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Implementation of TPM in a Process Industry: A Case Study from Pakistan

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Abstract: Quality of any manufactured product is closely associated with to maintenance of manufacturing systems of any organization. To achieve a world class manufacturing system, two new manufacturing paradigm Total Productive Maintenance (TPM) and Total Quality Management (TQM) have emerged over the period along with other widely used concepts. In this paper, a case study related to implementation of Total Productive Maintenance is shared for a packaging material manufacturing organization. TPM Concept is implemented in the business flexible unit equipped with various flexographic printing machines. Overall Equipment Effectiveness (OEE) is used as the key performance measure of success of TPM implementation. The losses associated with equipment effectiveness are identified and all the pillars of TPM are implemented in a phased manner eliminating the losses and thus improving the utilization of flexographic printing machines.

Keywords: TPM, OEE, flexographic printing

1. Introduction

To remain competitive in the global world, organizations seek to produce better quality and cost -effective products. This need forces the organizations to adopt several approaches related to production process and plant maintenance in order to run the plant at its full capacity by increasing productivity hence reducing the cost of manufactured parts. These approaches include Total Quality Management (TQM), Total Productive Maintenance (TPM) and Lean Manufacturing. Plant maintenance is playing an important role in the organization's profitability as 15-60% manufacturing cost is associated with the maintenance activities [1].

In order to achieve the above goals, Manufacturing organizations have compelled to adopt new manufacturing philosophies to improve overall equipment effectiveness which is directly linked with availability and performance of the equipment [2-3]. It is evident from the published literature that poorly maintained equipment caused machine downtime, performance of equipment and quality of the products hence pushing a

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manufacturing organization to lose its competitive edge in the market. Therefore, plant management team forces to rethink about the conventional maintenance practices adopted by the plant personnel. TPM has been recognized as a new manufacturing paradigm ever since. TPM involves everyone in the organization in order to keep a well maintained equipment throughout its service life.

TPM is widely accepted philosophy as most effective maintenance strategy by all organizations in general and manufacturing organizations in particular. Therefore, a handsome literature is available which enlightens the effectiveness of TPM in manufacturing organizations. Ahuja et al. gave a detailed review about TPM. Authors summarized the eight pillars of TM success i.e. focused maintenance, planned maintenance, autonomous maintenance, education and training, quality maintenance, safety health and environment, development management and office TPM [4]. Putro et al. presented a study about implementation of 5S in Bengkel ABC organization. The study concluded that with the successful implementation of 5S in spare and waste sections, there was about 30200cm^2 space available. The study further added th5S implementation provided an immediate return within 48 days [5]. Cesar et al. reported a work related to autonomous maintenance. According to the authors, autonomous maintenance is an important pillar of TPM as it reduces losses significantly by involving workers who are responsible for equipment working. The study concluded that 80% of machine downtime is caused by repetitive maintenance problems which can be easily rectified by the worker after getting some training and only 20% of the problems required external assistance [6]. Salunke et al. carried out a study related to another important pillar of TPM which is known as Kaizen. During the study, authors successfully implemented Kaizen, 5S to improve the inventory management in spare parts industry [7].

The above-mentioned literature reveals the importance of TPM pillars in different organization. Therefore, the present study focuses on implementing TPM in an industry busy in making food grade packaging located in Lahore, Pakistan. The organization is pioneer and the biggest supplier of packaging product to different industries all across Pakistan such as beverages, food and fast-moving consumers' goods etc. The study has been carried out in the Business Flexible Unit of that mainly deals in flexible packaging for food stuff. The business flexible unit was comprised on three flexographic printing machines. The current work focused on identification of weak areas and then planning for TPM implementation considering the importance of TPM pillars. 5S, Autonomous Maintenance, Kaizen, Training and Safety health and Environment. After successful TPM implementation the improvement was gauged by overall equipment efficiency that provides very encouraging results.

2. TPM Implementation

2.1. 5S

5S can be served as foundation for TPM starts. 5S is a new way of housekeeping given by Japanese as shown in Table 1. If not taken up seriously, can leads to 5D i.e. Delays, Defects, Dissatisfied customers, Declining profits and Demoralized employees.

Table 1. Meaning of 5S

	English translation	Equivalent 'S' term
Seiri	Organization	Sort
Seiton	Tidiness	Systematize
Seiso	Cleaning	Sweep
Seiketsu	Standardization	Standardize
Shitsuke	Discipline	Self-discipline

5S concept was introduced in the organization through forming the quality circle and detailed 5S implementation report is given in Table 2.

Table 2. 5S implementation steps

2.2. Autonomous Maintenance

The concept behind this pillar of TPM is that worker is responsible of small maintenance activities related to equipment such as cleaning, lubrication and inspection etc. to avoid unplanned down time and quality defects. Several maintenance activities taken under autonomous pillar is given in Table 3.

2.3. Kaizen

"Kaizen" principle aims at large number of very small improvements. It involves everyone in the organization to work for the betterment of organizational environment and to reduce losses hence improve the machine downtime. A flexographic printing machine was selected for Kaizen implementation. Two main problem areas were identified by using Pareto Diagram as shown in Table 4.

Table 3. Autonomous maintenance steps

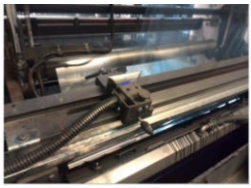
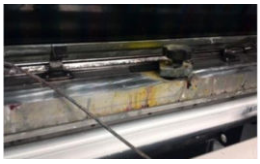
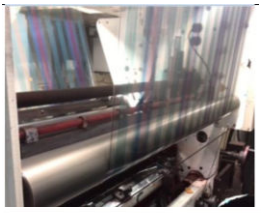
Component/ Subpart	Standard Picture	Description	Method/Tool
Rewinder		The condition of the rewinder will be check visually by the junior operator. He will be responsible for cleaning the re-winder as well as check the re-winder for any greasing or lubrication if required.	
Scanning Head & bar		Visual inspection of the scanning head and bar by the crew and cleaning of the instrument by cutting hosiery.	
Blade Holder		All 08 units blade holders will be checked and cleaning with cutting hosiery will be done using solvent and solvent resisting gloves.	
Inlet idle roller		If dust and ink is found deposited on the inlet idle roller, the machine crew will clean the roller using solvent and solvent resistant gloves	
CO2 Cylinders		Machine operator will visually inspect the condition of CO2 cylinders. Janitor staff will clean them with cutting hosiery. Machine operator will ensure the cleaning as per standard picture.	

Table 4. Problem areas identified by Pareto diagram

Sr #	Problem Area	Major Effects	Total Breakdown Time/Year
1	Cylinder manufacturing fault	Blade knurling due to improper clamping	8251 min
2	Air pasting fault	Heavy air pressure	8580 min

To avoid failures occurred due to the above-mentioned problems, root cause analysis was carried out using 5-why analysis technique. During the present study, the "why" question was asked only two times because the root cause was clearly identified. Figures 1 and 2 illustrate the root cause analysis for problem 1&2 i.e. cylinder manufacturing fault and air pasting fault using 5-why technique.

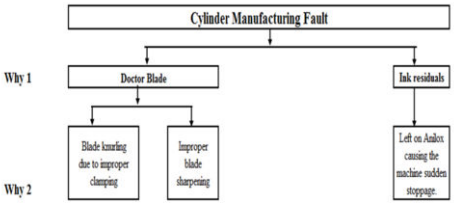


Figure 1. 5-why analysis for cylinder manufacturing fault

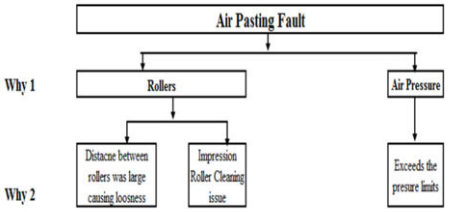


Figure 2. 5-why analysis for air pasting fault

2.4. Quality Maintenance

It aimed at customer satisfaction by providing a high quality product. This philosophy geared a transition of quality control into quality assurance. Quality maintenance has been carried out by implementing time series control charts to ensure that products are within the standard values. It also helped in predicting the possibilities of defects so that counter measures could be taken beforehand.

2.5. Training

Overall continuous improvement in the organization can only be possible through continuous improvement of worker's knowledge and skills at different levels. Training was provided at different levels in the organization as show in Table 5.

Table 5. Training activities

To Workers	To Management
Training was given to all operators regarding the importance of TPM and implementation. Training was given to the operator responsible for autonomous maintenance as mentioned above in section 2.2.	To bring TPM into organization culture, top management commitment important therefore, a one day workshop/month was given to departmental managers.

2.6. Safety Health and Environment

Safe workplace and surrounding is the main purpose of this pillar of TPM. The main objectives of this pillar are to create accident free environment with zero health damage and fires. Following steps were taken by the safety manager of the organization:

- Sufficient number of fire extinguisher is provided.
- Training is given to each individual about how to use fire extinguisher in case of emergency in every 6 months.
- Management is given suggestion for giving training to employee what to do in case of emergency? What should be the exit plan?
- Workers are advised to maintain cleanliness of toilets, regular cleaning of toilets is also done.
- Workers are also advised not to chew tobacco and spit it on shop floor and not to smoke within company premises.

3. Data Analysis

Overall Equipment Effectiveness (OEE) is widely use as the measure of success of TPM implementation. Overall Equipment Effectiveness is given as:

$$OEE = Availability \times Performance\ Efficiency \times Quality\ Rate \quad (1)$$

Table 6 gives the summary of observations made before and after TPM implementation (for one month).

Table 6. Summary of observations

Sr. #	Category	Before implementation	After implementation
1	Mechanical down time (frequency)	52	21
2	Mechanical down time (min)	5205	3525
3	Waste reduction (%)	7.92	7.21
4	OEE (%)	50	53

4. Conclusions

Following conclusion is derived from the current case study on implementation of TPM in business unit of flexographic printing process:

1. TPM success depends on various pillars like 5-S, Autonomous maintenance, Quality maintenance, Kaizen, and Safety health & Environment.
2. Successful implementation of 5S, Kaizen and autonomous maintenance resulted in significant reduction in mechanical down time and hence contributing to OEE.
3. Overall Equipment Effectiveness has improved from 50% to 53% indicating the improvement in productivity and improvement in quality of product.

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