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Productivity Improvement of Excavator Assembly Line

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Abstract: In this world of intense competition, each industry and organization are in the hunt of something new or creative so they can persist with the full efficiency and certainty, and contend with their competitors. This paper presents a case study to expand the productivity of the organization with the help of modern productivity improvement techniques. The case study focuses on the productivity improvement of the Excavator assembly line with the help of modern productivity improvement techniques like Total Productivity Maintenance, Total Quality Management, 6S technique, Just-in-Time, etc .

A methodology is proposed that helps to improve the productivity of the assembly line. The methodology consists of study of the current operations carried out on the assembly line, followed by various processes to achieve the objective of the study. Once the current working methods of the assembly line are studied and documented, all the operations carried out must be timed and the shortfalls in the working process should be identified and terminated. Operations analysis allows the reduction of non- value added activities and results in a set of standardized work elements together with a set of standard procedures for carrying out the operations on the assembly line. Various calculations are carried out for the current working processes to get a detailed idea of activities performed on the assembly line. These calculations are analyzed and possible improvements are implied to reduce the work time and labor required to complete the operations. Using various techniques of productivity improvement, different suggestions are put forward to enhance the working process. The predicted results, obtained from the improved calculations and application of the proposed suggestions, are satisfactory.

Keywords: Productivity, productivity improvement techniques, Total Productivity Maintenance, Total Quality Management, 6S technique, Just-in-Time.

I. INTRODUCTION

Productivity is significant for every organization to procure profits and contend in market. For the most part, the productivity is the ratio of output to the input. As such, productivity is characterized as creating greatest output with least input. Output implies number of items produced and inputs are different assets utilized like Man, Machine, Money, and so on. Before you can embrace any strategy for productivity improvement, you should quantify your current output levels, make a pattern and actualize answers for estimating change. Productivity can be increased with the effective use of available resources. Higher productivity ensures higher earnings. Therefore productivity improvement is of prime importance. The productivity of an organization can be improved with the help of various modern productivity improvement techniques such as Total quality management, Total productivity maintenance, Line balancing, Just-in-time, 6s technique, etc.

Organizations are encountering furious competitions because of globalization. Many organizations are practicing the advanced techniques of productivity improvement to help take out waste and increment productivity. Overall Equipment Effectiveness is the bar for measuring manufacturing productivity. Estimating OEE is a manufacturing best practice. By estimating OEE and the basic losses, you will gain significant insights on the most proficient method to systematically improve your manufacturing procedure. OEE is the absolute best measurement for distinguishing losses, benchmarking progress, and improving the efficiency of manufacturing equipment (i.e., eliminating waste).

II. AIM & OBJECTIVES OF THE STUDY

A. Aim

The aim of the study is to improve the productivity of excavator assembly line.

1) With Zero Accidents
2) With Zero Defects
3) Less Carbon Footprints
4) Without Overtime
5) Without Increasing Manpower

B. Objectives

Objectives for achieving the directed aim are as follows:

1) Analysing the processes, distinguishing the value added and non value added basic activities.
2) Conducting time study analysis of all the assembling operations.
3) Documenting the acquired information into standardized work sheets.
4) Providing standard work procedures for training of new operators.
5) Providing recommendations for development of the line tasks.

III.LITERATURE REVIEW

A. Productivity

Productivity is an average measure of the efficiency of production. It can be expressed as the ratio of output to inputs used in the production process. The productivity of an organization directly affects the profits the organization can gain. Higher productivity ensures higher benefits for an organization. Productivity improvement of an organization depends on various factors such as Man Power, Equipments and Machines, Input materials, Time, Space Available, Energy sources, Finance, etc.

B. Total Quality Management

Total quality management (TQM) is the consistent procedure of identifying and lessening or disposing of mistakes in assembling, smoothing out store network management, improving the client experience, and guaranteeing that representatives are up to speed with preparing. Total quality management plans to hold all gatherings associated with the creation procedure responsible for the general quality of the last item or administration.

Total quality management (TQM) is an organized way to deal with generally speaking authoritative management. The focal point of the procedure is to improve the quality of an association's yields, including merchandise and enterprises, through persistent improvement of inside practices. The norms set as a feature of the TQM approach can reflect both inward needs and any industry gauges as of now set up. Industry measures can be characterized at different levels and may incorporate adherence to different laws and guidelines administering the activity of the specific business.

C. Total Productivity Maintenance

TPM (Total Productive Maintenance) is a comprehensive approach to equipment maintenance that attempts to obtain perfect production:

1) No Breakdowns
2) No Small Stops or Slow Running
3) No Defects

In addition it gives importance to a safe working environment:

a) No Accidents

D. Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is a measure of the productivity or capacity of production of an organization. OEE of an organization is calculated by considering the various factors such as Availability, Performance and Quality. After considering the various factors the obtained results are expressed in percentage. An increase in OEE of the organization directly ensures increase in the productivity of the organization.

TABLE I
FORMULAS FOR OEE CALCULATIONS

PARAMETER	FORMULA
OEE	AVAILABILITY * PERFORMANCE * QUALITY
AVAILABILITY	RUN TIME / PLANNED PRODUCTION TIME
RUN TIME	PLANNED PRODUCTION TIME - STOP TIME
PERFORMANCE	(IDEAL CYCLE TIME * TOTAL COUNT) / RUN TIME
QUALITY	GOOD COUNT / TOTAL COUNT

The calculation of OEE is based on the Six Big Losses of Total Productivity Management.
There are six equipment losses recognized inside TPM that are utilized to calculate OEE;

1) Availability
   a) Breakdowns
   b) Changeovers
2) Performance
   a) Minor Stoppages
   b) Reduced Speed
3) Quality
   a) Defects
   b) Setup Scrap

E. Sample Calculation

A sample data is recorded for the calculations of OEE.

TABLE II. COLLECTED DATA

ITEM	DATA
SHIFT LENGTH	8 HOURS (480 MINUTES)
BREAKS	(2) 15 MINUTES AND (1) 30 MINUTES
DOWNTIME	52 MINUTES
IDEAL CYCLE TIME	1.0 SECONDS
TOTAL COUNT	20,000 PRODUCTS
REJECT COUNT	503 PRODUCTS

1) *Planned Production Time:* As mentioned above, calculation of OEE begins with Planned Production Time. Therefore calculate Planned Production Time by excluding all the time when there is no production, from the Total Time (mostly breaks).

   Planned Production time = Shift Length - Breaks
   Planned Production time = 480 minutes – 60 minutes = 420 minutes

2) *Run Time:* To calculate Run Time, calculate the difference between Planned Production Time and the Stop Time. Stop Time includes all Planned Stops (E.g. Changeovers) and Unplanned Stops (E.g. Breakdowns).

   Run Time = Planned Production Time – Stop Time
   Run Time = 420 minutes – 52 minutes = 368 minutes

3) *Good Count:* If the Good count is not directly obtainable, it also needs to be calculated.

   Good Count = Total Count – Reject Count
   Good Count = 20,000 products – 503 products = 19,497 products

4) *Availability:* The first factor of OEE calculation is Availability. The time when the production is not running (both planned and unplanned stops) is considered in Availability.

   Availability = Run Time / Planned Production Time
   Availability = 368 minutes / 420 minutes = 0.8761 (87.61%)

5) *Performance:* The second factor of OEE calculation is Performance. Performance considers for when the production is running slower than desired speed.

   Performance = (Ideal Cycle Time * Total Count) / Run Time
   Performance = (1.0 seconds * 20,000 products) / (368 minutes * 60 seconds) = 0.9057 (90.57%)

6) *Quality:* The third factor of OEE calculation is Quality. It considers the parts that are defected i.e. the parts that do not meet the quality standards.

   Quality = Good Count / Total Count
   Quality = 19,497 products / 20,000 products = 0.9748 (97.48%)

7) *OEE:* Now, to calculate OEE, multiply all the three factors.

OEE = Availability * Performance * Quality OEE = 0.8761 * 0.9057 * 0.9748 = 0.7734 (77.34%)

Thus the calculated OEE for the given data is 77.34%.

F. Just-in-Time

The just-in-time (JIT) inventory system is an administration procedure that adjusts raw-material requests from providers straightforwardly with production plans. Organizations utilize this inventory procedure to increase efficiency and reduce wastage of capital and time by receiving material just as they need them for the production procedure, which lessens inventory costs.

G. 6S Technique

Industries around the world practice 6S in order to enhance human capability and productivity. 6S technique is a systemized technique used by organizations which comes from the 5S Japanese technique. The 5S technique stands for- Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardize), and Shitsuke (sustain) and the sixth S refers to Safety‘. As safety plays a vital role in the industry, 6S contributes significantly in organizing a workplace for obtaining greater efficiency and decreasing waste and optimizing quality and productivity via monitoring an organized environment and keeping the workplace environment safe from hazards. It also provides useful practical demonstration to obtain more solid results.
Six Pillars of 6S are:-

1) *Sort:* Separate what is required in work place and eliminate the redundant materials.
2) *Set-in-order:* Arrange the remaining required materials.
3) *Shine:* Maintain a clean and effective environment on a daily basis.
4) *Standardize:* Standardize all the practices being followed that is sorting, inspection, cleaning and safety practices.
5) *Sustain:* Maintain the discipline every day.
6) *Safety:* Develop and maintain a safe workplace.

IV.METHODOLOGY

A. Study

The study is based on the excavator production in an organization. The production initiates at the fabrication shop where the frames and body of the excavator are fabricated.
The fabricated parts of the excavator are transported to the Assembly line with the help of cranes. The assembling begins at the sub-assembly line where all the sub-assemblies of the excavator are done at various sub-assembly stations like Main Control valve sub-assembly, Base plate sub-assembly, etc. These sub-assemblies are transferred to the main assembly line where the actual assembling of the excavator begins. Small parts that are required during the assembly are kitted and made available at the stations of the main assembly line with the help of kitting trolleys. Thus all departments of the excavator assembly work together for the production of excavators.

B. Data Collection

The data collection includes collecting various details of the excavator production like production per day, cycle time, Man-Machine relation, process flow of the assembly line, methods used for transportation of materials, etc.

C. Problem Observation

1) Number of excavators produced per day is less than the possible number of excavators that can be produced.
2) Higher cycle time.
3) Speed losses are more.
4) The assembly line is not balanced.
5) Quality of materials is poor.
6) Number of cranes is less.
7) Changeover time is more as the assembly line is multimodal.
8) Sorting and setting of stored materials is not in order & improper.
9) Excessive storing of inventory.

10) Filling of kitting trolleys beyond their capacity.
11) No proper communication system between store and assembly line workers.
12) Packaging of stored parts is not proper.
13) Several breakdowns of the robot welding operations in the fabrication shop.
14) Assembly line is not balanced and therefore consumes more time than required.
15) Improper tacking of the track frame of the excavator gives rise to problems during welding operations.

D. Suggestions for Improvement

1) Cycle time can be reduced with the help of line balancing and process sequencing.
2) Separate toolkits for each station at the assembly line must be provided.
3) Flexible kitting trolleys must used for material transportation.
4) Separate assembly lines for light duty models and heavy duty models are to be established.
5) 2S implementation in material stores.
6) Kitting trolley sets must be pre-defined.
7) Electric Stacker trolleys for parts that are heavy and are kept at more distance from the assembly line.
8) Inventory checks of the stores to be carried out regularly.
9) Proper packaging of parts and checking must be done regularly.
10) Parts must be inspected before storing.
11) Planned maintenance of the welding fixtures & machineries in the fabrication shop must be done.
12) New updated fixtures like hydraulic tacking fixtures must be employed.
13) Travel time of transport vehicles inside the shop floors must be decreased by changing the layout of the shops.
14) AGVs must be used for transportation of track frames to reduce travel time.
15) Better automated robot welding fixtures are required for track frame welding.

V. RESULTS

The detailed study of the Excavator Assembly line helped in identifying the importance of cycle time study and the line balancing. Numerous methods and suggestions can be applied to achieve desired results. Calculations based on the study are carried out and presentable results are drawn.
Following results can be acquired from the implementation of the various suggestions and improvements provided:-

A. Increase in the Overall Equipment Effectiveness of the assembly line.
B. Reduction in Losses due to elimination of non value added activities.
C. Carbon emission of forklifts reduced as the distance travelled by them is reduced.
D. Productivity of the assembly line enhanced.

VI. CONCLUSION AND FUTURE SCOPE

A. Conclusion

The case study supports that by using the Modern techniques of Productivity Improvement, various non-value added processes and losses in production process of Excavator can be reduced. Thus the Production in the Excavator assembly line can be improved. The ergonomic condition of the workers and manpower utilization can also be improved after implementation of proposed suggestions. Thus the overall productivity of the excavator production can be increased:
1) With Increased quality.
2) With Reduced accidents.
3) Without over time.
4) Without increasing manpower.
5) With Reduced carbon foot prints.

B. Future Scope

1) The research can be utilized to improve productivity of any organization by appropriately applying standard processes.
2) The research can be further utilized as a reference for further researches related to the case study.

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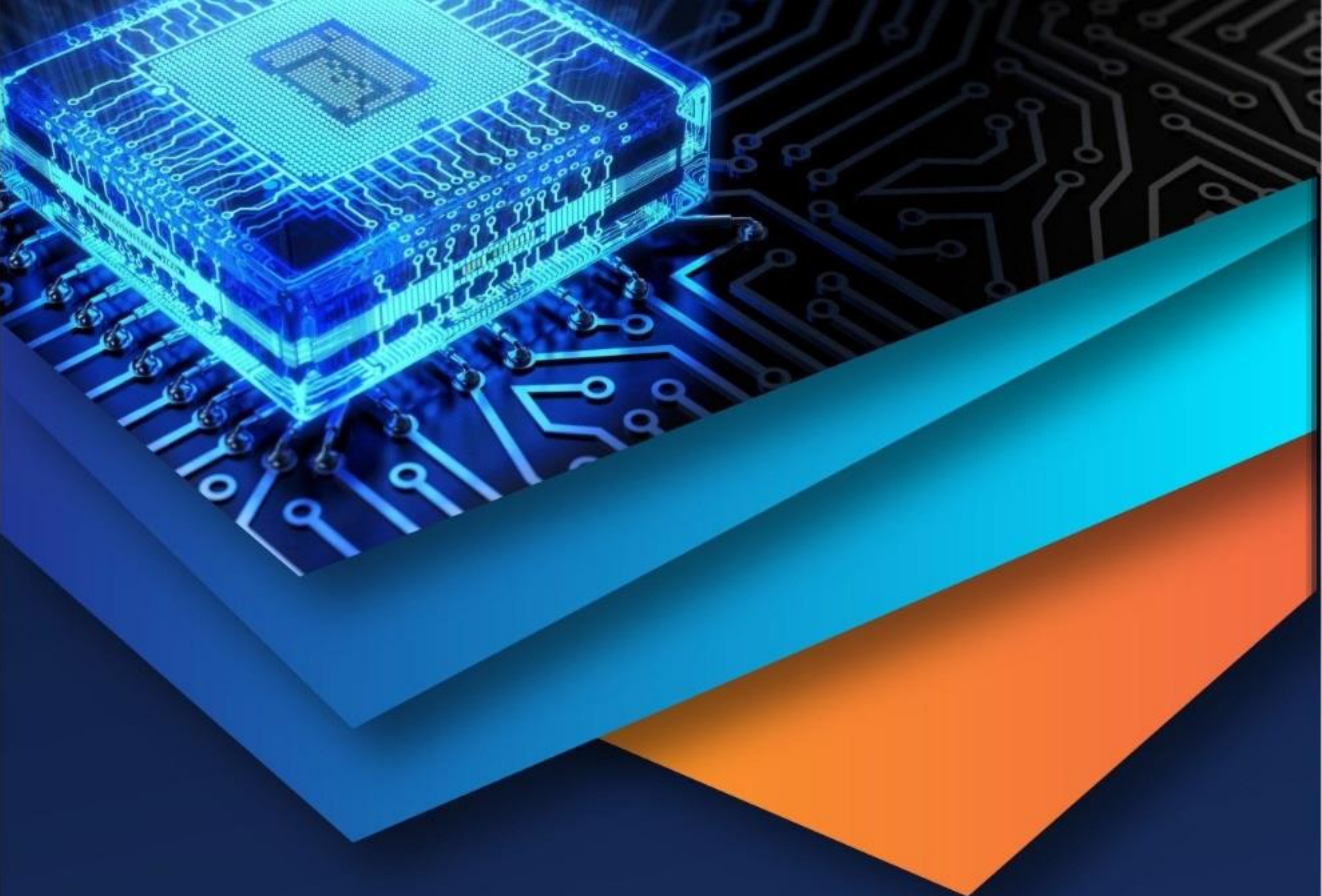

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