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EVALUATION OF OEE IN A CONTINUOUS PROCESS INDUSTRY ON AN INSULATION LINE IN A CABLE MANUFACTURING UNIT

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Abstract: The exploration for improving productivity in the current global competitive environment has created a need for rigorously defined performance measurement system in a manufacturing process. OEE, a vital KPI of TPM is used to evaluate performance and productivity of the machine. OEE is one of the performance evaluation methods that are most common and popular in the production industries. This paper tries to evaluate the OEE index on insulation unit in a cable organization and identifies the main loss elements of the process. OEE data on machine performance is an initial key point to understand the equipment losses and establish improvement to eliminate them. The results are compared with world class level. Result of the research demonstrates that although the OEE coefficient of the investigated process is not meeting the world class level, however with the continuous improvement, performance of the machine can be acceptable.

Keywords: Performance measurement, Overall Equipment Effectiveness, Key Performance Indicator, Insulation unit, cable organization

I. INTRODUCTION

Globalization has expanded manufacturing organization with competition characterized by both technology push and market pull has forced the manufacturing companies to achieve world class performance through continuous improvement in their products and process. Today various innovative techniques and management practices such as TPM, TQM, and business process reengineering (BPR), ERP and JIT etc. are becoming popular among the business houses. TPM is maintenance program which involves a newly defined concept for maintaining plants and equipment. It is a philosophy designed to integrate equipment maintenance into the manufacturing process. The goal of any TPM is to eliminate losses tied to equipment maintenance or, in other words, keep equipment producing only good product, as fast as possible with no unplanned downtime [3].

TPM is used to drive waste out of the manufacturing process by reducing or eliminating production time lost to machine failures. The goal of any TPM is to ensure that machinery and equipment is always available to manufacture products for the end customer by minimizing rework, slow running equipment and down time, maximum value is added at the minimum cost.

Successful TPM is an effort where the entire organization works together to maintain and improve the equipment. As an initial initiative it is critical to measure even a small change. OEE is a metric originally developed to measure the success of TPM by associating the six big losses with three measurable: Availability, Performance, and Quality. OEE enables organization to benchmark and monitor their progress with simple, easy to understand metrics. OEE provides both a gauge for the success of TPM and a frame work to identify areas that can be improved.

LAPP INDIA is a 100% subsidiary of the LAPP GROUP manufactures Cables, Connectors, Cable Glands, Conduits and Accessories. They are the pioneers in introducing the concept of “Total solutions in Electrical Connectivity” in India, with their unbeatable range of products. Lapp India started operations at Bangalore in 1996, with a manufacturing unit and today they are the third largest manufacturing facility of the Lapp Group. Each year about 100,000 km of ÖLFLEX® connecting and control cables and insulated single cores are produced.

II. OVERALL EQUIPMENT EFFECTIVENESS

The industrial application of OEE, as on today, varies from one industry to another. Though the basis of measuring effectiveness is derived from the original OEE concept, manufacturers have customized OEE to fit their particular industrial requirements. OEE is a way to monitor and improve the efficiency of the manufacturing process. OEE has become an accepted management tool to measure and evaluate machine productivity. OEE is broken down into three measuring metrics of Availability, Performance and Quality. These metrics help to gauge the machine efficiency and effectiveness and categorize these key productivity losses that occur within the manufacturing process. OEE empowers manufacturing companies to improve their processes and in turn quality, consistency and productivity measured at the bottom line [2].

OEE is essentially the ratio of Fully Productive Time to Planned Production Time. In practice, however, OEE is calculated as the product of its three contributing factors:

OEE = Availability x Performance x Quality.

OEE = A x P x Q

III. FACTORS OF OEE

Three main contributig factors of OEE are:

- Availibility(A)
- Performance(P)
- Quality(Q)

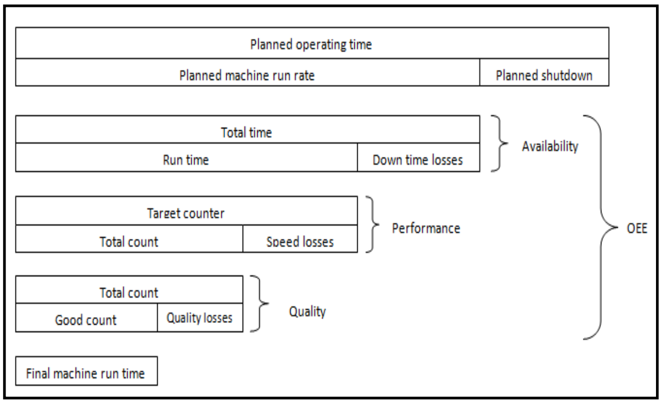

Figure 1Illustration of main components of OEE

A. AVALIBILITY

The "Availability" portion of the equation measures the percentage of time the equipment or operation was running compared to the available time. A comparison of the potential operating time and the time in which the system is actually making products or providing services. All planned stops and breakdowns will reduce the availability ratio, including set-up times, preventive maintenance, breakdowns and lack of operators.

$$\text{Availability} = \frac{\text{Operating Time}}{\text{Planned Production Time}}$$

B. PERFORMANCE

The "Performance" portion of the equation measures the running speed of the operation compared to its maximum capability, often called the rated speed. A comparison of the speed/actual output with what the system could be consistently producing in the same timeframe Loss of production due to under-utilization of the machinery. In other words, losses are incurred when the equipment is not run with full speed. Short, unregistered, stops may affect the performance ratio as well.

$$\text{Performance} = \frac{\text{Total Pieces }/\text{Operating Time}}{\text{Ideal Run Rate}}$$

C. QUALITY

The "Quality" portion of the equation measures the number of good parts produced compared to the total number of parts made. A comparison of the raw materials (or occurrences) put in to the process and the number of products/services that meet the customer's specifications. The amount of the production that has to be discharged or scrapped.

$$\text{Quality} = \frac{\text{Good Pieces}}{\text{Total Pieces}}$$

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IV. PROBLEM DEFINITION

As per the overall analysis in all the process, Insulation process was found to have a bottle neck as the line balancing was a big issue because insulation being the first stage and hence is input for other stages. Therefore further processes were idle. Since OEE helps in indicating the process, performance and as well as equipment problem. OEE was used as a measurement tool to evaluate the plant productivity. Thus this metric help gauge the machine efficiency, effectiveness and categorize these key productivity losses that occur within the manufacturing process.

V. CORE INSULATION PROCESS

The main scope of core insulation machine used to insulate the copper conductor. To ensure that the insulated conductor meets all the requirements of the specification as per the work order.

The procedure is as follows

Read the work order. Ensure that all required materials are available, if not inform the same to the Production section in-charge. Switch "ON" the Main Control panel and the computer behind the machine. Set temperature of each zone. Load the Work Order specified PVC and colour as in colour code. Load the Work Order specified Bunched copper wires on both the pay-off', in such a way that the finishing bunched end of one spool can be welded to the start of the next spool. Pull the bunched copper wire from the pay-off spool through the caterpillar and then the extrusion head through the die and nipple, and then the printing machine, the cooling trough, the accumulator, take-up caterpillar, dancer and on then the spool mounted on take-up. Ensure that the right type of PVC is used by checking with the Work Order and confirming with the inscription on the sacks. Select nipple and Die for a particular bunched wire. Initially set the extruder speed at around 10 rpm; purge the PVC until a homogeneous texture of PVC and colour is obtained. Set the voltage of spark tester on the control panel according to instructions given in the documents. Fix the selected nipple and die into the extrusion head, pull the bunched copper wires along the line unto the take-up-spool. Fasten this to the take-up spool. Switch on the water pump. Arrange empty spools on the take-up conveyor. All the above points must be checked again, before starting the line. Set the line tension between pay-off and Take-up caterpillar according to the graph on the control panel. Operate Decrease / Increase buttons under the heading PULL to decrease or increase the tension of the line respectively.

Switch the selector switch of the line to STARTING mode and selector switch of extruder to INDEPENDENT/ SYNCHRONISED as required. Independent push button is used while purging the PVC from the extruder to obtain the right blend. Synchronised push button is used when the line is in operation and also the colour-mixing device when the colour-mixing device is simultaneously put on. Switch ON the line by pressing START push button and extruder push button. Close the molten PVC discharge port; observe the diameter and finish of extruded core. To adjust the diameters required increase or decrease the speed of extruder using push buttons. The pull increase or decrease is used to give proper tension to the bunched copper wires entering the extrusion head.

At the take-up unit feed empty spools on the ramp and take-up pintails. Start the machine by pressing the start button on the control panel under the heading 'Line'. Check for the diameter of the core on the control panel and turn the knob to 'Production' on Control Panel. Empty the exit ramp as the spools are being filled up. After completion of the spools unloaded paste the label and offer to QC. Clean the machine and it's surrounding at the end of every shift and update the daily report, and hand over the scrap to QC.

VI. SIX BIG LOSSES IN MANUFACTUING PROCESS WITH RESPECT TO INUSLATION

Looking at machine operation, we distinguish six types of waste we refer to as losses, because they reflect lost effectiveness of the equipment. These six big losses are grouped in three major categories: downtime, speed losses, and quality losses. The major goals of OEE are to reduce and/or eliminate the most common causes of efficiency loss in the manufacturing process [14].

Table 1Six big losses in manufacturing process w.r.t insulation process

SIX BIG LOSS CATEGORY	OEE LOSS CATEGORY	EVENT EXAMPLES W.R.T INSULATION PROCESS
Break downs	Down Time Loss	• Die changing • Equipment Failure • Unplanned Maintenance
Setup And Adjustments	Down Time Loss	• Setup/changeover of printing wheels • Extruders shortages • Unskilled Operator • Color Change • Warm-up Time

Small Stops	Speed Loss	• Cleaning of the nozzle • Color trail • Temperature setting • Components Blocked • Hopper Problem • Mesh Block
Reduced Speed	Speed Loss	• Equipment Wear • Slow speed in CL2 Cu • Under Design Capacity
Start-up Rejects	Quality Loss	• Scrap • Rework • Printing problem • Diameter variations • Color Variations
Production Rejects	Quality Loss	• Scrap • Rework • Semi print problem on cables • No print problem • Texture Change (Core finish)

VII. CALCULATION OF OEE

- Working days in a month = 25 days
- No. of shifts in a month = 25 × 3
- Shift length = 8 hours = 480mins
- Short break = 0 mins (machine will not stop)
- Meal break = 0 mins
- Down time (machine + setup time) = 60 + 90
- = 150 mins
- Total length = 60,000 mts
- Rejected length = 1096.77 mts

A. AVALIBILITY

Availability = Operating Time / Planned Production Time
Planned Production Time = Shift Length – Breaks
= 480 - 0
= 480 min
Operating Time = Planned Production Time - Down Time
= 480 – 150
= 330 min

Availability = 330 / 480 = 0.6875*100
Availability = 68.75%

B. PERFORMANCE

Performance = (Total length / Operating Time) /Ideal Run Rate
= (60,000 length / 330 minutes) / 400 lengths per minute
= 0.4545 or 45.45%
Performance = 45.45%

C. QUALITY

Quality = Good length / Total length
Good length = Total length - Reject length
= 60,000 – 1096.77
= 58903.23

Quality = 58903.23 – 60,000
= 0.9817 or 98.17%
Quality = 98.17%

D. OVERALL EQUIPMENT EFFECTIVENESS
OEE = Availability x Performance x Quality
= 0.6875 x 0.4545 x 0.9817
= 0.3069 or 30.69%
OEE = 30.69%

VIII. RESULT AND DISCUSSION

The OEE tools were used to compute the OEE for the insulation process. OEE breaks the performance of a manufacturing unit into three separate but measurable components: Availability, Performance, and Quality gives OEE process. OEE of insulation process is 52.93%.the average OEE for the insulation process is as shown in the graph.

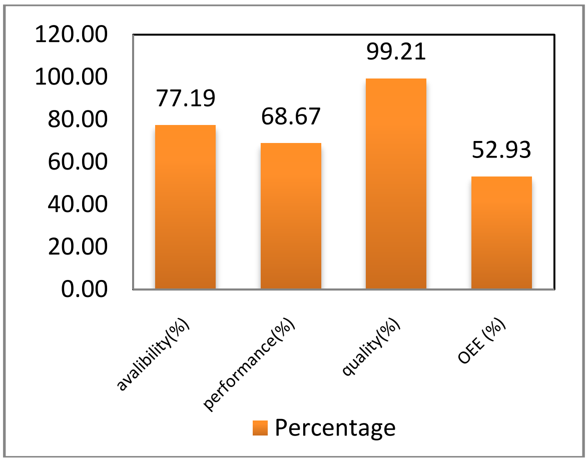

Figure 2 Graphical representation of OEE and its components

There are three main time losses during which are downtime loss, speed loss, quality loss. These losses are important to identify for calculation of OEE and to evaluate effectiveness and efficiency of the machine.

IX. CONCULSION

Comparison between World Class and Insulation process OEE rates:

Table 2 Comparison of World Class OEE factor And insulation process factor

OEE FACTORS	WORLD CLASS	ASSEMBLY PROCESS
Availability	90.0%	77.19%
Performance	95.0%	68.67%
Quality	99.9%	99.21%
OEE	85.0%	52.93%

The main aim of taking up this study in the company was to calculate the OEE which gives us an understanding about the machine efficiency and in turn gives the right percentage of the machine utilization there by helping us to detect the bottlenecks. According to performed studies on OEE factors in insulation unit, the Availability is 77.19%, Performance is 68.67%, and Quality is 99.21%. The achieved result show distance between OEE in this process and World Class Level. Therefore the world class level OEE for continuous production process is 85%. The major reason for the distance is performance factor level in this process. In order to reach to world class level, insulation process performance level has to enhance to 95%. On the other hand current level is 68.67% lower than what is necessary to reach to world class level.
Identify and measure 6 big losses of this process were other aim of the research. These losses mainly are downtime losses, speed losses, quality losses which affect OEE. To minimize these losses and to achieve world class OEE there should be reduction in events which are discussed in six big losses section. The main events which are responsible for losses in insulation process are:

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- Die changing
- Setup/changeover time of printing wheels
- Extruder shortages
- Colour change
- Semi skilled operators
- Slow speed for different class of copper
- Temperature settings
- Smoke from Herkula ink affects the health of operators

It is important to reduce these non productive events which affect efficiency of the process. They can be reduce by implementing new techniques and tools, standardized speed for running the line, skilled labours, special purpose machinery which wont affects the environment of the shop floor etc.

A. FUTURE RECOMMENDATIONS

The scope of improvement for the future course is highlighted by the recommendations which were done by a series of brain storming sessions and visiting the shop floor, observing the daily activities of the operators and the works.

This study selected the area of OEE and conducted an appropriate study on the subject. On the basis of the theory studied and analyzed, a set of recommendations were suggested in order to improve the OEE thereby increasing the output of the machine.

Table 3 Recommendation for insulation process

AREA OF OPPORTUNITY	RECOMMENDATIONS	BENEFITS
Core Extrusion (Insulation)	Use of the wind turbines in the shop floor. Line speed of the machine should be increased.	Operators can get rid of health hazards. Increases the productivity.

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