006). Identifying and eliminating the other losses mentioned earlier increases the effectiveness of the entire system.

Table 5 represents phenomenon matrix sheet which indicates the physical phenomenon for the breakdown occurred in machines and the countermeasures taken.

Table 6 represents the activity table. This was carried out to reduce the tool change loss occurring while changing the tools.

If we see the table denotes that the initially it take 15 min to replace the tool with 8 steps to carry out the operation and after keen observation eight steps has been reduced to a single step.

Time has been reduced to 4.5 min instead of 15 min, which saves nearly 15 min.

Proposed plan: To use tool with holder such that activities 2-7 was eliminated. After eliminating time taken to change the tool was 4.5 min, which saves nearly 11.5 min.

Figure 2 represents the tool change loss trend for last 4 months. It shows in vertical turning center1 the no of occurrence is reduced from 56-32 times in one month and time has been reduced from 567-208 min.

Figure 3-5 represent the trend chart for production, quality and cost, respectively after implementing TPM for all the machines in the cell.

Improvement activity for losses caused by breakdown: There area 2 types of breakdowns, total functions failure and partial functions failure.

Total function failures are unforeseen breakdowns that attract most of out attention.

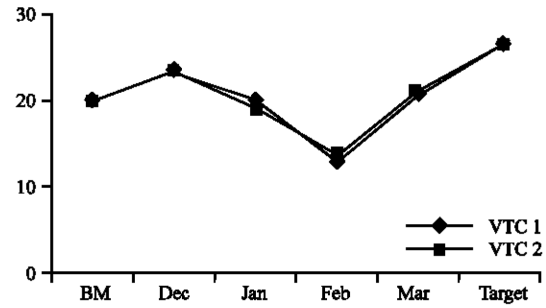

Fig. 3: Output per hour in VTC 1 and VTC 2

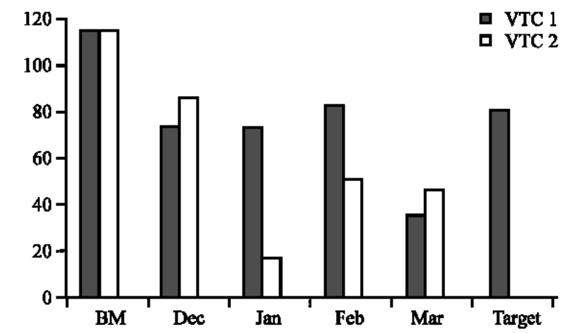

Fig. 4: Quality trend chart for VTC 1 and VTC 2

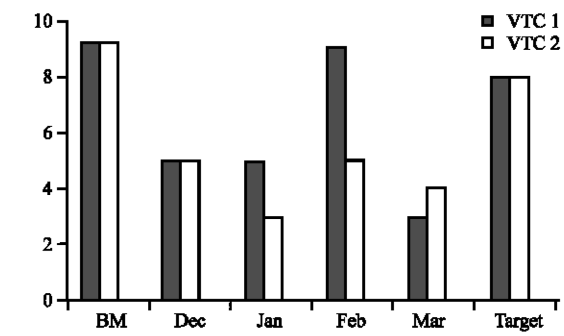

Fig. 5: Cost trend chart in VTC 1 and VTC 2

Partial function failures are breakdowns that partly affect normal functions. When the light of the fluorescent light dims, a partial failure occurs. This kind of breakdown is normally overlooked.

The reason why equal attention should be paid on partial failures also is because the overlooking can cause troubles such as frequent production stoppages, repairs and reduction of production speed, which are considered to be unforeseen defects. It is important to recognize that breakdowns caused by the partial failure are not rare and these should not be taken lightly.

Counter measures for zero breakdowns: To achieve zero breakdowns the following seven corrective measures are vital (Babiez, 2000; Ireland and Dale, 2001).

- Do not neglect forced deterioration.
- Basic conditions must be ensured (Cleaning, lubricating and tightening).
- Correct operation conditions must be kept.
- Improve the knowledge of the maintenance staff.
- Never let a problem end with emergency measures, but always implement drastic counter measures.
- Improvement of the weak points of the breakdown.
- Learn from the results or the breakdown.

RESULTS AND DISCUSSION

From the analysis of overall equipment effectiveness and the implementation of TPM (Kumar *et al*., 2006), the company finally achieves

- Productivity yields and improvement -1 to 1.5 times.
- Reduction in defective products -1/10.
- Reduction of maintenance cost -3 to 5 times.
- Inventory level - will be reduced significantly.
- Increase in employee suggestions -5 to times.

It has been understood by the company that with competition in manufacturing industries rising relentlessly, TPM can be maintenance philosophy prevents the failure of the organization. However, the employees must be appropriately trained, empowered and convinced that TPM is sustainable and the management should be totally committed to the programme. In conclusion, TPM is a journey to excellence and not mere destination.

CONCLUSION

TPM has a vast potential to provide business houses with a competitive advantage. TPM has a vital role to play in changing the worker's attitude and ensuring their active participation. The suggestions for the scheduled and implementation for the situation discussed herein are very promising.

It only increases the effectiveness of the manufacturing systems, but also increases the effectiveness of the entire organization through mandatory participation and continuously strives to achieve excellence (Carter, 1999) in each of the following areas:

- Productivity.
- Quality.
- Cost.
- Delivery.
- Safety and health.
- Morale.

Kriss Precision Engineering already started implementing the concept of TPM in their unit.TPM takes time to give results. Overall Equipment Efficiency improvement, maintenance and quality maintenance taking the core concept of TPM and being the lone tool for success has been visualized by the company.

It has been understood by the company that with the competition in manufacturing industries rising relentlessly, TPM can be maintenance philosophy prevents the failure of the organization.

However, the employees must be appropriately trained, empowered and convinced that TPM is sustainable and the management should be totally committed to the programme.

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