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Improvement of Overall Equipment Effectiveness of a Cable Factory

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ABSTRACT: In today's scenario, power generation has diverse applications in food, automobile and medicine industries. India is currently third largest electricity producer in the world. Moreover, Power Consumption has been increasing every decade with abrupt increase in population. The quality of power generated in different sectors depends on the quality of electric cables. Hence, it is imperative to focus on manufacturing cables of superior standards. This can be achieved if the overall equipment effectiveness factory can be improved substantially.

KEYWORDS: Power Consumption, overall equipment effectiveness

I. INTRODUCTION

Overall Equipment Effectiveness is a technique used to measure the productivity of a manufacturing process. In other words, it identifies the amount of time utilized effectively to sustain quality output. It is a useful technique to determine the worth of the assets within the factory. Primary assets of any manufacturing industry are People and machines. Hence, goal of Overall Equipment Effectiveness is to improve the efficiency of the machine and man by making suitable modifications. Overall Equipment Effectiveness concept is in conjunction with Lean Six Sigma process as both of them aim for reducing inefficiencies through the manufacturing system. OEE basically considers four important parameters into account for determining the effectiveness of the manufacturing process. Important parameters are Loading, availability, quality and performance. Loading indicates percentage of total calendar time that is scheduled for operation. Availability indicates percentage of time available to operate the machine. Performance indicates the speed or the output delivered by the machine and manpower. Quality determines the nature of the output. Experimentally, it is difficult to control availability factor but one can definitely control performance and quality of the output.

II. RELATED WORK

In related work, Ranteshwar Singh et al.[1] studied Overall Equipment Effectiveness and its analysis using automation and software development. Farhad et al.[2] analysed overall effectiveness of the market using data collection. Ladan et al.[3] studied OEE for manufacturing and cable process. Vivek Prabhu et al.[4] analysed and developed an algorithm for optimizing efficiency of manufacturing systems. De Ron et al.[5] analysed effectiveness of a semi conductor industry. performance of the flat plate heat exchanger for heating systems. Shekhar et al.[6] improved manufacturing process using hypotheses model. Vijayakumar et al.[7] improved overall equipment effectiveness of injection moulding industry. Debadyuti Das [8] developed a tool for achieving excellence in operation systems.

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III. CABLE MANUFACTURING PROCESS

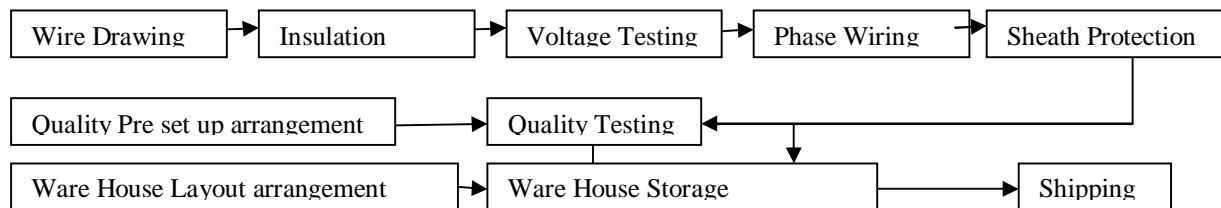


Fig. 1 Cable Manufacturing Process

In the above figure, the layout of cable manufacturing process has been shown. It is imperative to reduce inefficiencies in this process to improve overall equipment effectiveness. Further, this improvement should occur in continuous stages to improve sustainability of the manufacturing layout.

IV. OVERALL EQUIPMENT EFFECTIVENESS FOR THE CURRENT PROCESS

The effectiveness of the process is calculated as product of Availability, Performance and quality

$$OEE = \text{Availability} \times \text{Performance} \times \text{Quality}$$

$$\text{Availability} = (\text{Total Time available} - \text{Unplanned Down Time}) / \text{Total Time available}$$

$$\text{Performance} = (\text{Total production units} / \text{Operating Time}) / \text{Idle run rate}$$

$$\text{Quality} = (\text{Total Parts produced} - \text{Total defects}) / \text{Total parts produced}$$

Table 1. Parameters Involved To Find Effectiveness

Availability	Performance	Quality
Unexpected delay	Operator Inefficiency	Tool Wear
Maintenance	Fatigue Failure	Lack of Standardization
Public Holiday	Machine Inefficiency	Complacent attitude of workers

Availability refers to breakdown time, setup time and available time

Performance refers to reduced speed, efficiency of operator and machine

Quality refers to time wasted in rejection.

V. CASE STUDY

This study was conducted in Cable factory located in Chennai to find bottleneck operations in the manufacturing process. Objectives of the case study are to improve Overall Equipment Effectiveness, create enthusiastic environment to improve the efficiency of operators and machines.

5.1 PLANNED PRODUCTION DATA:

- Plant operating time = 8 hours x 3 shifts = 24 hours/day
- Working days = 24 hours/day
- Planned Down Time (breaks, refreshments) = 3 hours/day
- Ideal Run Rate of Machine = 10 metres/second

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5.2 ACTUAL PRODUCTION DATA:

- Unplanned Down Time = Change over time+ Break Time+ Power Loss+Mechanical Break down+ Electrical Breakdown

$$= 0.3+0.4+0.2+0.3$$

$$= 1.2 \text{ hours/day}$$
- Quantity produced(in meteres) = 3000 metres of copper wire.
- Quantity rejected (in meteres) = 850 metres of copper wire.
- Quantity Accepted = 2150 metres
- Actual Operating time of machine = 24- 4.2

$$= 19.8 \text{ hours/day}$$

5.3 OEE CALCULATION FOR CURRENT PROCESS:

- Availability = $19.8/24 = 0.825$
- Performance = $(3000/19.8)/(20/3600) = 0.841$
- Quality = $2150/3000 = 0.711$

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality} = 0.825 \times 0.841 \times 0.71 = 0.4923.$$

The OEE of the current process is 0.4923 which is below industrial standards. In order to improve OEE we need to analyse the root cause of the bottleneck operations. The standard OEE of an industry must be atleast 60 percent.

VI. FISH BONE DIAGRAM FOR IMPROVING OEE

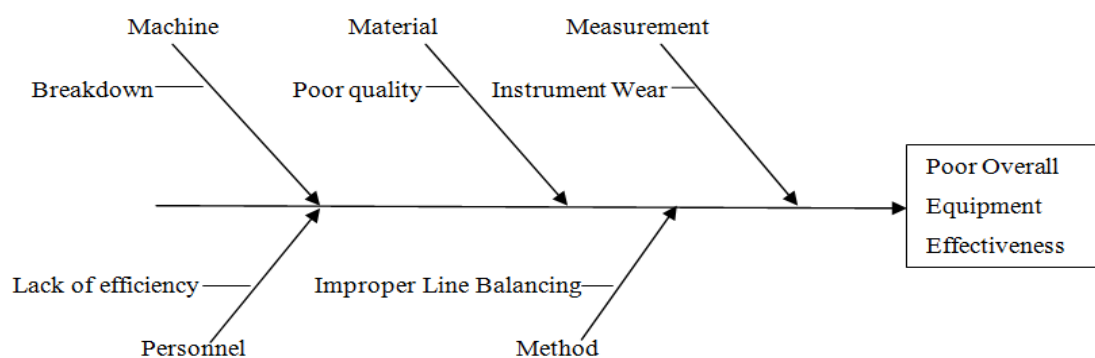


Fig. 2 Fish Bone Diagram

Fish bone diagram is used to find root cause analysis. It can help us to find different factors which are responsible the problem. This is a very important step because it can help us to find the right kind of solution for the given scenario.

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VII. PARETO CHART ANALYSIS

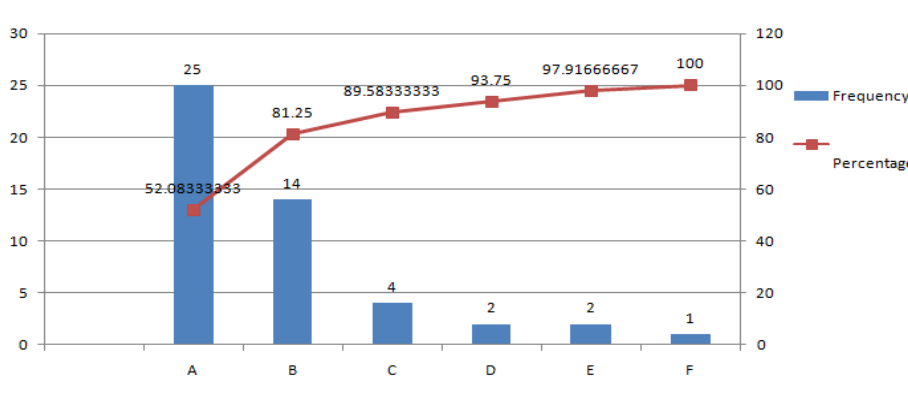


Fig. 3 Fish Bone Diagram

where A denotes Poor Output, B denotes Operator Inefficiency, C denotes unexpected Public Leave
D denotes Machine Breakdown, E denotes Organization Mismanagement
F denotes Lack of Poor Training

Here Pareto Chart shows that 80 percentage of the issues in OEE are caused because of poor output and improper operator efficiency. Hence, it is imperative to focus on improving operating efficiency and developing proper output. This can be done if the entire manufacturing system works in a balanced manner.

VIII. FEASIBLE SOLUTIONS

8.1 LINE BALANCING:

Line Balancing is a manufacturing technique in which the entire production line tasks are divided into equal proportions to improve productivity and reduce idleness. This can be improve the performance of the machine and labour and reduce defects.

Table 2. Production Activity Chart

TASK NAME	TASK SYMBOL	TASK TIME(Minutes)	TASK PRECEDENCE
Wire Drawing	A	35	-
Wire Insulation	B	25	A
Voltage Testing	C	12	-
Phase wiring and Protection	D	33	A,B,C
Marking	E	15	D
Data Collection Quality	F	25	-
Quality Inspection	G	30	A,B,C,D
Ware House Arrangement and cleaning	H	35	-
Transportation to Warehouse	I	35	G
Shipment	J	60	H,I

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In the above table the tasks are balanced such that the precedence of the tasks are not compromised. This makes the line balancing difficult to implement. Moreover, line balancing is done such that the time spent in each work station is closer to the cycle time of a workstation.

8.1.2 LINE BALANCING CALCULATION:

- Calculate Cycle Time(Minutes)

$$C = (\text{Production Time available/day})/(\text{Output Units/day})$$

$$= (24 \times 60)/(22)$$

$$= 65 \text{ Minutes}$$

- Calculate Theoretical Number Of Work Stations

$$N = (\text{Total Task Time})/(\text{Cycle Time})$$

$$= (242/60) = 4.03$$

- Draw Line Balancing Table and place the tasks in the workstations as per decreasing task time taking precedence relationship into account

Table 3. Line Balancing Chart

WORK STATION	TASKS COMPLETED	TOTAL TASK TIME
1	A,F	60
2	H,B	60
3	D,E,C	60
4	G,I	65
5	J	60

In the above table the assembly line is being balanced such each workstation takes close to 65 minutes. However, in the above scenario perfect line balance of 65 minutes in all work stations cannot be achieved. This leads to balance delay which is calculated by subtracting 65 minutes from the task time which is lesser than 65 minutes.

8.1.3 BALANCE DELAY:

- Balance Delay = (Cycle Time x number of Work stations)-(Total task time for all work station)
- $$= (325-305)$$
- $$= 20$$
- Balance Efficiency = Total tasks for all stations/ (Cycle Time x number of Work stations)
- $$= 305/325$$
- $$= 0.938$$

Improving line balance reduces the inventory and unnecessary delay time due to which efficiency of manufacturing system improves by 10%.

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8.2 ERGONOMIC CONSIDERATIONS

The above factory had poor Ergonomic working conditions. In order to increase efficiency of operators and other working staffs proper working conditions are required. Some standard guidelines for ensuring good ergonomic design are as follows

Type of Work and Factory areas	Illumination (foot candles)
1. Passage ways	5
2. Stair ways	10
3. Rough work	15
4. Normal work or auto-machine work	30
5. Ordinary bench work	50
6. Fine work	70
7. Fine assembly work	100
8. Minute and fine precision work	200-1000

Fig.4 Standard Lighting Conditions

In the above figure the illumination of work and factory areas are modified as per the standard requirements. This ensures that the work environment is conducive and safe to work. Moreover, it can avoid further accidents which otherwise would cause serious loss for the operator and the organization

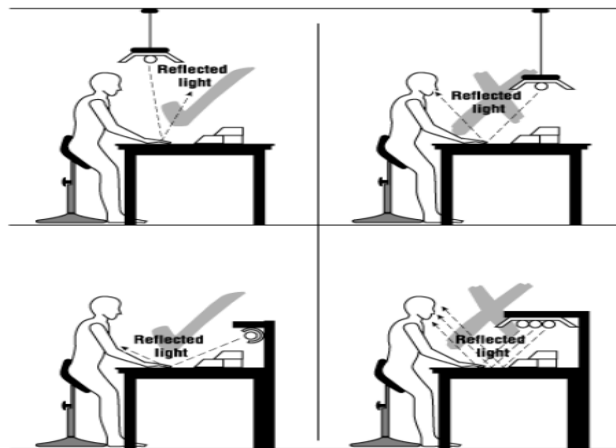


Fig.5 Standard Lighting Conditions

In the above figure the direction of lighting system is modified as per the needs of the operator. This ensures that operator does not experience any strain during working conditions. By implementing the above designs the operating efficiency of the personnel can increase by 3 percent.

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IX. OEE DATA FOR IMPROVED PROCESS

9.1 PRODUCTION DATA:

- Quantity produced(in meteres) = 3000 metres of copper wire.
- Quantity rejected (in meteres) = 500 metres of copper wire.
- Quantity Accepted = 2500 metres.
- Unplanned Down Time = Change over time+ Break Time+ Power Loss+Mechanical Break down+ Electrical Breakdown
= 0.3+0.4+0.2+0.1
= 1 hours/day
- Planned Down Time(breaks, refereshments) = 2 hours/day
- Ideal Run Rate of Machine = 20 metres/second
- Actual Operating time of machine = 24- (Unplanned time+ planned down time)
= 24-(3)
= 21 **hours**

9.2 OEE CALCULATION FOR IMPROVED PROCESS

- Availability = $21/24 = 0.875$
- Performance = $(3000/21)/(24/3600) = 0.91$
- Quality = $2500/3000 = 0.831$

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality} = 0.875 \times 0.91 \times 0.831 = 0.661.$$

Table 4.Comparison of the Parameters For The Current And Improved Process

PARAMETERS	CURRENT VALUE	IMPROVED VALUE	BENEFITS IN PERCENTAGE
Availability	0.825	0.875	6.0
Performance	0.841	0.91	8.33
Quality	0.711	0.831	16.87

Availability of the process is improved by 6%.
Performance of the process is improved by 8.33%
Quality of the performance is improved by 16.87%

X. CONCLUSION

We conclude that the Overall Equipment Effectiveness can be improved if we improve the quality of equipment and efficiency of the operator.We have improved the OEE of the existing manufacturing industry by **16.83%** using line balancing technique and modified ergonomic design for the operators.

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