# POLITECNICO DI TORINO

*Corso di Laurea Magistrale*

*in Ingegneria della Produzione Industriale e dell'Innovazione Tecnologica*

# Tesi di Laurea Magistrale

## A Standard Work for the Cell Design
## The case of Microtecnica


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# Chapter 1

# 1 The company

## 1.1 Working environment

The project that I will illustrate in the following pages was carried out at Microtecnica, a company that is part of the Collins Aerospace group.

The Microtecnica was founded in 1929 in Turin. After the end of the World War II, in which the military-type production was mainly addressed in the instrumentation as: compasses, gyroscopes and micrometers, due to the bombardment of the Allied aviation, it specialized in the production of instrumentation and equipment dedicated to the film industry. Until 1983 its production was diversified both in the civil field in precision instrumentation and in the military field for electromechanical and oleo dynamic actuation systems. Within the multinational group United Technologies Corporation in 2008 becomes an independent company remaining active in the production of components and parts in the fields: missile, aerospace and aeronautics.


*Figure 1 - Collins Aerospace Group*

Together with Carrier, Pratt & Whitney and Otis, Collins Aerospace (Fig.1) has a portfolio of 25% military customers and 75% commercial customers, and 40% aftermarket and 60% original manufacturing components.

The group has more than 70,000 employees, more than 16,000 engineers and 300 sites worldwide. (Fig.2)

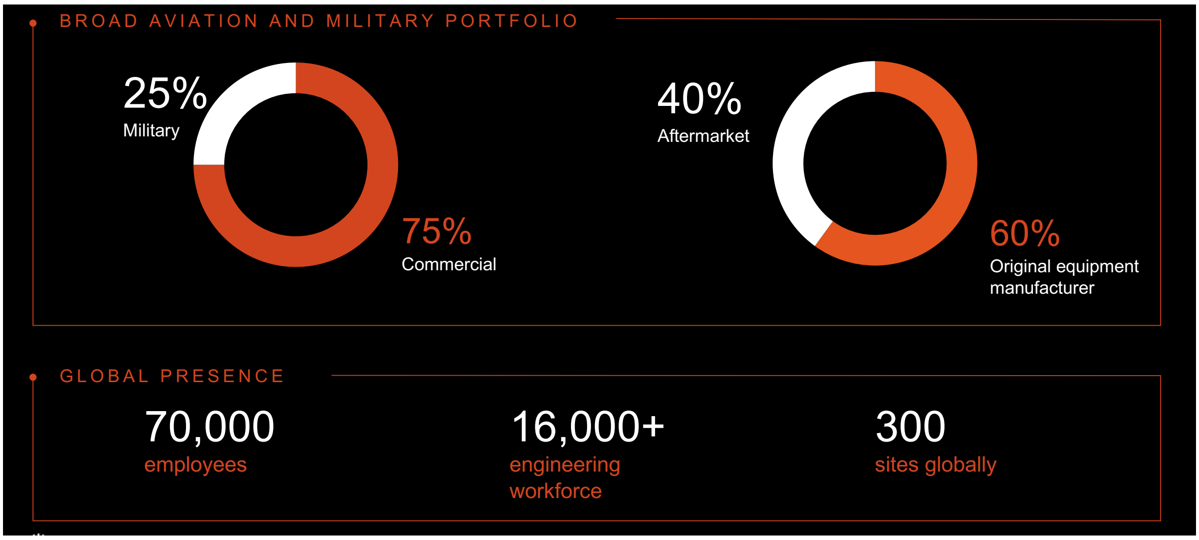



*Figure 2 - Balanced Portfolio, Global Footprint*

Its Strategic Business Units (Fig.3-4) consist of:

1. Aerostructures:
   - Nacelle systems
   - Flight control surfaces
   - Naval composites
   - Other material and structural components
2. Avionics:
   - Avionics systems
   - Cabin management systems
   - Information management systems and services
   - Aircraft sensors
   - Fire protection
3. Interiors:
   - Aircraft seating
   - Interior systems
   - Evacuation systems

- Life rafts
- Lighting
- Veneers
- Potable water systems
- De-icing products


*Figure 3 - Strategic Business Units*

4. Mechanical Systems:
    - Landing systems
    - Actuation
    - Propellers
    - Flight controls
    - Pilot controls
    - Hoist and winch systems
    - Cargo systems
5. Mission System:
    - Communication, navigation and guidance
    - Missile actuation
    - Simulation and training
    - Strategic command and control
    - Unmanned aircraft systems
    - Electronic warfare

- Ejection seats
- Intelligence, surveillance and reconnaissance
- Space solutions

6. Power & Controls:
    - Electric systems
    - Engine controls
    - Air management
    - Airframe controls


*Figure 4 - Strategic Business Units*

The Italian site comprising Turin, Luserna San Giovanni and Brugherio deals with the production and repair of air implementation systems.

In these three sites are mainly produced mechanical actuation pieces, de-icing valves, thermal control systems, primary and secondary flight control systems, hydraulic actuation parts and finally some special treatments are also performed.

Among the main customers we do not find only airlines with fixed or mobile wings, but also companies that deal with space, although part of the market is occupied by inter-company trade. (Fig.5)


*Figure 5 - Main Customers*

Microtecnica has been strongly committed to carry continuous improvement processes in order to ensure world-class quality of its products and processes.

Continuous Improvement approach based on Six Sigma, Kaizen and Lean methodology has been initiated in 2001-2002.

First workshops dedicated to production process/cell layout in accordance with “one-piece flow” and JIT strategy was carried in 2006.

## 1.2 Working team

Within the company I was part of the ACE (Achieving Competitive Excellence) Team, which mainly plays roles related to Lean Management and continuous improvement; more precisely, I was in the Transformation Team, and I worked on projects related to the transformation of the Shop Floor and the implementation of new innovative solutions to improve production processes.

In addition to my ACE colleagues, I had the opportunity to collaborate with many members of other departments of the company, especially during the events related to the creation and development of a new production cell, activity of which I will speak in depth in the next chapters, discussing with analysis and results.

During these events it was necessary to meet above all with Shop Floor managers and experts in the Manufacturing Engineering, a person of the Planning and Management people were also often present to be sure that our work was going in the right direction, compared to the company needs and expectations.

# Chapter 2

# 2 Case study

The traditional production model of "batch production", which aims at the efficiency of the individual production departments, heavily penalizes the overall effectiveness and efficiency of the system. In fact, batch management has a negative impact on the flexibility and time needed to pass through the production systems, significantly reducing the ability to respond to customer needs: in addition, the fragmentation of production activities makes it difficult to manage the materials and information needed for production progress and therefore leads to the generation of significant waste along the entire production flow.

It is therefore clear that the traditional "batch production" appears to be inadequate to the ever more pressing requests for cost reduction and service improvement wanted by the markets in which all companies now compete.

The solution, which manages to combine the overall effectiveness of the system with maximizing the efficiency of the system itself, lies in the companies' ability to implement the "flow production" indicated by the "Lean Production" model. In operational terms, flow production involves the transition from the management of "process villages" (the current production departments) to the management of "product cells", dedicated to specific product families.

## 2.1 Cell Design

Cell manufacturing in a process that involves the use of multiple "cells" in a single assembly line. These cells are composed of one or several different machines that perform certain tasks. The product moves from one cell to another, completing part of the manufacturing process in each station. Often, the cells are organized in a "U" design because this allows the supervisor to move less and have the ability to more easily monitor the entire process. (Fig.6)

*Figure 6 – Cell with U Design*

This type of process comes from the just-in-time method (JIT) and lean manufacturing that encompasses group technology. The goal of cellular manufacturing is to work as quickly as possible, make a wide variety of similar products and make the least waste. One of the biggest advantages of cellular manufacturing is the amount of flexibility it has. Since most machines are automatic, simple changes can be made very quickly. This allows a variety of adjustment for a product, minor variations throughout the design, and in extreme cases, completely transformations in the overall design. These changes, although tedious, can be achieved very quickly and accurately.

A cell is created by consolidating the processes necessary to create a specific output, such as a part or a set of instructions. These cells allow the reduction of strange steps in the process of product creation, facilitate the rapid identification of problems and encourage the communication of employees within the cell to solve problems that arise instantly. Once implemented, it has been said that cell manufacturing reliably creates massive gains in productivity and quality, while reducing the amount of inventory, space and time needed to create a product. It is for this reason that the cell of a piece of flow has been called "the ultimate in slender production."

While there are many advantages for forming cells, there are some obvious benefits. It is quickly evident that starting from the observation of cells is where inefficiencies are found, such as when an employee is too busy or relatively inactive. Solving these inefficiencies can increase production and productivity by up to 100% in many cases. In addition to this, cell formation constantly frees up space in the manufacturing/assembly environment (by having inventory only when absolutely necessary), improves safety in the work environment (due to lower quantities of product/inventory being handled). Improves morale (imparting feelings of achievement and satisfaction in employees), reduces the cost of inventory and reduces inventory obsolescence.

When the formation of a cell is too difficult, a simple principle is applied to improve the efficiency and flow, that is, to perform the processes in a specific location and collect materials up to that point at a speed dictated by an average demand of the customer (This rate is called the takt time).

Despite the advantages for designing a one-piece flow, the formation of a cell must be carefully considered before its implementation. The use of expensive and complex equipment that tends to break can cause massive delays in production and ruin production until they can be returned online

The short travel distances within the cells serve to accelerate the flows. In addition, the compaction of a cell minimizes the space that could allow accumulations of inventory between cell stations. To formalize that advantage, cells have often designed in rules or physical devices that limit the amount of inventory between stations. Such a rule is known, in JIT/lean parlance, as Kanban (from Japanese), which establishes a maximum number of units allowed between a workstation that provides and one that uses.

The simplest form, Kanban squares, are the marked areas on the floors or tables between the workstations. The rule, applied to the producing station: "If all the squares are full: stop, but fill them".

An office cell applies the same ideas: groups of highly trained cell team members that, in concert, quickly handle all processing for a family of services or clients.

## 2.2 Implementation Process

In order to implement cell manufacturing, a series of steps must be carried out. First, the parts that will be made should be grouped by similarity (in design or manufacturing requirements) in the families. Then a systematic analysis of each family should be carried out; typically, in the form of production flow analysis (PFA) for manufacturing families, or in the design examination/product data for design families. This analysis can be time consuming and very expensive, but it is really important.

There are also a series of mathematical models and algorithms to assist in the planning of a cellular manufacturing center, which take into account a large number of important variables, such as "multiple plant locations, multiple market assignments with planning the production and mixing of different parts ". Once these variables are determined with a certain level of uncertainty, optimizations can be made to minimize factors such as" total cost of maintenance, material handling between cells, external transportation, cost fixed to produce each part in each plant, machine and labor wages ".

## 2.3 Continuous Improvement

The key to creating flow is the continuous improvement of production processes. After the implementation of cellular manufacturing, management commonly "finds strong resistance from production workers." It will be beneficial to allow the change to cellular manufacturing to happen gradually.

It is also difficult to fight against the desire to have some inventory at hand. It's tempting, since it would be easier to recover suddenly from an employee by taking sick leave. Unfortunately, in cellular manufacturing, it is important to remember the main objectives: "They sink or swim together as a unit" and that the "Inventory hides problems and inefficiencies". If the problems are not identified and subsequently not resolved, the process will not improve.

Another common set of problems derives from the need to transfer materials between operations. These problems include "exceptional elements, distances between machines, and parts that generate delays/bottlenecks, location of the machine and relocation, routing of pieces, load variation in cells, transfer of inter and intracellular material, cellular reconfiguration, dynamic demands of parts and times of operation and termination". These difficulties must be considered and addressed to create efficient flow in cellular manufacturing.

## 2.4 Benefits and costs

Cellular manufacturing brings together dispersed processes to form short paths and focused on the concentrated physical space. Logically, a cell reduces flow time, flow distance, floor space, inventory, handling, planning transactions, scrap and repeat work (the latter due to rapid discovery of nonconformities). In addition, the cells lead to a simplified and more valid cost calculation, since the costs of producing articles are contained within the cell, instead of being dispersed in the distance and the passage of the reporting time.

Cellular manufacturing facilitates both production and quality control. Cells that have low volume or quality performance can be easily isolated and targeted for improvement. The segmentation of the production process allows problems to be located easily and, in this way, it is clearer which parts are affected or problematic.

There are also a number of benefits for employees who work in cellular manufacturing. The small cell structure improves group cohesion and reduces the manufacturing process to a more manageable level for workers. Workers can more easily see problems or possible improvements within their own cells and thus tend to become more self-motivated to propose. These improvements that are caused by the workers themselves cause less and less need for supervision, so over time the overhead can be reduced. In addition, workers are often able to rotate between tasks within his cell, which offers variety in his work. This can further increase efficiency because the monotony of work has been linked to absenteeism and reduced production quality.

There are several possible limitations to implement cellular manufacturing. Some argue that cellular manufacturing can lead to a decrease in production flexibility. Cells are typically designed to maintain a specific volume of flow of the parts that are produced. If the demand or quantity needed decreases, it is possible that the cells have to be realigned to adapt to the new requirements, which is an expensive operation and not normally required in other manufacturing configurations.

## 2.5 Basic components of a production cell

In general, it is necessary to understand the four basic components of production cells:

1) People,
2) Equipment,
3) Operating rules,
4) Material,

before it can successfully implement the production cells and transform raw materials into a product that can be sold effectively and efficiently. Of these four components, the primary variable that is most difficult to control is people or the human element. For example, it was found that for a successful implementation of the cells, the people who ultimately manage, support and maintain the production cells should actively participate in their design and development. In the integration of these four components, it is essential to focus both on technical problems (cell formation and design) and on human ones since each can greatly influence the design, implementation and operation of the cells. Important human aspects include employee assignment strategies, skills identification, training (workforce multi-functionality), communication, reward/compensation system, definition of workers' roles, teamwork and conflict management.

## 2.6 Cell production

Over the past 30 years, numerous techniques and methods have been developed to solve the problem of cell formation (Heragu, 1994, Joines et al., 1995, Singh, 1993). The archival literature has focused on determining the best groupings for products, parts or groups of machines. Some attention was paid to the selection of instruments, masks and equipment, to the determination of the process flow, to the determination of the cell capacity and to the selection of the equipment. An obvious weakness of many cellular training techniques is the focus on a single technical goal by identifying similar parts and their corresponding machines (Warner, Needy, and Bidanda, 1997). An extension of this problem concerns the grouping of similar parts and the corresponding machines and therefore the assignment of the work to the cells based on their work capacity and/or their technical capabilities.

In making the change in advanced production technologies such as cellular production in the workshop, it was found (Chung, 1996), that the following components are fundamental:

1) Have clear project objectives.
2) The use of a philosophy centered on man in which people are supported by technology and not vice versa.
3) Significant participation of workers at the beginning of the technology implementation lifecycle.
4) The use of pilot projects.
5) Implementation of effective training programs.
6) Presence of a sample of implementation of the technology at the highest level.
7) A concerted effort to overcome resistance to new technology.
8) Adaptation of the performance evaluation and reward system to adapt to the new technology.
9) Changes in organizational design to adapt to new technology.
10) Empowerment at the lowest levels in the organizational hierarchy.

# Chapter 3

# 3 Methodology applied

Before even starting with all the analysis the first action taken by my working group was to perform a GEMBA walk.

This was done to better understand the current situation of that part of the shop floor that was designed to become the future "Spring Cell".

At the time we did the GEMBA walk there was already a cell, but the production was not set for all the springs produced in the company and all the production processes were not optimized. For this reason we decided to film and take notes of the entire processes that were going on in the cell, just to be able at the end to create two value stream maps, one about the current state and another concerning the future state with all the improvements and optimizations.

The doubts that emerged after the first look at the cell were about the numbers of operators in the cell and the position of the machines in that space, also the tools on the benches were not well placed.

After this activity we went back to the office to discuss what we saw and write all down before starting to create the VSMs.

## 3.1 Value Stream Mapping

### 3.1.1 Current State

Once the ideas were clear, we started writing all the post-it, each one represented a single process, both of the material flow and the information flow.

We then added all the details to each process thanks to the observations made during the GEMBA walk.

This part of the work was not so easy to complete because every day by going back to the shop floor we discovered lots of activities that were not scheduled in the production cycles but were performed the same by the operators. Then other issues regarding the lot size and the raw material cut size started to emerge so we were slowed down a bit, but at the end we were able to build a complete value stream mapping of the current situation in the shop floor.

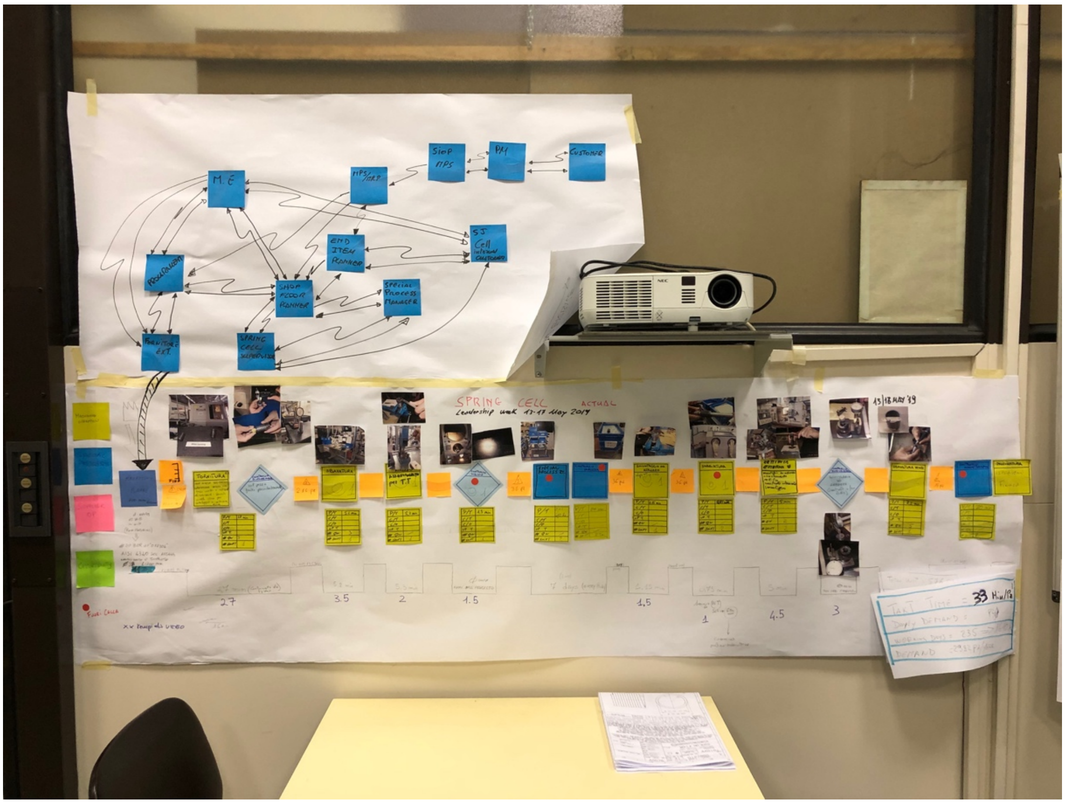


*Figure 7 - Value Stream Mapping Current State*

The yellow post-it represented the material flow, while the blue ones the information flow.

Each post-it had the description of the activity and for the yellow ones there was also a detailed table with all the information related to the various production times.

We also decided to add some pictures to make more visible and clearer each step of the production and to avoid confusion between some phases that were very similar.

Then we made some calculations to understand if in the reality the time assigned in the past for each activity was consistent with the actual situation of the cell of if it was obsolete.

We found out that the takt time calculated was similar to the one used in the cell but the time of some of the activities was completely different from what we expected, so we started to think about the possible improvements to apply both in the short and in the long period.

The first idea was about the tooling used to produce the spring, just by changing some tools or buying new ones and positioning them in a more effective way it was possible to improve a lot the efficiency of the cell.

The second idea was related to the layout of the cell and mostly the possibility to bring inside the cell a machine that was at that time located in an adjacent building, that increased a lot the walking time of the operator.

Finally, because the production process was already efficient and optimized in the years the last improvement concerned the lot size and the link with the special processes area (outside the cell) that was involved in the production flow of the springs.

### 3.1.2 Future State

After a long discussion about what was possible in the short period and what in the long period, we were able to create a Value Stream Mapping of the future state.

We simplified a lot the flow and we tried to reduce a bit the production time to obtain a better performance and to be more efficient and thanks to that the flow through special processes was also faster and more transparent.

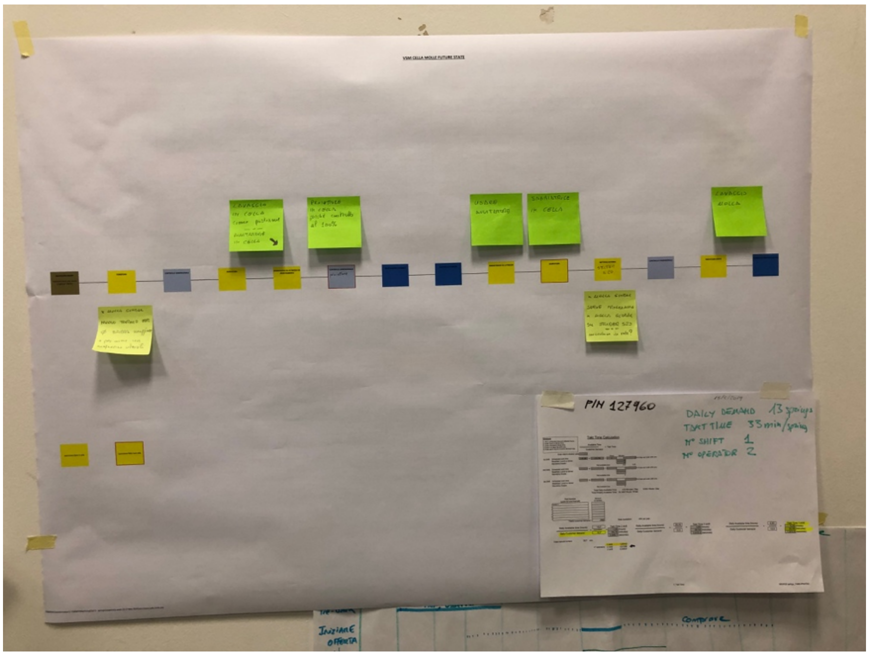


*Figure 8 - Value Stream Mapping Future State*

The major problem was related to the fact that normally the production was a lot per day to send to special processes, but we saw that this timing was not respected so the cell was often out of time.

For this reason, we decided to create a template that should have shifted the planning from daily to weekly, just to obtain a more robust plan to respect.

| *Week 20* | Pezzi non conformi | *Realizzati con ripianificazione* | Realizzati con piano | Pianificati | Aderenza al piano |
|---|---|---|---|---|---|
| Lunedì | 1 | 1 | 1 | 1 | **100%** |
| Martedì | 0 | 0 | 12 | 15 | **80%** |
| Mercoledì | 0 | 2 | 3 | 8 | **38%** |
| Giovedì | 1 | 0 | 13 | 15 | **87%** |
| Venerdì | 0 | 1 | 10 | 15 | **67%** |
| Sabato | 0 | 0 | 0 | 0 | **#DIV/0!** |
| **Settimana** | 2 | 0 | 43 | 54 | **80%** |

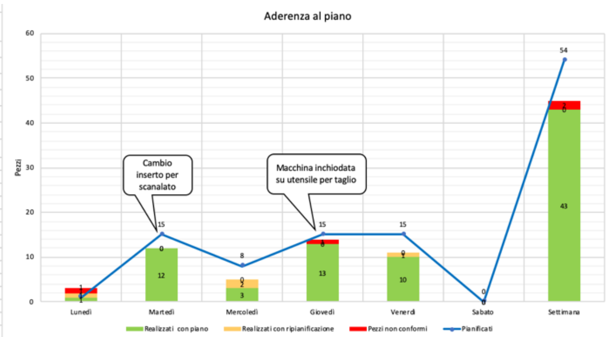



*Figure 9 - Adherence to the plan Weekly*

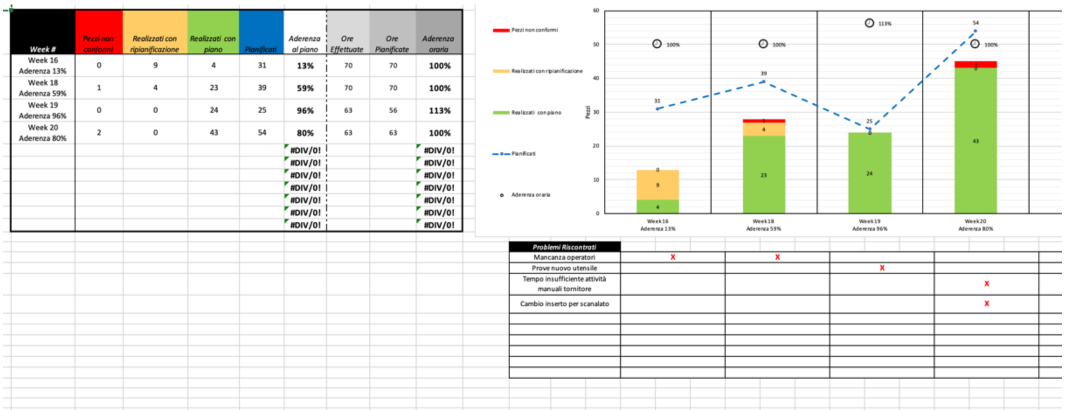



*Figure 10 - Adherence to the plan Total Weeks*

Because of this template we were able not only to have a weekly plan, but also to observe and calculate the adherence to the plan in the long period.

This was also helpful to collect all the possible problems observed during the production, so to be able to find a solution to each of them in the shortest time possible.

## 3.2 Define

### 3.2.1 PQ Analysis

The first analysis made was the "Product-Quantity Analysis" that consists of a list of the Part Numbers produced in the cell with their quantities, and the cumulative of their volume as in the picture below.

**Directions**
1. Enter Part Names, Part Numbers, and 3 months demand.
2. Click on the "sort data" button to the right (it will sort the demand from high to low)
3. Values in red will calculate automatically.

**Product Quantity Analysis Calculations**

| Analysis Period: | January 2020 - December 2020 | Analysis By: Vincenzo Modugno (Dati forniti da Matteis in data 10/05/2019) | Date: 13 May 2019 |
|---|---|---|---|

| | Part Number | Part Name | Demand Quantity | Running Total | % Total Quantity | Cumulative % Total Quantity | % Total Part Numbers |
|---|---|---|---|---|---|---|---|
| 1 | 127960 | NO-BACK SRING | 2982 | 2982 | 76,2% | 76,2% | 20% |
| 2 | 162067-1 | NO-BACK SRING global | 840 | 3822 | 21,5% | 97,7% | 40% |
| 3 | 145668-1 | NO-BACK SRING | 83 | 3905 | 2,1% | 99,8% | 60% |
| 4 | 123186 | NO-BACK SRING | 6 | 3911 | 0,2% | 100,0% | 80% |
| 5 | 147289-1 | NO-BACK SRING | 1 | 3912 | 0,0% | 100,0% | 100% |
| | | Total Quanitiy = | 3912 | | | Number of P/N's = | 5 |

*For diagram, see next tab - PQ Chart*

*Figure 11 - PQ Calculation*

From this analysis it was possible to obtain a Pareto Graphic to better understand which product is the most impacting in the production.

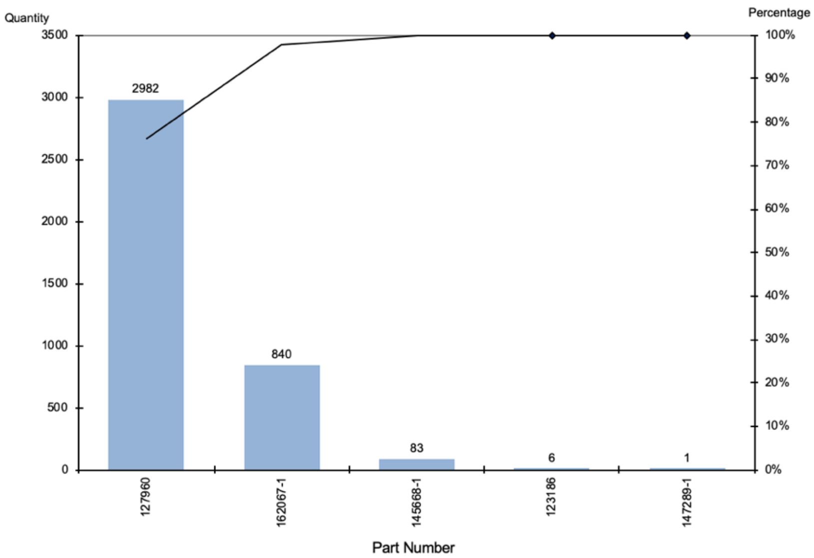



*Figure 12 - PQ Chart*

Before doing this anyway we asked a colleague to have the demand of all the spring to produce in the years 2019, 2020, 2021.

Thanks to a Pivot Table we were able to regroup in the most convenient way all the data obtained as follow.

**DOMANDA**

| Plus/Minus | '- | | | | |
|---|---|---|---|---|---|
| **Somma di Rec./reqd.qty** | | **Anni** | | | |
| **Material** | **Req Date** | **2019** | **2020** | **2021** | **Totale complessivo** |
| **123186** | | 5 | 6 | 35 | 46 |
| **145668-1** | | 34 | 83 | 67 | 184 |
| **147289-1** | | 9 | 1 | | 10 |
| **127960** | | 2272 | 2982 | 2175 | 7429 |
| **Totale complessivo** | | **2320** | **3072** | **2277** | **7669** |

*Figure 13 - Spring Demand 2019, 2020, 2021*

## 3.2.2 Process matrix

The second analysis made is called "Process Matrix", this helped us to clearly understand the production cycle of each PN made in the cell, we asked the Manufacturing Engineering all the production cycles of the part number of the spring cell and after that we created a table where it was possible to see which part numbers have a similar cycle so to be able to regroup all of them in families.

It also helped to have a better vision of all the single processes of each spring produced, in addition we used different colors to indicate activities done inside the cell and activities done outside just to understand if some of those activities could have been moved inside or outside to improve the production flow.

Each activity has its own duration within the box.

| # Parte | Nome parte | Programma | Domanda 2020 | % sulla domanda del 2020 | § | TWIN 65 | Banchi | ACIER | Piegatrice | Laboratorio NDT | ACIER | Controllo | Banchi | Banchi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Macchina / Processo | | | | | Tornitura fresatura completa (oppure) | Tornitura filettatura fresatura 2 denti | Spazzolatura | Taglio spira | Piegatura dentino | Controllo piegatura | Taglio dentino | Controllo dimensionale | Sbavatura | Scritturazione |
| 127960 | NO-BACK SPRING | EFA/EMBRAER | 2982 | 76,23% | 1a<br>27 | | | | | | | 1b | 2<br>5,1 | |
| 162067-1 | NO-BACK SPRING | GLOBAL | 840 | 21,47% | 1a<br>64 | | | | | | | 1b | 2<br>9,1 | 3<br>1,9 |
| 145668-1 | NO-BACK SPRING | DASH-8 | 83 | 2,12% | 1<br>42 | | 2<br>1,4 | 3<br>4,1 | 4<br>2,6 | 5<br>2,6 | 6<br>4,1 | | 7<br>4,9 | |
| 123186 | NO-BACK SPRING | G27J | 6 | 0,15% | | | | | | | | | | |
| 147289-1 | NO-BACK SPRING | EH101 | 1 | 0,03% | | | | | | | | | | |

*Figure 14 - Process Matrix (Part I)*

| # Parte | Nome parte | Banchi<br>Lavaggio | Banchi<br>Montaggio su attrezzo e assestamento | Proiettore di profilo<br>Controllo visivo | Trattamenti termici<br>Bonifica | Laboratorio NDT<br>Controllo durezza | Banchi<br>Smontaggio da attrezzo | Sabbiatrice<br>Sabbiatura | STUDER S20<br>Rettifica diamentro esterno | Controllo<br>Controllo dimensionale | Banchi<br>Sbavatura finale e creazione dei raggi sui dentini | Banchi<br>Lavaggio | Laboratorio NDT<br>Controllo magnetoscopico |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 127960 | NO-BACK SPRING | | 3<br>5,1 | 4<br>2 | 5<br>1,3 | 6<br>2,9 | 7<br>1,1 | 8<br>0,9 | 9<br>4,9 | 10 | 11<br>7,2 | | 12<br>4,1 |
| 162067-1 | NO-BACK SPRING | 4<br>0,8 | 5<br>3,1 | 6<br>2,0 | 7<br>2,1 | 8<br>2,9 | 9<br>1,1 | 10<br>0,9 | 11<br>13 | 12 | 13<br>7,2 | 14<br>0,8 | 15<br>3,2 |
| 145668-1 | NO-BACK SPRING | | 8<br>4,9 | | 9<br>2,4 | 10<br>1,8 | 11<br>2 | 12<br>5 | 13<br>7,1 | | 14<br>11 | | 15<br>3 |
| 123186 | NO-BACK SPRING | | | | | | | | | | | | |
| 147289-1 | NO-BACK SPRING | | | | | | | | | | | | |

*Figure 15 - Process Matrix (Part II)*

### 3.2.3 Part Family Definition

To complete the define part of the Manufacturing Standard Work Cell Design (MSWCD), we figured out from the Process Matrix what could have been the different product families to define.

The results are shown in the picture below.

| P/N | Nome | Programma | Famiglia |
|---|---|---|---|
| 127960 | NO-BACK SPRING | EFA/EMBRAER | A |
| 162067-1 | NO-BACK SPRING | GLOBAL | B |
| 145668-1 | NO-BACK SPRING | DASH-8 | C |
| 123186 | NO-BACK SPRING | G27J | C |
| 147289-1 | NO-BACK SPRING | EH101 | C |

*Figure 16 - Part Family Definition*

Each color represents a different family, as it is possible to see we identified three different families due to the similar production cycles and timing.

## 3.3 Measure

### 3.3.1 Spaghetti

After the “Define” part we started doing the “Measure” part, and we began with the Spaghetti Chart.

We analyzed the actual state of the shop floor and in particular the Spring Cell and the Heat Treatment and then we designed a first spaghetti chart to have an overall vision of the current situation.

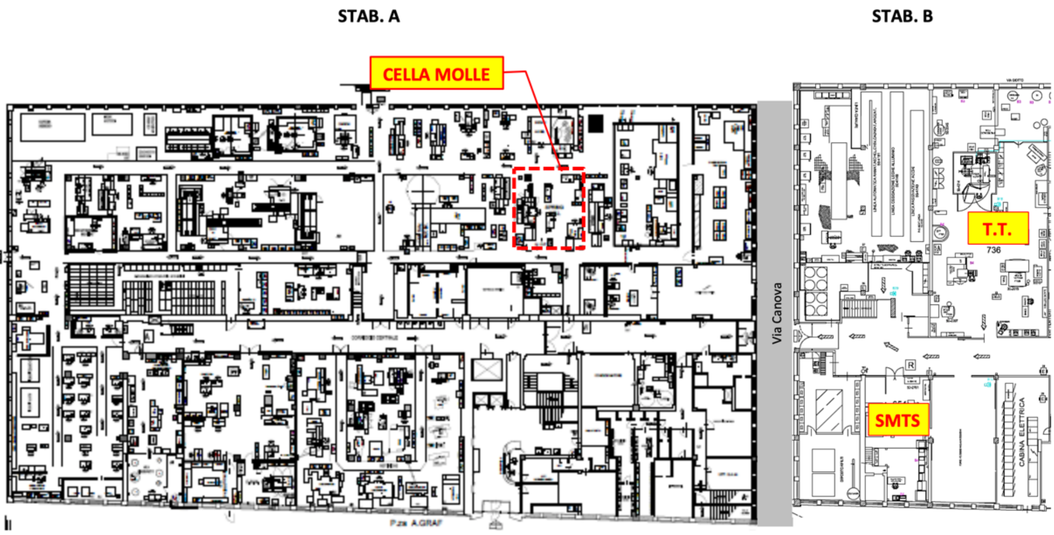



*Figure 17 - Spaghetti Chart Actual State*

Then we started to trace with two different colors the walking route of the two operators of the cell, calculating at the same time durations and distances for each single route.

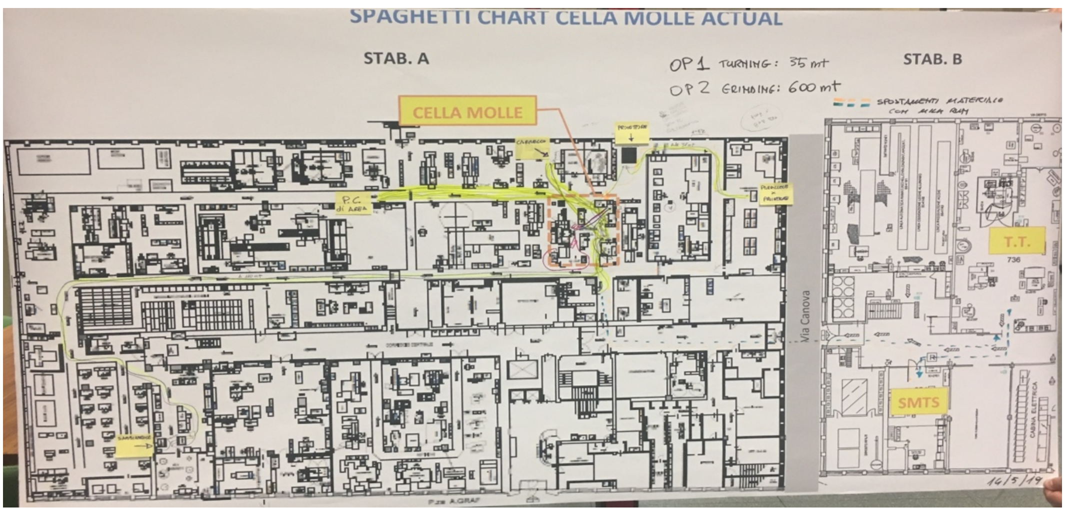


*Figure 18 - Spaghetti Chart with walking routes*

The picture above represents the results of this analysis.

It is possible to see how there is a very long route, about 600m, to be done once a day for each lot that impacts negatively on the takt time of the cell, for this reason we started to think about internalize that process in the cell, in detail we were looking for a new shot peening machine to place in the cell, not too big or expensive and mostly it should have been closed to avoid FOD (Foreign Object Damage) and it should not have been too noisy.

The rest of the work to shorten the distances and the walking time was done during the creation of the new layout as we will see later.

### 3.3.2 Process at a glance

The process at a glance as its name says, consists in a detailed description of each activity done during the production.

For every process we have two columns, one for the process in general, one for the same process related to a specific Part Number.

There are also seven rows:

1. Machine: it is a photo of the machine or the bench where the activity is done;
2. Work method: it is the detailed description of the sub activities to do to complete each process;
3. Material/Documents: it is the necessary material or document to possess to correctly complete the activity;
4. Tooling: it includes all the tools to use for each specific activity;
5. Fixture: it is similar to the tooling, but it is about fixed tools;
6. Measuring instruments: as it says, they are the measuring instruments to use during the process between some of the sub activities;
7. Other: everything else that cannot be placed in one of the previous six boxes.

Process At a Glance

Part Number: 127960

| Sequence | | | | |
|---|---|---|---|---|
| Operation | Tornitura filettatura fresatura 2 denti | | Controllo dimensionale | |
| | Common | Specific for P/N | Common | Specific for P/N |
| 1. Machine | TWIN 65 Tornio Fresa<br> | |  | |
| 2. Work Method | Carico barra<br>Tornitura<br>Sposto pezzo da mandrino a attrezzo contromandrino<br>Completamento tornitura<br>Rimozione pezzo da macchina | | Misura diametrale esterno e interno<br>Spessore della spira<br>Spessore dei dentini<br>Spessore totale | |
| 3. Material/ Documents | Ciclo di lavoro<br>Work order<br>Grezzo | | Molla<br>Ciclo di lavoro | |
| 4. Tooling | Attrezzo specifico per contromandrino | | | |
| 5. Fixture | | | | |
| 6. Measuring instruments | | | Micrometri centesimali, a piattelli, tamponi lisci e calibri dedicati | |
| 7. Other | Postazione per pezzi finiti<br>PC | | Banco operatore<br>PC<br>Shadow box | |

*Figure 19 - Process at a Glance*

### 3.3.3 Time Observation

One of the most difficult measuring analyses to perform was the time observation.

This was because in the cell there was not yet the one batch flow approach so each operator could do different activities on different batches, so to calculate the effective timing of the process for a single batch we had to go and come back several times, this took us lot of time and effort.

But at the end we were able to make more than one time observation, just to be more objective and avoid casualties that could have been distort the data collected.

| Time Observation Form | | | | | | Observed Part Name: NO-BACK SPRING | Observation Date: 15/05/2019 | Observation number: |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Observed Part #: 127960 | Observation Time: Minuti | Observer Name: Antonino Urso |
| **Component Number** | **Component Task** | **Observation # 1** | **Observation # 2** | **Observation # 3** | **Component Task Time** | **Notes: (List operator name/# and M-A-W-S times)** Tornitura fresatura dentatua | | |
| 1 | Carico barra | 0,2 | | | M | | | |
| | | 0,2 | | | | | | |
| 2 | Fase 1 Tornitura | 6,0 | | | A | | | |
| | | 6,2 | | | | | | |
| 3 | Controllo in macchina | 1,0 | | | M | | | |
| | | 7,2 | | | | | | |
| 4 | Montaggio su attrezzo contromandrino | 0,5 | | | M | | | |
| | | 7,7 | | | | | | |
| 5 | Fase 2 Alesatura, Fresatura | 21,0 | | | A | | | |
| | | 28,7 | | | | | | |
| 6 | Scarico pezzo | 1,0 | | | M | | | |
| | | 29,7 | | | | | | |
| 8 | Controllo dimensionale | 2,0 | | | M | | | |
| | | 31,7 | | | | | | |
| 9 | Sbavatura | 3,5 | 5,2 | | M | | | |
| | | 35,2 | | | | | | |
| 10 | Montaggio su attrezzo per TT e assestamento | 2,0 | | | M | | | |
| | | 37,2 | | | | | | |
| 11 | Controllo visivo | 1,5 | | | M | | | |
| | | 38,7 | | | | | | |
| 12 | Smontaggio da attrezzo da TT | 1,5 | | | M | | | |
| | | 40,2 | | | | | | |
| 13 | Sabbiatura | 1,0 | | | M | | | |
| | | 41,2 | | | | | | |
| 14 | Montaggio su attrezzo di rettifica e assestamento | 0,5 | 0,6 | | M | | | |
| | | 41,7 | | | | | | |
| 15 | Rettifica diametro esterno | 3,3 | 3,5 | | A | | | |
| | | 45,0 | | | | | | |
| 16 | Controllo in macchina | 0,2 | 0,3 | | M | | | |
| | | 45,2 | | | | | | |
| 17 | Smontaggio da atrezzo rettifica | 0,5 | 0,7 | | M | | | |
| | | 45,7 | | | | | | |
| 18 | Controllo dimensionale | 3,0 | 3,0 | | M | | | |
| | | 48,7 | | | | | | |
| 19 | Sbavatura dentini | 5,0 | | | M | | | |
| | | 53,7 | | | | | | |

*Figure 20 - Time Observation Form*

The picture above represents the Time Observation Form.

Each row is a single activity defined by:

- Component Number: it is a sequence of numbers starting from 1
- Component Task: name of the activity
- Observation #: it has in itself two different rows, the first one is the duration of the activity while the second one is the cumulative of the entire process; the last row is the total time spent to create a spring
- Component Task Time: it indicates if the activity is automatic or manual, so if it is done by a machine or an operator.

# 3.4 Analyze

## 3.4.1 Takt time

At this point we started the longest and most practical part of the MSWCD.

The takt time is the pace of production. It is about the time to produce a single component or the whole product, also known as the pace of sales. Indeed, if the productive stations are synchronized between them, the production stream will be continuous and balanced.

In order to calculate the takt time, it is therefore necessary to define the time horizon for which such a takt time is to be calculated, the volume of sale provided for in the previously established period and the working time available, before the planned breaks.

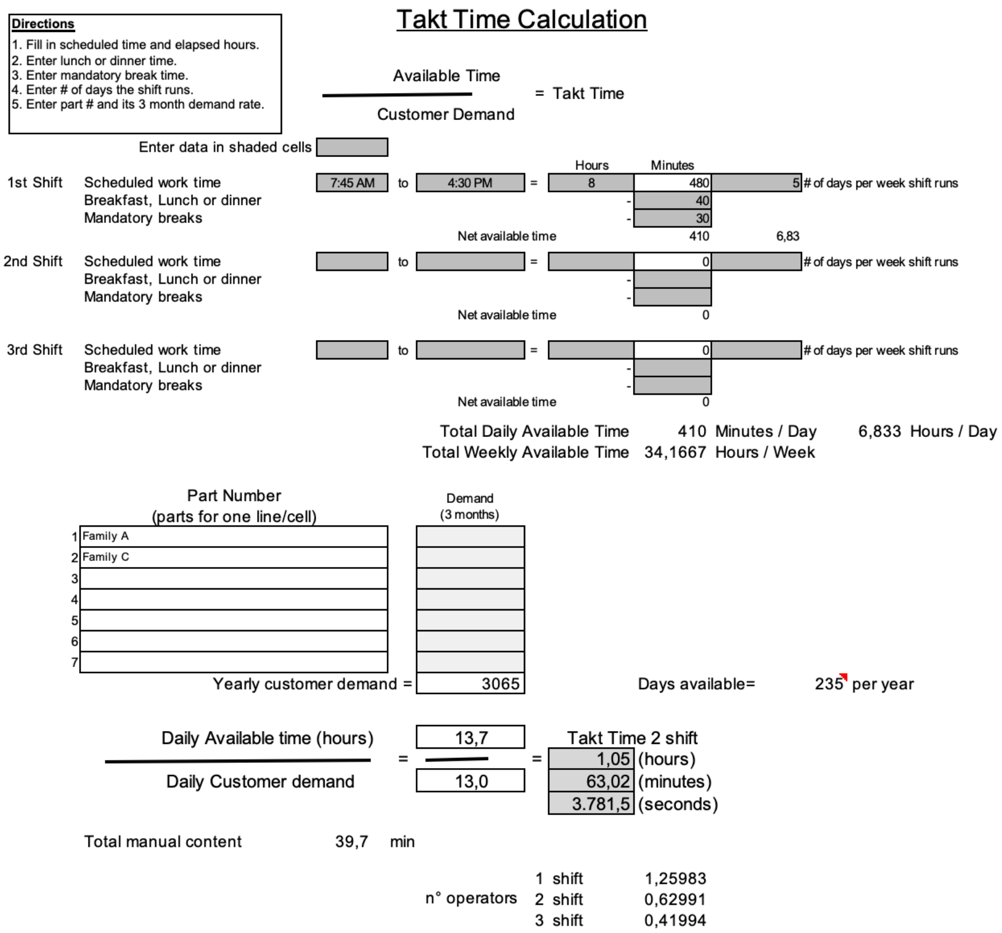



*Figure 21 - Takt Time Calculation*

As it is possible to see we put in the table all the data concerning the shift time and the available working days in the year, then thanks to Excel we obtained the number of operators necessary based on how many shift we wanted to work in the cell.

In our case we decided to work just a shift per day with two operators, so our takt time was 31,51 minutes.

### 3.4.2 Operations bar Chart

What we did later was to create a table where to insert all the time related to each activity of the production process of a spring, this was useful to see if there were activities that did not respect the takt time, their duration was greater than the takt.

In the pictures below we can see both the table with the data and the proper Operations bar Chart.

**Directions**
1. Using the time observation form, plot the manual, automatic, walking and set-up time for each operation below.
2. After table is complete, the graph will be generated on the following tab.

| Operation | Manual internal | Automatic (machine time) | Manual external | Takt time (1 shift) | Takt time (2 shift) | Takt time (3 shift) |
|---|---|---|---|---|---|---|
| Tornitura filettatura fresatura 2 denti & Controllo dimensionale | 16,0 | 27,4 | 1,7 | 31,51 | 63,02 | 94,54 |
| Sbavatura | | | 3,5 | 31,51 | 63,02 | 94,54 |
| Montaggio su attrezzo e assestamento | | | 2,0 | 31,51 | 63,02 | 94,54 |
| Controllo visivo | | | 1,5 | 31,51 | 63,02 | 94,54 |
| Smontaggio da attrezzo | | | 1,5 | 31,51 | 63,02 | 94,54 |
| Sabbiatura | | | 1,0 | 31,51 | 63,02 | 94,54 |
| Rettifica diamentro esterno & controllo in macchina | | 4,1 | 0,5 | 31,51 | 63,02 | 94,54 |
| Controllo dimensionale | | | 3,0 | 31,51 | 63,02 | 94,54 |
| Sbavatura finale e creazione dei raggi sui dentini | | | 5,0 | 31,51 | 63,02 | 94,54 |

*For diagram, see next tab - Operations Bar Chart*

Figure 22 - Operations Bar Chart Data

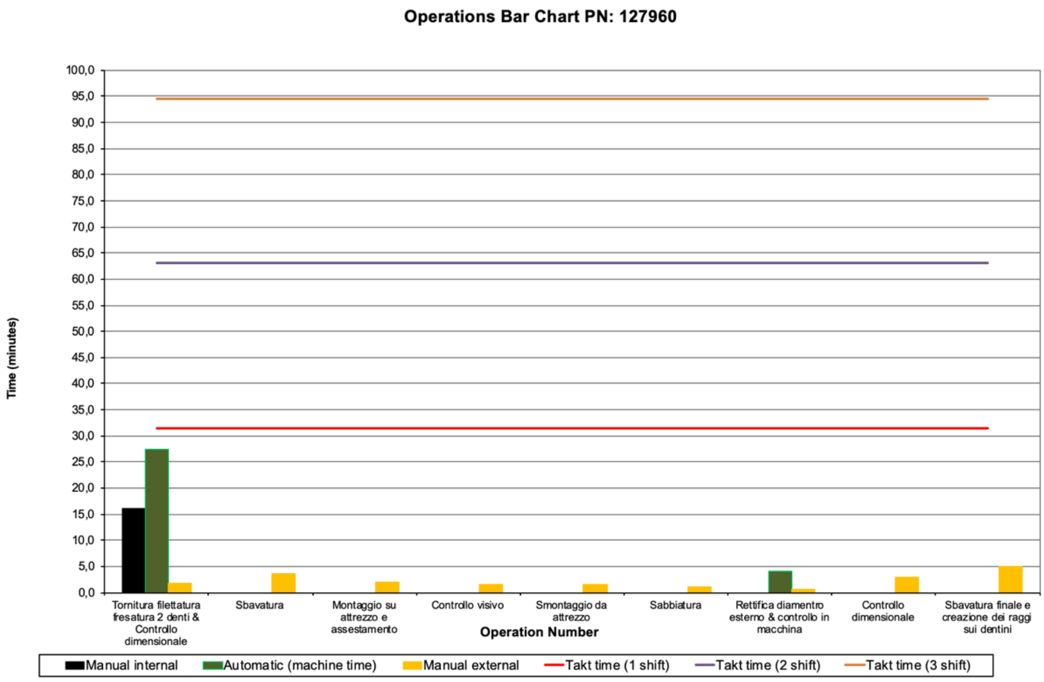



*Figure 23 - Operations Bar Chart*

It is clear from this chart that all the operations have a time lower than the takt time, it means that also by taking in consideration a margin the first idea to have two operators in one shift was feasible and in this case we did not have to change the two operators that were already in the cell at the moment of the analysis.

### 3.4.3 Capacity Analysis

Another important analysis to perform was the "Capacity Analysis".

This was useful to understand if the machines that were in the cell were able to produce the volumes needed in the year respecting the available working time.

We had two major machines in the cell, a turning machine (TWIN 65) and a grinding machine (STUDER S20).

| | | | PRODUCTION CAPACITY TWIN 65 | | | | | |
|---|---|---|---|---|---|---|---|---|
| | PN | Descrizione | Materiale | TEMPO MACCHINA in minuti | VOLUMI 2020 | | | |
| A | 127960 | NO-BACK SPRING | 077306 AISI 4340 SEC AMS 6414 | 27 | 2982 | 80514 | | |
| | | | Sum | 27 | 2982 | 80514 | 1341,9 | ore |
| | | | AWCT= | 27 | | | | |
| | | AVAILABLE WORKING TIME | 235 | 6,85 | 1610 | | | |
| | | | Uptime 98% | 1342 | 0,98 | 1369 | | |
| | | | Planned load | 1610 | 0,95 | 1.529 | | |
| | | | **MACHINES REQUIRED** | **1369** | **1.529** | **0,90** | | |

*Figure 24 - Production Capacity TWIN 65*

For each machine we analyzed the production time and the volumes, then we applied a margin of error also because we could not assume the efficiency of the cell at 100% and the result in the case of the TWIN 65 was 0,9 so one turning machine was enough to produce all the spring necessary in the year.

| | | | PRODUCTION CAPACITY STUDER S20 | | | | | |
|---|---|---|---|---|---|---|---|---|
| | PN | Descrizione | Materiale | TEMPO MACCHINA in minuti | VOLUMI 2020 | | | |
| A | 127960 | NO-BACK SPRING | 077306 AISI 4340 SEC AMS 6414 | 3,5 | 2982 | 10437 | | |
| | | | Sum | 4 | 2982 | 10437 | 173,95 | ore |
| | | | AWCT= | 4 | | | | |
| | | AVAILABLE WORKING TIME | 235 | 6,85 | 1610 | | | |
| | | | Uptime 98% | 174 | 0,98 | 178 | | |
| | | | Planned load | 1610 | 0,95 | 1.529 | | |
| | | | **MACHINES REQUIRED** | **178** | **1.529** | **0,12** | | |

*Figure 25 - Production Capacity STUDER S20*

About the STUDER S20 we can see that the percentage it is only 0,12 over 1 so 12% of saturation for the machine, but we also know that this grinding machine was also used to produced other products in the shop floor so after a discussion we found a way to saturate it at the 85% almost like the TWIN 65.

### 3.4.4 Operator % Loading Chart

To finish the Analyze part we checked how much the single operators were charged, and in order to do this we considered both the manual time of every activity done by each operator and the walking time to reach each machine or bench; as I said before one of the operator had to go 600 meters away to use the shot peening machine so this time was very important to consider.

The results are shown in the chart below.

**Directions**
1. Sum the manual, walk and wait time for each operator as identified in the Capacity Analysis.
2. Enter manual, walk and wait time for each Operator below.
3. Enter the takt time in cell B14. Be sure the value entered matches the units used below (i.e., seconds, minutes, etc.)

FUTURE STATE

| | A 56% | B 71% | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| Manual | 17,7 | 22,0 | | | | | | | |
| Walk | 0,0 | 0,5 | | | | | | | |
| Wait | 9,0 | 0,0 | | | | | | | |
| Takt Time 1 shift | 31,5 | 31,5 | 31,5 | 31,5 | 31,5 | 31,5 | 31,5 | 31,5 | 31,5 |
| Takt Time 2 shift | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 |
| Takt Time 3 shift | 94,5 | 94,5 | 94,5 | 94,5 | 94,5 | 94,5 | 94,5 | 94,5 | 94,5 |
| | 56% | 71% | | | | | | | |

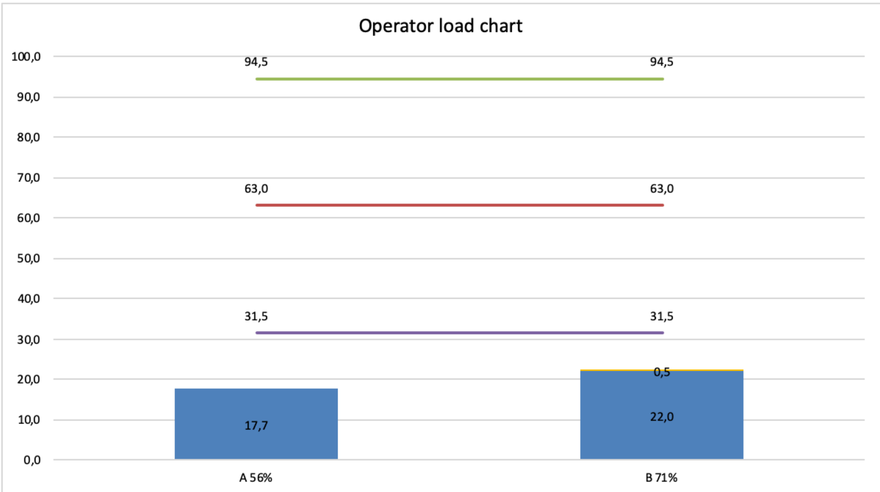



*Figure 26 - Operators Load Chart*

By looking at this graph though it was not completely clear which activities should have been done by each of the operators and moreover we could not see the activities of the two machines so we decided to create a new table with more information and with a graph able to show in a clearer way all the production processes with their time and relation to each operator or machine.

| Operation | Manual Turning | Automatic Machine | Manual Grinding |
|---|---|---|---|
| Tornitura filettatura fresatura 2 denti & Controllo dimensionale | 17,7 | 27,0 | |
| Sbavatura | | | 3,5 |
| Montaggio su attrezzo e assestamento | | | 2,0 |
| Controllo visivo | | | 1,5 |
| Smontaggio da attrezzo | | | 1,5 |
| Sabbiatura | | | 1,0 |
| Rettifica diamentro esterno & controllo in macchina | | | 4,5 |
| Controllo dimensionale | | | 3,0 |
| Sbavatura finale e creazione dei raggi sui dentini | | | 5,0 |
| Walking Time | | | 0,5 |
| Takt Time (min) | 31,5 | 31,5 | 31,5 |
| **Total % Charge** | **56%** | **86%** | **71%** |

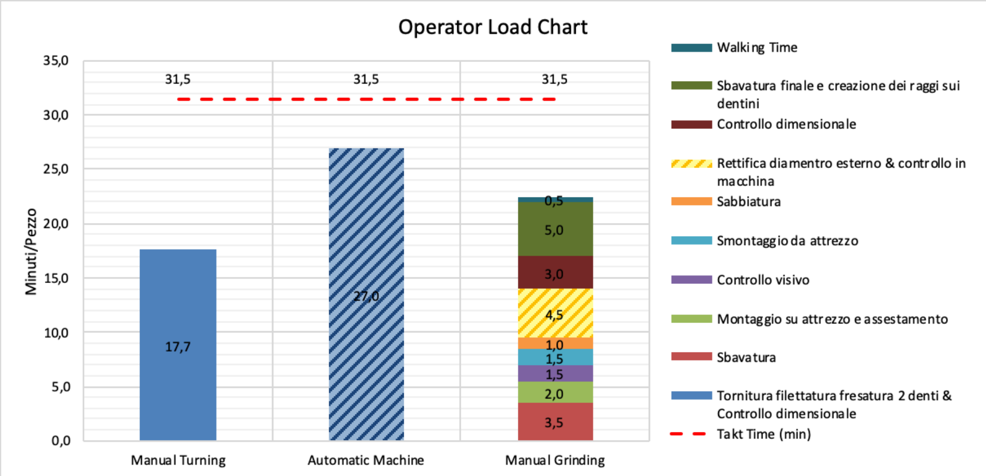



*Figure 27 - Summary % Load Chart*

It is possible to see how both the operators and the turning machine were even balanced, there is not the grinding machine because its time was considered manual time of the operator, this was due to the fact that when the grinding machine was working the operator had to be in front of the machine to check the spring processed and he could not work on another piece.

# 3.5 Improve

## 3.5.1 Elimination Waste

Because this project has been done during the "Leadership Week", so in five days, the Improve part was not properly done, or better it was not done at this point but during all the event.

In fact, the list of the wastes was one of the first thing that me and my team did, this went in this way to explain the management what kind of savings could have been done by acting on this cell and by improving its production.

The major wastes identified were:

- Inefficiency of the cell;
- Walking time exaggerated;
- Lot size obsolete;
- Tooling too old;
- Issues with the Heat Treatment department.

## 3.5.2 Optimize Operators

To optimize the operators, we created four graphs to have all the possible combinations of the two major families identified in the previous analyses.

In these graphs it is possible to see how many time and operator has to work and what precisely he has to do, there also the time of the turning machine to give a complete overview of the production process.

| | | Subfamily 1 | | Subfamily 1 | Takt time [min] | | |
|---|---|---|---|---|---|---|---|
| | | Machine | Operator 1 | Operator 2 | Machine | Operator 1 | Operator 2 |
| 1 | Tornitura filettatura fresatura 2 denti & Controllo dimensionale | 27,0 | 17,7 | | 31,5 | 31,5 | 31,5 |
| 1 | Sbavatura | | | 3,5 | | | |
| 2 | Montaggio su attrezzo e assestamento | | | 2,0 | | | |
| 3 | Controllo visivo | | | 1,5 | | | |
| 4 | Smontaggio da attrezzo | | | 1,5 | | | |
| 5 | Sabbiatura | | | 1,0 | | | |
| 6 | Rettifica diamentro esterno & controllo in macchina | | | 4,5 | | | |
| 7 | Controllo dimensionale | | | 3,0 | | | |
| 8 | Sbavatura finale e creazione dei raggi sui dentini | | | 5,0 | | | |
| | Total | 27 | 17,7 | 22,0 | | | |

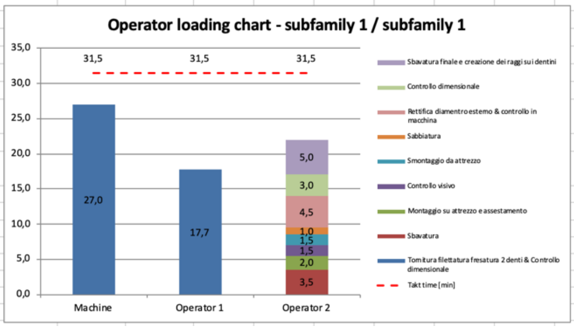



*Figure 28 -Operator Loading Chart Subfamilies 1/1*

| | | Subfamily 1 | | Subfamily 2 | Takt time [min] | | |
|---|---|---|---|---|---|---|---|
| | | Machine | Operator 1 | Operator 2 | Machine | Operator 1 | Operator 2 |
| 1 | Tornitura filettatura fresatura 2 denti & Controllo dimensionale | 27,0 | 17,7 | | 31,5 | 31,5 | 31,5 |
| 1 | Sbavatura | | | 3,5 | | | |
| 2 | Montaggio su attrezzo e assestamento | | | 2,0 | | | |
| 3 | Smontaggio da attrezzo | | | 1,5 | | | |
| 4 | Sabbiatura | | | 5,0 | | | |
| 5 | Rettifica diamentro esterno & controllo in macchina | | | 7,1 | | | |
| 6 | Controllo dimensionale | | | 3,0 | | | |
| 7 | Sbavatura finale e creazione dei raggi sui dentini | | | 5,0 | | | |
| | Total | 27,0 | 17,7 | 27,1 | | | |

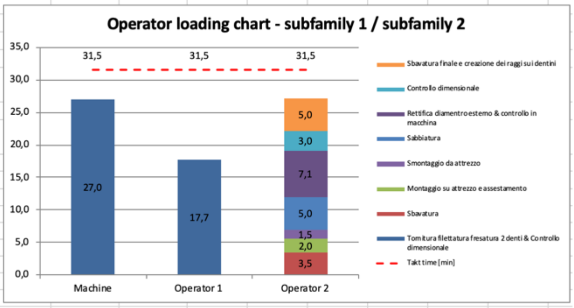



*Figure 29 -Operator Loading Chart Subfamilies 1/2*

| | | Subfamily 2 | | Subfamily 1 | Takt time [min] | | |
|---|---|---|---|---|---|---|---|
| | | Machine | Operator 1 | Operator 2 | Machine | Operator 1 | Operator 2 |
| 1 | Tornitura filettatura fresatura 2 denti & Controllo dimensionale | 42,0 | 17,7 | | 31,5 | 31,5 | 31,5 |
| 2 | Spazzolatura | | 1,4 | | | | |
| 3 | Taglio spira | | 4,1 | | | | |
| 4 | Piegatura dentino | | 2,6 | | | | |
| 5 | Taglio dentino | | 4,1 | | | | |
| 1 | Sbavatura | | | 3,5 | | | |
| 2 | Montaggio su attrezzo e assestamento | | | 2,0 | | | |
| 3 | Controllo visivo | | | 1,5 | | | |
| 4 | Smontaggio da attrezzo | | | 1,5 | | | |
| 5 | Sabbiatura | | | 1,0 | | | |
| 6 | Rettifica diamentro esterno & controllo in macchina | | | 4,5 | | | |
| 7 | Controllo dimensionale | | | 3,0 | | | |
| 8 | Sbavatura finale e creazione dei raggi sui dentini | | | 5,0 | | | |
| | Total | 42,0 | 29,9 | 22,0 | | | |

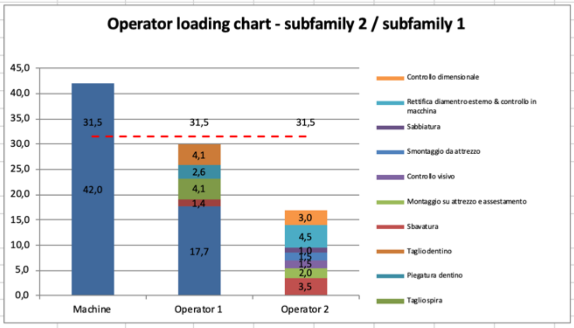



*Figure 30 - Operator Loading Chart Subfamilies 2/1*

| | | Subfamily 2 | | Subfamily 2 | Takt time [min] | | |
|---|---|---|---|---|---|---|---|
| | | Machine | Operator 1 | Operator 2 | Machine | Operator 1 | Operator 2 |
| 1 | Tornitura filettatura fresatura 2 denti & Controllo dimensionale | 42,0 | 17,7 | | 31,5 | 31,5 | 31,5 |
| 2 | Spazzolatura | | 1,4 | | | | |
| 3 | Taglio spira | | 4,1 | | | | |
| 4 | Piegatura dentino | | 2,6 | | | | |
| 5 | Taglio dentino | | 4,1 | | | | |
| 1 | Sbavatura | | | 3,5 | | | |
| 2 | Montaggio su attrezzo e assestamento | | | 2,0 | | | |
| 3 | Smontaggio da attrezzo | | | 1,5 | | | |
| 4 | Sabbiatura | | | 5,0 | | | |
| 5 | Rettifica diamentro esterno & controllo in macchina | | | 7,1 | | | |
| 6 | Controllo dimensionale | | | 3,0 | | | |
| 7 | Sbavatura finale e creazione dei raggi sui dentini | | | 5,0 | | | |
| | Total | 42,0 | 29,9 | 27,1 | | | |

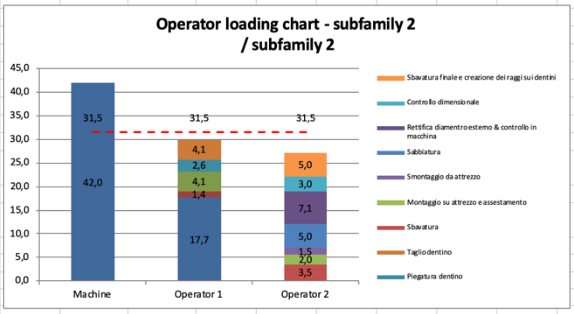



*Figure 31 -Operator Loading Chart Subfamilies 2/2*

It is evident that the family 2 has a machine time that is greater than the Takt Time, we decided to discuss this with the management and at the end we agreed that it was not a big deal since we already applied a restrictive margin and also this family's volume was not so big with respect to the rest of the production so we did not apply any further change.

### 3.5.3 Choose Concept

This step consisted of a table with a lot of requirements to respected, for each idea or layout concept, we created 7 different layouts using the same space, tools and machines, just by changing their position and at the end we did 7 evaluations based on our "Cell Design Guidelines"

The table used by my team was exactly the one in the picture below.

**Directions**
1. Print out Operations Bar Chart. Look at it to determine areas to eliminate waste. Circle areas of opportunity and determine actions needed to eliminate all bottleneck operations (bottlenecks are defined as any operation above takt time).
2. Print Operator Percent Load Chart. Look at it to balance the line. Ensure that each operator's workload is less than takt time. Circle areas of opportunity and determine actions needed to balance the line.
3. Using lean mfg guidelines and cell design concepts, develop 7+ potential cell designs and sketch design in area below.
4. Evaluate each idea based on mfg guidelines, cell efficiency (# of operators, leadtime, inventory, travel distance, sq. footage, etc.) and choose best 3 ideas. Determine all actions needed to implement each of the 3 ideas.
5. Mock up best 3 ideas to down select to 1 using 3P methodology.
6. Develop action plan to implement new cell based on actions define to eliminate bottlenecks, balance the line and create the new cell design.
7. Once implemented, revisit time observations to ensure time observation sheet matches current state.

**Layout Evaluation Sheet**

| No. | Guideline | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 | Option 6 | Option 7 | Option 8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Layout design with Consideration of the cell as a system of 7 Flows not individual machines.<br>– 1. Finished Goods Flow<br>– 2. Work in Process Flow<br>– 3. Raw Material Flow<br>– 4. Information Flow<br>– 5. People Flow<br>– 6. Machine/Tooling Flow<br>– 7. Engineering/Built-In Quality Flow | | | | | | | | |
| 2 | Design towards a Moving line as a pace maker for the entire process (green). Pulse if necessary (yellow). No Stationary Fixed Final Assembly Flow (red). | | | | | | | | |
| 3 | Equipment Construction and Layout permit easy material flow inside and leaving the cell. | | | | | | | | |
| 4 | Operators stations are narrow (approaching width of part). Deep is acceptable for Reduced Walking and Reduced Footprint. | | | | | | | | |
| 5 | No process villages. | | | | | | | | |
| 6 | Do not allow space or capability for batching and excessive inventory and WIP. | | | | | | | | |
| 7 | Equipment and layout allows the operator to move easily utilizing the "open room" concept to allow operators to see the big picture and the cell to be flexible to other products and processes. Standard work may be changed for increased demand without changing layout. | | | | | | | | |
| 8 | Machines are linked to make work flow smoothly and avoid excessive WIP. | | | | | | | | |
| 9 | Cell not constrained by shared resources. | | | | | | | | |
| 10 | Operator Walking Zones Inside the Cell Only. | | | | | | | | |
| 11 | Maintenance and Material Zones on Rear Side of Machine Periphery around the Cell. | | | | | | | | |
| 12 | Material Transportation Flow Does not Constrict Material Cell Flow. | | | | | | | | |
| 13 | Cell capable of Mixed model (make every part, every interval); changeover time between models is practically zero. | | | | | | | | |
| 14 | Flexible cell. Workstations and equipment on wheels, Flexible utility connections, etc. | | | | | | | | |
| 15 | One-Piece Flow (green). FIFO is second choice (yellow). Pull system when one-piece flow and FIFO not possible (yellow). No push systems and/or batching (red). | | | | | | | | |
| 16 | No forklifts, no cranes, no hoists | | | | | | | | |
| 17 | Product and Operators do not leave the cell or line during the work process | | | | | | | | |
| 18 | No process reversals | | | | | | | | |
| 19 | No trash containers in production areas | | | | | | | | |
| 20 | Where possible U-Shape Counter-clockwise for machining (material flow in counter-clockwise direction for right-handed operator). For assembly less than 30 feet use a straight line and beyond 30 feet utilize a return process. | | | | | | | | |
| 21 | No pits, No platforms | | | | | | | | |
| 22 | No processes requiring multiple persons | | | | | | | | |
| 23 | Everything must be less than 1.5 meters (5 feet) in height | | | | | | | | |
| 24 | Move as many inspection processes (parameters) upstream from the Run Test as possible | | | | | | | | |
| 25 | Use as many sub assembly lines as required to reduce the length of main line | | | | | | | | |
| 26 | Last station has takt time, pulls on immediate upstream-station, in turn that station pulls on preceding station, and so on. | | | | | | | | |

| Legend | |
|---|---|
| (green) | 100% Achieved |
| (yellow) | Somewhat Achieved |
| (red) | Not Achieved |

*Figure 32 - Cell Design Guidelines*

There was the possibility to fill each box with green if the requirement was 100% achieved, yellow if it was somewhat achieved or red not achieved at all.

We chose at the end the option with the highest number of green and yellow boxes.

### 3.5.4 Design & Simulate

After a careful consideration and most of all after a discussion with all the Management Team we finally decided which layout would have been the most suitable for the Spring Cell.

Our idea was to transform all the shop floor or most of it in a series of parallel layouts, so we paid a lot of attention in the use of the space and also in the positioning of the in/out shelves in order to create a sort of Kanban system.

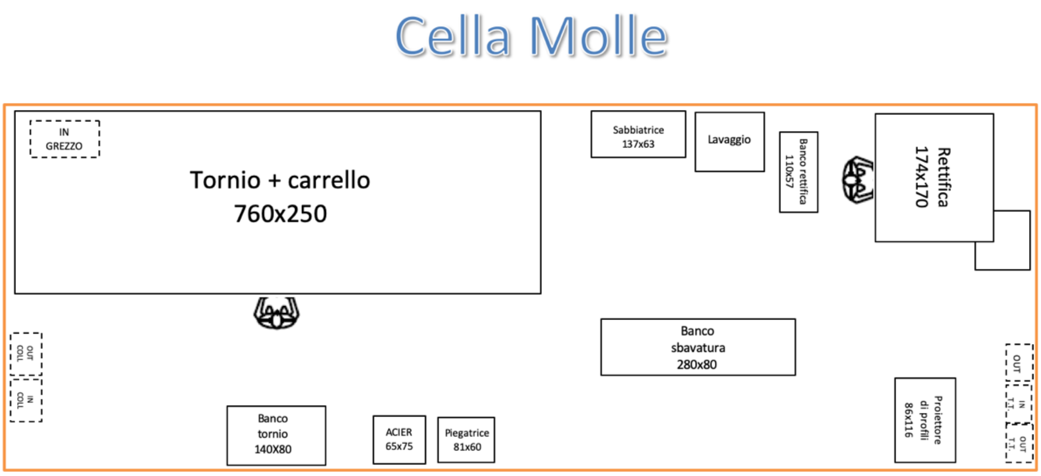



*Figure 33 - Final Layout Spring Cell*

The layout was developed in this way so to have the shortest distances possible and the lowest walking time but also to create a one batch flow with all the necessary machines and benches inside the cell, except for the ones concerning the heat treatments that of course could not be placed in this area.

### 3.5.5 Implementation

The implementation part was not yet concluded when I finished my internship because we needed to wait the summer holidays to be able to move the machines without interrupting the production.

What we did before that was buying all the new tools and benches necessary, we also started to move the smaller machines with some forklifts, and we adapted the springs’ lot size to respect our new configuration.

Last but not least we started the process for buying the new shot peening machine to put inside the cell once all the machines would have been placed as agreed in the new layout dispositions.

## 3.6 Control

### 3.6.1 Standard Work Combination Sheet

Although all the machines were not in their final position we started in any case the production following our new guidelines, so we were forced to create the Standard Work Combination Sheet that, together with the Standard Work Sheet and the Operator Loading Chart are the so called "Triplets".

These Triplets are documents that help the Cell Supervisor to take track of the trend of the cell and also to make sure that all the processes go on as scheduled, for this reason these documents are updated once every month but only if something change in any of the activity of the production flow and that is why we have it under the section called "Control".

The Standard Work Combination Sheets were done for all the activities, divided by subfamilies and operators, so in our case we created 4 different documents as follow.


*Figure 34 - SWCS Subfamily 1/Operator 1*

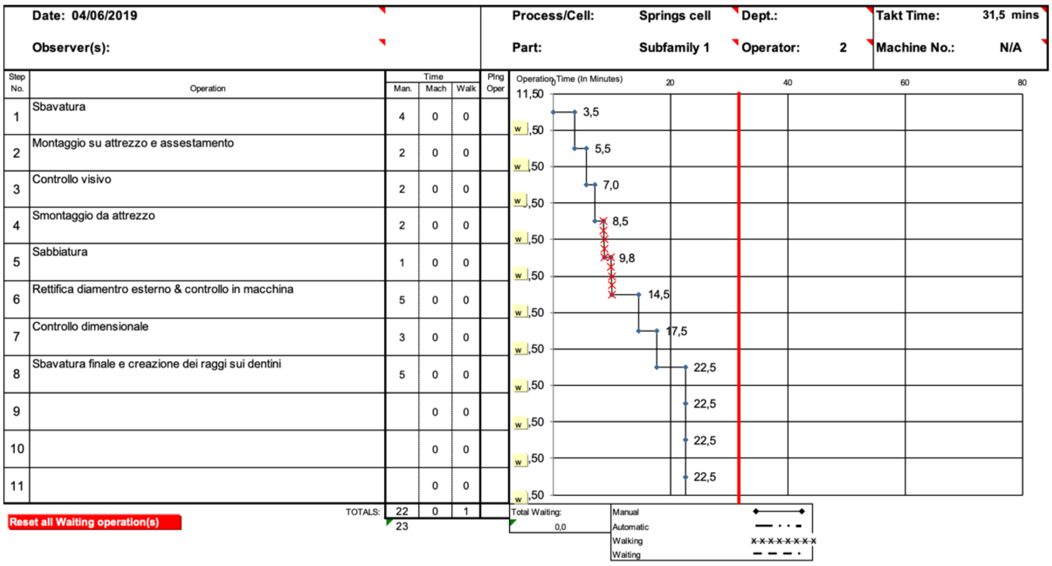


Figure 35 - SWCS Subfamily 1/Operator 2

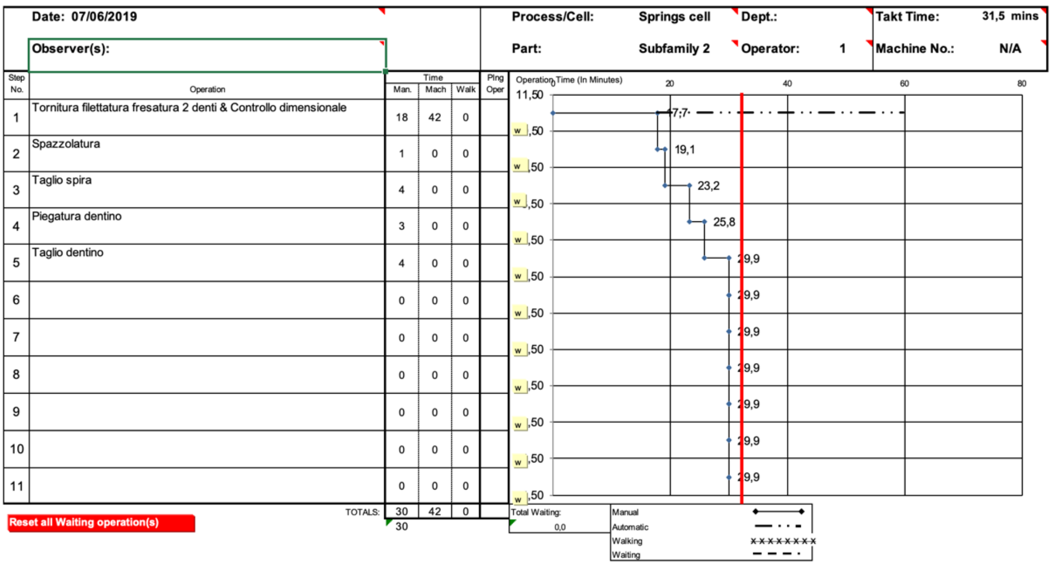
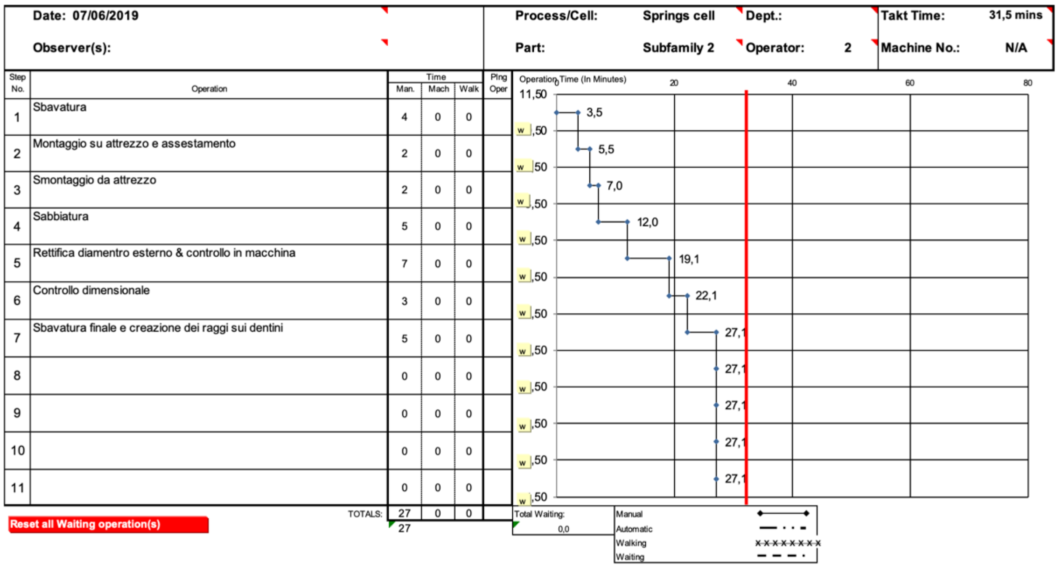


Figure 36 - SWCS Subfamily 2/Operator 1



| Date: 07/06/2019 | Process/Cell: Springs cell | Dept.: | Takt Time: 31,5 mins |
|---|---|---|---|
| Observer(s): | Part: Subfamily 2 | Operator: 2 | Machine No.: N/A |

| Step No. | Operation | Time Man. | Time Mach | Time Walk | Ping Oper |
|---|---|---|---|---|---|
| 1 | Sbavatura | 4 | 0 | 0 | |
| 2 | Montaggio su attrezzo e assestamento | 2 | 0 | 0 | |
| 3 | Smontaggio da attrezzo | 2 | 0 | 0 | |
| 4 | Sabbiatura | 5 | 0 | 0 | |
| 5 | Rettifica diamentro esterno & controllo in macchina | 7 | 0 | 0 | |
| 6 | Controllo dimensionale | 3 | 0 | 0 | |
| 7 | Sbavatura finale e creazione dei raggi sui dentini | 5 | 0 | 0 | |
| 8 | | 0 | 0 | 0 | |
| 9 | | 0 | 0 | 0 | |
| 10 | | 0 | 0 | 0 | |
| 11 | | 0 | 0 | 0 | |
| | TOTALS: | 27 | 0 | 0 | |
| | | 27 | | | |



*Figure 37 - SWCS Subfamily 2/Operator 2*

As it is possible to see in each table there is a list of the single activities done by each operator, their correspondent time dived by manual, machine or walking time, and on the right side there is a graph that represents these data in a easier to understand and more visual way; the red line is the Takt Time and we can see how it is never reached in any of the sheets.

### 3.6.2 Standard Work Sheet

The last sheets that we created to complete the Manufacturing Standard Work Cell Design were the Standard Work Sheets.

This document shows the sequence of the operations done by each operator for each subfamily taking as base the new layout and it is useful to check if the processes are respected and there is no waste of time  and resources as it happened in the past, that is why it is so important, the fact that the production activities were not done in the correct order was one of the major problems that pushed us to review the organization of this cell.

At the end we obtained the Standard Work Sheets, as shown below.

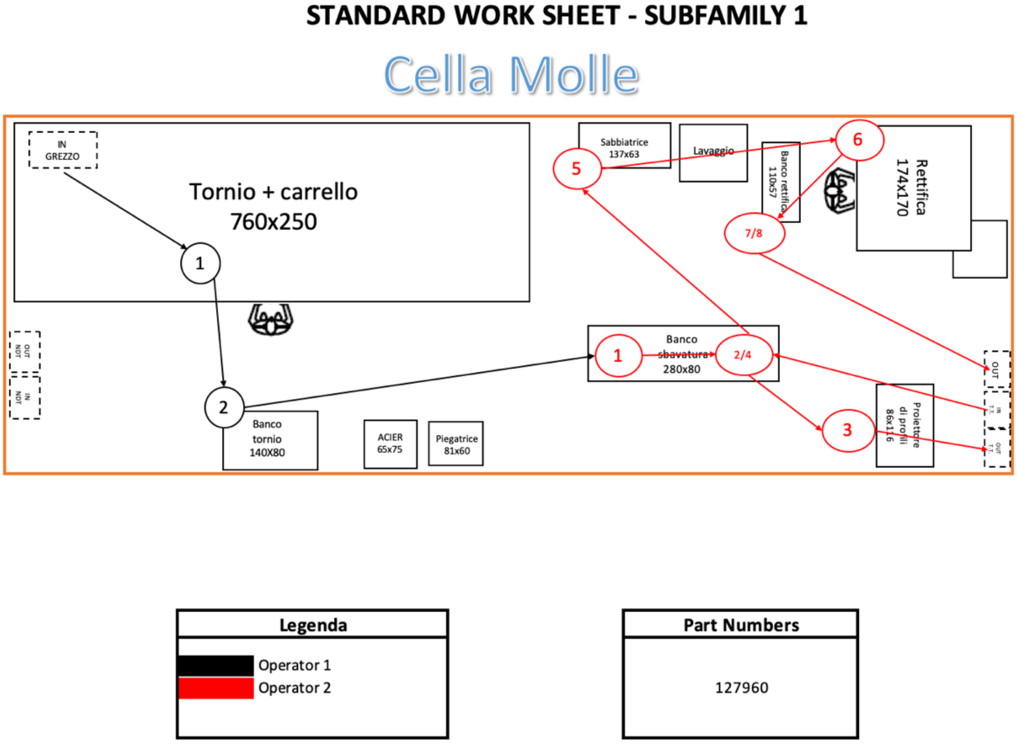



*Figure 38 - Standard Work Sheet Subfamily 1*

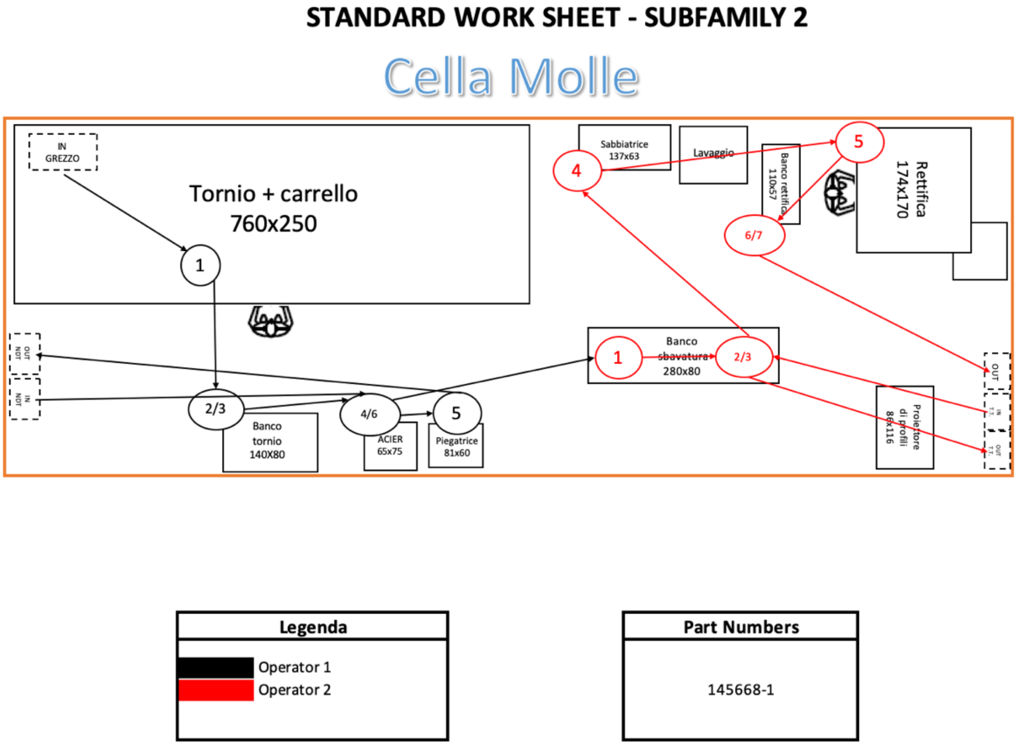



*Figure 39 - Standard Work Sheet Subfamily 2*

As it is said in the legend the black lines represent the activities done by the operator 1 and the red ones represent the activities done by the operators 2.

We also added for each subfamily the Part Numbers concerned.

# Chapter 4

# 4 Results

## 4.1 Improvements

Talking about the results it is evident that with all the changes listed and explained before the Spring Cell was working better than ever.

Firstly, its efficiency grew starting from the first weeks and it was clear also for the operators that the new flow without interruptions and with a new lot size was easier to follow.

Another important aspect were the 5s in the area, the order and cleaning made the cell look completely different and they also gave a better perspective of all the processes, included the Kanban system with its shelves and boxes.

The last improvement in the short period concerned the planning. We developed together with the shop floor planners a file that took in consideration both the production time and the number of pieces for each box in order to have a weekly plan and a daily plan of at least a lot per day.

The template that we create is represented in the picture below.

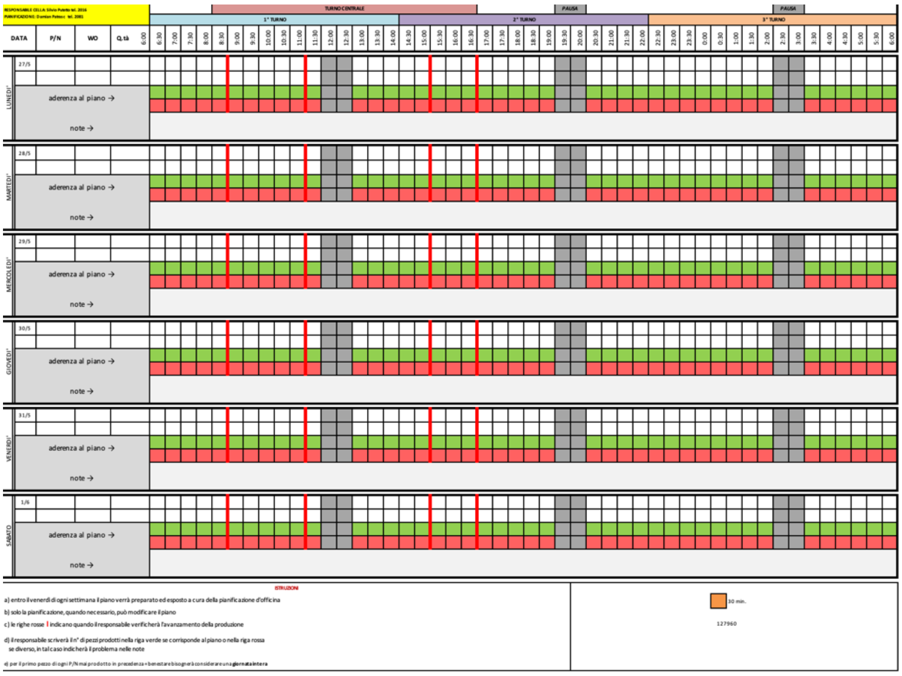



*Figure 40 - Production Plan Template Spring Cell*

In this table we have a very important aspect of the production, mostly for the cell supervisor, the so called “Pitch”.

It is the moment when the supervisor should check if the production is on time or not; that is why we have two rows, one green where to put the number of pieces done if the production is on time, one red to do the same if the production is not on time. If the last one is the case, we also asked the supervisor to write the reasons in the row below called “Note”.

At last, the grey columns represent the breaks, when the production is stopped, the white ones have to be filled with the orange boxes that is on the bottom-right corner of this template and each box represents a spring to produce; we have two different white columns in case there were two working orders in the same day.

The other data to insert for each working order were:

- Part Number
- Working Order Number
- Quantity

We also created a legend with all the instructions to follow to complete this file in order to avoid misunderstandings or files not properly completed.

## 4.2 Cost/Benefits analysis

Before even starting the project, we knew that in order to obtain some benefits both in the short and in the long period we should have invested quite a bit on new machines, benches and tools.

To do that we used the budget of the ACE Department that dealt also with the continuous improvement.

If the costs were related only on this new purchases and on the repositioning of the existent machines, the benefits expected were not only about cost reduction of both raw materials and finished goods for the company but also about the complete transformation of the Shop Floor, in fact this was just a part of a larger project that aimed to create a company completely based on a pull production system in all of its departments, it is important to remember that the shop floor and the spring cell with it were also suppliers of the "Screwjack Department", that is the most important and best-selling product of the Microtecnica.

The quantified analysis with all the details has been done by the Cost Saving Manager, because as I have already said we were supported by the management during all the process.

# Chapter 5

# 5 Conclusion

To conclude I would like to start from the beginning of this project.

The first thing the management asked us to do was a job ticket and a complete agenda of all the activities to complete day by day during the leadership week.

The Job Ticket was a summary of the current state of the cell, all the tools to use to bring it to the a new state, the expectations for the future state and the customer requirements; the customers in this case were not the company customers but we were talking about the customers of this project, so the Screwjack Department.

This document is composed of 10 sections:

1. Problem Statement: all the issues discovered;
2. Current State: major KPIs about the present situation;
3. Desired State: expectations for the future;
4. Customer Requirements: needs of the project customers;
5. Measures: KPIs used to measure our goals;
6. Winning Solutions: practical tools to reach our goals;
7. Event Management: how we planned to complete all the activities proposed in the event;
8. Completion Date: all the deadlines;
9. Event Ownership: list of all the owner of our project;
10. Event Participants: our working group.

## «Spring cell project – Leadership week 13-17 May 2019»

| | |
|---|---|
| **1) Problem Statement**<br>• At the moment, we have in the shop floor a "spring cell" which is not producing as the initial process design.<br>• Efficiency is very low<br>• In SAP the work centre of the spring cell is not well defined | |
| **2) Current State**<br>• Produced springs P/Ns: 127960; 123186; 145668-1 e 147289-1<br>• N°2 operators in the cell<br>• 2018 produced 2623 springs<br>• 2018 Efficiency 72%<br>• 2018 SRR 5k€<br>• 2018 variance 26k€<br>• OTD last 12 months (1/6/18-1/5/19) 7% | **3) Desired State (What success looks like)**<br>• Define flow (VSM)<br>• Redefined cell layout design (MSWCD)<br>• Operators Training |
| **4) Customer Requirements**<br>• Screwjack Cell: OTD + Quality<br>• Process cost reduction<br>• Operators<br>• Cell manager | **5) Measures**<br>2019 target indicators:<br>• Productivity 80%<br>• Efficiency 95%<br>• OTD 100%<br>• SRR/QN ≤ 50% del 2018 |
| **6) Winning Solution**<br>• VSM<br>• MSVCD | **7) Event Management**<br>Many activities have been planned; the risk is that we will not able to close all of them. In case, we will complete the activity next week |
| **8) Completion Date**<br>1. Leadership week 13-17 May 2019<br>2. Final state expected MSWCD partially completed according with the plan | |
| **9) Event Ownership**<br>- Event Leader: Marco Scelfo<br>- Event Co Leader: Urso<br>- Event Sponsor: M. Rancati<br>- Event Coach: Tomasello<br>- Implementation Leader: Urso | **10) Event participants:**<br>- Guarna (ME)<br>- Vello (ME)<br>- Modugno (transformation)<br>- Patrasc (on call)<br>- Matteis (on call)<br>- Saffioti (on call)<br>- Garza (on call)<br>- Sasso (on call) |

*Figure 41 - Job Ticket Leadership Week*

The event Agenda on the other hand was a detailed view of all the activities to do day by day; it also included the daily and final debriefs, a sort of public presentation to explain which point we reached and the problems found every day, so a summary of the work done by every group.

***Event: Leadership week 13-17 May 2019***
***Area: Spring Cell***

| | Monday<br>13.05.2019 | Tuesday<br>14.05.2019 | Wednesday<br>15.05.2019 | Thursday<br>16.05.2019 | Friday<br>17.05.2019 |
|---|---|---|---|---|---|
| **Content of event** | **9:00 Opening**<br>Scope Sheet/Agenda<br>Takt 5 min / Team (Leader)<br>Present:<br>• All | **Start 9:00**<br><br>KICK OFF<br><br>9:30 | **Start 9:00**<br><br>KICK OFF<br><br>9:30 | **Start 9:00**<br><br>KICK OFF<br><br>9:30 | |
| | Gemba walk in spring cell | VSM Future State<br><br>PQ analysis | Time observation<br><br>Takt time | Eliminate waste<br><br>Balance | |
| | Analysis of cell data | Process Matrix<br>Part family definition | Operation bar chart | Review action plan | |
| | VSM | Video of 127960 production | | **Preparation Final Debrief** | |
| | **12:30 – 13:30 Lunch** | **12:30 – 13:30 Lunch** | **12:30 – 13:30 Lunch** | **12:30 – 13:30 Lunch** | |
| | | Spaghetti chart | Capacity analysis | **Time TBD Final Debrief** | |
| | VSM Current State | Process at a glance | Operator % loading chart | Takt 10 min/Team | |
| | **15:00** Preparation for daily debrief | **15:00** Preparation for daily debrief | **15:00** Preparation for daily debrief | | |
| | **16:00 Daily debrief**<br>Present:<br>• Leader<br>• Co-Leader<br>• Facilitator | **16:00 Daily debrief**<br>Present:<br>• Leader<br>• Co-Leader<br>• Facilitator | **16:00 Daily debrief**<br>Present:<br>• Leader<br>• Co-Leader<br>• Facilitator<br>**Apericena** | | |

*Figure 42 - Agenda Leadership Week*

I can say that after all the difficulties found in our path, we were able to reach all the goals planned for the short term, of course these were just about the Leadership Week but as I said this project was part of a bigger plan and by accomplishing these objectives we made a great step towards an innovative transformation of all the company.

At the end a picture of all the people that worked with me all along to make sure that everything was done with the greatest professionality possible and the maximum effort. (Fig.43)

*Figure 43 - Working Team*

# References


- https://es.wikipedia.org/wiki/Manufactura_celular
- https://www.sciencedirect.com/science/article/pii/S0360835204001998