DIPLOMA THESIS

Ebrahim Mirzaiee Asrami

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Applying Lean Technique in a Production Environment

Insider consultant: Dr. Miklós Daróczi

Head of Department

Insider consultant's Institute/Department: Institute of Technology / Engineering Management

Created by: Ebrahim Mirzaiee Asrami

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worksheet

Ebrahim Mirzaiee Asrami *(CMNUO0)*

for

Title of the diploma thesis:

Applying Lean Technique in a Production Environment

Task reference:

- Study the connected literature review.
- Observe and analyze the situation before implementing Lean tools on ALIA Golestan Company.
- Implement suitable Lean tools to improve efficiency, increase production capacity, and reduce waste.
- Check the results and give suggestions.

Contributing department: Engineering Management

Internal consultant: Dr. Miklós Daróczi, Head of Department, MATE, Institute of Technology

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I approve **Received**

(Head of Department) (Specialist coordinator) Ebrahim Mirzaiee Asrami

Table of Contents

1 Introduction and Objectives

It emphasizes how important lean methods are to raising competitiveness and production efficiency. It emphasizes how important it is to implement lean concepts, like process optimization and waste reduction, to actional excellence. The case study aims to investigate the implementation of lean methodologies within the framework of the vegetable oil refinery plant of ALIA Golestan Company, clarifying the effects on output and efficiency.

1.1 Importance of Lean techniques in production

Producers are constantly searching for ways to boost their competitiveness and production efficiency. There are several ways to accomplish this, including investing in new technology, enhancing the quality and effectiveness of the services, and cutting down on waste. Toyota, a Japanese corporation, came up with the initial concept of eliminating waste after World War II. Their methods were later called "lean production ". Such lean production aims to "produce more with fewer resources" (*Krafcik, 1988*) (*Womack, 1990*) (*Womack, 1994*). The most widely used techniques are Just-in-Time, ABC, and Kanban; additional techniques like 5S, Andon, etc. are continually being added.

(*Levy, 1997*) observed that, in contrast to the procedures (methods) used in conventional mass production, a revised approach to quality management is one of the pillars of lean manufacturing. An integrated strategy that prioritizes lean thinking is more significant for quality management than distinct approaches and procedures. (*Lamming, 1993*). That's the cornerstone of total quality management (TQM), which over time concurrently engages management and all other members of the company in the process of continuously improving products, services, and procedures to achieve success through client happiness (*Martin Pech, 2018)*.

Numerous industrial sectors place a high value on lean concepts and tools. The market of today is plagued by several issues, one of which is the need to prioritize the removal of trash that results from numerous operations. Lean's primary goal is to use various lean technologies to find and eliminate waste in the industry (*Mandar M. Sumant, 2015*).

1.2 Purpose of the Case Study

I genuinely find the concepts and practices of lean manufacturing to be interesting. Lean Manufacturing is the notion that enables production processes to be improved (LM). It is assumed that all production-related waste will be eliminated (Japanese: Muda), which will shorten the material's transit time through the process (English: lead time) (*Rewers P., 2016*).

Lean approaches are commonly employed to enhance and streamline production processes. The primary tenet of lean methodology is to provide value to consumers through waste elimination and productivity maximization. Over the years, numerous researchers have investigated the advantages of implementing lean principles in different businesses. Research on the application of lean approaches in the vegetable oil business is still significantly inadequate. The major aim of this study is to assess the feasibility of implementing lean practices in a vegetable oil refinery plant and to pinpoint specific areas where lean strategies can be utilized to enhance the plant's efficiency. This study intends to establish a basis for future lean improvements in the sector by concentrating on identifying lean possibilities and implementation methodologies. This project aims to create a standard framework for identifying waste, implementing ongoing lean improvements in vegetable oil production, and optimizing plant resource productivity. Establishing this as a standard will help management and production line staff identify the type and location of trash in the plant. Simultaneously, it will improve the quality of vegetable oil output by eliminating several wastes in the system. Continuous improvements result in cost savings and great efficiency, which are the primary goals of lean management.

And my MSc degree is in a field related to management, and engineering, where the application of Lean techniques is highly relevant. Studying Lean in the context of a well-known Food Industrial company like Alia Golestan in Iran could provide valuable insights into its implementation and effectiveness.

1.3 Objectives

The project at ALIA Golestan Company's vegetable oil refinery plant encompasses a range of objectives aimed at transforming its operations and driving sustainable growth. At its core is the goal of increasing production capacity to meet rising market demands, achieved through the implementation of Lean technique to enhance operational efficiency and optimize resource utilization. By streamlining processes and workflows, minimizing waste, and reducing idle time, the project aims to significantly boost production output while simultaneously lowering production costs. These efforts not only improve the plant's competitiveness but also ensure its ability to meet customer needs in a dynamic market environment.

2 Literature Review

This chapter looks at the main ideas of lean manufacturing, such as the Lean Principles, which emphasize continual improvement and waste minimization. The use of value stream mapping as a tool for process visualization and optimization is discussed. Additional subjects covered include Kaizen Events for ongoing improvement projects, 5S tools for workplace management, and Takt time for production rate synchronization. In addition, talks about waste in manufacturing processes and the significance of standardized methods for efficiency and quality assurance are included, along with an exploration of JIDOKA and Poka Yoke for error detection and avoidance.

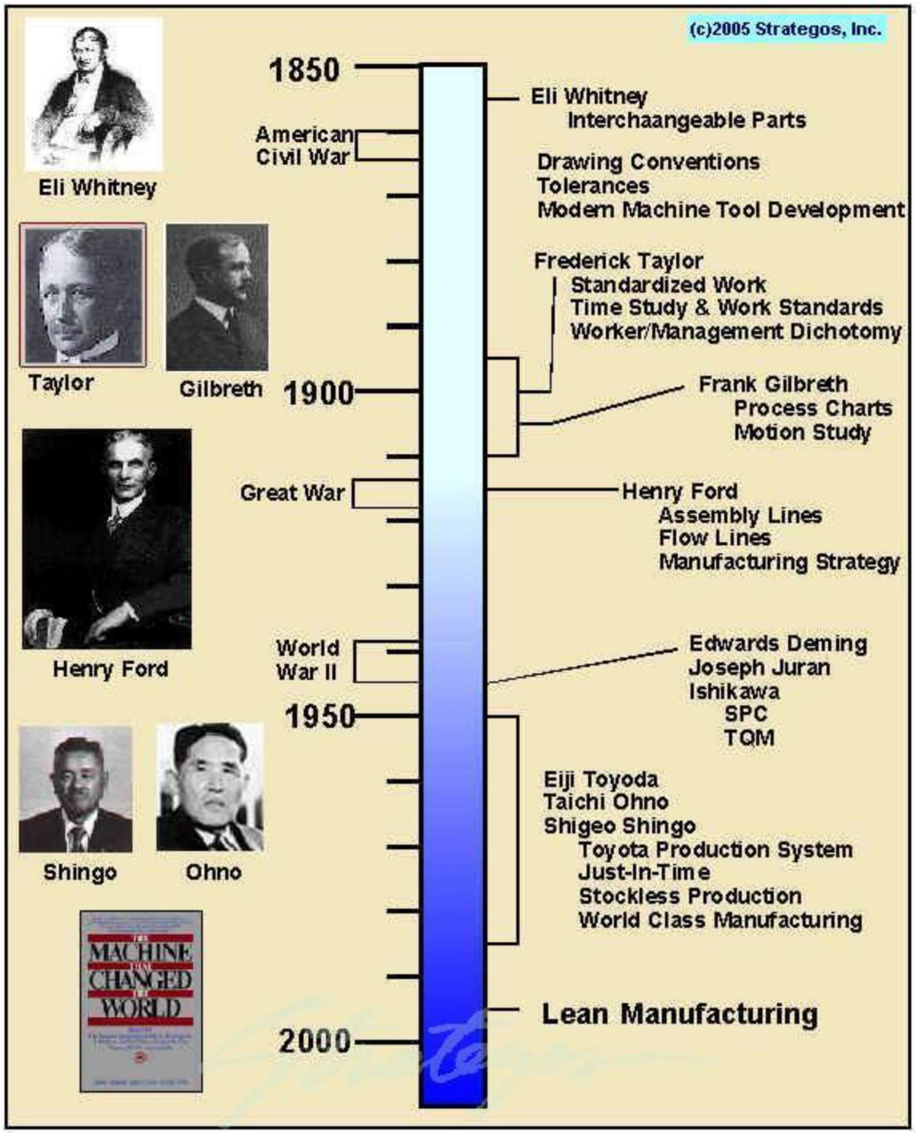
2.1 Lean Principles

Lean manufacturing, often known as lean production or just Lean, is a production methodology that views resource use for any purpose other than value generation as wasteful and should be eliminated. The amount a consumer would be prepared to pay is what is considered "value" from their point of view. The origins of the lean concept may be traced back to the late 19th and early 20th centuries when Henry Ford and other firms developed their manufacturing techniques. **(Figure 1)** provides a concise summary of how lean management has changed over time. In the cutthroat world of today, a plethora of businesses are developing their fields with meager resources. Ultimately, they require more advantages from the product department's manufacturing. This indicates that a large number of businesses have chosen to use limited resources to maximize their benefits. Using the lean management strategy is one of the finest strategies to boost the product's efficacy and efficiency. This method can help to improve the manufacturing service, for-profit and not-for-profit industries, as well as the health and education sectors. Small-scale industries are essential to many businesses. As a result, depending on fundamental elements, the major industries perceive their significance in different ways. Many industries have used the lean methodology to create better products more quickly and with fewer workers (*Dave, 2020*).

In the modern industrial setting, the production shop floor experiences enormous losses and waste. The causes of this waste include operators, maintenance issues, tooling issues, delayed component availability, low-value manufacturing activities, etc. Additional types of waste include broken-down machines, rejected parts, unusable machinery, and worker absenteeism. The attributes of waste hold great significance for the organization concerning resources such as time, materials, and market reputation (*Mihir K. Shah, 2015*).

Figure 1: History of the Lean Manufacturing

Source: (Mihir K. Shah, 2015)



2.2 Value Stream Mapping

Value stream mapping is a fundamental lean approach that was created at Toyota, just like many others. Learning to See by Rother and Shook is the book that has spread and popularized it. It is a fundamental component of a lean transformation because, rather than focusing on making discrete improvements to individual tasks within a larger value-adding process, it offers a basic blueprint for the kinds of changes required to move from a disconnected, dysfunctional flow kind of environment to one where material flows smoothly from one process to the next. Value stream mapping offers a broad framework for implementing additional tools and kaizens, as well as for seeing behind waste's outward symptoms to its true causes (*Inc., 2016*).

2.2.1 Elements of a Value Stream Map

There are three main components to a value stream map:

- Information Map: This diagram illustrates the fundamental data flow from the client to the manufacturing floor, production control/planning department, and suppliers,
- The Material Flow Map illustrates the movement of materials from suppliers to the manufacturing floor, inventory points, and manufacturing processes, ultimately ending at the client,
- The Lead Time Ladder measures the duration of value-adding operations about the overall period that items generated in the value stream have been produced (*Inc., 2016*).

2.2.1.1 Information Flow

See the data flow, or information flow, at the top of the value-stream map, which shows the stream's present state. Here, the client uses an electronic signal (fax, email, EDI, etc.) to transmit daily requirements to the production control organization. Every day, these are transformed into schedules for every factory process, and once a week, they are transformed into supplier orders. This is a pretty conventional, mass-production technique for expressing requirements to suppliers and factories. Every distinct process has a timetable, which is frequently generated by a computer scheduling system that makes an effort to adapt to changes in the production environment. These modifications would involve revisions to client delivery timetables, as well as modifications to engineering, scrap, rework, inventory, and other areas. In this instance, the schedule is a daily dispatch list, though it might also be delivered every shift or just a portion. of it (*Inc., 2016*).

2.2.1.2 Material Flow

The big block of boxes and triangles in the center of the picture called the Material Flow section of the map, shows the flow of products from raw materials to finished goods. The triangles represent inventory that has accumulated between process stages and is awaiting processing in a subsequent phase. The boxes represent discrete manufacturing operations, each of which contains data right beneath it. Important production data, including cycle time per piece, setup time, production interval, number of operators, downtime, and scrap rate, are recorded in the data boxes for each process (*Inc., 2016*).

An estimate of the quantity of inventory, expressed in time units based on takt time for the final products created in this value stream, is shown just beneath the inventory triangles in the Lead Time Ladder section of the map. For instance, it will take 30,000 seconds, or around 8.3 hours, until the inventory is consumed if the takt time is 1 unit every 30 seconds and 1000 units are waiting between two operations. Another way to look at it is that before any new material is consumed, it must first go through the feeding process and wait for roughly eight hours (*Inc., 2016*).

2.2.1.3 Lead Time Ladder

The Lead Time Ladder compares the total time spent in the value stream with the cycle times, or value-added time in each process, for each element. Value-added time and waiting time as inventory between processes are both reflected in total time. The lower steps on the latter represent value-adding time, whereas the upper steps represent wait time. The total of each of these lead-time kinds is shown at the far right, along with the occasionally startling discrepancy between the two figures (*Inc., 2016*).

2.2.2 Current State or Future State?

Value stream maps are typically found in pairs or triplets, consisting of the current state map and one or more state maps from the future. Generally speaking, the future state is intended to illustrate stages of improvement that can be attained in three to six months, not some far-off or remote future state. A corporation may want to plan out a year or more of work, in which case it may create two or more future state value stream maps, each of which builds upon the previous map (*Inc., 2016*).

The primary alteration to the information flow is the replacement of the conventional computerized scheduling logic with a pull system, which uses Kanban signals to withdraw all material from upstream operations and schedules only the assembly operation by client orders. In this instance, the main modifications to the material flow are as follows:

1. As much as feasible, group work processes into cells,
2. Calculate the production interval for every new cell, then adjust the lot sizes accordingly,
3. Establish managed supermarkets for the inventory of components and completed goods, and try your best to get rid of any inventory that exists between tasks,
4. Switch out the suppliers' weekly fax-based ordering and delivery procedure with a daily Kanban signal for ordering and daily material delivery,
5. To ensure that the demand is delivered back via the value stream in a consistent and recurring manner, level the schedule at the pacemaker process (*Inc., 2016*).

The Lead Time Ladder at the base of the future state map shows the impact of these modifications. Here, lead time decreases from <x> days to <y> days with almost no changes to cycle times in the process: this results in a <z>% change in lead time overall, a significant improvement in product flow, and a corresponding decrease in inventory investment (*Inc., 2016*).

2.2.3 Uses of the Value Stream Map

Value stream mapping's primary applications can be summed up as follows:

- It gives a broad overview of material flows, without which there is a propensity to focus on enhancing certain processes (drilling, grinding, hardening, etc.) as opposed to enhancing the value stream as a whole,
- Rather than focusing on specific procedures or roles, it enables the production, materials, and supply chain organizations to be organized around value streams. For example, a single person can be held accountable for the performance of an entire value stream, and limited resources can be concentrated on removing the causes of waste, variability, and strain rather than having different people in charge of each process in the plant,
- It gives accounting and operations a shared perspective and serves as the starting point for discussions on actual improvements,
- Rather of presenting decisions' effects as fluffy, idealistic guesses, it presents their effects quantitatively—in the form of the Lead Time Ladder,
- It links material and information flows,
- It may serve as the foundation for one or more implementation plans (*Inc., 2016*).

2.3 Striving for Excellence

This idea encourages the value stream to be continuously improved. The greatest way to put it was in Henry Ford's famous quote:

"Companies that growing to development and improvements, will not perish. But when the company stops being creative and believes that it has accomplished excellence and only has to persist in producing – it is finished"

(own translation)

It's crucial to remember that lean manufacturing is tailored for production procedures.

The aspects of human resources management are not given significant consideration by this approach. The primary distinction between Lean Manufacturing and its offspring, Lean Management, is that (*Dekier, 2012*).

While there are many ways to apply the lean concept, a clear vision is a "must have" for any organization transitioning to lean production. Establishing a sense of urgency and short-term goals to accomplish a steady pace of little improvements is another essential step in the lean process. While these components are crucial for implementing lean, organizational culture is the most important factor for ensuring that the concept is adopted and sustained. Lean adoption is simpler in societies that value collectivism than in those that value individualism. With the goal of building a competitive company, the lean approach entails an ongoing pursuit of perfection by all members of the firm, including the owners (*Leksic, 2020*).

People's profound realization that the actions they take affect them is the next essential component of a successful lean shift. Leaders in an organization must work very hard to achieve the desired behavior if they are seeking to influence the thinking of their staff. The connection between the lean toolbox and the organization's ongoing progress is known as lean leadership. Although a shop floor worker contributes value to the product, leadership is not a value-adding activity. Leadership is a vital component of continuous improvement. Employees on the shop floor should be motivated to pursue ongoing lean improvement. so, to describe the importance of shop-floor workers, an often-quoted Toyota principle could be used: 'Before we build cars, we build people' (*Leksic, 2020*).

2.4 Takt Time

Takt time tells us our demand frequency, or how frequently we must produce a product, and can be calculated as follows: Takt = Daily operating time ÷ Required quantity per day, for example, if our daily order is 890 units and we operate two 445-minute shifts, our takt time would be:

Takt = 890 ÷ (445 + 445) units = 1 minute

We would have to produce one product every minute (*Denis, 2019*).

2.4.1 Takt Time and Cycle Time

Takt time is not the same as cycle time, which is the real amount of time needed to complete the procedure. Our objective is to achieve maximum synchronization between takt time and cycle time. This enables us to support our objective of one-at-a-time production by integrating processes into cells (*DENNIS, 2015*).

To process parts one at a time (or, in certain situations, in a consistent small batch that is maintained throughout the process sequence), a cell is an organization of personnel, equipment, supplies, and techniques such that processing steps are adjacent in sequential order. A cell's goal is to establish and preserve an effective, continuous flow (*DENNIS, 2015*).

Takt time also enables us to quickly assess our production state. A product should pass us once per minute, for instance, if the takt time is one minute. We would be aware of a downstream issue if a product moved past every two minutes. This common knowledge inspires prompt corrective action to reestablish the flow of work and kaizen, which aims to eradicate the underlying source of the issue (*DENNIS, 2015*).

2.5 5S Tool

5S at its core is about removing non-value-added processes by developing standard methods for doing the necessary work. An effective 55 program therefore improves efficiency, quality, workflow, and employee safety (*Visco, 2016*).

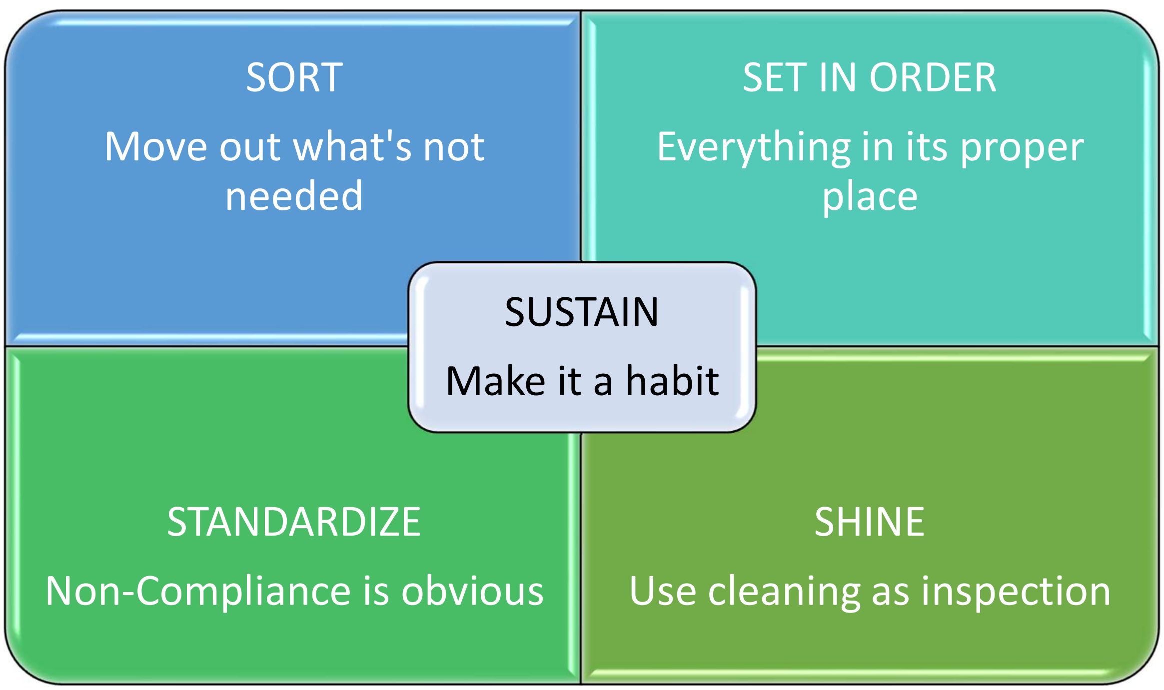
5S is based on the Japanese words that begin with the letter "s."

- Sort (Seiri)
- Set in Order (Seiton)
- Shine (Seiso)
- Standardize (Seiketsu)
- Sustain (Shitsuke)

These five "pillars" make up the 55 System (**Figure 2**) (*Visco, 2016*).

Figure 2*: 5S System*

Source: (Visco, 2016)



2.5.1 Benefits of 5S

- Prevents wasting time looking for tools,
- Minimizes the amount of walking necessary to finish tasks,
- Promotes safety by removing trip, stretch, and bend dangers,

- Makes equipment more dependable,
- Standardizes procedures to make cross-training simpler and more precise,
- Provides useful floor space,
- Assists in establishing a continuous improvement culture (*Visco, 2016*).

2.5.2 Summary of Each of the 5 Pillars

Sorting is the process of getting rid of everything that is unnecessary in the space. Going into every nook and crevice of the space, including all closets, drawers, cabinets, shelves, and corners, is part of this procedure. This is dealt with during a red tag event, where participants walk around labeling anything, they feel is superfluous in the area using pre-made red tags (either wired or sticky). After that, every red-tagged item is moved to the designated red-tag location in preparation for disposal (*Visco, 2016*).

Setting up tools, equipment, and procedures at the worker's point of use while simultaneously enhancing overall safety and ergonomics is known as "Set in Order." This phase usually takes longer than the others and calls for a lot of supplies—55 in total—including label machines, floor tape, tool control foam, pegboards, and tool shadow tape (*Visco, 2016*).

Shine: The Set in Order step takes care of a large portion of this stage. There are three goals here. Clean the space first. This can involve replacing flooring, painting walls, scrubbing or painting equipment, among other things. To ensure that the space is maintained to standards, create a schedule and assign roles. Thirdly, and perhaps most significantly, Shine creates a setting in which we may utilize cleaning to check machinery by making it simpler to identify machinery that requires repair (for instance, oil leaks are more obvious in a clean environment) (*Visco, 2016*).

Standardize: This phase aids in establishing obvious, accessible procedures for maintaining the area's agreed-upon status. The 5S Audit is one of the main instruments used in standardization. Regular audits are carried out in accordance with a rigid set of guidelines. The audit results are shared and tracked, and any necessary steps to enhance the outcomes are mentioned (*Visco, 2016*).

Sustain: Often seen as the most challenging of the five pillars, sustain is the practice that prevents things from returning to how they were before to the implementation of 5S.

It's actually much simpler than most people realize. All it takes to sustain is accountability, diligence, and repetition until it becomes ingrained (*Visco, 2016*).

How Is It Implemented?

This synopsis is merely an overview. In the upcoming chapters, we will go deeply into putting each of the five pillars into practice. The pillars are typically applied one after the other, in chronological order.

Once an organization chooses to implement 5S, it is critical to make the necessary plans. Choosing the appropriate project manager, 5S champion, team members, the size of the area to be addressed, the timeline, and the end goal are a few things to think about.

Project Leader: It is crucial that the project leader be well-versed in 55 and have a lot of expertise overseeing and carrying out process changes.

55 Champion—This is typically the person responsible for the area. They will be in the trenches while also giving guidance and instruction to the team.

Team Members-Make sure to get everyone who works directly in the area involved with the 5S implementation. Additionally, it is a good idea to have one or two people from outside the department, for some "fresh eyes" on the situation.

Size of the Area: Some want to install 55 at once throughout the whole plant. In general, this is a horrible idea. To ensure that all of the required work can be done, it is far more beneficial to select an area of approximately 1000 square feet. Select a location where a certain collection of job procedures starts and finishes. Work should go more smoothly through this set of processes thanks to 5S (*Visco, 2016*).

Timeframe: There are two possibilities for the first 5S event's duration. One option is to have the crew concentrate themselves to this event and close the region for three or four days. The second option is to run it for a few hours or a single day each week until the event is over. This alternative is less disruptive to the operation, which makes it easier for many organizations to manage (*Visco, 2016*).

Final Goal: Before moving farther with any process adjustment, it's critical to ascertain the end goal. Some businesses just tidy up using the first three pillars: Sort, Set in Order, and Shine. Even though the region is cleaned up, this is not sustainable in the absence of Standardize and Sustain. The business must determine up front if this is merely a brief cleanup effort or a comprehensive overhaul of its work process management system. Since it is constantly improving workflow and making it safer, faster, and easier, a real 5S program never ends (*Visco, 2016*).

2.6 Kaizen Events

In Japanese, kaizen means "continuous improvement." The word implies improvement that involves everyone-both managers and workers—and entails relatively little expense. The kaizen philosophy assumes that our way of life—be it our working life, our social life, or our home life-should focus on constant improvement efforts. This concept is so natural and obvious to many Japanese that they don't even realize they possess it! In my opinion, kaizen has contributed greatly to Japan's competitive success (*Imai, 2012)*.

Even while kaizen practices lead to tiny, gradual improvements, over time, the process produces remarkably positive outcomes. The Japanese business environment is dynamic, which is explained by the kaizen idea. In contrast, innovation is highly valued in Western management. It refers to significant modifications brought about by advancements in technology and cutting-edge production methods or management theories. Innovation is striking and definitely draws attention (*Imai, 2012*).

Conversely, kaizen is frequently subdued and unobtrusive. However, innovation is a one-shot deal with often disastrous effects, whereas the kaizen process, which is founded on low-cost and commonsense methods, guarantees gradual advancement that eventually pays off. Kaizen is another low-risk strategy. Managers can always revert to the previous procedure without facing significant expenses (*Imai, 2012*).

Most "uniquely Japanese" management practices, such as total quality control (TQC) or companywide quality control and quality circles, and our style of labor relations can be reduced to one word: Kaizen. Using the term kaizen in place of such buzzwords as productivity, total quality control (TQC), zero defects (ZDs), just-in-time (JIT), and the suggestion system paints a clearer picture of what has been going on in the Japanese industry (*Imai, 2012*).

All of these techniques fall under the general concept of kaizen. I quickly add, though, that these approaches should not be limited to Japanese management; rather, they should be seen as sensible guidelines that managers worldwide should follow. Any business, regardless of nationality, can gain from kaizen by adhering to the correct procedures and implementing the systems correctly. This is supported by the broad adoption of kaizen in management theory and the accomplishments of Kaizen Institute clients in over 50 countries (*Imai, 2012*).

2.7 JIDOKA

Put very simply, JIDOKA means "automation with a human element". This is the Toyota definition and is highly focused on an automated production line process. The four elements of JIDOKA are (*Tisbury, 2014*):

1) Detection of a problem,
2) Stop the line,
3) Correct the immediate problem,
4) Conduct root cause analysis and develop/implement corrective action to eliminate recurrence.

The same components of JIDOKA, albeit designed for an automated line, work equally well in any setting and can even be applied in an office or service setting. While most of the examples in this book will originate from the manufacturing sector, several will also demonstrate how versatile JIDOKA is in other business contexts. JIDOKA is delivered using a variety of tools, the two most frequently utilized being Poka-yoke and Andon, which will be covered in more detail in later chapters (*Tisbury, 2014*).
Apart from the particular instruments of JIDOKA, there exist cultural dimensions as well. This gives every worker the authority to halt output when an issue is found. This may not seem like much, but when you give it more thought and realize how much coaching and training has been provided to each employee to the point where management trusts them all to decide when to halt production, you start to see why this is such a strong culture (*Tisbury, 2014*).

A direct result of JIDOKA culture and practice is higher-quality products. For this reason, the two are connected in the diagram above. Numerous professionals have concluded that the two are interchangeable. I think the two are very different in how they approach things and why they utilize them, but when they work together, the advantages can be much bigger than when they work separately (*Tisbury, 2014*).

JIDOKA is one of the pillars of the Lean Business System as is shown in the Lean House diagram (**Figure 3**) (*Tisbury, 2014*).

2.8 Poka-Yoke (Error proofing)

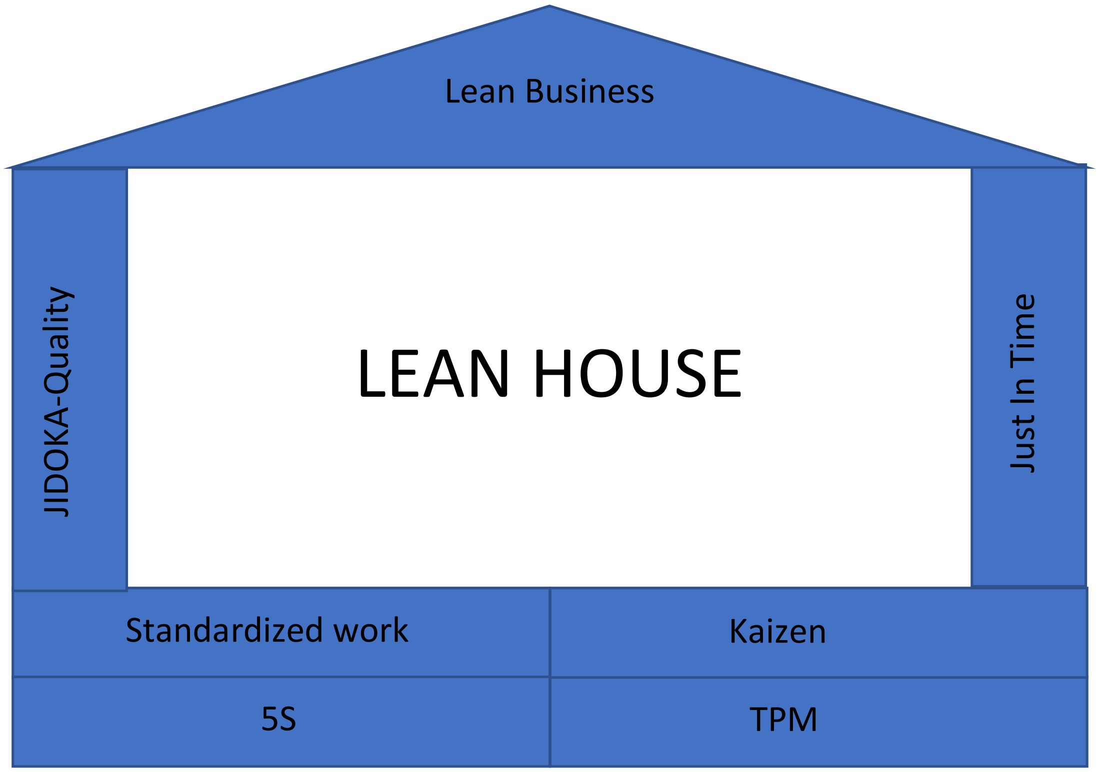
Poka-Yoke is a method used in the workplace to prevent basic human error.

Put simply, it's a mistake-proofing or fail-safe work style that strives to eliminate errors.

Poka-Yoke is essentially a mechanism meant to stop workers from making unintentional mistakes when carrying out a process (*Tobin, 2016*).

Figure 3: Lean House

Source: (*Tisbury, 2014*)



In Japanese, "Poka-Yoke" means "mistake avoidance" or mistake proofing. It involves the design of tools, fixtures, jigs, work procedures, goods, etc. that either stop errors from happening or stop errors from happening that lead to defects. Poke Yoke's secondary goal is to simplify the process of identifying any flaw with the least amount of effort, knowledge, and talent. It is accepted as a simple and inexpensive way of preventing defects from being made or identifying a defect so that it is not passed to the next operation, downstream process, and ultimately, the consumer (*Tobin, 2016*).

2.8.1 A Brief History of Poka-Yoke

Shigeo Shingo was the one who created Poka-yoke. Though he did not come up with the concept, he was the one who wrote the seminal works on this technique. Long before mistake-proofing was recognized as a distinct lean tool, the idea was in existence (*Tobin, 2016*).

At first, a lot of people referred to the method as "fool proofing," however this might occasionally be seen as disparaging the users of the gadget (*Tobin, 2016*).

2.9 Identifying wastes in the production process

Waste: What is it? Generally speaking, waste is any action for which your consumer refuses to pay. Value-added (VA) versus no-value-added (NVA) activities are typically used to explain it. There are eight categories in which waste can be classified. Overproduction, excess inventory, delays, excessive processing, underutilized workers, motion, and transportation are some of these categories. Every daily activity we perform either generates one or more of these wastes within our operation or adds value from the perspective of an external customer *(Frank Voehl, 2014)*.

Learning to pinpoint the locations, processes, and underlying causes of waste that materialize in your business is the main goal of a Lean Six Sigma (LSS) practitioner. We can utilize highly specific Lean concepts and methods to permanently eradicate these wastes from our operations once we know what they are and how to identify them (*Frank Voehl, 2014*).

2.9.1 Waste Identification

The ability to see waste is the capacity to perceive what others cannot. Lean practitioners perceive the company differently and with different preconditions and beliefs than we do. This is not to say that they see any better or worse than we do. In an LSS organization, the process of identifying waste is continuous. We're always learning how to recognize trash and comprehend its manifestations. Once we start to see, our perception of how waste adversely affects our product's performance or quality from the perspective of the client is permanently altered (*Frank Voehl, 2014*).

There are two applications for this waste identification method that make use of lean principles and tools. To begin with, waste can be discovered by qualitative methods, which do not always necessitate measurement. The main core strength of the Lean component of LSS is this. Finding waste from Lean management concepts like point of use storage (POUS) or quality of the source is an illustration of this qualitative method in action. When we comprehend the Lean POUS concept, for instance, we can quickly identify areas inside our organization where the concept may be applied to supplies, equipment, documentation, instruments, or other essential parts used in the VA process. More importantly, you begin to see the management philosophy that resulted in poor material storage to begin with (*Frank Voehl, 2014*).

Second, quantitative data tools can be used to identify waste. Utilizing quantitative methodologies necessitates measuring a specific process in order to pinpoint the location of waste. This method is a key component of the Six Sigma part of LSS and is applicable to a wide range of waste identification tasks (*Frank Voehl, 2014*).

2.9.2 Waste Elimination

After one or more of the wastes have been located, we can start applying lean principles or lean instruments to that waste to remove it from our operations. At first, look, eliminating waste seems like a straightforward case where Lean tools are applied. It's not quite that simple, though. A large portion of waste that enters our organizational processes is not caused by straightforward process flaws, but rather by operational or management philosophies about controlling all of the process inputs—materials, equipment, labor, techniques, and measurements being the main inputs. Our operational views regarding the management of these controlling-process inputs ultimately determine the amount of waste that will exist in our operation, its location, the steps that must be taken to eliminate it, and the instruments that will be required to do so (*Frank Voehl, 2014*).

2.9.3 Wastes in Vegetable Oil Refineries

At any factory, minimizing material and product losses is crucial to keeping production costs under control. Refineries for vegetable oil are not an exception. Plant losses have the potential to spread like a cancer, undetected but eating away at the company's profit and leaving management in the dark *(Gupta, 2017)*.

It is the duty of every management and supervisor to control losses at the facility. The management team of the company should adopt the idea of loss control as part of their culture because the operation's profitability also affects their compensation and any bonuses they may receive (*Gupta, 2017*).

A plant may experience losses in a variety of areas, including raw materials, completed goods, packaging, processing, low-quality items that need to be redone or discarded, etc. Because only clerical staff members gather and publish all of the data for product costing at the end of each month, the majority of these go unreported. Supervisors typically glance at these figures, but they are not appreciative of them since they are too busy to take the time to investigate and try to determine what caused any losses. The author is drawing on his own experience when discussing this. I was not very concerned about the losses the clerk mentioned because I was a production manager. But after I was put in charge of loss control for the facility, I found a gold mine. I discovered that other sites the clerk had previously indicated offered special chances to save money (*Gupta, 2017*).

2.9.4 Factors Contributing to High Plant Losses in Degrading and Variations

The plant's high deteriorating and variances can be linked to the management's lack of interest in participating in the accounting processes and their lack of attention. It is important to identify the places experiencing significant degradation and variability and to put policies in place to stop and manage them. The following is a list of the different contributing elements that cause high degradation and variability (*Gupta, 2017*):

1. accounting deficiency,
2. improper receiving and storage procedure for the packaging or raw material,
3. **improper operating practices resulting in high rate of reprocessing or losses,**
4. **equipment limitation,**
5. insufficient knowledge of cost elements and their impact on the cost degrading and variations,

6. other factors.

We are going to speak about the 3rd and the 4th factors in this paper.

2.9.5 Improper Operating Practices

Improper processing can result in serious losses that may go unnoticed. The following are some selected examples of variations due to improper process conditions (*Gupta, 2017*).

a. Using higher caustic dosage or more concentrated caustic solution can significantly increase refining loss,
b. Higher than required back pressure on the primary separator can result in high neutral oil loss in the heavy soap phase,
c. Incomplete bleaching causing process difficulties in hydrogenation, winterization, and deodorization may force the oil to be rebleached,
d. This can slow down the hydrogenation reaction, plug the filter, and shorten filter cycle time in both hydrogenation and winterization,
e. Storing deodorized oil at high temperature or without nitrogen protection may cause the flavor or the color of the oil to become unacceptable, requiring reprocessing,
f. Deodorizing under improper conditions, such as high temperature and/or poor vacuum may produce an unacceptable product that requires reprocessing.

2.9.6 Equipment limitation

a. Unreliable tank gauges can produce inaccurate inventory,
b. Poorly calibrated or unreliable flow recorders may produce high variations by reporting overfilling or underfilling of tanks, trucks, or rail cars,
c. The heat exchangers on the deodorizer may hold a large volume of oil at shutdown. This oil can cause high variations if the units are not properly drained before their cleaning and the oil is recovered *(Gupta, 2017)*.

2.10 Standardizing Work Processes

Probably the first image that comes to mind when you hear the term "work standardization" is a set of instructions hanging next to work stands (*Misiurek, 2016*).

Unfortunately, this is a frequently oversimplified method in which creating papers is the sole step in the job standardization process. Take a moment to consider whether the presence of such instructions above a workstation affects anything throughout the manufacturing process. Of course not, then! My experience in manufacturing allows me to state that, in organizations where job standardization has been reduced to document preparation, these instructions serve merely as ornamental and formal guidelines. All they do is hang beside work stands, unseen by everyone, possibly with the exception of an external auditor.

Without a doubt, instructions play a crucial role in standardizing labor (*Misiurek, 2016*).

But they are only useful for efficiently managing on-the-job training or enhancing a particular function. Put another perspective, instructions are not their own aim; rather, they are merely a means to an end, namely the standardization of the production process. Thus, we should reconsider: Is it crucial to write work instructions? Yes, is how I would respond to that. How well instructions are given has a big impact on how on-the-job training is handled and how work analysis related to improvement is carried out. It is nearly impossible to accomplish the efficacy of these two crucial tasks in the labor standardization process with inadequate instructions (*Misiurek, 2016*).

Now that we know what work standardization is not, let's clarify what it is: a procedure that outlines the most effective way to carry out a certain task at the moment, enhances it, and provides operators with training on it (**Figure 4**). As easy as it is to summarize, it is harder to carry out than it first appears (*Misiurek, 2016*).

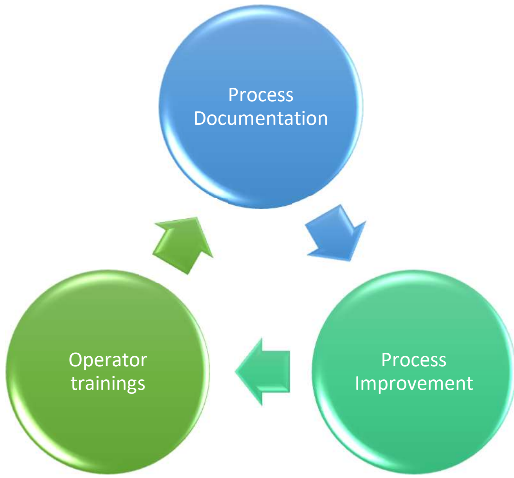
2.10.1 How Do We Get Standardized Work?

Firstly, a few preconditions, also known as prerequisite requirements, need to be met in order to support and accomplish standardized task. These are the following (*Bell, 2011*):

1. The task must be able to be completed by a human. Stated otherwise, the work needs to be something that an individual can perform safely, ergonomically, in the allotted time, and to the appropriate standard of quality,
2. The task needs to follow a repeatable procedure. The work must be designed so that the employee can complete it in the same manner every time it is expected of them,
3. The workspace, instruments, and equipment need to be extremely dependable. The job will be significantly impacted if any of these are unreliable or generate issues, whether in terms of time variations each cycle or frequent shutdown circumstances,
4. Premium materials have to be utilized. Inadequate materials and components can lead to frequent instances of defects and other quality difficulties, which will be a continuous source of problems that cause variation and disturb the worker (*Bell, 2011*).

Figure 4*: Three key elements of standardized work*

Source: (Misiurek, 2016)



2.10.2 The Required Components for Standardized Work

After the prerequisites for standardized work are established, we need to talk about the fundamental elements that are required in one way or another at all times (*Bell, 2011*).

1. Cycle (takt) time,
2. Work sequence,
3. Standard inventory (in-process stock).

3 Material and Method

A thorough history of the ALIA Golestan Company and the condition of its refinery facility before the project was implemented are provided in this chapter. It describes the goals of the project and the approaches taken, such as the use of break-even analysis to determine the project's financial sustainability. In addition, key performance indicators (KPIs) are created in order to assess how well the project's results and performance enhancements work.

3.1 Background of Company

Originally founded in 1950 as Panbeh Gorgan Company, Alia Golestan Food Industries (ALIA) was responsible for crushing, refining, and distributing vegetable oils and cotton ginning to the nearby community of the facility located in Kordkuy, Golestan Province, Iran (*ALIA, n.d.*).

With a 15,000 metric ton capacity, AG started producing vegetable oil continuously in 1978 after buying a complete vegetable oil refinery system line from ThyssenKrupp. Following a development strategy implemented by the new management in 1992, there was an increase in production capacity and the inclusion of new plastic packaging production lines (*ALIA, n.d.*).

With ThyssenKrupp's assistance, the factory's refining capacity increased by 300% from the original production lines to 45000 metric tons by 2004. Once more, the factory's total capacity reached almost 300 tons per day in 2018 after extending the previous refining line from 45 to 200 tons per day with the help of Harburg-Freudenberger Maschinenbau GmbH (HF-Group). This was achieved in 2013 when the factory's refining capacity reached 90,000 metric tons (*ALIA, n.d.*).

The company uses crude oils as raw materials for the refinery plant and specializes in sauces, plastic bottles, and consumable oil (fried oil, sunflower, canola, soybean, and corn oil) (*ALIA, n.d.*).

3.2 Overview of the refinery plant’s situation before Lean Implementation

There was an old vegetable oil refinery plant at the ALIA company the its nominal capacity of production was 50 metric tons of oil every day. Even though the plant has a lot of promise, it didn’t work in the best conditions. Because it didn’t have modern technology, most of the processes had to be done by hand, which was inefficient and made the workplace very dirty. The lack of Lean methods, especially the 5S method, makes organizational chaos even worse.

One of the most important problems at the plant was that it couldn't correctly calibrate important flow meters. So, it was hard to find the exact amounts of important raw materials like phosphoric acid, caustic soda, citric acid, anti-oxidant, bleach earth, and water, which made the quality and stability of the final product worse.

The fact that workers on the production line often made mistakes made the situation even worse. Too often, tanks fill with oil because the level controls didn’t work right or someone wasn't paying attention. Also, not having structured troubleshooting protocols made downtime from broken machines and pumps even worse, which caused expensive output stops.

In the end, these systemic problems led to daily drops in production rates, which hurt the plant's total ability to make a profit and be efficient. To deal with these problems, working processes needed to be completely rethought, money needed to be spent on modernization, and strict quality control measures needed to be implemented.

3.3 The 200 MT Refinery Plant Project

ALIA's CEO's decided to redesign operations using Lean methodologies, a strategic relationship was formed with Harburg-Freudenberger Maschinenbau GmbH (HF-Group), a prominent German business specializing in industrial automation and technology. The goal is to lead a transformative initiative aiming at revamping the existing vegetable oil refinery.

The project's blueprint, overseen by HF-Group, calls for a complete overhaul of the production line. The deployment of modern automation technology is crucial to this change, with the goal of bringing the facility to 80% automation. This improvement promises a large increase in production capacity, from 45 to 200 metric tons per day.

Most importantly, the redesigned line will have a cutting-edge control room that will serve as the nerve center of operations. Skilled workers will have real-time visibility and control over all stages of the processing cycle thanks to this command hub. Advanced monitoring systems will measure important metrics and performance indicators, revealing significant information about operational efficiency and product quality.

The switch to an automated system represents a paradigm leap for ALIA, with improved precision, dependability, and scalability. The facility intends to streamline processes, reduce errors, and increase throughput by limiting manual involvement and optimizing workflows. This strategic investment not only strengthens ALIA's competitive advantage but also positions the company for long-term growth and success in the dynamic vegetable oil market.

3.4 Methods Used

I address the use of break-even analysis for financial evaluation in the Methods Used chapter, where I also provide important performance indicators and their corresponding formulas, such as the Simple Linear Regression Model, Takt Time, Scrap Rate, Yield, and Cycle Time. These metrics are used by the ALIA Golestan Company's vegetable oil refinery plant to assess improvements and operational effectiveness.

3.4.1 Break-Even Analysis

The breakeven idea has been used, improved, expanded, and altered since it was first introduced in the 19th century in an effort to lessen or address its drawbacks and make it applicable to an increasing number of business scenarios. Breakeven analysis, sometimes referred to as cost-volume-profit analysis, is still one of the most effective approaches to concentrate on the link between cost, volume, and profitability despite its drawbacks and critics. Here, we've gathered the tools and techniques that we think managers will find most helpful *(Wentworth, 2010*).

3.4.1.1 The Essence of Breakeven Analysis

Cost-volume-profit analysis is more than just a calculation produced by using a certain formula. It is more than just a single figure that is used occasionally, like the quantity of a product that a business must make and sell. Essentially, breakeven analysis is a method of continuous thought that may be applied by individuals at any level of the organization to address a range of decision-making situations. As a result, it accepts the shared paradigm that underpins economics and accounting *(Wentworth, 2010*).

Comparing the amount of incoming value required by a business to serve its consumers by delivering an equal amount of exiting value is known as overall breakeven thinking. Breakeven thinking is a technique for evaluating the effects of projected changes by contrasting them with the current state of affairs in particular circumstances that may be changing. A breakeven formula may be used if these quantities are quantifiable. Yet, a mental comparison is still done when values are intangible or impossible to measure *(Wentworth, 2010*).

3.4.1.2 Business Situations Where Breakeven Analysis Is Useful

The conventional straightforward formula for figuring out breakeven for a business that manufactures and sells a single product may be found in many accounting textbooks. Certain literature provide breakeven calculations for businesses with many products. These formulas' simplicity has made breakeven analysis more vulnerable to criticism. Some applications for breakeven thinking and breakeven analysis are shown in the list below (*Wentworth, 2010*):

- Deciding whether to quit your job and start a new company,
- Deciding whether to outsource,

- Deciding whether to change capacity,
- Evaluating customer profitability,
- Making capital budget decisions,
- Deciding whether to start selling products on the Internet,
- Making changes to pricing policies,
- Evaluating how best to monitor operations on a daily, weekly, or monthly basis,
- Calculating the impact of changing prices and costs,
- Developing sales incentive programs,
- Determining the minimum number of transactions to complete per day, per week, or per month,
- Deciding to modify the composition of a product.

3.4.2 Key Performance Indicators (KPIs) for Lean Manufacturing

Key performance indicators (KPIs) are essential navigational tools that managers use to determine whether their company is headed in the right direction or heading in the wrong direction. The appropriate collection of indicators will shed light on performance and point out areas that require care. "If you can't measure it, you can't manage it" and "What gets measured gets done" are only two of the catchphrases that are used to emphasize how important metrics are. Managers are operating in the dark without the appropriate KPI’s (*Marr, 2012*).

The issue is that most managers gather and report a plethora of easily measurable data instead of understanding and identifying the critical few management measures. Consequently, individuals get overwhelmed with knowledge while yearning for more (*Marr, 2012*).

By reducing all important aspects of their company's success to the essential KPl’s, competent managers and decision-makers are able to assess how well everything is working. Lack of knowledge about important measures can frequently lead to anxiety and hinder people (*Marr, 2012*).

3.4.2.1 Simple Linear Regression Model

One kind of statistical model called a regression model seeks to determine the relationship between one or more explanatory factors (x) and a single outcome variable (y). It is assumed that the explanatory variables influence or predict the result variable. However, the explanatory variables are frequently referred to as independent variables because they are thought of as independent predictors of the outcome variable. Therefore, a lot of academics choose to refer to the variables that are part of a regression model as explanatory and outcome variables, responder and predictor variables, exogenous and endogenous variables, or something similar. The outcome variable and the response, or endogenous variable, are interchangeable (*Hoffmann, 2021*).

3.4.2.2 Linear Correlation: Meaning and Coefficient

The purpose of correlation is to examine the strength of the relationship between two variables under examination. The measure to quantify this level of link between the variables is the correlation coefficient. Applications typically employ one of two correlation coefficients: Spearman's Rank Correlation Coefficient or Pearson's Product Moment Correlation Coefficient (*Denis, 2019*).

Pearson's mathematical formulation to quantify the degree of relationship (R) between variables, namely, X and Y, can be given as (*Denis, 2019*):

$$R = \frac{n(\sum XY) - (\Sigma X) \cdot (\Sigma Y)}{\sqrt{n(\Sigma X^2) - (\sum X)^2} \cdot \sqrt{n(\sum Y^2) - (\sum Y)^2}} \qquad \text{3-1}$$

where,

n = Number of observations,

x = Measures of Variable 1,

y = Measures of Variable 2,

Σ x y = Sum of the product of respective variable measures,

Σ x = Sum of the measures of Variable 1,

Σ y = Sum of the measures of Variable 2,

Σx2 = Sum of squared values of the measures of Variable 1,

Σy2 = Sum of squared values of the measures of Variable 2.

The degree of correlative measure can be classified as Positive, Zero, or Negative correlation depending on the direction. Positive and negative correlations can be categorized in analyses in the same way because it is often uncommon to obtain a precise zero correlation coefficient between variables (*Denis, 2019*).

3.4.2.3 Scrap Rate

Scrap rate is a measure used in manufacturing to assess the amount of waste or defective products produced during the manufacturing process. It is typically expressed as a percentage of the total units produced. The formula for scrap rate is:

$$\text{Scrap (\%)} = \left(\frac{\textit{Number of defective units}}{\textit{Total number of units produced}} \right) \times 100 \qquad \textit{3-2}$$

3.4.2.4 Yield

Yield, in the context of manufacturing, is the ratio of usable output to input in a manufacturing process. It is the opposite of scrap rate.

The yield can be calculated using the following formula:

$$\text{Yield (\%)} = \left(\frac{\textit{Number of Good units produced}}{\textit{Total number of units produced}} \right) \times 100 \qquad \textit{3-3}$$

3.4.2.5 Cycle Time

In manufacturing, cycle time can refer to the time it takes to produce one unit of a product, from the moment raw materials enter the production line until a finished product is ready for the next stage or shipment. The formula to calculate the cycle time is:

$$\text{Cycle Time} = \frac{\textit{The Production Time}}{\textit{The Number of Units Produced}} \qquad \textit{3-4}$$

4 Results and Their Evaluation

In order to compare the financial performance, break-even analysis was carried out independently for three years prior to the project and one year following, as detailed in this chapter. To evaluate operational efficiency and productivity gains, key performance measures such the Simple Linear Regression Model, Takt time, Scrap rate, Yield, and Cycle time were used. These quantitative studies offer insightful information about how the project will affect the business's long-term operational and financial performance.

4.1.1 The Consumption of Raw Materials Before the Project

Before the project, the consumption of raw materials in the production line and their associated costs per liter of oil were recorded over the course of one year **(Table 1)**. This data provides insights into the expenses incurred and helps in assessing the financial performance of the plant prior to the implementation of productivity enhancements.

***Table 1**: Consumptions 1 year before the project*

Source: (Own work)

Raw Materials	Consumption per 1 Liter of oil (before)	€ per Kg	Cost per 1 Liter of oil (€)
Citric acid	0.0001	2	0.0002
Phosphoric acid	0.002	1.5	0.003
Caustic Soda	0.005	0.8	0.004
Bleaching earth	0.007	0.8	0.0056
Anti-Oxidant powder	0.0007	0.1	0.0007
crude oil (Soya)	1.07	0.525	0.56175
		Total Cost per 1 Liter	0.57525

In the **(Table 2)**, the total cost per liter of oil is calculated, encompassing not only the raw material consumptions but also the utilities and labor costs associated with the production process. This comprehensive analysis offers a holistic view of the expenses incurred in oil production, facilitating a deeper understanding of the overall cost structure and operational efficiency of the plant.

Table 2: *Total cost per 1 liter for 1 year before the project*

Source: (Own work)

	Cost per 1 Liter of oil (€)
Utilities costs	0.04

	Cost per 1 Liter of oil (€)
Labor Costs	0.132

Cost of Raw materials per 1 Liter	0.57525
Utilities Costs per 1 Liter	0.04
Labor Cost per 1 Liter	0.132
Total Cost for 1 Liter of oil (€)	**0.74725**

	€ per day
Maintenance Cost	**400**

4.1.2 Break-even Model 1 Year before the project

During the current situation, the refinery line produces 666,660 Liter/month, the variable cost of each piece 0.61105 EUR/Liter, while the fixed cost is 79,200 EUR/month, and the price of each liter 1 EUR.

$$\text{The total cost} = \text{Fixed cost} + \text{Variable cost} \qquad (4\text{-}1)$$

Variable cost = (variable cost for 1-Liter x Production amount for one month)

Variable cost = 0.61105 x 666,660 = 407,363 Euro per month

Fixed cost = 79,200 EUR/month

The total cost = 79,200 + 416,163 = 486,563 EUR/month

Revenue = Number of pieces x price of each pieces

= 666,660 x 1 = 666,660 EUR/month

$$\text{Profit} = \text{Revenue} - \text{Total cost} \qquad (4\text{-}2)$$

$= 666{,}660 - 486{,}563 = 180{,}097$ EUR/month

$$\text{Production Quantity at Critical point} = \frac{\text{Fixed cost}}{(\text{Price} - \text{variable cost for } 1\text{–liter})} \quad \textit{4-3}$$

Q critical = 79,200 / (1 – 0.61105) = 203,625.19 Liter per month

The results of calculations have been shown in the (**Table 3**).

Table 3: *BE Model 1 Year Before the Project*

Source: (Own work)

Before the project		
Production	666,660.00	Liter/month
r	€ 1.0	Eur/Liter
FC	€ 79,200	Eur/month
v	€ 0.61105	Eur/Liter
Revenue	€ 666,660	EUR / month
VC	€ 407,363	EUR / month
TC	€ 486,563	EUR / month
Profit	€ 180,097	EUR / month
BE1	€ 259,297	EUR / month
BE2	€ 259,297	EUR / month
Q Critical	203,625.19	Liter / month

In **Table 4**, the consumption of raw materials in the production line and their respective costs per liter of oil are documented over a span of two and three years before the project. This historical data offers valuable insights into the trends and patterns of raw material usage and associated costs over time, providing context for evaluating the plant's performance and identifying areas for improvement.

Table 4: *Costs of Raw materials for 3 years before the project*

Source: (Own work)

			2 Year Before		3 Year Before
Raw Materials	**Consumption per 1 Liter of oil**	**€ per Kg**	**Cost per 1 Liter of oil (€)**	**€ per Kg**	**Cost per 1 Liter of oil (€)**
Citric acid	0.0001	1.99	0.000199	1.98	0.000198
Phosphoric acid	0.002	1.48	0.00296	1.47	0.00294
Caustic Soda	0.005	0.8	0.004	0.7	0.0035
Bleaching earth	0.007	0.88	0.00616	0.79	0.00553
Anti-Oxidant powder	0.0007	0.96	0.000672	0.95	0.000665
crude oil (Soya)	1.07	0.510	0.5457	0.5	0.535
		Total Cost per 1 Liter	0.559691		0.547833

Table 5 shows the total cost per 1 liter of oil for 2 years before the project:

Table 5:*Total cost per 1 liter for 2 years before the project*

Source: (Own work)

	Cost per 1 Liter of oil (€)
Utilities costs	0.037

	Cost per 1 Liter of oil (€)
Labor Costs	0.132

Cost of Raw materials per 1 Liter	0.559691
Utilities Costs per 1 Liter	0.037
Labor Cost per 1 Liter	0.132
Total Cost for 1 Liter of oil (€)	**0.728691**

	€ per day
Maintenance Cost	**300**

4.1.3 Break-even Model 2 Years before the Project

2 years before the implementation of the project, the refinery line produced 1,022,212 Liter/month, the variable cost of each piece 0.58701 EUR/Liter, while the fixed cost is 79,200 EUR/month, and the price of each liter 0.99 EUR.

The total cost = Fixed cost + Variable cost

Variable cost = (0.58701 x 1,022,212) = 600,049 Euro per month

Fixed cost = 79,200 EUR/month

The total cost = 79,200 + 600,049 = 679,249 EUR/month

Revenue = Number of pieces x price of each piece

= 1,022,212 x 0.99 = 1,011,990 EUR/month

Profit = Revenue – Total cost

= 1,011,990 – 679,249 = 332,741 EUR/month

Production Quantity at Critical point = Fixed cost / (Price – variable cost for 1-liter)

Q critical = 79,200 / (0.99 – 0.58701) = 196,530.96 Liter per month

These results can be seen in the **Table 6 and 7**.

Table 6: *BE Model for 2 Years before the project*

Source:(Own work)

2 Years Before the project		
Production	1,022,212.00	Liter/month
r	€ 0.99	Eur/Liter
FC	€ 79,200	Eur/month
v	€ 0.58701	Eur/Liter
Revenue	€ 1,011,990	EUR / month
VC	€ 600,049	EUR / month
TC	€ 679,249	EUR / month
Profit	€ 332,741	EUR / month

Table 7: Continue of BE Model 2 years before

Source: (Own work)

2 Years Before the project		
BE1	€ 411,941	EUR / month
BE2	€ 411,941	EUR / month
Q Critical	196,530.96	Liter / month

And I showed the total cost for 1 Liter of oil for 3 years before the project in **Table 8**, and Its Break-even model can be found in **Table 9**.

Table 8: Total cost per 1 liter for 3 years before the project

Source: (Own work)

	Cost per 1 Liter of oil (€)
Utilities costs	0.036

	Cost per 1 Liter of oil (€)
Labor Costs	0.132

Cost of Raw materials per 1 Liter	0.547833
Utilities Costs per 1 Liter of oil	0.036
Labor Cost per 1 Liter	0.132
Total Cost for 1 Liter of oil (€)	**0.715833**

	€ per day
Maintenance Cost	**300**

4.1.4 Break-Even Model 3 Years Before the project

3 years before the implementation of the project, the refinery line produced same amount as 2 years before, 1,022,212 Liter/month, the variable cost of each piece 0.574511 EUR/Liter, while the fixed cost is 79,200 EUR/month, and the price of each liter 0.97 EUR.

The total cost = Fixed cost + Variable cost

Variable cost = (0.57451 x 1,022,212) = 587,273 Euro per month

Fixed cost = 79,200 EUR/month

The total cost = 79,200 + 587,273 = 666,473 EUR/month

Revenue = Number of pieces x price of each piece

= 1,022,212 x 0.97 = 991,546 EUR/month

Profit = Revenue – Total cost

= 991,546 – 666,473 = 325,073 EUR/month

Production Quantity at Critical point = Fixed cost / (Price – variable cost for 1-liter)

Q critical = 79,200 / (0.97 – 0.57451) = 200,258.95 Liter per month

Table 9: *BE for 3 years before the project*

Source: (Own work)

3 Years Before the project		
Production	1,022,212.00	Liter/month
r	€ 0.97	Eur/Liter
FC	€ 79,200	Eur/month
v	€ 0.57451	Eur/Liter
Revenue	€ 991,546	EUR / month
VC	€ 587,273	EUR / month
TC	€ 666,473	EUR / month
Profit	€ 325,073	EUR / month
BE1	€ 404,273	EUR / month
BE2	€ 404,273	EUR / month
Q Critical	200,258.95	Liter / month

4.2 Logframe

When applied imaginatively, the logical framework (also known as the log frame) approach offers a collection of design tools that may be utilized for project planning, design, implementation, and evaluation. Setting priorities and figuring out the expected outcomes and activities of a project can be done in an organized, logical manner with the use of log frames. When utilized properly, log frames can offer a reliable method for transforming a project concept into an extensive project design document (*Jackson, 1997*).

You can see the Logical frame matrix of the project in the (**Tables 10 and 11**):

***Table 10:** Logframe of the project*

Source: (Own work)

	Horizontal Logical Summary	Indicators	Verifications	Assumptions	Risks
Long-term Goal	Transform the vegetable oil refinery plant into a highly efficient and automated operation, aligned with Lean Management principles	Percentage increase in production capacity achieved	Comparative analysis of production capacity before and after project completion	Cooperation and support from all stakeholders, including management, employees, and external partners	Resistance to change from employees due to new processes and technologies
				Market demand for the increased production output	Market fluctuations impacting demand for vegetable oil products
Purposes	Value Stream Optimization	Reduction in process Cycle time	Time study analysis comparing pre- and post-implementation Cycle times	Availability of accurate historical data for comparison	Resistance to change from existing workforce

Table 11: Continue of the Logframe of the project

Source: (Own work)

	Horizontal Logical Summary	Indicators	Verifications	Assumptions	Risks
Purposes	Automation Integration	Percentage increase in automation rate	Comparison of manual vs. automated tasks before and after implementation	Availability of suitable automation technology	Integration challenges with existing systems
	Capacity Enhancement	Increase in daily production capacity to 200 MT	Production output measurement post-implementation	Sufficient raw material supply to support increased production	Equipment breakdowns causing downtime
	Quality Assurance	Reduction in defect rates	Quality control inspections and customer feedback analysis	Standardized operating procedures are followed consistently	Inadequate training leading to errors
Outputs	Implementation of 5S Principles	Adherence to 5S standards	Regular audits and visual inspections of workplace organization	Employee engagement in maintaining 5S standards	Lack of sustained commitment to 5S
	Integration of JIDOKA and Poka-Yoke	Reduction in production errors and defects	Defect tracking and analysis reports	Effective implementation of error-proofing mechanisms	Inadequate understanding of Jidoka and Poka-Yoke concepts
Activities	Conduct Lean Assessment	Completion of lean assessment report	Review of assessment findings and recommendations	Access to knowledgeable assessors	Limited availability of assessors
	Implement Automation Solutions	Deployment of automated equipment	Equipment installation and functionality tests	Timely delivery of automation equipment	Delays in equipment procurement

4.3 The Consumption of Raw Material After the Project

You can see the consumptions of raw material and the total cost of 1 Liter of oil after the project in the **Tables 12 and 13**.

Table 12: *Consumptions after the project*

Source: (Own work)

Raw Materials	Consumption per 1 Liter of oil (After)	€ per Kg	Cost per 1 Liter of oil (€)
Citric acid	0.00004	2	0.00008
Phosphoric acid	0.001	1.5	0.0015
Caustic Soda	0.0041	0.7	0.00287
Bleaching earth	0.0055	0.8	0.0044
Anti-Oxidant powder	0.00063	0.1	0.00063
crude oil (Soya)	1.03	0.515	0.53045
		Total Cost per 1 Liter	0.53993

Table 13:*Total Cost of 1 Liter of oil after the project*

Source: (Own work)

	Cost per 1 Liter of oil (€)
Utilities costs	0.05

	Cost per 1 Liter of oil (€)
Labor Costs	0.132

Cost of Raw materials per 1 Liter	0.53993
Utilities Costs per 1 Liter of oil	0.05
Labor Cost per 1 Liter	0.132
Total Cost for 1 Liter of oil (€)	**0.72193**

	€ per day
Maintenance Cost	**0**

4.4 Break-even Model After the project

After the implementation of the project, the refinery line produces 6,666,660 Liter/month, the variable cost of each piece 0.58993 EUR/Liter, while the fixed cost is 79,200 EUR/month, and the price of each liter 0.95 EUR.

The total cost = Fixed cost + Variable cost

Variable cost = (variable cost for 1-Liter x Production amount for one month)

Variable cost = (0.58993 x 6,666,660) =3,932,863 Euro per month

Fixed cost = 79,200 EUR/month

The total cost = 79,200 + 3,932,863 = 4,012,063 EUR/month

Revenue = Number of pieces x price of each piece

= 6,666,660 x 0.95 = 6,333,327 EUR/month

Profit = Revenue – Total cost

= 6,333,327 – 4,012,063 = 2,321,264 EUR/month

Production Quantity at Critical point = Fixed cost / (Price – variable cost for 1-liter)

Q critical = 79,200 / (0.95 – 0.58993) = 219,957.23 Liter per month

The result can be seen in **the Tables 14 and 15**.

Table 14: *BE After the Project*

Source: (Own work)

After the project		
Production	6,666,660.00	Liter/month
r	€ 0.95	Eur/Liter
FC	€ 79,200	Eur/month
v	€ 0.58993	Eur/Liter

Table 15: Continue of BE After the Project

Source: (Own work)

BE After the Project		
Revenue	€ 6,333,327	EUR / month
VC	€ 3,932,863	EUR / month
TC	€ 4,012,063	EUR / month
Profit	€ 2,321,264	EUR / month
BE1	€ 2,400,464	EUR / month
BE2	€ 2,400,464	EUR / month
Q Critical	219,957.23	Liter / month

4.5 Final Result of BE Model:

Significant gains in several important indicators are revealed by the break-even analysis's final results, which are presented in a table comparing the year before and after the project's implementation. Notably, the profit has increased by an astounding 1189%, indicating significant financial advantages. Furthermore, there is a significant spike in production rate—by 900%—highlighting improved output capacity and operational efficiency. Additionally, the project's efficiency benefits and cost optimization are highlighted by a noteworthy decrease in variable costs per liter of oil. Overall, these outcomes demonstrate how the project significantly improved performance and generated financial growth at the vegetable oil refinery facility of the ALIA Golestan Company.

The Comparison can be seen in the **Table 16**.

Table 16: Comparison Results of BE Model

Source: (Own work)

	1 year Before the project	1 year After the Project	Differences	Unit
Production	666,660	6,666,660	900%	Liter/month
r	1	0.95	-5%	Eur/Liter
FC	79,200	79,200	0%	Eur/month
v	0.61105	0.58993	-3%	Eur/Liter
Revenue	666,660	6,333,327	850%	EUR / month
VC	407,363	3,932,863	865%	EUR / month
TC	486,563	4,012,063	725%	EUR / month
Profit	180,097	2,321,264	1189%	EUR / month
BE1	259,297	2,400,464	826%	EUR / month
BE2	259,297	2,400,464	826%	EUR / month
Q Critical	203,625.19	219,957.23	8%	Liter / month

4.6 Simple Linear Regression Model:

In this case of study, I calculated this model with 2 different outcomes, first time is considered the independent variable (Predictor) is Profit, and the dependent variable (Outcome) is the variable cost for 1 Liter of oil, and it is calculated by using the values of 3 years before the project comparing 1 year after the project to have a realistic result:

x: Profit, y: variable costs

Correlation Coefficient = -0.70257

R-Squared = 0.9974

So, in this case, a correlation of -0.70257 suggests that as the variable cost for 1 liter of vegetable oil decreases, the profit tends to increase, this negative correlation is significant.

And R-squared of 0.9974 means that 99.74% of the variance in the variable cost for 1 liter of vegetable oil can be explained by the profit. This is an extremely high percentage, indicating that profit is an excellent predictor of the variable cost.

Second time I changed the outcome with “Production per month”, and the results were as follows:

x: Profit, y: Production

Correlation Coefficient = 0.99743

R-Squared = 0.99997

So, a correlation of 0.99743 suggests that as production per month increases, profit also tends to increase, production per month also tends to increase. This positive correlation is very strong.

And With an R-squared of 0.99997, it means that 99.997% of the variance in the production per month can be explained by the profit. This is an almost perfect relationship, suggesting that profit is an almost perfect predictor of production per month.

4.7 Scrap Rate:

$$\text{Scrap (\%)} = \left(\frac{Number\ of\ defective\ units}{Total\ number\ of\ units\ produced} \right) \text{ x } 100 \qquad 4(4)$$

Before the project, 5 tones or 5,556 Liter per month was considered as defective units,

Scrap rate before the project = (5,400 / 666,660) *100 = 0.83 %

After the project, the number of the defective units is 20,000 Liter per month but comparing to the production the scrap rate is as following:

Scrap rate after the project = (20,000 / 6,666,667) * 100 = 0.3 %

The Scrap rate decreased significantly, the rate of reduction in this waste is:

Rate of reduction in Scrap = ((0.83-0.3) / 0.83) * 100 = 63.85 %

4.8 Yield Rate:

$$\text{Yield (\%)} = \left(\frac{Number\ of\ Good\ units\ produced}{Total\ number\ of\ units\ produced} \right) \text{ x } 100 \qquad (5)$$

Before the project, 560,00 Liter per month was considered as a good unit produced,

Yield before the project = (560,000 / 666,660) *100 = 84 %

After the project the number of the good units due to increasement of capacity is 222,223 Liter per month, the Yield rate is as following:

Yield = (6,466,667 / 6,766,667) * 100 = 95.56 %

The Yield rate increased; the rate is:

The rate = ((95.56 - 84) / 84) * 100 = 13.17 %

4.9 Cycle Time:

$$\text{Cycle Time} = \frac{\textit{The Production Time}}{\textit{The Number of Units Produced}} \qquad (6)$$

To calculate the Cycle time, I considered 1 day for the production time for both aspects (Before and After the project).

Before the project the number of units could be produced in 1 day was 44,444 Liter or 40 MT:

$$\text{Cycle Time (Before)} = \frac{1}{40} = 0.025$$

After the project the number of units can be produced, Increased to 200 MT:

$$\text{Cycle Time (After)} = \frac{1}{200} = 0.005$$

Reduction rate in Cycle time is: ((0.025-0.005) / 0.025) * 100 = 80%

4.10 Technical issues

The degumming phase of the line was a bottleneck in terms of technical problems and maintenance,

with the centrifuges from *Sharplex* Company being a major source of these issues. The real images of old centrifuges from Sharplex Company can be seen in the **Figures 5 and 6**.

Figure 5: *Sharplex Centrifuge*

Source: (Own work)

Figure 6: *Degumming line before the project*

Source: (Own work)

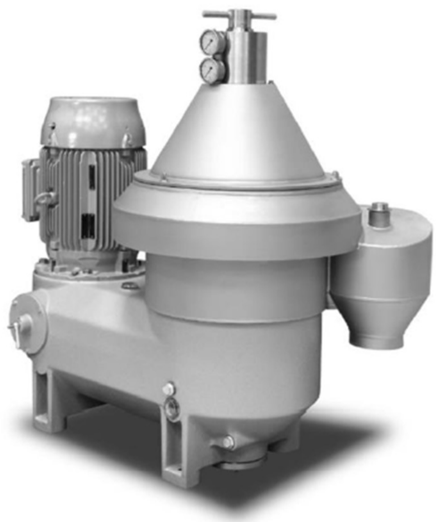
4.10.1 Changes made:

4.10.1.1 New Centrifuges:

Replacing the 8 old centrifuges from *Sharplex* Company with 2 units from *GEA* (**Figure 7**).

***Figure 5**: GEA Centrifuge*

Source: (GmbH, n.d.)



4.10.1.2 Ball Bearing 6004:

Maintenance: In the old centrifuges, the ball bearing 6004 (**Figure 8**) needed to be changed daily as part of maintenance.

Costs: This bearing had a significant cost associated with its frequent replacement, contributing to maintenance expenses.

***Figure 6:** Ball Bearing 6004*

Source: (GmbH, 2022)

Having fewer units (from 8 to 2) can simplify maintenance procedures, reducing complexity and potential points of failure and conclude to simplicity in maintenance.

New centrifuges and pumps are likely to be more energy-efficient, reducing operating costs over time that led to improving in efficiency.

GEA is a reputable brand known for high-quality equipment, so the new centrifuges and pumps may perform better and more reliably than the old ones that will enhance the performance.

While there may have been significant upfront costs, the long-term savings from reduced maintenance, energy efficiency, and improved performance can offset these costs.

4.11 Lean Techniques Applied

4.11.1 Value Stream Map (VSM)

A value stream is the set of activities, both value-adding and non-value-adding, that occur in taking a product from concept to launch, from order to delivery, and from raw material to finished product.

Value stream mapping (of the production value stream) develops a kind of graphical diagram, showing each activity that occurs in the flow of material from the supplier to the customer as well as the information flow from the customer back to the production floor and the supplier and a lead time diagram contrasting value-adding time to elapsed time. (Inc., 2016)

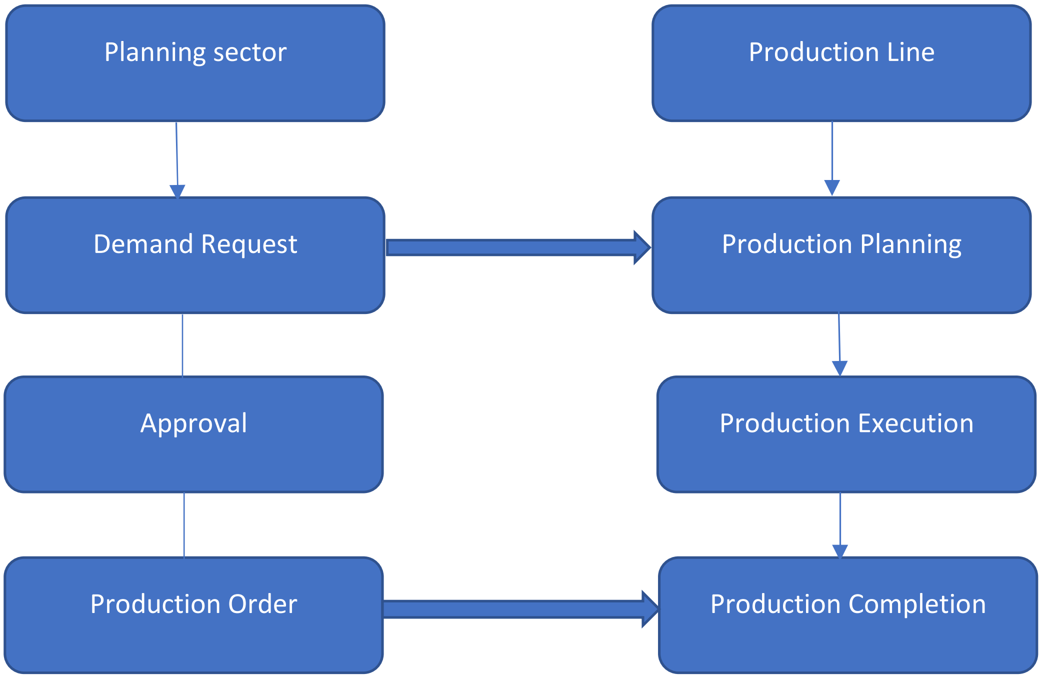
4.11.1.1 Information Flow

Before the project, the planning sector receives demand requests and initiates the production planning process. However, due to limited capacity and operational inefficiencies, there are delays in fulfilling the demands. It takes approximately 2-3 weeks to process and fulfill the requested demand **(Table 17**).

After the project implementation, with increased capacity and reduced failures, the planning sector can respond to more demands efficiently. Demand fulfillment is rechecked daily or even during each shift to ensure timely and accurate production planning and execution **(Table18).**

Table 17: Information flow before the project

Source: (Inc., 2016)



4.11.1.2 Takt Time

To determine the Takt time before and after the project, we need to understand the definition of the term:

Takt time: The available production time divided by the customer demand.

Let's calculate it before and after the project:

Before the Project:

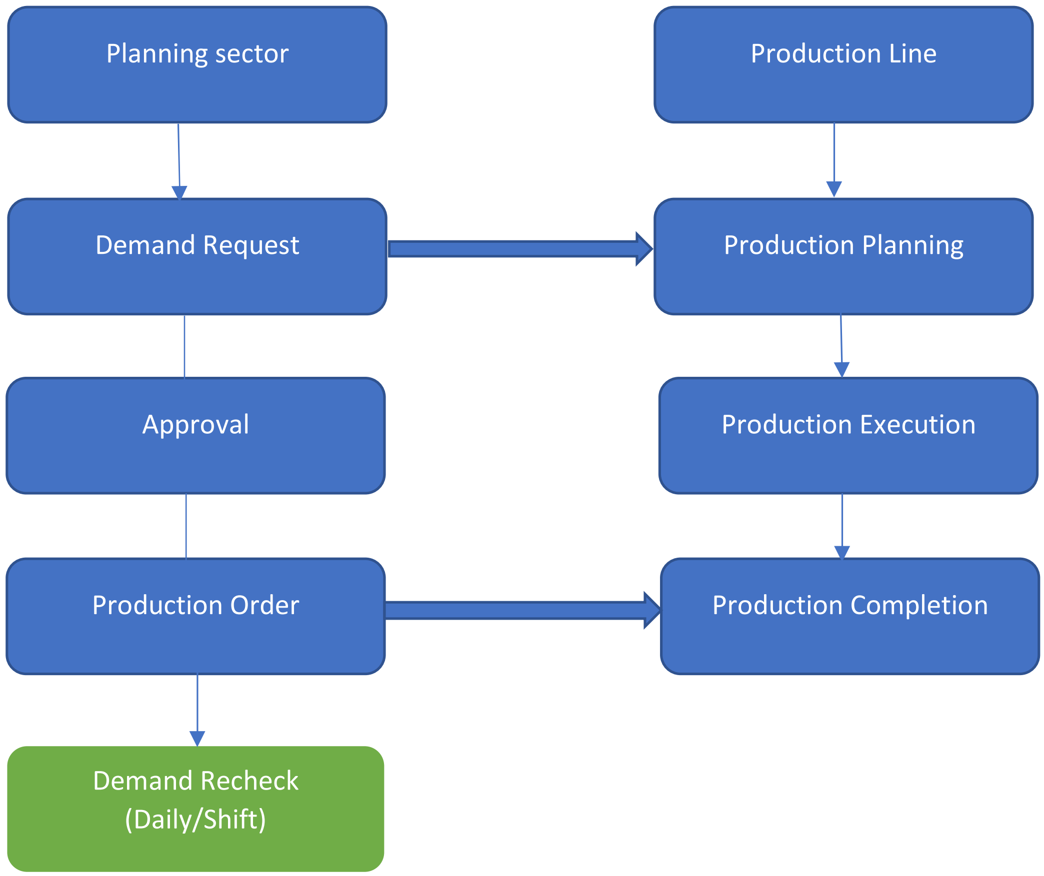
Available production time per month = 15 days/month * 24 hours/day * 60 minutes/hour = 21,600 minutes

Customer demand = 33.33 liters/minute * 21,600 minutes = 720,048 liter/month

Takt time before = Available production time per month / Customer demand = 21,600 minutes / 720,048 liters ≈ **0.030 minute/liter**

Table 18: Information flow after the Project

Source: (Inc., 2016)



After the Project:

Available production time per month = 30 days/month * 24 hours/day * 60 minutes/hour = 43,200 minutes

Customer demand = 153.7 liter/minute * 43,200 minutes = 6,642,240 liters

Takt time after = Available production time per month / Customer demand = 43,200 minutes / 6,642,240 liters ≈ **0.0065 minute/liter**

Improved Efficiency = (1 - (0.0065 / 0.030)) * 100 = 78.3

Takt Time significantly decreased from approximately 0.030 minutes/liter to 0.0065 minutes/liter after the project, indicating improved efficiency by **78%** in meeting customer demand.

4.11.2 5S

When discussing the improvements resulting from the implementation of the 5S technique after the project, it's essential to quantify the changes to demonstrate the tangible benefits. Here's how we can talk about the improvements with specific numbers:

4.11.2.1 Reduction in Waste:

Wastewater: Before the project, the consumption of water was 30% of the flow rate of oil, and wastewater discharged into the sewage system accounted for 20% of this water consumption. However, after the project, this discharge decreased to zero.

This improvement demonstrates a significant reduction in water consumption and wastewater generation, resulting in environmental benefits and potential cost savings. The elimination of wastewater discharge indicates improved efficiency and sustainability in the production process. Additionally, it may reflect better control over water usage and potential optimization of processes to minimize water waste.

4.11.2.2 Time Savings:

Before the project, maintenance and cleaning of the degumming phase required 2 hours, while cleaning and restarting the filters in the bleaching phase took 3 hours. However, after the project implementation, significant improvements were observed in the efficiency of these processes:

Degumming Phase Maintenance:

Before: 2 hours

After: Reduced time due to concurrent setup capability; centrifuges can now be set up while previous steps are operational; self-cleaning system implemented for centrifuges.

Bleaching Phase Filter Cleaning:

Before: 3 hours

After: Eliminated downtime for cleaning and restarting filters

Overall Efficiency:

Before: Downtime during maintenance and cleaning tasks.

After: Minimal to no waste in time due to the implementation of self-cleaning systems and concurrent setup capability.

These improvements result in significant time savings, reduced downtime, and increased operational efficiency. The implementation of self-cleaning systems and the ability to perform setup tasks concurrently with ongoing operations contribute to a streamlined and uninterrupted production process. Additionally, the elimination of downtime for maintenance and cleaning tasks enhances overall productivity and throughput in the refinery plant.

4.11.2.3 Worker Movements:

Before the project, due to the manual nature of the production line, workers were required to physically traverse the entire line to implement changes and monitor each process in person. However, after the project implementation, with 80% of the line automated and centralized control capabilities in the control room, significant improvements were observed:

4.11.2.3.1 Reduction in Worker Movements:

Before: Workers had to move throughout the entire line to perform tasks and monitor processes manually.

After: Worker movements significantly decreased as operations could be monitored and controlled from the centralized control room (**Figure 9**) by a single operator.

Figure 7: *Control room of the plant*

Source: (Own work)

4.11.2.3.2 Efficiency Gains:

Before: Manual monitoring and intervention required extensive worker presence along the production line, leading to increased labor and time requirements.

After: Centralized control from the control room enables streamlined operations, reducing the need for manual intervention and optimizing workforce utilization.

4.11.2.3.3 Increased Focus and Productivity:

Before: Workers may have been spread thin monitoring multiple processes simultaneously, potentially leading to reduced focus and productivity.

After: Centralized monitoring allows for better focus and attention to detail, enhancing overall productivity and efficiency.

4.11.2.3.4 Improved Safety and Ergonomics:

Before: Workers may have been exposed to physical hazards and ergonomic strains associated with manual monitoring and intervention across the production line.

After: With centralized control, workers are removed from potentially hazardous environments, improving safety and reducing ergonomic risks.

4.11.3 Kaizen Events

Reduction in Downtime:

Before Kaizen events: Centrifuge maintenance and cleaning required 2 hours/day in the degumming phase, and filtration process stops accounted for 3 hours/day in the bleaching phase, totaling 5 hours/day.

After Kaizen events: Downtime reduced to zero due to improved maintenance procedures, calibrated instruments, and optimized processes.

Reduction in Rework:

Before Kaizen events: Quality issues due to inaccurate raw material injections led to rework, impacting production efficiency and requiring additional resources.

After Kaizen events: Quality control improvements and accurate raw material injections resulted in zero rework, eliminating waste and increasing overall productivity.

Reduction in Water Consumption:

Before Kaizen events: Water consumption accounted for 30% of the flow rate of oil, and 20% of this water was wasted to sewage system.

After Kaizen events: With process optimization and accurate flow metering, water consumption reduced significantly to 12% of the flow rate of oil, and all the waste water recycled.

Reduction in Energy Consumption:

Before Kaizen events: Manual monitoring and inefficient processes led to higher energy consumption due to prolonged production cycles and equipment downtime.

After Kaizen events: Automation and process optimization led to more efficient energy usage, reducing overall energy consumption and associated costs.

Reduction in Material Waste:

Before Kaizen events: Inaccurate injections and process deviations resulted in material waste, such as oil and bleaching earth, contributing to increased costs and environmental impact.

After Kaizen events: Improved process control and quality assurance measures minimized material waste, ensuring optimal utilization of resources and reducing environmental footprint.

5 Conclusions and Proposals

The vegetable oil refinery undertook a thorough operational overhaul, characterized by several strategic interventions and process changes, as part of a drive to increase productivity.

The cornerstone of this change was the adoption of 5S principles, which are a rigorous approach to workplace organization and cleanliness. This involved creating a workstation that is conducive to productive work by cleaning, organizing, polishing, standardizing, and maintaining it. The plant streamlined procedures, organized workspaces, and promoted a clean culture to cut down on needless movements and idle waiting times. An incredible feat of operational efficiency was achieved by this meticulous attention to detail, which resulted in a noticeable decrease in cycle times and scrap rates as well as an increase in yield rate.

Furthermore, the plant thoroughly examined all of its operations to find and remove waste, led by the ideas of lean methodology. Value stream mapping, Poka-Yoke, JIDOKA, and other lean methods and tools were used by the plant to identify and eliminate inefficiencies in several areas of its operations. We did not spare any detail in our pursuit of operational excellence. The end effect was a smaller, more productive business that reduced waste and maximized resource usage—a demonstration of the effectiveness of continuous improvement.

Infrastructure and equipment renovation were a key component of the makeover. Acknowledging the necessity of technical progress, the plant made investments in cutting-edge machinery and automation systems. This involved setting up a centralized control room to supervise operations and installing new machinery with cutting-edge sensors and monitoring features. As a command center, the control room allowed for real-time production process monitoring and quick reaction to any deviations or problems, which was essential to guaranteeing smooth operations.

Strategic interventions were implemented to alleviate bottlenecks and limits within the production line, in addition to equipment upgrades. To increase performance and dependability, crucial parts including injectors for raw materials and centrifuges were improved. Throughput was raised and overall system resilience was strengthened by these focused enhancements, guaranteeing continuous output even in the face of operational difficulties.

In addition to these technological advancements, the facility created operational norms and standardized work practices. Every task had explicit instructions, which guaranteed uniformity and adherence to the best standards throughout the company. In addition to increasing productivity, this uniformity made training and knowledge transfer easier and gave staff members more confidence and effectiveness in their work.

These initiatives culminated in a notable improvement in profitability and manufacturing capacity. The factory demonstrated its dedication to excellence and continuous development by cutting operational cycle time while concurrently meeting expanding market needs through process optimization, modernization, and streamlining of operations.

5.1 Proposals

As some proposals I can mention to emphasize some points:

It is essential to fund training initiatives to raise the proficiency and expertise of plant staff. By offering continual learning opportunities, employers may make sure that staff members have the knowledge and skills needed to carry out their jobs well and improve processes.

Moreover, improving supplier cooperation is critical to raising the dependability and efficiency of the supply chain. The timely delivery of components and raw materials is ensured by tight collaboration with suppliers. Additionally, it offers chances for teamwork in cost-cutting and process optimization.

Furthermore, in order to satisfy customers and maintain consistent product quality, it is essential to adopt strong quality management systems. This entails putting quality control mechanisms in place at every stage of the production process, auditing them often, and making any corrections.

Another crucial element is embracing data analytics and digitization. To increase overall productivity and efficiency, real-time data can be leveraged for process optimization, area identification for improvement, and data-driven decision-making.

Building trusting bonds with clients, staff, and the community is also crucial. Customer input can be used to find areas where products can be improved and innovated. Participating in decision-making procedures increases staff motivation and morale. Corporate social responsibility is demonstrated by involvement in community projects.

By putting these suggestions into practice, the vegetable oil refinery facility will become more sustainable, competitive, and successful in the long run.

6 Summary

In this thesis, we implemented a variety of lean techniques and technologies, such as 5S, Kaizen, JIDOKA, VSM, and Poka Yoke, to initiate a complete endeavor to rejuvenate the vegetable oil refinery plant of ALIA Golestan Company. Our main goals were to increase overall efficiency, reduce waste, and streamline operations.

ALIA Golestan Company decided to revamp the complete refinery line due to a number of important issues. First, modernization was required to improve production and cut expenses due to operational inefficiencies caused by manual operations and antiquated equipment. Second, in order to adapt to shifting customer preferences and maintain competitiveness in a market that was changing quickly, flexibility and responsiveness were essential. Lean management principles were put into practice as a tried-and-true method of streamlining procedures and increasing operational effectiveness, which complemented the business's objectives of innovation and distinction. Furthermore, enabling staff members to take part in Lean projects promoted a continuous improvement culture that fueled sustainability and innovation. The restoration project's ultimate goal was to set up the business for long-term success by maximizing productivity, satisfying consumer demand, and cultivating an excellence-oriented culture.

The results are highly expressive due to their careful examination and measurement. A remarkable 900% rise in production rate was seen, indicating a significant enhancement in output attained by means of streamlined workflows and improved procedures. This accomplishment proved that lean concepts can effectively drive operational excellence, surpassing our initial expectations in the process.

The impact on finances was as significant. We made the product more affordable for customers by lowering its price per liter by 5%. At the same time, we saw a remarkable 1189% gain in profit and an astounding 850% increase in revenue. These outstanding results highlight the plant's increased financial stability and competitiveness in the market, highlighting the real advantages of our lean initiatives.

The changes were similarly notable from an operational standpoint. By reducing variable expenses per liter by 3%, we demonstrated our dedication to economy and efficiency. Furthermore, we saw a noteworthy 63.85% drop-in scrap rates, indicating a significant decrease in waste and inefficiency. Concurrently, there was a 13.17% rise in the yield rate, indicating improved process efficiency and product quality.

Moreover, the 80% cycle time reduction highlights our capacity to meet client requests quickly and increase total throughput. This accomplishment enhances client satisfaction and solidifies our position as a dependable and effective provider in the industry.

To sum up, the vegetable oil refinery plant of ALIA Golestan Company has achieved outstanding results in achieving all of its objectives due to the application of lean tools and techniques. Our lean initiatives have cleared the path for long-term growth and operational excellence, resulting in notable gains in income and production rate as well as cutbacks in expenses and waste. We have proven the transformative power of lean concepts in bringing about good change and delivering measurable results in the vegetable oil refinery business through rigorous examination and measurement.

7 References

ALIA, n.d. *Alia Golestan Food Industries Co..* [Online]
Available at: https://aliagolestan.com/en/

Bell, T. D. M. &. J. T., 2011. *New Horizons in Standardized Work: Techniques for Manufacturing and Business Process Improvement.* Boca Raton: CRC Press.

Dave, P. Y., 2020. The History of Lean Manufacturing by the view of Toyota-Ford. *International Journal of Scientific and Engineering Research.*

Dekier, Ł., 2012. The Origins and Evolution of Lean Management System. *Journal of International Studies,* pp. 46-51.

Denis, J. D., 2019. The origins of correlation and regression: Francis Galton or Auguste Bravais and the error theorists?. *History and Philosophy of Psychology Bulletin,* Volume 13, pp. 36-44.

DENNIS, P., 2015. *LEAN PRODUCTION SIMPLIFIED.* New York: CRC Press.

Frank Voehl, H. J. H. C. M. R. C., 2014. *THELEAN SIX SIGMABLACK BELT HANDBOOKTools and Methods for Process Acceleration.* Boca Raton: CRC Press.

GmbH, G. W. S. G., n.d. *Instruction manual: Centrifuge easyrefine 100.* 0714 ed. Germany: GEA Mechanical Equipment.

GmbH, W. R. W., 2022. *Addventures.* [Online]
Available at: https://addventures.zone/en/ball-bearing-6004-2rsc3-skf.html

Gupta, M. K., 2017. *Practical Guide to Vegetable Oil Processing.* 2nd ed. London: Academic Press and AOCS Press.

Hoffmann, J. P., 2021. *Linear Regression Models: Applications in R.* 1st ed. s.l.:Chapman and Hall/CRC.

Imai, M., 2012. *Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy.* 2nd ed. s.l.:McGraw Hill.

Inc., Q., 2016. *Training Guide.* Santa Barbara, California: QAD Inc..

Jackson, W., 1997. Designing Projects and Project Evaluations Using The Logical Framework Approach. *ResearchGate.*

Krafcik, J., 1988. Triumph of the Lean Production System.. *Sloan Management Review,* Volume 30, pp. 41-51.

Leksic, I. S. N. V. I., 2020. The impact of using different lean manufacturing tools on waste reduction. *Advances in Production Engineering & Management,* Volume 15, pp. 81-92.

Levy, D., 1997. Lean production in an international supply chain. *Sloan Management Review,* pp. 94-102.

Mandar M. Sumant, P. R. P., 2015. Importance of Lean Tools and Techniques in Industrial Sectors: Literature Review. *International Journal of Applied Engineering Research,* Volume 9, pp. 765-771.

Marr, B., 2012. *Key Performance Indicators: The 75 Measures Every Manager Needs to Know.* London: PEARSON.

Martin Pech, D. V., 2018. Methods of Lean Production to Improve Quality in Manufacturing. *QUALITY INNOVATION PROSPERITY.*

material, S., 2023. *Managerial Economy.* Gödöllő: s.n.

Mihir K. Shah, V. A. a. R. M., 2015. A Review on Lean Tools & Techniques: Continuous Improvement in Industry. *International Journal of Advance Industrial Engineering.*

Misiurek, B., 2016. *Statndardized work with TWI: Eliminiating human errors in production and service processes.* Boca raton: CRC Press.

Rewers P., T. J. C. P., 2016. *Tools and methods of Lean Manufacturing - a literature review.* Czech Republic, s.n.

Tisbury, J., 2014. *Your 60 Minute Lean Business JIDOKA.* 1st ed. s.l.:www.lulu.com.

Tobin, E., 2016. *Poka Yoke: An Introduction to Poka Yoke for Engineers.* s.l.:validationresources.org.

Visco, D., 2016. *5S Made Easy: A step-by-step Guide to Implementing and Sustaining Your 5S Program.* Boca Raton: CRC Press.

Wentworth, M. E. C. a. J., 2010. *Breakeven Analysis: The Definitive Guide to Cost-Volume-Profit Analysis.* New York: Business Expert Press.

Womack, J. a. J. D., 1994. From Lean Production to the Lean Enterprise.. *Harvard Business Review,* pp. 93-103.

Womack, J. J. D. a. R. D., 1990. *The Machine that Changed the World.* New York: Rawson Associates..

8 List of tables and figures

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