VALUE STREAM MAPPING OF 1LA025 -31 MOTOR FAMILY

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Abstract - *Manufacturers always face cost-reduction and efficiency challenges in their operations. Industries require improvement in Production Lead Times, costs and customer service levels to survive. Because of this, companies have become more customers focused. The result is that companies have been putting in significant effort to improve their efficiency.*

In this paper Value Stream Mapping (VSM) tool is used in bearing manufacturing industry by focusing both on processes and their cycle times for a product 1LA0 25-31induction motor. In order to use the value stream mapping, relevant data has been collected and analyzed. After collecting the data customer need was identified. Current state map was draw by defining the resources and activities needed to manufacture, deliver the product. The study of current state map shows the areas for improvement and identifying the different types of wastes.

The lean principles and techniques implemented or suggested and future state map was created and the elimination of non-value-added time of 17 mins can be saved per motor.

Key Words: Lean Principles, Value Stream Mapping, Wastes, Work in Process, Production Lead Time.

1. INTRODUCTION

A Value Stream Mapping is a tool of LEAN MANUFACTURING. A Value stream mapping is a lean manufacturing technique used to analyse the flow of materials and information currently required to bring a product or service to a consumer. It is a paper and pencil tool that helps you to see and understand the flow of material and information as a product or service makes its way through the value stream. At Toyota, where the technique originated, it is known as "material and information flow mapping". Value Stream Mapping is primarily a communication tool but is also used as a strategic planning tool and a change management tool.

A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product:

1. The production flow from raw material into the arms of the customer, and
2. The design flow from concept to launch.

Taking a value stream perspective means working on the big picture, not just individual processes, and improving the whole, not just optimizing the parts.
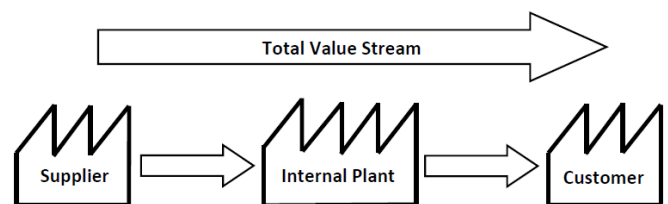

Fig-1 Total Value Stream

A Value Stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product:

- The design flow from concept to launch,
- The supply flow from supplier to plant and
- The production flow from Raw Material to the arms of the customer.

Value Stream Mapping can be used in Lean manufacturing to identify opportunities for improvements in lead time.

The value adding steps can be drawn across the center of the map and non-value adding steps be represented in vertical lines at right angles to the value stream. Thus, the activities become easily separated into value stream, which is focus of one type of attention and the 'waste' steps, another type. Value stream is the process and the non-value streams the operations. The thinking here is that non-value adding steps are often preparatory or tidying up to the value adding steps and are closely associated with the person or the machines that executes the value adding step.

2. LITERAUTRE REVIEW

Value Stream Mapping (VSM) tool shows all the activities, from supply to final product through the different processing steps. In other words, it is a sketch of a production line [1].

Value Stream Mapping (VSM) is used to define and analyse the current state for a product value stream and design a future state focused on reducing waste, improving lead-time, and improving workflow [2].

A value stream map provides a blueprint for implementing lean manufacturing concepts by illustrating how the flow of information and materials should operate [3].

VSM is divided into two components: big picture mapping and detailed mapping [4].

Rajenthirakumar and R.G. Shankar reported a noticeable reduction in cycle time and increase in cycle efficiency with an application of value stream mapping (VSM). The production flow was optimized thus minimizing several non-value-added activities/times such as bottleneck time, waiting time, material handling time, etc. [5].

K. P. Paranitharan provide useful platform for research in implementation of lean tools in any manufacturing unit. Their results show a significant improvement in productivity, reduction of Production Lead Time and reduction in inventory. These can be achieved by creating flow by layout modification and balance to TAKT time [6].

R.M. Belokar reported a case study of application of VSM in an automobile industry where they achieved nearly 67% improvement in cycle time by improvement in value adding activities [7].

2.1 Why to use Value Stream Mapping?

To Attack MUDA (waste): Any Activity that does not increase the Market Form or Function of the Product or Service based on the Critical Customer Requirements. These are things the customer is NOT willing to pay for.
Value Added: Any activity that increases the market form or function of product or service. (These are things the customer is willing to pay for).
Non-Value Added: Any activity that does not add market form or function or is not necessary. (These activities should be eliminated, simplified, reduced, or integrated.)

2.2 Scope of Value Stream Mapping:

The project aimed at mapping to understand the current process of 1LA0 25-31 motors. Thus, VSM will give current state maps. Current state maps will enable locating waste in form of inventory, waiting time, transportation and overproduction at every stage of manufacturing process. Thus, giving a clear picture of areas to be targeted for improvement.

2.3 Steps in Value Stream Mapping:

Value Stream Mapping is a pencil and paper tool that helps you to see and understand the flow of material and information as a product makes its way through the value stream. Production path from customer to supplier is carefully mapped by visual representation of every process in material and information flow. Then ask a set of key questions and draw a 'future state' map.

3. APPLICATION OF VSM TO 1LA0 FAMILY

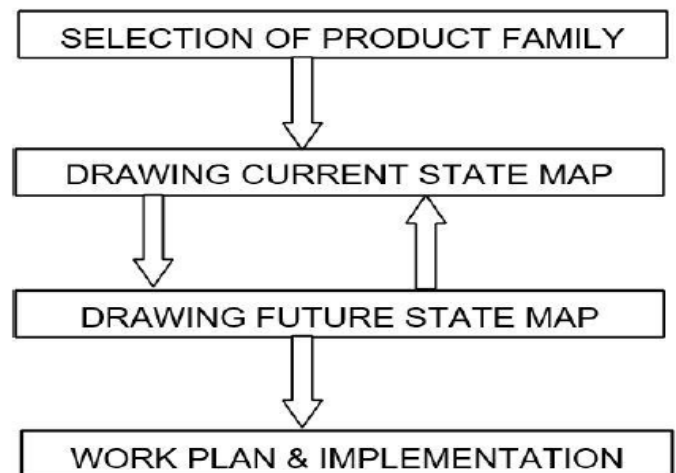## 3.1 Procedure Followed:

3.1.1 Selection of product type:

Fig-2: Steps in Value Stream

The quantity of 1LA0 25-31 manufactured per month on an average is around 400. Per day around 17 motors of this type are manufactured in 2 shifts. Hence if the production process of this motor is targeted favourable results can be achieved. Moreover, VSM will help identify the loopholes and give a clear indication of target areas to be focused on for overall improvement. Thus, an efficient manufacturing of these motors can be possible which will increase the overall productivity of the system.

3.1.2 Drawing the current state map:

The production process of 1LA0 motor type was carefully observed and studied. By doing so a sense and sequence of material and information flow was gained. The mapping is done through the door to door flow of a system starting at the customer end and going upstream towards supplier end. This way mapping will begin by process directly linked to the customer which should set pace for other processes further upstream. Value stream map was hand drawn on a paper. The reason for a paper and pencil approach to mapping
instead of using a computer is that by hand drawing key points can be understood and the focus will shift on understanding the flow instead of how to use a computer. The main point of value stream mapping is not the map but understanding the material and information flow.

Now since mapping will begin from customer end, a process icon shown below the customer factory icon is used to note down the customer demand/month, customer demand/day, Takt time and Lead time of product. The next step is to draw the basic production processes. To indicate the process a process box is used. The data to be recorded in the process box is:
a) Cycle Time: (C/T) Machine on to machine on time of a process. The time an operator takes to finish the process before starting it again.
b) Changeover Time: (C/O) When a machine switches over from one product time to another a change is made in the machine setting.

c) No. of Shifts: The no. of shifts per day.

d) No. of Operators: The no. of operators working on that process.

The amount of inventory is recorded between two workstations i.e. to be processed and processing jobs of a workstation. As the mapping approaches the supplier side the raw material inventory in the factory is recorded. The Production Planning and Control Department monitors the Customer end, Supplier end and the manufacturing activities in the factory.
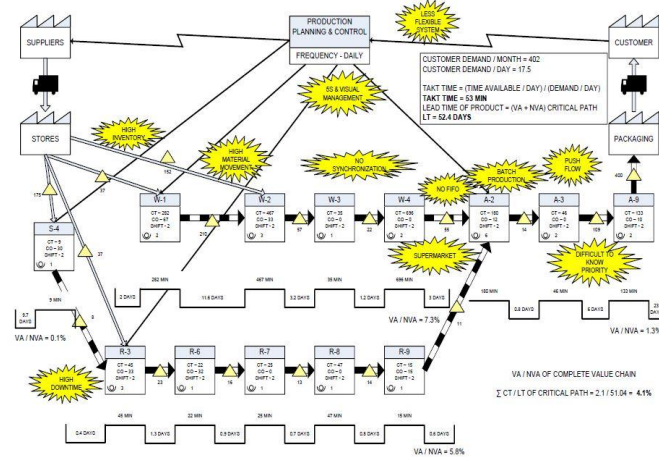

Fig-3: Current State VSM

3.2 Analysis of Current State Map:

Less flexibility of the overall system: Since the company caters to customized requirements, it disturbs the original production method. This causes delay in delivery of the motors at certain time which shows the incapability of the system.

High inventory: During our door to door mapping, we have found high accumulation of inventory at places in the shop floor. This high inventory not only restricts space but also locks the money involved in production due to material waiting which is also a waste.

Poor 5S and Visual management: 5S denotes:

SORT: remove unnecessary items, eliminate obstacles, evaluate necessary items,

STRAIGHTEN: easy availability of items preventing loss of time, smooth workflow,

SHINE: workplace should be clean,

STANDARDISE: everything according to standards, orderliness,

SUSTAIN: to keep everything in working order.

High material movement: Due to high quantity of orders, the company outsources certain sub- assemblies which lead to a very complicated network of material movement. Keeping track of the activities viz. transportation, rework etc increases the time.

No synchronization in flow: Due to improper communication, unavailability of material, difference in process timings between the parallel paths there exists no proper synchronization.

No FIFO: "FIRST IN FIRST OUT" procedure is not followed throughout the shop floor. Most times the components are picked up randomly.

Batch production at certain places: Unnecessary batching of motors due lack of single piece flow increases the inventory between processes restricting space.

Overall push flow: "PUSH" means the process produces something regardless of the actual needs of the downstream customer process and pushes it ahead hence adds up the inventory for the next workstation.

Difficulty to know priority: Lack of identification makes it difficult to identify the sequence hence priorities can't be determined. Most times it is verbally communicated but can lead to miscommunication causing disruption in flow.

High downtime at certain workstations: Machine breakdowns occurs due to the following like overrunning machine's capability, improper maintenance, asking untrained person to operate the machine, rough use by operator etc. Breakdowns at certain machines create bottlenecks in the process halting the entire flow.

3.3 Conclusions and Target Areas:

- As per the observations from the current state map and the analyzing of the critical path the final assembly is the pacemaker process.
- By using the supermarket pull systems, the scheduling needs to be done only at one point in your door to door value stream. This point is called as the 'Pacemaker Process', because how the production is controlled at this process sets the pace for the further downstream processes.
- Line assembly is the juncture which is the final customer in the factory.
- By monitoring this point, the assembly requirements from upstream can be demanded in a predetermined manner.
- This will regulate the working of the entire plant for this motor type.
- Thus, Line Assembly being the pacemaker process is selected as the target area for improvement.
- Considering the fact that 17 motors are produced on line assembly on a daily basis currently instead of production in batch if a single piece flow is implemented the production will take place as per the takt time.
- Thus, the delay or excessive inventory dumped upon the next workstation will be completely eliminated.

4. DRAWING THE FUTURE STATE:

The goal is to build a chain of production where the individual processes are linked to their customers either by continuous flow or pull and each process gets as close as possible to producing only what its customer needs when they need it. The map is one assuming the inventory values and other changes in the flow as per the answers to the key

questions. The main practices to be included in the future state map were:

- **FIFO (First in First Out):** This ensures that when a product is being produced it should be consumed by the next workstation in the sequence in which it is handed over by the previous workstation. FIFO builds up inventory but it is a controlled inventory. The maximum and minimum limit in a FIFO lane is predetermined. Once the max limit is reached the supplier gets an indication to stop producing.

- **Supermarket:** There are places in value stream where batching continuous flow is not possible and batching is necessary. Thus, by supermarket system batching is done in a regulated amount. The customer pulls whatever is needed and it is replenished by the supplier. A production kanban triggers production of parts, while a withdrawal kanban is a shopping list that instructs a material handler to get and transfer parts.

- **Safety Stock:** This is used to protect against sudden fluctuations in customer orders. By monitoring and analysing the distribution database the particulars of the safety stock can be determined. While making the future state map it was observed that at some places a due to high changeover times batch production was mandatory unless a thus by providing a safety stock option it would be ensured that the availability of sub assembly would be as per the requirement without disturbing the setting of the upstream process.

- **Milk Run:** It is a system wherein delivery of raw material from the supplier side can be monitored so as to keep a check on the inventory present at the delivery site. The raw material inventory is a type of waste unless converted into a finished product. Thus, this inventory not only locks in the investment but also utilizes space. Milk Run will ensure that the delivery of raw material can be done as per the daily requirement. It should be ensured that a safety stock is maintained before employing this method.

5. METHODOLOGY:

As stated, earlier Line Assembly is the pacemaker process here. Thus, the planning and implementation of future state was done at Line Assembly.

5.1 Current setup of Line Assembly:

Line assembly mainly assembles motor type LA0 25, 28 & 31. Line assembly receives its direct input from following workstations:

- Vacuum Pressurized Impregnation (VPI)

- Rotor Balancing

Line assembly mainly consists of the following main sub-operations:

I. Packet pressing
II. Terminal box connection
III. Rotor preparation
IV. Main motor assembly

Packet pressing: The wound stator packet received from VPI is then cold pressed in a Cast Iron Housing which acts like a cover for a motor. The fixtures of packet pressing setup are:

- o Centering ring
- o Pressing fixture
- o Pushing plate
- o Ram and key

Centering ring is decided on the basis of the housing diameter. The housing is mounted on the centering ring. The wound stator packet is lifted by using the inner diameter lifting tackle. The wound stator packet is then inserted in the housing. It is ensured that the stator packet is inserted with proper aligning. Pressing fixture is mounted on the stator packet. Pressing fixture determines the pressing distance of the wound stator packet. Pressing is always carried out from the non-drive side. The pushing plate is loaded above the pressing fixture. With the help of the lever the ram located at the center of this arrangement is drawn out. A key is located in the slot of the ram. By applying a pressure of around 140 bar with the help of the lever the ram is pushed down. The pushing plate ensures the pushing while the pressing fixture ensures that the pressing distance is maintained. The key ensures that the ram does not displace downward more than the required amount. Thus, the wound stator packet gets fully inserted in the housing.

Terminal box connection: The terminal box assembly consists of the following:

- Terminal block
- Terminal box
- Distance piece

The leads of the winding are already pulled out of the terminal box slot in the housing. The distance is an optional accessory which is used to increase the height of the terminal box. Just in case whether the terminal position is not standard, that is the top position then an adaptor plate is used so that the terminal box position can be o the LHS or RHS of the motor. Smaller sleeves are also pulled out according to the ACH (Anti Conditional Heater), PTC (Prior Temperature detector), RTD (Resistance temperature Detector), and BTD (Bearing Temperature Detector) as per

customer requirements. The leads of the winding have studs brazed on their ends. These studs are inserted in the terminal block so as to create the R-Y-B phases. The leads are connected to form a delta or star connection. The sleeves for auxiliary accessories connection are pulled out of the smaller slots in the terminal box. A connecting link is used to connect the adjacent leads in the terminal blocks. The terminal box and distance piece are given a rubber gasket lining in order to fix it firmly and prevent any leakage in the lining after the assembly of the terminal block a terminal box is fixed over it to act as an enclosure. The smaller sleeves for auxiliary connections are pulled out of the small slot in the terminal box. Lugs are fitted over the wires of the sleeve and its ends are crimped for further connections. Cable end is attached on the fourth end of the terminal box.

Rotor preparation: The finished rotor from the grinding workstation is the basic input for this workstation. Balancing of the rotor is the most important operation before the rotor insertion. This balancing is done usually to prevent vibrations in the motor. This workstation prepares the balanced rotor for its insertion in the wound stator. During balancing identification marks are given to about 12 places along tar rotor circumference. It is then rotated and an automated system gives an exact indication to the points as to where weights need to be added. The components which are usually assembled on the rotor are:

o Inner Bearing cover
o Bearings
o Scavenging discs
o Circlips

The inner bearing cover is firstly inserted in the rotor shaft. After the inner bearing cover, the bearings are inserted. The bearings are heated to a temperature of 180^0C in the oven. The fit between the shaft and the bearings is shrink fit. The scavenging discs are also heated in the oven and inserted after the bearings. The purpose of the circlips is to act like a stopper and a seal to prevent the components from slipping and also prevents leakage of grease.

Main motor assembly: Main motor assembly consists of the following operation:

o Rotor insertion
o End shield fixing
o Fan and Fan cowl fixing

The assembly of the motor starts with the rotor insertion. The rotor is inserted in the stator by using a C-tackle. An air has to be maintained between the rotor and the stator housing to induce magnetism. The air gap is checked with the help of feeler gauges. The end shield is fixed over the drive side of the motor. The outer bearing cover of the drive side is also fixed over it. At the non-drive side, the same procedure is followed after which the fan and the fan cowl are fixed over the shaft.

The motor is then passed on to the next workstation that is Test field where it is given a final testing. Then it is passed over to paint shop. The pre-painting assembly includes assembly of final parts of the motors that is the terminal box covers, auxiliary box covers etc. The motor is then handed over for painting. After which it is placed on the conveyor for drying and final inspection and finishing. The name plate is then fixed and the motor is sent for packing.

5.2 Current Observations at Line Assembly:

The components required for line assembly are stored in bulk as per trolleys of frame size 25, 28 and 31. There are following trolleys on the line assembly:

o 3 Kanban Trolleys as per frame size which hold the bearings, inner bearing covers, outer bearing covers and scavenging discs for the drive and non-drive side.
o 3 Endsheild Trolleys as per frame size which hold end shields for drive and non-drive side.
o 1 Trolley and pallets for Terminal box.
o 1 Trolley for Terminal Blocks
o 1 Trolley for Distance Piece
o 1 Trolley for Fans
o 1 Trolley for Fan cowls

Thus, during motor assembly, the operators have to walk up to the trolleys to collect the components causing high worker movement.

5.3 Following Are the Major Observations:

• **No single piece flow:**
  The current setup of line assembly is not fully utilized as a single piece flow workstation. The activities are carried out independently at the sub-stations, leading to material in waiting. Due to this un-synchronized nature of work the next workstations are affected.

• **Batch production:**
  The output of the line assembly is received in the form of a batch to the next workstation that is Test field, thus causing inventory accumulation and also a load on the Test field.

• **Material unavailability:**
  The above-mentioned trolleys are stacked beforehand as per the required no of components to be included in each trolley. At times due to non-standard requirements a material unavailability is generated which holds up the motor production.

• **High operator movement:**

Since to assemble the motor the operator has to walk up to the trolleys and fetch the components. This unnecessary movement causes non-value time addition. High operator movement also causes worker fatigue.

- **Underutilization of available resources:**

  Due to uncoordinated nature of work, idle labour conditions are observed and hence underutilization of man power prevails. Thus, there is lot of scope for improvement in terms productivity and manpower utilization.

- **High inventory:**

  High accumulation of assembled motors between the motor assembly workstation and the Test field is observed since the output is achieved in parts thus causing materials in waiting which holds up space and causes problems in functioning of the current and the next workstation.

- **Poor space utilization:**

  The components stored in the individual trolleys mentioned above are stored for a particular period of time. Thus, the Just In Time (JIT) principle is not followed. Also, FIFO is not followed. Thus, restricting the space.

- **No visualization:**

  The machine cards giving a description of the motor requirements are inserted in the fins of the housing. Hence each time the operator has to walk up till the motor and open the card to understand its components. Also, it is difficult to identify a priority motor.

5.4 Proposal for improvements at Line Assembly:

- **Proposal - Kitting trolley system:**

  Option suggested for line assembly was kitting trolley system. Instead of having trolleys loaded with all the components required for assembly of various motors over a time period, it was suggested to have a set of trolley which would contain components only for a single motor. Thus, by having components for a single motor loaded in one set of trolley the current operator movement would be drastically reduced. The kitting trolley would be at point of use of the operator thus completely eliminating the non-value adding time of walking up to a trolley, locating the component and getting it to the workstation for further use. The components would be at a hand's reach of the operator. This set of trolley is called as a kitting trolley since the trolley acts as a kit for a single motor containing all the components required for the assembly of the single motor. A single kit would be delivered to the operator at the line assembly. The operator would only have to assemble the components. Thus, the time required for location and identification of component would be completely reduced. The kitting would be done at a different place and these kits would be delivered at the line assembly for motor assembly. The sequence of the arrangement would be decided as per the daily production order.

The kitting trolley comprises of a set of 2 trolleys:
- ✓ Drive Side Trolley
- ✓ Non-Drive Side trolley

A detailed description of these trolleys is given below:

- ✓ **Drive Side Trolley:**

  This trolley would mainly cater to the Rotor Preparation sub-station and the Final Motor Assembly sub-station from the Drive Side. The components required for these operations would be loaded in the trolley. The trolley would first go to the Rotor Preparation sub-station and then to the Drive side of Final Assembly sub-station. The components loaded in this trolley are as follows:
  - o Inner Bearing Covers (Drive and Non-Drive Side)
  - o Bearings (Drive and Non-Drive Side)
  - o Scavenging Disc (Drive and Non-Drive Side)
  - o End-shield (Drive Side)
  - o Outer Bearing cover (Drive Side)

- ✓ **Non-Drive Side Trolley:**

  This trolley would mainly cater to the Terminal Box Assembly sub-station and The Final Motor Assembly sub-station from the Non-Drive Side. The components required for these operations would be loaded in the trolley. The trolley would first go to the Terminal Box Assembly sub-station and then to the Non-Drive side of Final Assembly sub-station. The components loaded in this trolley are as follows:
  - o Distance Piece
  - o Terminal Block
  - o Terminal Box
  - o End-shield (Non-Drive Side)
  - o Outer Bearing cover (Non-Drive Side)
  - o Fan
  - o Fan cowl

- **Highlights of kitting trolley system:**
- ✓ **Single Piece Flow:**

  The current setup at line assembly follows batch production. The output is delivered to the next workstation in uneven time intervals and in a batch. This affects the further processing and least to building up of inventory. Kitting trolley will ensure that the next job won't be taken up unless the work with the current trolley is finished thus leading to a single piece flow in the system. Thus, one set of trolley per motor will automatically cause single piece flow at line assembly.

- ✓ **Reduction in Process Time:**

The most important advantage of kitting trolley is that the components are available at the point of use that is they are within the operators reach. Thus, the non-value adding time in the current setup will be totally eliminated. This automatically reduces the process time thus there will be saving of time per motor.

✓ **Elimination in material unavailability:**

Since a ready kit for a motor will be provided on the line assembly itself the question of material unavailability won't arise. Even if there is unavailability for a component it will be realized at the point of kitting itself, thus ensuring that last minute problems won't persist.

✓ **Availability of materials at point of use:**

All components required for motor assembly are available at hands reach. Thus, the non-value adding time of walking to a trolley to fetch a component is completely eliminated. This is the most economical way of material usage. This also reduces operator exertion caused due to unnecessary movement.

✓ **Reduction in Non-value adding operations:**

Value adding operations are those for which a customer is willing to pay. Operator movement falls in the non-value adding operation category. Non-value adding operations like fetching components is completely eliminated thus reducing the cost of manufacturing. By the use of kitting trolley all the components will be available at the point of use of workers. Thus, the operator movement will be eliminated causing reduction in non- value adding operations.

✓ **Reduction in idle time:**

By use of kitting trolley an operator will be compelled to work at his own workstation. Since there will be a single piece flow an operator won't be able to move from his workplace. Thus, by improvement in process time and single piece flow there will be elimination in idle time.

✓ **Efficient space utilization:**

In case if a component is unavailable the motor is kept on hold restricting space of that workplace and restrict workflow leading to waiting time. Also, the many individual trolleys in the current setup will be eliminated thus leading to efficient space utilization.

• **Why proposal should be Implemented?**

The proposal suggested was that of the Kitting Trolley system. The major advantages of previous trolley were its space utilization and the standardized sequence in which the arrangement was done. But the important changes like implementation of single piece flow, reduction in inventory and reduction in non-value adding operations were not seen. The operator would still have to walk up to these workstation trolleys to collect the components. Thus, there would be an improvement only in the storage technique. Kitting trolley insures that all the above-mentioned loopholes would be eliminated. Kitting trolley is a much more compact version of material storage facility. Since one trolley is assigned for one single motor automatically a single piece flow can be observed. The elimination of non-value adding operations is one of the most important advantages of the kitting trolley due to this there is reduction in process time too. The operator movement is restricted. A uniform productivity graph can be seen throughout the process at line assembly. The upcoming workstations will not face a load since batch production will be converted to a single piece flow. Reduction in inventory is an additional advantage. Thus, kitting trolley is a much better option to implement for line assembly.

6. KITTING TROLLEY:

6.1 Design of Kitting Trolley:

The trolleys were first designed in 3-D form in order to attain a better visualization.

• **Drive side trolley:**
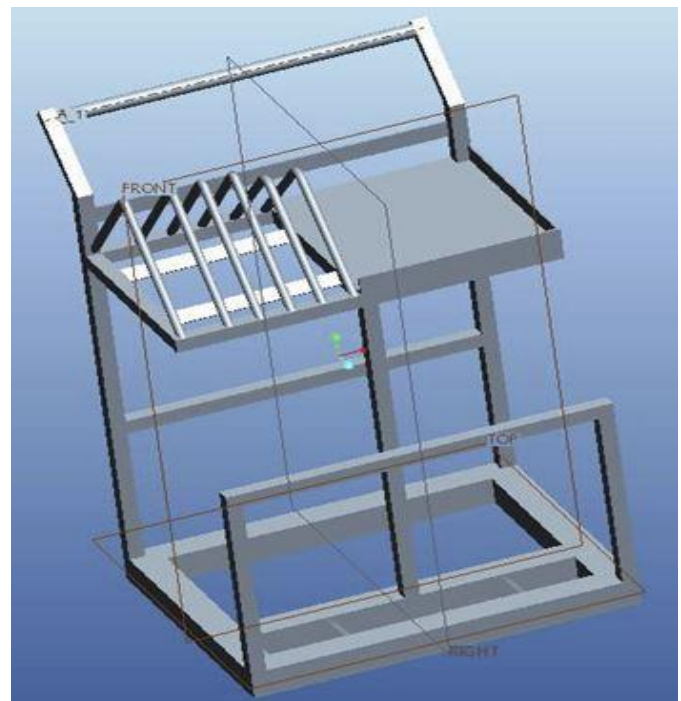
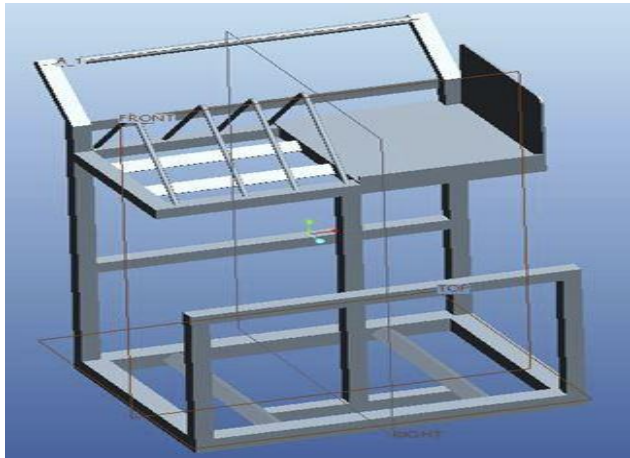**Fig-4:** Drive Side Trolley

• **Non-Drive side trolley:**

Fig-5: Non-Drive Side Trolley

6.2 Details of Kitting Trolley:

The daily customer demand is around 18 motors per day i.e. 9 motors per shift. The kitting trolleys will be delivered to the line assembly before the start of each shift.

Once the trolleys are used the empty trolleys are replenished and taken back to the stores for replenishment.

6.3 Material Movement:

Material movement or material flow diagrams are used to indicate the flow of various materials or components through workstations. These diagrams give a better understanding of not only the layout of workplace but also the flow of work between these workplaces.

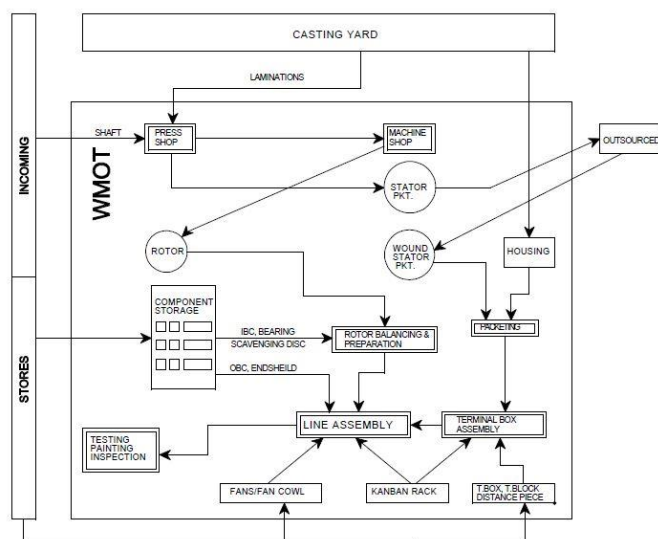● **Material Flow (Existing):**

Fig-6: Material Flow Existing

The line assembly receives its major inputs in the form of rotor and wound stator packet from the Rotor grinding and

VPI (Vacuum Pressure Impregnation) workstations respectively. The other components like Motor Housing, distance piece, terminal box, terminal block, IBC, OBC, scavenging discs, End shield, Fan, Fan cowl, etc. are received from the casting yard and stores. These are assembled at the sub-stations and then the assembled motor is forwarded to the next workplace. The current material flow clearly depicts the material movement of components at line assembly.
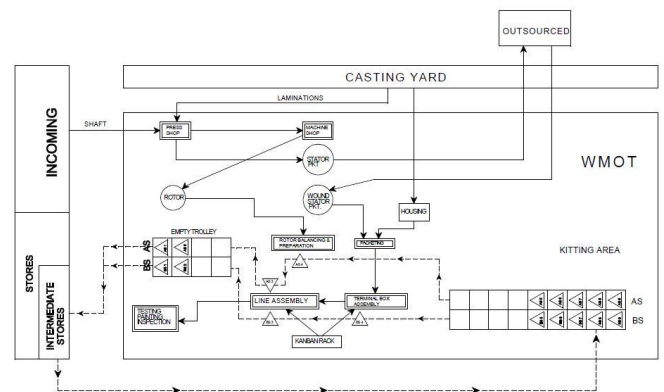
● **Material Flow (Proposed):**

Fig-7: Material Flow Proposed

By introduction of kitting trolley at line assembly certain material handling and material movements will undergo changes. The major changes will take place for the material handling of individual components. The kitting trolleys will be brought to the line assembly at the start of the shift. The operator will pull one set of trolley and get it to the line assembly. The drive side trolley will be taken to the rotor preparation sub-station and then to the drive side of the motor for final assembly. The non-drive side kitting trolley will be taken to the terminal box assembly sub-station and then to the non- drive side of the motor for final assembly. After which they are taken back to the stores for replenishment.
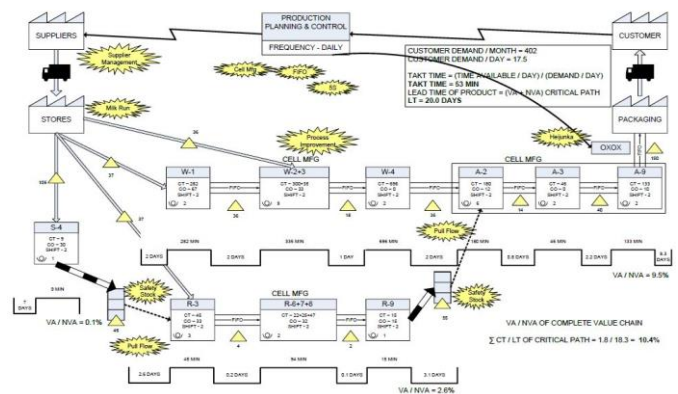

Fig-8: VSM Future State

7. RESULTS AND CONCLUSIONS:

● **Elimination of Non-Value adding time:**

Time study is conducted by practicing MOST (Maynard Operations Sequence Technique). After a thorough study of MOST sheets considering that kitting trolleys will be implemented at line assembly it is found that by elimination of Non-Value Adding time around 17 minutes can be saved per motor.

• **Single Piece Flow:**

Achieving single-piece flow will help achieve true just-in-time manufacturing. That is, the right parts can be made available when they are needed in the quantity they are needed. It is the most economical manufacturing technique. Single piece flow will also eliminate the overburdening of the upcoming workstations. It will also keep a control on inventory.

• **Reduction in cost of manufacturing:**

Cost of manufacturing is determined by the raw material, operations undertaken, manpower etc. While the quality of a product cannot be compromised the main target area in this case would be elimination of non-value adding time which is a type of waste. The customer will pay only for the required value adding operations.

• **Controlled Inventory:**

Single piece flow ensures inventory prominently in the form of WIP (Work In Progress). Inventory is nothing but material in waiting. Investment is locked in the form of inventory. Returns are obtained to the company only after sale of product. Thus, by reduction in inventory and production within takt the objective can be fulfilled.

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