Reducing the Truck Turnaround Time inside a Heavy Manufacturing Industry through Makigami Analysis

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Abstract- ***Any manufacturing industry is dependent on the effectiveness of the system to make the parts available on the assembly line in time. Material flow plays a vital role in the final production capacity of the industry. The turnaround time of trucks determine the efficiency of the unloading system and storage facility in the plant. The higher the number of parts involved, the higher will be the complexity of storage system and hence, the truck turnaround time will be higher. This turnaround time is a loss for the plant as it is the waiting time for materials in assembly line. A case study has been conducted at a heavy engineering company which follows the JIT philosophy to understand the effect of material flow on the productivity of the plant.***

Keywords: Material Flow Analysis (MFA), Total Productive Maintenance (TPM) tools, Makigami Analysis, PDCA Cycle, Kaizen, Overall Equipment Effectiveness (OEE)

I. INTRODUCTION

Truck turnaround time or the time taken by the truck to enter the gate, complete all operations inside the plant and exit the gate is a major concern for all industries. It increases traffic and hence coagulation of trucks at unloading bays, causing delays. Also increased number of trucks inside the plant campus also raises the safety concern of the plant [1]. In heavy manufacturing industries, where the number of parts involved is very high per unit product and also the parts are huge in size and cost effective and are mostly outsourced to vendors around the world, truck turnaround time becomes a major factor to ensure high productivity of the plant [13].

Logistics of the parts involve movement of trucks from the vendors or ports into the manufacturing facility. These trucks follow pre-defined routes inside the plant for the unloading of all materials. Since the number of parts involved in the manufacturing of a single unit of equipment is huge, the number of trucks carrying them to the plant is also high. These trucks arrive at the plant and their entry is usually done on FIFO basis [14].

The truck turnaround time is calculated by measuring the average time taken by a truck's from its arrival at the facility to its departure.

It is a part of Material Flow Analysis. MFA is the study of physical flows of resources and materials into, through and out of a system. It is based on categorically organised accounts in physical units and uses the principle of mass balancing to analyze the relationships between material flows, including human activities, energy, economic and trade developments and environmental changes [2].

A. Problem Statement

In any production industry, the industrial business function can be broadly classified into "Manufacturing" and "Supporting Functions" like supply chain, quality management, administrative management, etc. [3]. In order to increase the hold of an organisation in the market, quality of the product and services associated with it must be improved continuously. Logistics and supply chain are the most important links in the supporting functions for the production. By understanding the variety and interrelationship of supply chain risks, managers can create balanced and effective risk-reduction strategies for companies [4].

The focus is shifting to post-manufacturing operations, an area that has been greatly neglected so far. Functions like logistics, supply chain, service, etc. are gaining more importance in order to provide value to customers and to quicken the cash flow [5].

Using Japanese philosophy of continuous improvements or Kaizens in the supportive business functions, the production of equipment can be made lean and agile. Improving the service quality of the 'supportive business function' is bound to give a higher Return on Investment (ROI) in a shorter Payback Period [3].

According to Bolstroff, truck turnaround time is the most important key performance indicator in any kind of logistics operation [6]. A short turnaround time is economically beneficial, making efficient use of the available time and materials [7]. It ensures quick loading/unloading activity and hence fast material flow and quicker delivery at the assembly line.

B. Objective

To study the truck turnaround process in heavy industries in detail, a case study was conducted at a construction machinery manufacturing plant in Eastern India.

The primary objectives for the study were designed as follows:

a. To ensure quick and smooth flow of materials inside the plant.

b. To ensure minimum number of trucks inside the plant at a time.
c. To improve the efficiency of material handling in the plant.

To ensure a quick truck turnaround, the processes involved are to be understood in detail. The activities that do not add value to the process need to be identified suitably so that they can be eliminated or optimised. In order to do so, a number of tools are available for use. This paper discusses the application of 'Lean Philosophy' and Total Preventive Maintenance (TPM) in the supporting functions of a production industry. An office TPM tool- Makigami Analysis- has been used to study the process and pinpoint the non-value adding (NVA) activities in it.

C. TPM Tools

5 S Philosophy:

The 5S philosophy simplifies work environment, focuses on effective work place organization and reduces waste while improving quality and safety. There can be no improvement if wastes or scrap are continuously present. Auditors enter the individual 5S scores for every task and then check the result with the decided benchmarks.

Japanese Terms	English Translations	Equivalent 'S' Terms
Seiri	Organising	Sort
Seiton	Tidiness	Systemize
Seiso	Cleaning	Sweep
Seiketsu	Standardization	Standardize
Shitsuke	Discipline	Self-Discipline

Table 1. The 5 S's in a shop floor

Why-Why Analysis:

Why-why analysis method is a root cause analysis method by continuous questioning in order to identify the root cause(s) of a problem. Once the root cause is known, suitable solution can be suggested. Rather than taking evasive actions or temporary solutions, a why-why helps to really prevent the issue from happening ever again.

Kaizen:

Kaizen is a Japanese term where "Kai" means change and "Zen" means good (or for the better). A kaizen is a small improvement without much data analysis to bring a change for the better. The Kaizen concept stimulates productivity improvement as an on-going process in a company. With practice, continuous improvement becomes a habit or a culture.

Value Stream Mapping:

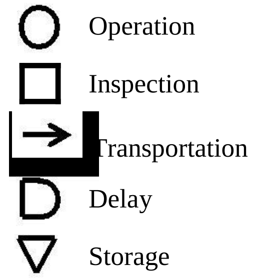
Value Stream Mapping (VSM) is a special type of process flow chart that uses symbols known as "the language of Lean" in order to depict and improve the flow of inventory and information in an industry. It is a tool used to visualise the presence of waste in the whole process flow from the supplier's raw material and parts delivery until it sees its way through till finished product delivery to the end customer.

Makigami Analysis:

Makigami Analysis is a Japanese TPM philosophy used to pin point the non-value adding activities in the process. It is a LEAD (Lean Enterprise Across Discipline) technique of office TPM and is used to identify the losses in the current process flow in order to design the future state process map [3]. It is done in the following steps.

1. Study the overall process in consideration
2. Identify the area of improvement in the entire process
3. Study the steps involved in the identified process
4. Pin-point the non-value adding activities in the process
5. Suggest suitable Kaizens
6. Prepare a Future State Makigami Analysis
7. Apply Kaizens

Makigami literally translates to 'Roll of Paper' where the complete process is structured in detail in a long sheet of paper with standard ASME process symbols [15].



Once the complete process is clear on a sheet of paper, the NVA activities and NVA time can be identified with ease.

Makigami Analysis vs. VSM:

The standard value stream map does not give the complete information of shopfloor environment. It makes it difficult to reflect on and to work on to make the processes and working system better [8]. The Makigami Analysis approach has been built upon traditional hybrid swim-lane mapping to provide all details, like type of flow, medium of flow in the process, etc., in a structured manner. It also offers a step-by-step approach to create a transactional swim-lane. This approach, being simple as well as consisting the additional details within the map, has led to its increasing popularity among value analysis practitioners [9].

Also, the use of Makigami Analysis has been used in processes where the flow is not physically visible. This paper discusses the use of the method for visible processes in the industry. The entire material flow has been analysed using this method as discussed further in details in this paper.

II. WORKING METHODOLOGY

The following steps were taken for the study to reduce the turnaround times for all the trucks inside the plant.

Step 1. Selection of appropriate *administrative* process for the Analysis, which has higher impact on entire organization

Step 2. Perform Makigami Analysis of the selected process, through Plan-Do-Check-Act (PDCA) way (data collection, current state process mapping, brainstorming for Muda identifications (wastes), and future state process mapping etc.)

Step 3. Conformation of outcomes through expert reviews.
Step 4. Further Identification of area for improvements Step 5. Work on identified improvement areas through PDCA
Step 6. Recurring of the improvements in continual way
Step 7. Identify scope for improvements for project hand-off
Step 8. Reporting of the work, summarize the improvements as conclusions

PDCA Cycle:- PDCA Cycle was used to analyse the process flow in consideration. PDCA is a continuous improvement tool and a framework that provides a methodical approach to problem solving and continuous improvement. Sometimes it is also called by Shewart Cycle / Deming Wheel [10].

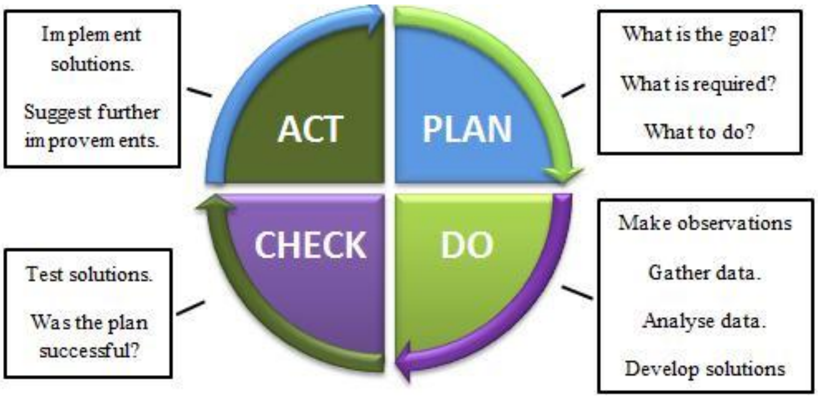


Fig.1. PDCA Cycle

Plan:

- An overview of all activities in the plant to get a "Bird's Eye View"
- What are the processes involved in truck turnaround?
- Who is involved in the process?
- How to map the truck turnaround?
- What resources are required to collect the data?
- Who will note the times for the trucks?
- Who will analyse the time taken and the losses?
- What loss identification tools are to be used?

Do:

- Study the activities performed by the trucks inside the plant.
- Study the time taken by the trucks in each activity.
- Study the documents or media involved in the flow of the process.
- Map all readings in the process sheets.

Check:

- Apply loss identification tools.
- Identify the losses involved in the truck turnaround.
- Suggest loss reduction methods.
- Simulate the suggested methods.
- Propose a future state process map.

Act:

- Apply the changes in the truck turnaround process.
- Make everybody in the plant aware of the changes in the process.
- Train concerned personnel about the changes in the process.
- Take repeated follow-ups and feedbacks about the changes.
- Define a platform for further improvements.

Using a conventional PDCA cycle, the Makigami Analysis can be done for the truck movement and material flow inside the entire plant. However, the implementation of the changes in the plant is a time consuming and challenging. Similar to any other lean manufacturing methods, the implementation of the outcomes of Makigami Analysis has criticisms like inability to cope up with the variability and changes, lack of considerations of human aspects, lesser scope of flexibility, clarity issues from the top and middle management, lack of commitment, etc. [11].

III. PROCESS OVERVIEW

The sequence of operation is shown in Fig.2.

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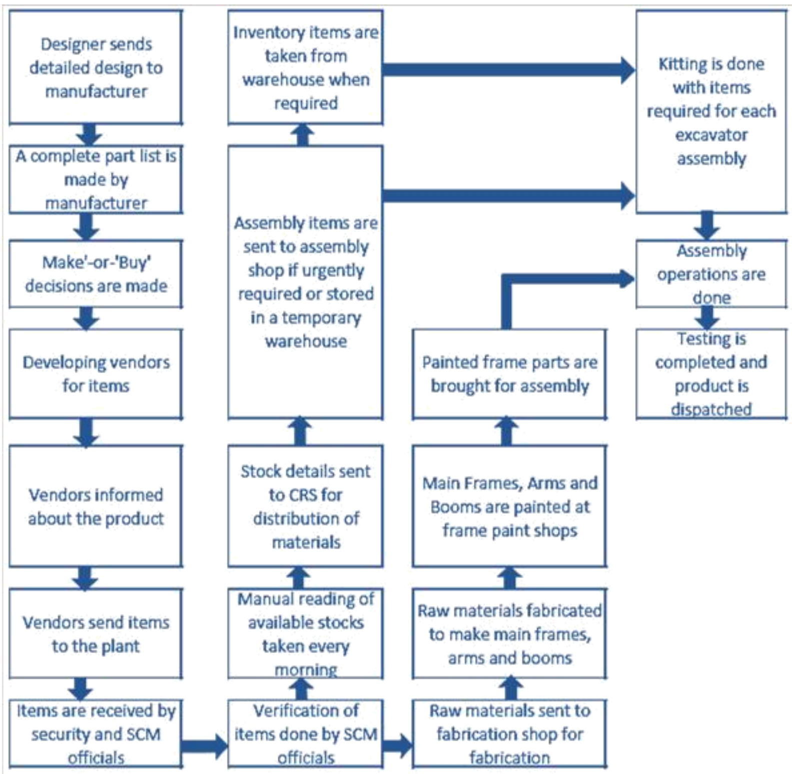


Fig.2. Sequence of Operations in the plant

There are primarily two types of trucks moving inside the plant:

- Open Trucks (Domestic goods only)
- Container Trucks (Domestic and Imported Goods)

The truck turnaround time in the plant is governed by the following workstations:

- Gate office – entry for all trucks
- Central Receiving Stores (CRS) – unloading of Open Trucks
- Dock Leveller – unloading of Container Trucks Apart from the workstations, time is also consumed in the movement of the trucks from one station to another.

For every station a sample of 10 trucks were taken to take an average reading. All trucks carried different number of items. An average has been taken for 10 packages and 10 invoices in each truck in order to maintain uniformity.

IV. DATA PLOTTING

Makigami Process Sheets:-

The process is plotted on the Makigami process sheets in detail with time taken for each step noted carefully from several observations.

Several Makigami sheets are required to understand the detailed nature of the process.

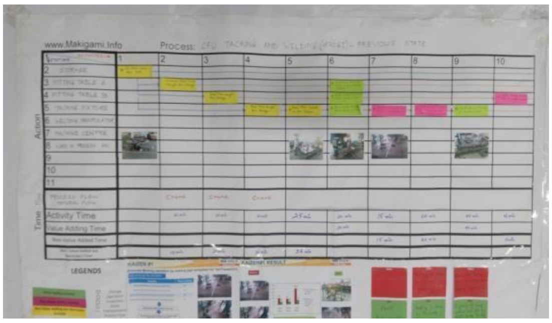


Fig.3a. Single Makigami Sheet

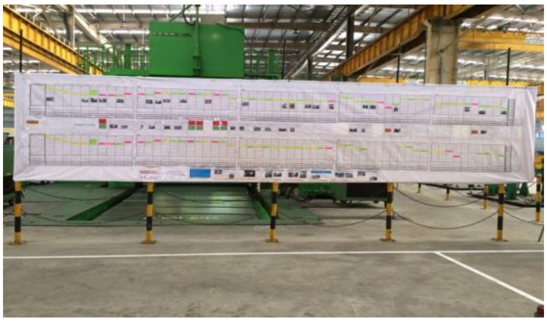


Fig.3b. Several sheets taped together to get the complete picture showing the present and future state

The complete plot is not feasible to be put in the paper. So the following results were obtained and were plotted graphically.

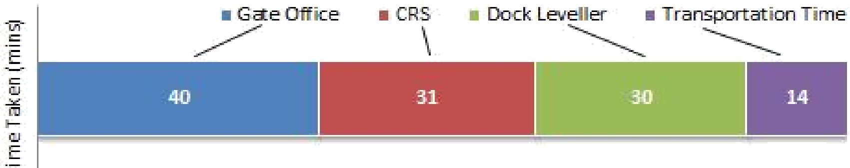
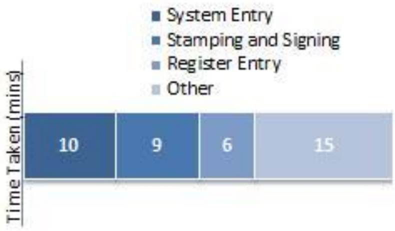


Fig.4. Time taken in all stations



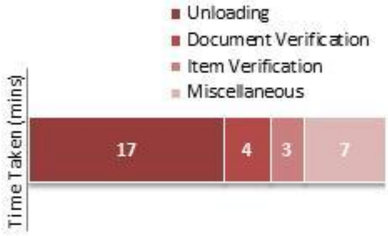


Fig.4a. Time taken at Gate Office

Fig.4b. Time taken at CRS

Fig.4c. Time taken at Dock Leveller

Fig.4d. Transportation Time

V. OBSERVATIONS

From several readings, the following observations were made.

1. Unloading is done by overhead cranes, forklifts and battery trolleys and is time taking for more number of packages per truck.
2. System entry and documentation at the gate office is the major contributing factor to truck turnaround time.
3. The deviation from the mean time taken at gate office is very high.
4. Inventory management is done manually, leading to errors and excess orders, and hence increases the average truck turnaround time.
5. Supplier Relationship Management (SRM) is not effective as all vendors are not linked with the internal system. This causes delays in documentation process and increases truck waiting time, which too causes loss to the industry.

VI. CALCULATION OF OEE

The basic measure of TPM is the Overall Equipment Effectiveness (OEE). OEE highlights the actual "Hidden capacity" in the organization. OEE is not an exclusive measure of how well the maintenance department works. The design and installation of equipment as well as its operation and maintenance affect the OEE. It measures both efficiency and effectiveness with the equipment. It consists of three basic indicators of equipment performance and reliability. The three factors are mentioned below [12].

OEE is calculated by the following formulae:

$$OEE = A \times P \times Q$$

where,

A (Availability Rate) is the time the equipment is actually being utilised for production, versus the time it could have been running without stoppage. A low availability rate indicates downtime losses:

- Equipment failures
- Setup or Adjustment Time

It is calculated as:

$$A = \frac{\text{Operating time} - \text{down time}}{\text{Total Operating Time}}$$

P (Performance rate) is the quantity produced during the operation of the equipment, versus the potential quantity that could have been produced, considering the designed speed of the equipment. A low performance rate indicates speed losses:

- Idling and minor stoppages
- Reduced speed operation

It is calculated as:

$$P = \frac{\text{Total output}}{\text{Potential output at Rated speed}}$$

Q (Quality Rate) is the number of good quality or usable products versus the total number of products produced. A low quality rate indicates the following defect losses:

- Scrap and rework
- Start-up losses

It is calculated as:

$$Q = \frac{\text{Total Output} - \text{Product Rejected}}{\text{Total Output}}$$

The present OEE, upon calculation, for unloading equipments is coming close to 48%. In order to increase this, the following approaches are suggested.

VII. ALTERNATIVE APPROACHES

Root cause analysis is done to understand the reason behind the losses. An expert committee consisting of the head of SCM, material handling engineers and production engineers is called to draw conclusion from the readings taken in the plant for truck turnaround time. Several brainstorming sessions are conducted in the presence of the experts, regular employees and an external agent (novice) to give unbiased and innovative solutions.

The following alternative approaches are suggested based on the detailed observation and analysis.

1. Automation:-

- Automated unloading activities using loadplates will reduce the unloading time of containers.
- Computerised data entry using bar codes or other unique serial numbers instead of manual register entry for records keeping will make the documentation process faster.
- Automated stock updation using tags will make the stock updation process more efficient and decrease the chances of manual errors.

2. Utilization of Resources:-

   Using a gate (materials gate) closer to the storage facility will reduce transportation time inside the plant.

3. Process Improvement:-

- Stamping and signing activity on the documents can be automated using metal punches to put embossed seal on a set of documents at once.
- Allotment of ASN (Allotted Serial Numbers) to all vendors will quicken the data entry process on the server through SAP.
- Regular updation of purchase orders on the server will ease the SAP entry process.
- Skill improvement of present Data Entry Operator
- .
- Manufacturing plans must be made weekly instead of daily.
- Using a single door warehouse facility with FIFO queuing and stock entry at door every time a part crosses it in any direction.
- Improved hardware and updated software can be used to prevent such IT failures.

4. Process Simplification:-

- Vendors can be asked to send the copies of the invoices stapled separately.
- Colour coding the three different sets of invoices will make it easier and quicker to separate.

VIII. CONCLUSION

Thus, using a less known and detailed TPM tool like Makigami Analysis, where the Bird's Eye View of the complete process is taken in order to find the non-value adding activities, the OEE of a production plant can be improved. In other words, the productivity of a facility can be increased by complete visualisation of the process on one sheet and analysing the same.

Makigami Analysis is usually very useful tool for processes that are not physically visible, but this thesis shows that the usage of Makigami Analysis for visible process can also improve the process.

Not only for visible process, but it is also useful to get a clear picture of a complex process. Given the simple nature of the Makigami sheets, any process can be plotted on it easily. A very detailed visualisation of the entire process can be made easily.

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