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Transformation to Lean Production system of a Water Heater company in Oman

Mohammad Khadem, Abbas Al-Bulushi, Jaifar Al-Mazroui, Majid Al-Harthy & Zahir Al-Hashmi,

Department of Mechanical and Industrial Engineering
Sultan Qaboos University, Muscat, Oman

Abstract

Lean production not only successfully challenged the accepted mass production practices in the automotive industry, significantly shifting the trade-off between productivity and quality, but it also led to a rethinking of a wide range of manufacturing and service operations beyond the high-volume repetitive manufacturing environment. We describe a case where lean principles were adapted at a large Water heater production company in Oman. Value stream mapping was the main tool used to identify the opportunities for various lean techniques. A simulation model was developed to contrast the "before" and "after" scenarios in detail, in order to illustrate to managers potential benefits such as reduced production lead-time and lower work-in-process inventory.
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Keywords
Lean Production, Value Stream Map,

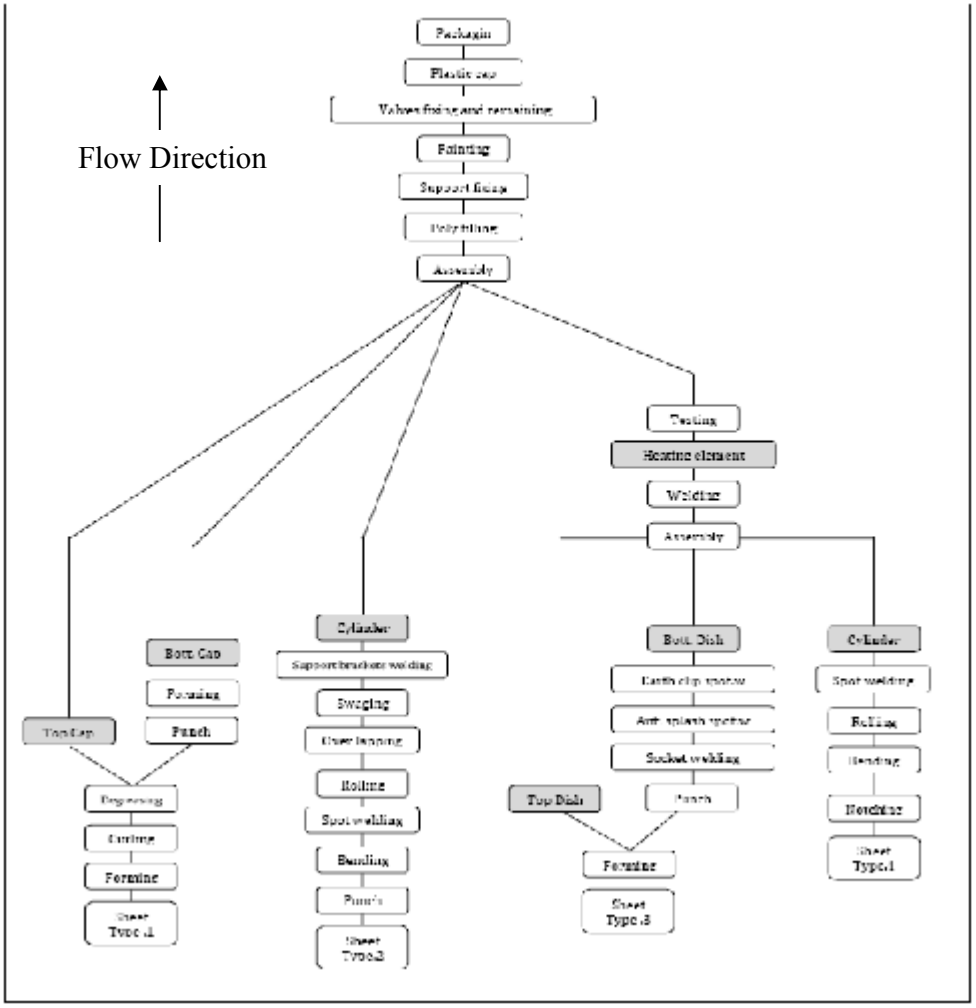
1. Introduction
Lean manufacturing is one of the initiatives is needed to apply in industrial and business sector. The main concern of this approach is to reduce the cost of non value added (wastes) activities. The waste can be overproduction, defects, unnecessary inventory, inadequate processing, excessive transportation, waiting and unnecessary motion [1]. The "lean" approach has been applied more frequently in discrete manufacturing than in the continuous/process sector, mainly because of several perceived barriers in the latter environment that have caused managers to be reluctant to make the required commitment [2]. Value stream mapping is a visual representation of the material and information flow of a particular product family [3]. Identifying value stream mapping is second step in lean thinking and it is the target of this project to visual the manufacturing system. A value stream includes all of the actions, both value added and non-value added, required to bring a product from raw material into the hands of the customer [4]. A value stream map is a tool used to chart the flow of materials and information from the raw material stage, through the factory floor, to the finished product. The purpose of the map is to help identify and eliminate waste in the process. It is a systematic approach that empowers people to plan how and when they will implement the improvements that make it easier to meet customer demand. Value stream mapping has many benefits. Mapping will help visualize the entire production of a product at a plant level, not just single process level. It is important to be able to understand the entire flow of a product at a plant level to best understand what to fix. A particular process may appear to be a problem, but when looking at the entire manufacturing process it may not be a problem at all. Value stream map will help identify the source of the real problems. Value stream maps will help show wastes and more importantly help identify the sources of waste. After studying the company assembly line some wastes and non added value activities were identified. During this project, the aim was to suggest ways to reduce lead-times and increase the productivity, efficiency and quality by converting it to be a lean. To accomplish this, value stream mapping (VSM) was used to help identify critical areas of improvement and suggest ways to fix problem areas. Information was gathered using information given from factory and by observations made on the shop floor. This information was used to construct a current state map that will show the flow of information and material. Then, the data was analyzed to determine areas that need the most improvement.

2. A case study- Water Heater assembly system

The national heater industry is located in the Rusail industry area. It produces water heaters in different types and sizes. The demand of this company is to be around 1000 heater per day. Some parts are produced in house using existing raw materials and some parts are purchased. The assembly system which applied in the national heater factory is traditional system which is push system. The system has six lines, the sixth line is to assemble all sub assemblies of the other five lines. The existing system was not designed for lean system. Therefore, the redesigning the lines to lean is a major challenge. The wastes appear as work in process (WIP), in progress inventory, unnecessary movements and the lines (stations) are not arranged in effective way. The objective of this study is to design lean assembly line for National Heater Co.. To do so, a collection of data had been done and analyzed in order to know the area need improvements by implementing lean.

3. The Flow Process of the Water Heaters

In this section the process of manufacturing Heaters will be discussed. The chart below shows each process, starting from the basic raw materials- represented as the lowest boxes in the chart- until the final packaged product- which represented by top box in the chart.



4. Current State Layout

In current state layout (Figure 4.4), the processes are far away from each other. The location of machines that used to serve such parts is spread in the plant. The travelled distance that one component of heater travelled is quiet long in compare to actual cycle time to produce the part. Here, the concern is in the precedence activity (related activity). These traveled or transport distance are defined in lean as non value added (wastes).

Figure 4.4 Current Layout

Table 4.2: Process of National Heater Regarding the layout

1	Forming	15	Socket welding (spot welding)
2	Curling	16	Anti splash spot welding
3	Degreasing	17	earth clip spot welding
4	Punching	18	Notching
5	Forming	19	Bending
6	Punching	20	Rolling
7	bending	21	spot welding
8	Spot welding	22	Boiler Assembly
9	Overlapping	23	Boiler welding
10	Rolling	24	Heating element fixing
11	Swaging	25	Boiler testing
12	Support brackets welding	26	Heater assembly
13	Forming	27	Heater painting
14	Punching	28	Packaging

5. Value Stream Mapping

The creation of a VSM is divided into five basic steps: 1- Identify the product. 2- Create a current VSM. 3- Evaluate the current map, identify problem areas. 4- Create a future state VSM. 5- Implement the final plan.

The first step is identifying the product and it consists of choosing which specific product the VSM will focus on. After the product used has been chosen, an initial VSM of the current process is created. Following the completion of the current map, the team evaluates the process and the steps involved. All this information is then compiled on a map and analysis are performed. On a usual VSM every step of the process is included. For each step, parameters could include cycle time, TAKT time, work in progress (WIP), set up time, down time, number of workers, and scrap rate. A VSM identifies where value is added in the manufacturing process. It will also show all other steps where there is non-added value. After analyzing and evaluating the current process of the product, the problem areas can be identified. Once you have changed the current process to minimize problem areas completely, you can create a final state VSM. The last step of the value stream mapping process is to implement the new ideas, which will in turn create a more efficient lean manufacturing process.

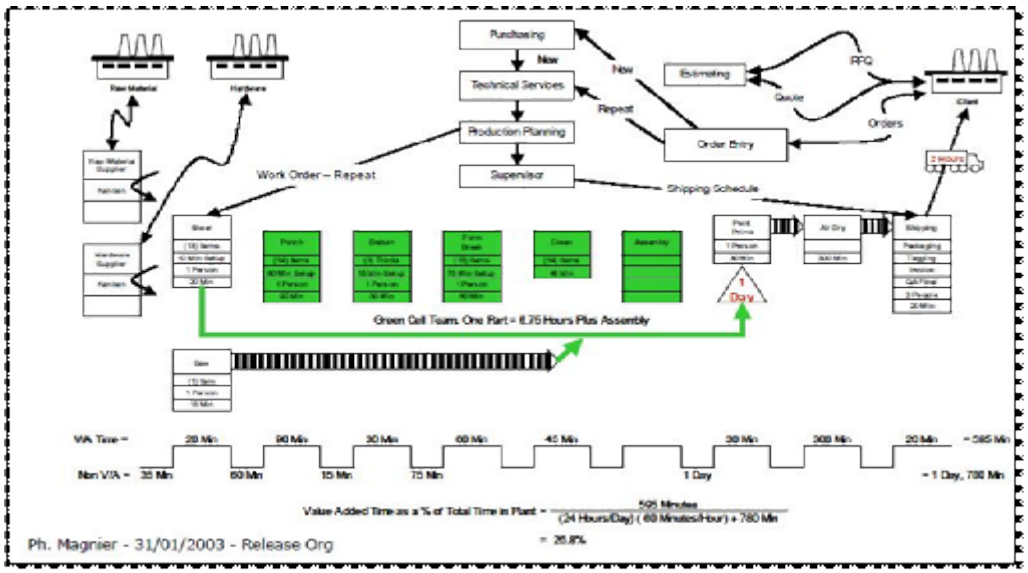


Figure 1: Example figure for demonstration

6. Results and Discussion

Based in what had been found form the simulation model of the current state and discussion of the existing VSM is that major wastes were caused by a) Work in process b) Unnecessary movements and c) Waiting activity
The major waste was work in process which caused by un-balanced production lines. So, the following scenarios were discussed to reduce or eliminate these wastes

6.1 Scenario 1: Reducing of Transfer Time

This scenario is a trail to reduce the transfer time by mean of replacing carts with conveyors and rearranging the layout of factory. First, when replacing carts with conveyors the transfer time will be minimized due to faster in transfer of parts. Further, this will decrease the effort that workers doing during transferring parts by means of carts. On the other hand, this may let the worker works efficiently because such task could lead to fatigue for workers due to loading and unloading. Secondly, the transfer distance is reduced by rearrangement of the layout. The rearrangements have been cut a lot of traveled distances and make the process and machines served a part are aligned and close to each other.

6.1.1 Procedure for Redesign Layout

Here, the algorithmic approach which is Relationship diagramming was used to find the suitable layout. After complete relationship diagram, the construction relation diagram took place by the flowing steps:

- **A** relationships are considered first and are identified by connecting the activities with four lines.
- Next, the **E** relationships are incorporated in the partial REL diagram using three connecting lines.
- **I** relationships are incorporated using two connecting lines.
- Finally, the REL diagram is completed by considering **O** relationships, which have a single connecting line.

But here it is important to keep the sequence of operation to be in aligned with others.

6.1.2 Improved layout

The improved layout was constructed based in the above procedure. The machines that are served a part in sequence are arranged to be aligned and in order to reduce transport time and work in process time. Also, the layout has been change from job shop to flow shop. By that, almost 4 recognized lines that are produced the main 4 parts of heater which are dishes, cups, inner cylinder and outer cylinder. The layout is in the figure below.

6.2 Scenario 2: Reduce the Bottlenecks Process

This scenario will be focus on bottleneck process (machines) like degreasing since it has the largest processing time in term of parts and travelling time in term of distance. By the new layout the degreasing process is close to the precedence processes. But, it stills the bottleneck in term of processing time. Therefore, it is recommended to replace the existing degreasing to decrease the time of processing to let parts move fast. By done such modifications helps to increase the capacity of machine when it replaced by the new. Other, suggestion is to add a machine of the same type of existing to increase number out in this process. This will made changes in work in process (WIP) time, stock, increase the output and decreases total time required to produce that part as well the timing of producing full unit (heater).

6.3 Scenario 3: Increasing Worker Utilization

From the simulation model, it found that some workers have low utilization which means they are idle most of time. In such case, it is recommended using these workers in other tasks to perform other tasks and help other workers that have high utilization because when the utilization the company is paying for the working time not for relaxing time. In the simulation, a set of resource property is used to assign worker to serve in other location (process). Due to these changes, the utilization will be high. The company could use such idle worker to utilize him/her-self in some process in-order that company is paying for value-added worker.

Table 6.1: Summary of Results (in Minutes)

	Current Model	Suggested Model	Amount improved
VA Time	6.0610	5.8915	2.310%
Wait Time	51.2151	35.3164	31.04%
Transfer Time	2.4939	0.6914	61.44%
Cycle Time	29.6456	22.0132	25.74%

From the table, is clear that the suggested improvements will influence the company behavior positively. The suggested improvements affect the Transfer Time mainly. The Wait Time could be reduced more if the other production lines are balanced. The bottlenecks operations which are covered in scenario one is located in production line number one and there are lots of bottleneck operations in other lines.

Table 6.2 shows the comparison between current and suggested results

Parts	Current Model	Suggested Model	% of improved
Top & Bott. Caps	33.2434	17.2582	48.08%
Outer Cylinder	2.8642	2.7298	04.92%
Top & Bott. dishes	29.3859	26.9789	08.18%
Inner Cylinder	3.6663	3.4096	07.53%

The amount reduction in WIP in Entity1 reflects the benefit of reduction in Degreasing and Curling processes. In the current state the processes after Degreasing are hungry because it waits the parts that come from Degreasing process. Here, the conclusion is summarized that the production lines should be balanced to reduce the WIP to the minimum amount.

7. Conclusion

The researcher concludes that value stream mapping with Simulation Model are effective tools to suggest ways to reduce lead-times and increase the throughput of a manufacturing process. That was done by magnified studying of assembly lines and the manufacturing processes in Water Heaters Company. Further, data was collected in different timing during production time but it has some limitation due to some restriction from management.

The current state map arrange the manufacturing process while the timeline comparing value added and non-value added times clearly showed large amounts of wastes contributing to long lead-times. Many times process improvement efforts will focus on reducing set up times or increasing machine and operator efficiencies. The current state map shows that most of the waste in the process contributing to long lead-times is in the non-value added times while the product waits in queue. Large reductions in lead-times can be achieved just by reducing time that the product waits in queue. Throughput rate increased was achieved through careful scheduling of a controlled bottleneck.

The layout revision and redesign was involved in this project to be part of lean in order to reduce transfer time in term of parts and walking distance in term of workers. Algorithmic approach which is relationship diagramming was used to find the relation between the manufacturing processes and flow of materials.

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