JJMIE

Volume 4, Number 5, November 2010
ISSN 1995-6665
Pages 579 - 590

Jordan Journal of Mechanical and Industrial Engineering

Reduction of Wastages in Motor Manufacturing Industry

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Abstract

Lean manufacturing appears to hold considerable promise for addressing a range of simultaneous, competitive demands including high levels of process and product quality, low cost and reductions in lead times. This research addresses the application of lean manufacturing concepts to the continuous production sector with a focus on the motor manufacturing industry. The goal of this research is to investigate how lean manufacturing tools can be adapted from the discrete to the continuous manufacturing environment. This paper presents lean manufacturing as a leading manufacturing paradigm applied in many sectors. The fundamental focus on lean production is the systematic elimination of non-value added activity and waste from the production process. The implementation of lean principles and methods results in improved system and surrounding performance. Value stream mapping is used to first map the current state used to identify sources of waste and to identify lean tools to eliminate this waste. The future state map is then developed for a system with lean tools applied to it. To quantify the benefits gained from using lean tools and techniques in the value stream mapping, a detailed simulation model is developed and a designed experiment is used to analyze the outputs of the simulation model for different lean configurations. This paper demonstrates the implementation of lean philosophy through layout modification.

Keywords: Lean manufacturing, layout, value stream mapping, witness, VIPPLANOUT, Bottleneck.

1. Introduction

Lean is a popular fact that JIT system started in the initial years after the World War II in Japan for the Toyota automobile system. Toyoda family in Japan decided to change their automatic loom manufacturing business to the automobile business. But they had few problems to overcome. They could not compete with the giants like Ford in the foreign markets. Therefore Toyota had to depend upon the small local markets. They also had to bring down the raw materials from outside. Also they had to produce in small batches. They haven't had much of capital to work with. Therefore capital was very important. With these constrains Taiichi Ohno took over the challenge of achieving the impossible. With his right hand man Sheigo Shingo for next three decades he built the Toyota production system or the Just In Time system.

Long production runs, big backlogs and long lead times are fast becoming operating styles of the past. Flexibility and quick response must become the norm. The driving force behind this need is customers who increasingly expect short lead times for products configured exactly as specified and delivered on time, every time. The trend of quick-response, no-excuses delivery has put many manufacturers in the uncomfortable position of having to conform or lose business to a competitor who has developed short cycle time capabilities. To meet competitive requirements and reduce costs, many manufacturers are turning to lean manufacturing techniques to drastically cut cycle time and increase their competitive edge.

Lean operating principles began in manufacturing environments and are known by a variety of synonyms; Lean Manufacturing, Lean Production, Toyota Production System, etc. It is commonly believed that Lean started in Japan (Toyota, specifically), but Henry Ford had been using parts of Lean as early as 1920's, as evidenced by the following quote: "One of the most noteworthy accomplishments in keeping the price of Ford products low is the gradual shortening of the production cycle. The longer an article is in the process of manufacture and the more it is moved about, the greater is its ultimate cost." [1].

In order to set the groundwork for this paper, let's begin with the definition of Lean, as developed by the National Institute of Standards and Technology Manufacturing Extension Partnership's Lean Network. A systematic approach of identifying and eliminating waste through continuous improvement, flow the product at the pull of the customer in pursuit

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of perfection. Keeping in mind that Lean applies to the entire organization. Although individual components or building blocks of Lean may be tactical and narrowly focused, and achieve maximum effectiveness by using them together and applying them cross-functionally through the system.

In its most basic form, lean manufacturing is the systematic elimination of waste from all aspects of an organization's operations, where waste is viewed as any use or loss of resources that does not lead directly to creating the product or service a customer wants when they want it. In many industrial processes, such non-value added activity can comprise more than 90 percent of a factory's total activity. The objective is to make the production flow through the system quicker and in more predictable manner. Some of the activities to improve the production environment are discussed below. The intent is to eliminate waste thereby permitting better wages for workers, higher profit for owners and better quality for customer. Types of wastes, effects of waste, using lean tools as explain to the following table 1.Value stream mapping is a set of methods to visually display the flow of materials and information through the production process. The objective of value stream mapping is to identify value-added activities and non value-added activities.

Value stream maps should reflect what actually happens rather than what is supposed to happen so that opportunities for improvement can be identified. Value Stream Mapping is often used in process cycle-time improvement projects since it demonstrates exactly how a process operates with detailed timing of step-by-step activities. It is also used for process analysis and improvement by identifying and eliminating time spent on non value-added activities.

Lean Manufacturing is a buzzword. More often it is used with the terms like benefits, cost reduction, lead-time reduction etc. but if you have not started implementing lean manufacturing yet and if you have not started benefiting from lean manufacturing yet, you will need some numbers to be motivated. We shall look into some quantified benefits of lean manufacturing where the principles of lean are implemented successfully.

2. Background

2.1. Lean Manufacturing Implementation

Lean philosophy implementation in a forging company: implementing lean manufacturing in forging industry and the methodology of implementation of lean tools. Due to increased customer expectations and fierce global competition, the Indian forging industries are desperately trying to improve productivity at lower cost and still retain excellent product and service quality. In this paper, the effectiveness of lean principles is substantiated in a systematic manner with the help of various tools, such as value stream maps, Taguchi's method of parameter design [2].

The development of a survey instruments to assess the implementation of lean practices within an organization. The results of a literature review, which was used to identify lean manufacturing practices and existing lean assessment tools, are presented. The findings of this review were synthesized to develop an instrument to assess both the number and the level of implementation of a broad range of lean practices in an organization. As part of a larger research project, an exploratory study was completed using the survey. A cross section of electronic manufacturers in the Pacific Northwest was used for the exploratory study. Analysis of the survey results from the exploratory study are summarized in this paper to illustrate how the survey can be used to understand what factors might contribute to the implementation of lean practices [3]. In the exploratory study completed, it was found that while electronic manufacturers have implemented a broad range of lean practices, the level of implementation does vary and may be related to economic, operational, or organizational factors [4].

The concepts of lean manufacturing can be successfully transferred from the manufacture of cars and electrical goods to software development. The key lean concept is to minimize work in progress, so quickly forcing any production problems to get sequence solution. Production is then halted to allow each problem with the system producing the goods, to be permanently corrected. While frustrating at first, the end result is very high levels of productivity and quality. Lean software development indicates that software quality problems are often the result of deeply embedded organizational habits of recruitment, retention and motivation. To obtain organizational change there is a need for fast results from low cost actions. Change requires motivation, which is triggered and sustained by results. The lean technique has demonstrated that it can go right to the core of the problems of motivation, quality assurance and staff evaluation [5].

Lean manufacturing appears to hold considerable promise for addressing a range of simultaneous, competitive demands including high levels of process and product quality, low cost and reductions in lead times. These requirements have been recognized within the aerospace sector and efforts are now well established to implement Lean practices. Lean manufacturing was initiated within the automotive sector. A Lean implementation case comparison examines how difficulties that arise may have more to do with individual plant context and management than with sector specific factors [6].

This session discusses lean implementation and challenges faced while implementing lean in various environments. The lean implementation in forging company, aerospace sector, electronics manufacturers and software development are discussed.

2.2. Design of Lean tool

Traditional costing systems consider the accumulation of costs, but not their timing. Value stream mapping presents a good picture of the time consumed and operations performed for the production of a product within a manufacturing facility, but it does not track the accumulation of costs. The cost–time profile (CTP) is a tool that follows the accumulation of cost in the manufacturing of a product through time; and it finds the cost–time investment (CTI), which is an indicator of the use of resources in the manufacturing of a product through quantities and timing. In this paper, the expected impact of Lean implementations on the CTP and CTI is discussed. The CTP is proposed as a useful tool for the evaluation of the improvements achieved by the implementation of Lean tools and techniques [7].

The value stream analysis was carried out by breaking down each step into a series of activities, the time taken for each activity was recorded, and each activity was given a designation to indicate whether it added value. Value-add activities were designated as operation, while non-value add activities were categorized as 'delay' (including queuing and rework), 'transport' (of material or information) or 'inspection'. Supporting information was also collected, such as numbers of people involved, any discussion required, use of equipment and systems, and problems encountered. This analysis enabled improvement opportunities specific to each process area to be identified.

Lean manufacturing appears to hold considerable promise for addressing a range of simultaneous, competitive demands including high levels of process and product quality, low cost and reductions in lead times. These requirements have been recognized within the aerospace sector and efforts are now well established to implement Lean practices. Lean manufacturing was initiated within the automotive sector. However, since the publication of the influential book, The Machine That Changed the World [8], there has been a range of documented cases of Lean implementation in a variety of sectors. Despite this evidence, the perception remains that Lean manufacturing is to some degree, an 'automotive idea' and difficult to transfer to other sectors especially when there are major differences between them. In this paper we discuss the key drivers for Lean in aerospace and examine the assumption that cross- sector transfer may be difficult. A Lean implementation case comparison examines how difficulties that arise may have more to do with individual plant context and management than with sector specific factors [9].

These papers investigate the importance of the resource cost of resource usage with the time line in value stream mapping. This paper discusses the traditional costing system for calculate the resource usage. The paper motivates me to analyze further feasible design alternatives.

2.3. Summary of Literature Survey

Lean manufacturing has served the manufacturing sector with speed and quality. Those papers investigate the existing scenario of the lean philosophy in various sectors. The paper also reveals the challenges faced while implementing in the diverse environment. During the course of literature survey, there is scope for applying lean tools in any industry.

3. Objective

Objective of our project is to demonstrate systematically how lean manufacturing tools used appropriately so that industry can eliminate waste. Hence better inventory control, better product quality, and better overall financial and operational procedure can be achieved. To study of opportunities for continuous improvement (KAIZEN) and Conducting VE study for cost reduction in assembly line. From the figure.1 is to explain the Objective of lean implementation

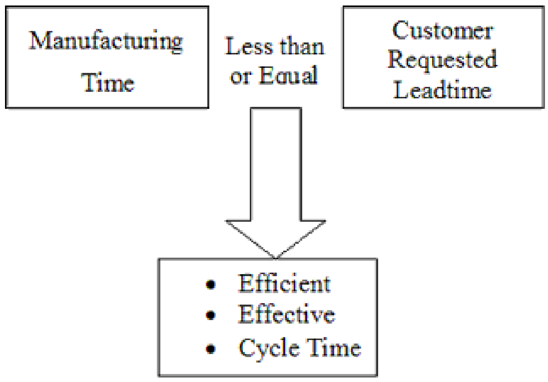

Figure 1 Objective Flowchart

4. Methodology

Getting started with an effective program to implement lean manufacturing requires careful planning, design and execution of the business changes needed to achieve the desired improvement goals. Implementation should not begin unless top management is solidly championing the effort with an understanding that many business processes must be changed. Starting with a pilot product line or another contained area of the business is a big help to "proof" your concept and methodology.

Organize and plan for Lean manufacturing with executive champion.

- Conduct extensive education
- Value stream map administrative, engineering and production processes
- Develop concept for lean manufacturing pilot
- Establish improvement targets
- Develop time-phased implementation Plan
- Present lean manufacturing pilot concept and plan to management
- Obtain management approval and commitment

- Train all employees involved in pilot
- Implement pilot

The implementation of lean concept is step by step process. Implementation steps are explained in the flowchart as shown in the Figure 2.Current state process of assembly layout in a motor manufacturing company is analyzed and current state value stream mapping is plotted (drawn). With the help of VSM bottle neck operations at machines and the nature of wastes (transportation time, distance, and work in process) are identified using calculations. Wastage type is identified and evaluated. A new layout model is developed using VIP plan out.

4.1. Selection of Critical Shop Floor

The first step in this methodology is selection of the critical Shop floor. All the production environments were studied. Assembly shop was reflecting the most number of defects and was not meeting the customer demands. So the assembly shop floor was selected as the critical shop floor.

5. Value stream mapping

A manufacturing system operates with timing of step-by step activities. The various steps in implementation of VSM are shown in Figure 3 and are discussed

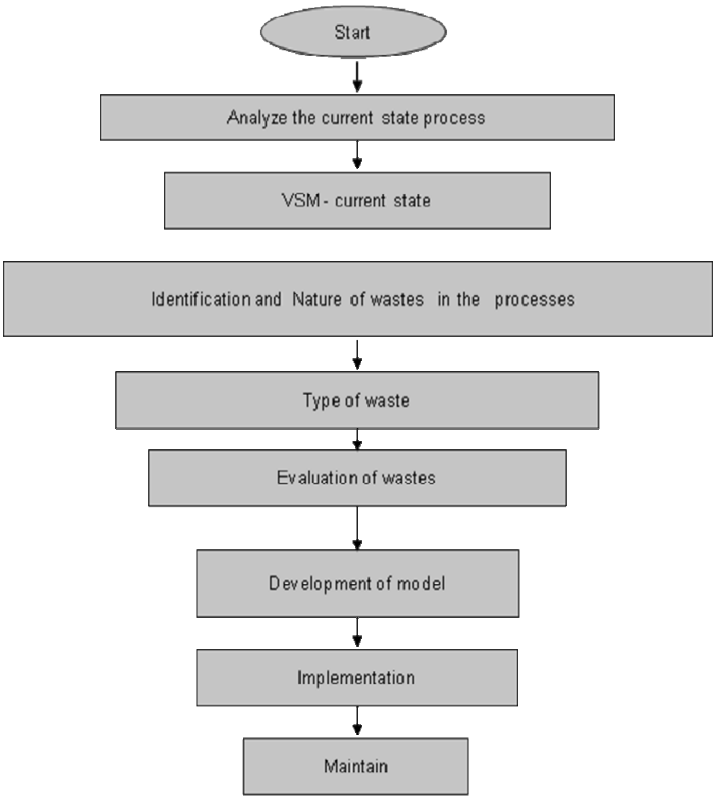

Figure 2 Methodology Flowchart

in the following sections. The process analysis is carried out by collecting the data from various enquiries with expertise in shop floor, workers and directly participating in measuring the time of various processes [2].

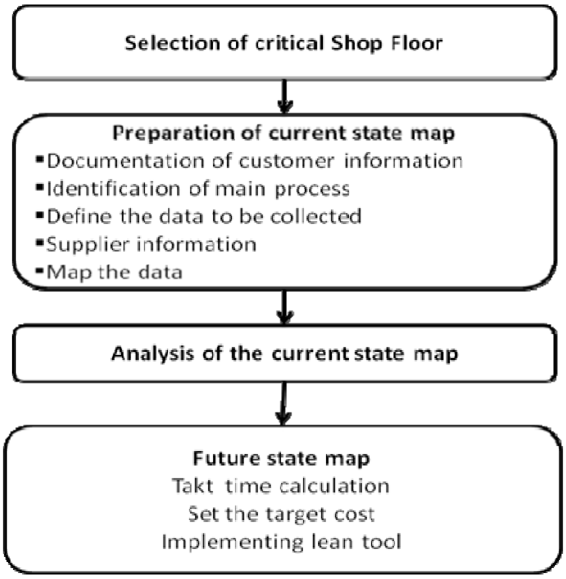

Figure 3 VSM Implementation flowchart

5.1. Preparation of Current State Map

Interaction with the industry the information of the customer's requirement. The company has a wide range of customer requesting for a wide range of product from BN56, BN63, and BN73 (induction motor). Requirement of motors are 15000 motors/month.

- Identification of Main Processes

Quick walk through the shop floor (gemba) helps to identify the main process. The main process involved in assembly shop floor is heating motor body and pressing stator, wiring & testing ,outer diameter turning ,inspection ,excess wire cutting & inserting contact pins, high voltage testing, rotor & cover assembly, quality testing, painting ,fan fixing, packing.

- Define the Data to be collected

The data in the data box serves to track down the opportunity for improving the collection of appropriate data benefits in quick tracking of the opportunities. The data box envelopes the following data like cycle time, change over time, up time and available time. The inventory triangle envelopes two data work in process between each process and respective inventory.

Table 2. VSM input data

Customer Order	15000(per month)
Demand	600(per day)
Working Hours	One Shift 8 Hours (per day)
Break	One Hour (per day)
Raw Materials	Every 15 Days

Table 3 . Process cycle time

Process	Cycle time (sec)
Heating motor body & pressing stator	87
Testing	24
Drilling & turning	71
Inspection	10
Excess wire cutting	47
Fixing terminal board	120
High Voltage testing	22
Rotor & cover fitting	135
Quality testing	80
Painting	45
Fan Fixing	80
Packing	60

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5.2. TAKT Time: A Benchmark for Process Pace

Takt demonstrates the rate at which the customer buys the product. TAKT reflects the frequency at which the product has to come out of the manufacturer to meet the customer demand. From Figure 4 Takt time is calculated by dividing available working time per shift (in sec) with the customer demand per shift.

TAKT Time of 42 seconds represents, every motor has to be completed in every 42 seconds. The current state map sights out that the Fixing terminal board & 7nserting contact pins, rotor & cover assembly processes takes 78 Seconds and 93 Seconds more than the Takt time. In order to address the problem layout modification was carried out.

Available Time =Working hours – Breaks= (8 x 60x 60) – (1 x 60 x60) = 25200 sec

$$TAKT\ Time = \frac{Available\ working\ time\ per\ shift}{Customer\ demand\ per\ shift}$$

$$TAKT\ Time = \frac{25200}{600}$$

TAKT time = 42 seconds
Demand=15000 motor/month
Demand per shift=600motor.

5.3. Process improvement (Removing Bottlenecks)

Improvements in quality, flexibility and speed are commonly required .The following lists some of the ways that processes can be improved.

- Rearranging the layout to eliminate large amounts of inventory between operations
- Add additional resources to increase capacity of the bottleneck (an additional machine can be added in parallel to increase the capacity)
- To improve the efficiency of the bottleneck activity
- Minimize non-value adding activities(decrease cost, reduce lead time)
- Eliminating the batching and moving to one piece flow

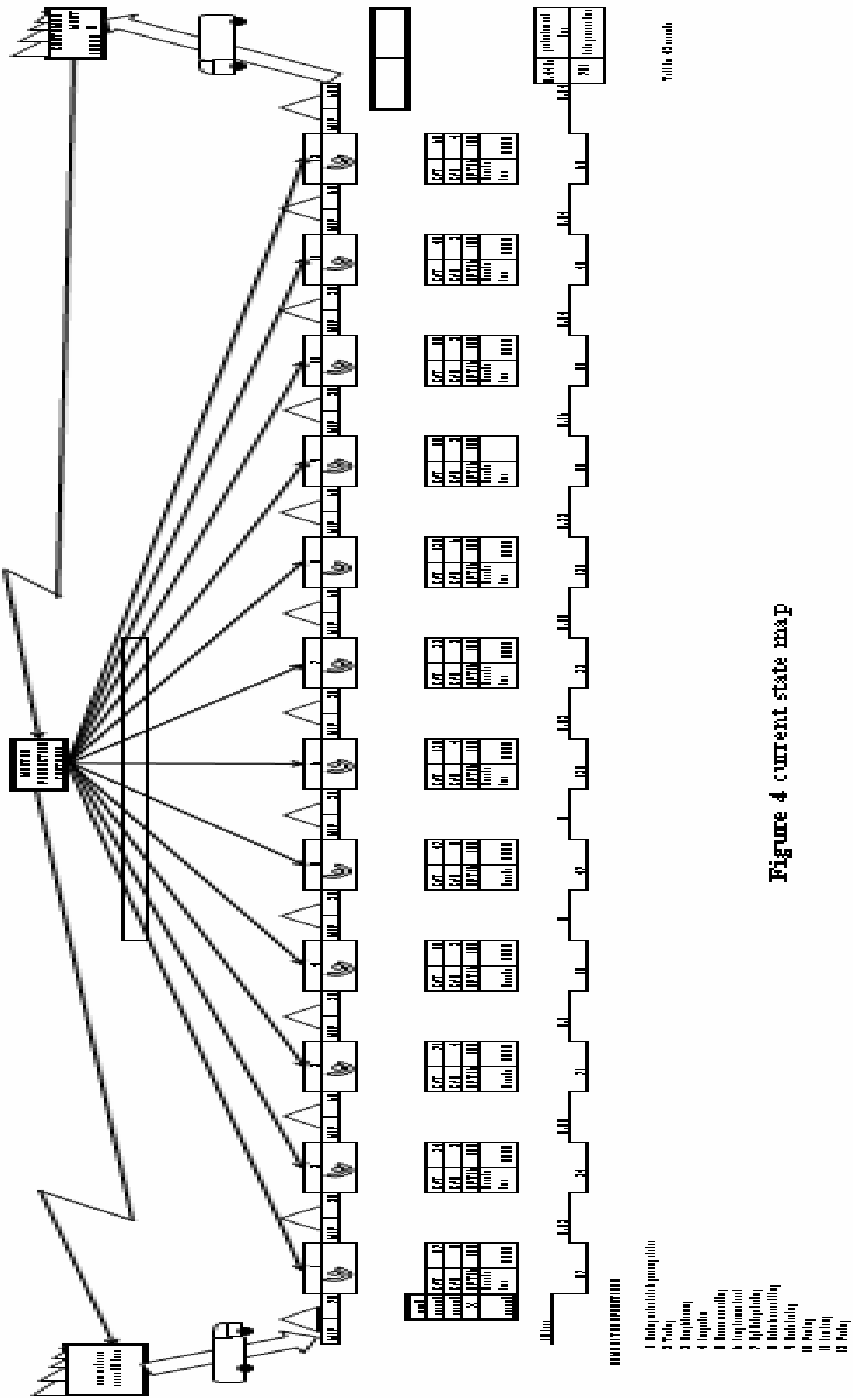


Figure 4 current state map

6. Layout modification

6.1. Current layout

The current layout motor manufacturing assembly operation. The assembly layout is shown in the Figure 5. From the Figure 5 The flow of materials are from oven to heating aluminum body and pressing stator. Then the part is moved to wiring and testing. After testing the body face in and out are done in separate workstation. Then it is passed to inspection, fixing terminal board, HV testing, rotor and cover assembly and it is tested again and painted. Fan is fixed and finally packing is done

In the industry they use batches as 50 parts. Though worker working in first assembly process of heating body and pressing stator finishes his the daily demand in shift time, the worker working in assembly process of packing, painting could not able to finish their work in shift time. Due to which extra transportation time, waiting time affects entire assembly process to meet daily demand. Similarly the part from oven takes more transportation time due to present layout in the process.

6.2. Witness model

The current layout of witness model is shown in Figure 6. From that model it has found out average machine time, average buffer size time, and number of operations. The witness model, to enter the number of machines or operations, cycle time of the each operation, part moving direction (push, pull direction) and to define the number of buffers, buffer size and to select place of each buffer. All data should be enter and to getting the current layout model. The output of the witness model is shown in table 3 and table 4.The table 3 to explain the machine statistics like % idle, %busy, number of operations. The table 4 to explain the buffer statistics like total input, total output, average buffer size and average machine time

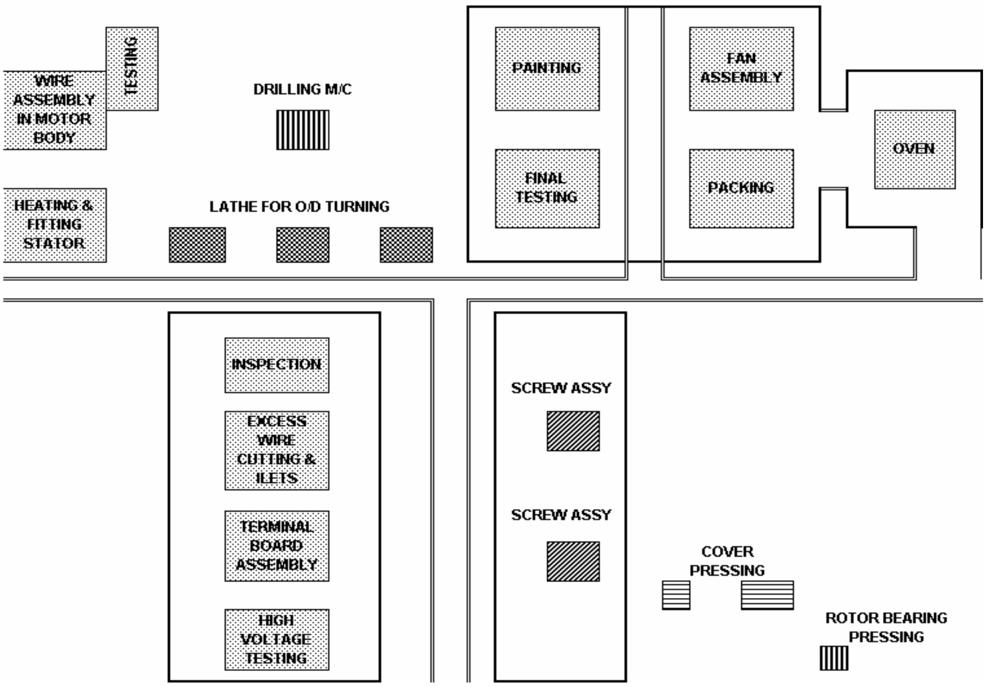


Figure 5 Current layout

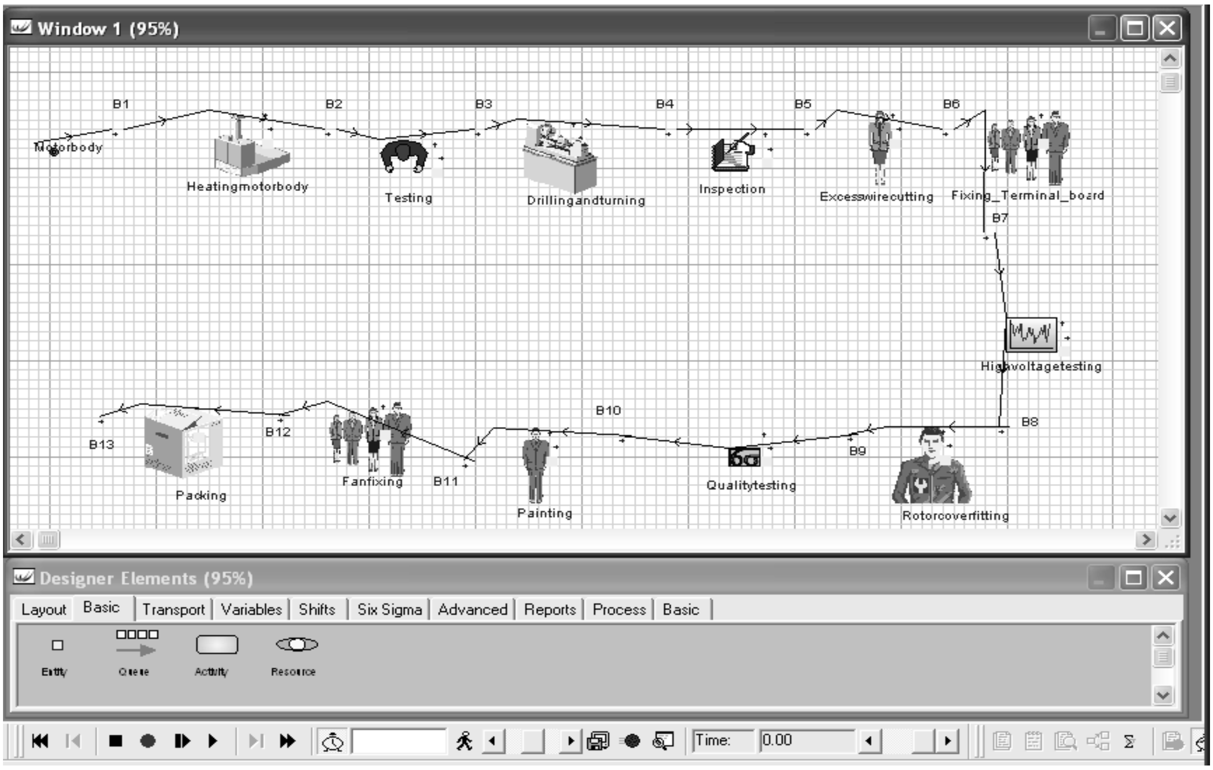


Figure 6 Witness model Assembly layout

Table 3. Current layout performance table: Machine Statistics

WITNESS

Machine Statistics Report by On Shift Time

Name	% Idle	% Busy	% Filling	% Emptying	% Blocked	% Cycle Wait Labor	% Setup	% Setup Wait Labor	% Broken Down	% Repair Wait Labor	No. Of Operations
Heatingmotorb	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	450
Testing	72.45	27.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	450
Drillingandturni	18.61	81.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	449
Inspection	88.55	11.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	449
Excesswirecut	46.20	53.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	448
Fixing_Termina	0.61	99.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	324
Highvoltagetes	81.82	18.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	324
Rotorcoverfitti	0.97	99.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	287
Qualitytesting	41.44	58.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	287
Painting	41.64	58.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	286
Fanfixing	67.17	32.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	286
Packing	56.36	43.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	285

Table 4. Current layout performance table: Buffer Statistics

WITNESS

Buffer Statistics Report by On Shift Time

Name	Total In	Total Out	Now In	Max	Min	Avg Size	Avg Time	Avg Delay Count	Avg Delay Time
B1	1451	451	1000	1000	0	989.68	26741.93		
B2	450	450	0	1	0	0.00	0.00		
B3	450	450	0	1	0	0.00	0.00		
B4	449	449	0	1	0	0.00	0.00		
B5	449	449	0	1	0	0.00	0.00		
B6	448	325	123	123	0	61.21	5356.82		
B7	324	324	0	1	0	0.00	0.00		
B8	324	288	36	36	0	17.80	2153.94		
B9	287	287	0	1	0	0.00	0.00		
B10	287	287	0	1	0	0.00	0.00		
B11	286	286	0	1	0	0.00	0.00		
B12	286	286	0	1	0	0.00	0.00		
B13	285	0	285	285	0	139.97	19255.42		

6.3. Performance table

From the current process layout to Identification of the wastes such as transportation distance (total process), inventory between the processes and part waiting time are reflected in the table 5.

Table 5 Current layout Wastages

Waste	Units
Transportation	140 meters
Inventory	45 parts
Part waiting time	250 seconds

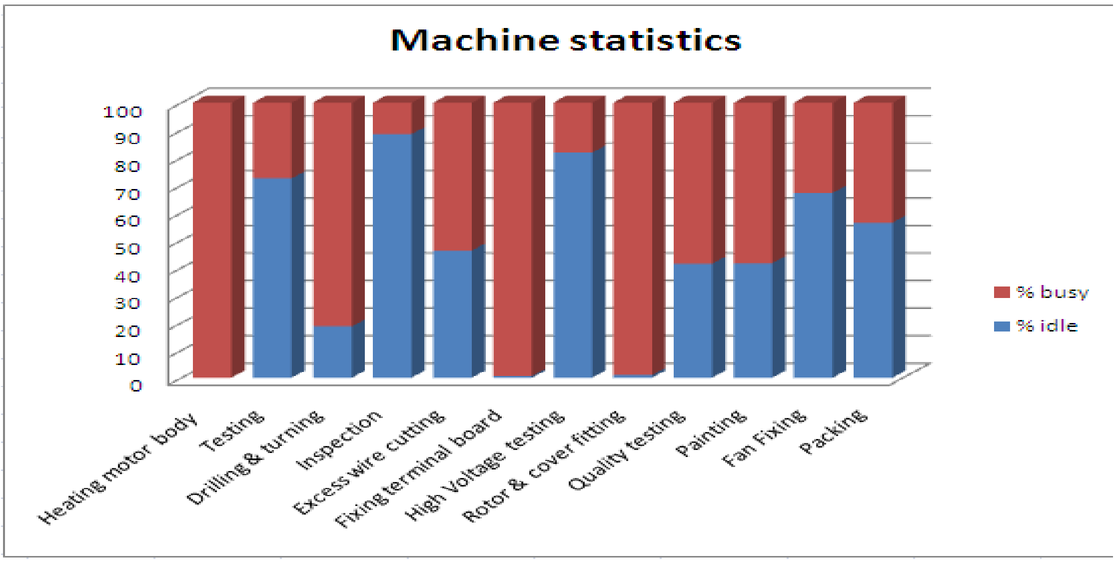


Figure 7 Machine Statistics

From the Figure 7 to explain that the percentage of machine utilization. The machine utilization value is given by table 3.The first machine is 100% busy, the second machine is 74.45% busy and 27.56% idle, like that all machine performance as shown in the figure 7.If the fixed terminal board and rotor cover fitting is 99.3% busy. To increase the machine utilization and to increase the productivity.

6.4. Modified layout

The optimized layout is show in figure 8. This layout modified using VIPPLANOPT software. The objective of modified layout is to minimize the transportation cost, inventory between the process and part waiting time.

From figure 9 to explain the transportation distance between machine to machine. Those distances are based on new modified layout. This layout modified using VIPPLANOPT software. For example the distance between 1'st machine and 2'nd machine is 51.6meters, like that calculate to total modified layout distance is 75.6meters

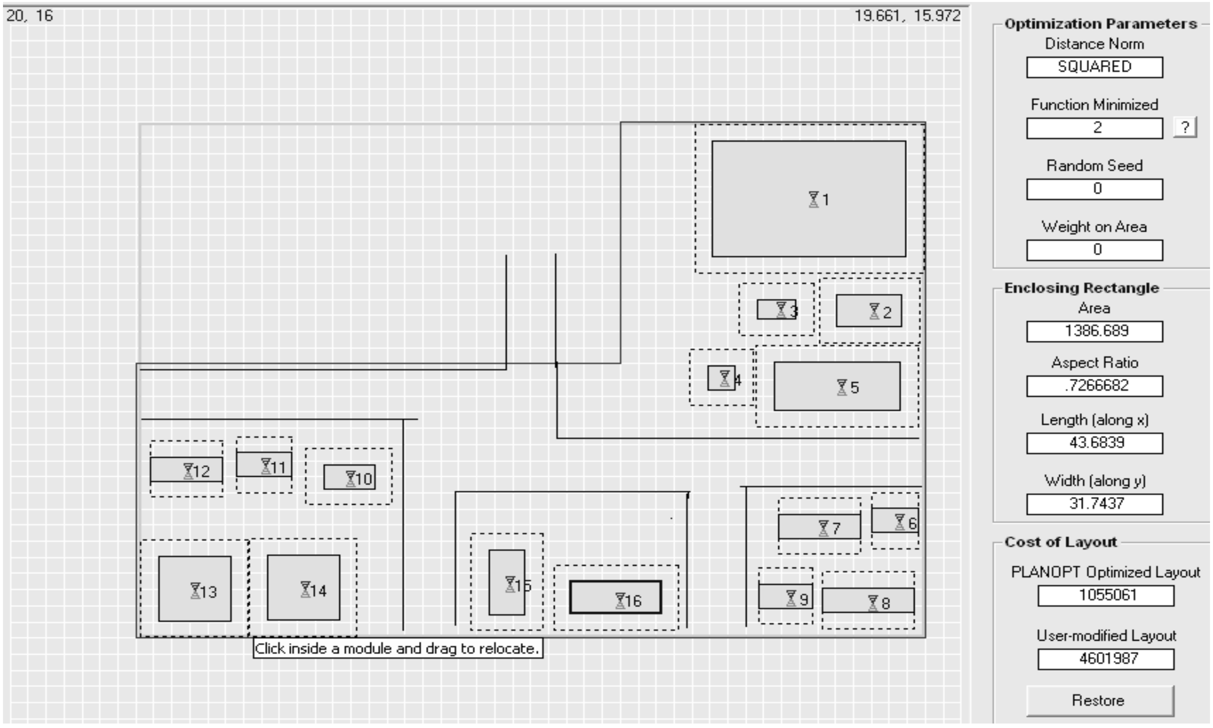
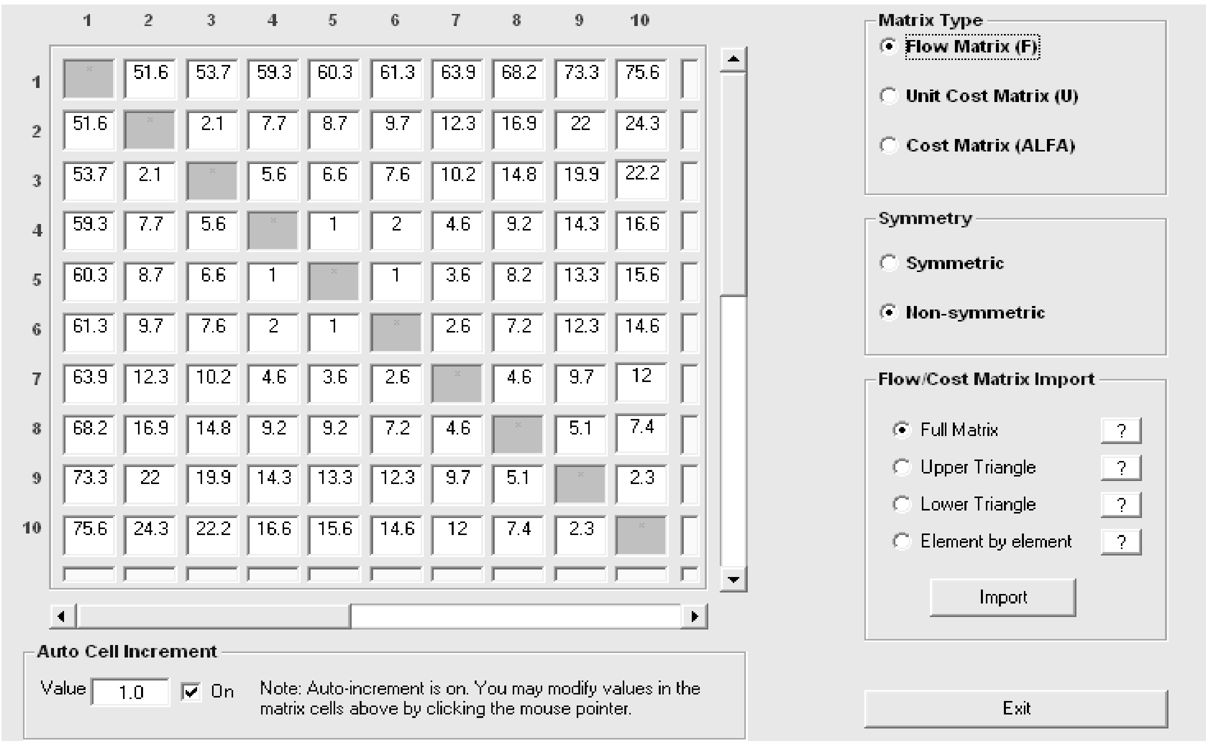


Figure 8 VIP layout model



	1	2	3	4	5	6	7	8	9	10
1		51.6	53.7	59.3	60.3	61.3	63.9	68.2	73.3	75.6
2	51.6		2.1	7.7	8.7	9.7	12.3	16.9	22	24.3
3	53.7	2.1		5.6	6.6	7.6	10.2	14.8	19.9	22.2
4	59.3	7.7	5.6		1	2	4.6	9.2	14.3	16.6
5	60.3	8.7	6.6	1		1	3.6	8.2	13.3	15.6
6	61.3	9.7	7.6	2	1		2.6	7.2	12.3	14.6
7	63.9	12.3	10.2	4.6	3.6	2.6		4.6	9.7	12
8	68.2	16.9	14.8	9.2	9.2	7.2	4.6		5.1	7.4
9	73.3	22	19.9	14.3	13.3	12.3	9.7	5.1		2.3
10	75.6	24.3	22.2	16.6	15.6	14.6	12	7.4	2.3	

Figure 9 Transportation distance

7. Conclusion

From this paper it was inferred that VSM is an ideal tool to expose the waste and to identify improvement areas. In this paper the effectiveness of lean principle is substantiated in a systematic manner with the help of simulation softwares in a systematic manner. Availability of information such as material and money flow which facilitate and validate the decisions to implement lean manufacturing. This can also motivate the organization during the actual implementation in to obtain the desired benefits. The results from these simulation software show that there can be much improvements to be made in the manufacturing of motors. It helps the companies to reach their ultimate goal of sustainability and profitable growth in the future.

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