The effect of standardization of the industrial process on product quality, Competitiveness and capacity utilization.

The Case of Coggiola S.R.L.

By

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To My mother, may her soul rest in peace.

Acknowledgment

I wish to show my gratitude to my Mother, Father, Brother, and family. Also, I'd like to thank my professor Luigi Benfratello. His supervision helped me during the research and writing of this thesis. I wouldn't have imagined having a better advisor and mentor for my master's study.

Abdelhamied Ashoush.

Abstract

Standardizing of the industrial process or practice inside a company or a firm is a type of practice that needs collaboration across Variant disciplines, it needs consistency to be applied. It can be introduced through a transitional phase in which the company gathers all the kind of information and the know-how that it has, Then analyzing this Collected data to reorganize all the flows of the industrial processes from the smallest one to the biggest, Eliminating all the non-adding value processes and wasting time procedures to reach the maximum utilization of the resources available. The idea of the standardization should be clear to the upper-level managers that the fact of standardizing is applied to the Flow of the processes, not the human as standardizing the human kills the innovation and the Possibility of Generating Creative ideas inside the Firm.

In our case, we will introduce the steps taken By Coggiola (an Italian company working in the thermoforming industry of the Plastics) to reach a standardized flow of the industrial process to increase the capacity of the production considering the Huge Impact of the variables from the market on their plans and objectives. Also, we shall see the impact of the standardization on the product quality which leads to Fewer Customer Returns and Complaints, which by default leads to gain more trust from the customers and increase the future scale of orders, finally how standardization helped the company to reduce the expenses across different stages of the industrial process.

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Chapter One

Introduction

1. The purpose of Chapter One is:

- To define the meaning of the standardization.
- The history of the standardization in the industry.
- Review on lean manufacturing implementation inside a firm.

1.1. What does industrial process standardization mean?

It's the consistency of executing the process in a unique order and under the same criteria every time it gets executed, and the term (Standardized process) is referring to the shortest, most effective and the safest method to do a job as a result of using existing in the right way. We can see that the lack of standardization in the industrial process keeps the door wide open to the variance in the produced products or services, due to different skill levels, education, way of thinking and experience of the personnel and between a manufacturer and other manufacturers.

1.2. The history of the standardization in the industry.

Starting from the industrial revolution and the invention of the steam engine by James Watt in 1782 the level of manual and low-level production was completely changed into mechanized production and the formation of the word factory instead of the old classical workshop, this fact led to an urgent need of more labors to cover the demand in the market of the mass production, the only available labor force in huge numbers was found in the agriculture market and they were un-skilled and low-cost labor force that back to the 18th century they counted for 30% of the total labor force in the UK, as their low level of experience they were assigned to specific simple task this should be attributed to in-company

standardization, so we can say from here the standardization of the industrial process was born.

The modern standardization process started by the interchangeability of the parts between some of the manufacturers due to same-function modularity and dimensions then it moved to cover different stages of production not only the final product, for example, unification and simplification of the industrial process. The second step of standardization was introduced by private standardization organizations as it was needed to solve the multiple issues between integrated industries and manufacturers so by that time the companies were applying not only their standards but also the ones developed by private organizations (Association level). By the introduction of the modern and fast transportation methods, the standards were expanding and covering new levels of communication between the manufacturers under national and international levels [1]

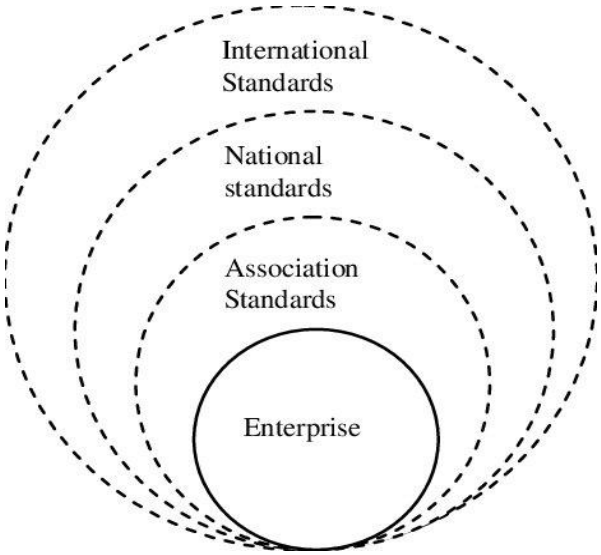


Figure 1 externalization of standards used by the company

1.3. Lean manufacturing and the role of standardization

Lean concepts are mainly from the Japanese industry, Especially from the prestigious Toyota. Lean manufacturing is a waste reduction technique, so it's considered as a technology to reduce waste, but in fact, lean production maximizes the value of the product or service

provided. then align the process with the customer and continuously seeks perfection by continuous improvement to put an end to waste by sorting out Value Added activity (VA) and No-Value-Added activity (NVA). The fount for the NVA activity wastes, for example, are Inventory, Overproduction, Transportation, Motion Waiting, Over-processing, and Defects. Elimination of these wastes could be achieved by the implementation of lean elements. A huge number of researchers concentrate on one or two elements to find out the existence of wastes and suggest their point of view to implement techniques to eliminate those sources of waste creation [2].

1.3.1. Review of Lean manufacturing implementation

There are several steps to follow to achieve a lean manufacturing process:

1) **Scheduling**: it's a plan in which all the resources are allocated upon different tasks performed and orders received are arranged to form a queue, thanks to the readily available scheduling software's that this process is not hard to execute anymore[3].
2) **The perception of the employees**: these can be done using surveys to understand the factors which affect the success of the implementation from employees' point of view, as the survey goes into more details as the results will be clearer and sharper, this will help us transform the perception factors into intrinsic factors (belief, collaboration, and commitment) and external factors (Communication, lean work method, and KPI understanding.
3) **Value stream mapping (VSM)**: is a lean manufacturing tool to evaluate, design and control the flow of material and necessary data between suppliers, manufacturers and distributors to deliver a product to a customer, the visual creation of the VPM facilities the process of distinguishing between NVA activity and VA activity, then the next step is to create the future VSM based on eliminating all the NVA activity, the new VSM will help to validate the future decisions and also motivates the organization throughout the real process of implementation of the lean system, it should also indicate the inventory's level, Lead-time, bottleneck, time of different processes, etc. and process flow from which we figure out bottleneck cycle time

against Takt time. Different simulations of VSM to depict the real situation could be useful especially with variable demand states and at the variation of processes time especially at the bottleneck because with a static template of VSM one cannot determine how inventory levels change in different scenarios, so the simulation technique is important to forecast the inventory rate during demand uncertainty.

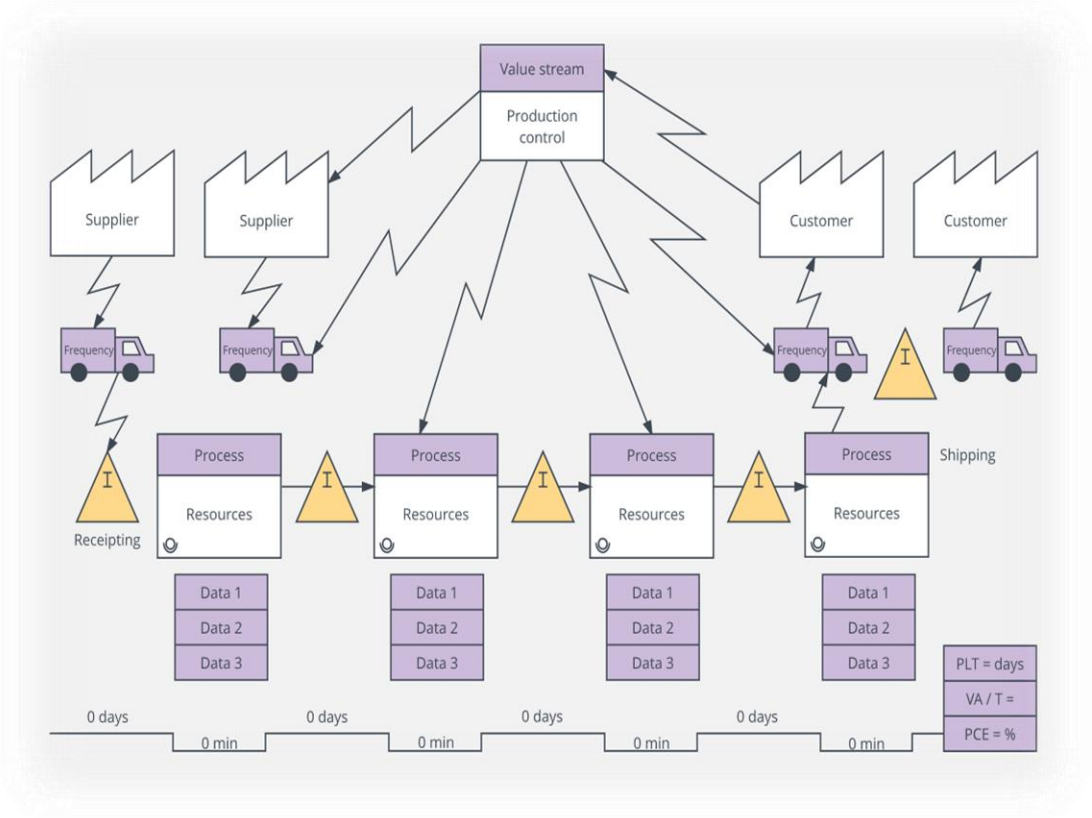


Figure 2 Value stream mapping chart (zero values)

4) **Takt time:** it means generally the frequency or the capacity of production of a specific part, takt time is usually calculated on monthly production demand and if the demand increases it means that the takt time should decrease as the variances are less and as the demand decreases it indicates that the take time will increase. Takt time helps improve the spending efficiency of the firm as it eliminates the production lead-time (ahead of the demand) which includes also eliminating the cost of overproduced products, premature purchasing of raw material, lost resources to perform unnecessary extra work [3].

5) **Bottleneck process:** the production capacity is decided by the bottleneck process duration which is the longest cycle time on the line, it also works as an indicator for meeting the customer demand, by checking the bottleneck is less than the takt time then the customer demand is met, if bottleneck process is larger than takt time then the customer demand is not met.

6) **Grouping the similarities Technology:** it's composed of grouping similar products in designing and manufacturing processes to form what is called (same technology group) and also grouping different function machines to form what is called (a cell of machines) based only on the sequence of different actions performed.

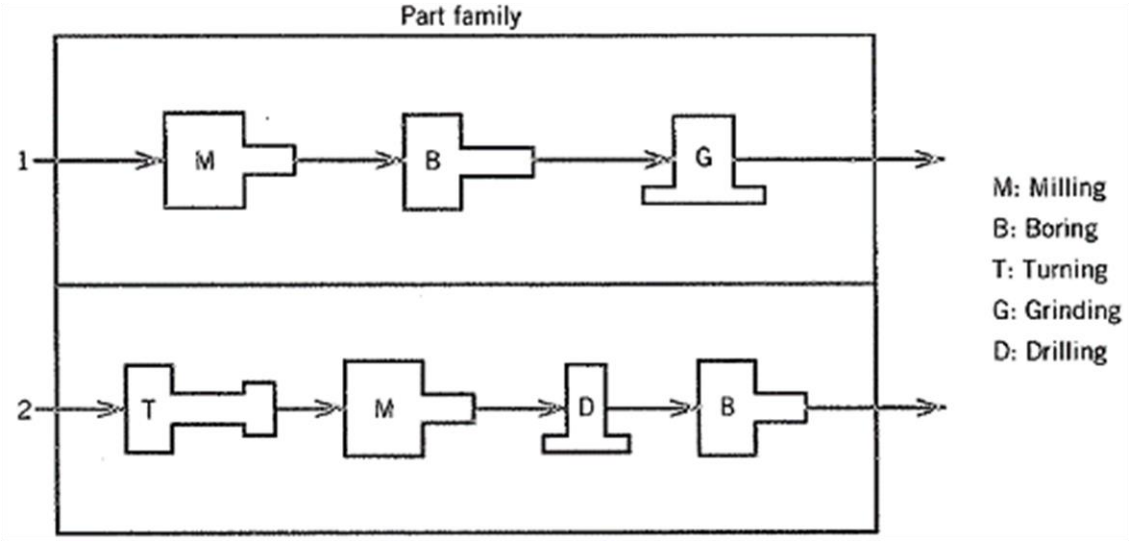


Figure 3 group technology illustration

7) **Cellular manufacturing (CM):** it means forming a group of machines with different functions to manufacture a family of parts, based on the VSM which gives a route map for every existing part. It was recommended that the best way to cluster or reform the machines, workstation and employees is in the U-shape form which facilitates the interaction between the employees [3].

8) **steady Flow of the Manufacturing process:** this term refers to the steady state of productivity in which we always produce a part in time equal to the time of the cycle. To have a multi-skilled operator and a standardized cycle time.

9) **Small lot size and batch:** a batch is defined as a group of parts from the same part family, the old conventional way was suffering from the high buffering rate of the parts to overcome the equipment break down which leads to low-quality products due to high capacity of production, Absenteeism, which has contributed to high lead time. to improve the content flow and solve consistency and lead time problems, the buffer volume should be customized. Throughout the action, Lean is synonymous with zero inventories to maximize the efficiency of commodity movements and improve the use of energy, we can say that Lean term is associated with zero inventory load of extra products due to optimizing the buffered quantity.

10) **U-line shape:** this shape was found to provide the highest flexibility and the least no. of needed workers to perform the same number of tasks as compared to other forms or shapes.

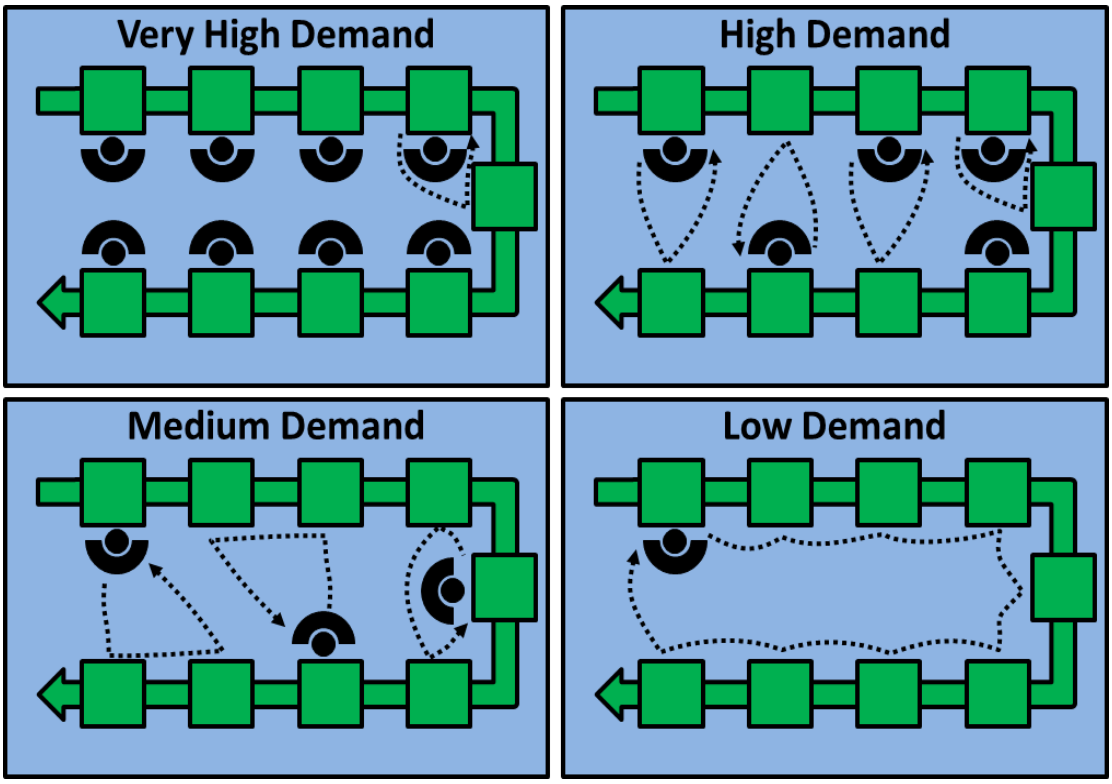


Figure 4 U line balancing structure

11) **Inventory:** Various scientific articles had shown that almost 60% of the waste in the whole manufacturing process comes only from the firm, We can generally classify the inventory's categories into raw materials (RM), semi-finished products or work-

in-process products (WIP) and finished products (FP). We can easily discover that lack of good projection and planning of the manufacturing process that we have led to an increase in the raw material which leads to an overproduction level which leads also to an increase in the level of the WIP and FP, inventory level should be decreased through raising quality levels, production duration, rejection rates, lead-time, and customer satisfaction, WIP is adjusted by a method called “cellular line Assemble” which indicates manufacturing the parts according to the customer desire to reduce the amount of the FG so that the FG will be delivered to the customer on time without delay. Also, it was found that to reduce the impact of the imperfection of adjacent processes, decoupling buffers should be placed between the processes. Those buffers allow teams to decide by visual process controls that enable the personnel to quickly identify variations in the manufacturing process so that the source may be eliminated immediately or even to stop the line for some cases. In theory buffering violates the lean idea but practically it was found necessary in case of system fluctuations.

12) **One-piece flow (pull system):** The Pull mechanism allows output based on customer demand; the downstream process/customer selects the product/service they need and pulls' it away from the manufacturer. One-Piece Flow refers to the idea of transferring one component at a time between cell operations. One-Piece Flow production system also requires considerations such as timing, set-up time and make-to-order strategy to be considered while preparing production. The user has planned walking cycles for an established one-piece modular manpower unit. In which operators have been given a routine series for loading and unloading machine tools. Their versatile line of manpower was a flow cycle line where the units were placed in U-line. The specification of the job layout, the transfer of the project to the U-line and the output schedule are important factors to consider when creating the one-piece flow. Through U-line while moving a job or another activity, In U-line as Switch of job or other activity takes place, the entire production line is interrupted in such a situation that the One-Piece Flow buffer is required based on a condition to solve such problems. In the one-piece pull production system, the

producer begins development when the customer displays the Kanban card/signal for the pieces.

13) **Kanban:** it's considered to be a subsystem of the lean manufacturing used to control the inventory level. The Kanban Approach implements a set of principles and procedures for handling and developing workflows. It is an incremental, non-disruptive approach that encourages the gradual improvement of the organization's operations. When you adopt these standards and procedures, you will be able to successfully use Kanban to maximize the benefits of your business process–boost efficiency, reduce cycle time, increasing your business performance. It has four foundational principles; Begin with the priority of the moment: the Kanban Process mainly stresses on not making any changes to your current setup/process right away. Kanban must be directly applied to the existing workflow. Any planned changes can be made slowly over a while at a rate that the team is satisfied with. Agree to seek gradual, genetic changes: Kanban urges you to make simple and gradual improvements instead of just make major changes that may contribute to opposition within the staff and the company. Firstly, honor current roles, duties and job titles: unlike other approaches, Kanban does not force any systemic adjustments on its own. It is therefore not necessary to adjust your current positions and duties that may be doing well.

    The team will work collaboratively to define and incorporate the necessary changes. Those three concepts allow organizations to conquer the traditional emotional resistance of any sudden change that could happen. Motivate leadership at all layers: Kanban promotes continuous improvement at all stages of the company and insists that leadership activities do not have to come exclusively from top management. Kanban is a non-disrupting evolutionary change management framework. This indicates that the current method is being strengthened in small steps. When making several minor changes (instead of a large one), the damage to the existing system is that. Kanban's developmental strategy contributes to minimal or no opposition in the team and the stakeholders concerned.

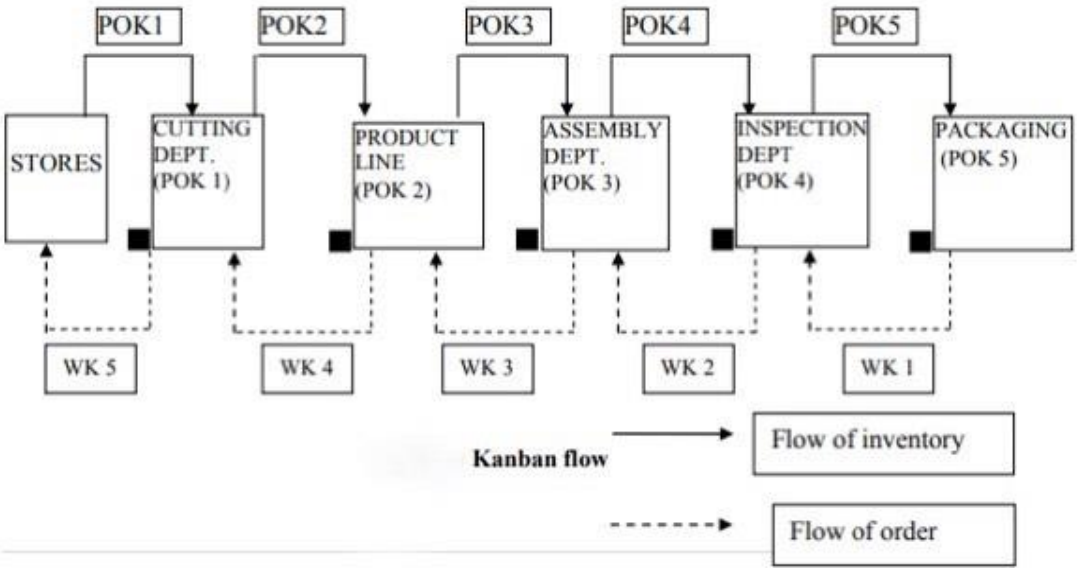


Figure 5 Kanban flow

14) **Heijunka:** It may be easier to understand Heijunka and how it can enhance the production process by comparing it with the conventional batch production method. Batching has been a common method of arranging the manufacturing process since the advent of mass production. Batching produces a large number of products without taking into account variations in customer demand. The production that is not purchased will be placed in the inventory, The conventional batching approach has several drawbacks: customer demand is never reliable. If consumers pursue an unanticipated pattern of buying, the retailer can suffer uncertainty and disarray. demand for upstream systems is unpredictable. The loss of unsold items kept in warehouses limits productivity. Batch often results in poor product quality and overworked machines and operators, Heijunka helps to avoid manufacturing inefficiencies in large batches by getting the production process closer to customer demand. Heijunka versatility offers three advantages to manufacturing: predictability occurs while demand is in a stable period, flexibility is accomplished by minimizing changeover period, Quality–average production rate and form over the long term. Heijunka demands that supply be adjusted to reflect customer demand as closely as possible. When a company produces all types of

products and retains a limited inventory balance throughout the year, there is greater flexibility to satisfy increasing customer demand trends. The reserve inventory will be liquidated during the year and supply will be able to meet peak demand and be adjusted to consumer requirements.

Lean six sigma promotes the development of every type of product every day. It allows producers to reduce the time needed to convert the line from one drug to another. The success and financial achievability of Heijunka are calculated by the

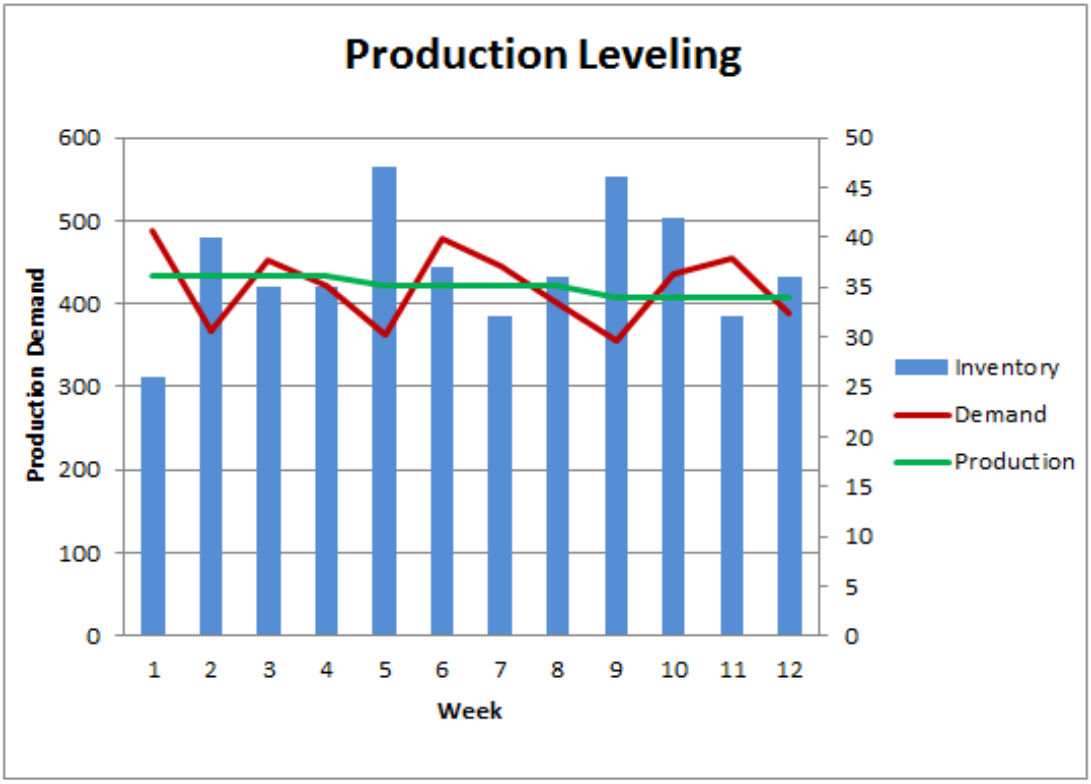


Figure 6 Hejunka stabilizing mechanism for inventory

reliability of the changeover process. The first step in balancing production in line with customer demand is to set the pace of output in line with what Heijunka considers Takt period. This is the purchasing cost of the consumer or the time it takes to produce the commodity and satisfy the customer's demand. Matching the

production rate to customer demand helps to create a level production cycle that is free from bottlenecks. Manufacturers exist to satisfy the consumer.

15) **Quality at the source:** reducing the lot size in lean manufacturing in some cases to one piece. Allowing the operator to inspect the conveyed piece in real-time. as a result, any statistical sample inspection is eliminated. At the inspection of a defect, instantaneously the production line will be stopped till the elimination of the cause. Incorporated false-proofing or what is called Poka-Yoke in a production line to detect the error occurrences. The quality problems are due to human errors in loading, setup, and unloading. The priority should be given to setup errors as it creates problems for a huge number of products at a time.

16) **Kaizen:** we mean by kaizen the process of continuous improvement, Continuous Improvement is directly proportional to the desire for improving the quality, it's a method in which staff at all layers of a company work efficiently and effectively together to create frequent, incremental progress in the production process. In a way, it integrates the collective resources within an organization to create a powerful production engine.

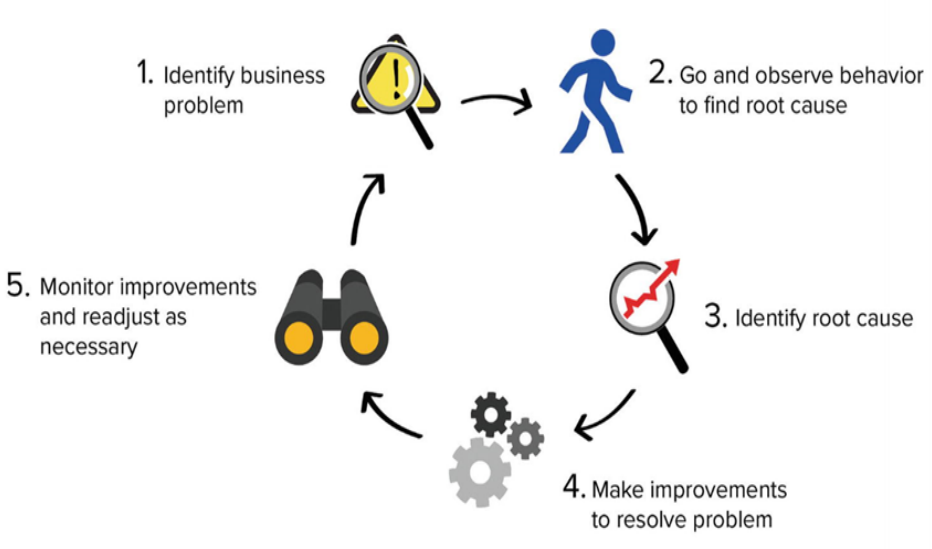


Figure 7 kaizen loop of continuous improvement

Kaizen works in conjunction with standardized practice incorporate the current best standards for workflow and seeks to improve those systems. Kaizen consists of several steps to be followed:

- Set goals and provide the necessary background.
- Review the current status and establish an improvement plan.
- Apply Enhancements.
- Examine and patch what's not right.
- Report summary and any follow-up items found

17) **Standardized workflow:** in 1983 Standardized Work Chart (SWC), Standardized Work Combination Table (SWCT) and Standardized Operation Sheet (SOS) were introduced by Monden, all those tools are used for improving the standardized work. standard work chart shows the movement of the operator and the position of the material concerning the system and the overall layout of the processes. It should show takt time, the sequence of jobs, and regular WIP. The structured task map, along with the uniform work mix table and job direction sheet, is one of three basic forms for producing organized jobs, SWCT aims to help finding the waste such as WIP and overburden of work., For each operation in a development cycle, the uniform task mix table shows the combination of manual work time, walk time and machine process time. This method is a process design tool that is more detailed than the Operator Balance Map. Identifying the cost of waiting and overburden and verifying traditional job −in − the process can be very beneficial. Finally, the SOS describes the instructions of the processes

Chapter Two

Research approach and methods

2. The purpose of Chapter Two is:

- Literature review
- To understand the Research approach.
- Quantitative and qualitative methods.

2.1. Literature review

To deeply understand the aim of this project and to get some deeper knowledge about the topic. A literature review has been conducted based on some recommended books and articles on the web. Google scholar was mainly used as a search engine with some suitable keywords for example (lean manufacturing, standardization, Kanban, inventory and standardization of the industrial process), the target was to understand the threshold that the modern science has reached with regards to the standardization process to identify the road map conducted by the company to reach their goal.

Many conferences and lectures held at the polytechnic school of Turin also helped me to simplify the objective of the study and to have a clear vision of what should be done accordingly.

2.2. Research's approach

There are two different types of research approaches, the first one is the deductive approach in which the researcher work is based on a known theory of a specific domain and based on that the data shall be gathered and analyzed to test the theory, this approach is connected to the quantitative method. The quantitative method is using the practice to obtain results and setting the facts, while the second method is the inductive approach the collected data shall lead after the analysis to a conclusion and so a theory. The inductive approach is linked to the qualitative method.

As the framework of this study is the standardization of the industrial process. It's concluded that the approach used is the deductive approach[4].

2.3. Quantitative method and qualitative method

There are two ways to gather and analyze data: qualitative research and quantitative research. The first involves numbers and statistics, while qualitative research involves words and literature analysis. Each of these types of research has a different approach and methods, but both are important for gaining different kinds of knowledge.

Quantitative studies: are graphically and numerally represented. Mainly It is used to confirm or test theories and hypotheses. This type of research can be used to construct wide facts about a subject.

Qualitative research is expressed mainly using the language. It is used to understand concepts, ideas or experiences. This type of research allows you to gather in-depth insights on topics that are not well understood, Also can be used to find out the actual problems, so it can be said it's more used to find and solve problems in the industrial sector depending on observations. Based on this research, more precise research questions can be formulated. Various methods can be used to collect quantitative and qualitative data. It is important to use a data collection method that will help answer your research questions. Now we can classify the methods used to collect the data for both qualitative and quantitative methods in the following sections.

2.3.1. Quantitative data collection method

1) Survey: A closed, or multiple-choice list distributed to the sample (online, in person or by phone).
2) Experiment: The case of controlling and manipulating variables to establish a causal relationship.

3) Observation: Observe people in a natural environment where variables cannot be controlled.
4) Content analysis: systematically record the existence of certain words or topics in a set of texts to analyze communication patterns.

2.3.2. Qualitative data collection methods

1) Carrying out Interviews: Orally ask open questions to the interviewee.
2) Creating a Focus group: A discussion between a group of people on a topic to gather ideas for further research.
3) Perform a Case study: An in-depth study of an individual, group, event, or organization.
4) Literature review: Survey of work published by other authors.

The rule of thumb for the decision whether to use qualitative or quantitative methodology is: If it's wanted to confirm or verify (theory or hypothesis), it's better to use quantitative research, If it's wanted to know something (concept, thought, experience), use qualitative research But as mentioned by Bryman, A. (2012) that both methods can be combined in one research. In this research, both methods are combined to conduct the work.

Figure 8 quantitative vs qualitative

Chapter three

Causes to Choose this topic

3. The purpose of Chapter Three is:

- Why Did I choose this topic to work on?

3.1. Reasons to choose this topic to work on.

As mentioned in earlier parts, this study aims to apply previous studies on standardization to the field of strategic management, meaning corporate effects and implications are of interest, but the reasons and rationale behind corporate involvement in the creation of standards are even more focused. Corporate decision-making processes which lead to standards creation Competitive and, besides, mutual structures of vital interest in the sector (either within a company or within an international standardization committee). Future research from a strategic management perspective (such as the study in hand) will examine further how corporate strategies shape industrial standards, and how industrial standards form the strategies of companies per se. Since the competitive movements of firms towards the standards represent the basic elements of interfirm competition [5], exposing how competitive movements of firms in the war of norms affect industry quality and boost firm efficiency may help to expand knowledge of standardization dynamics. Towards an in-depth discussion of how businesses will generate value through standardizing and standards, Accordingly, a successful standardization strategy depends on the external environment of the company[6]; however, it is equally based on the company's goals and a collection of micro-activities related to intra-organizational standardization [7]. An inquiry and review of the specific challenges, behaviors and relationships intrafirm.

Finally, I can summarize all of that by saying that how approaching standardization can affect the performance of the company in the local market with the local competitors and on the long run how can it affect globally by applying a successful strategic plan of standardization

3.1.1. To better understand corporate challenges to apply standardization.

As already stated in this chapter, it is by no means a small matter to make standardization-related decisions and manage corporate standardization. To look into standardization management processes and practices, current work (including standards and standardization literature, as well as inductive approach) is conducted to clarify the challenges facing the corporate through the path of seeking standardization inside their practices,

3.1.2. To better understand how companies, Identify critical issues?

To begin with, simply identifying value-potential problems in today's global standardization environment could be a super challenging task for companies. As Betancourt and Walsh (1995) have pointed out, companies must be able to examine the different aspects of standardization through their entire business and industrial environment to make the optimum standardization decisions that fit their organizational structure and the environment at the same time.

3.1.3. To identify factors affecting the timing of application of standardization.

To better understand the environment of the market and internal condition that lead the firm to decide to standardize the production process, for example, is it due to the maturity of the market and the intense of the competition, or maybe to increase the profitability as a normal reaction to a decline in the revenue, should the shareholders or the stakeholders reach an agreement before applying the new model of standardization?

So all of the above-mentioned factors can be combined to form the decision and depending on the scale of effectiveness of those factors the timing of taking the decision get affected

Is the implementation of the standardization related to the speculations of the market or it is more affected by internal problems?

3.1.4. How does the company measure the success of the implementation?

Like any model, the effect of the standardization should have means to measure it, by mentioning means it is meant all the impacts due to the implementation of the new standardized model, but there are many questions related to how company measurements for the successes of the implementation and about the parameters they consider when evaluating the model, to understand deeply how companies measure the success of implementing a standardized model, the following questions where obtained during the literature study and should be understood during the internship period.

1. If a lack of standardization implies more uncertainty, reduced stability and less perceived quality will be some of the inevitable consequences of that. So to what is extent the quality would be enhanced due to the application of standardization?
2. Through reducing inefficiency standardization improves profitability. This is the product of removing uncertainty by providing quality assurance: projects are performed more effectively, and there are fewer problems of quality control with activities that have not been done correctly the first time. Which helps the company to reduce waste and increase profitability, but to what extent the profitability can be enhanced? when the company is going to breakeven the cost of implementation?
3. Standardization can help employees feel the accomplishment, the pride of the success and the achievement. Standardization doesn't have to imply implicit or explicit monotony and lack of creativity; it can (and should) mean norms that anyone can learn and take pride in participating in the continuous improvement inside the company. But how do companies measure those effects on the employees and to what extent the satisfaction can reach?
4. better customer satisfaction is a logical result with less uncertainty, higher output efficiency, improved productivity, and enhanced morale. But can we get more market share and acquiring more customers, or the market is already a

mature market and the peak is already satisfied so the only chance is to keep our current list of the customer away from competitors.

Chapter Four

Company's introduction

4. The purpose of Chapter Four is:

- Company's Description.
- Overview of the software used by the company.
- Workflow inside the company.
- Main external problems (in the industry).
- Main internal problems (inside the company).

4.1. Company's Description.

Since 1989, Coggiola was founded in Italy but not serving the Italian market only as they are providing their services to a huge number of manufacturers abroad, for example, France and oversees as Argentine.

Coggiola offers plastics processing, thermoplastic and thermosetting molding, assembly, and metallization for serving many sectors for example caravan, camper, automotive, agricultural machinery, earth-moving machine, medical, industrial, bathroom fixtures, sports, and gymnastics.

Coggiola has two factories, the first one is based in Turin (Italy) and the second one is in Venice (Italy), They had produced throughout thirty years more than 20,000 products for their customers, the factory based in Turin where I had my intern at is composed of 6 thermoforming machines (Vacuum thermoforming technology-based) different in their dimensions to different parts and five CNC machines to perform the complex type of cuts on the semi-finished products that come out of the thermoforming machines,

The enterprise resource planning (ERP) software that is used is called GEC, with a new updated version with some added features for planning and optimizing the usage of the machine (GEC 2.0). The company's total number of human resources is between (51-

100), allocated between operators, draft men, drivers, employees, engineers, and managers. This number can indicate that it's a medium-sized enterprise.

The factory is working 24 working hours a day with rotating shifts to meet the demand and deliver orders on time.

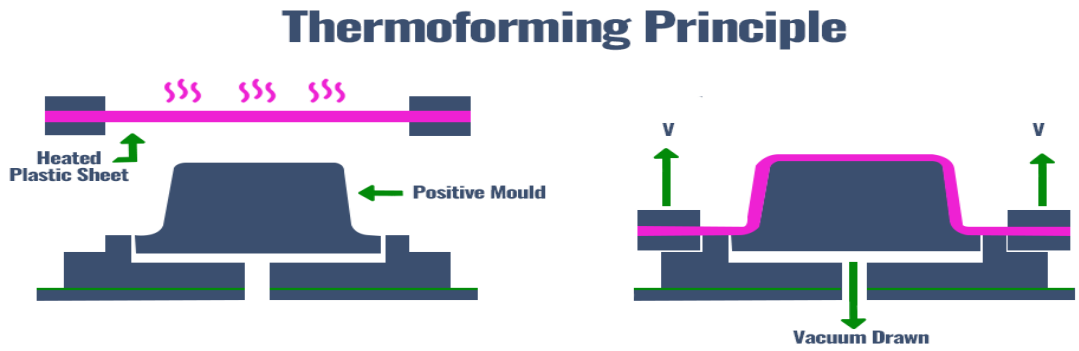
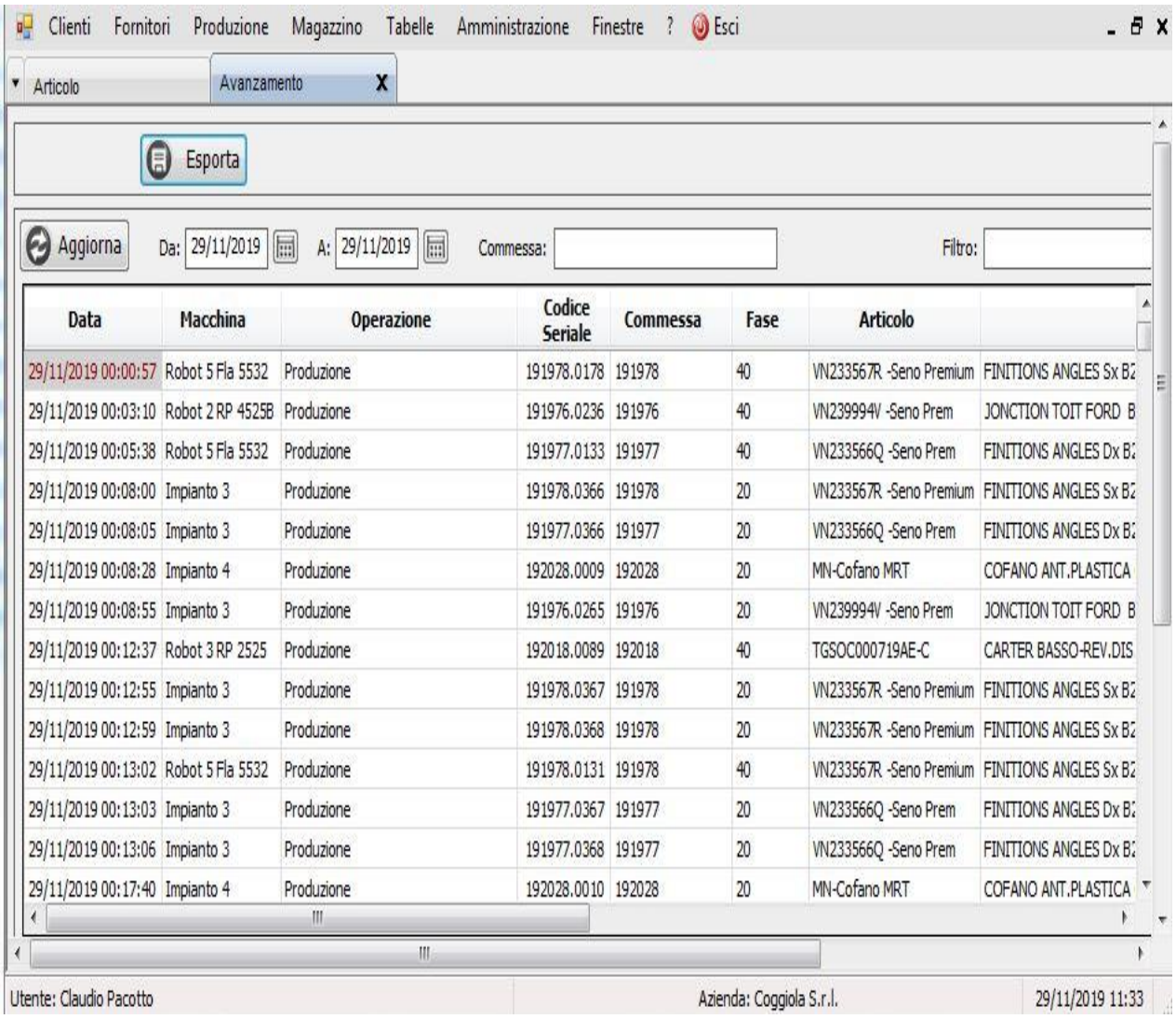


Figure 9 thermoforming principle of molding

Coggiola is using a technology of shaping formed or extruded plastic sheets into completed pieces up to a thickness of nine-millimeter thickness. The raw material shall be heated to its appropriate thermoforming temperature and instantly molded to the required configuration. At manufacturing levels, the material is very foldable, enabling it to be quickly molded into extremely complex parts with a minimum of energy. The thermoforming method has several advantages over other traditional solutions to p art production, one of the main advantages of thermoforming technology is economical is it allows significant cost saving by up to 90% in tooling prices, relative to injection molding. Also being ideal for a small number to a medium number of production parts, in the operations, it's more convenient as Device and component changes can be made quickly and efficiently as it takes from one hour to two hours to change the mold and set the adjustments to start the production of the new part, compared to the setting used in metal forging it's found that thermoforming is more convenient in the case where both materials are accepted for the same function.

4.2. Overview of the software used by the company.

Coggiola is using a customized enterprise resources planning software called GEC, this software allows the company to manage the production activities and some limited logistic functions including only the inbound logistics and registering the incoming goods



Data	Macchina	Operazione	Codice Seriale	Commessa	Fase	Articolo	
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29/11/2019 00:03:10	Robot 2 RP 4525B	Produzione	191976.0236	191976	40	VN239994V -Seno Prem	JONCTION TOIT FORD B
29/11/2019 00:05:38	Robot 5 Fla 5532	Produzione	191977.0133	191977	40	VN233566Q -Seno Prem	FINITIONS ANGLES Dx B2
29/11/2019 00:08:00	Impianto 3	Produzione	191978.0366	191978	20	VN233567R -Seno Premium	FINITIONS ANGLES Sx B2
29/11/2019 00:08:05	Impianto 3	Produzione	191977.0366	191977	20	VN233566Q -Seno Prem	FINITIONS ANGLES Dx B2
29/11/2019 00:08:28	Impianto 4	Produzione	192028.0009	192028	20	MN-Cofano MRT	COFANO ANT.PLASTICA
29/11/2019 00:08:55	Impianto 3	Produzione	191976.0265	191976	20	VN239994V -Seno Prem	JONCTION TOIT FORD B
29/11/2019 00:12:37	Robot 3 RP 2525	Produzione	192018.0089	192018	40	TGSOC000719AE-C	CARTER BASSO-REV.DIS
29/11/2019 00:12:55	Impianto 3	Produzione	191978.0367	191978	20	VN233567R -Seno Premium	FINITIONS ANGLES Sx B2
29/11/2019 00:12:59	Impianto 3	Produzione	191978.0368	191978	20	VN233567R -Seno Premium	FINITIONS ANGLES Sx B2
29/11/2019 00:13:02	Robot 5 Fla 5532	Produzione	191978.0131	191978	40	VN233567R -Seno Premium	FINITIONS ANGLES Sx B2
29/11/2019 00:13:03	Impianto 3	Produzione	191977.0367	191977	20	VN233566Q -Seno Prem	FINITIONS ANGLES Dx B2
29/11/2019 00:13:06	Impianto 3	Produzione	191977.0368	191977	20	VN233566Q -Seno Prem	FINITIONS ANGLES Dx B2
29/11/2019 00:17:40	Impianto 4	Produzione	192028.0010	192028	20	MN-Cofano MRT	COFANO ANT.PLASTICA

Figure 10 Registering Real-time production of produced parts

As seen in figure (10) the program has some main function tabs as we are going to define them as the following:

1) **Clients**: a tab contains all the necessary information about the company's clients as their addresses, contacts, representatives, and their payment conditions.
2) **Suppliers**: a tab contains all the necessary information about the company's suppliers with their catalogs, addresses, and payment conditions.
3) **Production**: the most important tab which monitors the production process at the actual time, as the product exists from the machine and the operator does the inspection he has to add the barcode sticker and scan it, the scanning device will send this barcode which includes the serial number of the part to indicate several parts produced, the client, the operating phase, part number and the description of the part to the computer. Also, some cells are accessible in this part for example by pressing the article code a screen will be shown with all the kind of required information about the delivery date and the number of times this particular part has been performed on the machine.
4) **Inventory**: for monitoring the movements of the parts and raw materials from and to the warehouse, this tab also is used to check the stock of raw material in the warehouse before doing the purchasing order if it exists.
5) **Tables**: this tab is considered to be the master data of the company; it has a table matching all the production part number with the raw material used by specifications, dimensions, and colors. Also, it's used to add new codes as creating new material to the master data which will be reflected in all the other tabs, It has also a table to list all the in-bound and out-bound operations done by the company in the last ten years with other types of information mentioned.
6) **Administrations**: this tab limits the access of the user to the information that he can obtain from the software. Mainly there are three different types of access to the software as the following:
    - Full access
    - Access to the technical data
    - Access to financial data only

7) **Windows**: This software can run six windows in parallel at the same time so by pressing this tab a new window will be opened. Performing separate operations but not allowing duplication of the current screen opened in case of modification.
8) **Export**: this tab exports all the data to an excel page to perform some type of basic analysis and to measure the efficiency of the production process. by exporting production time of each part registered on the system to an excel sheet
9) **Codes master data**: as seen in figure (11) by clicking on the codes, for example, VN233567R, a screen with the necessary information from the raw material used

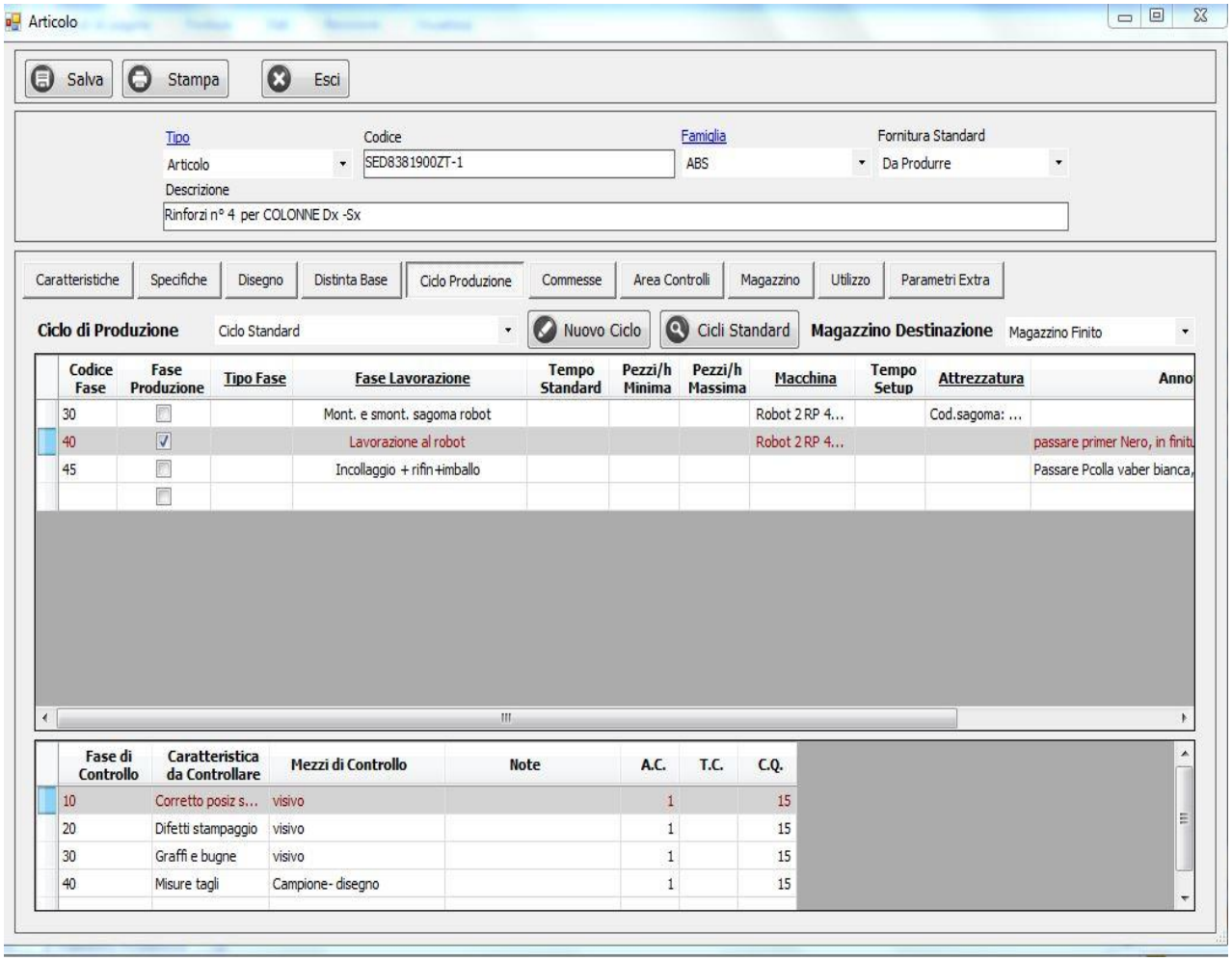

Figure 11 sample of the production cycle from GEC

following the production process till the storage location in the warehouse, even the history of production orders received by the client

4.3. Workflow inside the company

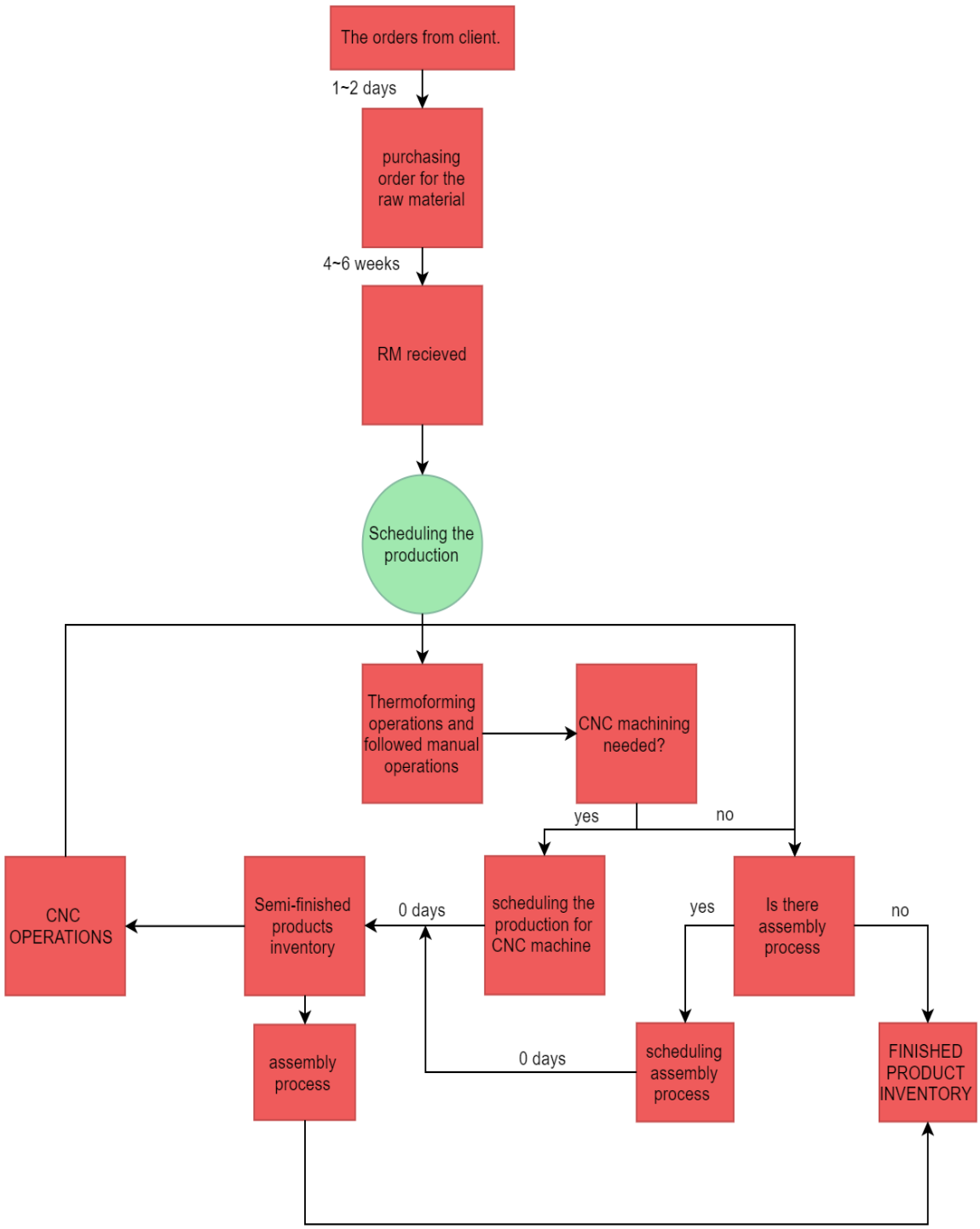

Figure 12 workflow of the company

As seen from the workflow process of the company in figure (12) that the main problem of the company is the lack of proper scheduling as the parts coming out of the thermoforming machines will be stocked first before entering to the CNC machine and so on, this added step leads to more cost of transportation and losing time and resources to be conducted while with proper pre-determined scheduling those kinds of non adding value action shall be eliminated. It will also increase the level of storage in the inventory unnecessarily,

Also, in some cases, the semi-finished products have to wait for more than two weeks till the first availability of a CNC machine which for some types of material is a hazardous condition if not stocked well.

4.4. Main external problems (in the industry).

The market for thermoforming products has a lot of variables which leads to problems

1) due to the location of thermoforming industry in the supply chain and the relativity of the bargaining power between the industry and their customers and suppliers,
2) some other factors are implicit as the industry is a usual semi-automated, Combined activity of man and machine are conducted which leads to more non conforming final products due to human error.

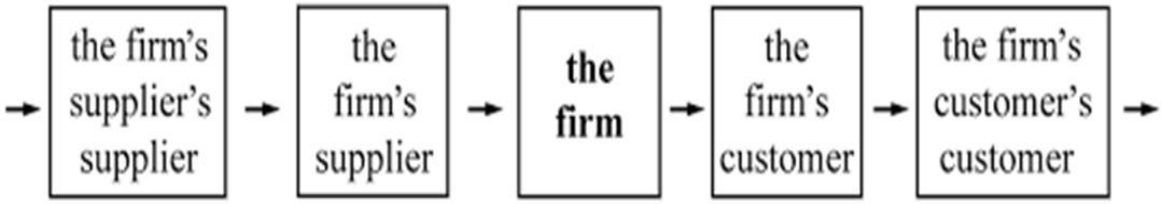

Figure 13 supply chain illustration simplified

firstly, we begin with market analysis to understand the problems raised due to supply chain relation and bargaining power.

4.4.1. Problems due to the location of the industry on the supply chain.

1) **Problems with raw material suppliers:** the lead-time between sending the purchasing orders and receiving the goods is too long (four to six weeks), but the main problem is due to the bargaining power between both sides, as the suppliers such raw material used by the company are feeding many other fields and also there are not many players (suppliers) of this materials in the market (two main suppliers in Italy). Those materials are (ABS, polystyrene, PETG and, HDPE). One of the extremist problems that happen during my internship period is that the lead-time reached two months, reaching almost one month of delay. Also, the suppliers made a minimum order volume, so the company has to wait to reach the minimum required to perform a purchasing order. Those two conditions lead to less flexibility with the first-tier supplier.
2) **Problems with clients**: as clients don't tolerate any kind of delay due to market circumstances, also they request a precise delivery date, as what Coggiola supply like a final product is going to be introduced to an assembly process in the client's plant and they are also forced to deliver a final product in a precise date to the customer, also, on the other hand, their demand is varying which leads also to inefficiency in the production process at Coggiola and affect the purchasing order volume done by Coggiola as mentioned before. Finally, the catalog of Coggiola has more than 1000 production code and each code is representing a final product, almost 300 codes are considered to be active codes (produced frequently), so the client's orders cover a wide range of products which leads to instability of the production line due to changing the mold and preparing the raw material with specific thickness and color.

Now as a simple analysis of this dual problem of the supply chain leads to a simple best scenario, a higher level of demand from customers leads to higher value purchasing orders done and higher bargaining power for Coggiola with the suppliers

and optimum lead-time that allow Coggiola to plan their production based on less number of variables.

4.4.2. Problems implicit of being a semi-automated industry.

As the part comes out of the machine, Several manual operations will be performed as deburring and other basic operations, those manual operations are depending on the operator's experience and the precision of the tool used, but at the end that condition will lead to a higher rejection rate of the goods delivered to the customer also a higher scrap rate than of the automated industry. Also, the speed of the manual operation as being in a series connection with the automated one (the operator gets the workpiece from the machine then performs the manual work), leads to slow down the entire process and decrease the efficiency of the whole process and the utilization of resources. From a different perspective, manual operations need a higher frequency of quality control process over the outcome products to check the quality and to do the inspection to make sure that the products are conforming.

4.5. Main internal problems (inside the company).

Internally the firm was facing many problems which have led to uncertainty and some production problems which all lead to inefficiency in results and inefficient usage of resources, we can classify those problems that the company was facing to five main types as following

4.5.1. Lack of standardized workflow of operations

The lack of the standardized workflow has led to conducting the work in a different order every time the work has to be conducted, for example, if the product that comes out of the machine still needs three more operations to be done manually, the operator does those three operations in a different order as there's no standard workflow of the process, and as participating in measuring the average time of each different method of

them, it was found that they are all different and there's only one optimum way which is called optimum workflow. As shown also in figure (14) that it might exist three or four different alternatives per reaching the same goal but there's only one short efficient and standard way, so the factory has to train the operators on the operational (standardized workflow) guide to reach the required goal efficiently.

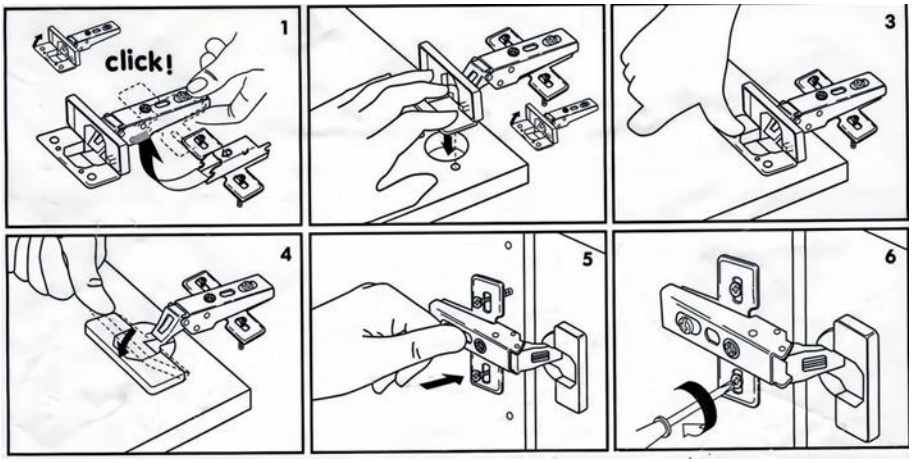

Figure 14 simple example of standardization of workflow

4.5.2. Lack of measurements for the production capacity

The lack of production capacity knowledge has led to the decrease of the overall capacity of production due to an important consideration, if the operator on the production line doesn't have a reference to the production capacity translated to pieces/hour, it will be impossible to measure his efficiency and it affects also the relative performance of the following shift as the next operator working on the same machine will consider automatically the produced parts during the whole shift as a standard, neglecting the possibility of problems that might have happened during the previous shift as the stoppage of the machine for the quality issue, for example, by practice, it was found that by measuring the real-time of production of one part in the first shift and estimating upon this the minimum number of produced parts during the whole shift and adding it to the production orders given to the successive shift has led to a more produced parts in the following shifts, so undoubtedly having measurement standards

to measure the production capacity was a must that should be defined for every single part from the catalog. Overall, the statistical measurements found a general lack of standardization in evaluation and reporting. The findings highlight the need for standardization to enhance the efficiency of production by recommendations on a standard approach.

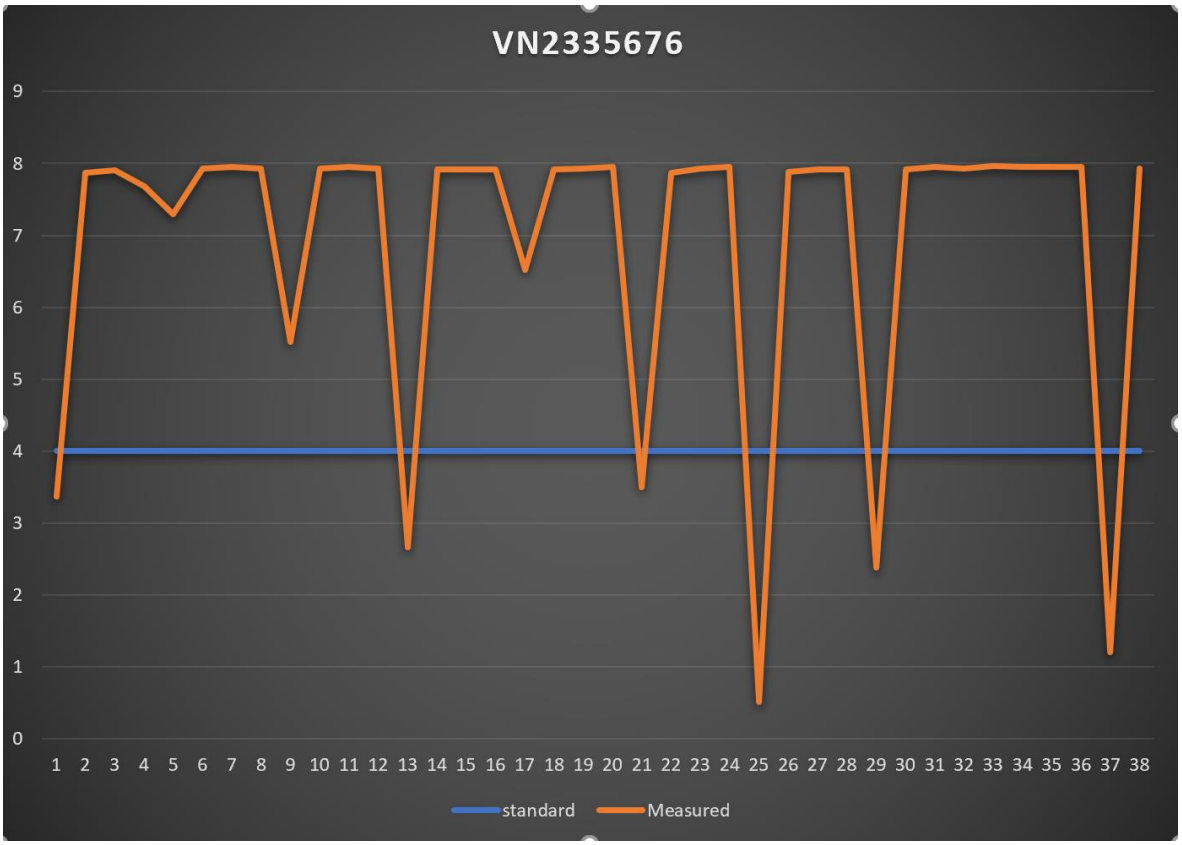

Figure 15 38 samples of registered time vs standard time

4.5.3. Non-adding value actions in the workflow.

A required activity is an activity that must be completed but does not necessarily add importance to internal or external customers. The most common required activities are those required by law or government framework. Although certain required activities do add value, in many cases they are mandatory activities, but they do not add any value. However, this does not mean that it cannot be optimized to eliminate waste and

minimize the cost of required activities. Some people classify business activities such as HR (recruitment) and building conservation as required business activities that do not add value. However, these activities are not required for value-added activities. For example, discovering and hiring suitable people when needed and doing it effectively can add value. The organization's human resources are its most important resources. The human resources department is providing invaluable services to the other departments in the organization, enabling them to raise a better value to the products they produce.

1) **Waiting time:** This is one of the most manifest wastes and does not add value. For example, if machine operators are wasting time waiting for the next batch of components to arrive, better scheduling can eliminate waste. However, not all waiting time is a waste of time. Suppose a worker's job is to handle large pieces of plastic from a pallet and place them in the thermoforming machine. He unloaded as soon as another worker is free, and then he waited for about ten minutes until the part exists and a couple of minutes till another operator is free to handle down the part. Is this a waste of time? Not necessarily In some jobs, "waiting time" may be a valuable break time for workers to keep doing their job well. However, in the mentioned example, there are many opportunities for advancement in eliminating waste. For example, why does a human need to physically move large pieces of plastic? Maybe there is a better way of using machinery?

Waiting time is defined as free time, during which someone who might be doing something does nothing. Eliminating or minimizing this free time eliminates waste and improves value-added activities.

2) **Excess Motion:** the term " Excess Motion": refers to the movement of materials, supplies, humans, and equipment. Suppose in this example that the part needs more manual operations after thermoforming, then the operator will transfer the part to the deburring machine and then transferred on a pallet to a location where workers load the pieces into a finishing machine. Moving the finishing machine near to the deburring operation eliminates unnecessary movement. The plastic is then

deburred to the appropriate size and directly passed to the finisher without having to move it in and out of the warehouse eliminates the Excess Motion of plastics (transported waste).

3) **Excess Handling:** Excess Handling refers to unnecessary activities of workers and unnecessary disposal of products, machines, and equipment. In the example of large plastics in dimensions, why must the worker transfer the plastics from the pallet to the thermoforming machine? What if the plastics are handled automatically to the thermoforming machine instantly through a feeder? plastics no longer need to be handled by employees, eliminating waste.
4) **Excess Inventory:** Inventory costs storage space and inventory taxes. Inventories raise the risk of retraction, deterioration, and obsolescence. This also increases processing costs because you need to move items in and out of inventory, and workhours must be used to compute the inventory constantly. Only a minimum, necessary inventory should be preserved to add value to the final product or service. Too much inventory is waste. Let's look at an example again. The production ordered received of a hundred and thirty parts but on the pallet received the minimum amount of raw material is a hundred and fifty of raw material. Because it’s more convenient producing one hundred and fifty parts instead of the required amount, the parts are made and then stored for future orders in a repository. The same goes for all production lines.
5) **Over-processing:** This means more effort is being placed into a product or service than the end customer needs. For example, extra wrapping cost to make the final product looks fancy and not providing extra protection during transportation is an extra cost and require more resources that can be saved for other adding value actions
6) **Overproduction:** Overproduction means that more products are produced than are instantly needed. If more parts are produced than sold, they will pile up in the warehouse. If most parts were sold within four weeks before high demand seasons and need to increase supply before the season, this may make sense. In most cases, overproduction will lead to a large waste of inventory.

7) **Defect:** Defective products must be discarded or reformed. Defective services must be completed. Doing the right thing the first time is crucial to eliminating waste. Although eliminating all defects may seem like an impossible task, there are lean methods (such as Poka-Yoke) that can efficiently eliminate defects, thus eliminating the need to check for defects, thereby saving even more costs.

4.5.4. Software problems.

The enterprise resource planning software used by Coggiola is supposed to manage the production part and inventory but lacking some functionalities which lead to many errors.

1) **Quality issues**: for example, a production order of hundred parts is received by the company, the quality department generate 105 barcodes to be attached to the finished products considering the percentage of the scraps, the operator scans them in groups as ten by ten so the software receives that there are ten ready finished products while there are no produced parts yet, also it leads to misordering the finished products as the operator made a hypothesis that all of the 10 products are quality controlled and they are all valid parts, also it leads to vague statistical measurements of results as we would have ten parts produced in ten seconds which is the actual time of scanning the codes and 40 minutes of production time to produce the eleventh.
2) **Limitation of Scheduling**: GEC is very limited software concerning the planning and scheduling, only processes the changed data, GEC is not able to plan the resources or to show the scheduling plan of the machines or when will the first machine be ready to receive a new order. GEC doesn't support any lead time scheduling, or even calculating planned order dates based on routing times. GEC doesn't link the receipt goods to the availability of starting the production process, it doesn't schedule backward

3) **Limitation of resource planning:** Automatic planning in the MRP identifies the gaps between the demand and supply and establishes automatically the correct acquisition components to fill this gap. those alerts shall be generated for critical circumstances so that you can rework the preparation outcomes in a specific problem field**.**

   In the case of inhouse production, as in our case, the BOM should be identified and GEC should measure the dependent variables i.e. the number of components needed to produce the part**.** also upon the history of production order, it can estimate the annual usage of certain material and the annual production of parts, so it can estimate an estimation of the raw materials in this period, Also it would guarantee the availability of material on time.

4) **Warehouse issues**: ERP's provide businesses with the ability to track the products and raw materials needed to build a product that satisfies customer demand, the consistency of the inventory system influences the purchasing, planning, and creation of the company's divisions. The planning department utilizes inventory details to set up a production schedule to satisfy customer demand. Accurate production reports make it possible for the purchasing, The ERP will gather sufficient data to help in the collection and preparation of potential product requirements. A well-optimized ERP software can provide the business with details on the products used in manufacturing as well as on surplus and waste. Such information would enable the procurement process to determine the exact sum of inventories for the packaging materials, GEC only registers the inbound logistics of raw materials and goods received but doesn't assign them to the warehouse internally, and doesn't include the functionality to record the outbound logistics and balance the inventory so they have to be assigned manually. Employee mistakes can create inaccuracies in inventory reports, which may contribute to a failure to buy materials or an excessive amount of inventory. Employees responsible for the handling of supplies or task orders must assign the storage location and monitor the inventory system carefully as GEC doesn't include this functionality.

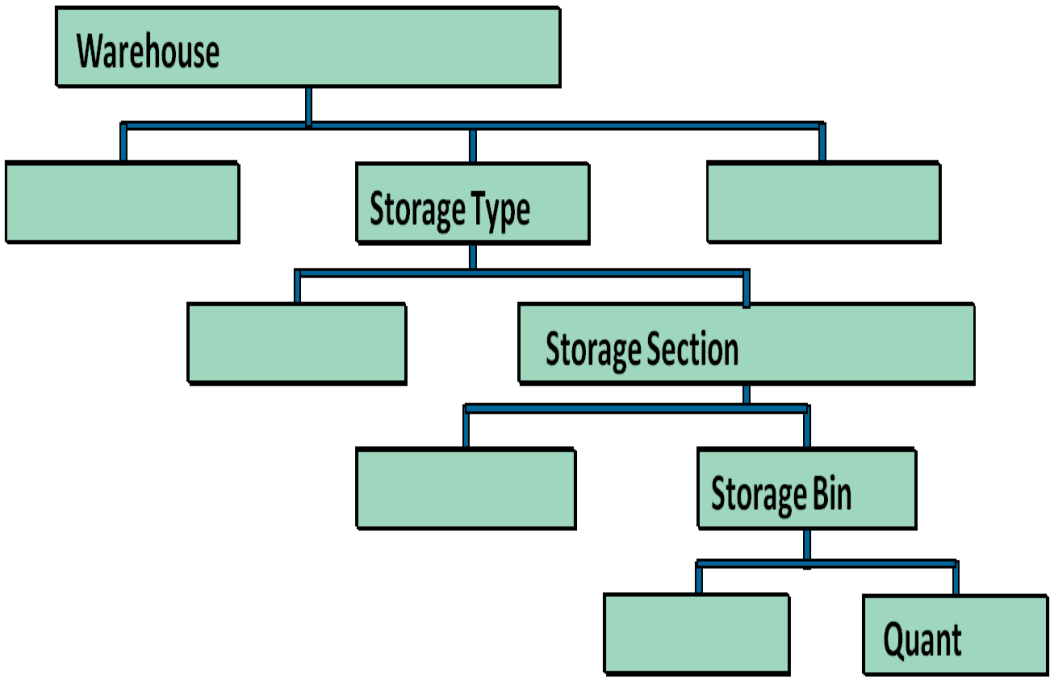

Figure 16 storage location classification

Chapter five

Case Study

5. The purpose of Chapter Five is:

- Pre-standardized state.
- Information gathering.
- Company's new ERP software.
- The new approach with the environment.

5.1. Pre-standardized state.

In this part, we are going to measure the overall efficiency of the production process, the methods used to collect the data and the results obtained from the analysis. We are going to neglect any external factors from this part as we are going to discuss the main problems affecting the production internally, for example, if the lead time was scheduled and planned that the raw materials will arrive after two weeks, the fact that it might come after three weeks will not be considered, so it should be considered as a limitation for this study.

5.1.1. Determining the overall equipment effectiveness of the production process.

OEE is a measure that describes the amount of expected production time that is productive. The OEE score of 100 percent reflects flawless performance: production of only good parts, as quickly as possible, without interruption. and could be used as a measure to make a comparison of a particular output resource with international standards, equivalent in-house resources, or outcomes for different shifts in the same resource.

It can be used as a benchmark to measure improvement over time in reducing waste from only a defined output asset. A theoretical study was conducted to better understand how the OEE can be measured and now we are going to discuss the procedure.

5.1.2. The OEE method to calculate the overall production efficiency.

OEE = (Number of good parts X Ideal cycle time) / Total time consumed

So this simple equation discusses some terms as the following:

- Number of good parts produced without any defects
- Ideal cycle time calculated upon the fastest possible time to produce one part
- The total time which is not the planned time but the actual time consumed to produce this number of parts

Overall Equipment Effectiveness	Recommended Six Big Losses	Traditional Six Big Losses
Availability Loss	Unplanned Stops	Equipment Failure
	Planned Stops	Setup and Adjustments
Performance Loss	Small Stops	Idling and Minor Stops
	Slow Cycles	Reduced Speed
Quality Loss	Production Rejects	Process Defects
	Startup Rejects	Reduced Yield
OEE	Fully Productive Time	Valuable Operating Time

Figure 17 OEE losses

The alternative method of calculating OEE is inseparably linked to the simple calculation mentioned above, but gives a much better explanation of losses in the production process by delving deeper into three-loss factors:

- Loss of availability includes all planned and unplanned stops such material shortage and lost time during the change of the shifts
- Declining performance: including the longer time of cycle compared to that of the ideal one.
- Quality issues: losses due to the produced parts that don't meet the quality standards.

OEE is a useful tool for management, but it can be a bit complex for plant floor employees. Plant floor workers can perform much better if they have real-time goals, quickly understood and highly motivated. TAED is a good illustration of an important collection of plant floor metrics:

- Target: it's defined as a real-time output goal powered by those of the expected production capacity.
- Actual: effective performance registered and monitored.
- Efficiency: the plan-to-actual ratio; how far ahead or behind the production is operating in terms of total
- Downtime: built-up unforeseen downtime for real-time shifting; this retains a heavy emphasis on the main verifiable progress area.

There's a benchmarking method related to the OEE to measure your performance and track your progress like the following:

- 100%: is flawless performance: production of only quality issued parts, without any waste time, without stopping time.
- 85%: is deemed to be called world-class, It is an acceptable long-term goal for many businesses, and by default, it was the long term goal for Coggiola.
- 65%: is typical for discreet producers but shows that there is significant room for improvement. And it is considered as a medium alarm for

companies as overtime without improving the company will be out of the race for its market share.

- 40%: should be an alarm for the company as the chances for direct and forward implementations of enhancement of the industrial process can be done. And some authors consider it as a clear sign for the resignation of the management team or for the company to go out of the market (in case the industry is mature and saturated and had already it's well-established tool and equipment with known high efficiency and high speed)

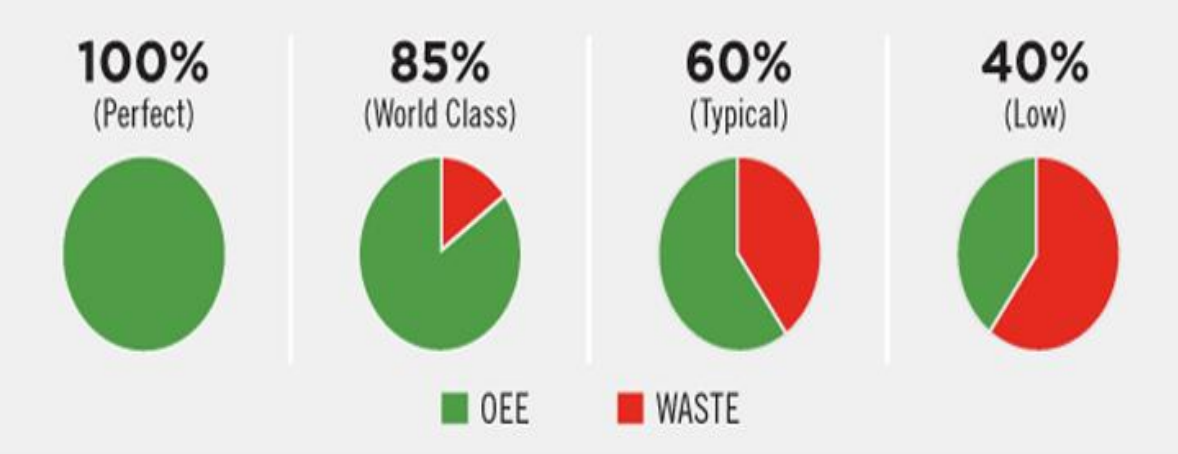

Figure 18 OEE benchmarking indications

5.1.3. Measuring the Ideal production time of each part.

There are six thermoforming machines, each of them is working on a separate working order, and they are separated based on the financial account (for example the amount of raw material used and the revenues from each machine), it was more convincing for the managers to measure the efficiency of each of them separately, as discussed before the target was to evaluate the efficiency of the machine before implementing the new standards to the industrial process, so we have to apply the method of OEE and the first step was to know the ideal time of each process for each

part, it was concluded that there are two different methods that should be done to measure the effectiveness of the production process as following:

- Measuring the time of thermoforming machines only and neglecting manual operations time as the manual operations should be done by the operators while the thermoforming machine is working.
- Measuring the total time from the withdrawal of the raw material from the pallets to the disposal very end of the last manual operation.

After observations, it was found that the second way is more realistic as the manual operation might be longer than the thermoforming operation, the operator waits until he finishes the part so that the working table would be empty to make him introduce the finished working part from the thermoforming machine, so the relation between the two processes was found to be a series relationship, so it's not a parallel relationship as it was considered by the first assumption.

Due to difficulties in obtaining those results from GEC, as discussed before operators scan the bar-codes of the production parts without having the part being produced from the machine, so we didn't rely on GEC for obtaining the results, a traditional method was used to get the results (stopwatch), several samples were taken during the working shifts of the same production order to make sure that results obtained will be accurate. The samples were taken as follows:

- Three successive samples at the beginning of the production order.
- One more sample after two hours.

The effective ideal time measured for the thermoforming machine was found to be constant depending only on the thickness of the raw material used during the thermoforming process.

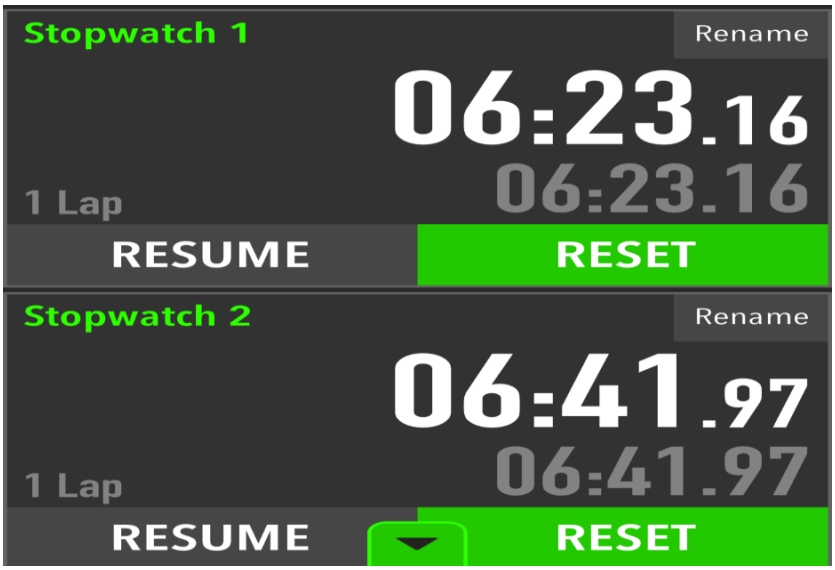

Figure 19 Sample of time registered for the TGOC0037654

5.1.4. Measuring the overall equipment effectiveness of one machine.

After measuring the average production time of each part, the data from the GEC was exported to an excel sheet to obtain the overall efficiency, this exporting function from GEC has many advantages over tracking the process inclusively by existing close to the machine, those advantages can be summarized in the list:

- Eliminating all the non-production phase from the consideration. for example, maintenance.
- Considering the time waste during the working shifts turns.
- Any stoppage time due to Quality Issues.

As seen in figure 20, there's a filter applied to indicate the production phase only, then an overall efficiency calculation was conducted to measure the overall efficiency of production order in two different ways, like the following:

- Excluding the waste time during shift turns and coffee breaks.
- Including the waste time during the shift turns and coffee breaks.

DATA	MINUTES	production lin	PHASE	SERIAL	Order No	WORKING PHASE	PRODUCT TYPE	QC
06/11/2019	10	Impianto 2	Produzione	1.917.760.001	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.002	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.003	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.004	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.005	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.006	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.007	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.008	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.009	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.010	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.011	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.012	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.013	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.014	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.015	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.016	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.017	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.018	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.019	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.020	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.021	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.022	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.023	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.024	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.025	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.026	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.027	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.028	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.029	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.030	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.031	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.032	191776	20	TGOC002148AD-GG	1
06/11/2019	10	Impianto 2	Produzione	1.917.760.033	191776	20	TGOC002148AD-GG	1

Figure 20 sample extracted from GEC to calculate the OEE

This is a table down below extracted from an excel sheet for measuring the efficiency of part-number (TGOC002148AD-GG) which has a standard production time of 10 minutes, the total production order was of 85 pieces and the total time consumed to produce those parts was twenty-two hours (including the coffee

breaks and time consumed in changing the working shifts), as a result, the overall efficiency was dropped down to 64%. According to the production standard, Coggiola was considered to be a typical performer as the efficiency of their machine counted between (65% - 75%)

NOT CONSIDERING THE COFFEE BREAKS AND TIME CONSUMED DURING SHIFTS		
TOTAL TIME CONSUMED	21:06:10	HOURS
FACTOR	00:01	CONVERTING TO MINUTES
MINUTES OF PRODUCTION	1.266	TOTAL MINUTES OF PRODUCTION
STANDARD PRODUCTION TIME	10	STANDARD TIME OF PRODUCTION
PEZZI DEVONO ESSERE LAVORATI	126,6166667	NUMBER OF PARTS SHOULD BE PRODUCED
PEZZI LAVORATI	85	ACTUAL NUMBER OF PRODUCED PARTS
EFFICIENZA	67,13%	EFFICIENCY

5.1.5. The Results of the (OEE) of the production process.

It was found by measuring the efficiency of the firm for 15 days by the previous technique that the efficiency was always around 65%, in the figure down, it shows all the efficiency of the production process during November 2019 for all production lines. One of the major problems as seen from the plotted graph is four days of stoppage time due to the failure of the fourth line, By performing this analysis, there was no doubt that the firm was far away from the optimum utilization of the resources, those big losses incurred in the pre-standardized state at Coggiola have caused a major declination of the overall efficiency of the machine as was expected, so as the results were obtained it was understood that Coggiola is looking for standardization to better utilize the resources due to the low percentage of the OEE.

The reports during the full period of the fifteen days were conducted in three different ways

- daily efficiency of the firm.
- daily efficiency of every production line (machine). based on the production order which can last more or less than one day

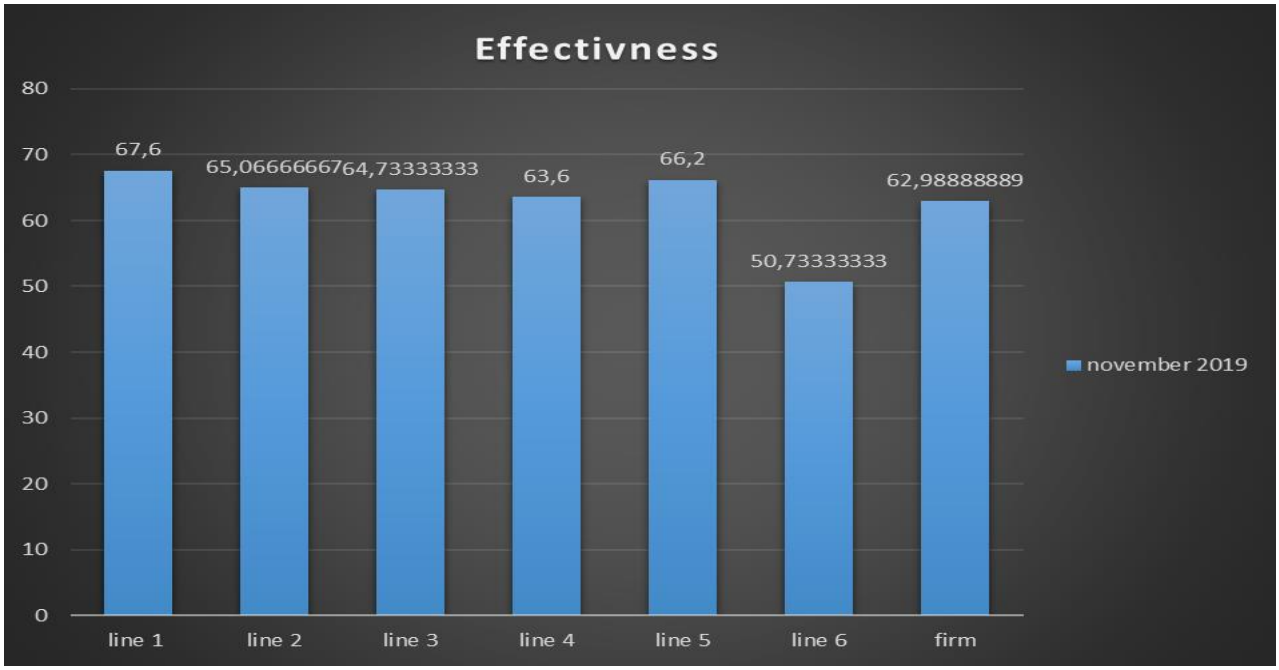

Figure 22 overall efficiency of the production process

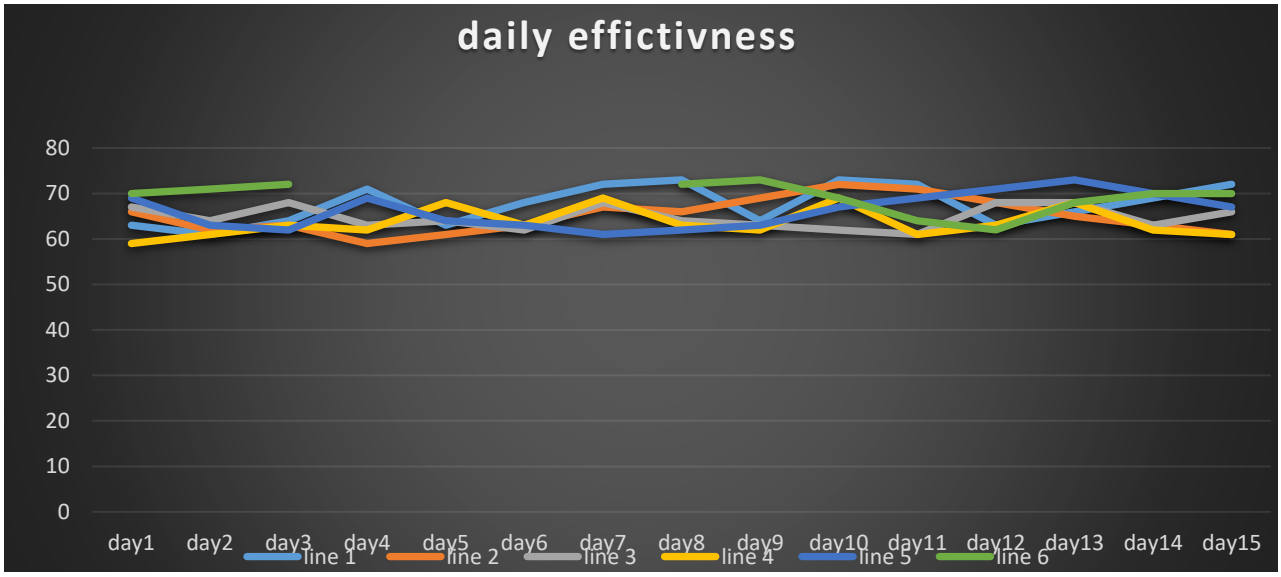

Figure 21 firm overall OEE score

5.2. Data analysis.

As the backbone of any industrial decision is the availability of information, it was necessary to identify all the Ideal production time of the parts inside the firm throughout different steps, this kind of information was also required to be inserted as a master data for the new version of the GEC.

Also, it was required to gather all ideal time of the produced parts on the CNC machine and to add them to form one complete ideal cycle of the production of each part, also it was required to extract and update all the operations to be done on each part and classify them for a purpose that will be discussed later in this chapter. So the information gathering process was divided into several steps to be conducted in the right way, starting from the ideal time of the thermoforming machine, manual operations and ideal time on the CNC machine.

The next points shall simplify the type of information request and method to obtain them to supply the master data for the new software.

Coggiola

Applicazione Di Ottimizzazione Della Programmazione (1)

code	Complete thermoforming process	number of parts produced	CNC Time	Complete Description	parts	Impronta T Stima	total time
202901770-1772		1		base codice madre stampaggio	1	0	
202901774 - 1775		1		TRAVE POST. CURVA in USCITA	1	0	
212885Q		1		COVER, REAR BED-03140	1	0	
615701po13ST		1		CONTROMUSETTO ANT. 1300	1	0	
A13551000900		1		RIPARO Mod.555 "X Ant.	2	0	
A13551031300		1		RIPARO Mod.551 "X" Post	1	0	
A13553001200		1		RIPARO Mod.552 Sx Traversa "Y"	2	0	
A13553001300		1		RIPARO Mod.553 Sx Traversa "Y"	3	0	
A13554001000		1		RIPARO Mod.554 Ant.TESTA	1	0	
A13554001100		1		RIPARO Mod.555 Motore "Z"	1	0	

Figure 23 model 1 of data gathering for Coggiola

5.2.1. Calculating the ideal time of the production parts.

As discussed before, the technique that was used to gather this data was a classical method using a stopwatch with ten samples each at the beginning, the number of samples was much more, in this case, to identify the performance of the machine during the time to measure the thermoforming machine long periods of working time, the samples have shown a constant relationship between the working hours of the machine and the operating time of the part on the machine. The first step was by identifying more than three hundred production orders received by Coggiola and to be performed during November and December, the measuring technique was conducted and performed on all of the production orders to get the ideal time of more than 250 part.

Coggiola

Applicazione Di Ottimizzazione Della Programmazione (1)

code	Complete thermoforming process	number of parts produced	CNC Time	Complete Description	parts	Impronta T Stima	total time
202901770-1772	8,5	1	5	base codice madre stampaggio	1	8,5	13,5
202901774 - 1775	10	1	6	TRAVE POST. CURVA in USCITA	1	10	16
212885Q	3	1	3	COVER, REAR BED-03140	1	3	6
615701po13ST	9	1	5	CONTROMUSETTO ANT. 1300	1	9	14
A13551000900	10	1	6	RIPARO Mod.555 "X Ant.	2	5	11
A13551031300	10	1	5	RIPARO Mod.551 "X" Post	1	10	15
A13553001200	10	1	5	RIPARO Mod.552 Sx Traversa "Y"	2	5	10
A13553001300	12	1	6	RIPARO Mod.553 Sx Traversa "Y"	3	4	10
A13554001000	7	1	4	RIPARO Mod.554 Ant.TESTA	1	7	11
A13554001100	4	1	6	RIPARO Mod.555 Motore "Z"	1	4	10
A13554002100	8	1	7	RIPARO Mod.556 Infer.Testa	2	4	11
ACDIS16110-0103	5	1	8	VASCH.SCAR.COND.GR-MODULA-ES.2	1	5	13
AIC/PALL.C.062	3,5	1	7	VASCH.SCAR.COND.GR-MODULA-ES.2	1	3,5	10,5
BL4020-0001-00	4	1	4	COPERT.CLIMATIZ-MODULA-ES.2	1	4	8
BS002951100	12	1	5	VASCHETTA EVAPORATORE-ES.MOD.3	1	12	17
BS002951200	8	1	4	RIP.X DESTRO-03138	2	4	8
BS002954700	7	1	6	RIP.X DESTRO-03138	1	7	13
BS002968900	6	1	5	COPERCHIO POSTERIORE-03138	1	6	11
BS003226301	8	1	4	COPERCHIO POSTERIORE	1	8	12
BS003230800	4	1	6	TRAVE POST. CURVA in USCITA	1	4	10
BS003329401	7	1	5	RIPARO POST. ASSE Y	1	7	12
BS003333801	7	1	7	RIPARO ANTER.MONTANTE Z=2500	1	7	14
BS003411901	12	1	6	GRIGLIA ANTER.BETA MONTECARLO	1	12	18
BS003411901	12	1	4	RIPARO ANT.MONTANTE	2	6	10
BS003412801	12	1	8	TRAVE POST. CURVA in ENTRATA	1	12	20
BS003412801	12	1	4	RIPARO POST.MONTANTE	2	6	10
BS003413200	4	1	3	COPERCHIO SUPERIORE MONTANTE	1	4	7

Figure 24 sample of obtained result of ideal time

5.2.2. Specifying the standardized work chart for each part.

In this part, it was requested to assign the operations done on each part, this task includes the actual operation performed on each part or updating the actual operation list if exists, this task was performed by extracting all part codes from GEC and then checking them one-by-one from the production cycles inserted in the database of GEC as discussed before.

Due to the lack of knowledge of the modifications data on the updates, the modification was done after guidance from the senior engineers at Coggiola. The four classifications were as following:

- Thermoforming.
- CNC.
- Assembly.
- Manual operations classified as others.

Product Code	Product Description	Thermoforming	CNC	Assembling	Altro lavoro
BS002976301	RIP.CARRO XZ C&D (HE,AC)-03138	Y	Y	Y	Y
BS002976301-Rinforrzo	RINFORZO x 002976301	Y	N	Y	Y
BS002980200	COPERCHIO ANTER.G-PHOON-03138	Y	Y	N	Y
BS002980300	COPERCHIO POSTER.G-PHOON-03138	Y	Y	N	Y
BS003013700	RIPARO INF.CARRO CENTR.-03129	No available data			
BS003013701	RIPARO INFER.CARRO CENT.-03138	Y	Y	N	Y
BS003013702	RIPARO INFER.CARRO CENT.-03138	Y	Y	N	Y
BS003013703-cl	RIPARO INFER.CARRO CENT.-03138	N	Y	N	Y
BS003013704	RIPARO INFER.CARRO CENT.-03138	Y	Y	N	Y
BS003022300	RIPARO CARRO X-Z GLB A-03139	Y	Y	N	Y
BS003060301	RIP.CARRO XZ C&D (IM,RF)-03138	Y	Y	N	Y
BS003088601	.IPARO SUP.MONTANTE NHC-03138 - Lotto min. 25 pz	N	N	Y	Y
BS003126102	RIPARO POST. CARRO X-03138	Y	Y	N	Y
BS003146303	RIP.FRONT.CARRO Y-Z M/M-03139	Y	Y	Y	Y
BS003146402	RIP.POST.CARRO Y-Z-03138	Y	Y	N	N
BS003184301	COPERTURA POSTERIORE MANDRINO	N	Y	N	Y
BS003184400	COPERCHIO POST.MANDRINO-03138	Y	N	N	Y
BS003191003	RIP.FRONT.CARRO Y-Z CNC-03139	Y	Y	N	N
BS003219301	RIPARO SX CARROX-03138	Y	Y	N	Y
BS003219401	RIPARO DX CARROX-03138	Y	Y	N	Y
BS003221001	RIP.FRONT.CARRO Y-Z MM-03139	Y	Y	N	Y
BS003221101	RIP.POST.CARRO Y-Z FR-03138	Y	Y	N	Y
BS003221201	RIPARO SUP.MONT.X FRESAT-03138	N	N	Y	Y
BS003221201 Dx		Y	Y	N	N
BS003221201 Sx	RIPARO SUP.MONT.X FRESAT Sx	Y	Y	N	N
BS003226301	COPERCHIO POSTERIORE	Y	Y	N	N
BS003230801	COPERCHIO POSTERIORE	Y	Y	N	N
BS003234200	RIP.CARRO X GLC CLASSIC-03139	Y	Y	N	Y
BS003238300	RIP.DX TRAVE GLOBAL SOF.-03138	Y	Y	N	Y
BS003242100	RIP.CARRO X GLOBAL SOFF.-03139	Y	Y	Y	Y
BS003329401	RIPARO POST. ASSE Y	Y	Y	Y	Y
BS003333801	RIPARO ANTER.MONTANTE Z=2500	Y	Y	N	N
BS003334001	RIPARO POSTER.MONTANTE Z=2500	N	Y	N	N
BS003334101	RIPARO POST.MONTANTE Z=2500	N	Y	N	N
BS003334201	RIPARO SUP	Y	Y	N	N

Figure 25 sample of assigning operations to parts

5.2.3. Analyzing production orders (creating kits).

The benefit of analyzing production orders is to identify the parts that are mostly requested together by the clients and grouping them, this will help Coggiola creating a kit, the kit can be defined as a group of different molds mounted together on the same piastre to produce two different parts at the same time, this will help the company duplicating its production capacity and decreasing the uncertainty of the process, but some factors should be considered during the formation of the kit those factors are as the following:

- The same type of raw material.
- The same thickness of the raw material.
- Orders should be from the same client with less than two weeks of lead time between two orders.
- The parts should be of the same color.

Coggiola

KIT CODICE	CODICE
A101	A13553001200 A13551000900
A102	A13553001300 A13554002100
A103	BS003411901 BS003412801
A104	BS003622800 BS003627500
A105	BS003624200 BS002968900
A106	BS003627100 BS002951200
A107	BS003790600 BS003230800
A108	BS003811200 BS003413200
A109	CP22J-54-R4180 CP22J-54-R4380
A110	CP2A1-54-14380 CP2A1-54-14390

Figure 26 sample of kit creation of different parts

The analysis has been conducted including over a thousand purchasing order to form the kits, finally, over a hundred kits were created, those hundred kits were grouping.

5.2.4. Classification of the customers.

Client Code	Client Description	Client Priorit
Source : GEC	Source : GEC	Manual
Text	Text	A/B/C
C50427	3xS S.R.L.	
C50567	A.I.S.I. S.R.L.	
C50110	A.STA.T. S.A.S.	
C50001	ABECRIL TECNO SYSTEM S.R.L.	
C50194	AC GRAF CLIMATIZZAZIONE S.R.L.	
C50293	ACRYL GLASS S.R.L.	
C50234	AD.EL.GROUP ADVANCED ELECTRONIC SRL	
C50507	ADECCO ITALIA SPA	
C50002	AERNOVA ENGINEERING S.R.L.	
C50314	AF SYSTEM di BUTERA GIUSEPPE	
C50557	AGCO INTERNATIONAL GmbH	
C50512	AGCO ITALIA S.P.A.	
C50404	AISI SYSTEM S.R.L.	
C50211	AIT SAS di SACCONE F. & C.	
C50488	AL.TIP S.R.L. Socio Unico	
C50405	ALL JOB SOC.COOP.	

Figure 27 table of client's classifications

In this part, a classification of the customers was conducted, the classification of the customer's need was to prioritize the production order, as it's normal that the firm didn't want to lose the most important customers due to delay periods, this technique of prioritizing the customers shall help Coggiola through the scheduling process, a benchmarking method was used to classify the clients into three categories as following:

- Category A: a client with a high frequency of ordering (at least 2 orders every month), in high quantity (above a hundred and fifty part).
- Category B: a client with medium or high frequency of ordering (between 2 to 3 orders every 45 days), in medium quantity (75 to 150 part)
- Category C: seasonal clients.

Due to the uncertainty in the arrival of the raw materials and other problems that might occur during the production process the company has to leave a margin of error, this margin of error is considered to be maximum delay time, the maximum delay time is related to the type of the client, this target is considered to be a great leap towards customer satisfaction compared to the history of delayed delivers before. Especially that those delay days is not presenting the ideal case but the worst-case scenario as decided from the owners of the company, and also that the client should be informed by any form of delay at least with two weeks in advance, this adds a more challenge to the scheduling process and more satisfaction to the customers, and down below the table shows the maximum period of delay depending on the customer classification.

Client Priority	Max Delay Time
Manual	Manual
A/B/C	Integer (days)
A (VIP)	0-1
B	3-4
C	7

5.3. Proposal for standardized work.

As discussed before, this part is an approach towards the standardized work, the problems that were discussed before shall be solved using some standardization tools, some cases shall be solved using tailored solutions depending on the observations. The problems related to the limitations of the GEC software shall be solved in the following part.

5.3.1. Standardized work chart

After breaking down the working process into steps, the time of production for each part was added to the production capacity sheet which represents the ideal time of production for each part.

As suggested by Liker & Meier (2006), three necessary documents should be available for any industrial process to achieve the standardized work and they are:

- **Standardized work chart**: As discussed before, the optimum sequence of operating flow was measured before and the optimum operational flow (order of manual operations) was found, also the list of the operating tasks was already known from the phase of gathering information, as discussed before, therefore the standardized work chart can be done for each part. But due to the variance in the part that an operator can perform more than thirty parts during one month, there's no certain training to help increase the efficiency of the operator, but the
- **Standardized work combination table**: it's mainly to illustrate the flow of multi-stage automatic and manual work but in our case, there's no complication or a multi-stage automatic process, that the automatic process is done one time and the rest is all manual processes, so the standardized work combination table wasn't valuable in this process.
- **Production capacity sheet:** it's a list of the capacity of production for each part, it was performed several times as illustrated before, the fact that the production capacity should be attached to the production order and delivered to each machine to allow the standardized measures to take over the comparisons done between the working shifts.

In certain cases, a combination of solutions creating a tailored solution as a unique document in which all of the necessary information as a work combination and production capacity should be attached to the production order.

CODE	Part/hour	Working shift
202901770-1772	7	53
202901774 - 1775	10	75
212885Q	20	150
A13551000900	7	50
A13553001200	7	50
A13553001300	6	45
A13554001000	9	64
A13554002100	10	75
ACDIS16110-0103	12	90
AIC/PALL.C.062	17	129
BL4020-0001-00	15	113
BS002954700	9	64
BS003411901	5	38
BS003412801	5	38
BS003622800	5	41
BS003624200	5	38
BS003627100	6	45
BS003627500	8	56
BS003790600	9	64
BS003811200	9	64
BV5000116701P/A	5	38
BV5000116701P/B	9	64
CONDENSER	9	64

Figure 28 production capacity sheet

5.3.2. Changing the layout of the shop floor.

The main purpose of this part is to enhance the entire production area according to the activities conducted on the production floor. Also, the removal of the misplaced objects would help to make it easy for working operators to add more tools or simplify the production process. There are two main ideas for achieving a better layout for the shop floor, like the following:

- **Transferring the rack to warehouse:** One of the main problems at Coggiola is the layout of the production floor, the production floor at Coggiola is leading to wasted time due to misplaced components and non-optimum usage for space, one of the main problems is the existence of the huge racks containing production molds near each machine, most of these molds aren't

used frequently but at maximum once or twice a year, occupying one of the most important spaces near the operator, those racks need to be transferred to tools warehouse and transferred to the workshop when needed, instead creating a buffering zone near each machine shall help to prepare the next processed part more efficiently, this will help to eliminate the time waste occurs when the manual operations and the ideal working of the machine, in this case, the manual operations are longer in time than the ideal processing time of the part on the machine, non the less the time consumed to assure the part's quality before being stocked on the pallet.

Figure 29 example of racks and shelfs of the molds and CNC shapes

- **The design of the shop floor:** there is no generic design in our case, for example, it not an assembly line to have the U-shaped layout design, but there are some machines allocated so close to each other, this close distance makes it more difficult to handle the finished pallets by the fork lifter, so it was recommended to design a new layout to gain more space to save the excess motion, so we don't have to transfer pallets or parts to clear the path of the fork lifter.

As seen in figure 30, the fork lifter to lift or to handle goods to line 2 it has to pass by line number 1, this transportation process is a disruptive effect for the performance for the same line. Also as seen near line 6, the raw material sheets are placed over the ground, if by any means there where accumulated material, this will lead to blocking the path for the fork lifter.

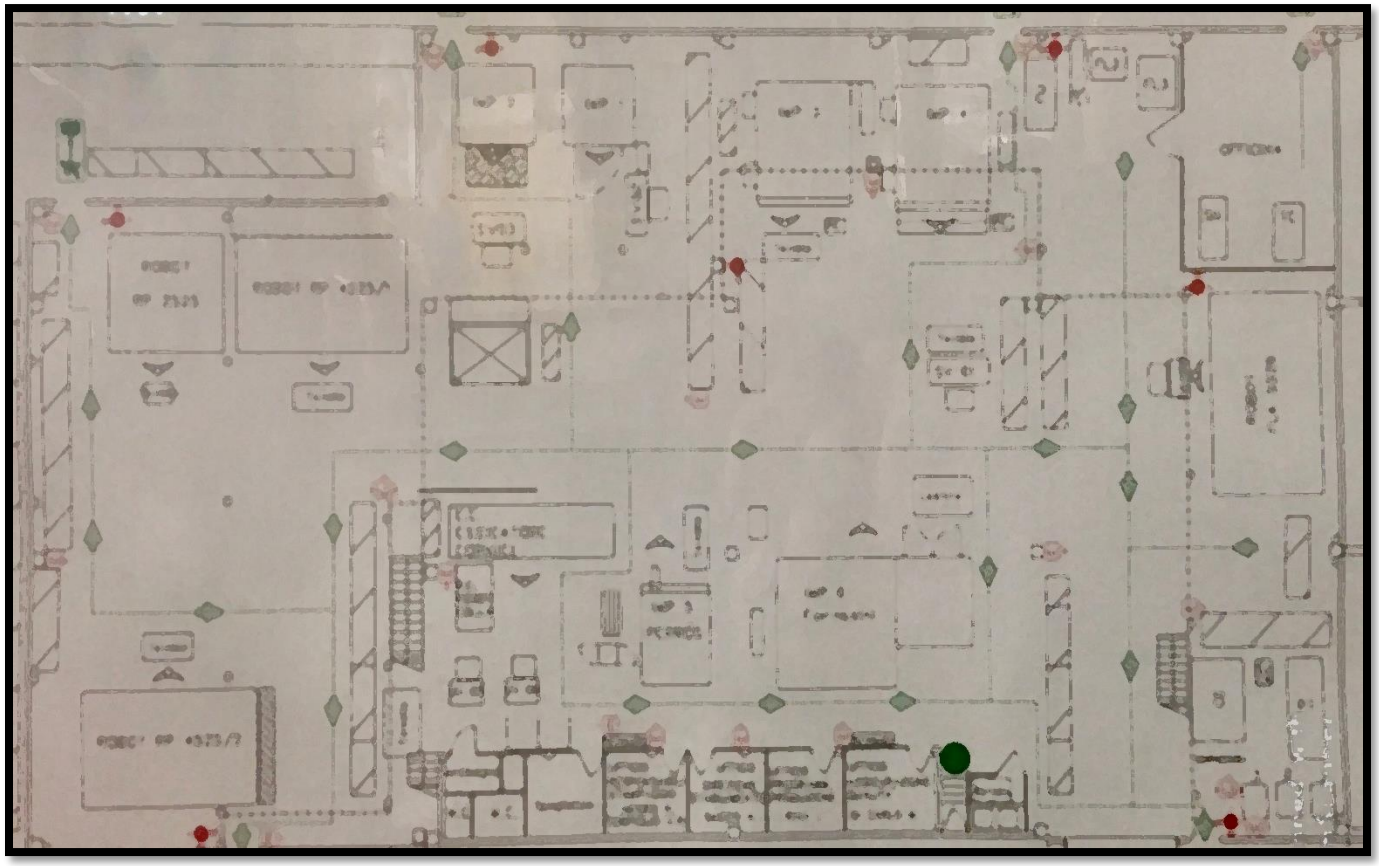

Figure 30 Coggiola layout of shop floor

5.4. Coggiola new software.

Coggiola has found that GEC needs to be upgraded, the upgraded software should be more tailored to fit the whole process, the new software is GEC 2.0, Some additional functions have been added to better manage the process. In the following points, We are going to summarize the new features and updates.

5.4.1. Complete warehouse integration.

1) The new version of GEC is customized to differentiate between the raw materials, semi-finished products, and finished products. This was done by creating new codes for semi-finished products and internal new codes for raw materials.

2) The warehouse was divided into sections, those sections represent different zones in the warehouse, every single zone has racks for raw materials and storage bins for finished products, Codes were generated to represent the racks and storage bins. Those codes were added as master data for the new GEC software.
By doing so, the sorting of the goods was simplified and became more accurate.

3) Two different financial accounts were created for the raw materials inside the warehouse, the first account for the purchased goods and the second for the consignment goods, the matter of the consignment goods will be discussed later.

4) the software has functionality for generating invoices with all the required data, this invoice is generated internally, the invoices are for the goods in arrival with the codes for the new pallets related to the raw material received. The new methodology helps in sorting the raw material in a fixed rack.

5) The new GEC requires to confirm the prices of the acquired material or update them manually, which helps to generate the inventory balance sheet.

5.4.2. Some enhanced functionalities for production monitoring.

1) After the introduction of kits, there was a huge need for the big “piastres”. Large machines can use both. Small machines can only use small piastres. It was necessary to have a relationship between piastre and machine. The GEC had assigned the piasters accordingly, this was done to avoid the time wasted during the dismantling and changing the piastres, so every machine was available

2) Newly created kits had their codes and were defined for GEC as a set of different parts, so GEC understands that the produced kit stands for more than one part.

3) GEC can differentiate the production sequence of the kit, for example, if the received production order doesn’t have the exact amount produced for both parts

on the kit, GEC will assign the extra number of the second part to be stocked as a finished product. But the complete kit is always produced.

4) An order which is received externally is regenerated internally for the exact amount required. But during buying sheets, the extra amount is usually purchased knowing that there will be poorly produced products. Sometimes you have to send more quantity than asked by the customer. In any case, GEC estimates the quantity to be produced depending on the history of the previous orders, as the final estimation is linking the purchased raw materials with produced and quality assured parts.

5) the problem of scanning the codes by the operators was solved by applying a lead time between two successive scanning's in case of the same part on a unique mold, the lead time is less than the ideal production time with a minute or thirty seconds to prevent the worker from scanning several codes at the same time.

6) A new function was added to GEC, OEE daily reports are now a function implemented in the algorithm, which can generate hourly, daily and by each order OEE efficiency report.

5.5. Coggiola's new approach to the working environment

Coggiola Recently was able to find creative solutions to overcome the problems discussed earlier, those problems were mainly with the suppliers and clients.

5.5.1. Creative solution with clients.

Coggiola was used to receive the monthly demand from their clients which will be transformed into production orders for different parts, the cycle was so slow and inconvenient for both sides, as the orders might be not enough in volume to create a purchasing order for the raw material which leads to higher delay time and more uncertainty, but in order to decrease the level of uncertainty, Coggiola has made an

agreement with category A clients to send their demand upon three months estimation, by doing so, the demand level was increased, this helped a lot in the scheduling process and for the company to be prepared for acquiring the amount of the raw material. By doing so, the queue of the production orders was more stable and higher in volumes, this helped the company a lot to stabilize the working environment internally.

5.5.2. Creative solution with suppliers.

The previous estimation orders from the major A-class clients helped the company to set a deal with one of their major suppliers to create an account of what is called a consignment stock, The consignment account is a supplier-owned stock kept and stored in the warehouse of the producer, this stock is to be paid upon consumption of the material, this was a major move made by the company, the raw material used by the company is now available at the warehouse, the lead time of the orders became zero in many cases. But like a double-edged weapon, the higher level of the stock in the warehouse will always lead to a higher cost due to different reasons as discussed before.

Also, 45% of the material of a plastic sheet becomes scrap after the production process, this 45% passes to a new crushing machine introduced recently to the firm and then to be sent to the plastics supplier for the regenerating of the plastic.

Chapter Six

Conclusion

6. The purpose of Chapter Six is:

- Conclusion of the thesis

6.1. Conclusion of the work done.

The results of this study showed that the standardization of the industrial process helps the company securing the stability of the system, the system should be tailored and customized to fit the industry needs perfectly, the tasks should be steady and repeated continuously. The repetition of the tasks improves the quality of executing the work overtime. Developing a standardized work sequence always starts by evaluating the pre-standardized situation using lean tools, for example, The takt time and the 0EE measurements. There are necessary tools for standardized work to be established.

Those documents work as a reference, mainly the following:

- Standardized work chart.
- Standardized work combination table.
- Production capacity sheet.

Finally, the main definition of a standardized process is the best way to perform at the current time and create a basis for future enhancements, this opens the gate to future improvements and continuous innovation by the people performing the process.

Also, the firm should be able to find possible ways to adapt the industrial process to the environment, as seen in the case of Coggiola that the environment wasn't easy and many elements were acting as barriers for the standardization process, those barriers have been eliminated by using innovative solutions.

Finally, the standardization process might be expensive and needs time to be implemented successfully, but the collaboration of the workers and different

departments would help running the process smoothly and effectively and in the long run, the expenses will be regained.

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