Implementing Lean Manufacture to Enhance Performance In Gas Valve Production Line

Eng. Khaled Hassan Soufi, PhD Researcher at Faculty of Graduate Studies for Statistical Research, Cairo University, Egypt. Prof. Abdul Hadi Nabih Ahmed, Faculty of Graduate Studies for Statistical Research, Cairo University, Egypt. Prof. Abd El Hakim Al Manhawy, Faculty of Graduate Studies for Statistical Research, Cairo University, Egypt.

Abstract

The purpose of this study is to address that Lean Manufacturing is the most suitable technique which can be used in developing countries like Egypt, mostly past Covid-19 era, lean is cheap easy and has positive quick effect on quality and productivity in shop floor in order to achieve the latest trend in quality management (Lean, 6σ and supply chain). Lean manufacturing has been the buzzword in the area of manufacturing for past few years. The concept originated in Japan after the Second World War when Japanese realized they could not afford the massive investment required to build facilities similar to those in the USA. lean manufacturing aim is to reduce waste in human effort, inventory, time to market and manufacturing space to become highly responsive to customer demand while producing quality products in the most efficient and economical manner. Nicholas (1998) found that waste takes many forms and can be found at any time and in any place. Waste consumes resources and not adding any value to product. Russell and Taylor (1999) define waste as anything other than the minimum amount of equipment, effort, materials, parts, space, and time that are essential to add value to the product. Lean manufacturing combines the best features of both mass and craft production: the ability to reduce costs per unit and dramatically improve quality while at the same time providing an ever wider range of products and more challenging work (Womack et al., 1990).

Keywords

Lean manufacturing, Value Stream Mapping, and Gas valve production line.
Introduction

Improvement and mass production are the key words to develop industrial sector in Egypt which is facing great challenges more than ever in Covid-19 pandemic era which will create great questions about the future of Egyptian economy, especially in the industrial sector, which may have the opportunity to boom after this world crisis.

Egypt has a great opportunity to get the most benefit out of the current crisis, whether at the level of exporting or local industry, in fact the industrial map of the world will change, and create opportunities for our country to be a worldwide industrial center by relying on ourselves, encouraging local industry and focus on producing high quality products and minimizing production wastes this can improve our products reputation in worldwide markets and permit local industry to lead the Egyptian economy for better future, through applying lean manufacturing in the work place where lean is easy, cheap and fast methodology to achieve rapid positive changes.

In this study we will prove that applying lean manufacturing in the shop floor will reduce production time, scrap, material, cost and manpower in Production Line with minimum cost for improvement.

Theoretical background

The gas valve is one of the most sophisticated components in the cooking stoves industry due to the complicated production steps and the high safety measures that need to be accomplished in the final product, using Lean manufacturing will improve performance and consequently save money, time.

The present study is carried out in XYZ gas valve production line located in Cairo, Egypt. The production line was established in 1990 consists of 10 machines making 19 different operation steps in 340 second to produce one gas valve which is relatively a long production time.

Around 60 technicians and inspectors as direct employees and 21 indirect employees are needed to run and maintain the production line, which is considered a large investment in manpower. Local market's capacity is more than 9 million valves per year and the factory is producing only 1.6 million valves per year which is 17% of market share in the same time around 50% of the needed amount imported from different countries due to the lack of the local production capacity.

Study problem

Negative feedback through management review and internal audit reports showing long production time and large scrap rate in flange production which passes through two steps automatic mould casting to produce four semi finished flanges on a tree and each flange should go through machining one by one creating a bottle neck in the production line, applying lean manufacturing will enhance performance of the production line.

Two types of machines used in the conventional method of the flange production:

- Automatic Molding Machine and Machine Center through 5 steps:

  1. 2nd step is separating the four semi finished flanges from the tree manually by the operator in five seconds.
  2. 3rd step is visual inspection of the semi finished flanges to insure that the flange is free from any damage or defect in ten seconds.
  3. 4th step is feeding the semi finished flanges to two stations machine center manually to adjust the final dimensions of the flange in seventeen seconds. 5th step is final inspections of the flange to the final shape to check the dimensions using go/no-go gauge in ten seconds for each piece by one operator each shift.
Current State Flange Production Flow Chart

Quality tools (flow chart and value steam mapping) were used to identify the current state of the processes and activities as shown in figure (2) & (3).

Fig (2): Current State Flange Production Flow Chart
Studying the flow chart and VSM for flange production, production steps are performing a bottleneck due to the accumulation of the semi finished flanges before machining and forming high scrap after the machining. The accumulation of semi finished flanges before the machining step is due to the sequential production way, where the 1st finished flange was produced in 67 sec production time equation according to sequential production method is (38 + nx17) sec, where (n) is the order of the flange in the production sequence, also there is 10% scrap after the machining step due to the miss feeding by the operator, it is around of the daily produced quantity.

The team started studying the types of waste in the current flange production method, there are three types of Muda in the flange production method where Muda is any activity the does not add value to the process as follows:

- **Waiting time**

  Casting cycle time is 14sec to produce four semi finished flanges connected on one tree.

- **Scrap**

  The semi finished flange is relatively small in size, manually fed into machine center and due to small size of the parts and miss adjustment due to human error, 10% of the daily production for the semi finished flanges are scrap after the machining step.

- **Excess motion**

  5000 semi finished flanges are produced each day by the casting machine transferred in specific containers to the machining area for ten meters which lead to excess motion as another type of Muda.
Using lean manufacture to reduce flange production wastes in the current state.

A team was formed and brain storming exercise was conducted to generate creative solutions for waste reduction in the current state of flange production, realizing that:

Machining process for the semi finished flange is the root cause of all problems in the flange production because of the sequential production method; the team suggested two solutions to solve the problem:

Add another three machine centers to the production line to substitute the sequential production by simultaneous flange production.

Cancel the machining step and try to produce the flange in the final shape directly through precision casting.

The first solution was rejected due to the high investment needed and in the same time it will increase the scrap, the team started to study the second solution as follows:

Mould consists of two parts, the first part contain four holes, injection head and four runners.

The second part contains four locators pressed into the holes to give flange the required shape.

After studying the mould dimensions and the flange dimensions team planned the future state of the flange production as follows:

Keep the external dimensions of the mould and change some internal parts of the mould in order to produce finished flanges without using the machine center which will minimize the cycle time, number of workers, amount of used material and the scrap.

The new design of the mould was necessary to combine the two production steps of the flange to one step.

Fig (4): Value stream mapping represents flange production future state.
Analysis of the flange production VSM in the future state.

- After applying the new method for producing the flange in a single step through casting the cycle time was decreased from 67 seconds to 38 seconds, the number of operator needed to perform this production step was only 3 steps.

- Number of machines is one instead of two, all of this improvement reflected on the types of wastes which the team designated earlier where the waiting time was eliminated to zero also scrap was reduced by 10% where only small percentage of scrap where resulted after casting.

- finally the excess motion was eliminated because the transportation of the finished flanges after casting will be directly to the next assembly step.

Evaluation of flange production present and future state.

The comparison between the Value Stream Mapping in the present state and in the future state flange production steps are given in table (1).

The magnitude of improvement calculated in the last column.

<table>
<thead>
<tr>
<th>Points of comparison</th>
<th>Present State</th>
<th>Future State</th>
<th>Percentage of decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle time</td>
<td>67 sec/piece</td>
<td>38 sec/piece</td>
<td>43.4%</td>
</tr>
<tr>
<td>Manpower</td>
<td>5 workers/shift</td>
<td>3 workers/shift</td>
<td>40%</td>
</tr>
<tr>
<td>Number of machines</td>
<td>2 machines</td>
<td>1 machine</td>
<td>50%</td>
</tr>
<tr>
<td>Used material</td>
<td>14 grams/piece</td>
<td>12 grams/piece</td>
<td>14.3%</td>
</tr>
<tr>
<td>Steps of flange production</td>
<td>5 steps</td>
<td>3 steps</td>
<td>40%</td>
</tr>
<tr>
<td>Scrap due to machining</td>
<td>10%</td>
<td>0%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Table (1): Comparison between the Present and Future State for the Flange.

**Fig (5): Comparison between the Present and Future State for the Flange.**
Cycle time was decreased by twenty nine seconds due to the usage of the new mould which eliminate the two steps of machining and the visual inspection. The percentage of decrease is 43.4%.

The number of workers was decreased by two workers due to the removal of machine operator and the inspector of the flange after machining. The percentage of decrease is 40%.

The number of machines will be one instead of two machines after using the new die with the final dimension which will produce the flange in the final shape instead of the semi-finished one. The percentage of decrease is 50%.

The amount of used material per piece was decreased by 2 grams / piece which affect the annual production as follows:

\[
2 \text{ grams/piece} \times 1,200,000 \text{ piece/year} = 2400 \text{ kg/year.}
\]

The percentage of decrease is 14.3%.

The number of steps was decreased from five to three steps after using the new mould where the machining step and visual inspection step where decreased after using the new final dimension die which give the flange after mould casting in the final dimension instead of the semi-finished flange which produced from the conventional mould. The percentage of decrease is 40%.

### Calculation of cost reduction in flange production process.

- Time needed to produce one finished flange will be as follow:
  - Casting cycle time is 14 seconds to produce four finished flanges.
  - Cycle time for one finished flange will be 4.5 seconds.
  - Daily customer demand = Customer demand (year) / working days = 1,200,000 / 240 = 5000 pieces.
  - The direct cost and indirect cost for the machining step is 20.89 Pt / Piece.

Numbers of parts produced in one year 1,200,000 •

The total saving cost in one year is 1,200,000 x 20.89 = 250,680 LE / Year.

- The cost of the new mould is 20,000 Le.
- The period for the mould price retrieve

\[= \text{Price of new mould} \div \text{saving cost} \]
\[= 20,000 \div 250,680 = 1 \text{ month.} \]

This means that the cost of the new mould will be covered in one month.

The new mould can work effectively for 6 years. •

Amount of saving in 6 years = 6 x 250,680 = 1,504,080 LE.
<table>
<thead>
<tr>
<th>Cost Reduction</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>direct cost and indirect</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Numbers of parts</td>
<td>1200000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The total saving cost in one year</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The cost of the new mould</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total amount of cost saving in 6 years</td>
<td>1600000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Daily customer demand</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
References:


