USING LEAN TOOLS AND ARENA SIMULATION TO IMPROVE PRODUCTIVITY

Ayat Sabah\textsuperscript{1}, Ass.Prof.Dr.Luma A.H.Al-Kindi\textsuperscript{2}, Ass.Prof.ZainabAl-Baldawi\textsuperscript{3}

\textsuperscript{1, 2, 3}University of Technology, Baghdad, Iraq

E-mail\textsuperscript{1} pme.19.30@grad.utoTechnology.edu.iq, E-mail\textsuperscript{2} Luma.A.Alkindi@utoTechnology.edu.iq, E-mail\textsuperscript{3} 70063@utoTechnology.edu.iq

ABSTRACT

Most industrial organizations are associated with reducing waste activities. They often use Lean manufacturing technologies as the best method to achieve their objectives. Unnecessary movement, inadequate processing, excessive transport, defective, waiting, unnecessary inventory, and overproduction may lead to these non-add-value wastes and long lead time production. This research presents the application of lean concepts in the leather shoes manufacturing industry in Baghdad using simulation software. Simulation is a set of methodologies used to simulate the characteristics and behaviors of a real system using software programs. This study aimed to decrease lead time and improve the productivity of the leather shoe manufacturing industry. Interviews and observation in the production department are used to identify the highest process cycle time by the line graph and generate a simulation model by ARENA simulation. After adopting lean tools, productivity has been improved by 43% depending on the decrease of the total production cycle time by 31%.

Keywords ARENA simulation; Cycle time; Improvement; Lean; Productivity

I. INTRODUCTION

Lean manufacturing is a collection of methods that when properly integrated and implemented can reduce the waste in the activity of the production line. Every industry needs to improve its manufacturing strategy because nowadays the competition in the manufacturing sector is fierce. Many industries have experienced the benefits of applying the lean concept in their area to improve the production process, resource utilization, and reducing waste in the activities which is the goal of the lean concept in the manufacturing industry (Nasution et al. 2018). ARENA simulation is computer software used in modeling and analyzing the flow of the process, idle, and the queue in a different kind of manufacturing system to overcome the problem, also it helps to detect process bottleneck, maximize the throughput, and assess the future improvements process. To find the bottleneck in the production line and improve the productivity, cycle time of all the processes must be identified and measured, where cycle time is an important tool to keep the production in line with demand, the cycle time of the process refers to the time the product takes in the production or assembly system from the start to the end of the process (Ali and Zulkifli 2017). In this paper, the process mapping is drawn to identify all the steps of manufacturing that assist in the industry improvement. The line graph is also used, it is a simple chart used to display improvements over time, and assist in identifying the bottleneck processes.

II. LITERATURE REVIEW

Organizations whether manufacturing or service are being challenged to address obstacles and difficulties as a result of the increasingly evolving market environment, and the organization needs to respond to these changes, therefore the principle of lean manufacturing was created to maximize resource utilization by eliminating waste (Sundar et al. 2014). The identification of waste (MUDA), Lean concept can be combining with other tools which lead to improving productivity, optimize the resources utilization of the industry, and eliminate the waste (MUDA) (Dhake and Gosavi 2014). The combination of the important lean tools, VSM with the simulation of the current and future state of a production system in the pump manufacturing industry, has a positive impact on the performance of the system. Where lead time, WIP, and takt time have reduced, and an increase in throughput rate and utilization have been achieved (Tahir et al. 2015). The implementation of lean tools by identifying the
non-value activity and the bottleneck station using a value stream map to explain the current situation and 5S to minimize excessive man and material motions, lead to increase the productivity of the water pump pipe by reducing the cycle time. (Suganthini Rekha, Periyasamy, and Nallusamy 2017). Identify the cycle time of the process and the simulation in the assembly line in the furniture industry, where ARENA simulation is used which is a discrete event simulation and automation program that enables the development of an experimental model helped in increasing the efficiency of the cycle time of the process (Ali and Zulkifli 2017). Integrate value stream map with simulation software, help identify and find the value-added, and non-value added of the process. The simulation model was built before and after the implementation of lean tools to improve the process and illustrate the potential benefits of increasing the output and reducing lead-time, cycle time, takt time, and WIP. (Maheshwari 2017). Adapt lean principles for the process assembly line using line balance and leveling the work in process (WIP) and simulation were used to validate the result and improve the throughput rate (Nagi, Chen, and Wan 2017). The implementation of some lean tools in the manufacturing industry has a positive impact on the productivity of the system, where the defectives rate has decreased as a result of the use of lean tools. (Katikar 2020)

III. THE METHODOLOGY

This research is done using a collection of data. The data collected is classified into two categories: qualitative and quantitative data. Qualitative data are data that describe qualities or characteristics than measure it and are collected using interviews, focus groups, observation; these data may be in the form of descriptive words. Quantitative data are structured and statistical data, in the form of numbers and values, are generated through experiments and reports. The methodology flow chart for this study is shown in the following Figure 1.

![Figure 1. Research methodology](image)

Implementation of the Research Methodology

The proposed approach has been validated through a case study in the State Company for Textile and Leather Industries with the focus on the selected factory which is the men's leather shoe factory. The factory produces various types of civilian and military leather shoes and occupational safety shoes in various models, colours, and sizes. Its products are distinguished by that they are made of natural leather, which is cowhide, with specifications approved by the Central Agency for Assessment and Quality Control, where manufacturing is made according to demand and the demands of the market in various measurements. One of the most standard model demands in the factory was selected to implement the proposed method.

4.1 mapping the process of manufacturing

One of the most important applications of process mapping is in the manufacturing industry. Many various processes need to be mapped in the manufacturing sector. A process map is a strategy and management tool that represents the flow of work visually. It is used to describe any activity involved in determining what a
manufacturing industry does. Figure 2 shows the process mapping of shoe manufacturing. There are four main stations in the processing of shoes, starting from station A cutting, station B sewing, station C lasting, and finally station D finishing.

4.2 Graph of the Cycle Time

The cycle time for the four main stations: cutting, sewing, lasting in addition to the last process cleaning and packaging is determined starting with the time the component is picked to the time it is placed at the next process. The cycle time is calculated and recorded based on job sequences determined through observation. The information of the station and the process’s cycle time is identified in Table 1.

Table 1. The station information

<table>
<thead>
<tr>
<th>The station</th>
<th>No of process</th>
<th>Cycle time</th>
<th>No of workers</th>
<th>Total No of processes</th>
<th>Total cycle time</th>
<th>Total No of workers</th>
</tr>
</thead>
</table>

Figure 2. The process mapping of shoe manufacturing
The graph of the process cycle time is constructed as shown in figure 3. Based on the graph, process 20 (the name of this process is gluing 6 as identified in the graph) which is gluing all inner edges and the base manually in section C has the highest cycle time to be finished. In addition to this process, the other two processes that have the highest cycle time in section C are processes 25 (gluing 7) and 26 (convection oven); these processes are the gluing of the shoe and sole manually and the convection oven of the shoe.

![The Graph of the Process Cycle Time](image)

Table 1: Cycle Times of Processes

<table>
<thead>
<tr>
<th>Station</th>
<th>Process ID</th>
<th>Cycle Time</th>
<th>Station Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>372 sec</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>852 sec</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>1488 sec</td>
<td>14</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>320 sec</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 3. Graph of the process cycle time

**Simulate the current situation**

To simulate the current production, a simulation module is developed and the data from the preview observation is coded into the ARENA software. The module is designed as a pull system and has no buffers between the stations. In this module different shapes are used based on their purpose therefore, it only uses create, processes, station, transfer, and disposed. In this case, there are four previously mentioned stations, as well as the dispose module, which is configured as the end of the simulation flow. At the end of the simulation, the result showed that the 274 pairs of shoes are the output of the simulation model which means the number of production shoes in the industry has been produced in a month (working 20 days) as shown in figure 4.
The Proposed Improvement

After the collected data is analyzed and running in the simulation module, and the result of the simulation showed that the long process cycle time leads to not meeting the customer demand. Some changes are implemented in the production system to eliminate the waste of time and improve productivity.

Working on minimizing the highest cycle time which is in process 20 and 25 by increasing the skill of manpower and increase the number of workers in the station, also in process 26 the improvement is increasing the degree of heat and the speed of the oven to decrease the cycle time. The number of workers in the station B, C, and D is increased to minimize the cycle time. In station A and B, the workers are eliminated due to the merging of two processes, and changing the process in the station A, B, and C which is manually where it takes long time in the process by a machine lead to minimize the processing time and minimize the manual activity.

IV. THE RESULTS

The new process cycle time after improvement by increasing the number of workers, change the manual process to be done by machine, and reducing the number of the process by merging some of them, this improvement is shown in table 2. From the table, there is a decrease in the cycle time in station A by 18%, in station B by 22%, in station C by 43%, and in station D by 19% therefore, the total percentage of decrease in cycle time is 31%. The total number of processing steps minimized from 33 steps to 31 steps and the total number of workers increased from 40 workers to 46 workers. In figure 5 the difference between the two lines of the process cycle time is very

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Figure 4. Simulation module of the current production.
large and the number of the processing steps is eliminated, which leads to minimizing the total cycle time of the shoe production line.

Table 2. The station information after improvement

<table>
<thead>
<tr>
<th>The station</th>
<th>No of process</th>
<th>Cycle time</th>
<th>No of workers</th>
<th>Total No of processes</th>
<th>Total cycle time</th>
<th>Total No of workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>304 sec</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>664 sec</td>
<td>16</td>
<td>31</td>
<td>2072 sec \ 35 min</td>
<td>46</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>844 sec</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>260 sec</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. Graph of the process cycle time after improvement

Figure 6 shows the simulation module result after applying the proposed improvement. The new cycle time is putting in the simulation module and the number of the processes is minimizing. The resulting output of the simulation increased to 393 pairs of shoes in the month. The decreased in the cycle time of the process leads to an increase in the productivity of shoe manufacturing.
This research presents the application of lean manufacturing tools to improve the productivity of the leather shoes manufacturing industry and it has a great impact on the industry improvement. The line graph of the process was used to analyze and find the longest cycle time of the process. Arena simulation was an effective tool used to validate the productivity of the shoes before and after the implementation of the proposed improvement in the industry. From the study, we can conclude that the amount of production increased from 274 to 393 pairs of shoes, the productivity has 43% increased, and a 31% reduction in the total cycle time of production is gained.

V. CONCLUSIONS

REFERENCES