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OEE Improvement by Implementation of TPM in Pencil Manufacturing Industry

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ABSTRACT : *Total Productive Maintenance (TPM) is a strategy that emphasizes keeping machinery in top shape in order to avoid failures and reduce manufacturing process delays. The fundamental goal of TPM is to reduce the frequency of emergency and unforeseen maintenance incidents. (TPM) is a strategy that emphasizes keeping machinery in top shape in order to avoid failures and reduce manufacturing process delays. The following paper discusses about the implementation of TPM in a Lacquering Machine Department in the Pencil Manufacturing Industry. TPM is implemented in Lacquering Machine Cell, where the Lacquering Machines are connected in a chain by conveyor belts. The success of TPM is measured by Overall Equipment Effectiveness. The losses associated with the equipment's effectiveness are identified and are worked upon them. The results of implementing TPM in improving efficiency and productivity are clearly observed. The paper is put down in order: Section 1 gives an Introduction to TPM. Section 2 is a Literature review. Section 3 gives detailed steps for the implementation of TPM. Section 4 gives detail about the implementation of TPM in Pencil Manufacturing Company. Section 5 is based on the Before and After OEE calculations. Section 6 discusses results and conclusions.*

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I. INTRODUCTION

According to a recent study (Mobley, 1990) [9], factory maintenance activities account for 25–30% of total production costs. As maintenance expenditures make up a significant portion of the operational budget of manufacturing organisations, the importance of maintenance services has grown as a result of their involvement in maintaining and enhancing availability, product quantity, and safety standards (Al-Najjar and Alsyouf 2003:85-100) [10].

II. LITERATURE SURVEY

Seiichi Nakajima, also regarded as the Father of TPM, initially introduced TPM. outlines the fundamentals of Total Productive Maintenance (TPM), its goal, and the key procedures for putting TPM into practice. For the duration of the equipment's life, it establishes a rigorous system of Preventive maintenance (PM).

In addition to focusing on overall equipment effectiveness (OEE), Osama Taisir R. Almeanazel [2] describes the objectives and advantages of implementing TPM. The author also discusses six BIG losses in the industry.

The focus on the suggestion scheme was described by Veronika I.D. Buech, Alexandra Michel, and Karlheinz Sonntag [3] and examined the processes underlying employee involvement as well as the connections between the interactional justice of the suggestion system, its valence, employees' well-being, and their motivation to submit suggestions.

J. Venkatesh [4] outlines the idea of TPM, as well as its significance and necessity, and highlights several TPM and TQM similarities and contrasts. The author also discusses different maintenance phases of the TPM implementation and comes to the conclusion that employees need to be informed about the fact that TPM is not just another "Programme of the Month" and that management is fully committed to the programme and the extended time frame required for full implementation.

Faisal Talib, Zillur Rahman, M.N. Qureshi [5] describes that to satisfy customer need continuously improvement of the performance of products, processes, and services is must. Some key factors are to be identified which play an important role in the success of TPM. These key factors are termed critical success factors (CSFs) and for sorting of the CSFs, they use the Pareto analysis quality tool. Critical success factors (CSFs) are the name given to these important variables, and the Pareto analysis quality tool is used to classify the CSFs.

The TPM philosophy has altered how manufacturing companies operate. Certain TPM ideas run utterly counter to conventional methods of thinking. In Indian companies, very little research on TPM has been done. More research on Indian industries is required, with a focus on the potential advantages and TPM implementation issues. In the Indian context, data can be examined and suitable models can be created.

III. ABOUT TPM

Total productive maintenance (TPM), sometimes known as "total maintenance optimisation," is a cutting-edge approach to maintenance that "optimises equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance by operators through daily activities involving the entire workforce."

Total Productive Maintenance (TPM) focuses on the following:

a. Maximizing overall equipment effectiveness.
b. Establishing a planned system of Preventive Maintenance (PM) for the equipment's life span.
c. Involving all employees from top management to shop floor workers.
d. Empowering employees to initiate corrective activities.
   The Nakajima (Nakajima 1988) asserts that the word "total" in TPM has three interpretations:
   Total effectiveness reflects TPM's pursuit of financial success and operational performance.
e. A maintenance system includes maintenance (MP) and maintainable improvement (MI) and PM. In essence, this is "maintenance-free" design through the incorporation of reliability, maintainability, and supportability features into the equipment design.
f. Total participation of all employees includes autonomous maintenance (AM) of operators through group activities. In essence, maintenance is completed by a "team" with the operator being held accountable for the long-term upkeep of his or her equipment.

Benefits of TPM:

1. Less unplanned maintenance.
2. Reduced equipment downtime.
3. Lower Manufacturing costs.
4. Strengthened workplace safety.

3.1 Pillars of TPM

i. 5S Program:

Similar to how a physical construction begins with a solid framework, establishing a strong TPM process necessitates a solid base made up of the 5S principles. This workplace organisation technique may be broken down into the following 5 simple steps:

1. SORT- Sort tools, equipment, and materials to identify which of these can be discarded

2.SET IN ORDER- Straighten and set things in proper order to reduce unnecessary motion and efficiently travel between working groups and locations

3.SHINE- Shine refers to performing necessary housekeeping to clean up the work area

4.STANADARDIZATION-Standardize and schedule activities to systematically form the habits to keep the workplace organized

5.SUSTAI- Sustain the process and principles for long-term applications

The 5S method is a methodical cleansing process to reveal hidden issues and difficulties in the workplace.

PILLAR 1 – Autonomous Maintenance:

The personnel who use the equipment should be the first to do maintenance and care. The ability of operators to efficiently do small maintenance jobs frees up the maintenance crews to concentrate on more specialised activities.

PILLAR 2 – Kobetsu Kaizen:

Continuous Improvement, often known as the Japanese phrase Kaizen, encourages the mind-set of moving towards zero losses and zero defects. The organisation develops its overall effectiveness and efficiency through tiny but frequent adjustments to its operations. It is true that many little improvements over a few significant ones make a difference in an organisation.

PILLAR 3 – Planned Maintenance:

Equipment breakdown can be avoided with the help of planned maintenance actions. In order to proactively avoid deterioration and mechanical breakdowns, planned maintenance is carried out by routinely inspecting the state of the equipment.

PILLAR 4 – Quality Maintenance:

Manufacturing procedures strive for zero-defect production to guarantee client satisfaction. There should be high quality standards in place, along with checks to see if the criteria are being met. Identifying any potential reasons for production variations from zero defects is the aim of quality maintenance.

PILLAR 5 – Training:

Everyone should do their part to increase the overall productivity of the production process, according to the TPM philosophy. The right training is necessary to give each member the theoretical and practical know-how of operating machines and equipment in order to achieve optimum performance and to build their competence.

.**PILLAR 6 - Safety, health, and environment:**

The creation of a safe workplace is the eighth and final pillar. When actively applied to each of the other pillars, the essence of this pillar is realised. This pillar's effective implementation will help create a safe and risk-free workplace..

3.2 Overall Equipment Effectiveness (OEE) Calculation:

OEE (Overall Equipment Effectiveness) takes into account performance rate and quality rate in addition to availability. In other words, OEE deals with all losses brought on by the equipment, including breakdowns, set-up, and adjustment losses, reduced speed, idling, and minor stoppage losses, and failure to produce first-pass quality output due to flaws, rework, or start-up losses. A key objective of TPM is to cost effectively maximize Overall Equipment Effectiveness through the elimination or minimization of all six losses. OEE measurement, in Nakajima's opinion, is a useful tool for evaluating the effectiveness of a single machine or an integrated production system.

Overall Equipment Effectiveness (OEE)=***AxPRxQ***.

Where, *A- Availability of the machine*.

PR- Performance Rate.

Q- Refers to quality rate.

OEE CALCULATION SHEET:

Table 1. OEE Calculation Sheet

A	Shift Time (General)
B	Planned Downtime
C	Running Time (A-B)
D	Running Time losses
E	Actual Operating Time (C-D)
F	**Availability** (C-D)x100
G	Production
H	Machine Speed (No. of Components/ min.)
I	Expected output (HxE)
J	**Performance** (Gx100/I)
K	Rejection
L	**Quality** (G-Kx100)/G
OEE	***Availability x Performance x Quality***

a. An OEE score of 100% is perfect manufacturing: producing only good parts as quickly as possible without downtime. An OEE score of 85% is world class for individual manufacturers. For many companies, it is suitable long-term goal.
b. An OEE of 60% is fairly typical for discrete manufacturers, but indicates there is substantial room for improvement.
c. An OEE score of 40% is not at all uncommon for manufacturing companies that are just starting to monitor and improve their production

IV. TPM IMPLEMENTATION IN PENCIL MANUFACTURING INDUSTRY

In this section, TPM implementation is exhibited through a case study in a Pencil manufacturing company. Section 4.1 gives brief information about the case organization and the TPM implementation procedure is explained in Section 4.2.

4.1 About Hindustan Pencils Pvt. Ltd.

Hindustan Pencils Pvt. Ltd. is one of the prestigious Pencil manufacturing company in India. Hindustan Pencils Pvt. Ltd. is a manufacturer of Pencils, writing materials and other stationary items, established in 1958 in Mumbai. It became a household name in stationery along with their flagship brands Nataraj and Apsara. It is the largest pencil manufacturer in India making pencils, erasers and writing implements. Hindustan Pencils produces 8.5 million Pencils, 1.7 million Sharpeners, 2.7 million erasers, 0.3 million rulers and about 1 million pens Daily. Traditionally, the organization did not give much attention to the maintenance work. The machines were checked and repaired only after the breakdown. But with the growing industrialization and global competitive market, the organization decided to adopt “Total productive maintenance”.

4.2 TPM Implementation at Hindustan Pencils Pvt. Ltd.

In this section, TPM implementation in Hindustan Pencils Pvt. Ltd. is discussed briefly. Various pillars of TPM i.e. 5S, Autonomous Maintenance, Kaizen, Planned Maintenance, Quality maintenance, Training, Office TPM, Safety, Health and Environment and OEE have been implemented.

i) Selection of Machine:

The first step of this work is selection of machines on which the study is carried out. For starting the TPM activity, few machines have been selected for TPM implementation, which is known as TPM model machine. In Hindustan Pencils there are six sections Lacquering machine1-4 have been selected from Lacquering section for implementation of TPM. The machines are studied thoroughly to identify each part and understand the working of every components.

ii) Implementation of 5S on machines:

5S is implemented on TPM model section.

1.SORT- Some questions were asked to the persons who work in that space to access the items in that space. They are the ones who can answer the following questions: What is the purpose of this unit? When was this product last used? How often is it used? Who uses it? Does it really have to be here? These questions help determine the value of each item.
If the team decided that some items were not needed, the following points were considered: Give the items to another department. Recycle / discard / sell items. Put the objects away. For cases where the value of an item is uncertain—for example, a tool has not been used recently, but someone believes it may be needed in the future—a red label area has been made. All items in this category will be placed in the red label area.
2. SET IN ORDER - Things to consider when sorting: Which people (or workstations) use which objects? When are items used? Which items are used most often? Should products be grouped by type? Are some workplaces more ergonomic for workers than others? Do you need more storage containers to organize things?
With the excess clutter gone, it's easier to see what's what. At this point, everyone has to decide which arrangement makes the most sense. It requires the completion of tasks, the frequency of tasks, the movement paths of people through the room, etc.

3. SHINE The 5S Shine phase focuses on cleaning the work area, which means sweeping, mopping, dusting, wiping surfaces, putting away tools and materials, etc. In addition to basic cleaning, Shine also includes regular maintenance of equipment and machines which makes people take ownership of the space, which in the long run means people invest in their work and the company. “The shine in the department was carried out as, the operator daily cleans the machines and their following belongings in the given 15 minutes time daily, before starting the machine (9:00-9:15)’’.
4. STANDARDIZE - When the first three steps are in play, it’s time to standardize these new practices. All employees are included in the creation of set of standards that will become the new norms of the workplace. Labels, Signs, Posters, Banners, flood marking tapes, etc. are used to help people remember new set standards. Regular tasks are assigned, schedules are created, instructions are posted so the activities become routine. A checklist is prepared to maintain effectiveness of the 5S program. Employee details are displayed on the board near the machine on which he/she is working. Cycle process chat is displayed on each machine.

5. SUSTAIN - One of the hardest steps in 5S is Sustain, i.e. changing old working habits. It's easy to fall back into old habits. The old ways seem fine, but they probably need to change. All the new employees receive the training about their 5S procedures. Incentives are given to the employees who follow all standards properly, helps to increase the interest of the employee to perform well. Company’s Mission and Vision is displayed in Hindi, English as well as in Gujarati language.

iii) Implementation of JISHU HOZEN:

Jishu Hozen also called Autonomous Maintenance is a team-based maintenance approach. The main goal of Autonomous maintenance is to prepare operators for doing some equipment care independently of maintenance staff. Autonomous maintenance is to maintain the machine in new condition.

The activities that are involved in Autonomous maintenance are, basic cleaning, lubricating, tightening and inspection of various machine parts.

Approach:

- In a pair of two, operators are given training about daily CLTI (Cleaning, Lubricating, Tightening and Inspection) activity.
- Autonomous maintenance standards were introduced, which is mandatory for all operators to follow.
- A CLTI (Cleaning, Lubricating, Tightening and Inspection) checklist was prepared, in which the person has to mark the activity done daily. The Supervisor will do the inspection work
- Red tag and White tag approach were introduced.
- All the parts of the machine are grouped according to the type of breakdown i.e. Which is to be done by Maintenance Department and which is to be done by Production Department itself.
- In case of any breakdown, operator identifies the type of breakdown and applies Red tag and White tag accordingly.
- Red tag is placed for maintenance work to be done by maintenance department.
- White tag is for maintenance work to be done by production department itself.

The standards are shown in Table 1.

iv) Classification of Fuguaies:

Many Fuguaies were identified on lacquering machine 1. Abnormalities are notes as Fuguaies which are identified during initial clean-up activity.

List of Fuguaies which were identified are listed in the Table 2.

v) Implementation of Kobetsu Kaizen:

'Kaizen' basically means 'change for betterment'. In Kaizen activity, small but continuous improvement is carried out at all levels of organization. It is said that very large number of small improvements are more effective than few improvements of larger value.

Approach:

- Numbers of Kaizens were performed on lacquering machine 1.
- A proper kaizen sheet is filled for each kaizen, which contains all information like before and after photographs, analysis, countermeasures, ideas and benefits. It is shown in Table 3.
- It is very helpful if further modification is suggested.
- Separate Kaizen sheet is filled for all the Kaizens performed on lacquering machine 1.
- Some Kaizen sheets are shown in Table…
- A Cause and Effect diagram was prepared for the Pencil falling problem which is shown in Fig 1.
- Analysis of Cause and Effect diagram is shown in Table 4.

vi) Implementation of Planned Maintenance:

Planned maintenance is any planned, documented and scheduled maintenance activity. The type of work to be done and the frequency varies based on the equipment being maintained, and environment in which it is operating. Planned maintenance reduces unplanned equipment downtime and improves overall equipment performance.

Approach:

- Planned Maintenance uses trained maintenance staff to help train the operators to do basic maintenance work.

- For preventive maintenance, all fitters along with engineers of maintenance department are given training every week i.e. on Thursday which is scheduled by Head of Maintenance Department.
- Predictive maintenance is done in collaboration of machine operators and engineers of Maintenance department.
- The maintenance schedules are integrated into the production schedule to avoid schedule conflicts.
- Operators are given training to identify the areas which are more likely to fail, so that they can inform Maintenance department in advance and take corrective action before any major break down.

vii) Quality Maintenance:

Quality maintenance aims to assure zero defect conditions by understanding and controlling the interactions between machine, material and methods. Quality maintenance is performing maintenance action for the equipment's care, so that it does not generate quality defects, certifying that the machinery meets the basic condition for 'zero breakdown' and that this equipment is within the technical standards.

Approach: Before TPM, the quality checking was done as 100% inspection, which was done only in general shift. Due to 100% inspection, man power required was more and also due to the inspection only done in general shift, problems like increased inventory, handling of pencils, mixing of pencils would occur. It effects smooth flow of processes.

Now, instead of 100% inspection, AQL standard is used as quality checking process.

In AQL, from a lot of 25,000 pencils (one trolley), 125 units are selected as random (according to Single Sampling Plan –ISO 2859-1). The selected samples are further categorised as Minor defect, Major defect and Average defect.

From the selected samples if 4 major or 6 minor or any 1 critical defect is observed, the lot is rejected, and if the samples observed are under this limit, then the lot is accepted. The rejected lot now goes for 100% inspection.

With the help of AQL, now 60% (approx.) lot is directly accepted and only 40% goes for 100% inspection.

Online inspection process was also introduced for Design machine. In this process, operator is provided with a table on machine, and checks the pencils using visual inspection method on machine itself.

This thing helps, as the operator comes to know immediately which type of defect is occurring and can do setting on the machine accordingly. It also helps to reduce the further process of the reject pencils which would otherwise have been done if the online inspection was not in process. (Clear coat, End cutting, Dipping).

viii) Training:

Continuous improvement in knowledge and skills is possible through continuous training program. Training program for various levels in organization were introduced on timely basis.

Approach:

- Training is given to the operators for 100% visual inspection to detect visual defects.
- Training to read measuring instruments like, Vernier calliper, screw gauge, dial gauge, etc were given.
- Training for using 'Go and No go' gauges for 100% inspection were given.
- Weekly training regarding QC were organised for the quality department.
- Daily Training program was started regarding Machine operation, safety, Housekeeping, etc.
- Mock drill was practiced to train employee, what to do in case of emergency.

ix) Safety, Health & Environment:

This pillar focuses on to create a safe workplace and a surrounding area that is not damaged by companies process or procedures. The goal is zero accidents, zero injuries and zero fires.

Approach:

- Sufficient number of fire extinguisher is provided all over the shop floor.
- Training is given to each and every individual about how to use fire extinguisher in case of emergency on regular basis.
- Proper training is given to employee what to do in case of emergency? What should be the exit plan?
- Regular cleaning of toilets, eye wash, water tanks and water coolers is practiced.
- To create awareness among employee's various safety slogans, posters related to safety are used at various locations inside the company.

V. IMPROVEMENT IN OEE:

OEE is the measure of success of TPM program. The OEE is calculated before and after of TPM implementation on all the machines.

The following Tables explains before and after conditions of OEE on Lacquering machine 1.

OEE for Lacquering Machine 1:

Table 2. Before TPM

BEFORE TPM IMPLEMENTATION		
A	Shift Time (General)	480
B	Planned Downtime	30
C	Planned Operating Time (A-B)	450
D	Running Time losses	102
E	Actual Operating Time (C-D)	348
F	**Availability** (E/C) x 100	**77.33 %**
G	Production	1659
H	Machine Speed (No. of Components/ min.)	6
I	Expected output (HxE)	2087
J	**Performance** (Gx100/I)	**79.49 %**
K	Rejection	66
L	**Quality** (G-Kx100)/G	**96%**
OEE	***Availability x Performance x Quality***	***58.97%***

Table 3. After TPM

AFTER TPM IMPLEMENTATION		
A	Shift Time (General)	480
B	Planned Downtime	45
C	Planned Operating Time (A-B)	435
D	Running Time losses	83
E	Actual Operating Time (C-D)	352
F	**Availability** (E/C) x 100	**81.01%**

G	Production	1824
H	Machine Speed (No. of Components/ min.)	6
I	Expected output (HxE)	2112
J	**Performance** (Gx100/I)	**86.36%**
K	Rejection	73
L	**Quality** (G-Kx100)/G	**96%**
OEE	***Availability x Performance x Quality***	***67.16%***

OEE is calculated for all the selected machines in Lacquering Section. AN OEE graph for machine 1-4 is shown in Fig 5.

I. CONCLUSION:

OEE is a powerful tool to identify previously hidden manufacturing losses and inefficiencies. Tracking OEE scores and using them to drive improvements in manufacturing processes is a vital step forward towards world-class manufacturing for organizations of all sizes and industries.

It is clearly observed that there is improvement in OEE of every machine after implementation of TPM. Before and After OEE calculation is shown in Table 5.1 and Table 5.2 respectively. Improvement in OEE is shown in fig.2 for lacquering machine 1-4.

Some problems were faced during TPM implementation at Hindustan Pencils are:

1. Workers are not well educated.
2. Fear of losing jobs after adopting TPM.
3. Extra work to be done in TPM process.

TPM does go against the traditional view that machines only stop when there is a breakdown.

TPM develops the ideas of maintenance and preventive maintenance by involving all departments and people within an organization. With an organization-wide mind-set focused on taking responsibility for the machines and equipment, increasing overall performance is achievable even with a limited number of resources.

Table 4. Standards of CLTI

CLTI CHECK LIST FOR LACQUERING MACHINE (CELL C)

LOCATION	PART NO	PART DETAIL	TYPE (CLTI)	METHOD	FREQUENCY	SPRACKETS STRAIGHT
PART 1	A	FULL MACHINE	C	COTTON WASTE	DAILY	FULL CLEAN
	B	CONVEYOR DRIVE CHAIN	L	MP GREASE	MONTHLY	20 gm
	C	CONVEYOR DRIVE CHAIN AND SPRACKET ALLIGNMENT	I	HAND PRESSING	MONTHLY	SPRACKETS STRAIGHT
	D	CONVEYOR DRIVE CHAI N TENSION	I	HAND PRESSING	WEEKLY	FULL TENSION
	E	ALL PILLOW BLOCK BEARING	L	(MI SE GUN	MONTHLY	2 STROKE
	F	STOPPER UNIT CHAIN	L	MP GREASE	MONTHLY	20 gm
	G	STOPPER UNIT CHAIN TENSION	I	HAND PRESSING	WEEKLY	FULL TENSION
	H	STOPPER UNIT CHAIN AND SPRACKET ALLIGNMENT	I	THREAD	MONTHLY	SPRACKETS STRAIGHT
	I	SPUR GEAR	L	MP GREASE	MONTHLY	20 gm
	J	FLOPPER CAM	L	20/40 OIL CAN	DAILY	2 STROKE
PART 2	A	MAIN CONVEYOR DRIVE CHAIN	L	MP GREASE	MONTHLY	20 gm
	B	MAIN CONVEYOR DRIVE CHAIN TENSION	I	HAND PRESSING	WEEKLY	FULL TESION
	C	MAIN CONVEYOR DRIVE SPRACKET ALLIGNMENT	I	THREAD	MONTHLY	SPRACKETS STRAIGHT
	D	PUSHER CHAIN	L	MP GREASE	MONTHLY	20 gm
	E	PUSHER CHAIN TENSION	I	HAND PRESSING	WEEKLY	FULL TESION
	F	PUSHER CHAIN & SPRACKET ALLIGNMENT	I	THREAD	MONTHLY	SPRACKETS STRAIGHT
	G	MAIN CONVEYOR GEAR BOX ABNORMAL SOUND	I	HEARING	WEEKLY	NO SOUND
	H	PUSHER CHAIN GEAR BOX APNORMAL SOUND	I	HEARING	WEEKLY	NO SOUND
PART 3	A	VIBRATOR DRIVE CHAIN TENSION	I	HAND PRESSING	WEEKLY	FULL TESION
	B	VIBRATOR DRIVE CHAIIN & SPRACKET	I	THREAD	MONTHLY	SPRACKETS STRAIGHT
	C	VIBRATOR SHAFT BLOCK	L	20/40 OIL CAN	DAILY	2 STROKE
	D	PUSHER UNIT BEARING	L	MP GREASE	MONTHLY	20 gm
PART 4	A	INCLINED DRIVE CHAIN	L	MP GREASE	MONTHLY	20 gm
	B	INCLINED DRIVE CHAIN TENSION	I	HAND PRESSING	WEEKLY	FULL TESION
	C	INCLINED DRIVE SPRACKET	I	THREAD	MONTHLY	SPRACKETS STRAIGHT
PART 5	A	FLOPPER DRIVE CHAIN TENSION	I	HAND PRESSING	WEEKLY	SPRACKETS STRAIGHT
	B	FLOPPER DRIVE SPRACKET	I	THREAD	MONTHLY	SPRACKETS STRAIGHT
	C	SPUR GEAR	L	MP GREASE	MONTHLY	20 gm

Table 5. Fuguaies Found in Machine

Fugies found in Lacquering Machine-1

Sr. No.	Fugies Description	What will happen if left as it is	Why did it become so	Countermeasure Plan
1	Hopper base guide plate problem	Pencil breaks	Wear out	Change
2	Main vibratore , key way and grube screw problem	Stoppages, Rejection	Thumb wear out	Change
3	Pusher rod holder problem	Pushing problem	Wear out	Change
4	1st , 2nd and 3rd belt problem	Pencil falling	Uneven tension	Weld fixing
5	Lasing problem	Belt breaks	More tension	Change lasing
6	M.S transport roller problem	Pencil not moving further	Wear out	Change
7	Transport roller shaft , holder problem	No transfer of pencil	Shaft bend	Alignment
8	Vibratore unit problem	No falling of pencil from hopper	no attention	Chang and allign
9	Main Drive sprocket problem	Chain sliping on sproket	Shaft bend of Main motor	Shaft change
10	Pencil stopper unit problem	Stick on stopper and fall	No setting	Proper setting
11	Raising conveyore aluminium clit problem	Pencil stuckup on conveyer	Clit comes out	Refixing
12	All belt alignment problem	Pencil falling	Setting disturbed	Resetting.

Table 6. Kaizen Sheet

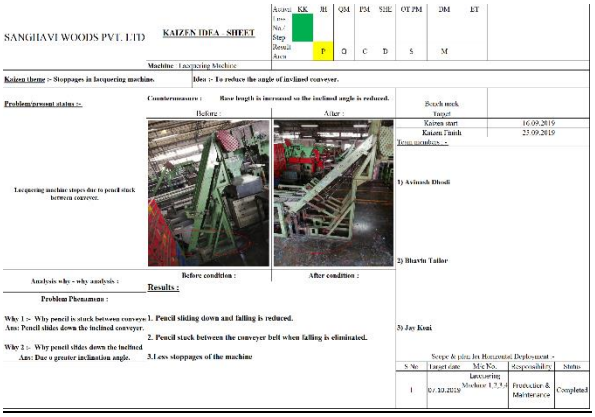


Figure 1. Cause and Effect diagram

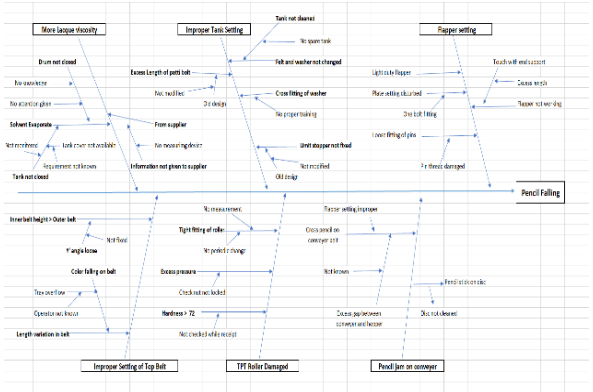
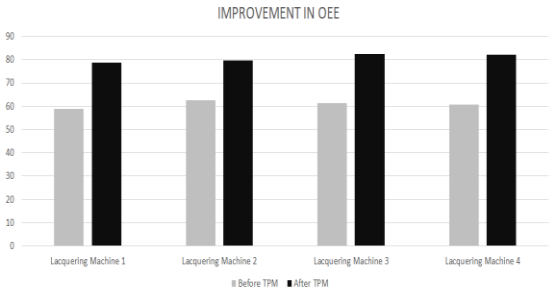


Table 7. Analysis of Cause and Effect

ANALYSIS OF FISHBONE DIAGRAM

PROBLEM	OCCURANCE	CORRECTIVE ACTION
1.More Lacque viscosity	1. Solvent evaporates - Drum not closed - No attention given - Tank not closed - Tank cover not given	1.Operators are said to keep an eye on the lacquer drum and keep it closed. - Respective Tank covers are provided and now operators make sure to cover the tank after filling the lacquer.
	2. From supplier - Information not given	2. Standard required Viscosity of lacquer is analysed and information is conveyed to supplier.
2.Improper Tank Setting	1. Excess length of patti bolt - Old design	1. Excess length is cutted down as standard length and then welded, so now no adjustment is required.
	2. Felt and washer not changed - Tank not cleaned - No spare tank available	2. Many tanks are ordered and the tank collector make sure that each tank is cleaned properly. - The setter is now responsible to change tank daily.
	3. Cross fitting of washer - No training	3. Proper training is given to the setter by the maintenance people for proper fitting of washer.
	4. Limit stopper not fixed - No training	4. Proper training is given to setter for fixing the limit stopper .
3.Flapper Setting	1. Light duty flapper	1. Replaced by heavy duty flappers.
	2. Plate setting disturbed - One bolt fitting	2. Plate setting is fixed using duel bolt fitting.
	3. Loose fitting of pins - Pin threads damaged	3. Making sure not to give over pressure when fitting pins which damages the thread.
	4. Flapper not working - Excess length - Touch with end support	4. Excess length is cut down and made standard.
4.Improper Setting of Top Belt	1. Length variation in belt - Lacquer falling on belt - Tray overflow	1. Periodic changing of the collection tray.
	2. Inner belt height > outer belt - 'Y' angle loose	2. 'Y' angle setting is changed, making the inner belt heigh equal to outer belt.
5.TPT Roller Damaged	1. Tight fitting of roller - No periodic changing - No measurement available	1. Setter make sure the proper fitting of TPT roller, changing periodically (every 24hrs) of working.
	2. Excess pressure - Checknut not locked	2. Coller is provided to prevent excess pressure on roller. Checknut is locked.
	3. Hardness greater than 72 - Not checked while recipt	3. Hardness of the TPT roller is checked when receiving from supplier.
6.Pencil Jam on Conveyer	1. Cross pencil on conveyer - Flapper setting improper - Excess gap between conveyer and hopper	1. Flapper setting is fixed to standard. - The gap between the conveyer and hopper is made standard (32mm)
	2. Pencil sticking on Disc - Disc not cleaned	2. Operaters are provided with scrapers for regular scraping of stopper disc.

Figure 2. OEE Improvement



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