Application Of Lean Six Sigma in Industry: A Sugar Company Case Study

Soheir Backar, Beshoy Raafat and Nermine A. Harraz

***Abstract*— The integration between lean manufacturing and six sigma methodology – Lean Six Sigma (LSS) – is often used in many industries, e.g., to overcome nonvalue adding practices and wastes. Many Researchers applied LSS in industries like oilfield, food, ores, foundry clusters, etc. Also, it is used in Services, e.g., to improve quality of performance and increase market share. These services are, e.g., hospitals, educational institutes, healthcare. LSS tools used in both application types may be similar, but the results gained differ quantitively and qualitatively. This paper shows different types of applications used LSS and the tools used, whether in industries or services, and the results reached in each due to the usage of various tools. A case study was held in one of the sugar companies in Egypt, showing the impact of this method and its tools to improve such an industry. The five stages were applied with the suitable tools reaching promising results, as will be explained.**

***Keywords*—** Inventory, Lean, Six Sigma, Waste.

I. Introduction

Lean six sigma methodology is widely used nowadays in industries and services to benefit from integration between the two strategies, lean manufacturing and Six Sigma. As a definition, Sigma is a Greek letter that stands for the standard deviation in the science of statistics. Six Sigma is a methodology used to optimize errors and value, where the sigma level is used to measure any company's performance [1].

On the other hand, lean manufacturing is defined as: "*a set of techniques that intend to remove various types of wastes throughout the value chain*" [2]. According to Wilson (2009), the reasons for calling lean with such a name are the ability to use less material, investment inventory, space, and people while running it [3].

The main target of lean manufacturing is reducing costs through waste elimination. Lean has two primary bases: Just in time (JIT) and Jidoka [3]. Feld [4] stated that Lean manufacturing consists of five main elements: manufacturing flow, logistics, organization, process control, and metrics.

The integration between lean and six Sigma – named lean six Sigma (LSS) – includes both tools and philosophies to reduce and eliminate waste, variations, and non-adding value activities and improve the quality of the product or the service [5].

Atmaca et al. (2013) found that applying LSS where Six Sigma focuses on quality over speed while lean management focuses on speeding the process. Their integration helps the process be quick lean-to increase the sigma level [6].

In the review section, a summary is given for the usage of LSS in different industries and services, the tools used in each, and the results obtained for this application. Then a case study is presented in an Egyptian sugar company to show the effect of the application in such industry as an example of waste management in the field of perishables inventory control.

II. Review

The critical failure factors of LSS were discussed by Albliwi et al. (2014), including Lack of resources, training, top management, and poor project selection [7].

Many researchers applied lean six Sigma for different types of industries or services. LSS could be used in electricity stations [8], oilfield operations [9], healthcare [10-12], and education [13].

In this review, the implementation of LSS is shown in many industries and services using different tools, and the results obtained from this implementation compare the effect on both.

According to Saad et al. (2017), LSS is used in many manufacturing places, but for non-manufacturing (services) places, it isn't the best to be used. They used LSS in an electricity distribution company using only the first two steps: Define and Measure with main tools like project charter, Pareto chart, and pie chart [8].

Sagnak et al. (2016) used LSS in reducing the pollution resulting from flue gas emissions. They found that lean and Six Sigma integration helps eliminate many limitations while using lean practices only. One of these limitations is the inability to check the project's variation reduction [2].

Van et al. (2006) used this integration to eliminate defects (complications) in hospitals and increase waiting times. Tools like a flow chart, SIPOC, project charter, stakeholder analysis,

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FEMA, and fishbone diagram were suggested for usage in similar services cases. They discussed the importance of the integration of six Sigma and lean. They noticed that lean practices only have a problem with diagnosis and analysis methods while six Sigma needs lean standards. [11]

Buell and Turnipssed (2004) discussed the role of a combination of LSS and ISO to improve the oilfield operations industry. This integration leads to a controlled system for safer, faster, and better with high net benefit using tools like Quality function deployment (QFD), FEMA, process flow mapping, control charts, and control plans [9].

While Laureani, Brady, et al. (2013) used LSS in the medical field to improve the managerial process. Application of LSS in this field with main tools, e.g., 5S, checklist, process mapping, and control charts, aids in the reduction of lead times and falls. They found that using LSS is very useful in any process, even if applied by nearly beginner users [10].

Costa et al. (2018) provided an extensive review of lean, six Sigma, and their integration. Furthermore, they applied LSS integration to improve the food industry using value stream mapping (VSM), cause and effect diagram, process mapping, 5S, and other tools. [14].

Trakulsunti et al. (2018) tried applying LSS to reduce drug errors in the medical field. They used lean tools like VSM, spaghetti diagram, five whys, kanban, and voice of the customer (VOC) in improving the workplace and then load on the workforce to mitigate incorrect calculations [15].

Indrawati et al. (2015) increased process capability in the ores industry using LSS by using process activity mapping to reduce wastes and non-value added activity (NVA) [16].

Using LSS in the production lines, according to Morais, Sousa et al. (2015), allow the process of touching the reasons for losses in productivity. Using standardization and tools like control charts, Ishikawa diagrams, and Pareto analysis helped reduce defective parts by 84% [17].

Abdelwanis and El Feitouri (2018) used value stream mapping (VSM) as one of the most valuable tools in lean-to improve the quality of construction operation through a flow diagram of the process's activities. The related tasks of such a procedure done by different contractors tend to be complicated. Still, the usage of LSS reduces waste and increases the value steam efficiency (VSE) up to 75% [18].

Vijaya sunder (2016) applied LSS in higher education institutes (HEIs), showing its singularity compared to manufacturing industries. It was found that the quality of education was achieved using LSS like manufacturing and services. For example, applying LSS reduced the time needed to find a library book by nearly 66% [19].

Bhaskaran (2016) succeeded in applying LSS to foundry clusters using 15 lean manufacturing tools, therefore, reaching the sigma level near six Sigma (5.1 to 5.8) from (4.1 to 4.3) and decreasing the defective products. [20] He also used LSS in light engineering clusters reaching a sigma level (4.4 to 5.0) from (4.1 to 4.6) [21].

Lean Six Sigma is used to reduce patient waiting time in outpatient departments and uses tools such as project charter, SIPOC, Process map, and Cause and effect diagram. The average waiting time was reduced by 57%, and the standard deviation was reduced by 70 %, as shown by Gijo (2014) [22].

The researchers' review shows that the same tools may be used in both fields of industries and services, but each field seeks its needs and benefits. In industry fields, LSS is needed, e.g., to reduce wastes, costs, non-adding value activities and therefore increase production profits. On the other hand, services need, e.g., easiness in communication, customer satisfaction by decreasing waiting times, and increasing competition by increasing speed of service delivery.

III. Experimental Work

A. *Problem Statement*

The case was held in a sugar company that extracts sugar from the beets. The project's target was to increase the percentage of extracted sugar concerning other extracts as sugar is the company's main product. Other extracts are shown in **Fig.1.**

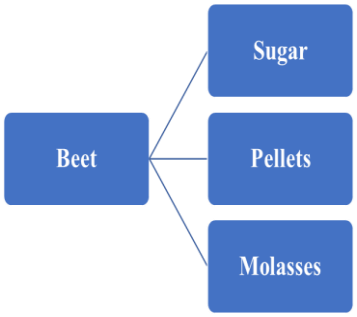

Fig. 1: Beets Extracts

Beets are stored in a conditioned beet yard if the processing capacity on the production line is complete. Otherwise, the beets enter the washing conveyor directly, then to slicers, and end by the extraction station.

B. *Methodology*

LSS methodology was used to control the inventory of the beets by applying its main phases and selected tools shown in **Fig. 2** to reduce non-adding value times between processes and in inventory, therefore reaching our target.

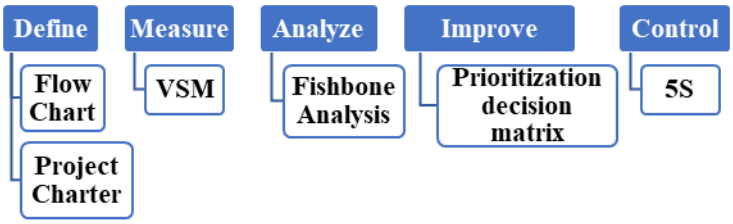

Fig. 2: LSS phases and tools

C. *Data Collection*

Data were collected by questionnaire and evaluated to define the company's problem. The times taken by each process and in

inventory were measured through different periods and visualized using value stream mapping. Then the analysis was made to help in reaching results improving the process.

IV. Findings And Discussion

The data gained from the measure phase was analyzed using the fishbone diagram shown in **Fig. 3** to get the root causes of the problem that needed to be solved. These causes were then prioritized using a decision matrix to focus on the main solutions required to improve the process.

The decision matrix depended on collecting opinions from the company's engineers and employees for each solution's effect on each root causes to prioritize solutions for implementation.

Suggested solutions in this case were:

- Establishing a good supply chain.
- Increasing the processing capacity.
- Increasing the number of suppliers of beets (farmers).
- Increasing conditioning in the beet yard.

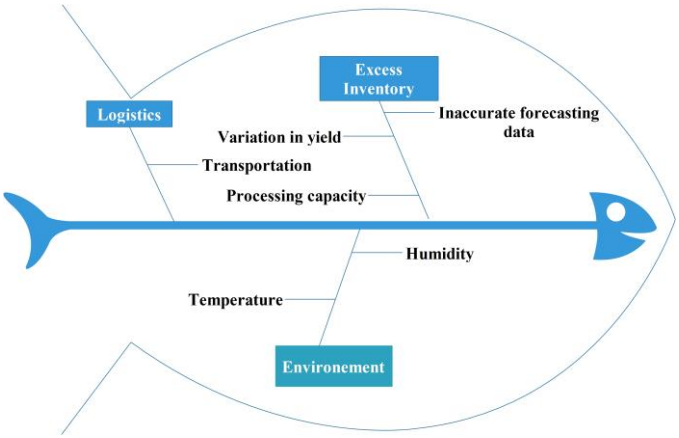

Fig. 3: Fishbone diagram

After using the decision matrix **Fig.4**, the first solution was increasing processing capacity in the production line to increase entering the beets and decreasing inventory time.

Causes / Proposed Solutions	Processing Capacity	Yield Variation	Inaccurate forecasting	Temperature	Humidity	Transportation	Total	Priority
Good Supply Chain	1	3	3	1	1	3	2.2613	2
Increasing Processing Capacity	3	2	3	1	1	1	2.376	1
Increasing Farmers Dealings	1	3	2	1	1	2	1.7453	3
Increasing conditioning	1	1	1	3	3	1	1.2797	4

3= High influence
2= Moderate influence
1= Rare influence

Fig. 4: Decision prioritization matrix

As a result, to apply this solution, the percentage of sugar loss decreased from 1.7% to 1% only, which increased the production and profits of the company a lot.

V. Conclusion

Lean Six Sigma methodology proved its effectiveness while dealing with both industries and services. The tools used in both categories may be similar depending on the application, but the results required and expected may vary. In the case of industries, most results revolve around reducing wastes, costs, and non-value-adding activities. The results centered on reducing waiting times and increasing competition and market share in services.

The application of LSS in the case of sugar companies showed flexibility in examining different parts of the process, measuring, analyzing, and improving it. LSS helped deal with factors that were excluded while using other methods. By reaching the best solution and increasing processing capacity in our case, the influence on the production, costs, and profits was significant. For future work, applying LSS may be done for other sectors in the company and secondary products like molasses and pellets.

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