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Implementation of Total Productive Maintenance for Overall Equipment Effectiveness Improvement in Machine Shop

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ABSTRACT: In Total Productive Maintenance tiny cluster behavior are interweave. Independent protection is one of the most vital pillars of TPM. Self-directed preservation aims to instruct the accomplice in the principle and philosophy of self-directed maintenance and to furnish them chance to extend their skills & assurance. TPM lend a hand to elevate the value of OEE by providing a structure to make easy the judgment of the losses. TPM look for to cheer the setting of striving, but reasonable goals for raising the value of the OEE. In the present work, machines were suspiciously considered and this revision discover the ways in which auto constituent business be able to execute TPM as a policy and society for civilizing its presentation. In this study, it is proposed to initiate a innovative term "give up" in the OEE computation. This helps in giving a better account of the material utilization.

Index terms: Overall equipment effectiveness, Total productive maintenance, Performance efficiency.

I. INTRODUCTION

Observance ahead of the pastime is tougher than always in today's industrialized business. Struggles in all-inclusive and advertise are express flattering charge insightful. These disputes are forcing companionship to employ a mixture of efficiency progress labors to gather the needs of still varying promote stipulate [1]. The Total Productive Maintenance paradigm, launched by Nakajima in 1980's has provided a quantitative metric for measuring the productivity of an individual production component.

A great amount of companies find, that in spite of the huge improvements in the productivity in the last years, there is still a big potential to be better in utilizing the machine tools and in reaching the better productivity goals. One main method to meet these challenges is the TPM, Total Productive Maintenance [2]. TPM is a methodical come up to accepting the apparatus's purpose, the equipment's affiliation to product quality and the possible source and occurrence of breakdown of the dangerous apparatus components [3]. Though Overall Equipment Effectiveness (OEE) is a ingredient of TPM, it has been second-hand broadly exterior the preservation example. OEE has been used comprehensively for equipment yield improvement.

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OEE was renowned as a elementary technique for determine equipment recital opening the late 80's and early on 90's. Now it is acknowledged by management consultants as a primary routine metric [4].

The OEE measure attempts to reveal the out of sight costs linked with a piece of equipment. While it is useful by self-governing miniature groups on the shop floor mutually with quality manage tools.

OEE is an imperative harmonize to the established top-down sloping routine extent systems. OEE is often used as a driver for humanizing performance of the business by centering on quality, productivity and equipment availability concern and therefore intended at dipping non value addition behavior regularly intrinsic in developed practice [9].

II. TOTAL PRODUCTIVE MAINTENANCE

TPM is a lively, turnover leaning approach to plant and equipment organization, TPM mingles the concept of defensive and prognostic upholding with management strategies that boost fertility and come back on assets from side to side employee contribution. TPM creates a scheme to stop every kind of loss and achieves zero losses by overlapping small group behavior [5].

- TPM aspires at construction up a business society that systematically chase construction structure effectiveness or OEE
- Generates a system to prevent dissimilar losses
- Face all departments counting manufacture, product and course expansion, and advertising and management
- Necessitate complete participation on or after summit administration crossways the plank to front workers

OVERALL EQUIPMENT EFFECTIVENESS

OEE is now a number for family member comparison of equipment performance. The genuine profit comes on or after using the reason of OEE, which direct to source cause examination and abolish the basis of poor performance [6].

SIX MAJOR LOSSES

While taking OEE into consideration, there are six main equipment losses[7].

- Equipment failure and breakdown
- Setup and adjustment
- Idling and minor stoppages
- Reduced speed losses
- Quality defects and rework
- Start-up losses

The primary two losses are known as downtime losses and are second-hand to compute the availability of a apparatus.

The third and fourth losses are speed losses, which resolve the performance competence of a machine. The final two losses are observed as quality losses as the in a straight line influence the quality rate of the equipment [8].

III. CONCLUSIONS FROM THE LITERATURE REVIEW

- The literature emphasizes the use of TPM to improve the OEE by concentrating on autonomous maintenance. **(**Sharma et al 2002)

- The process of calculating the OEE is alienated into four ladders, whose aims are to bring onward enhanced maintenance of the mechanical equipment (Tsarouhas 2007)
- Also, the permanent and methodical examination of the manufacture process is attained from side to side capacity of the OEE. (Tsarouhas 2007)
- In our study we have incorporated the term yield so as to give the management a comprehensive view about the material utilization. The yield differs from industry to industry and in our case study yield is nothing but the ratio between the quality products to the input equivalent. (Raja and Kannan 2007)

Yield = (Quality Products) / (Input Equivalent)

- The literature clearly states that TPM take full advantage of equipment's success and yield, and diminishes machine thrashing reducing equipment breakdowns, minimizing idling and minor stops, decrease quality defects and claims, decoration labor and costs, shrinking inventory, cutting accidents, and encourage employee participation. (Bidot 2006)

IV. PLANNING AND IMPLEMENTATION OF TPM

According to Nakajima the five development activities of TPM are as follows.

1. REMOVE SIX BIG LOSSES

Eliminate the 'six big losses' and thereby improve the effectiveness of the equipment.

Losses due to downtime:

1. Apparatus failure - beginning go down
2. set of connections and modification - from switch over of die in molding machines, compress, and so on

Speed losses:

3. Inactive and slight work to rule - due to the irregular action of sensors, obstruction of work on shaft, etc.
4. abridged speed - due to inconsistency flanked through particular and real speed of equipment

Losses due to defects:

5. Process flaws - due to scarp and redraft
6. Condensed defer - from device start-up to stable.

2. DEVELOP A MAINTENANCE PROGRAM

Expand an autonomous preservation plan.

The seven steps of independent protection are :

1. Early onslaught: Clean to remove dust and dust mostly on the cadaver of the equipment: grease and make tighter; learn problems and accurate them.
2. Contradict events at the basis of problems: Prevent the source of dust, dirt, and spattering of liquids; recover that piece of equipment that are hard to fresh and oil; diminish the time required for crackdown and grease.
3. Clear out and lubrication standards: create standards with the intention of decrease the occasion exhausted cleaning, lubricating, and tightening (denote daily in addition to interrupted farm duties).
4. All-purpose examination: Go after the commands in the examination labor-intensive; superiority circle associate find out and accurate small equipment faults.
5. Self-directed inspection: Enlarge and make use of self-governing assessment and verify sheets [10].
6. Neatness and compactness: Normalize the personality place of work organize grouping; methodically systemize maintenance management:

- Examination values for onslaught and lubricate
  - Principles for copy data
  - Values for fraction and instrument maintenance.

7. Completely autonomous maintenance: Expand a business rule and goal for safeguarding; raise the promptness of development behaviors.

This stepladder founded on the five basic principles of process association: organization, compactness, cleanliness, discipline.

3. BUILD UP A PLANNED MAINTENANCE

This is frequently prepared in collaboration with manufacturing business. The level of program greatly assists the expansion of a standard continuation program [11].

4. ENLARGE THE EXPERTISE OF MACHINIST AND PRESERVATION HUMAN RESOURCES.

The operators are supposed to labor with the preservation group at the instance. PM work is completed on their tools, talk about harms and explanations. Division of the operator's work is to stay minutes on the presentation of the apparatus. So the machinist has got to learn as perceptive.

5. WIDEN AN APPARATUS SUPERVISION COURSE

A evidence of the use of machines and tools denoting how much they were used it [12]. Nakajima delineate twelve steps mixed up in mounting and put into practice a sum creative safeguarding line up:

V. OBSERVATIONS AND CALCULATIONS

1. Running time – The effective work time in the industry
2. Planned downtime – Periodic maintenance and break sessions
3. Unplanned downtime
   - Breakdown losses
   - Setup & adjustment losses
   - Idling & minor stoppages
   - Reduced speed losses
   - Quality defects & reworks
   - Startup losses
4. Loading time = Running time – Planned downtime
5. Operating time = Loading time – Unplanned downtime
6. Rate of Quality products = (Output – Defects)/Output
7. Ideal cycle time – The standard time required for machining a product
8. Actual cycle time – The time actually required to machine a product
9. Actual processing time = Actual cycle time x Output

10. Operating speed rate = Ideal cycle time / Actual cycle time
11. Net operating rate = Actual processing time / Operating time
12. Availability = Operating time / Loading time
13. Performance efficiency = Operating speed rate x Net operating rate x Availability

OEE = Availability x Performance efficiency x Rate of Quality products x 100

- **Calculation of OEE for machine a – vt450 for a shift**

Process Involved: Inner diameter turning of brake disc

1. Running time = 8 h = 480 min (1 shift)
2. Planned downtime

- Maintenance – 16 min/day = 5.33 min
- Miscellaneous - 60 min/day = 20 min

Total = 25.33 min

3. Unplanned downtime

- Breakdown losses = 60 min/day = 20 min
- Set up & adjustment losses = 1 min
- Idling & minor stoppages = 3 min
- Reduced speed losses = Negligible
- Quality defects & reworks = 13.2 min
- Startup losses = 10 min

Total = 47.2 min

4. Loading time = Running time – Planned downtime
= 480 – 25.33
= 454.67 min
5. Operating time = Loading time – Unplanned downtime
= 454.67 – 47.2 = 407.47 min
6. Output/Shift = 160 units
7. Number of defects = 6 units
8. Rate of Quality products = (Output – Defects)/Output
= (160 – 6)/160
= 0.9625
9. Ideal cycle time = 1.8 min
10. Actual cycle time = 2.2 min
11. Actual processing time = Actual cycle time x Output
= 2.2 x 160 = 352 min
12. Operating speed rate = Ideal cycle time / Actual cycle time
= 1.8/2.2 = 0.8181
13. Net operating rate = Actual processing time / Operating time
= 352/407.47 = 0.86386
14. Availability = Operating time / Loading time
= 407.47/454.67 = 0.8961
15. Performance efficiency = Operating speed rate x Net operating rate x Availability
= 0.8181 x 0.86386 x 0.8961
= 0.6333
16. OEE = Availability x Performance efficiency x Rate of Quality products x 100
= 0.8961 x 0.6333 x 0.9625 x 100
= **54.62%**

Actual OEE = 70%

- **Calculation of OEE for machine b- AMS 405 for a shift**

Process Involved: drilling four identical holes in a brake disc.

1. Running time = 8 h = 480 min (1 shift)
2. Planned downtime

- Maintenance – 16 min/day = 5.33 min
- Miscellaneous- 60 min/day = 20 min

Total = 25.33 min

3. Unplanned downtime

- Breakdown losses = 60 min/day = 20 min
- Setup & adjustment losses = 1 min
- Idling & minor stoppages = 3 min
- Reduced speed losses = Negligible
- Quality defects & reworks = 11.7min
- Startup losses = 10 min

Total = 45.7 min

4. Loading time = Running time – Planned downtime
= 480 – 25.33
= 454.67 min
5. Operating time = Loading time – Unplanned downtime
= 454.67 – 45.7 = 408.97 min
6. Output/Shift = 265 units
7. Number of defects = 9 units
8. Rate of Quality products = (Output – Defects)/Output
= (265 – 9)/265
= 0.9660
9. Ideal cycle time = 1 min
10. Actual cycle time = 1.3 min
11. Actual processing time = Actual cycle time x Output
= 1.3 x 265 = 344.5 min
12. Operating speed rate = Ideal cycle time / Actual cycle time
= 1/1.3 = 0.76923
13. Net operating rate = Actual processing time / Operating time
= 344.5/408.97= 0.8423
14. Availability = Operating time / Loading time
= 408.97/454.67 = 0.8994
15. Performance efficiency = Operating speed rate x Net operating rate x Availability
= 0.76923 x 0.8423 x 0.8994 = 0.5827
16. OEE = Availability x Performance efficiency x Rate of Quality products x 100
= 0.8994 x 0.5827 x 0.9660 x 100
= **50.62%**

Actual OEE = 68%

- **REVISED OEE WITH "YIELD"**

In the machining process, yield plays an important role in assessing the overall performance of the process. If the effectiveness of the machining process is analyzed without considering the yield it will mislead the management that the material utilization is good and there is no need for further improvement in the process.

So, we introduce the term "yield" in the OEE calculations of the machining processes.

Yield = (Quality Products)/ (Input Equivalent)

For Machine A- VT450

Input materials are accounted in weight

Input materials Weight/shift= 4.62 x 160 = 739.2 kg

Disc weight = 4.25 kg

Input equivalent/day = 739.2 / 4.25 = 173.929 discs

Input equivalent = 174 discs

Output Quantity / shift = 160

Rejection discs = 6

Quality discs /shift = 160 - 6 = 154

Yield = (Quality products) / (Input equivalent)

= 154 / 174

= 0.8850

OEE = Availability x Performance efficiency x Rate of Quality products x yield x 100

= 0.8961 x 0.6333 x 0.9625 x 0.8850 x 100

= **48.34**

For Machine B- AMS 405

Input materials are accounted in weight

Input materials Weight/shift= 5.55 x 265 = 1470.75 kg

Disc weight = 5.27 kg

Input equivalent/day = 1470.75 / 5.27 = 279.07 discs

Input equivalent = 279 discs

Output Quantity / shift = 265

Rejection discs = 9

Quality discs /shift = 265 - 9 = 256

Yield of the process in the system

Yield = (Quality products) / (Input equivalent)

= 256 / 279

= 0.9175

OEE = Availability x Performance efficiency x Rate of Quality products x yield x 100

= 0.8994 x 0.5827 x 0.9660 x 0.9175 x 100

= **46.44%**

VI. PARETO ANALYSIS

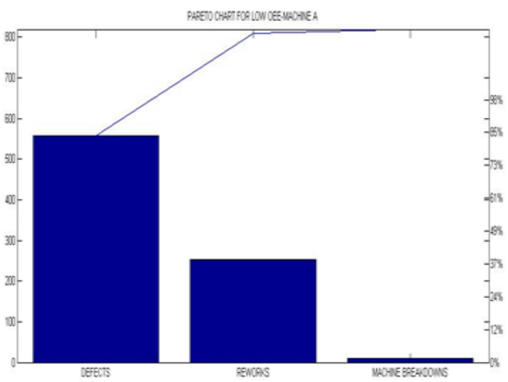

Figure : 1 Pareto chart for low OEE- Machine A

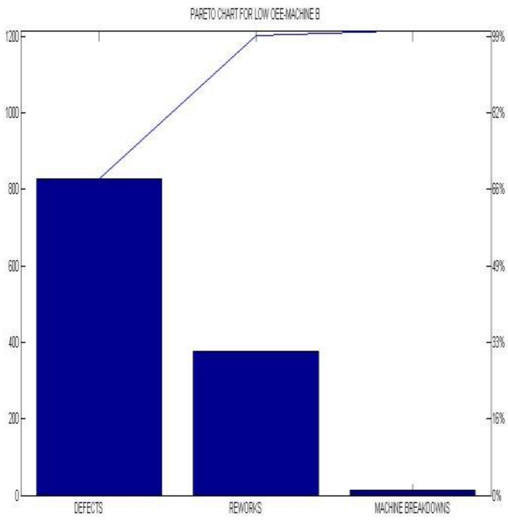

Figure : 2 Pareto chart for low OEE – Machine B

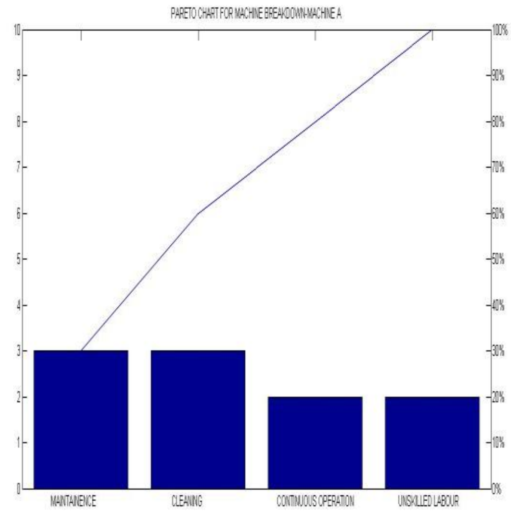

Figure : 3 Pareto chart for machine breakdown – Machine A

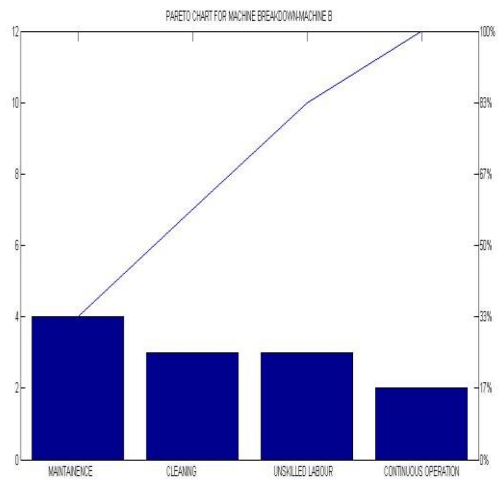

Figure : 3 Pareto chart for machine breakdown- Machine B

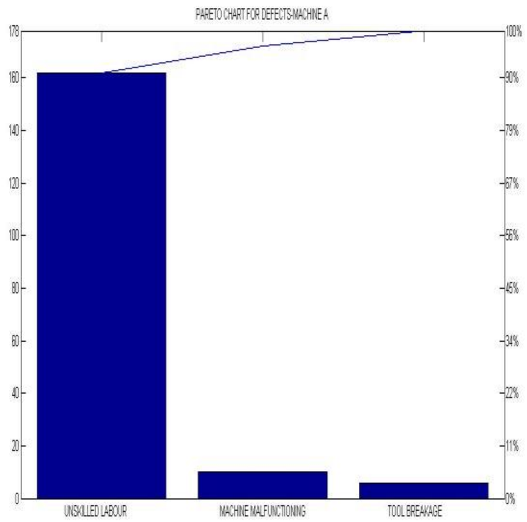

Figure : 5 Pareto chart for defects- Machine A

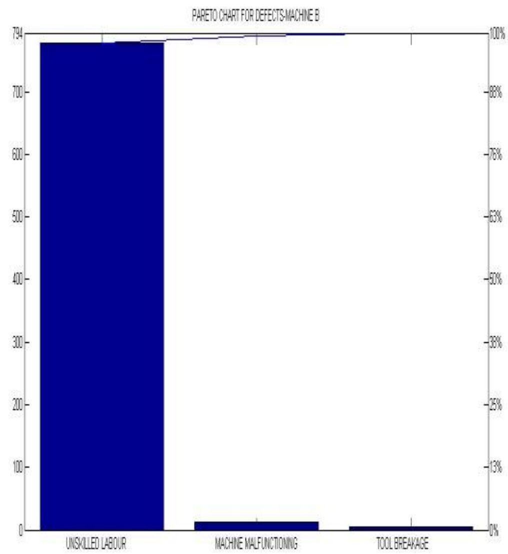

Figure: 6 Pareto chart for defects- Machine B

VII. CONCLUSION

The exact definition of OEE differs from authors and applications. OEE calculation does not take into account all factors that reduce the capacity utilization, lack of material input etc. however it is required to create an organization's own classification framework for the losses in the OEE calculation.

Yield plays an important role in accessing the overall performance of the firm. So, we have included the term in the OEE calculation. Figures 1 and 2 shows the Pareto analysis for low OEE. For any industry the main objective is to improve the performance of the equipment and the processes etc. to achieve it the parameters of the processes or the equipment should be optimized.

From our work, we have learnt that the deviation of the calculated OEE from the actual OEE is quite high. The calculated OEE further decreases with the introduction of the term "yield" which gives the exact picture of the material utilization in the industry.

Analyzing all the factors pertaining to this vast deviation of OEE, we can very well see that unskilled labor, poor maintenance, improper cleaning, continuous operation etc. are some major factors. Figures 3 to 6 illustrates the Pareto analysis of machine breakdown and defects. Out of these factors unskilled labors play a vital role in the reduction of OEE.

In order to improve the OEE of the equipments and the processes, the following measures may be implemented:

- Provide autonomous maintenance
- Implement regular training programmes to all the labour and staff
- Follow Kaizen's theory of continuous improvement
- Strictly adapt 5s concept
- Ensure planned maintenance on a regular basis
- Try to reduce the idle time to a minimum
- Ensure effective inspection of all the machined parts
- Try to implement advanced and sophisticated technologies
- It should be ensured that all work pieces undergo effective testing prior to the machining process to reduce material and surface defects
- To ensure the best performance of the machines, the following measures should be taken into account:

a. Keep a regular check upon the cooling system and change the coolant on a regular basis
b. Do not overload the machine
c. Make sure that the tool is effectively used
d. The work piece should be mounted properly in order to avoid improper machining and tool wear
e. Make sure that the machine is cleaned properly after each operation

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