1. INTRODUCTION

1.1 PROJECT INTRODUCTION
In present global scenario, with manufacturing becoming a more and more competitive market, globally organizations make every effort to increase their effectiveness. The primary aim of any organization is to continuously reduce waste and maximize flow which would ultimately lead to customer satisfaction by providing right product at right time in right quantity with right quality at a reasonable price. To reduce cost and remain aggressive with manufacturers abroad, companies use a variety of different methods. One of the main methods is called “lean manufacturing.”

With the mechanized field getting bigger and spreading more widely across the globe, it is important for companies of different sectors such as automotive, aerospace, construction etc., to adapt to the increasing and evolving business strategies. Several processes in manufacturing are crucial but do not add value while others are not essential and do not add value. As soon as manufacturers focused on processes, they found waste related with changeovers, quality defects, process control, factory layout, and machine down time. So they tried to find ways to reduce or eliminate waste. By reducing the non-value adding activities from the processes and reshuffling, the information flow significant optimization results can be realized. The project aims at reducing the lead time by using lean concepts as a tool for operational improvements. Value stream mapping (Lean manufacturing technique) was chosen because it gives good visualization about the overall manufacturing processes.

1.2 PROJECT BACKGROUND
In increasingly competitive world, many manufacturing firms are looking for a winning performance over their competition. Smaller lead times cost and service of the customer must be high to be competitive for the industries in the present world.

Here we are using Value Stream Mapping as it is the proven technique to enhance performance of the process. It is also used to identify value adding and non-adding activities.

1.3 OBJECTIVE
The aim of this project is to:
- Identify and understand the Availability, Performance and Quality factors across the plant and based on that I shall calculate the Manufacturing Lead Time of the Component by using Lean tools and formulas.
- Understand the current state” of the Plant, as how the factory is performing their Processes at present.
- Identify the key areas of waste, problem and opportunities across the Plant.
- Developing of Future State Map of entire Process.
- Develop an action plan to achieve the higher production and lead time reduction using Lean practices.

1.4 SIGNIFICANCE OF THE PROJECT
The importance of this project is to help the industry to reduce the time taken by them to manufacture the component and suggesting them to implement few Lean practices relevant to their Manufacturing Layout. The study of the whole Manufacturing layout will provide me an insight of how an entire process of component in manufacturing shop works; it also will help me understand the Production Management basics adopted by the industry. Calculation of Manufacturing Lead time will be an eye opener for them as they have never realized or measured how well their company is progressing currently, therefore this will help them realize the current production efficiency of their plant.

2. LITERATURE REVIEW
Lean manufacturing is a technique which is used to identify the wastes in the process and helps them to eliminate the source. The main intension of the lean manufacturing is to increase the value of the customer and to decrease the waste. Lean manufacturing was originated from Toyota Production System (TPS) and later came to be known as Lean. Most of the top companies in the world are asserting this technique and after asserting some of the companies
have seen a significant improvement in the cycle time, cost reduction, waste and defect reduction. According to TPS in Japanese, with respect to MUDA there are seven wastes (explained in the table)  

3. VALUE STREAM MAPPING  
3.1 INTRODUCTION TO VALUE STREAM MAPPING (VSM)  
It is the tool which is used to analyze the certain steps in the manufacturing processes. There is actually seven wastes namely excessive production, delaying, transport, movement, over processing, stock, defects. This tool is basically used to eliminate and reduce the above mentioned wastes. In reduction process, the different steps involved are as follows,  
- Product identification  
- VSM creation  
- Problem areas identification  
- VSM future scope creation  
- Final plan implementation  

3.2 LEAN PRINCIPLES  
- Identify the value stream.  
- Eliminate non-value added activity.  
- Process Mapping.  
- Value stream mapping: Current state & Future state Mapping  

3.3 TOOLS OF LEAN MANUFACTURING  
- WASTE REDUCTION: Full involvement, training, learning. Cellular manufacturing, Kaizen (continuous improvement) & standard work, 5S.  
- CONTINUOUS FLOW: SMED (Shingo) Single Minute Exchange of Dies, Takt time, Line balancing, Smooth production flow  
- CUSTOMER PULL: Just-in-time and Kanban  
These are done by  
1. Carrying out 5s (sort, set, shine, standardize, self-discipline)  
2. Create Flow Kanban (Produce only what is needed by the next person/customer.)  
3. Put in visual controls. (Make a chart to show the actual against the schedule.)  
4. Job standardization. (Draw up procedures and standards to ensure repeatability.)  
5. Set up reduction (After completing a job, see if you can reduce the time taken before starting the new job.)  
6. Continues improvement (Keep on applying steps 1 to 5 in all that you do.)  

3.4 TAKT TIME  
It is a German acronym for pace and is very important term in production system design. It is the method of meeting the customer demand rate by allowing product manufacturing method. It is calculate as follows  
\[
\text{Takt time} = \frac{\text{Working time in one day}}{\text{Daily demand}}
\]

3.5 VISUAL CONTROLS  
These are visible indicators which show the status of a machine or resource or an entire plant. In visual management, simple visual tools are used to identify the target state, and show deviations to take corrective actions. Various control tools of visual management are coloring, charts, Andons, etc on the floor. These include visualization displays which communicate information about the Work environment, Storage, Safety, Quality, Operations and Equipment.  

3.6 TRAINING ON KAIZEN PRACTICAL  
It is a long lasting activity which aims at improving a directed process or a directed / aimed at production process. It must consists of three to four members. PKT participants should make physical changes, if possible. Small tools training should be available, and workers who seek these skills should be encouraged to participate.  

a) PKT training should address:  
- Muda  
- Standardized work  
- Kaizen  
The desired output for each PKT is usually confirmed standard work charts for the newly designed process, physical changes and a shared understanding across shifts of the new process.  
b) Key Factors for PKT Success  
- Communication with workers and supervisors of all shifts is essential for PKT success.  
- PKT members must grasp what is actually happening.  
- PKT members must rigorously confirm every action by using the PDCA cycle. Role of Supervisor is not only to produce the required quantity and quality, but also to lead kaizen.  
c) The FIVE “S”  
The FIVE: “s” is a improved method to organize the work place. Its aim are to:  
- Workplace waste elimination  
- Means of reduction in non value added activity  
- Availing good working ambiance  
- Improve safety.  
- Improve quality.  
- Enhances the morale of employee.  
d) The 5 “s” are  
1. SEIRI (Sort)  
   Clear out, Classify and Identify:
2. **SEITON (Set in order)**
   - Put everything in its correct place:

3. **SEISO (Sweep)**
   - Clean and Check:

4. **SEIKETSU (Standardize)**
   - Conformity

5. **SHITSUKE (Self Discipline)**
   - Adhere to the system rules
   - Additional benefits:
     - Schedule must be simplified
     - Transactions must be less
     - Variation must be less
     - Accurate prediction of forecast
     - Liable design changes
     - Response of the market
     - Clear visualization of the problem
     - Discarding departmental problems
     - Training facilities

4. **DETAILS OF THE COMPONENT MANUFACTURED**
   **4.1 COMPONENT FEATURES:**
   - The integral fuel floor (IFF) is a longitudinal structural member in the fuselage of the LCA-NAVY aircraft. Naval landing gears are designed to take high load due to deck landing. There is a need for very strong back up structure in the fuselage to take these high landing loads. This part is designed to act as fuel floor as well to react to pivot and jack attachment of the naval gear.

5. **METHODOLOGY**
   - The methods applied in this project study are by using the lean concepts as explained below:
     1. Data collection
     2. Root cause analysis
     3. DMAI method
     4. Value Stream Maps
        - It includes:
          - Identification of specific value stream to be viewed. In this project VSM is studied for the component Integral Fuel floor as an example in CNC Shop.
          - Waste identification that exists in VSM
          - Value stream mapping
          - Analysis and evaluation
   **5.1 DATA COLLECTION**
   - An essential part in creating the VSMs for the Integral Fuel Floor (IFF/IFW) process was to obtain existing data. There were a few ways in which we gained information. The first, we acquired data directly from the Company. To do talked with the operation managers as well as the floor managers of the CNC shop where the actual processing was taking place.
   **5.2 ANALYSIS BY ROOT CAUSE**
   - It is a technique that is usually used to identify the main cause for a given process by repeatedly breaking down the main problem into the sub problem and again identifying the root cause for that sub problem to identify the main cause. Ishikawa diagram is the main tool which is used for root cause analysis
   **5.3 Value Stream Maps**
   - It is the tool that is used for merging flow of information and flow of the material in order to understand the relations and importance between value added and non-value added process. This tool helps the team to handle projects for a systematic and corrective lean approach. It involves two steps
     **5.3.1 Current State Value Stream Map (CVSM)**
     - It is a tool that is used for mapping flow of information and flow of material as a component passes through several
production processes. This mapping includes various setup times, waiting time and cycle time.

5.3.2 Future State Value Stream Map (FVSM)
In order to create the flow of the lean, a chart is required which is suggested by Future State Value Stream Mapping. Here techniques of lean are used to reduce or eliminate waste and also to reduce activities related to non-value added. Flow chart of the entire process of Integral fuel floor component starting from raw material stage to final finished product is shown in the figure.

6. DATA ANALYSIS AND INTERPRETATION
For carrying out the study, the case of the production of Integral Fuel Floor (IFF/IFW) component in CNC shop was considered. The objective is to reduce the production lead

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**Figure 3.1: VSM Steps**

**Figure 3.6.1: Traditional Inspection**

**Figure 4.1: Integral Fuel Floor**

**Figure 4.1.1: IFF Process Steps**
time of IFF. After defining the problem, the data relevant to the study is collected from the CNC shop. For analyzing the data VSM tool is used where the CVSM is drawn to find out the non-value added activities occurring at each stage of processes.

6.1 DATA COLLECTION

a) The data is collected from the Route Card/Process Sheet where we get information regarding different operations involved with the detailed description.

b) Time studies

c) It is conducted to obtain data on each cycle times within each shop floor. It is a controlled process of directly observing and gauging human work in order to set up the time necessary for fulfillment of that work. The measured cycle times and other obtained information are arranged in a systematic manner. The obtained data is mapped on VSMs.

6.2 ANALYSIS OF ROOT CAUSE

Analysis of root cause is basically done to find out the main causes for the effect “Increase in lead time”.

6.3 DMAIC Analysis

It is the systematic way of determining and analyzing the process characteristics. DMAIC denotes Define, Measure, Analyze, Improve and Control. It is clearly discussed in the table.

6.4 VALUE STREAM MAPS

6.4.1.1 Analysis of CVSM

The map shows the movement of component under different processes in CNC shop. It is represented by timeline below the CVSM which includes the value added and the Non value added process times from entry of raw materials to the final finished product. Here Process Activity Mapping (PAM) is employed wherein it helps in formulating solutions to minimize waste. It is observed based on time considerations that the total manufacturing lead time is days which accounts for minimum of NVA/VA is 39.49%. Different NVA activities in the processes are found to be:

- Process is delayed due to non-availability of machine while the machine is engaged in some other job.
- Process waiting time as some of the processes were only running in one shift. (when datum location is finished in 3rd shift then next job is started in 1st shift may be due to insufficient casual workers during 3rd shift)
- After deburring process with the completion of all 3 setups, CMM inspection is carried out, in which 1 day delay may be due to prioritizing some jobs on the machine.
- Defects occurred during machining is referred to design to give dispositions in the form of “Snag”.
- Waiting time during clarifications (Corrections in Route Card/Job Tickets )
- During finishing stage, delay is due to non-availability of special tools of required dimensions.
- Frequent tool changing time is observed during the processes.
- Before final inspection 2 days delay is seen for rework and finalization.

Figure 5.3.2: IFF Setup2

Figure 5.3.3: IFF Setup3

Figure 6.2: Root Cause
6.4.1.2 Elimination of NVA and wastes
- Process waiting time is reduced by implementing “pull system” at that point where the next operator should be ready to pull the previous job done.
- The machine operator is trained to deburr the component where minor work is involved in order to reduce the processing time involved when carried out separately.
Defects and deviation in the process found are detected at right stages by the operator instead of continuing the process which hinders quality.

- Snag raise should be done at the point when the defect occurs instead of raising it during final inspection.
- Root Cause Analysis is done in order to avoid the occurrence of the same defect.

6.4.2 Analysis of FVSM

It was suggested to put forward the subsequent steps to be taken to assert a Future State Value Stream Map (FVSM). Lean Manufacturing tools will endeavor in removal of Non value added activities and in turn purge the wastes in the manufacturing process. From FVSM it is noted that the lead time reduction with waste elimination. The % of Non-value added is also reduced. Also Supply Chain matrix response is suitable. By considering the recommendations mentioned above, the non-value added activities was found to be minimized which further leads in the reduction of lead time.

7. FINDINGS

- Different cause for the increase in lead time is found by root cause analysis.
- By drawing CVSM, the NVA time is found to be min and NVA/VA is 39.49%
- From FVSM, the NVA time is found to be min and NVA/VA is % 18.43%
- From 15 days to 7 days, the lead time can be reduced.

8. RECOMMENDATIONS

8.1 RECOMMENDATION – 1: LEAN MANUFACTURING

It is an operational approach oriented toward achieving the shortest possible cycle time by removing waste. Lean manufacturing is used to represent half the human effort in the company, manufacturing space, investment in tools, and half the engineering hours to expand a new product in half the time. It is indicated in the figure.

8.2 RECOMMENDATION-2: STREAM MAPS USING DRAWING VALUE

The lean manufacturing inventiveness of the current value stream map can be drawn in 25 minutes, complete with data it can be drawn by using noted cycle times of a particular current process based on route cards etc. This gives clear visualization of process. The visualization process is indicated in the figure.
8.3 RECOMMENDATION – 3: SPAGHETTI DIAGRAMS TO VISUALIZE MOTION
These diagrams are the nervous system for the floor layout improvements. The floor layout was copied into e-VSM as a picture and then paths drawn on top to show the motion. Motion paths were color-coded and then a report generated with automatic path length calculation. From this shortest possible path among the factory can be obtained. It is shown in the figure.

Figure 8.3: Spaghetti Diagram

8.4 RECOMMENDATION – 4: REDUCING STOCK
The stock related to MUDA of keeping raw materials, parts and WIP which are unnecessary. These conditions result when flow is constricted in a plant and when manufacturing is not related to the tapping of the market (pull). Workers and supervisors make extra, “just in case” and WIP accumulates. It is shown in the figure.

Figure 8.4: Stock Reduction

8.5 RECOMMENDATION – 5: KAIZEN EVENTS
It is a day to day activity whose principle goes beyond improvement. It is a process when done systematically, humanizes the workplace, removes hard work (both mental and physical), and teaches people how to do swift experiments using the scientific method and how to learn to see and eliminate waste in manufacturing processes. It is shown in the figure.

Figure 8.5.1: Kaizen Event 1

9. CONCLUSION
The study in the CNC shop at the company set to use the Value Stream Mapping in identifying ways of reducing the non-value added activities in the production process. This was achieved through the development of the Future State Map which has decreased the NVA from 39.49% to 18.43%
Also well trained and experienced operators for all set of operations and coordination among the manufacturing layout, lead time can be reduced. Also various types of losses observed in the shop such as material handling wastes, travelling waste and waiting time can be reduced using simple lean techniques.
The distinctiveness of this project is that there was no suggestion made regarding automation because automation of operation means heavy investment, which is not a philosophy of lean as it incurs financial loss. Therefore an attempt was made to suggest them some lean practices which does not exceed their annual improvement budget, so that could implement it very soon in the future and reduce their manufacturing lead time and increase production rate as soon as possible.
Further I can say with this set of improvements, the method of operating can be simplified which in turn leads to the reduction in the lead time and increments in the profit.

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