School of Innovation, Design and Engineering

AQ Segerström & Svensson AB

Case study: Production and OEE improvement for an 800 tons stamping press

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Abstract

The actual industrial development linked to the financial situation over the world lead automotive and other companies to expand their production level to stay competitive. Changing an organization to raise its production or profit is not a one day journey, but requires some steps.

Tools exist to develop the production level of manufacturing industry since more or less the fifties, and the continuous improvement is measured by some available and famous indicators around lean manufacturing mainly. Pressing equipment especially like a metal stamping press expressed through the following case study can be improved by respecting some fundamentals. Lean manufacturing aspects as 5 S's and TPM (Total Productive Maintenance) for example are tools that can be applied to improve the production rate of a stamping press. To even better improve the OEE (Overall Equipment Effectiveness) of the same machine, a tool like SMED (Single Minute Exchange of Dies) reveals to be really powerful when improving the global output rate of the machine.

The case study developed inside this present report aims to investigate all the possibilities to improve the OEE of pressing equipment facing theoretical aspects and reality issues. The tools involved are part of the content, but the way to support a company for the organizational change required to the success is another part of the content.

Technical solutions are taking part of the outcome, and a strong link to change management is included. Correlation between both technical and managerial aspects is the main line followed to get the final results. An experimental and actual OEE is calculated, and improved following a rating according to the possible improvements. Those results are analyzed to provide a weighted feedback related to the whole research.

Keywords: Overall Equipment Effectiveness (OEE), Single Minute Exchange of Dies (SMED), 5's, pressing equipment, Lean Manufacturing

Acknowledgements

Writing this thesis has been a great opportunity for me. I had to deal with the real working community, had to face some more or less important problems and I have been able to gather a great amount of knowledge during the whole period of the project. That is why in this coming part, I would like to acknowledge all the people who helped me to accomplish my mission.

I would like to give a special thanks to Leif Plate, General Manager at AQ Segerström & Svensson. This person gave me the opportunity to transfer my skills and knowledge from Mälardalen University, straight to his company, which was challenging and really interesting at the same time. Leif is a comprehensive and patient person, and more than willing to support me and students in a general way.

My second special acknowledgements are addressed to Antti Salonen, my University supervisor, who was really available and really helpful to guide and adjust my way of leading this project. Antti is the tenant of a PhD graduated from Mälardalen University in Sweden and is a person greatly skilled regarding the industrial world especially concerning maintenance and strategic maintenance, which has been a profitable bonus concerning my case study.

The whole organization and especially the press operators with Per, Andrea and Andreas, have to be highly acknowledged as well. Indeed, they have been very willing to offer me some time and to share their precious experience. They were all really kind, to gently treat me and my loads of questions. Kind regards to them.

Richard Miles the production manager and all his staff need to be thanked. Richard always welcomed me for any type of questions, and very gently shared his experience within the AQ Segerström & Svensson organization. He was always up to discussion with me about different problems concerning the workshop in general.

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Aurélien Narses.

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1. INTRODUCTION

The company AQ Segerström & Svensson has the philosophy to develop its production plant in order to stay competitive within the automotive parts market which is evolving more and more. The production manager Richard Miles is improving and implementing a new workshop organization which has for goal to reduce the lead time for any parts produced, and enables the company to be more reactive regarding the customer. The main changes are done to make the last steps before expediting the parts, smoother and quicker. The following important process that causes problems when working upstream is the presses area. Presses are not producing as they should according to the managers. In this case, an agreement could be found between the company and me, to develop the overall equipment effectiveness of the presses area. Changeover time for the 800 tons press should be reduced in order to stay reactive, and to be able to handle what is required from the customers' side.

1.1 Background

Nowadays trends and markets lead companies to be more and more competitive. To reach the best level of competitiveness, general productivity always needs to be improved within a company. To stay competitive, companies have to aim for continuous innovative development, high quality products and short lead times. Designing flexible and powerful production systems is the way to lead towards lean production. (Bellgran, et al., 2010)
(Slack, et al., 2008) defined that performance objectives like quality, cost, speed and flexibility in term of manufacturing output should reflect the dynamic market requirements.

Total Productive Maintenance (TPM) is a core concept developed by (Nakajima, 1988) which has for goal to keep improving the production performances. This concept is nowadays widely extended in manufacturing industries and well-known for its powerful results.
Several key indicators exist in order to measure the level of competitiveness of a company. A famous one, Overall Equipment Effectiveness (OEE) is on average 60% for manufacturing industries, which is lower than the world class estimated to be around 85%. It is hence obvious that there is a lack of effectiveness for many companies regarding any type of their equipment. This lack is often due to some operations that require a long time to be performed while the machine is not running, or a poor maintenance of the machines which involves regular breakdowns. Integrated maintenance systems can also improve and develop equipment efficiency (Bamber, et al., 1999) and these maintenance aspects can often dominate the six big losses from TPM, which needs to be considered.

The management staff from AQ Segerström & Svensson AB already knows that there is a lack of effectiveness when producing parts over all the presses standing within the workshop. The purpose of this present thesis work is to calculate the actual OEE of an "experimental" press. Knowing this actual OEE, some solutions would be proposed to the managers, presenting for each solution, mainly its cost and the OEE improvement. The company should then choose the most appropriate according to their actual requirements.

Developing some skills towards lean manufacturing implies some other aspects. Indeed, many researchers claimed that transforming an organization to lean manufacturing requires a cultural change within the organization, before changing technical and manufacturing issues.(Balle, 2005). To change an organization to lean manufacturing involves most of the time radical change in structure, strategies, decision making and technical features of a company.(Smeds, 1994).

1.2 Problem formulation

From the previously presented background, industrial companies in general are interested in lean concept and in developing their organization, but do not have the right keys or methods to reach their goal. To implement lean tools and concept within an organization even small is time-consuming and investments need to be done soon or late. For that reason, many companies nowadays stay rough regarding the subject. When coming to lean sustainability, some problems are once more occurring for many organizations. Indeed, to implement and sustain a new process or system, a certain kind of management evolution is required. This is why the following study is conducted around two main subjects who are lean manufacturing in one hand and change management in the other hand. To be more precise, the present report will combine the two methods to get a clear overview of the different mandatory stages to reach lean goals.

The pressing equipment studied through the case study is too often down. It means that there is a lack of production on this machine hence the company loses money while this machine is not running. My goal in this project is to analyze the process and to clearly find out why the machine is so often down. The machine is an 800 tons mechanic press that shapes parts thanks to a die. The die is different for each part code, and has to be changed between each series. The dies that can fit within the machine weigh between 1500 and 14000 kg. The raw material is a metal sheet coil varying in size according to the parts requirements that have to be produced.

The most relevant step for me in order to really get into the problem was, in the early stages of the project, to walk around the shop-floor and to see by myself how the work is actually done. It was quite obvious that a lot of time was lost by the operators, but not in purpose. All the steps the operators had to follow to run the machine were numerous, and of many different types. The tool changing is the most time consuming operation, which takes between two and three hours, and have to be executed two or three times a day. Operators also had to stop the machine to fix some obsolete or poorly designed – but useful – objects.

1.3 Aim and Research questions

Improving machine efficiency as the present case study is a task that could seem easy in the first description. A period of about six months is available to run this project, so the expected outcome cannot be a real improvement of productivity on the machine of 30%. My expected result is in one hand to provide the company a strong review of all the problems they face and the way to get around them with a price consideration. In the other hand, I would like this present report to be scientifically advanced in order to strongly link theory with practical manners. A person willing to improve similar equipment should be able to use this report as a practical support useful to implement technical tools.
To make this report scientific, I decided to investigate two fields at the same time: Improvement of OEE and leading change. The final aim of this report is to provide answers to the following research questions:

RQ1: How important are the operators when improving OEE?

In many companies, operators and bureaucrats are often arguing each others, and are not willing to work hand in hand. This is problematic in many cases, since both are working in their own interest, and are not following the same rules and goals. From this situation, many disagreements occur and can sometimes lead an organization in the total chaos. It seems interesting to investigate this field, in order to improve the willingness of operators to work, and to improve the global work produced on a shop-floor.

RQ2: How important is a good communication and change management through all the steps?

This research question is in some ways linked with RQ1. Bad communication in any organization can lead to disaster situations. Many organizations believe that their internal communication is good enough to run the company. It is often right in order to remain at an acceptable level, but not enough to improve and to change an organization. In the case of implementing OEE, it is relevant to observe and reflect on how communication and organizational change should be handled.

RQ3: What are the major issues when developing and implementing a higher OEE?

Improving OEE is one of the logical manners to follow for any company willing to improve its productivity. However, to get a higher OEE, there is not only one mathematical formula to apply. Many tricks and problems can occur on the implementation journey, according to the machine type, the number of employees within the firm, the culture anchored for decades and so on. This is why it can be interesting to sort out all the different issues that can take place in a more general way.

1.4 Project limitations

The first step is to improve OEE of an 800 tons press, investigating SMED, 5 S's and TPM. To implement this improvement, a period of about one month is required in order to be involved in the project. Indeed, being known and accepted by the different actors of the project is a crucial early stage. Getting the operators confidence is according to me the most important step in order to get a stable base to begin the project. Telling the operators that I will not teach them how to work on their own machine they are familiar with for more than ten years. Instead, I am telling them that I am just a transparent element that is just present in their surroundings to make their working conditions more comfortable in the future.

2. RESEARCH METHODOLOGY

In this section research method is described and analyzed the research methodology employed to drive this project through all the steps. Research methodology is the amount of procedures by which researchers go through to achieve their work of describing, explaining and predicting phenomena.(Rajasekar, et al., 2006) That section represents my way of thinking, my way of acting and the different methods used to lead to the results. Different approaches can be considered when writing and running a scientific project, each of them having its own particularities. Those particularities will be exposed, described and analyzed within this part in order to have an overview of how the project goes on.

*"**Research approach** is a design or plan to conduct research, for example, using case study, phenomenology, or grounded theory."* (Lichtman, 2010 p. 7)

2.1 Literature review

"Literature review *is the selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed."* (Hart, 1998 p. 13)

The study of literature is a great way to develop skills and knowledge within a field. Being aware on how the whole project should look like, I started to read books, articles, reports or any other type of literature related to the fields I am interested in. In one hand, the OEE, studying many aspects of its improvement, and in the other hand, the way employed to lead change. An investigation has been done before readings, in order to get the best theoretical data; thus, the majority of the books and articles read come from leading authors within their respective field. The part "Theoretical Framework" taking part of this present report gathers and details this literature study.

2.2 Data collection

"*Data* *are defined as symbols that represent properties of objects, events and their environment. They are the products of observation, but are of no use until they are in a useable (i.e. relevant) form. The difference between data and information is functional, not structural."*(Ackoff, 1989)

Data collection consists of gathering those symbols in order to have a good basis for deeper studies on a subject. Data collection can be of two types as described in the following Table 1: Qualitative or Quantitative. Qualitative data collection methods will be mainly employed through the project, but some from the quantitative part will be employed as well, as the standardization of procedures for example.

Qualitative Data Collection	*Phases in the Process of Research*	*Quantitative Data Collection*
• Purposeful sampling strategies • Small number of participants and sites	Sampling	• Random sampling • Adequate size to reduce sampling error and provide sufficient power
• From individuals providing access to sites • Institutional review boards • Individuals	Permissions	• From individuals providing access to sites • Institutional review boards • Individuals
• Open-ended interviews • Open-ended observations • Documents • Audiovisual materials	Data sources	• Instruments • Checklists • Public documents
• Interview protocols • Observational protocols	Recording the data	• Instruments with scores that are reliable and valid
• Attending to field issues • Attending to ethical issues	Administering data collection	• Standardization of procedures • Attending to ethical issues

Table 1: Phases in the data collection process for qualitative and quantitative research (Creswell, et al., 2007)

2.3 Interviews

***"Qualitative interviewing** is a technique of data collection that ranges from semi-structured to unstructured formats. Interviewing is seen as a conversation in which an informant and a researcher interact so that the informant's thoughts are revealed and interpreted by a researcher."* (Lichtman, 2010 p. 7)

Interviews will be conducted to some consciously chosen actors within the studied process. It will start with the employees working with the machine; it will continue with the production manager, the CEO and some others related to these first interviews. These interviews (mainly open-ended) are the most important ones in order to build a strong basis to investigate some other issues. All the interviews are and will be driven with the aim to be as complete as possible to provide a good analysis for the research questions.

2.4 Observation

***"Observation** provides the opportunity to document activities, behaviour and physical aspects without having to depend upon peoples' willingness and ability to respond to questions."* (Taylor-Powell, et al., 1996 p. 1)

Improving a machine process within a company dealing with many types of parts and about 200 employees is not an easy task. Observation linked to the case study is a powerful manner to gather data. Having a walk through the workshop every day is an important and useful accomplishment, just to observe what is going on the shop floor. Something new is showing up to each visit; it can be a very small detail, or operator behaviour or even some comments. This technique to go on site is recommended and detailed later on as a tool to implement Lean Manufacturing.

2.5 Qualitative and quantitative approaches

When a scientific research project has to be run, the principal actors of the project should be aware of what are the different options available in order to reach the ultimate goal. This is why it is essential to know what could be the difference between a qualitative and a quantitative approach in particular, in order to know in which direction the research should be conducted. Julia Brannen is an expert regarding the field of comparing qualitative and quantitative approaches. Investigating and studying one of her book called "*Mixing methods: qualitative and quantitative approaches*" that she wrote in 1992 has been the research starting point; the relevant parts are summed up in the coming section.

The actor wants first of all to mention, that very often, some researchers refer themselves as belonging to the qualitative paradigm, while some others claim to belong to the quantitative one. Some of them even affirm to combine both methods in their work. The most important to have in mind, is to choose the right method to answer the research question in one hand, and to develop the theoretical framework in the other.

*"**The qualitative researcher** is said to look through a wide lens, searching for patterns of inter-relationships between a previously unspecified set of concepts."*(Brannen, 1992 p. 4)

*"**The quantitative researcher** looks through a narrow lens at a specified set of variables."* (Brannen, 1992 p. 4)

*"**Quantitative research** is a term describing traditional methods of hypothesis testing, determining cause and effect, and generalizing."* (Lichtman, 2010 p. 8)

Even if the two research approaches are different in the way of utilizing them, it is not impossible to combine them. Brannen in her book mentions that combining both methods can be a good way to enlarge the outcomes and to have a more open minded reflection about the topic. Once again, choosing the approach greatly depends on the type of research that has to be realized.

A very relevant aspect of the data collection was enumerated by(Cain, et al., 1981). They actually argued that data are "more valid" if they are generated by several manners. Different instruments should be employed and not only one interview question should be asked. However, many qualitative researchers especially, are concerned with the real origin of their data. They can wonder if the data come from a negotiation between interviewer and interviewee, or if they justify the actual action given to other players in a given situation? They interrogate on the different relations that data have with the initial theory, and with the formulation of the research questions. (Cain, et al., 1981)

This concern is interesting to have in mind through all the steps of the research in order to be aware of its accuracy level. This is particularly relevant when applied to this project research, as it will be developed in the coming sections, to answer the research questions.

Regarding this thesis project, the company AQ Segerström & Svensson AB will be used as the main implementation case study. Some similar cases are going to be studied and analyzed in order to be aware of what type of problems can be met, and how to get around them.
All what is learnt from those case studies will be compared and transferred to the next actual case. The different problems that will be met will be mentioned, and some solutions to get around them should be found and exposed.

As the main aim of this project is to improve the effectiveness of a machine, some aspects surrounding the machine will have to change. It could be some technical devices, some work station modification or some way to act, that could be modified. To do so, changing the management is crucial if the company is willing to get some good results. That is why two studies are going to be led at the same time, but interacting between each others. Figure 1 corresponds to the research model that will be followed along this project, starting from the problem definition to reach the final objective.

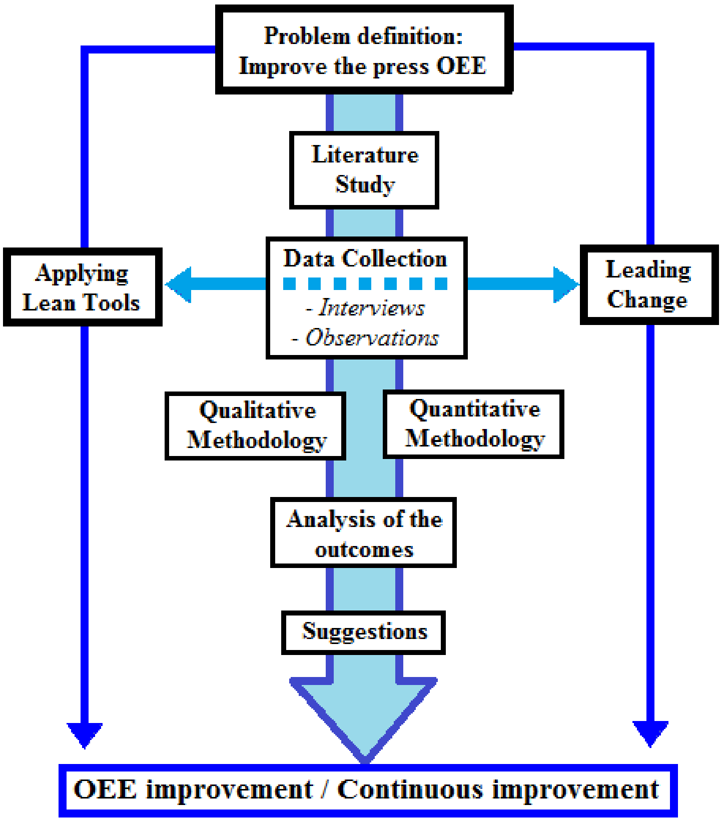


Figure 1: Research methodology model for my case study

3. THEORETICAL FRAMEWORK

This thesis project is being supported by the case study with the company AQ Segerström & Svensson as mentioned earlier. The preliminary stage is to present in this part, all the research that has been done concerning the subject of OEE and the lead of change. This research has been conducted in a way to be the most appropriate as possible, and as reliable as possible in term of information.

3.1 OEE: Understanding and early stages

OEE (Overall Equipment Effectiveness) is a tool developed by S. Nakajima (1988) who proposed this in order to evaluate the progress of TPM (Total Productive Maintenance) that he originally created. (Jeong, et al., 2001) OEE is the multiplication of three factors; availability, performance and quality. Its particularity is that the hidden losses are taken into consideration in order to higher the degree of relevance regarding equipment utilization.
Before the creation of OEE, availability was the only parameter considered which falsified the final result, and an overestimation of equipment utilization was observed. (Ljungberg, 1998)
Figure 2 is a representation of how OEE could be defined, gathering all the key functions affecting the final result.

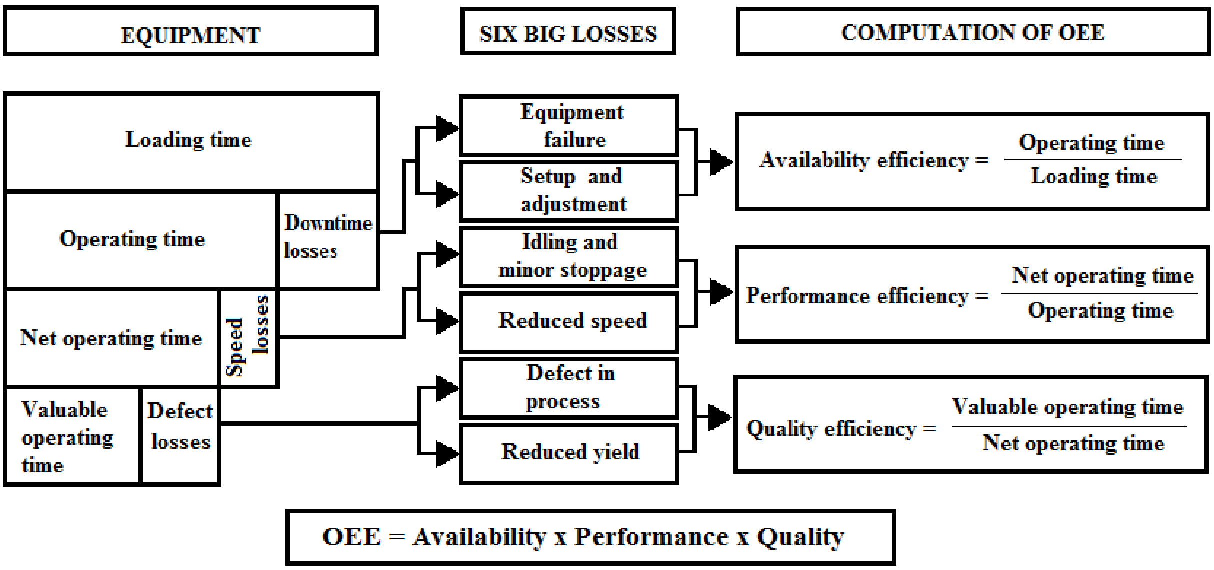


Figure 2: OEE computation and procedure – (Nakajima, 1988)

OEE is a really powerful concept to interpret how well is utilized a machine for a given process in order to optimize this latter. However, data collection takes a great part of responsibility regarding the accuracy of the results. Each machine and process is different, so the method to collect data needs to be justified and reflected to attain the desired outcome. (Nakajima, 1988) proposed a classification of the hidden losses in six categories, more famous as "Six big losses":

- Downtime losses affecting availability: Equipment failure and setup/adjustment.
- Speed losses reducing performance: Idling/short stops and reduced speed of equipment.
- Defect losses acting on the final quality: Defect in process and reduced yield.

Moreover, some other losses could be added to get even more accurate results. Planned maintenance for example can be added or focused maintenance time, where the machine could be turned down while improvements are performed on the system.

3.1.1 OEE and TPM

OEE takes place into a complete program called TPM as mentioned previously.(Bufferne, 2011) claims that Total Productive Maintenance could be seen as a culture that has some goals which are to improve the production system in one hand and the human resources in the other hand. This culture is ruled by several principles which are:

- Machine failures become unacceptable, and conflicts between maintenance and production should be cancelled.
- Cancel dramatic situations, or dramatic ideas.
- Stop getting blurry in equipment cleanness and equipment condition.
- Find root cause of problems.
- Applying continuous improvement.

This cultural change consists of involving production manager responsible for equipment's quality, employees' skills and the organization's efficiency. In a long term, operators have to be able to use equipment according to its conditions of use, to clean it, to indentify pre-failures and fix them by themselves when possible. (Bufferne, 2011)

TPM is constructed on eight pillars (Figure 3), each of them having its specificities described and detailed thereafter.

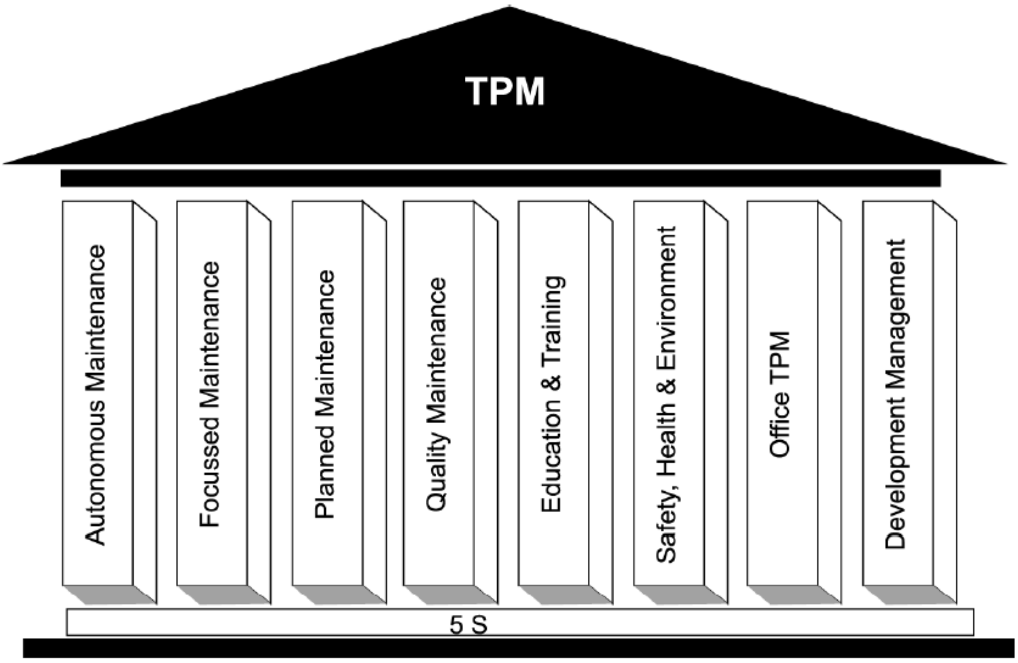


Figure 3: Eight pillars approach for TPM implementation (Ahuja, et al., 2008)

Autonomous maintenance – *Keep the place clean to make maintenance easier to perform*

- Fostering operator ownership

- Perform cleaning – lubricating – tightening – adjustment – inspection – readjustment on production equipment

Focused improvement – *Always look for some new improvements*
- Systematic identification and elimination of 6 losses
- Working out loss structure and loss mitigation through structured why-why, FMEA analysis
- Achieve improved system efficiency
- Improved OEE on production systems

Planned maintenance – *Minimize unplanned failures*
- Planning efficient and effective PM (Preventive Maintenance), PdM (Predictive Maintenance) and TBM (Time Based Maintenance) systems over equipment life cycle
- Establishing PM check sheets
- Improving MTBF (Mean Time Before Failure), MTTR (Mean Time To Repair)

Quality maintenance – *Tend to no scrap*
- Achieving zero defects
- Tracking and addressing equipment problems and root causes
- Setting 3M (machine/man/material) conditions

Education and training – *Involving and enhancing human resource*
- Imparting technological, quality control, interpersonal skills
- Multi-skilling of employees
- Aligning employees to organizational goals
- Periodic skill evaluation and updating

Safety, health and environment – *Make the working area more comfortable*
- Ensure safe working environment
- Provide appropriate work environment
- Eliminate incidents of injuries and accidents
- Provide standard operating procedures

Office TPM – *Extend TPM principles to offices*
- Improve synergy between various business functions
- Remove procedural hassles
- Focus on addressing cost-related issues
- Apply 5S in office and working areas

Development management – *Continuously developing ideas and procedures*
- Minimal problems and running in time on new equipment
- Utilize learning from existing systems to new systems
- Maintenance improvement initiatives (Ahuja, et al., 2008)

The TPM concept is based on 5 S's technique which is detailed in the following part "The Toyota Way: A reference in Lean Manufacturing." To implement TPM, a cultural change inside an organization is required to get everyone aiming for the same goals and directions. This implementation has to be built according to a structure (implementation methodology) described in the coming paragraphs related to change.

3.2 The Toyota Way: A reference in Lean Manufacturing

Lean manufacturing is a technique developed over more than twenty years since the 1950's by the Japanese automotive company Toyota. This technique could be summarized with two terms: Continuous Improvement (Kaïzen) and Respect for People which are the two main pillars of the Toyota Production System (TPS). All the main ideas constituting the fourteen principles presented in the book "The Toyota Way" (Liker, et al., 2004) where developed by Sakichi Toyoda, his son Kiichiro Toyoda and his nephew Eiji Toyoda supported all the way long by Taiichi Ohno. The fourteen principles are summarized in the "4 P" model Figure 4. This model is actually representing the vision of which steps need to be accomplished, in order to become a state-of-the-art industry.

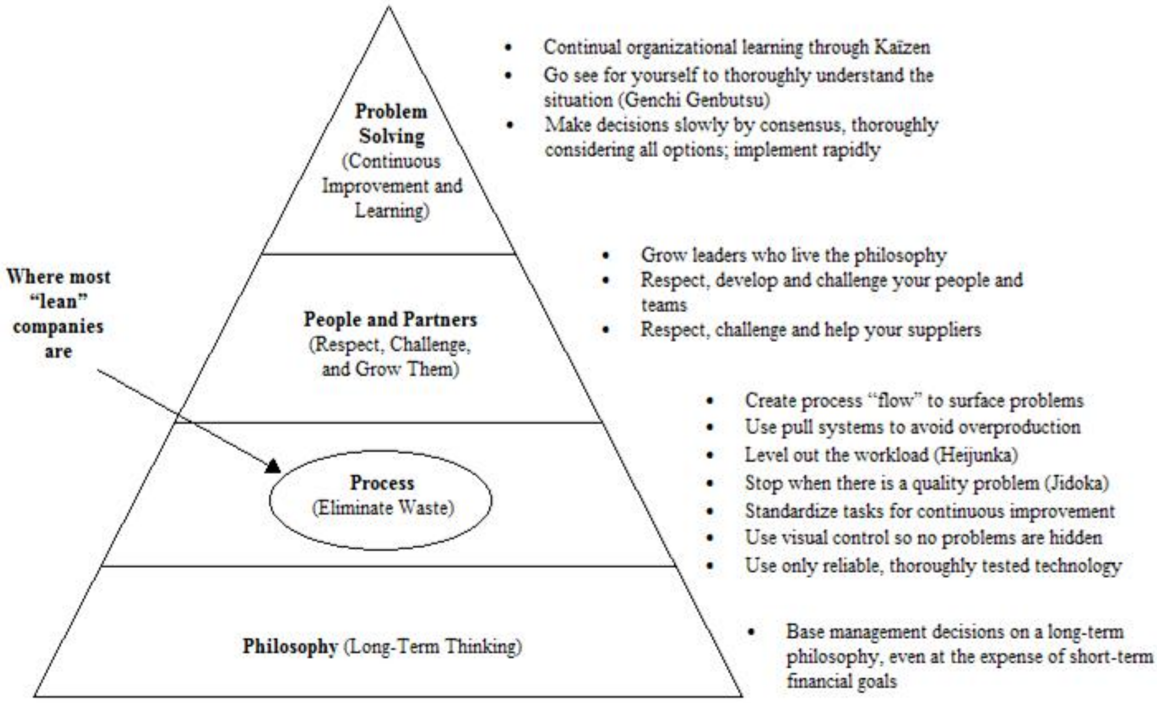


Figure 4: The "4 P" model and where most companies are (Liker, et al., 2004)

To achieve this result, different lean tools exist, each of them having a special function. All these tools are summed up within the Toyota Production System (TPS) in the following Figure 5.

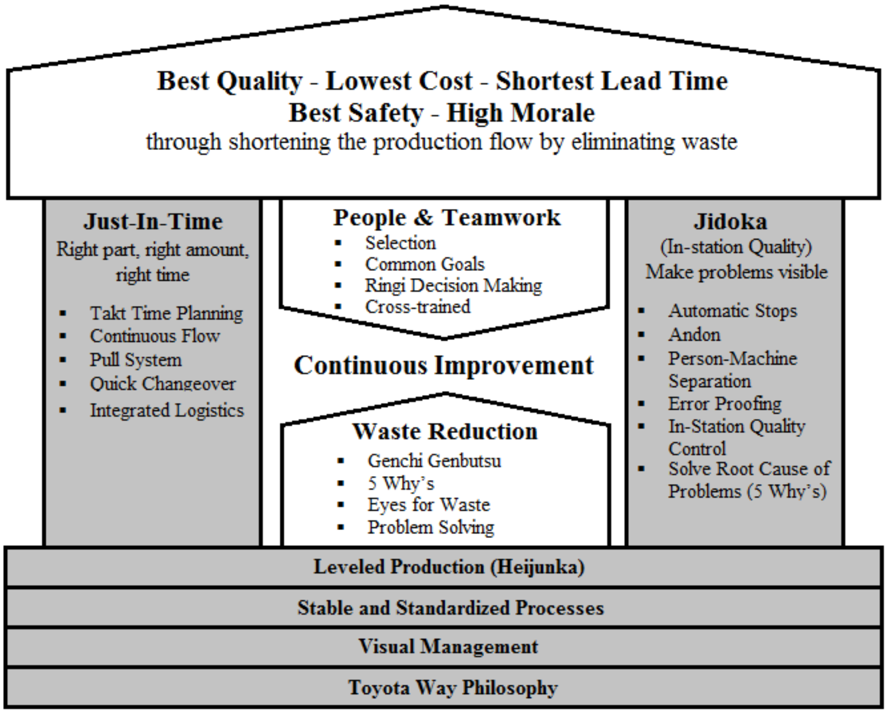


Figure 5: The Toyota Production System (Liker, et al., 2004)

As the study consists of improving one machine only, all the lean tools and aspects should be kept in mind, but not all of them will be required to improve the Overall Equipment Efficiency. The tools and techniques employed are described a bit more in detail through the following parts.

3.2.1 The eight wastes

The Toyota Way is based on the manner to remove the waste. Waste as a whole is divided in eight different categories, and each of them has its particularities. These wastes are detailed as follow by (Liker, et al., 2004):

- *"**Overproduction:** Producing items for which there are no orders, which generates such wastes as overstaffing and storage and transportation costs because of excess of inventory.*
- ***Waiting (time on hand):** Workers merely serving to watch an automated machine or having to stand around waiting for the next processing step, tool, supply, part, etc., or just plain having no work because of stock-outs, lot processing delays, equipment downtime and capacity bottlenecks.*
- ***Unnecessary transport or conveyance:** Carrying work in process (WIP) long distances, creating inefficient transport, or moving materials parts or finished goods into or out of storage or between processes.*
- ***Over-processing or incorrect processing:** Taking unneeded stops to process the parts. Inefficiently processing due to poor tool and product design, causing unnecessary motion and producing defects. Waste is generated when providing higher-quality products than is necessary.*
- ***Excess inventory:** Excess raw material, WIP, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also, extra*

inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times.

- ***Unnecessary movement:*** *Any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking parts, tools, etc. Also, walking is waste.*
- ***Defects:*** *Production of defective parts or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort.*
- ***Unused employee creativity:*** *Losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to your employees."* (Liker, et al., 2004 pp. 28-29)

3.2.2 Level out the workload: Heijunka

When implementing lean manufacturing, the different actors from Toyota were using the word "*muda*" to name the waste. According to them, lean manufacturing could be seen as getting rid of "*muda*". Eliminating only "*muda*" is not sufficient and can even cause dramatic consequences for a company. "*Muri*" and "*mura*" are two other M's added and linked to "*muda*" and create a system (Figure 6).

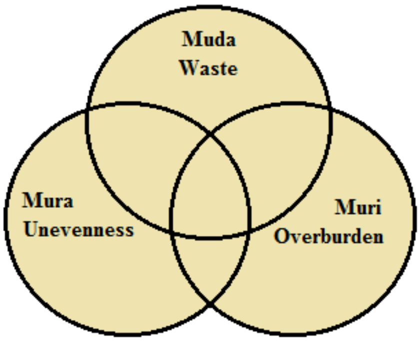


Figure 6: The three M's (Liker, et al., 2004)

*"**Muda: Non-value added.** The most familiar M includes the eight wastes mentioned earlier. These are wasteful activities that lengthen lead times, cause extra movement to get parts or tools, create excess of inventory, or result in any type of waiting.*
Muri: Overburdening people or equipment. *This is in some respects on the opposite end of the spectrum from muda. Muri is pushing a machine or person beyond natural limits. Overburdening people results in safety and quality problems. Overburdening equipment causes breakdowns and effects.*
Mura: Unevenness. *You can view this as a resolution of the other two M's. In normal production systems, at times there is more work than the people or machines can handle and at other times there is a lack of work. Unevenness results from an irregular production schedule or fluctuating production volumes due to internal problems, like downtime or missing parts or defects. Muda will be a result from mura. Unevenness in production levels means it will be necessary to have on hand the equipment, material and people for the highest level of production – even if the average requirements are much lower than that."* (Liker, et al., 2004 p. 114)

3.2.3 The 5 S's

The 5 S's is a visual way to reduce or even to prevent problems. The most important is not to confound 5 S's and lean production. This technique can quickly show good results, so that is why many companies think they are lean after implementing – partly – the 5 S's.

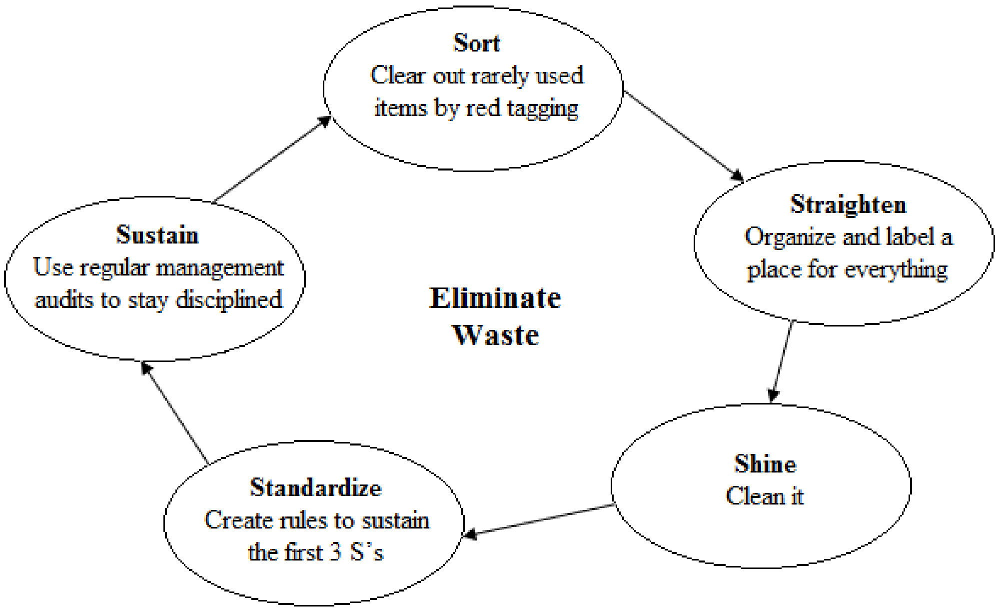


Figure 7: The 5 S's (Liker, et al., 2004)

The previous Figure 7 summarizes the 5 S's cycle that should be applied in order to get rid of the central waste. The 5 S's come from the Japanese terms which are (seiri, seiton, seiso, seiketsu, shitsuke). They have respectively the following meaning:

- Sort: Only what is needed should be conserved. Remove all what never uses.
- Straighten: Every object has its standing place, and has to be there when not in used.
- Shine: Machines especially should be clean. It facilitates maintenance aspects.
- Standardize: Extend a way to keep on the three first S's.
- Sustain: Takes pas of the continuous improvement. Employees should constantly think about what can be improved within this visual control.

3.2.4 Problem solving

Problems of any kind are always taking place in any organization. That is the reason why it could be useful to analyze and to follow the procedure described in Figure 8. It seems to be a helpful device to solve problems of any kind, as the procedure does not differ much from one problem to another.(Liker, et al., 2004)

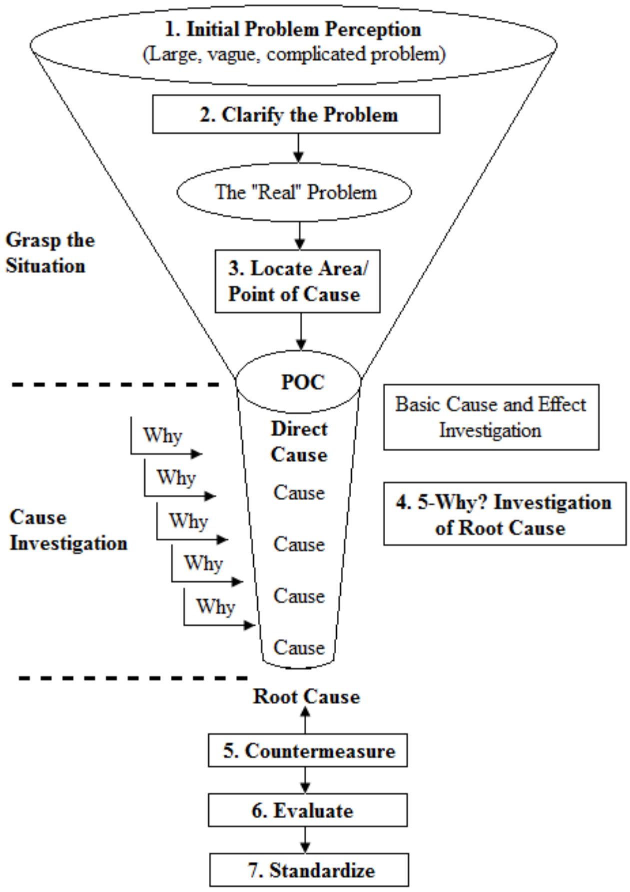


Figure 8: Toyota's practical problem-solving process (Liker, et al., 2004)

As long as a problem is detected – important or not – it has to be treated. From its detection is able to start the next steps narrowing down to the point of cause (POC). The "5 Why's" method described thereafter enables the investigation to lead to the root cause. The last three stages are taking and applying measures to solve the problem. An evaluation is required to check if it has been solved and a standardization to sustain the problem solving.(Liker, et al., 2004)

3.2.5 The 5 Why's

The "5-why's" is a method employed to develop root cause analysis. It can be used whenever a problem occurs, and is especially utilized within any maintenance field. The technique consists of asking five times "why" does a certain situation happen. On the following Table 2 is an example of how could be implemented the 5 why's.(Liker, et al., 2004)

Level of Problem	Corresponding Level of Countermeasure
There is a puddle of oil on the shop floor	Clean up the oil
Because the machine is leaking oil	Fix the machine
Because the gasket has deteriorated	Replace the gasket
Because we bought gaskets made of inferior material	Change gasket specifications
Because we got a good deal (price) on those gaskets	Change purchasing policies
Because the purhcasing agent gets evaluated on short-term cost savings	Change the evaluation policy for purchasing agents

Table 2: The "5-Why" investigation question (Scholtes, 1998)

This method has a strong link with observation. Indeed, there is no better way than seeing a problem occurring, and investigating how it occurred by observing. Experience from operators – if the technique is applied to a machine – is really important as well, as they are used to perform a task or to run equipment.
A good way to come up to the five why's proposed by (Liker, et al., 2004) in "*The Toyota Way*" is to go and see what really happens, analyze the situation, use *andon* to surface the problems, and to ask "why" five times until a solution comes up to reach the root cause.

3.2.6 Standardize tasks

According to "*The Toyota Way*" from (Liker, et al., 2004), standardizing tasks is an important manner to lead to continuous improvement. A task has to be carefully analyzed before being standardized. This will be the basis of any further work, so standardization needs to be strong and well done. Standardization needs to come after the implementation of a new process, otherwise all that have been learned so far is left aside, and there is no base for any continuous improvement. So it is important to know that standardization and learning are really complementary.
Also the famous automotive CEO Henri Ford (Ford, 1988) mentioned that *"if you think of standardization as the best you know today, but which is to be improved tomorrow, you get somewhere. But if you think of standards as confining, then progress stops."*(Ford, 1988 p. 81)

3.2.7 Visual Control

The visual control is linked with observation. A visual control can be useful for diverse applications. A previous example was mentioned with the 5 Why's. Another example is that an andon can be used to avoid big problems which would force to stop the machine for hours or days. Andon is a manner used in many industries nowadays by putting a light on top of each machine to make problems easier to see. Visual control in a more global way can be used as well, employing for example the "genchi genbutsu". This term consists of going on site to face the reality in order to detect and to sort out all the types of problems that could happen along a process.(Liker, et al., 2004)
Not only managers should practice this technique, but also operators themselves. It is a good way to involve every actor in the development phases, and to make everyone aware of the reality. All what is seen should be recorded – on a paper or by a video – in order to be analyzed later on.

3.2.8 PDCA: Plan – Do – Check – Act

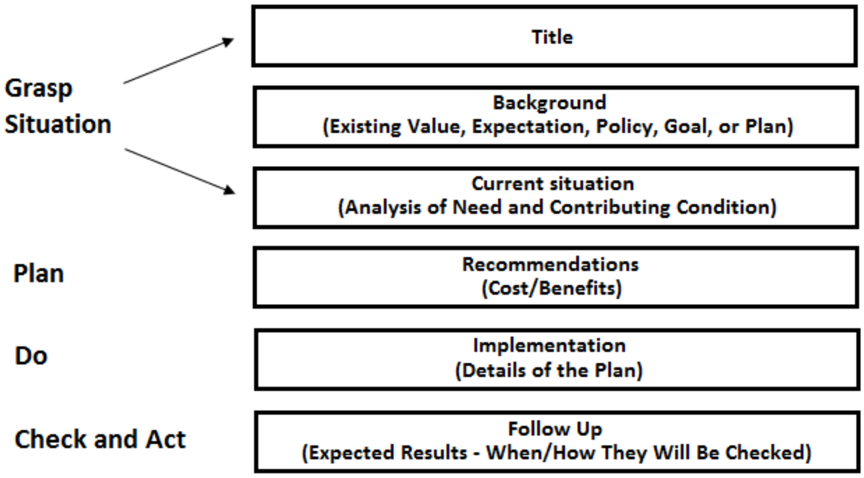


Figure 9: Plan-Do-Check-Act in the proposal process (Liker, et al., 2004)

Figure 9 is a visual summary of what PDCA is. PDCA is based on organizational learning and could be applied at any level of a company. This process is employed when a new directive, product or service has to be implemented within a group or a company. Self-reflection and observations constitute the early stages of this process which is to grasp the situation. When the basis is strong enough, some plans can be built involving costs and benefits to get out the parameters that are implied. “Do” step, corresponds to the implementation phase, where some trial runs on a new product for example can be realized. Right after this step, comes the checking step in which expected and actual results are compared. The “act” step consists of smoothing the process by creating a flow based on the good results previously obtained.(Liker, et al., 2004)

3.2.9 The suppliers’ place

A principle enounced in “*The Toyota Way*” (Liker, et al., 2004) is that partners and suppliers have to be respected. It is really important for any company to find and to deal with solid partners. The concept is to begin dealing with some suppliers, and challenging them to evaluate how strong they could be to respond to stretched targets. Quality, costs and delivery are the key factors to determine if a supplier can match or not. A supplier replying to the offer considering and respecting those conditions has great chances to get involved further within the supply chain.

Hiring an external vendor or outsourcing products can be sometimes complicated. The external partner does not have the same perspective and common goal as the hiring company, so troubles might happen regarding the quality and delivery time especially.

“Respect your extended network of partners and suppliers by challenging them and helping them to improve.” (Liker, et al., 2004 p. 199) It means that every actor of the supply chain should work hand in hand, to produce a better development to each others. Several learning enterprises represent the highest form of lean.

3.2.10 Operators and leaders

Respect for people comes as an essential aspect of "*The Toyota Way*" (Liker, et al., 2004) principles. Respect for people according to (Liker, et al., 2004), is that it is not based on love for an individual or another. Every employee should be seen as a useful part of the chain. Indeed, without employees, there would be no work done. However, respect for people does not mean that employees are allowed to waste their time. The whole relationship is based on confidence regarding mind and capability. It is a mutual task, between two operators, between operators and leaders, all working for the same reason: earning money to feed their families.

A very famous phrase through Toyota factories is *"Before we build cars, we build people"* (Liker, et al., 2004 p. 182). It is short but means a lot. Building people is one of the leaders' tasks, and the best leaders for the brand Toyota were made of common traits:

- *"Focused on a long-term purpose for Toyota as a value-added contributor to society.*
- *Never deviated from the percepts of the Toyota Way DNA and live and model them around this for all to see.*
- *Worked their way up doing the detailed work and continued to go to the gemba – the actual place where the real added-value work is done.*
- *Saw problems as opportunities to train and coach their people."*
  (Liker, et al., 2004 p. 182)

Leaders within the Toyota Corporation have to encourage people and need to have an accurate understanding of the work which is done on the shop-floor. A leader who does not really understand what is the added-value work, could be called a facilitator. Facilitators are mandatory as well, because they are skilled to teach and motivate people to reach common goals. The most important for a leader is to practice *genchi genbutsu* which consists of observing what happens within a workshop, and to encourage people, especially those who have a great technical knowledge. This will be the most effective approach to make good decisions.

3.3 The SMED System: Shigeo Shingo's vision

SMED is a technical term which means Single Minute Exchange of Die. This technique is mostly employed to increase the OEE in order to shorten the changeover time (time while the machine is down). This part consists of gathering the best information available within his book "*A revolution in manufacturing: The SMED system*" (Shingo, 1985).

Shigeo Shingo is a Japanese man who has been collaborating with Toyota in the late 70's, but started dealing with the SMED system for Toyo Industries in 1950 for a study. His principal action plan was to investigate the possible time reduction that could be saved when changing tools regardless of the machine. His vision is to save time for a certain task. Shigeo clarifies his vision with the formula one example. Indeed, if a random person is able to change four wheels of a car in about one hour, a pit-stop crew in formula one racing is able to switch four wheels in eight seconds. The crew also fills up the tank during this amount of time.(Shingo, 1985)
According to Shingo, SMED is a technique largely based on theoretical aspects and years of experimentation and training. He points out the fact that this scientific approach, tends to reduce changeover time could be applied to any factory and to any machine.

3.3.1 How to implement the SMED system

After nineteen years of development since 1950, Shigeo realized that there exist two types of setup operations:

- **Internal setup:** setup that can be performed when the machine is stopped only.
- **External setup:** setup that can be performed when the machine is still running.

"A new die can be attached to a press, for example, only when the press is stopped, but the bolts to attach the die can be assembled and sorted while the press is operating." (Shingo, 1985 p. xxii)
In many industries not applying lean tools, internal and external setup operations are confused. For example, some setups that could be performed while the machine is running are performed while the machine is down instead, which lets the machine standing still for a useless period.

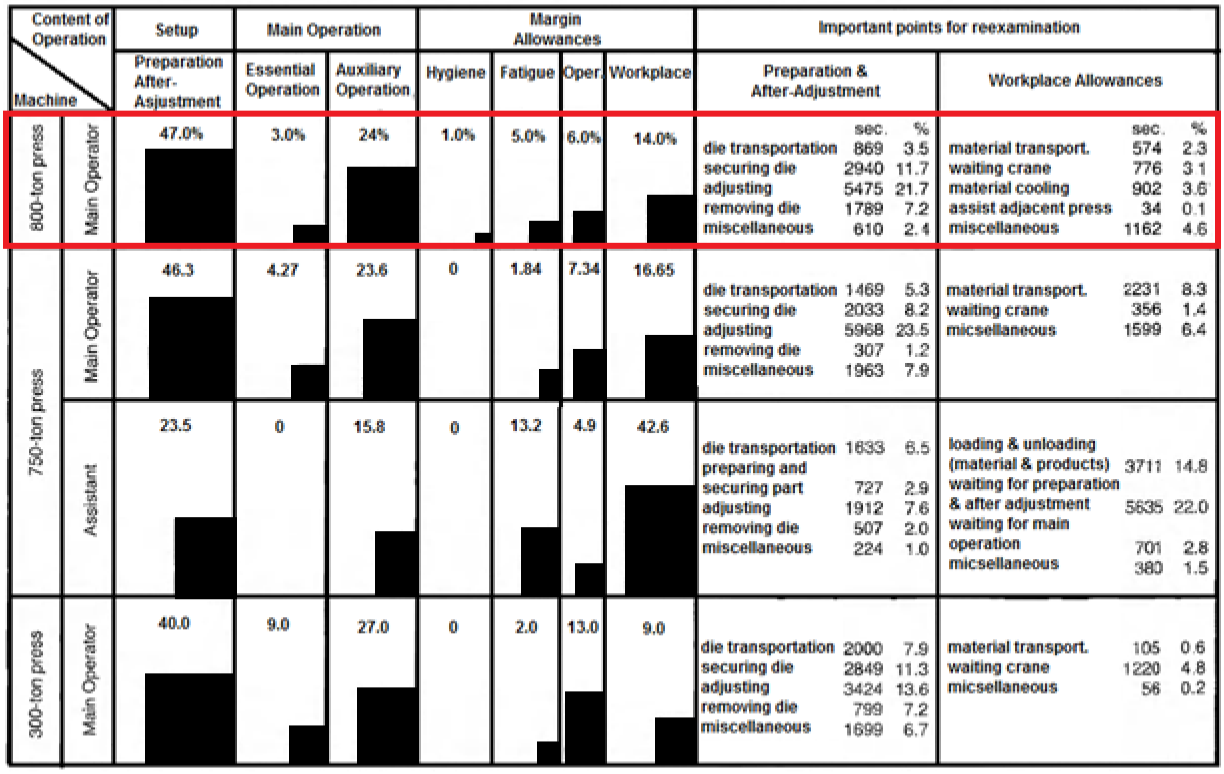


Figure 10: Production Analysis of a Large Press (Shingo, 1985)

Figure 10 gives an overview of how could be analyzed a press before starting any kind of tool implementation. This is the first step to get a clear understanding about how the press is working.

Preliminary stage: Data collection

When planning to implement SMED, the reality and the set of actions happening on the actual shop floor should be studied in detail. Some methods to collect data exist in order to perform the SMED implementation. The way to collect data needs to be chosen according to the available resource, and what is the expected outcome. The methods are summed up by the following list:

Stopwatch: A production can be analyzed using a stopwatch and reporting the times on a paper sheet which gives a good approach. This technique however required to be skilled and takes a large amount of time.

Sampling study: Samples can be used to note what happens during a changeover time. This manner works, but requires a long period of time. Indeed, to be accurate, the operation should be repeated a great amount of time.

Interviewing workers: Interview workers could give many points of view about what could be improved especially, which all those points of view together, give a quite useful approach.

Videotaping: Recording video of a die changing is a powerful way to be accurate. Indeed, it is possible to go back at any time to check what is happening during the operation.

"At any rate, even though some consultants advocate in-depth continuous production analyses for the purpose of improving setup, the truth is that informal observation and discussion with the workers often suffice." (Shingo, 1985 p. 29)

Stage 1 : Separating Internal and External Setup

This first stage is probably one of the most important when implementing SMED. As mentioned earlier, making difference between both internal and external setups can be noteworthy in time cutting.

It is obvious that maintenance of dies, or preparation of die need to be performed while the machine is down. However, Shigeo claims that it is astonishing to observe how many campnies do wrong.

By distinguishing those setups, normal setup time could be reduced by 30% - 50%. "*Mastering the distinction between internal and external setup is thus the passport to achieving SMED."* (Shingo, 1985 p. 29)

Stage 2: Converting Internal to External Setup

In the first stage, just separating internal and external procedures can reduce normal setup time by 30% to 50%. This step is pretty good, but not enough to reach the real SMED objectives.

The second stage presented here consists of converting internal setup to external. However, two fundamental aspects have to be considered:

- Operations should be analyzed in detail to know if some steps are wrongly supposed internal.
- Ways to convert these steps to external setup should be defined.

"Operations that are now performed as internal setup can often be converted to external setup by re-examining their true function. It is extremely important to adopt new perspectives that are not bound by old habits." (Shingo, 1985 p. 30)

Stage 3: Streamlining All Aspects of the Setup Operation

After converting to internal setup, there is one more step – which can be linked with stage 2 – which is to focus effort to streamline each crucial internal and external operation. This third stage is a detailed analysis of each elemental operation.

Shigeo exposes some examples of companies in which stages 1, 2 and 3 were successful:

"At Toyota Motor Company, the internal setup time of a bolt maker – which had previously required eight hours – was cut to fifty-eight seconds.

At Mitsubishi Heavy Industries, the internal setup for a six-arbor boring machine – which had previously required twenty-four hours – was reduced to two minutes and forty seconds.

Stages 2 and 3 do not need to be performed sequentially; they may be nearly simultaneous. I have separated them here to show that they nonetheless involve two notions: analysis, then implementation." (Shingo, 1985 p. 30)

3.3.2 Suggestions of improvements

- **Improving transportation of dies and other parts**

Generally, parts or dies have to be transported from the place where they are stored to the machine. After the process, they go back to their storage area. It is obvious that to save time, this transportation operation must be performed while the machine is running, either by the operator, either by a second person assigned to this task.

Thereafter is an interesting interview from Shigeo Shingo, given to a press factory foreman:
"One factory I worked with conducted setup operations on a large press by extracting the die on a moving bolster. A cable was attached to the die, which a crane then lifted and conveyed to the storage area. I suggested a number of changes to the shop foreman:
Have the crane to move the new die to the machine beforehand.
Next, lower the old die from the moving bolster to the side of the machine.
Attach the new die to the moving bolster, insert it in the machine, and begin the new operation.
After that, hook a cable to the old die and transport it to the storage area.
"That's no good," the foreman argued. "Cables would have to be attached twice, and that's inefficient."
"But", I replied, "It takes four minutes and twenty seconds to transport the die to and from the machine. If the press were put into operation that much earlier, you could manufacture about five extra units in the time you would save. Which is preferable, attaching the cables only once or producing five extra products?" The foreman agreed right away that he had been looking at the setup operation the wrong way, and the new system was implemented immediately.
This example illustrates a tendency of people on the shop floor to be distracted by small efficiencies while overlooking bigger ones. Considered on a deeper level, it shows the need for front-line management to understand internal and external setup thoroughly." (Shingo, 1985 p. 35)

- **Function standardization**

Function standardization is a technique that aims to remove small adjustments between two processes. It tends to get the same setting parameters for different devices.
"Efficient function standardization requires that we analyze the function of each piece of apparatus, element by element, and replace the fewest possible parts. The example below (Figure 11) illustrates the principle of function standardization." (Shingo, 1985 p. 43)

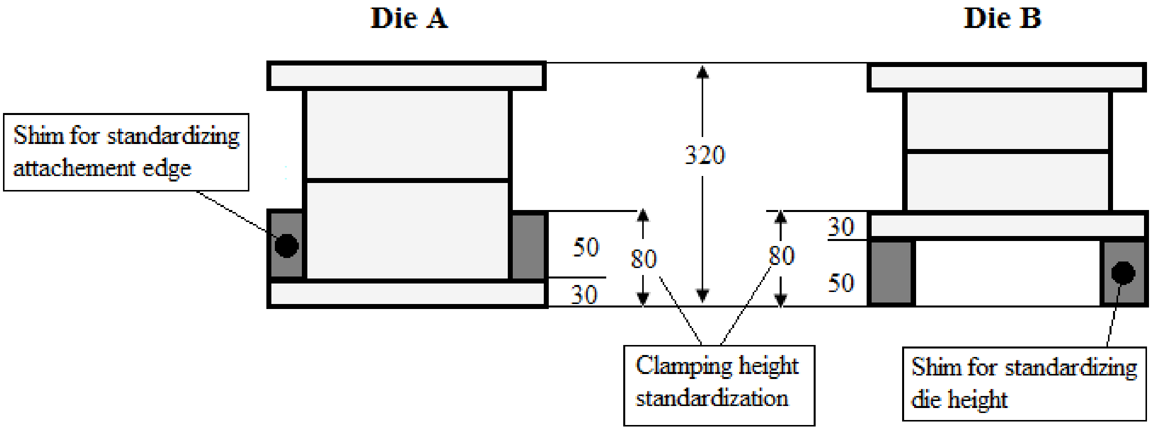


Figure 11: Standardization Height of Die and Attachment Edge (Shingo, 1985)

Screw is the "standard" way to secure a part or a device. However, it does not mean that screws need to be used to secure any piece. Basic functions should be cautiously analyzed, and in many cases, long and big screws are not required. The direction in which the effort should be applied the force required have to be known, and a less costly and faster method can be employed. (Shingo, 1985)

An important citation from Shigeo Shingo has to be considered, in order to get "out of the box". Indeed, intuition is good, but needs to be left beside to go ahead.
"In my frequent visits to factories, I often tell the foremen: "Since you are not so convinced of the value of determining settings by intuition, just do it three times on the same machine. If you get the same results each time, then there's no problem. If you get good results only twice, then the method has to be abandoned." (Shingo, 1985 p. 66)

- **One-touch concept**

The concept presented in this part is supported by an example of limit sensors. Let is admit that five different parts need to be detected according to their process in different location. Instead of moving one switch between each process, the concept is to link five sensors to five electric switches. The example is described on the following
Figure 12:

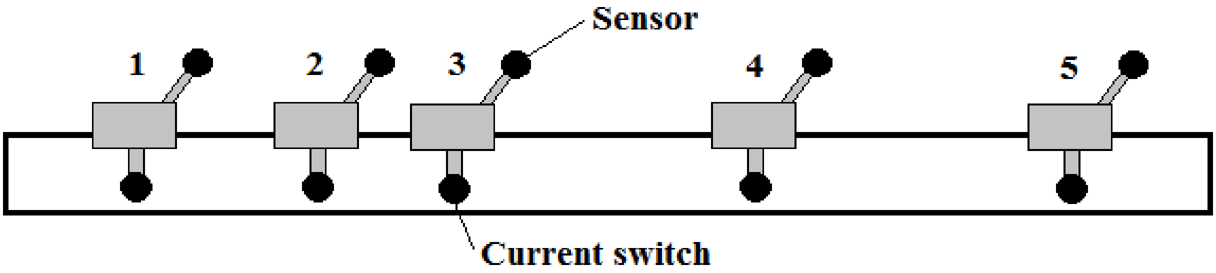


Figure 12: Changing limit switches (Shingo, 1985)

If the third sensor has to be the one activated, then the third switch should be turned on. In this case, all the others remain off and will have no effect on the detection.

"This arrangement made it possible to perform setup simply by flipping a switch. It demonstrates the successful application of the "one-touch" concept. Using this technique, it became possible to change limit switches in less than one second." (Shingo, 1985 p. 86)

- **Mechanization of die tightening and loosening**

To ease the dies securing phase for example, a remote control could be used to tighten and loosen it. It could be a device driven either by air or by oil pressure. It could be cost effective, but could be faster to perform than regular screws, especially on large machines.

However, to excessive and complex mechanization can have dramatic effects on the improvement, and its maintenance costs could interfere with the actual benefits. (Shingo, 1985)

3.3.3 Similar case study: the effects of SMED

In his book "*A revolution in manufacturing: the SMED system*", Shigeo Shingo describes some actual case studies he has been performing previously. Table 3 summarizes the best improvements that have been achieved, showing the previous required time and the new changeover time after implementing SMED.

No.	Company	Capacity (in tons)	Before Improvement	After Improvement	1/n
Presses (single shot dies)					
1	K Auto	500 t-3 machines	1 hr 30 min	4 min 51 sec	1/19
2	S Auto	300 t-3 machines	1 hr 40 min	7 min 36 sec	1/13
3	D Auto	150 t	1 hr 30 min	8 min 24 sec	1/11
4	M Electric	"	2 hr 10 min	7 min 25 sec	1/18
5	S Electric	"	1 hr 20 min	5 min 45 sec	1/14
6	M Industries	"	1 hr 30 min	6 min 36 sec	1/14
7	A Auto Body	"	1 hr 40 min	7 min 46 sec	1/13
8	K Industries	100 t	1 hr 30 min	3 min 20 sec	1/27
9	S Metals	"	40 min	2 min 26 sec	1/16
10	A Steel	"	30 min	2 min 41 sec	1/11
11	K Press	"	40 min	2 min 48 sec	1/14
12	M Metals	"	1 hr 30 min	5 min 30 sec	1/16
13	K Metals	"	1 hr 10 min	4 min 33 sec	1/15
14	T Manufacturing (dies for springs)	80 t	4 hr 0 min	4 min 18 sec	1/56
15	M Ironworks	"	50 min	3 min 16 sec	1/15
16	H Engineering	50 t	40 min	2 min 40 sec	1/15
17	M Electric	"	40 min	1 min 30 sec	1/27
18	M Electric	"	50 min	2 min 45 sec	1/18
19	H Press	30 t	50 min	48 sec	1/63
20	K Metals	"	40 min	2 min 40 sec	1/15
21	Y Industries	"	30 min	2 min 27 sec	1/12
22	I Metals (multiple dies)	"	50 min	2 min 48 sec	1/18
23	S Industries (progressive dies)	150 t	1 hr 40 min	4 min 36 sec	1/22
24	K Metals	100 t	1 hr 50 min	6 min 36 sec	1/17
25	M Electric	100 t	1 hr 30 min	6 min 28 sec	1/14
				Average	1/18

Table 3: Time reduction achieved by using SMED(Shingo, 1985)

- **Stockless production**

Producing small-lots and with a high-diversity is a nowadays trend. It enables a quicker response to get the customers' satisfaction, but might cause some troubles when changing production. So, high-diversity and small-lot of products, lead to the fact that more setup operations are required. The challenge is thus to reduce of this setup phase in order for the company to stay competitive.
When a company decides to deal with the minimal inventory level – which refers to lean manufacturing – some effects can occur, and they can be the following ones:

- *"Capital turnover rates increases.*
- *Stock reductions lead to more efficient use of plant space. (For example, the manager of a Citroen factory told me that twenty-two days' worth of inventory had been reduced to eight days' worth after SMED was adopted. He said this made the planned construction of a new building unnecessary.)*
- *Productivity rises as stock handling operations are eliminated. (Production in the Citroen plant cited above rose 20 %.)*
- *Unusable stock arising from model changeovers or mistaken estimates of demand is eliminated.*
- *Good are no longer lost through deterioration.*
- *The ability to mix production of various types of goods leads to further inventory reductions."* (Shingo, 1985 pp. 113-116)

- **Increased machine work rates and productivity capacity**

"If setup times are drastically reduced, then the work rates of machines will increase and productivity will rise in spite of an increased number of setup operations." (Shingo, 1985 p. 116)

- **Elimination of setup errors**

From standardizing tasks and functions, setup are less and less required. Setup errors are reduced, and the elimination of trial runs lowers the incidence of defects.

- **Increased safety**

When the operator has to deal with simpler setup, there is less risk for the person to be hurt. Some training might however implemented if new techniques are taking place within the setup operation, in order for them to be done by the right way.

- **Simplified housekeeping**

Standardization is linked with 5 S's. All what is useless is thrown away and the mainly used materials are arranged in an easier and more effective way.

- **Decreased setup time**

Man-hours are consequently dropped when the SMED is implemented as the setup phases are done much faster.

- **Operator performance**

After implementing SMED techniques, a tool changing is fast. The operator will agree that there are no longer any reasons to avoid changing the tool. His willingness to work would be even higher later on, which involves a growth in quality.

- **Lower skill requirements**

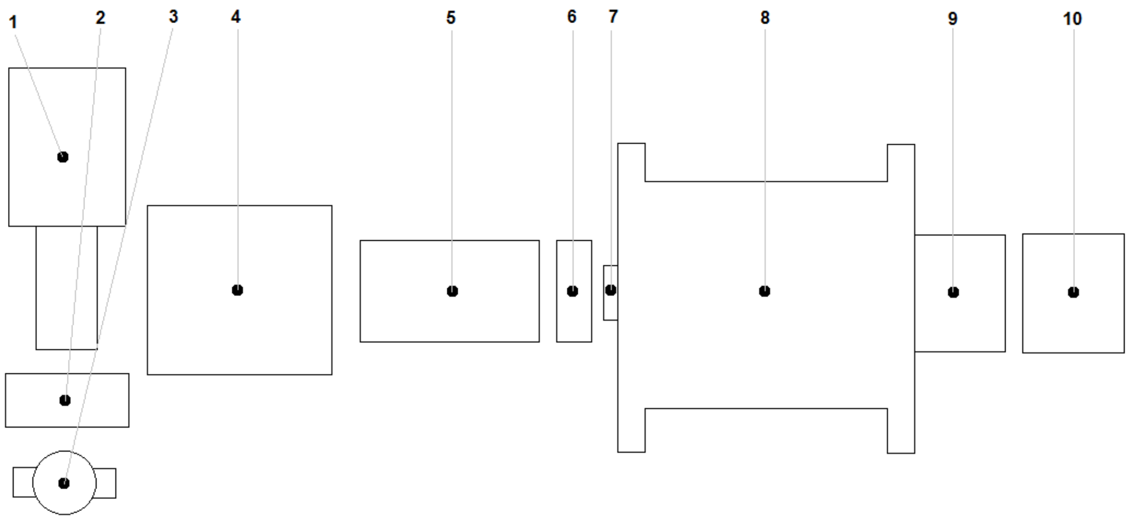
Skilled workers are not anymore required as changing tool became easy and quick.
"I once observed a setup operation for helical gear on a gear-cutting machine at a Citroen plant in France. By using SMED, an unskilled worker in charge of the machine was able to complete in seven minutes and thirty-eight seconds an operation which previously had taken a skilled specialist about an hour and a half to perform."(Shingo, 1985 p. 117)

3.4 Using SMED on a 500-tons press

In his book, Shigeo Shingo presents an example with a case study conducted at Sarunage plant. The example consists of applying SMED to a 500-tons press producing interior fittings for cars. 70000 parts were produced per month in average, and within the same period of time, dies had to be switched between eight and a hundred of times.

Those parameters involve a large lot production and lead to losses. It is then obvious that decreasing the amount of time spent to change dies is a precious advantage.
The changeover time has been cut-off from thirty minutes in 1977 to a bit more than four minutes in 1982. This performance has been achieved applying the following techniques presented in this part.

On Figure 13 is exposed the layout on-top viewed of the press, with the different elements composing the hole equipment.



No.	Name of Machine	Setup Operation
1	uncoiler	coil change
2	coil lift car	transport operation (between [1] and [3])
3	coil changer	new coil preparation and old coil storage
4	leveler	operation to regulate thickness
5	looper table	operation to raise and lower table
6	coil centering apparatus	coil centering adjustments
7	coil feed regulator	coil feed regulation
8	500 ton press	die attachment and removal
9	product ejection conveyor	set conveyor position
10	polyethylene box changer	positioning and storage

Figure 13: Setup procedures on 500-ton press line (Shingo, 1985)

After being aware of the setup operations required to run the press with a new production, Shigeo has been able to distinguish the internal and external setup. The aim of the first steps was to reduce those internal setups, and all improvements ways are summarized in the following Table 4.

Operation	Item	Details of Improvement	Result
Internal setup			
1. Upper and lower die clamping bolt removal		Assign bolts exclusively to this operation and modify storage methods	Reduced adjustment time for bolt attachment and removal
2. Die removal transport		Explained in improvement example [3]	Transport to die storage area is moved to external setup
3. Bolster, ram cleaning			
4. Die transport		Improved retrieval of dies from storage (numerical, color coding). As in item 2, transport to press in external setup	Delivery to press is moved to external setup
5. Die positioning		Explained in improvement example [1]	Positioning with a scale; gauge adjustment operations are eliminated
6. Attachment of upper and lower die sections		Provide attachment U-grooves in dies; do away with blocks	
7. Stroke adjustments		Standardize die-heights	Elimination of stroke adjustment operations
8. Material feed pitch adjustments		As in improvement example [2]	Elimination of trial runs on the basis of feed pitch scale measurements and adjustment operations
9. Align material feed centers		Install cassette width gauges by raw material type	Elimination of material feed center alignment operations
10. Oil feed adjustments for press coils		Imprved method uses 3-step (high, middle and low) oil feed cocks, thus making fine adjustments easier	Reduction in oil feed adjustment time
11. Chute setting		Sectional dies make this a one-touch operation	Attachment time reduction
12. Air hose attachment		Group air hoses	Attachment time reduction
13. Trial run			
External setup			
1. Coil transport		Improved methods of retrieving dies from storage (numerical, color codes)	Reduced time for selecting coils put aside for storage
2. Coil disposal		Use a speed vise for final disposal of coils after use	Reduction in coil disposal time
3. Uncoiler		Install a rotating coil holding rack near uncoiler and eliminate coil changing and transport operations	Elimination of internal setup transport from coil storage area to uncoiler
4. Settings on coiler leveler		Bring down to the single minute range by linking the two leveler plate thickness adustment handles together with a chain	Reduction of leveler plate thickness adjustment time
5. Scrap disposal		Attach light for summoning lift	Does away with waiting for transport device

Table 4: Outline of improvements (Shingo, 1985)

Detailed improvements will not be shown in this part, but are available to consult in chapter 13 of "*A revolution in manufacturing: The SMED system"* (Shingo, 1985).
Table 4 however gives an idea of the type of improvements that can be done without doing a lot of expanses. It takes time to get obvious results, but it is clear that it works when applying theoretical techniques in a right way.

3.5 A 300 tons coil-fed press case study

A similar case study dealing with a 300 tons press is presented by Gary Zunker in his article (Zunker, 2003). The author had to improve the changeover time on this machine, and achieved to some good results without high expenses and without a long period of time. He reduced changeover time from 30 minutes to 10 minutes.

His main action was to analyze with the operators the different setup operations required to change die. They carefully analyzed what they recorded on a videotape, in order to see themselves what went wrong. The next step for all of them was to sort what they recorded, with the help of pockets of time so they could produce a graphic to see which operations took the largest amount of time. (Figure 14)

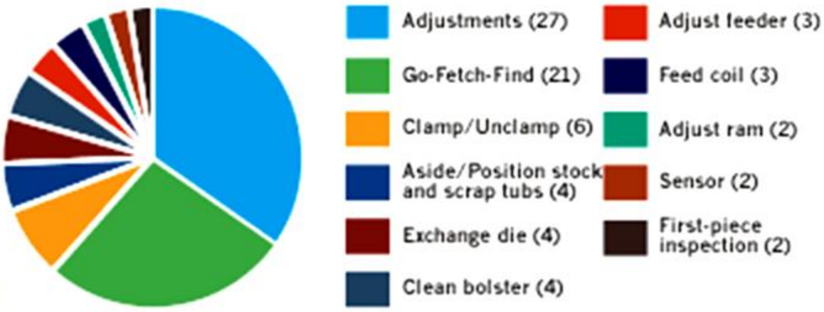


Figure 14: Pockets of time for 300 tons press (Zunker, 2003)

After this step, their common task was to extract the operations that could be done externally, or that could be reduced in term of time consumption. Just to reduce the time consumption, new strategies and designs had to be done to optimize the time required to complete a certain operation.

Layout changes and standardization were not left beside. All these aspects that can optimize the changeover time were taken into consideration. The last step was to build-up a schedule in order to define and to reach short-term goals. At the end of this analysis, employees were able to come up with a list of things that can be eliminated (waste). This list is the following one:

- Too many wrenches, no socket wrench on open-back inclinable presses
- No preplanning
- Too many turns to tighten bolts
- Too much time spent on go-fetch-find
- Operator has to get off fork truck to load and unload die
- No pre-staging of die or material
- Carts filled with odd-sized T bolts at each press
- Lack of labeling on die storage racks
- Clamping strap used instead of one-piece clamp
- Congested layout
- No standardized wheeled baskets

Getting rid of this waste does not cost a lot of money, and is easily achievable by any company according to Gary (Zunker, 2003). Many metal stamping companies are around the same level, and it is obvious that changeover time could be reduced by some efforts to surface the problems, to fix them, and to train staff in order to sustain. However, investing money into new equipment or considerably changing the layout of a plant could even better improve a changeover time.

3.6 Leading Change: The theoretical aspects

In every business willing to implement new techniques and methods, the organization cannot only input them within the system and wait for some results. A long step of organizational change has to be performed forward and during the implementation phases. Changing an organization requires great skills and motivation to succeed. The “guru” in term of change within any kind of organization is John P. Kotter, a pioneer who worked, learned and developed his change vision over 30 years he spent to observe and to help companies through this development.

As the business world is nowadays constantly and rapidly evolving, any companies have to aim towards development for a better future. The book “*Leading Change*” from (Kotter, 1995) is a great support in order to change a company. “Beyond change management” from (Anderson, et al., 2010) has also been studied to reinforce the scientific aspects of this part. The most important parameters to have in mind before changing an organization will be described in the coming paragraphs.

3.6.1 Quick history of organizational change

It is only after the year 1970 that leaders in general began to understand what organizational change could be. Before this period, the most important was to run the company based on a current state. During this decade, innovation, technologies and environmental cares began to disturb many companies, and were involved to apply some restrictions. Change had its full place for organizations willing to stay competitive on the market.(Anderson, et al., 2010)

What is a leader?

Many different definitions of what is a leader are available. One seemed relevant from different reading through different kind of sources, which is the following comparison that Heifetz and Laurie made in their article “*The work of leadership*”:

> *”Followers want comfort and stability, and solutions from their leaders. But that’s babysitting. Real leaders ask hard questions and knock people out of their comfort zones. Then they manage the resulting distress.”* (Heifetz, et al., 1997 p. 1)

In other words, this definition is very close to the one that (Kotter, 1995) makes when emphasizing the difference occurring between managers and leaders. He noticed that a manager has to be able and skilled to maintain the current level of the company to make it run stably. He also describes a leader as a person skilled to create a storm within the company, in order that change happens. Kotter also illustrates different kind of leadership by an example. You are a guide with a group of people, and a heavy storm is coming. The goal is to convince everyone to follow the guide towards an apple tree to stay dry. It could be achieved saying “Follow me and now!” or “What about going all together to the apple tree?” The second situation is more adapted due to its formulation. Respect for people is a key parameter to have in mind to make everyone willing to be on the same ship.(Kotter, 1995)

3.6.2 Three kinds of organizational change

(Anderson, et al., 2010) present in their book three different approaches to change according to what the current state is, and according to the goal the organization is willing to reach. The three approaches are presented thereafter to give an overview of what they are, and each of them has its own tricks and solving methods. They are not exposed, but are available in the book from (Anderson, et al., 2010).

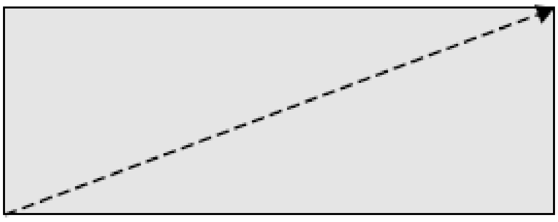


Figure 15: Developmental change (Anderson, et al., 2010)

The previous Figure 15 which is quite basic shows how simple is the developmental change. Its improvement is only the enhancement of the old state which leads to a new one, without following proper rules. This kind of change is relatively slow though its implementation and development phases, and does not show amazing results in term of improvement. (Anderson, et al., 2010)

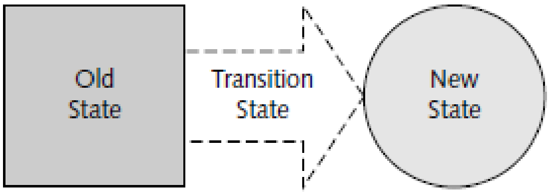


Figure 16: Transitional change (Anderson, et al., 2010)

Transitional change characterized by Figure 16 shows that the step between the old and the new state is more structured. The transition process is based on the old state problem that has been identified. The transition process is however not a random principle that should be applied, but needs to be managed in an accurate manner. Design, implementation and timetables are the main words to classify this change. (Anderson, et al., 2010)

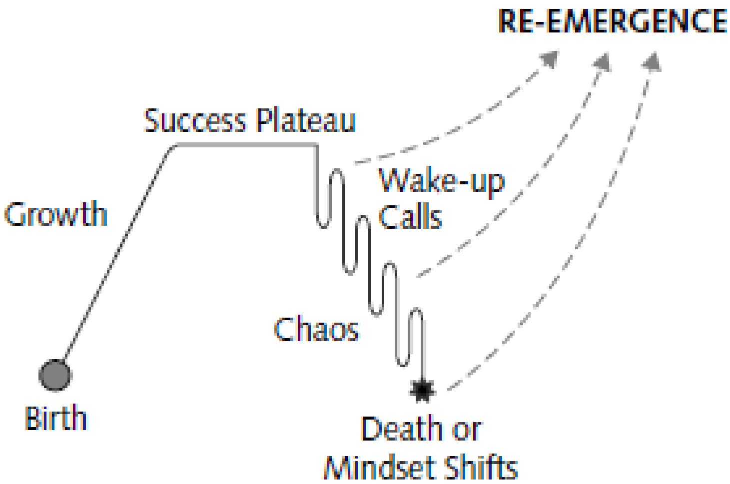


Figure 17: Transformational change (Anderson, et al., 2010)

Figure 17 is describing the most advanced kind of change. It is called the transformational change. It is the most commonly used because it happens when the emergency situation is already rather advanced – for example if a company is close to be dead – or if the emergency situation is created in time. This change is the most powerful to achieve to good results and enable an organization to remain competitive.

At first with this approach, the new state is blurry. It comes from observations, trial and error discoveries, learning, and gives an idea about the actual problem.

The second aspect is that to reach the new state, an organization has to set principles, change behaviors and culture, all designed and managed accurately by the business direction.(Anderson, et al., 2010)

In the next paragraph are explained in a more detailed way, the different steps that an organization must follow to change properly.

3.6.3 Going forward through leadership and transformational change with Kotter

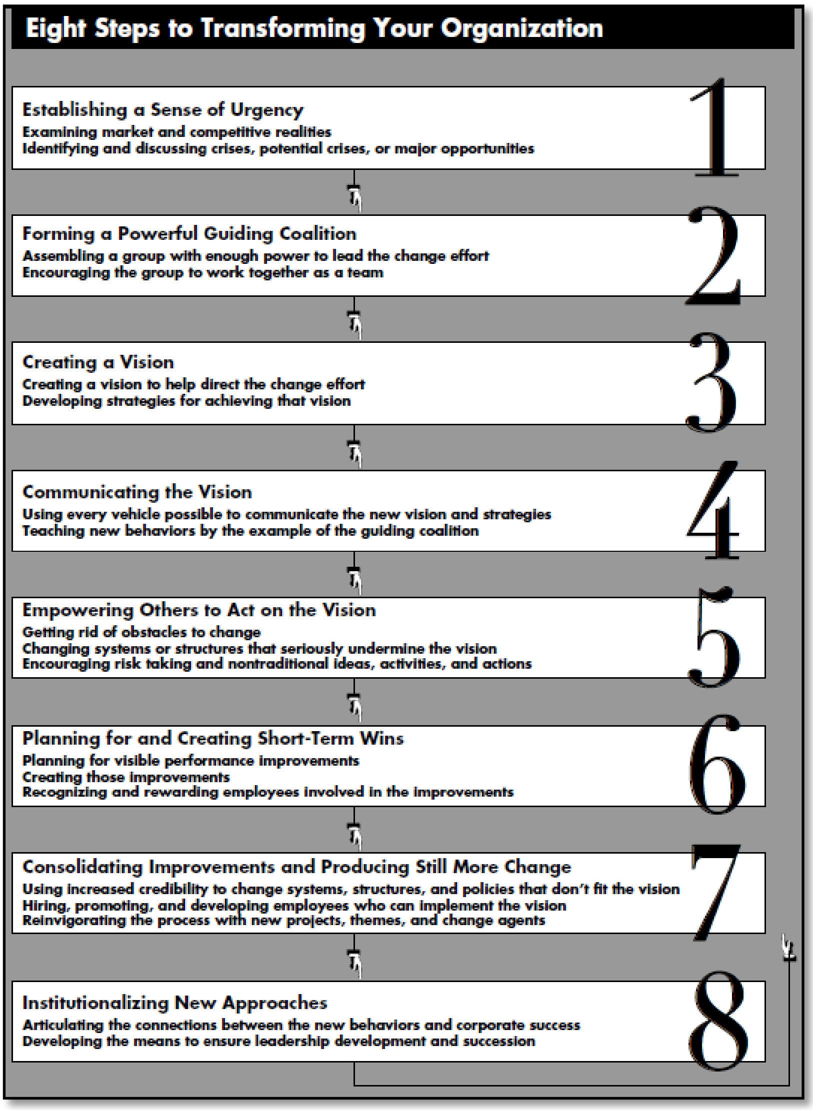


Figure 18: Eight steps to transforming your organization (Kotter, 1995)

The previous eight steps in Figure 18: Eight steps to transforming your organization that Kotter presents are taken from an article "*Why Transformation Efforts Fail*" he wrote concerning the failures that come-up the most often when applying change methods within an organization. This is based on real applications, which means that its reliability is pretty high. Being aware of the failures is a very good aspect to have in mind, but not enough. That is why the next step was to read Kotter's full book "*Leading Change*", in order to be aware as well of the fundamental points that a company should follow to implement change operations in good conditions.

Get people confidence and trust is an essential condition when leading change. When a problem occurs, every actor should wonder why it happens. Doing so, any organization will tend to prevent the following behavior that many people have met at least once in their career:

> *"The "Buts" come. But we really are making some progress. But the problem is not here, it's over there in that department. But there is nothing else I can do because of my thickheaded boss."* (Kotter, 1995 p. 37)

According to Kotter, change can occur when the financial situation of a company is very low, or when a person coming from outside the company as a consultant for example, that does not have to defend his or her status and past actions. (Kotter, 1995)

3.6.4 Create a sense of urgency

In any case, as the first step of Figure 18 mentions, a state of urgency needs to be created. It means that one person (in general) detects that the organization should change if it wants to stay competitive. Only saying this fact to the top management will not create a sense of urgency. To create this sense of urgency, the tenant of the idea that change should take place has to convince some key actors that in a couple of years, the company will crash down. This step is the most important as it will "move people out of their comfort zones" as mentioned earlier in the leader's definition. If this sense of urgency is not high enough, change could get started for a while, but will surely collapse before being complete. This first step is then not to be neglected.(Kotter, 1995)

From the state of urgency, the company willing to change needs to be aware of where it stands it term of decision making. The following Figure 19 illustrates the principal decision making stages to perform until reaching a new process involving a guiding coalition.

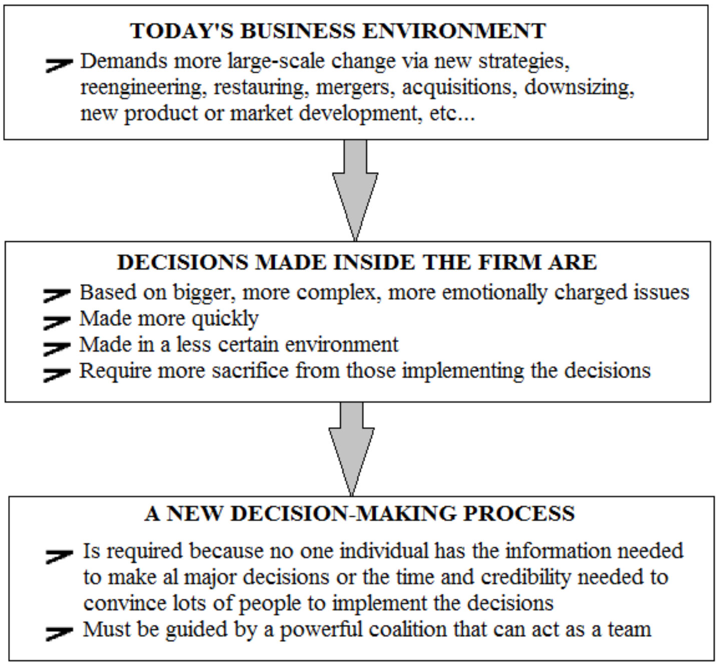


Figure 19: Decision Making in Today's Business Environment (Kotter, 1995)

3.6.5 The guiding coalition

Building a guiding coalition is the second step defined by Kotter to lead change. The coalition can be seen as a military group leading operations, and therefore needs to be accurately built to achieve the expected result. Kotter exposes four essential features that members should be made of, in order to fulfill the requirements of an effective guiding coalition:

1. *"Position power: Are enough key players on board, especially the main line managers, so that those left out cannot easily block progress?*
2. *Expertise: Are the various points of view – in term of discipline, work experience, nationality, etc – relevant to the task at hand adequately represented so that informed, intelligent decisions will be made?*
3. *Credibility: Does the group have enough people with good reputations in the firm so that its pronouncements will be taken seriously by other employees?*
4. *Leadership: Does the group include enough proven leaders to be able to drive the change process?"* (Kotter, 1995 p. 57)

In his book "*Leading Change*", Kotter presents an interesting comparison between different actors involved within a guiding coalition. It is thereafter represented in Figure 20 by four squares in which each member is represented by a cross if it is more a leader or a manager.

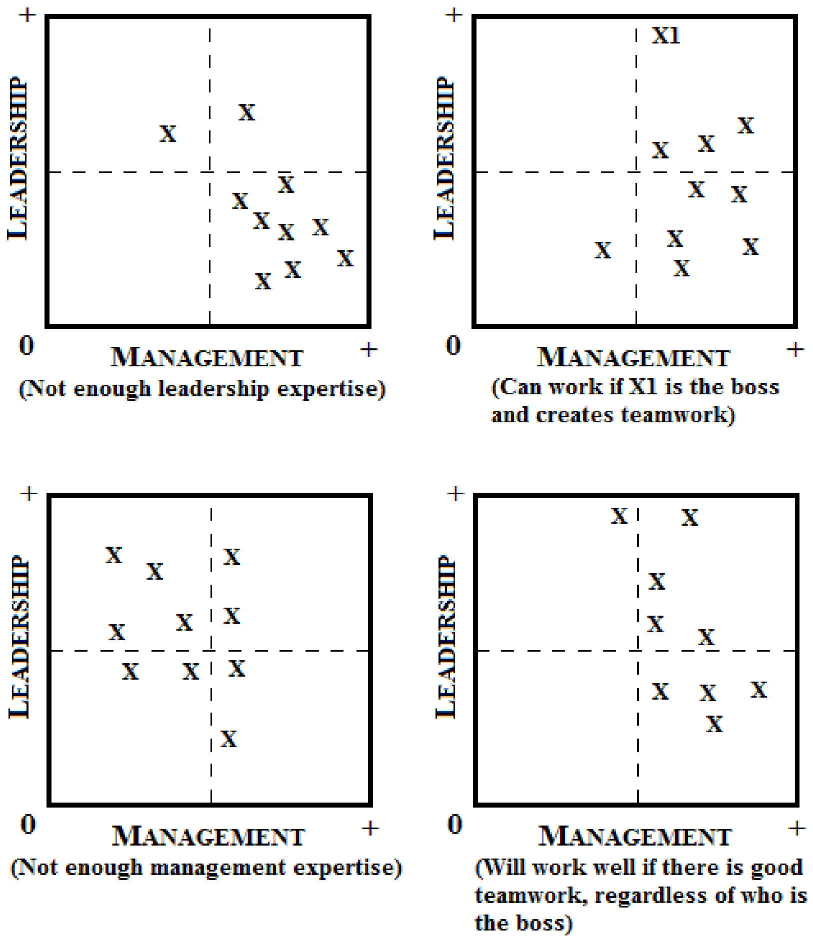


Figure 20: Profiles of four different guiding coalitions (Kotter, 1995)

The size of an effective coalition is not random and is often referred to the size of the organization. Two or three persons are often the first drivers of change. If these persons are successful, it can rapidly grow up until it reaches 10 members in a relatively small organization, and can grow up until fifty members for a large firm.(Kotter, 1995)
The coalition could also be compared to a sport team. To develop the team spirit and the way to act of every member, sports coaches plan some off-site meetings, with as a main objective, to become a strong team. Being a strong team consists of trusting each others, relying on each others. Some games can take part of the training to reinforce these features. It can totally be used within any firm as well.

3.6.6 Create a vision

After the guiding coalition is built and conscious of the sense of urgency, it is time to decide for a future. It is the third step expressed by Kotter: “create a vision”. This vision is a support for every employee in an organization to get into the early stages of change. Once more, a vision is not only a random idea, but should respect some criteria as follow:

- *“Imaginable: Conveys a picture of what the future will look like.*
- *Desirable: Appeals to the long-term interests of employees, customers, stockholders, and others who have a stake in the enterprise.*
- *Feasible: Comprises realistic, attainable goals.*
- *Focused: Is clear enough to provide guidance in decision making.*

- *Flexible: Is general enough to allow individual initiative and alternative responses in light of changing conditions.*
- *Communicable: Is easy to communicate; can be successfully explained within five minutes."* (Kotter, 1995 p. 72)

Kotter affirms after observation and his experience that, if the vision cannot be described to someone in five minutes and get their interest, then it must be thought again.

"Key elements in the effective communication of vision:

- *Simplicity: All jargon and techno babble must be eliminated.*
- *Metaphor, analogy, and example: A verbal picture is worth a thousand words.*
- *Multiple forums: Big meetings and small, memos and newspaper, formal and informal interaction – all are effective for spreading the word.*
- *Repetition: Ideas sink in deeply only after they have been heard many times.*
- *Leadership by example: Behavior from important people that is inconsistent with the vision overwhelms other forms of communication.*
- *Explanation of seeming inconsistencies: Unaddressed inconsistencies undermine the credibility of all communication.*
- *Give-and-take: Two-way communication is always more powerful than one-way communication."* (Kotter, 1995 p. 90)

In the book "*Leading Change*" (Kotter, 1995), the author describes an example of a company which has a problem. Its problem is that employees are still working according to the old way. After discussing with the manager, they agreed that resisting change is within the human nature. As long as employees in this case feel that the change will not bring any direct positive aspects for them, they do not have to make any efforts to support the change. The fact is that the Human Resources department was not totally aligned with the new vision. No performance appraisal, compensations or promotions were planned for employees, which had a negative impact for the vision development.

3.6.7 The journey of transformation

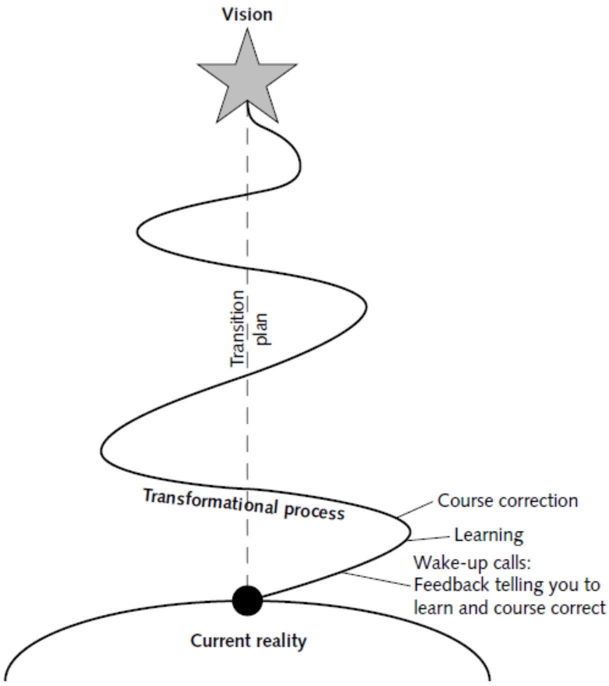


Figure 21: The journey of transformation (Anderson, et al., 2010)

Figure 21 is a visual representation of what could look like a journey to change a whole organization. It could be seen as the step between chaos and re-emergency mentioned previously in Figure 17. This figure above emphasizes especially on the adjustments that have to be done through the whole way in order to reach the ultimate vision. The major adjustments have to be done in the early phases principally, and they are the trickiest ones. Adjustments should be carefully handled.(Anderson, et al., 2010)

3.6.8 Short term wins

When the vision has been communicated and starts to show some positive effects, short term wins have to take part of the journey. They are really important in order to get everyone's confidence, and they enable to "valid" the change. Not having short term wins can be dramatic. Some people can jump-off the boat, give-up or even be willing to breakdown the process. As mentioned previously, every employee should see any recognition even in short term wins to make them stay on track towards the same direction. (Kotter, 1995)

3.6.9 Anchor the new culture

(Kotter, 1995 p. 155) Also mentions that *"Cultural change comes last, not first".* A culture in a company gathers all the habits the organization as a whole has. It could be the use of an obsolete machine, a layout that did work well during the past decades or even the use of paper sheets only instead of computers. Cultural change can occur after and only after new behaviors produced some benefits or after employees see the performance improvement. That is why cultural changes have to take place in the late stage of a project. Changing culture within the first stages often lead to a disaster, because employees are anchored to their habits, and makes the task impossible or very difficult to make them believe in a revolution without any prove.

"Interdependencies left over from earlier eras that add no value will be less tolerable. In this sense, the twenty-first-century organization will probably be a lot cleaner than the one we typically see today. Fewer structural cobwebs and less procedural dust will make surfaces slicker and faster." (Kotter, 1995 p. 169) Differences between twentieth and twenty-first century businesses are sorted in the following Figure 22:

Twentieth Century	Twenty-first Century
Structure	**Structure**
Bureaucratic	Nonbureaucratic, with fewer rules and employees
Multileveled	Limited to fewer levels
Organized with the expectation that senior management will manage	Organized with the expectation that management will lead, lower-level employees will manage
Characterized by policies and procedures that create many complicated internal interdependencies	Characterized by policies and procedures that produce the minimal internal interdependence needed to serve customers
Systems	**Systems**
Depend on few performance information systems	Depend on many performance information systems, providing data on customers especially
Distribute performance data to executives only	Distribute performance data widely
Offer management training and support systems to senior people only	Offer management training and support systems to many people
Culture	**Culture**
Inwardly focused	Externally oriented
Centralized	Empowering
Slow to make decisions	Quick to make decisions
Political	Open and candid
Risk averse	More risk tolerant

Figure 22: The twentieth and twenty-first-century organization compared (Kotter, 1995)

Companies remaining the best in term of competitiveness are the ones able to adapt very quickly to a situation. It means that decision making is much faster in this case, and the company as a whole is easier to drive.

"After a period of adjustment, most people seem to like the dynamic quality of the environment. It's challenging. It's never boring. Winning is fun. And for most of us, making a real contribution is pleasing to the soul.

People who are attempting to grow, to become more comfortable with change, to develop leadership skills – these men and women are typically driven by a sense that they are doing what is right for themselves, their families and their organizations. That sense of purpose spurs them on and inspires them during rough periods. And those people at the top of enterprises *today who encourage other to leap into the future, who help them overcome natural fears, and who thus expand the leadership capacity in their organization – these people provide a profoundly important service for the entire human community. We need more of these people. And we will get them."* (Kotter, 1995 p. 186)

3.6.10 Leader and employees behaviour

An idea expressed by (Anderson, et al., 2010) has a real impact on the cultural change in an organization. Indeed, both employees and leaders have to adapt their behavior to each others. Behavior reveals a person's style, impression and has to be adapted to lead every actor to the desired culture. *"Therefore, leader and employee behavior denotes the ways in which leaders and employees must behave differently to re - create the organization's culture to implement and sustain the new organizational design."* (Anderson, et al., 2010 p. 35)

3.6.11 Implement culture change strategy and process

According to (Anderson, et al., 2010), culture change is not an accurate science and always has to be adjusted. The first idea and plans of the change journey is only the best estimation of what is the goal. Other more focused changes and new challenges will appear to adapt the situation to the rethought vision. If obstacles come up on the way, they should not lead to a failure of change implementation. Discovering why they happened is an important step before over-passing them.

3.7 Links between Lean and Leading Change

In 2008, Hasenfratz published the result of a survey she conducted (Figure 23) showing how willing are top-management departments from her study, to implement lean manufacturing within their organization. This gives an idea on how successful can be the lean implementation, but only if the top-management is open to change.

Becoming lean involves many parameters, but the management should not turn into a lean organization to make more money at first, but to be a competitive structure. From this point, a company is able to change. If a staff from an organization has in mind that change should occur, then leading change can begin. It means from this step that the players have to be open-minded and willing to apply new techniques and new tools. Going through the leading change steps leads to the implementation of those new techniques, which lead to learning and continuous improvement, which leads to a lean manufacturing organization. (Hasenfratz, 2008)

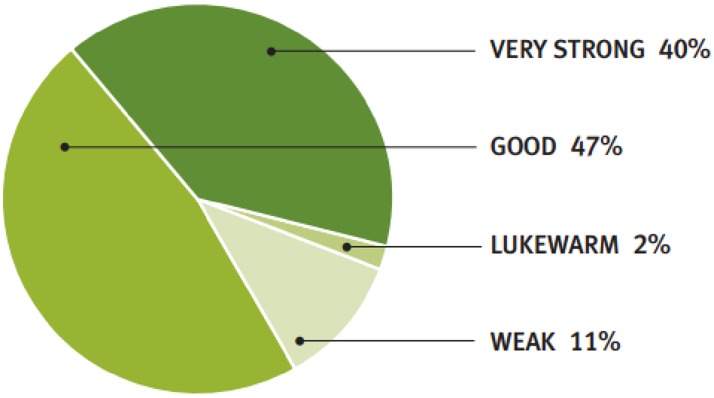


Figure 23: Level of support for lean implementation (Hasenfratz, 2008)

The Figure 24 presented thereafter is a good way to link lean aspects and the cultural changes within a structure. The culture is seen as an iceberg, pointing out of the surface every techniques characterizing lean production, but underneath the surface stands the culture change. It means that going towards lean production is not an easy task and has to involve soon or late some cultural changes.

If it would be only the upper part floating as a boat, then it would be rather easy to move toward the desired direction. In this case, the cultural aspects have a strong impact on the force required to change the actual situation. (Liker, et al., 2004)

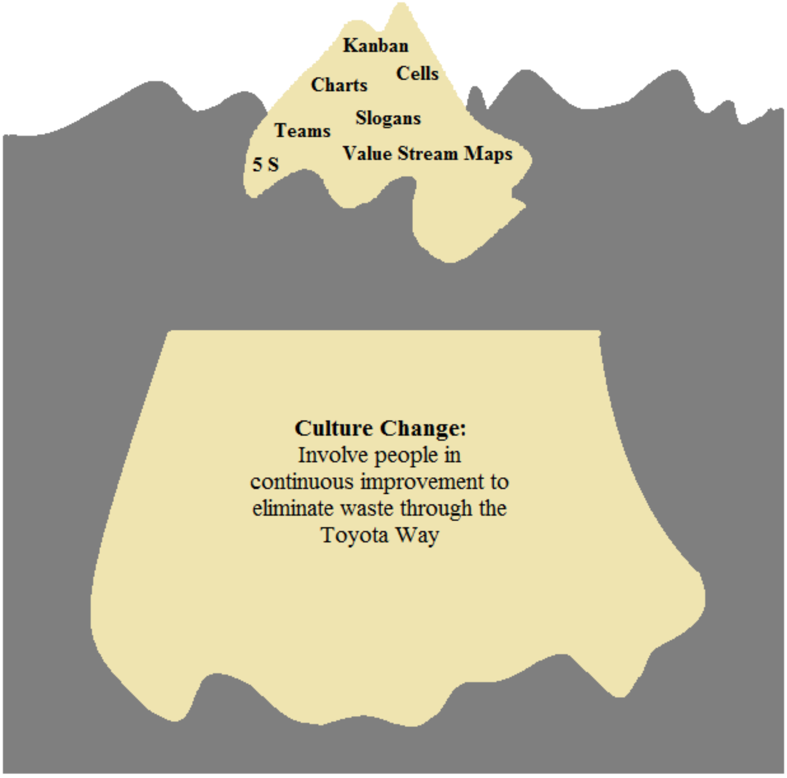


Figure 24: Iceberg model of TPS (Liker, et al., 2004)

The lower part of the iceberg may contain only one term – cultural change – but cannot be easier to deal with than the upper part. This cultural change is an aspect which is continuously alive and takes a great place through all the implementing steps of lean tools.(Liker, et al., 2004)

3.7.1 The role of employees within the organization

The “democratic Taylorism” is a term developed by (Adler, 1995). This author actually emphasizes the fact that employees and especially operators are not just “a thing” mounted with two grippers able to move stuff, but he defines operators and the work force as the most valuable resource. Paul Adler was in charge to implement standardization at NUMMI (New United Motor Manufacturing) which is a Toyota/GM plant based in California. His idea of “democratic Taylorism” was to involve the workforce willing to reach common goal, and not to screw people down. There was no military hierarchy involving different levels, but everyone works as best as he can to do the job.

In this way, it is linked with the vision that Kotter has when every actor is on the same ship aiming toward the same direction. Adler affirms that changing the employees mind is not always an easy task, but can often be achieved using the right way. Building a leaders team is also an indispensable stage to bring people on, and Paul Adler gives an example in his essay (Adler, 1995) where a team is built based on different prerequisites to fulfill the tasks. Specific personal qualities, ability to deal with recalcitrant people and willingness to teach are the three features required to get involved in a team.

In opposition, the coercive vision is emphasizing on the “military hierarchy” were operators are seen as machines and where the respect for people is misinterpreted. Doing so, employees will become less and less willing to develop the organization or to make any efforts. Even worth, they could become a heavy problem for the company’s progress. The following Figure 25 is a summary of the different options available to lead a structure with their own characteristics.

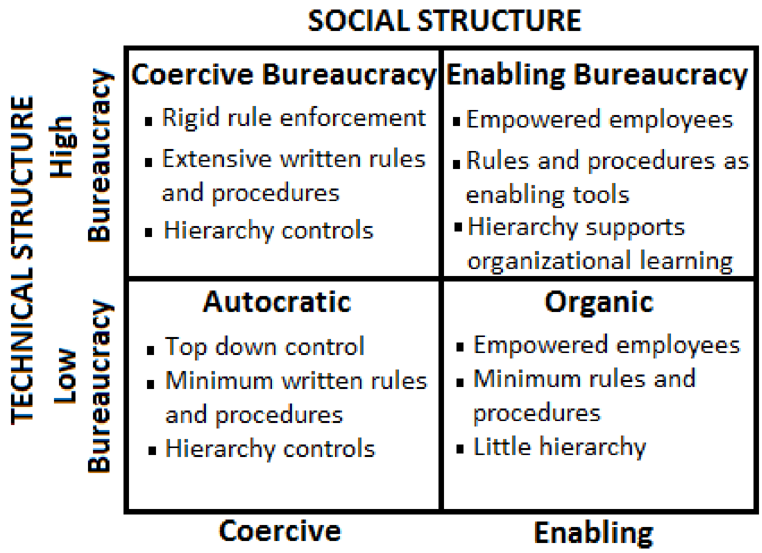


Figure 25: Coercive versus enabling bureaucracies (Liker, et al., 2004)

A very relevant point mentioned in *The Toyota Way* (Liker, et al., 2004) is that when a problem occurs, the root cause should be determined instead of the source which often is human. The best behavior that an employee could have is admitting something went wrong, take responsibility and gives ideas to prevent the "wrong event" to happen again. In this manner, the "5 Why's" method could be useful.(Liker, et al., 2004)

3.7.2 Lean functions

Very often, managers and leaders dealing with TPS, TPM, TQC and TQM background are not on the same waves, and disagree at some points. Communication plays a key role to make everyone able to understand each other's. They have different skills – useful skills – and they need to put them all together to maximize the chances for the company to grow-up toward the organizational change.
Lean thinking is a global vision that needs to be transmitted to all employees within a firm willing to become a lean organization. Basic concepts of lean manufacturing have to be taught to employees, in order to involve them in the lean principles. Later on, employees should know the techniques to solve problems, and the best achievement is when employees are able to use their own mistakes as training when applying root cause analysis. (Womack, et al., 2003)

3.7.3 Change and TPM

As mentioned previously in the part "*OEE: Understanding and early stages*", implementing TPM has to integer some change skills. (Nakajima, 1988) known to be the pioneer concerning TPM has developed the following methodology (Table 5) to get good results when implementing TPM:

Phase of implementation	TPM implementation steps	Activities involved
TPM **PREPARATION**	Declaration by top management decision to introduce TPM Launch education and campaign to introduce TPM Create organizations to promote TPM Establish basic TPM policies and goals Formulate master plan for TPM development	Declare in TPM in-house seminar Carried in organization magazine Managers: trained in seminar/camp at each level General employees: seminar meetings using slides Committees and sub-committees Benchmarks and targets evolved Prediction of effects Develop step-by-step TPM implementation plan Framework of strategies to be adopted over time
Preliminary implementation	Hold TPM kick-off	Invite suppliers, related companies, affiliated companies
TPM **IMPLEMENTATION**	Establishment of a system for improving the efficiency of production system Improve effectiveness of each piece of equipment Develop an autonomous maintenance (AM) program Develop a scheduled maintenance program for the maintenance department Conduct training to improve operation and maintenance skills Develop initial equipment management program level Establish quality maintenance organization Establish systems to improve efficiency of administration and other indirect departments Establish systems to control safety, health and environment	Pursuit of improvement of efficiency in production department Project team activities and small group activities (SGA) at production centers Step system, diagnosis, qualification certification Improvement maintenance, periodic maintenance, predictive maintenance Group education of leaders and training members Development of easy to manufacture products and easy to operate production equipment Setting conditions without defectives, and its maintenance and control Support for production, improving efficiency of related sectors Creation of systems for zero accidents and zero pollution cases
Stabilization	Perfect TPM implementation and raise TPM	Sustaining maintenance improvement efforts Challenging higher targets Applying for PM awards

Table 5: TPM implementation methodology – adapted from (Nakajima, 1988)

This methodology is quite similar in some ways to the one proposed by Kotter. The preparation stage could be identified as the one planning and creating a sense of urgency. The kick-off consists of spreading out the new concept using to appropriate manner. Then the implementation phase comes where all the tools are applied and checked out. The stabilization aims to sustain the development that has been done, to make it reliable and to even developing it more.

4. EMPIRICAL CASE STUDY: A 800 tons metal stamping press

This part gathers all the reflection made around the case study, in relation to the theoretical framework previously presented. A case background and presentation is done to structure the further work. The actual problems are also exposed, and suggestions are offered and weighted to reduce the importance of the problems or to solve them. These aspects always have to involve the continuous improvement thinking for the company.

4.1 Company background: AQ Segerström & Svensson AB

The company AQ Segerström & Svensson has been purchased by the Aros Group AQ in 2009 while the company was getting into a worse and worse financial situation. The group owns several companies all around the world in different areas, and has a supporting role, providing especially a financial support to Segerström & Svensson AB to enable the company to survive.
This situation works "hand in hand" since the company is getting some money to run, the company has to prove that it can be self-sufficient by realizing some profit.

To get an idea on how the firm managed to partly reach this goal, the company realized a negative profit over 2010 which was roughly -9 300 000 SEK. By the end of year 2011, new results came up with a negative benefit of -1 700 000 SEK, and by the end of year 2012, the profit was positive by +2 700 000 SEK. This is quite a dramatically improvement, but which needs to be kept up. A visual support is shown in Figure 26 including the planned profit to achieve by the end of year 2013 which is around 10 000 000 SEK.

To do so, AQ Segerström & Svensson AB had and still has to get new customers, get new markets and implement lean aspects and strategies in order to stay in good shape and in order to provide a valuable job to more or less 200 employees.

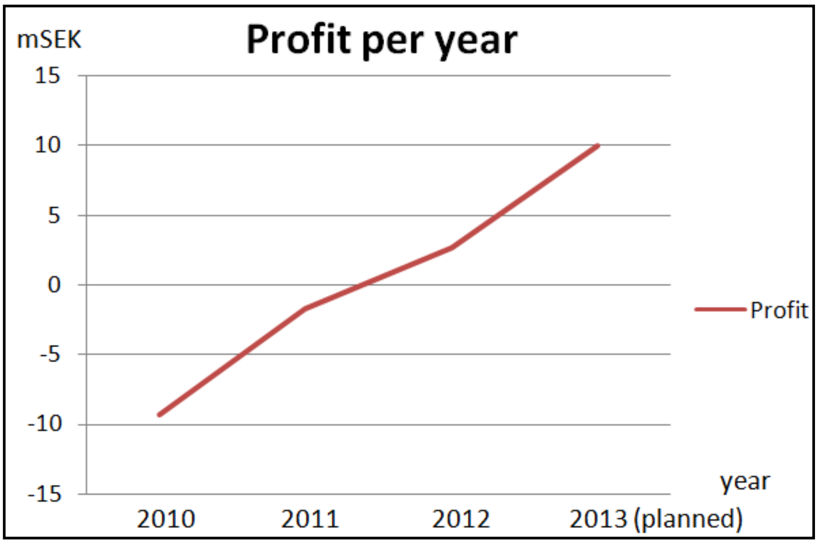


Figure 26: Profit per year AQ Segerström & Svensson AB

4.2 The pressing area

AQ Segerström & Svensson is a company producing a lot of stamped parts. Small to quite large parts can be produced, so that is why a quite wide broad of presses is available on the shop floor. The lightest press develops a pressure of 20 tons and the biggest one can shape parts under 1000 tons pressure. Figure 27 is a representation of half the workshop of the company. The other half is dedicated to the welding department mainly and some other subdivisions.
The press related to the case study corresponds to the square in the bottom right hand corner called “Manzoni 800T”. The majority of the dies used on this machine are stored in the “die storage” which stands about fifty meters away from the machine.

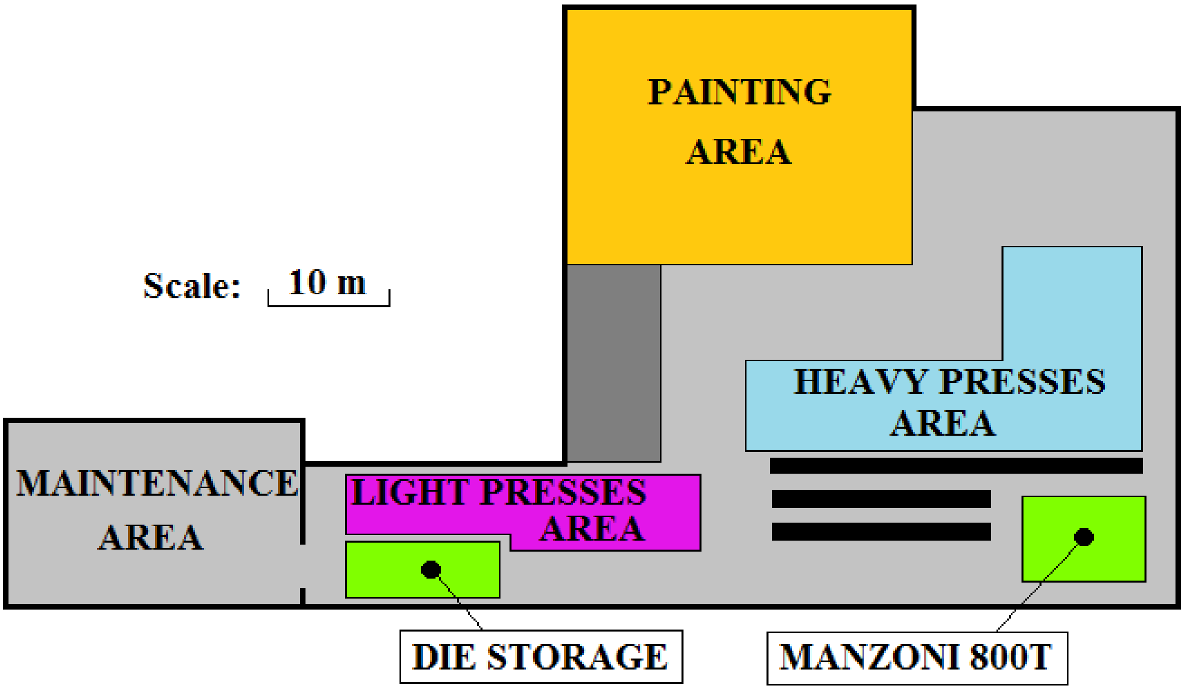


Figure 27: Schema of the half-workshop layout

4.3 The 800 tons MANZONI Press

The press was installed and is operative within the workshop since 1998. This is a mechanic press, which means that a cam shape creates the up and down movement. Otherwise, it could be due to hydraulic pressure in the case of hydraulic presses. The press delivers a compression of 800 tons to shape metal sheet into parts. About 30 different parts number are manufactured by the press, and the parts look like the one on the following Figure 28. The whole press is shown by the Figure 29.

Figure 28: Example of part produced on the Manzoni

Figure 29: Picture of the actual press

The pressing equipment has the next technical features and capacities:

- Coil feeding height: 200 to 500 mm
- Bolster size (lower table): 3150 x 1600 mm
- Slide size (upper table): 2900 x 1600 mm
- Stroke: 500 mm fix
- Minimum tool height closed: 645 mm
- Clamping height: 50 mm
- Slide adjustment: 200 mm
- Maximal coil width: 1037 mm
- Coil thickness: 5 mm

Dies specifications:

Nowadays, 17 tools are available to fit into the press for production. Their size can vary between 700 x 900 x 600 mm up to 900 x 2400 x 1200 mm. Their weight is situated between 1.5 and 8 tons. Dies for the machine are stored in a storage area among many other tools that can fit in the 5 other heavy presses. Three carts are available to toe all those different tools towards the five machines.

4.3.1 The press problems

The Manzoni press is running five days a week – sometimes more – based on two shifts. The main problem with the press is that it is too often down, so the machine intrinsic capacity to produce at its maximum rate is not optimum. Being aware of this problem, the OEE of the machine obviously needs to be improved. To do so, technical and managerial tools presented in the "Theoretical framework" part should be implemented.

2009 - 2012 REPORT					
Year	Reported qty	Rep. time	Planned time for rep. qty.	Rep. cost	Planned cost for rep. qty.
2 009	267 143,00	892,65	673,63	976 563,87	736 953,52
2 010	604 021,00	2 048,71	1 276,01	2 241 293,53	1 395 952,40
2 011	852 251,00	2 046,83	1 820,70	2 239 228,44	1 991 846,77
2 012	696 139,00	2 843,06	1 773,82	3 110 304,35	1 940 554,67
	2 419 554,00	7 831,25	5 544,16	8 567 390,19	6 065 307,36

Table 6: 2009-2012 yearly report on Manzoni 800T

A summary of the actual production over the previous years (2009 - 2012) is presented in Table 6. It shows in 2012 that 696 139 parts of different types have been produced on the Manzoni press, and it took approximately 2843 hours to produce them. In ideal conditions (considering only the production time per part, and the production time available), this amount of parts should have be done in about 1774 hours. It represents a loss of 1 169 750 SEK over the year, which is the difference between the reported cost and the planned cost for reported quantity.

With this type of information, the goal of this project as mentioned earlier is to increase the reported quantity or to decrease the reported time, hence the reported cost. The next step concerning this project was to build a model to get a more accurate vision of what is the OEE of the stamping machine.

Based on the data available from the internal network of the company, it was possible to establish the Table 7, which gives the OEE of the 800 tons Manzoni press achieved over the year 2012.

OEE calculation

Production data						
Shift length	4030	hours =	241800	minutes		
Short breaks	448	breaks of	18	minutes each	8064	minutes in total
Meal break	448	breaks of	24	minutes each	10752	minutes in total
Down time	71220	minutes				
Ideal run rate	9,6959	PPM (part per minute)				
Total pieces	696139	pieces				
Scrap pieces	700	pieces				

Support variable	Calculation	Results
Planned production time	Shift lenght - breaks	222984
Operating time	Planned production time - down time	151764
Good pieces	Total pieces - scrap pieces	695439

OEE factor	Calculation	AQ OEE%
Availability	Operating time / Planned production time	68,06%
Performance	(Total pieces / Operating Time) / Ideal run rate	47,31%
Quality	Good pieces / Total pieces	99,90%
Overall OEE	Availability x Performance x Quality	32,17%

OEE factor	Wolrd class	AQ OEE
Availability	90,00%	68,06%
Performance	95,00%	47,31%
Quality	99,90%	99,90%
Overall OEE	85,00%	32,17%

Table 7: Annual OEE for the 800T Manzoni press

The results presented in Table 7 have been worked out in order to be the most accurate as possible. Indeed, a deep data collection has been done through the computerized system operating within the company, in which are gathered all the data and statistics concerning the production, purchase department, inventories and so on. Table 7 shows that the OEE concerning the Manzoni press over a year is not good. The quality factor is pretty high as it is the same as the world class. However, the performance factor is much lower than what it should be. This is due to all the breakdowns that occur to the machine. The planned production time employed for the calculation is not the same as the one presented in Table 6 because they have not been obtained following the same manner, so they differ. The one in Table 6 is the planned production time for the reported quantity which is lower than the planned production time over a year for the machine.

Improving the machine efficiency is not only intrinsic to the machine, but has an impact on the whole production. The organization tends to become more and leaner through its production, so the eight wastes presented in the theoretical framework are the ones that should be erased. Regarding the machine, mainly 5 S's, maintenance and changeover have to be improved. The actual states with their respective problems are presented later on.

Working Center	Name	SEK/hrs	Wages + Socials	Machine	L-TO	Total
1080	Exc. Aut. 800 tons	**Regular**	284	670	140	**1094**
		Previous	233	554	165	**952**
		Future	233	525	194	**952**
		2 Operators	568	670	280	**1518**
		Future	0	0	0	**0**

Table 8: Regular Manzoni press hour cost for year 2013

Table 8 contains the financial aspects of the Manzoni 800 tons press. Prices expressed in Swedish crowns are the actual costs to run the machine. The named "regular" row shows the wages and social costs for one operator, which is 284 SEK per hour in this case. The machine costs as electricity, compressed air, maintenance costs and so on are sold 670 SEK per hour to customers. The L-TO column defines the managers' wages or the building rent for example and some others indirect costs. All these costs added lead to a cost per hour of 1094 SEK to run the machine with one operator. A row is dedicated to the cost per hour if two operators are employed to run the machine.

Having two operators is actually an idea to suppress according to the production manager, based on some previous analysis. Indeed, if two operators can produce 150 parts per hour, and a single operator can produce 100 parts per hour. 150 parts divided by 2 operators, means that a rate of 75 parts per operator is the outcome, which tells that it is less effective than a single operator producing 100 parts.

Table 8 is a useful summary to know how investments should be done. It will constitute a basis to develop the different technical suggestions to improve the OEE on this machine.

4.4 The main reasons for a low OEE

As expressed with Table 7, OEE for the Manzoni press is very low. The quality resulting from the machine fits with the world class, but the availability and performance indicators are far behind what they should be.
For each machine or each process, OEE is given following several different features and parameters. It mainly depends on the kind of machine, the layout of the workshop, the size of the company and so on. After analyzing in detail the process of this case study, the low OEE mainly comes from three aspects which are: 5 S's respected at level 1 out of 4 – according to the production manager – a long changeover time, and a poor maintenance.
These three points are about to be detailed and expressed among the following paragraphs with a list, to get a better understanding of the real problems related to the press, that really occur on the shop-floor. That list has been built over the whole period of the project – about six months – and thanks to the different interviews and observations conducted within the whole factory. Ideas to improve the situation are given to each problem after its description.

4.4.1 Around the 5 S's

Situation in 2013:

To grasp the situation about 5 S's nowadays within the organization, conversations were led with especially the operators of the Manzoni press and the production manager. Three main questions had to be answered, which were:

- Does every employee know what 5 S’s really are?
- How does the organization control that 5 S’s progress and sustain?
- What does work and what does not with 5 S’s implementation?

The production manager made a summary about the 5 S’s within the factory. He claimed that everyone, every employee hired gets a note explaining what the 5 S’s are, but often quickly ends to the trash without being explored.

To implement and improve the 5 S’s, one hour per week has been planned by the staff to allow operators to suggest what they would like to improve concerning the 5 S’s. This concept is good, but very few people are able to propose anything leading to improvement. Most of the operators think that 5 S’s mean cleaning the place only. At first, one “ordering” per month was planned which consists of re-arranging and cleaning the place, but it finally occurs once every six months instead due to lack of time and interest from operators.

To enhance people dealing with 5 S’s, the organization offers higher wages to the employees aware of 5 S’s based on a scale from 1 to 7. For example, a person able to say what are each “S” gets a 3. Richard affirms that there are maybe 10 employees able to say so among the 200 employees within the factory.

To develop 5 S’s, the production manager would like to train people with little groups to be more accurate regarding the expected outcome and results. Time in this case is a constraint and this training is delayed. Production and quality come on top of the priority list and 5 S’s are close to come the last ones.

4.4.2 List of problems and improvements

Problem 1 - Messy area

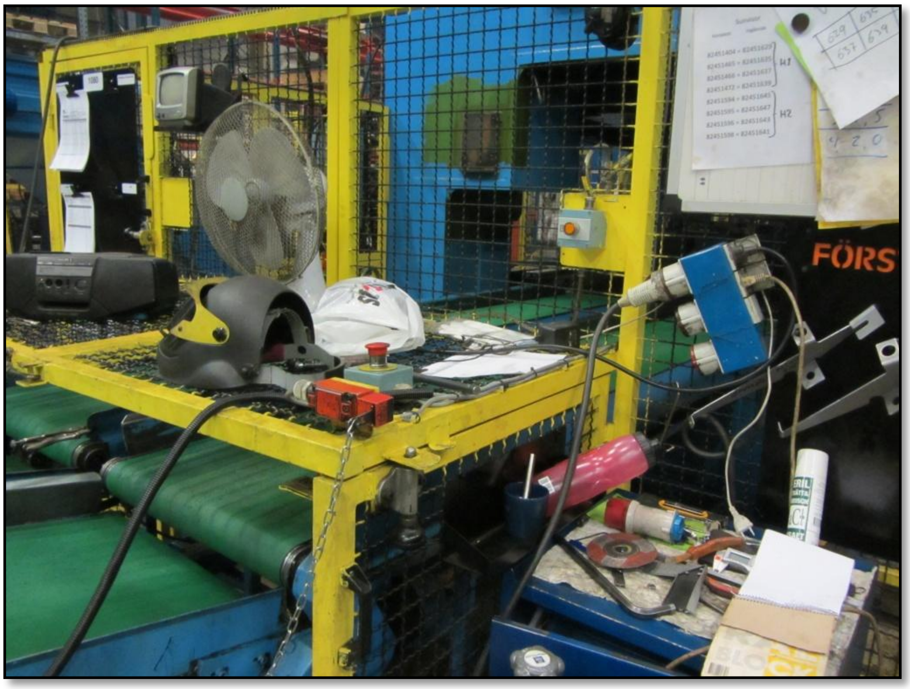


Figure 30: The Manzoni working space

After talking to the operators working on the press, it came out that they see 5 S's as keeping the space clean and that 5 S's are only logic and being clever. They meant that when working, it consists of finding the best and easiest way to do the job. It is clear, especially when looking at Figure 30, that even keeping the working space clean is not acquired. There is a great job concerning the 5 S's development to expend on the Manzoni press area and over the whole shop-floor as well.

Improvement:

Training remains the best alternative in order to get rid of this kind of problem. Once that training has been followed by the operators, a continuous improvement phase needs to be held to check and affirm that 5 S's are getting sustainable and efficient.

Problem 2 - TV control too small

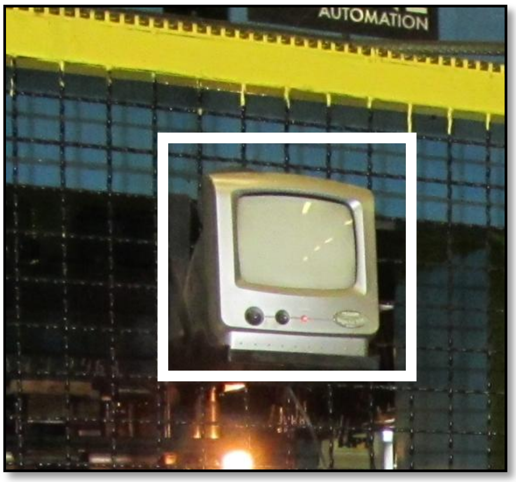


Figure 31: Coil control - TV screen

To control how the coil is rolled out when the operators stand in the packing area, a TV screen (Figure 31) transfers what is recorded by a camera pointing the coil. The TV screen has a very bad quality, and points only the coil at the back of the machine.

Improvement:

The operators would like to get more cameras, on the side, back, inside the machine and with a bigger and higher quality screen. Implementing condition monitoring would be interesting in this case as well. It consists of a signal – light or sound – in case of a problem detected. This signal could appear when a situation is getting problematic, so it prevents the machine to be down.

Problem 3 – Sheet feeding problems

Figure 32: New feeder installation

A device has been installed in the machine couple of years ago. This device was built to align the sheet with the die level just before this latter. Differences in height of the dies required a lot of adjustments, so a lot of time. This device has been replaced during my project period by a new feeder shown in Figure 32. The main function of this feeder is to scrap fewer raw materials, as it is closer to the die. Indeed, with only one feeder – located close to the coil axle – the last four meters of the metal sheet had to be scraped, and represented a large amount of money over a year. However, this feeder does not really solve the alignment problem, and adjustments are still required to insert the sheet in the die.

Improvement:

An automated arm could be installed to support the metal sheet even between the new feeder and the die, so the operator does not need to climb inside the machine to give a hand to the sheet when it enters in the die.
The other option that needs to be thought is to implement the function standardization for the dies height. Its description is given in Figure 11 page 30.

Problem 4 – Pallets out of the right place

Figure 33: Pallet waiting to be transferred to the next step

A problem that occurs rather often in the surroundings of the press is that full pallets stand anywhere as in Figure 33, waiting for a forklift to be picked-up and driven towards the next step.

Improvement:

An operator thought interesting – proof that they have solutions to propose – to have maybe a Wi-Fi system between machines and forklift. For example, the operator could push a button when a pallet is ready to be picked-up, and a signal would appear in the forklift mentioning that the Manzoni press needs help to unload a pallet from the area.

Problem 5 – Loading the pallets content

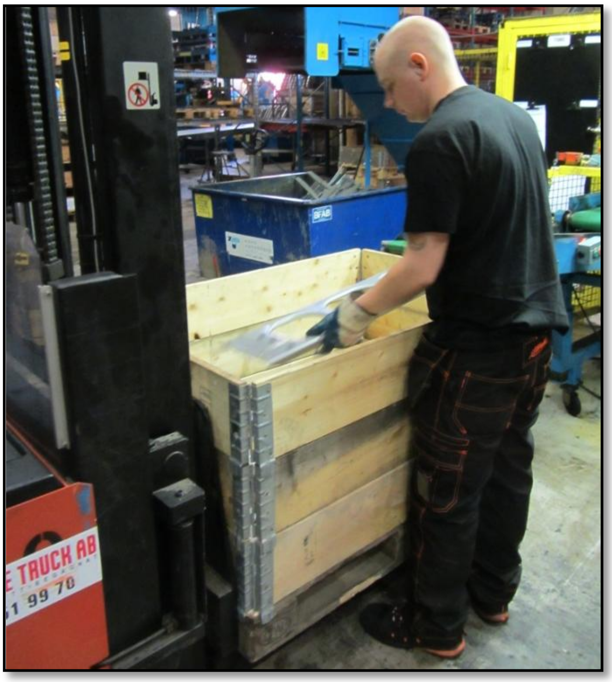


Figure 34: New lifting device

Operators from the Manzoni often complained that other departments had some lifting devices dedicated to be ergonomically adapted to their kind of job, so they would like to get one. They suggested it to the production manager, and this device finally came up (Figure 34). This small forklift enables operators to work in better conditions and to reduce back pains for example. It is used when operators are packing parts, but is also used to move heavy pallets ready to be sent away.

Improvement:

Operators gave another idea of improvement that could be done, even if it is not directly related with the 5 S's. This improvement could help the organization to be more accurate when collecting data in the future.
Within the computer system, there is an option to choose "ställstid" to say the machine is down when employees are in the toilets, helping someone else and so on. This should be detailed by several buttons or they should be able to write down a message. Then within monitor – the computer database – it would be possible to have a feedback on what really happened.

Problem 6 – Unsafe supports

Figure 35: Dangerous support

A safety issue was obvious when observing the machine. Right beside the press, a control panel stands on a movable arm. This panel is fitted with some sharp edges and screws at a height of about 1m70 (Figure 35). It makes this support standing on the way of any human face. This could be a problem especially for a customer coming to visit the factory as this person does not know the surroundings of the machine. An operator could hurt himself as well, but he is more aware about what is standing around the machine.

Improvement:

Either some “light” protection pads can cover the hazardous parts; either the control panel can be supported from the top surface at a lower height. The assembly would be lighter in this case so it would be easier to move.

Problem 7 – Height difference in the batch

Figure 36: Height difference in the batch

After the parts have been machined, they are transferred to the batch by a conveyor. The extra material that needs to be scraped also uses the conveyor sometimes to be thrown away in the scrap batch as on Figure 36. For a certain type of parts – but almost every type – the batch gets full right under the conveyor end, which creates a difference in height as expressed by the white line in Figure 36. This becomes an issue for the OEE when it gets full because the operator needs to stop down the machine to move the batch or to mix the parts to level them.

Improvement:

- The first option would be to have a vibrating and lifting device on which could stand the batches. This could be rotating so empty batch can be placed really quickly. And removing the full batch could become an external setup operation as in Figure 51 page 75.
- The second option would be to install some automatically movable conveyors so the tail slowly moves from right to left to right in order to level the items dropped in the batch.
- The third option would be to get a diverter automated fitted on the conveyor so items can be driven to the right or the left side of the batch.

Problem 8 – Dirty and oily floor

Figure 37: View under the conveyors

Figure 37 shows how the actual situation is just underneath the conveyors. The quality of the picture is not good enough to reveal how oily it is on the floor. Indeed, parts that have been shaped are dropped on this conveyor and transferred to their storage batch. Parts are getting out from the machine with a very oily surface, and the conveyors are not protected to prevent oil leaking on the floor. It creates a puddle of oil on the whole area under the conveyors. It might not seem important to get rid of this problem as nobody will walk in this area but it comes into the 5 S's by keeping the place clean.

Improvement:

In this case, to prevent oil leaking on the floor, it would be good to isolate the floor with a retention batch right under the conveyors. This batch could be only a plate welded under each conveyor, containing a bleeding outer which would allow oil to leak in a container. This container would be emptied every time it gets full.
Moreover, the conveyors probably do not have to be 3 meters long and could be short cut. It could be a good opportunity to gain some space, and the best alternative would be to buy new conveyors to replace the ones getting old, to redesign the area.

Problem 9 – Non-standard protection fences

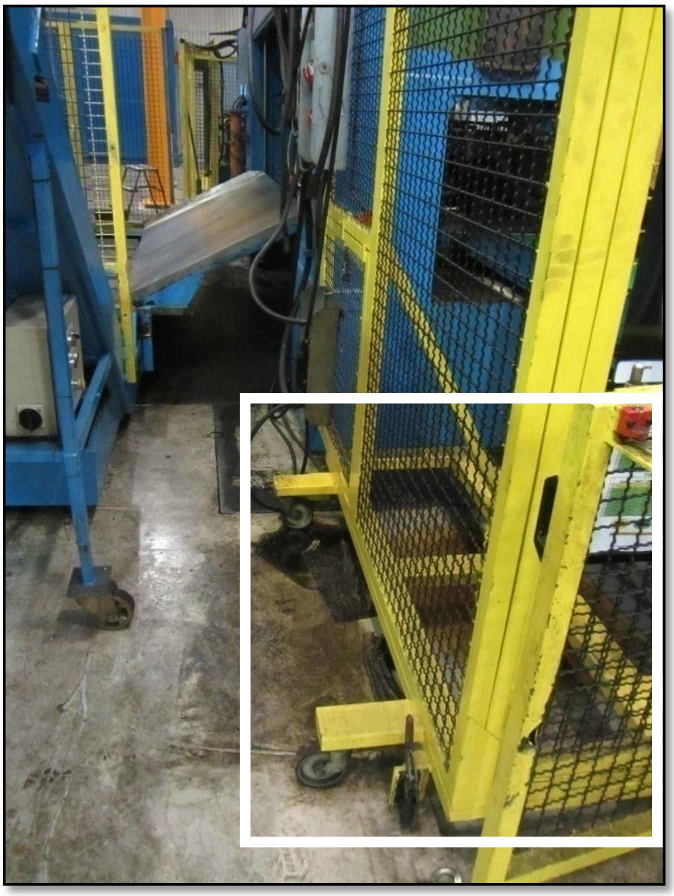


Figure 38: Protection fence legs

Here comes the protection fences problem. Within the conveyors area, a fence is placed around them to prevent a human to introduce the machine. This fence is required by the law and cannot be removed. However, as it is shown on Figure 38, the fence is linked to the floor by oversized supports. The white square in Figure 38 indicates that these supports are wheel mounted to be moved away. In reality, they stay on site, they are never moved out, and so many beams to support a light fence are not required. The negative points of such a support are that is becomes much harder to clean the floor, and it could be an obstacle for operators as the wheels stand in the walking way.

Improvement:

Having a standardized type of fence through the factory could be the best alternative. One simple way to fit fences on the floor could save much space, and would allow in this case to get rid of the wheels, that are not required.
It is already possible to see some simple links to the floor for some other fences within the workshop so standardization can start soon.

Problem 10 – Dirty and obsolete spraying device

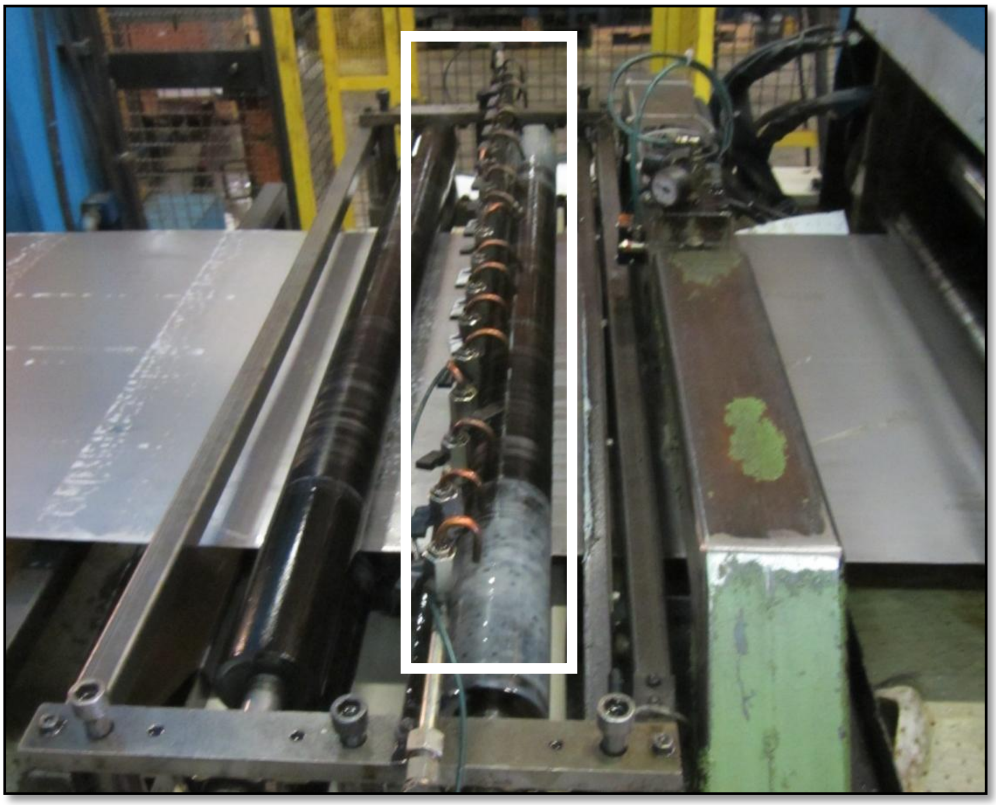


Figure 39: Oil sprayers

On Figure 39, it is possible to see inside the white square some little copper pipes. These pipes are the ones employed to spray oil over the metal sheet, so the stamping becomes smoother, and the parts result in better quality, especially the surface aspect. The pipes are manually controlled by adjustable valves. The device on which are mounted those valves is quite old, and does not benefit of any protection. The oil sprayed is not accurately controlled and the excess of oil needs to be evacuated somewhere. That is why this fact is linked to 5 S's, as much oil leaks under the metal sheet due to gravity.

That situation leads oil to the problem illustrated by Figure 40. In Figure 40 is the picture of a retention batch placed right under the metal sheet – between the sprayers and the manual feeder – so oil does not leak directly onto the floor, and the excess is evacuated and stored into a plastic tank. The retention batch has been installed during a focused maintenance week performed on the machine to fit on new equipment purchased as the manual feeder for example.

A problem remains because oil still leaks onto the floor by a space that has not been protected. A provisory plate has been installed, but does not completely solve the negative point. This plate is shown in Figure 40 by the white box drawn to highlight the part installed.

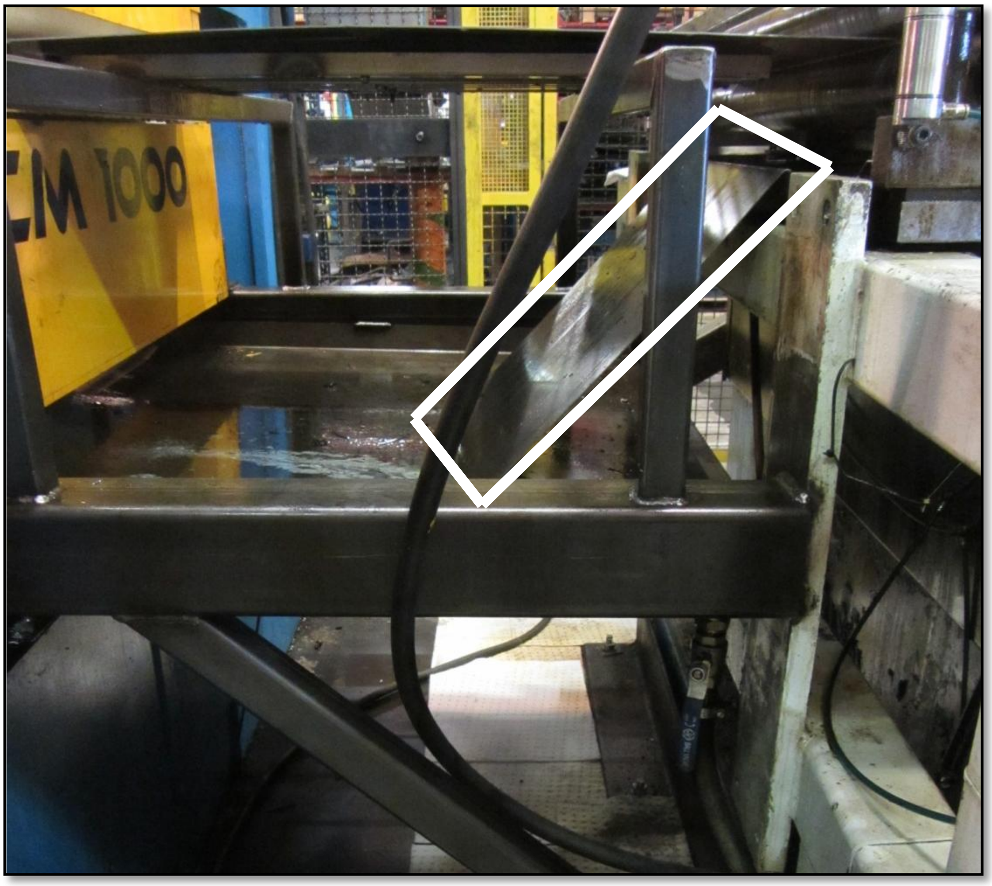


Figure 40: Plate preventing oil leakage

Still due to the oil spraying problem, white cleaning paper is placed right under this region to absorb the oil fallen on the floor. This requires a certain amount of time which could be saved to perform another task instead if the oil leaking would be avoided.

Improvement:

To improve the actual situation, welding a wider plate to even more protect the floor could be a good option.
The second option would be to invest in a new spraying device that could automatically open the right valve to spray oil. Having a more recent system could save oil and have less waste, which could be profitable for the finances. This system would be much faster to set, if the width of the sheet is input through the control system, there would be no need for the operator to climb on the oily device to adjust the sprayers.
It would also prevent to get the oil pump standing on the way, so it would prevent the risks of tearing away the pump and its hoses.

Problem 11 – Inappropriate oil tanks

Figure 41: Oil tanks

To continue with the oiling problems, the upper Figure 41 illustrates the actual way which is used to store oil employed to lubricate parts. Several old plastic batches are used because different type of oil is required for different parts. Some parts need to be lubricated with a mix made of 50% oil and 50% water, and some others need a mix composed of 20% oil and 80% water. Once more, the selection is manual, and a hose needs to be moved into the right batch according to the kind of part that is about to be produced. One of the problems with this system is that the area gets dirty quite quickly, and all the tanks stand on the way the operator uses to work close to the coil axle region.

Improvement:

The idea to solve the problems would be to install a specially made tank device that could stand somewhere else than on the operators way. It could be a device with several compartments for each oil type, and it would be automated as well. The type of oil to spray could be selected through a computerized window, or simple manual valves could open or close the desired oil circuit.

The best would be to have only one type of oil for every part, but two types at least have to be conserved according to the different thickness of the material to shape.

Problem 12 – Disordered wires and cables

Figure 42: Wires and messy area

The 5 S's are about to keep the working space clean and ergonomic to work in a smarter way. When looking at **Figure 42**, it is possible to see many wires in every direction and tools lying on the floor. It makes the atmosphere much less nice to work in and can create many problems. Indeed, the length of the different wires is often not required to be so long. Having a long wire makes easier the mistakes caused by someone coming to close to them. A wire or air hose can be accidentally unplugged or damaged, and if damaged can hurt an operator or even a customer visiting the shop floor. Security issues are engendered in this case, and ergonomic rules are not optimized when an operator has to lift the heavy cutting tool from the floor.

Figure 42 gives an idea about the situation around the machine, but many other areas follow the same rules. Moreover some other useless objects have been lying on the floor for couple of weeks and for no reason, without being removed like empty cupboard or dirty towels for example.

Improvement:

The first step would be to check and analyze all the wires and hoses in order to see which ones can be cut done. If none of them can for any security margin, the second step would be to assign "wire ways" that the cable should follow.
The last step joins the education. If operators are trained in a powerful manner about what really are the 5 S's, the "sustain" phase should be a great way to apply on site what has been learnt.

Problem 13 – Unused devices

Figure 43: Example of useless device

All what is unused should be removed to respect the 5 S's law. The previous Figure 43 is a good example. The roll present on the picture is used to straighten stainless steel metal sheet. This roll has been standing on site for ever without being used since the company is not dealing with stainless steel parts and should not shape this kind of material in a coming future. As this device is not employed, it should be removed in order to make the machinery surroundings more pleasant to work in.

Improvement:

In this case again, by educating operators, this device would have disappeared earlier. It is fair to say that the roll could be conserved in the case where stainless steel parts would be produced on the machine, but should at least be stored in another area.

Problem 14 – Nuts feeder standing in the way

Figure 44: The nut feeder on the way

Behind the machine stand two devices marked with “ESSVE Automotive” shown on Figure 44. Those devices are two tanks for raw nuts that can be inserted by pressing them in the right place to get a finished part without welding the nut. This is a great solution to avoid another manufacturing operation to realize a part. The device is used once or twice a month when the production of parts containing inserted nuts is planned. Even though, the two devices – for two sizes of nuts – continuously stand in the walking way behind the machine. That way is employed by the operator when changing the tool, and the two nuts tanks take some space that could probably be saved for something else.

Improvement:

- The first option would be to store the tanks that are wheel supported in another area, and brought on site when the production requires nuts. It would not prevent the fact that tanks are standing on the way, but would limit the problem for a certain period.

- The second option could be to transfer if possible the tanks, to the top of the machine. The top of the machine is an area where stairs lead, and some free space is available up there Figure 45. This option – if realizable – could probably save some energy as the nuts could even reach the die by gravity only. Some space is even available on the top to store nuts in cupboard before feeding them into the tank.

Figure 45: Top of the Manzoni press

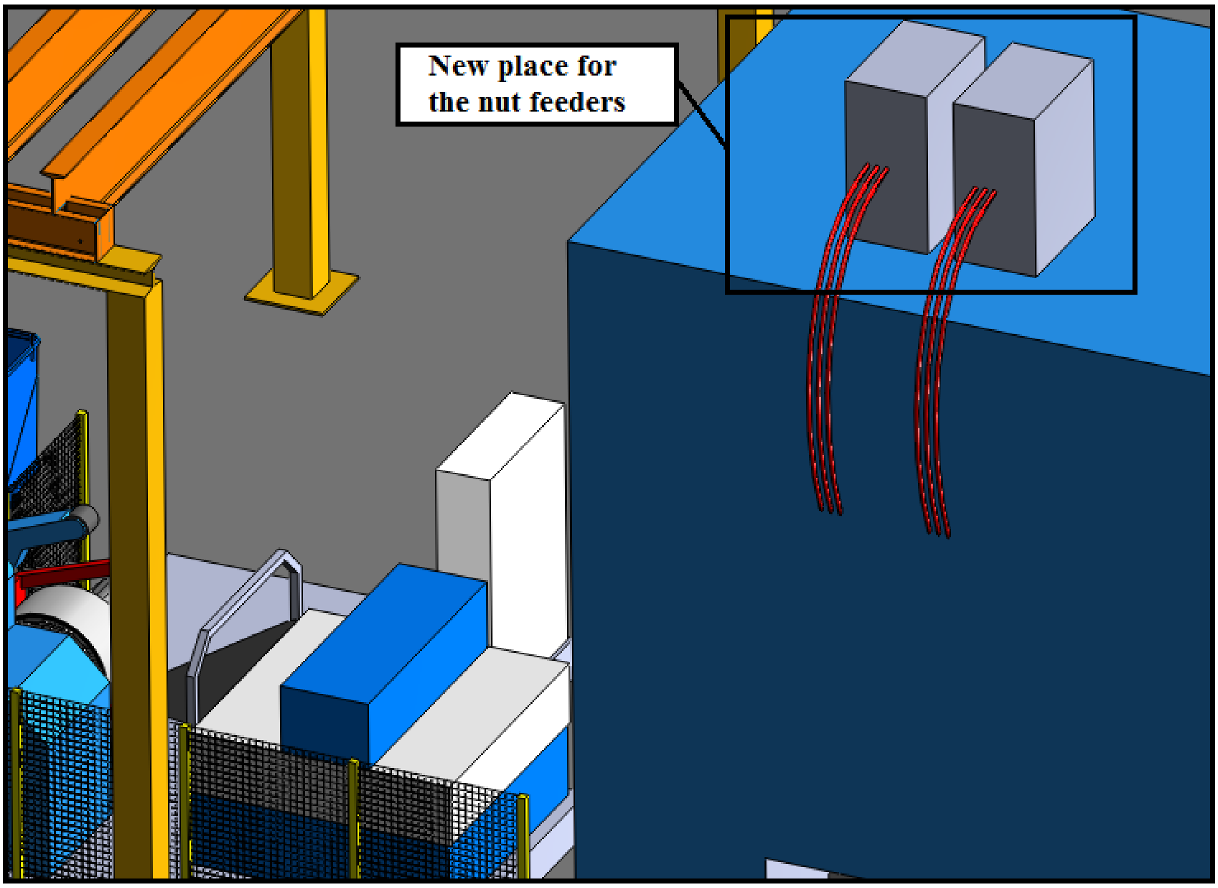


Figure 46: New place for nuts feeder

Figure 46 is a visual support to see how the nuts feeder could stand on top of the machine. It gives a representation and an overview of the solution to save some space on the shop floor.

Problem 15 – Loading table gutters full of scrap

Figure 47: Loading table surroundings

Figure 47 is a picture that has been taken close to the dies storage area. In a corner of this area stands a table (Figure 48) which is used to pre-load dies that are about to be used for production. Dies are conveyed to the table with a crane, and the die is clamped on the table. This allows a faster die changing time as the assembly table and die are transported to the machine and inserted all together. Adjustments and setup times are reduced before the production starts.

Around that table, on each side, a gutter is fit to collect the excess of oil that could leak onto the floor. One of the gutters is shown by the white shape in Figure 47. When looking at the picture, it is possible to see that the gutter is full of scrap pieces, wooden sticks and a cleaning tool that have no reason to stand there. Moreover, the floor is really slippery due to the excess of oil that is spread all around the table because the gutters do not fulfill completely their roles, and oil is leaking from somewhere else.

Improvement:

Educating employees and having some more appropriate tools and devices could limit the excess of scrap pieces in that place of the workshop.

Problem 16 – Loading table

Figure 48: Die on its table

The upper Figure 48 concerns the whole table and the die lying over the latter. Through this picture, it is possible to see the two gutters on each side, and it is easy to see that oil straightly goes onto the floor if it leaks from anywhere else than over the gutters.

Improvement:

This improvement goes with the previous one. But before using this idea, operators need to be trained in order to sustain the 5 S's in that area. Indeed, if this improvement is implemented, it will work for maybe a month, but after two month, the retention table might be really dirty, full of scrap pieces, wooden sticks, so 5 S's would be a failure. Figure 49 gives an idea about what could look like the new retention table.

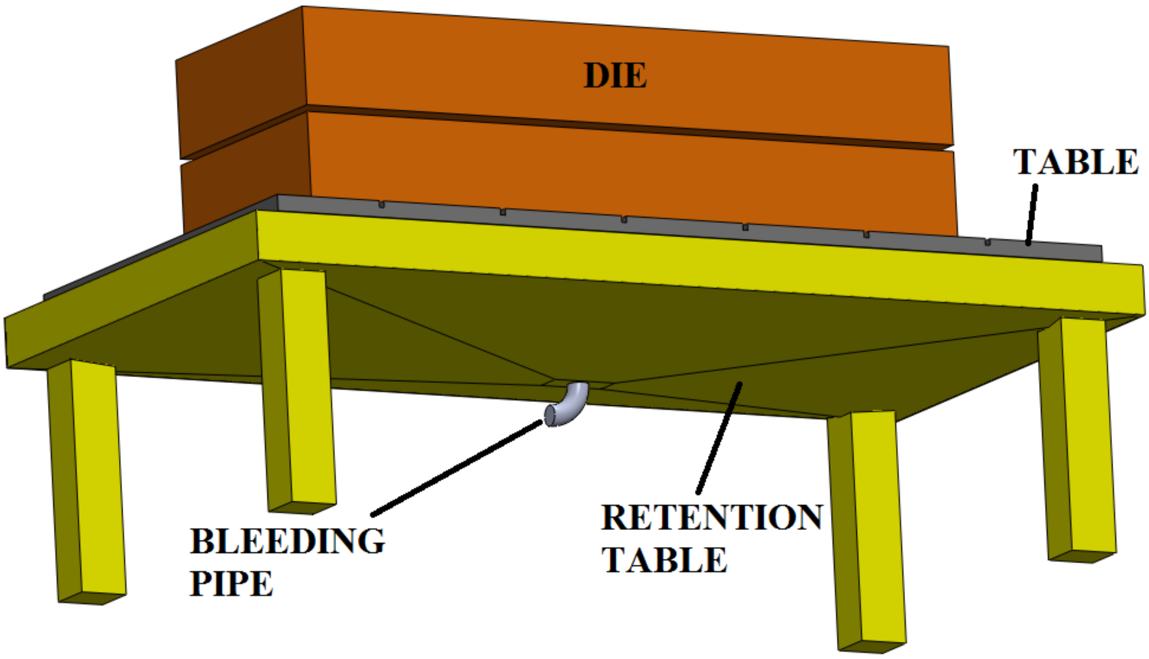


Figure 49: New loading table

Problem 17 – Poorly designed sensors

Figure 50: Sensors on the die

When the production is automatically running, the metal sheet is fed into the die between each hit. A sensor is used to detect when the material has reach the right position to be hit. Sensors look like the ones in Figure 50. They are the source a many breakdowns occurring when the production is started. As it is possible to see on the Figure 50, the plate to get in contact with the metal sheet are installed with many screws, thick and thin metal pieces, which make the assembly quite fragile. Indeed, production stops often due to a sensor which gets loose mainly, but can come from a plate which is bended and does not fulfill its role.

Improvement:

This improvement could be linked with the next part since sensor supports are built up by the maintenance department. The improvement in this case would be to have a more rigorous method to manufacture those supports, and to banish the screws. When saying screws, it implies getting loose so put out of order the sensor. The design should be optimized. Another idea could be to install a one-touch sensor device as mentioned in the theoretical framework (3.3.2 Suggestions of improvements). This option requires much more development and needs to be realized in a very smart way so it does not have to be removed when switching production.

The coming Figure 51 has been design with CAD software in order to give an idea about what could be done to achieve a satisfying 5 S's level around the packing area. It also sums up some of the previously proposed improvements, and constitute a visual support, that can be shown to the operators to show them would could be improved.

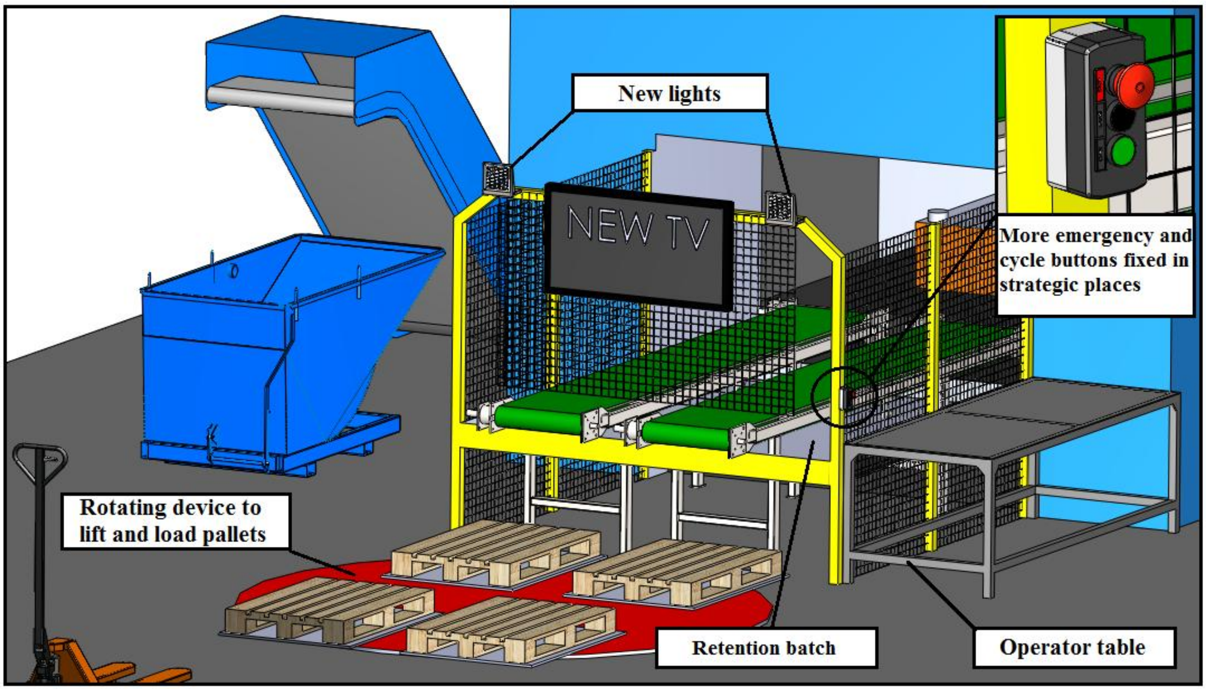


Figure 51: New packing place

4.4.3 Around maintenance

Maintenance is a crucial aspect when improving the efficiency of equipment. This needs to be developed all the time in order to get a convenient situation that can be sustained to run the equipment more effectively preventing failure and down time.

MAINTENANCE EVOLUTION	
YEAR 2011	**YEAR 2013**
CORRECTIVE MAINTENANCE	
• 25 - 30 stops per days were recorded on average **Cause:** Old machine program failures and mistakes	• No corrective maintenance performed in 4 months, or at least nothing that the maintenance manager is aware of.
PREVENTIVE / PLANNED MAINTENANCE (Performed around November - December)	
• **Every year:** Small maintenance (oil check and other minor checking are performed) = 1 day • **Every two years:** More parts and systems in the machine are checked and fixed if getting in bad conditions = 2-3 days • **Every three years:** The whole equipment is controlled (bearings, cam shape, endless screws, etc...) = 1 week	
AUTONOMOUS MAINTENANCE	
---	Performed daily by operators (cleaning, oil check, temperature)
FOCUSED MAINTENANCE	
---	• Investment of scrap conveyor in (october 2012) • New sheet feeder (march 2013) • New automated oil spraying system: planned to be installed during summer 2013

Table 9: Maintenance evolution at AQ Segerström & Svensson AB between 2011 and 2013

Table 9 is a presentation of how maintenance grew up within the workshop especially on the Manzoni press since 2011. Before that, maintenance was pretty minor in term of load and was rather unstructured. In 2011, a structure started to appear with the corrective and preventive maintenance. Corrective was performed very often on the machine everyday because the programs used by the machine to run get obsolete, and breakdowns occurred often within a day. Preventive maintenance was performed on the machine every year to a more or less important level. This maintenance was planned around November, where the machine is down for a day if small maintenance is performed, or for a whole week (every three years) if a much larger maintenance has to be operated.

Nowadays, the corrective maintenance has been getting rid since the automated program has been replaced. It could happen that corrective maintenance needs to be performed, so in this case, a company in charge to repair the broken device can come in emergency. Preventive maintenance has not been changed since 2011 and is performed following the same way. The main difference in 2013 is that a form of autonomous maintenance now takes part within the structure, and some basic works are performed daily by the operators.

The management also deals with focused maintenance which has a goal to always reduce future corrective maintenance by investing or refreshing some parts of a machine for example. Some of the applications done according this manner to improve the Manzoni press are given among those in Table 9.

4.4.4 List of problem and improvement

Problem 18 – Messy maintenance area

Figure 52: Dies maintenance area

The maintenance department has a special room containing milling machines, lathes and grinding machines for heavily damaged tools, or to manufacture new parts required to fix a die for example. Otherwise, for minor reparations regarding tools and to unfit them apart, a corner of the storage area is dedicated to the dies maintenance as shown on Figure 52. As expressed by the picture, there is no structure on this site, and the place does not seem appropriate at all to fix tools. Wood sawdust is lying everywhere on the floor, maintenance crew is operating directly on the floor and the global mess is predominant.

Figure 52 takes place within the TPM part since it is directly linked to maintenance. That figure with its problem could also stand within the previous 5 S's part, as well as the 5 S's section could have its place among the TPM related problems. Indeed how it has been mentioned in the theoretical part, 5 S's and TPM are linked, but the outcome and results coming in the next parts are not supposed to be affected.

Improvement:

Maintenance staff requires an education as well concerning both 5 S's and TPM, as they are directly dealing with this latter. This is the first step before any improvements for sustainability. All what is unused should be removed or at least stored somewhere else to establish a proper area dedicated to the dies maintenance. That area would have a limit on the floor so there is no confusion for anyone. The most common tools could stand in that area within a shadow table or an adapted toolbox. Ergonomics needs to be improved so the operators do not work directly on the floor. An adjustable table could be employed for example, so workers can adapt their position to what they like.
An appropriate lighting could be interesting to couple in this area so workers have a better vision about what they are doing.

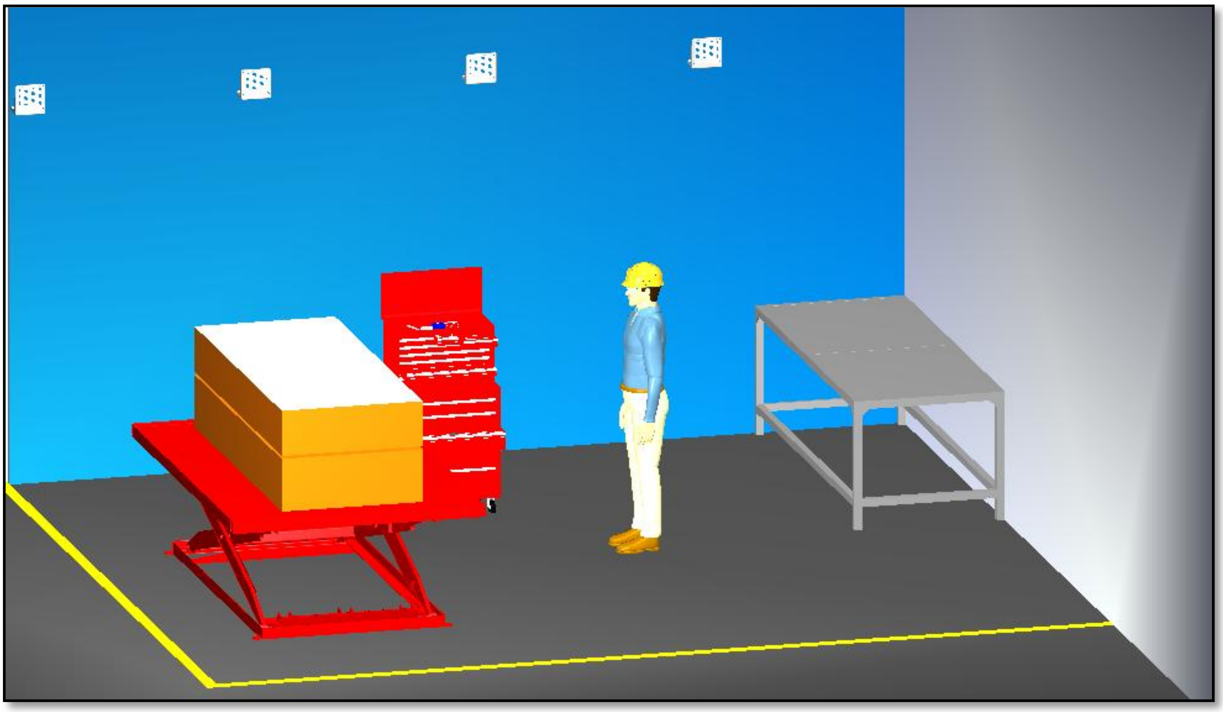


Figure 53: Vision of maintenance area after improvements

The upper Figure 53, gives an overview of what could look like the maintenance area after implementing 5 S's, dealing with TPM and continuous improvement. It could be compared to Figure 52 to have a better understanding of general amelioration that can be achieved.

4.4.5 Around change-over

As mentioned previously, SMED is the most effective manner to improve the OEE of the studied press. The machine is down when a tool is being changed, and this time is rather variable. For the Manzoni press it can take from one hour and a half up to three hours to change a tool. The aim of this part is to find solutions that could decrease this time by 50% first and even more, when the company will have enough profit to invest in more efficient and reliable devices.

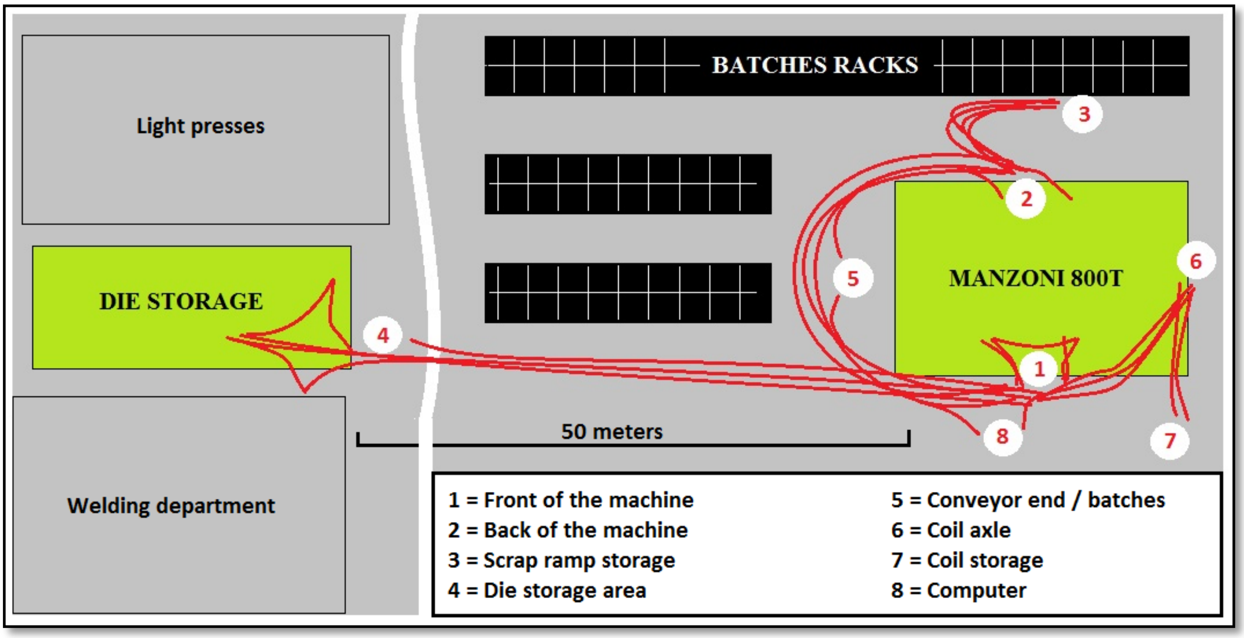


Figure 54: Average spaghetti diagram for a die changing (Manzoni 800T)

The Figure 54 is a spaghetti diagram that represents an overview of the walking / transportation that is required to perform a die changing operation in the actual configuration when the machine is stopped down. In this case, transportation or walking is an action that requires quite a large amount of time, but this is coupled with all the different activities that need to be performed in front of each key point. This spaghetti diagram can seem quite well structured, but many of these transportation steps can be cancelled when the machine is down, and could be performed when the machine is running. This is the starting point of the analysis about what could be done externally or internally.

4.4.6 List of problems and improvements

Problem 19 – Unreliable carts

Figure 55: One of the three carts

In order to load dies inside the machine, carts as the one on Figure 55 are used. Three carts are available for all the presses dealing with heavy tools within the workshop, and the carts are also used to transport the die from the storage place to the machine. The first problem observed with those carts is that if three die changing are performed simultaneously, a fourth machine is not able to realize a quick changeover since the operator needs to wait for an available cart.

This problem is even greater when it comes to the forklift. Only one forklift is available to toe this kind of trailer, and is very often utilized by another operator. It makes the changeover time becoming much longer by just waiting an available forklift, which represents a large amount of waste.

Another problem pointed out by the operators – and by observation – comes when the cart needs to be adjusted to the machine. Hydraulic cylinders are operated to center the cart onto the locators fitted on the machine. To execute this move, one cart is rather fast, one is acceptable and one is quite slow. Employees are convinced that there should be a way to boost them so they can be faster even if they are old equipments.

Improvement:

The most affordable investment that could be done to improve the efficiency of these carts would be to restore them, and to boost the two slowest so they get all set up to the same features.

It could be interesting to purchase a new forklift as well, or to adapt other forklift from the workshop so they are able to receive the toeing hook required to carry the cart.

The last solution could be to invest in some new carts that do not necessitate any forklift to be towed away.

Lastly, the arms to insert or remove the die could be improve so there is no need to switch them from long to short size during that operation.

Problem 20 – Adhering carts surface

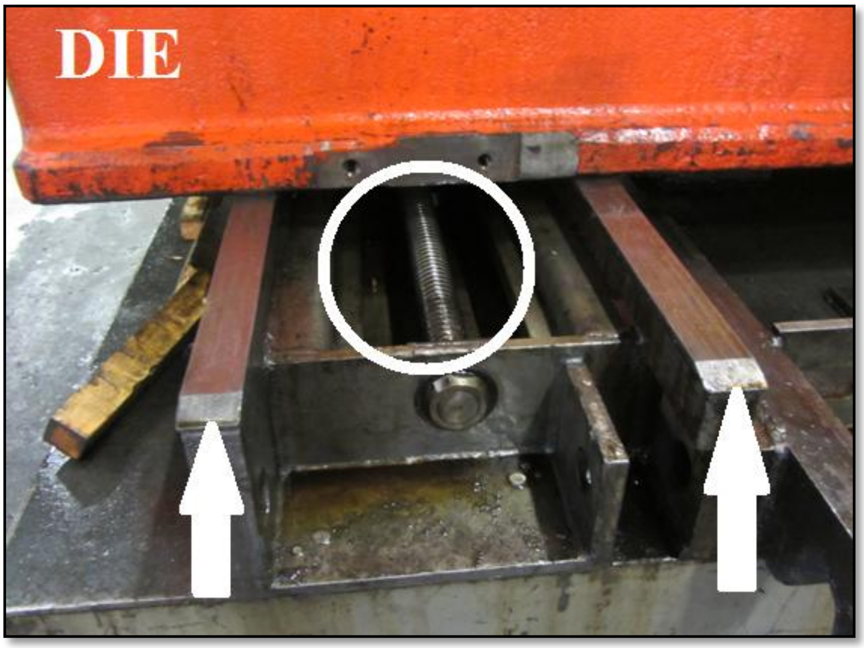


Figure 56: Sliding surfaces on the cart

Still related to the carts, a problem remains. Figure 56 shows two arrows pointing to the sliding surfaces on which the die is lying. When the die is inserted or removed from the machine, it slides on these surfaces, which creates a contact steel to steel. Inside the circle on Figure 56 is an endless screw which creates the back and forth move to the die. As the heavy dies are moved on a quite adhering surface, the screws and their nuts containing bearing balls are getting damaged after a certain life time.

This can be fixed internally, but the maintenance department affirms not being willing deal with this kind of trailers. This problem take part of the TPM section as well, but comes into the SMED one since the move is getting very slow by the adherent surface. The friction is the cause to a loss of time when performing the changeover.

Improvement:

To make the first improvements in a close future, it might be interesting to one of the device shown through Figure 57. These are simple linear air bearings that can be adapted to the trailer. The die does not lie on the rolls during transport, so it stays stable. When the cart is installed in front of the machine, pressured air is plugged to the cart so the bearings can lift up the die. The rolls will make the die much easier to handle, so the time to insert or remove the die will be improved.

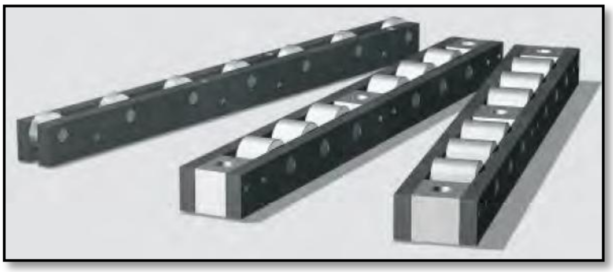


Figure 57: Example of rolling system (Serapid, 2009)

Problem 21 – Ground sheet flatters before the die

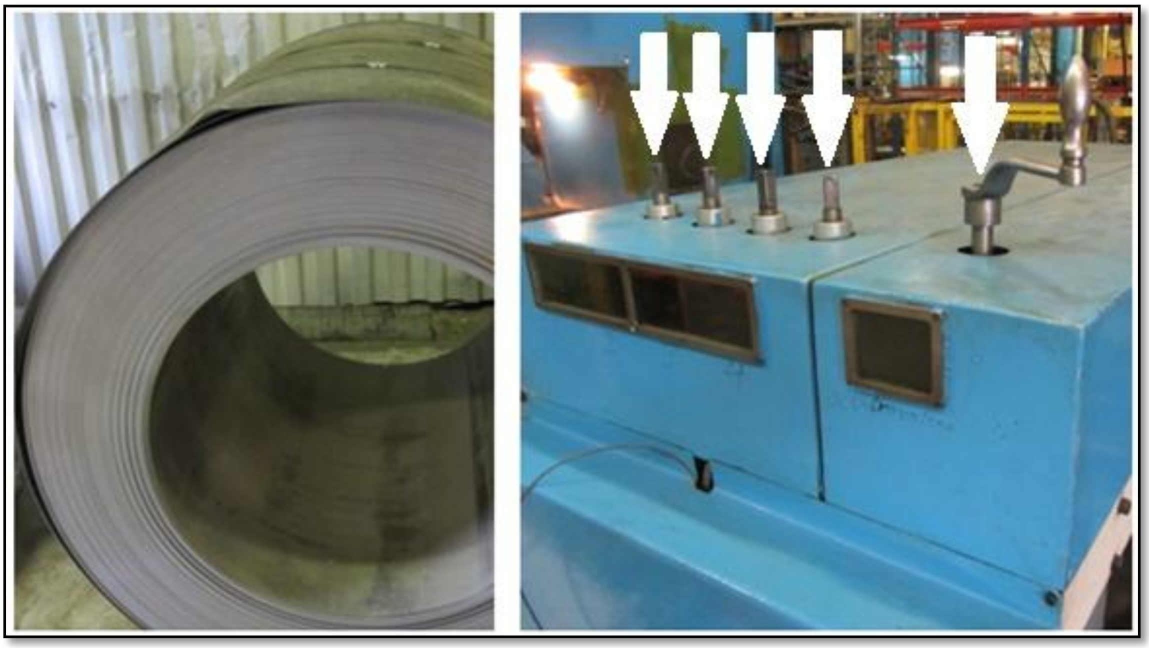


Figure 58: A coil and the sheet flatter

Figure 58 exposes on its left side, the kind of coil employed to produce parts from the Manzoni press. When the straps around the coil are released, the metal sheet is not ready for use as it stays roughly curved. It needs to be flattened down before introducing the die. On the right side of Figure 58 is shown the device exploited to flatten the metal sheet. A lever is manually driven to apply more or less pressure on rolls that put back into shape the metal sheet. The four arrows on the left are pointing out the flatters, and the right side arrow is pointing at the automatic feeder.

The problem of this process is that metal sheet thickness is varying between orders and the pressure on the rolls needs to be adjusted for every die changeover. This stage asks a pretty long time to perform, especially because differences exist between two same sized coils. Indeed, the operators have a standard setting for each kind of coil, but as raw material is not coming from the same supplier and the quality differs, it takes some tries and adjustments to get a satisfying outcome in term of quality.

Improvement:

The most important stage to improve this phase would be to become faithful to one type of supplier. Adjustments and settings would be reduced if the metal sheet quality is always the same or with few differences.
The next stage would be to invest in a fully automated feeder that could be able to set the right pressure to the right rolls. The guide for the width would be automatically set as well, so in total, much less manual handling would be required.
The aim is to standardize this operation by being faith to one supplier, and having preset parameters entered into the controlled system.

Problem 22 – Dies lockers and lifting hooks

Figure 59: Hooks and connecting rod

Within the storage are, an action needs to be performed before moving any die from or to the cart. Hooks as the ones circled on Figure 59 have to be installed on the upper part of the die to lift it with the crane. They need to be removed – once the dies on the cart – to let free the surface inside the machine, or to be able to store other dies on this surface.

The connecting rod squared by the white rectangle in Figure 59 is required to hold and to link the upper and lower part during lifting. Four rods like this are mounted on each die, so eight screws need to be loosened and tightened which represents a waste of time. Another problem with them is that on some dies, only three rods are present, so when the die is lifted up, a torsion occurs, which can result in a light bending of the die, so the general quality of the parts produced with this die is decreased.

Improvement:

The idea to improve that operation would be to let the lifting hooks permanently fastened on each die. A security control could be performed every two years, to check that no cracks are appearing. This operation would save quite a large amount of time since the hooks do not need to be carefully selected among the ones available, and the duration spent to fasten them would be removed.

The other idea is to improve the connecting rods so they get a new shape which makes them easier to put on. In this case, the screws stay permanently on the die as well and require only one turn maximum to be tightened. A visual explanation is presented on Figure 60. It could be smart as well to install a kind of pocket on the die in which the rods could be stored so they do not get lost.

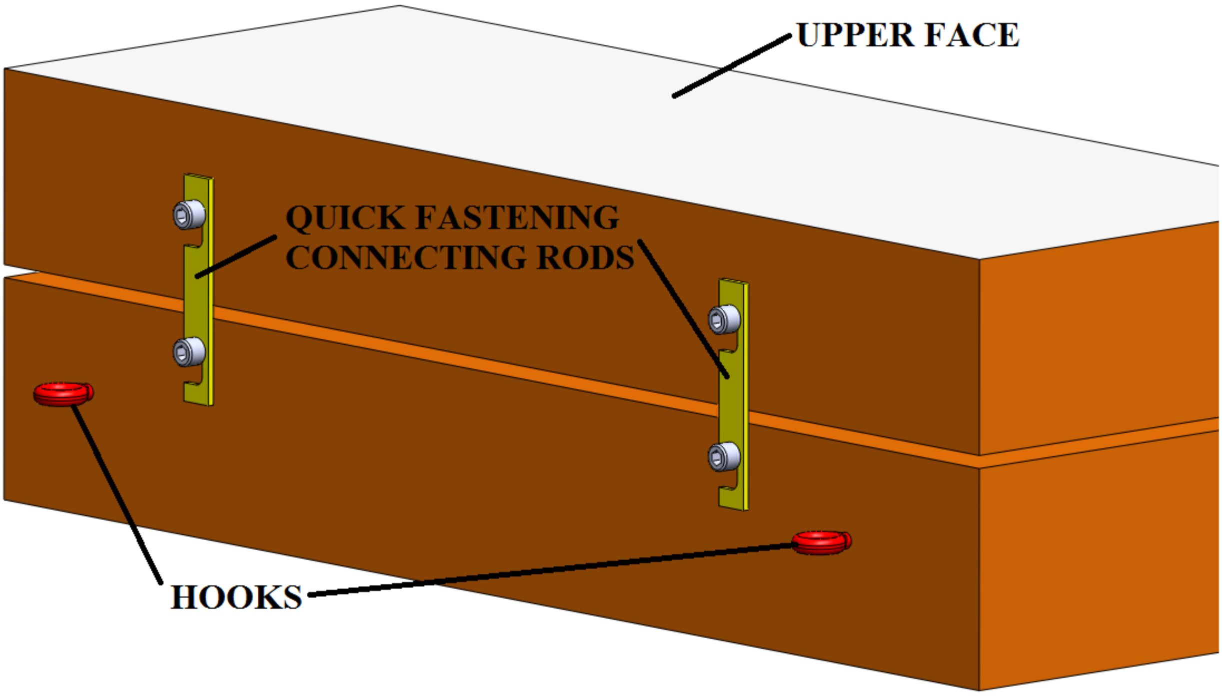


Figure 60: Die lifting improvement

Problem 23 – Evacuation ramps screwed

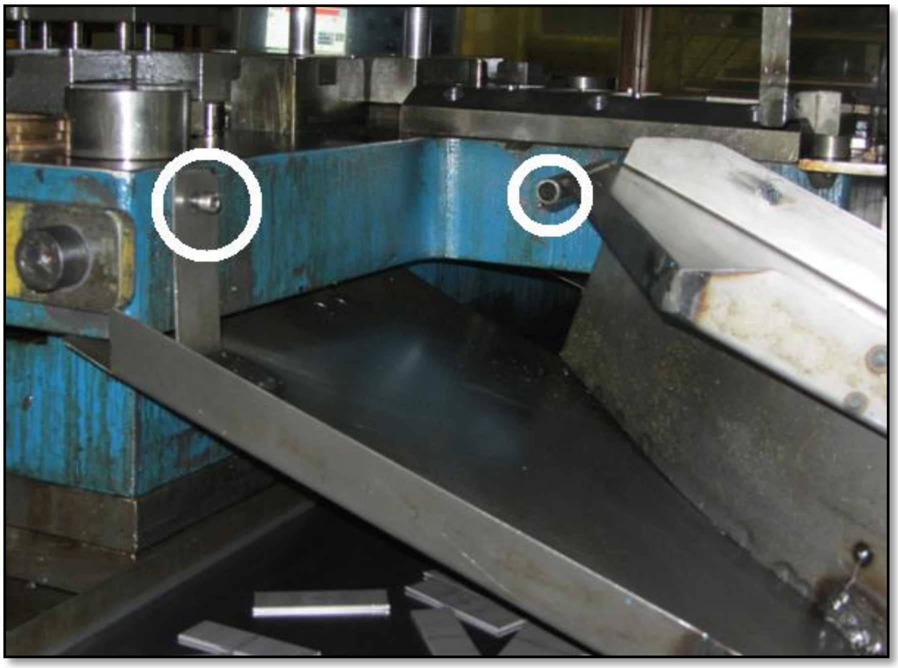


Figure 61: Evacuation ramps screwed

Another problem related to screws tightening or loosening is expressed by Figure 61. After the last die hit, when a part is finished, it falls down into an evacuation ramp that leads the parts on the conveyor. Those ramps are different for every die, and are generally screwed on the die directly, as the two circles in Figure 61.

Figure 62: Ramp not fulfilling its task

As there is no standard to place the ramps, it happens that finished goods are dropped into the wrong place and get stuck as shown with Figure 62. This problem could take part of the 5 S's section or even of the TPM one as well but is standing among the SMED chapter as it is related to the ramps in a general manner that are installed during the changeover.

Improvement:

For this problem, a rigorous design can be a good alternative. Some standards to respect should take part of the designing stage of the ramps, and screws should be banished as much as possible. A clamping device should be the one employed to fit on ramps. More accuracy and a higher quality would result in a fast installation of the ramps.

Otherwise, it could be thought to get rid of every ramp, that would save both time and space. In this case, the conveyors need to be adapted so they get an integrated ramp, and could be designed in order to be closer to the die.

Problem 24 – Non-standard clamps

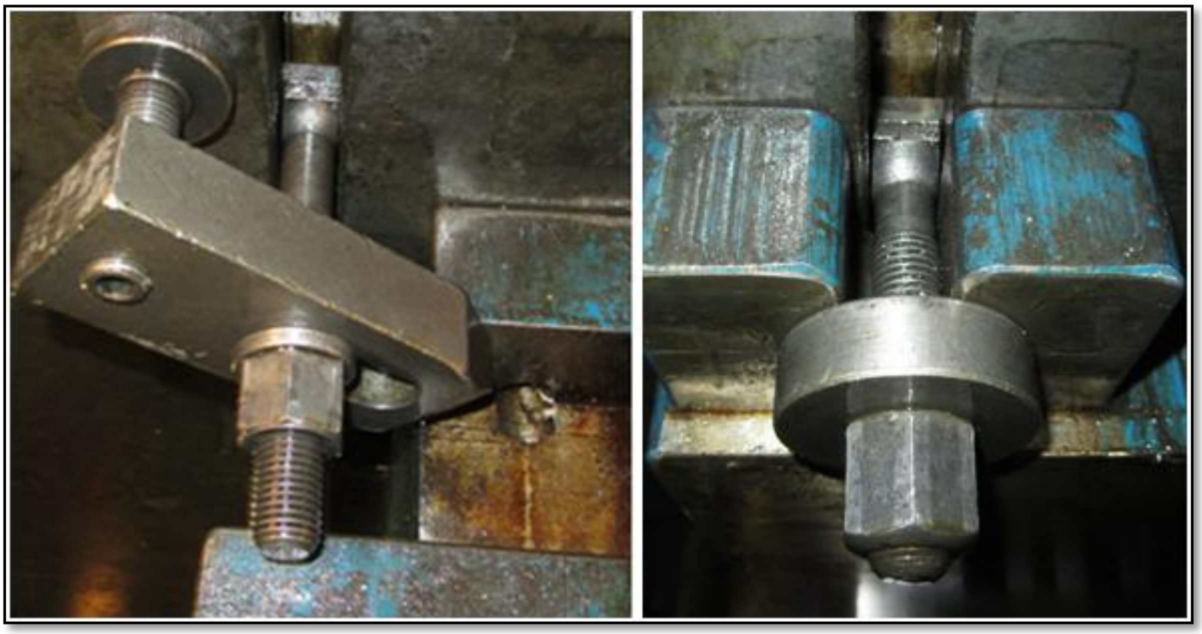


Figure 63: Non standard clamping system

When talking about standardization and SMED, it comes to the clamping step. Clamping the die to the machine is an operation that requires a large amount of time as well. When observing Figure 63, it is possible to see that the two clamping tools shown are different. Several problems to the difference in clamping appear. The table grooves are not always aligned with the clamping step on the die, and different sizes of clamps exist, so the right one needs to be chosen carefully.

Figure 64: Difference in grooves pitch

Figure 64 highlights the problem dominating when dealing with the die clamping. It is possible to observe that the places for screws on the die are not at the same pitch as the grooves on the table. This is why the problem exposed in Figure 63 occurs. It makes the time to choose the right clamp and to adjust it much longer than if the grooves were aligned.

Improvement:

Several solutions are possible to improve the clamping time:
- The first one would be to weld a long clamping step along the whole die so clamping becomes possible at any point.
- The other solution would be to machine grooves in the die as shown on Figure 65 so they can match with the grooves already machined on the table. Smaller steps as the ones on Figure 64 can be welded instead of having a long step.
- The last solution, which would be the most efficient one, is to purchase and install a magnetic clamping device that some companies can propose nowadays. That technology requires electricity for 1 second to clamp or to unclamp, time to activate or deactivate the magnet. That solution would prevent the use of any clamp, which avoids the mess and mistakes. This could be the best alternative since walking phases to the back of the machine would be cancelled for the clamping operation.

For any option, the die needs to have a standard step height as mentioned in the theoretical part (chapter 3.3.2 Suggestions of improvements)

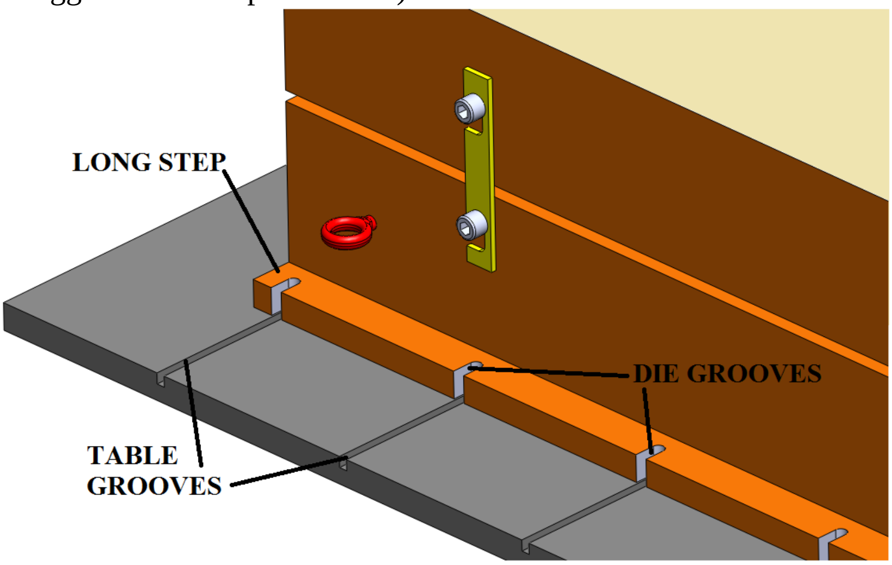


Figure 65: Improvement for a faster clamping

Problem 25 – Maladapted scraping ramps

Figure 66: Scrap ramp inside the die

When the metal is being shaped, if a hole is made for example, some scrap pieces like a washer fall down into a vibrating ramp that conveys the scrap parts to a scrap batch in the end of the chain. Figure 66 gives a good view of what is wrong with those ramps, even if this problem could be more related with the 5 S's and TPM also. Through the figure, it is obvious that the ramp partly fulfills its tasks because some scrap washers are beside the ramp. This makes the environment dirtier, takes a long time to clean, and some metal pieces can reach the table grooves. This latter is a problem when changing die as a metal piece can stand on the way of the table, which prevents it to move. Some time is required to clean, and in the worst case, the machine table or the die can be damaged.

Improvement 25:

To prevent small scrap pieces to get out of the ramp, educating operators sounds to be a good option first. It will allow them to choose the right size of ramp that needs to be put in the die. A protection could be placed where parts are getting out. It could look like a protection behind the wheel of a car to prevent mud to be sent away. Otherwise, the ramp sides could be higher, so pieces do not cross over it.

Problem 26 – Maladapted scrap ramps fastening

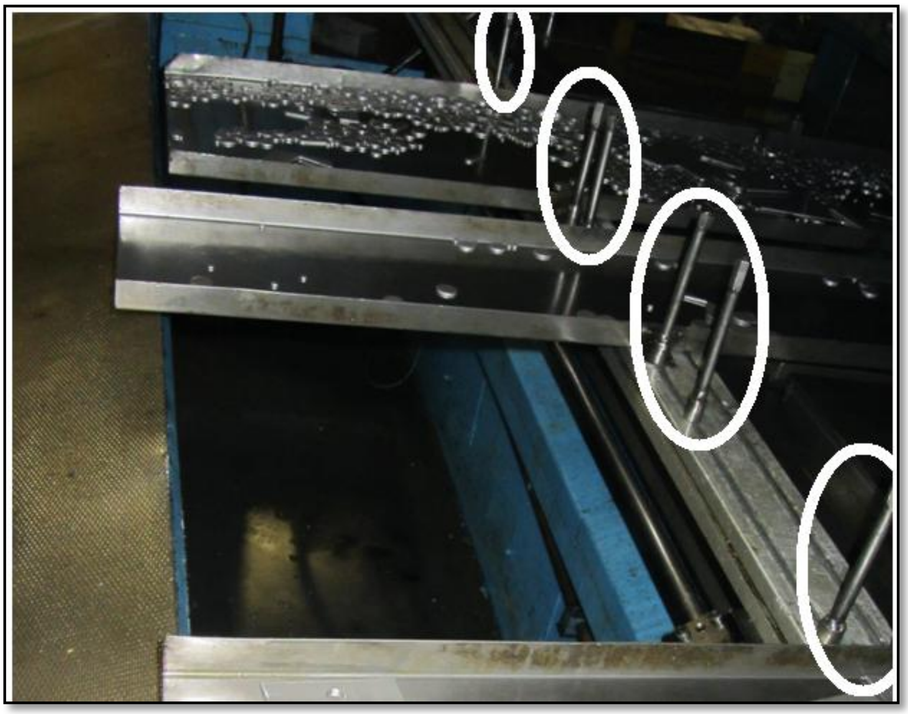


Figure 67: Scrap ramps holders

The ramps going through the lower part of the dies need to be fastened to the vibrating device which gives the move. Figure 67 with the white loops represents the manner to fix the ramps. It consists of regular screws manually driven by the long stick shown on the figure. About 8 screws need to be tightened after the ramps have been adjusted and inserted into the die, which is once more, greatly time consuming.

Another problem slowing down the changeover and that needs to be stated, is the cleaning of those ramps. The excess of scrap parts left on the ramp need to be sent away manually, takes some time as well, and could be improved.

Improvement:

That idea would be to remove all the screws required to install the ramps, and the best would be that there is no need for the operator to go to the back of the machine, so time could be saved. Several solutions exist, and one of them, which need to be developed and optimized in term of design, could look like the one exposed on Figure 68.

The system would be to conserve the actual vibrating system, but just placing a magnetic apparatus over this latter so the ramps can be “pre-linked” to the vibrating beam. A last automated device could effectuate a pressure on the ramps so the link to the vibrating beam is more complete. All the ramps could be fastened at the same time, and no positioning would be required which limits the problems.

The ramps would be simpler in term of design, since no “U-groove” would be required for fastening so they would be straight on their sides. This detail could be a great time improvement, so the ramps could be inserted into the die from the front side of the machine.

The steps would be to insert the ramps from the front, and to push a button to tight them.

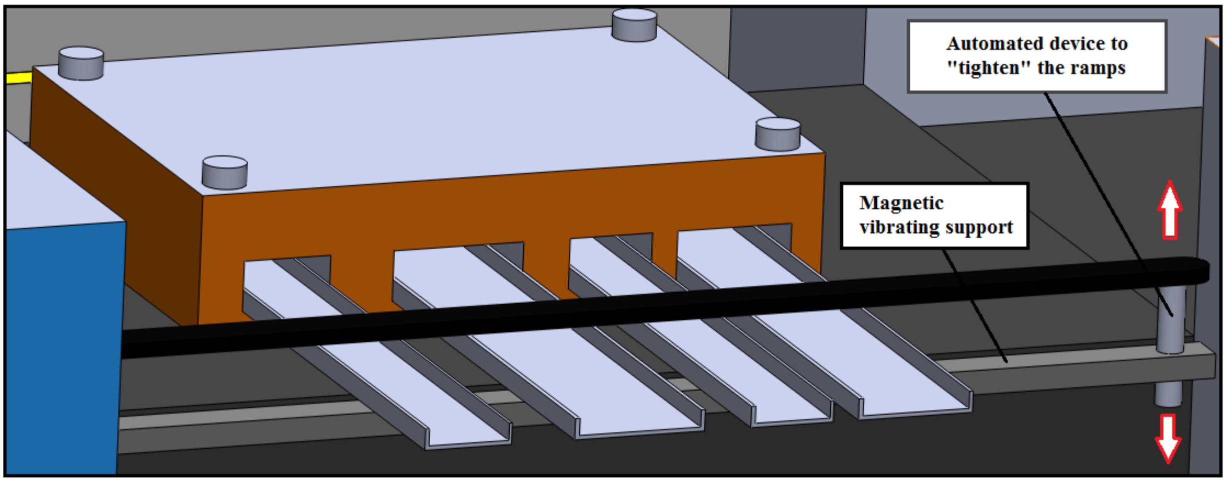


Figure 68: New ramps support and fastening

It could be clever as well to realize ramps with an adapted material so the scrap pieces do not stay "glued" on the ramp. It exist material with special surface shapes which could be adapted to this requirement.

Problem 27 – Scrap ramps maladapted storage area

Figure 69: Scrap ramps storage place

When a die changing operation is performed, removing and installing the scrap ramps is pretty time consuming, especially in term of transportation. Ramps are manually carried from their storage place shown with Figure 69 inside the arrows. The storage area is located about five meters away from the point where ramps should be installed. That length is not huge, but the added spent time to travel can rapidly grow, especially when pallets or batches stand in front of the storage and need to be moved away as on Figure 69. Those batches are not standing on their right place, which create a waste of time for the operator who needs to move them.

Moreover, several widths of ramp are available, and there is no standard existing to any die. The operator is so losing time measuring the width desired to fit in the die. Adjustments and approximations enable some ramps to be used for several different dies, but ramps can get damaged as they are not belonging to one kind of die.

Improvement:

To solve this problem, two alternatives would be profitable to safe time, which are:

- Either to standardize the ramps' size so there is no need to measure them, no time would be lost. This option is technically really complex to implement because the dies need to be re-arranged. In this case, the ramps should be stored maybe on the side of the machine, or close the front of the machine. For any case, the ramps storage area has to follow the 5 S's requirements. They need to be ordered, properly stored so they do not get damaged and the surroundings of the storage do not get dirty or oily.

- Either the ramps could stand for ever within each die. The principle would be that each ramp looks like a drawer, pulled outside the die to fasten them or pushed inside for transportation and storage. However, more design development needs to be performed in order to be reliable.

Problem 28 – Weak security sensors

Figure 70: Security sensor

For security reasons, a sensor is placed close to the coil axle. When someone walks through this laser barrier, the moves from the machine are stopped. Figure 70 shows the two sensors inside the circles. They are mounted on a support by screws, and send a signal to mirrors in the other side of the protected area. An operator explained that either the sensor either the mirrors get loose after a certain time, and need to be adjusted. The adjustment cannot be performed by the operator himself, but needs to be done by a certified company. This problem can happen once a month and lets the machine still standing for several hours in some cases.

Improvement:

Once more, standardization could be the best option. Indeed, on some other machines in the workshop, strongly supported laser barriers exist. This barrier does not need to be adjustable, so a stiff mounting would be appropriate to avoid settings problems.

Problem 29 – Door opening and closing

Figure 71: Door action button

A minor problem acts on the changeover time which is shown through Figure 71. A security door protects the operators in the front of the machine. Many door opening and closing are performed during production, and some happen during the changeover time. On Figure 71 are presented two positions to move the door. "Öppna" means open in Swedish and "stäng" means close. To open the door, only one touch to the button is enough to lift up the protection, but to shut it down, the button needs to be held on for 10 seconds.

Improvement:

The easiest way to get around this problem could be to set the "close" button to be handled on the same way as the "open" one.
Otherwise, the door can even be removed and a laser barrier sensor could replace the security provided by the door to prevent anyone introducing the machine when running. However, the inconvenient would be oil projection, and the floor or even the operator would get dirty by oil spatters.

Problem 30 – Coil guides

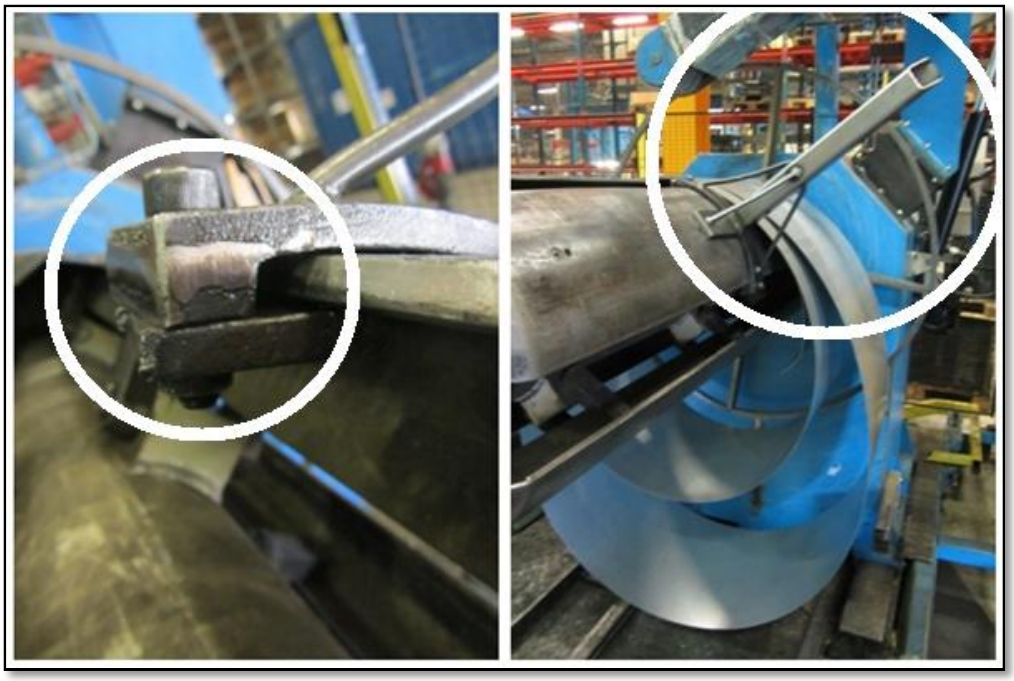


Figure 72: The coil guide

After the coil is loaded on the axle, a security needs to be fit on and is shown in Figure 72. That security is useful when the axle is turning to unroll the coil. Due to uncoordinated moves and the coil weigh, the coil diameter raised as on the right part of Figure 72. Many moves from the sheet are engendered when the axis is turning, and the coil can move so it is not aligned anymore with the production way. To fit the coil guide, screws are used, and the device is not the most practical to put on the axle, so in this case again, time is wasted. Moreover, it happens that the coil manages to go over the boundary set by the guide so the machine needs to be stopped down to realign the coil. That operation is fastidious and can last close to one hour.

Improvement 30:

Two possibilities exist to optimize the mounting time of this device:

Firstly, the same type of guide could be conserved, but only the tightening system could be modified for a "one-turn" option. This improvement is the most affordable and the one requiring fewer modifications than the second one.

Secondly, a completely new device could be installed. This device could be fixed compared to the floor, so there would be fewer problems due to the rotation. It could look like the one in Figure 73, roughly represented thereafter.

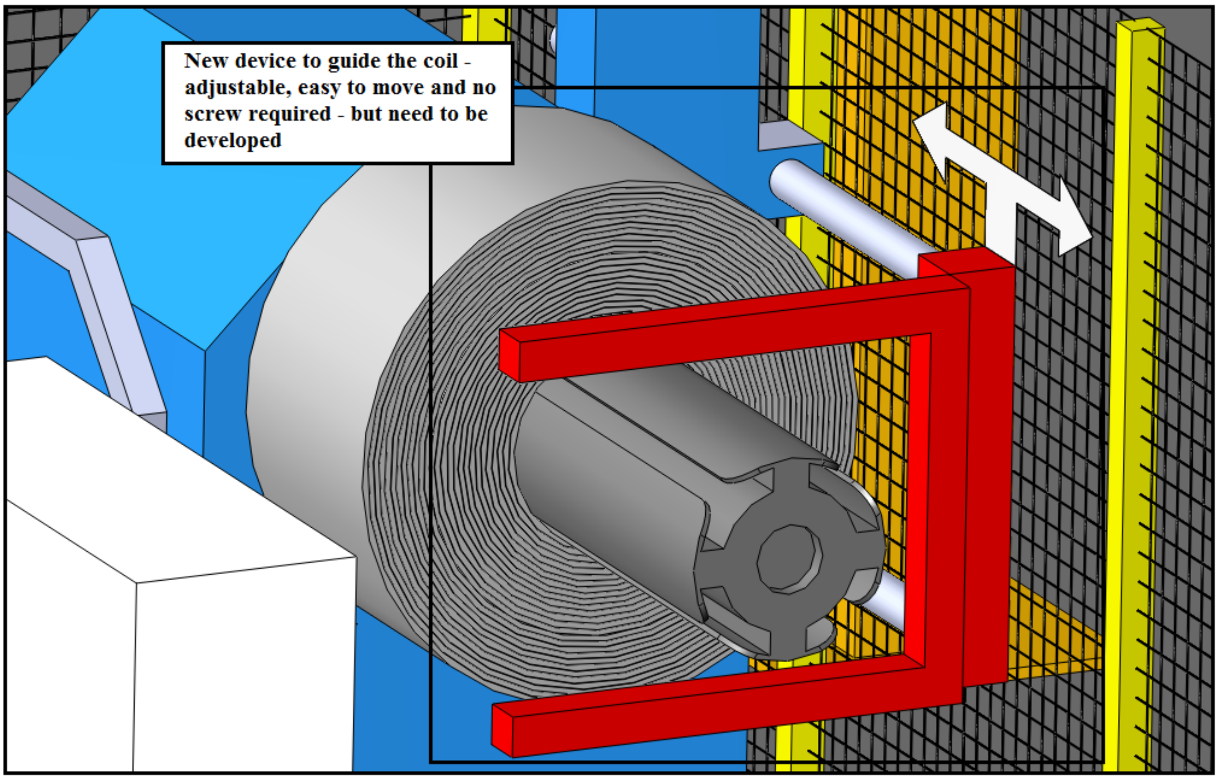


Figure 73: New coil guide

5. RESULTS AND SUGGESTIONS

The "results" part is dedicated to the exposure of all what has been done through the case study. In this part will be presented and analyzed all the information that has been gathered during the project period, to provide a strong support to answer the research questions through the analysis section.

5.1 Relations between employees

Research question number 1: How important are the operators when improving OEE?

Discussions were once taking place on the shop floor, talking about different issues with Per Ullervik, an operator who has been working on the Manzoni press for more than ten years. His technical knowledge and experience about this machine are quite advanced. In our conversation, we were talking about the importance of the operator when improving and optimizing the working area. Per tried for many years to suggest small but very useful ameliorations to the top management. He gently said to me that after many tries, he finally gave up. An example of what he mentioned to me is the following one:

> "We, operators, have to move the scrap batch when it is full. This batch made of steel and full of metal can weigh up to 2 tons. A small manual forklift is available to carry this batch away, but it is very power consuming and painful to drive. I was asking for a couple of years, a new forklift with a driving assistance. It never came up, that is why I gave up…and today, here it is" (showing me the new forklift). He then asked me "do you know why?" and I replied him back "no…?" He explained me "because the operator working in the afternoon shift asked for it, and as he is in a good relation with the production manager, his suggestion was accepted…but I have the feeling that no one is willing to talk to me here or even to listen to me. It is a very bad feeling to me, and I finally don't want to make any more efforts."

The second operator Andrea Bylund was interviewed as well concerning his work. This operator has been working with the Manzoni press for one year and a half. He thinks that this job is pretty dangerous, especially when loading and preparing the coil before feeding. "The coil is so powerful that it's a spring that can kill someone" he said. Thus, he talked to me about an interesting point:

> "I am very willing to propose some improvements, but every time I do, people either don't consider it or laugh at me. A first example is to have a movable control panel to operate the coil axle to control it from 5 meters away so I am in a safe place, instead of 1 meter with a fix panel. The managers told me that it would cost 200 000 SEK so it is too expensive." Even after telling the managers that 200 000 SEK is cheaper that a human life, he could not get what he was asking for. Andrea had another idea – among some others – which was to replace a security sensor. "This sensor works well, but is hit about once a month, so it needs to be adjusted by an electrician. The machine is by this fact down for two hours or even more. This proposition was still too expensive for the managers, and it will stay as it is so far. I begin to be on the "giving up" side, and stop propose solutions if I am not listened."

An interview has been given to the boss Leif Plate to get more information about the global vision of the company. Indeed, after my readings regarding change management, I had to know how the company as a whole is working with this aspect. It helped me to make some links with the OEE improvements and to have a broader view of what is the real relation between every actor within this plant. Leif told me that they already developed a vision in 2009 when the financial situation of the company was bad. At this time, the emergency situation was quite obvious. “Either we develop a vision, and decide to change so that most of the employees keep their job, either there is no vision, and the company closes down.”

The vision and keywords were clearly displayed on a wall in the office. Leif also added to the conversation that all the employees are aware of the vision, and that the focus on the customers’ side is their priority. The vision is made with several pages that presented in appendix A.

Just after interviewing the boss, I interviewed the production manager Richard Miles, to have his explanation about how the vision is implemented and perceived by the operators working within the workshop. Once more, Richard told me that the customers’ satisfaction is the first goal. His main word to describe the vision is “structure”. “The workshop has to be structured in order to go ahead towards lean aspects.” He developed a bit more his way of thinking, telling: “everyone is in the bus, on the same road, toward the same direction.” Saying that means there is respect for all employees even if some of them, have the feeling to be lowered. “It takes quite a long time to get everyone aiming for the same goal, especially because we have some other important problems to solve” said Richard. He also affirmed that all the feedbacks go up and down the hierarchy. It is linked with the respect of people and the way to lead change once more. Operators tell managers who tell the production manager who tell to the boss what the suggestions are. This latter takes a decision concerning the different suggestions made, and information can go back downstream. Every manager has its own responsibility no one would tell “the production manager told me to do say you…” So doing that, nobody should have the feeling to be really superior compared to someone else. Even if it does, the feeling is reduced.

Concerning quality problem that the customers meet, the production manager takes his whole responsibility for the issue. He will never blame any employee saying “you did wrong.” He takes the fault to himself, and acts understanding why this happened, and what could be the alternative to prevent the issue to occur in the future. During our conversation, he had two actual examples of problem, which he described me.

- The first problem was a customer who complained that one of the parts was too much loaded with painting. The manner employed to prevent this problem was almost installed from previous complaints. A new automated controlled system for the painting area was planned instead of a manual painting.
- The second problem was that a part containing screw threads had one of its threads painted, and the screw was tight to insert. Some plastic caps are placed into the holes to prevent the paint fitting on the surface. Mentally disabled people are employed to fulfill this task, and they don’t think that inserting a broken cap could be a problem. The manager has then to find a solution to either remove all the broken caps from the chain either educate employees a bit more.

As mentioned previously, the company was purchased by the group AQ in 2009. This group present in several countries around the world has its vision, which is transferred to every company within the group through a small book. This book is not the easiest way to transmit the vision, so AQ Segerström & Svensson decided to input its own way to communicate the vision and the core culture. A meeting with all employees is held every six weeks to discuss about different problems, and this moment is the opportunity to diffuse the vision.

A third interview has been given regarding the vision to Patrik Nilsson, the purchase manager. To sum up the situation, as everyone is working to satisfy the customer, they have to be satisfied by the suppliers as well. The most important for Patrick and his purchasing point of view is that they have to work hand-in-hand with the suppliers in order for them to get better, so the last customer of the supply chain will have the highest quality. So far, the purchasing department is experimenting and working with different suppliers, from Latvia, Russia, Sweden or Finland. When looking more in details and coming back to the project with the 800 tons press, the raw material quality differs if the coil comes from a country or another. The price difference does not justify the fact of purchasing a coil from Russia (which is less expansive and with a lower quality) because breakdowns and time to fix problems will cost more than a coil coming from Sweden. If the Russian or Latvian companies can improve their quality, it might become interesting to be faithful with this supplier. The winner of the competition according to Patrick is the one able to be the best at three parameters: "QDC: Quality – Delivery – Cost."

The previous interviews give quite a broad representation about everyone's role within the organization. Each interviewed person has its own point of view about the situation. Some others smaller – but interesting – interviews have been conducted randomly to any people met within the company, which enabled the study to get more points of view regarding the global situation at AQ Segerström & Svensson. It is obvious to understand that there is a different between the vision exposed by (Kotter, 1995), and the AQ Segerström & Svensson vision exposed in Appendix A - AQ Segerstrom & Svensson vision.

From this paragraph can be added that generally, the employees within the company – from any hierarchical level – think that communication through the organization is not as it should be to get the best results. It comes interesting to investigate a bit more in detail the situation to provide a good support to answer the second research question.

Research question number 2: How important is a good communication and change management through all the steps?

From the previous interviews and from observation, a negative mood from operators working on the press was palpable. After discussions mainly, it came out that an operator went to work just because he has to feed his family, and working on the Manzoni press is for him worst than unpleasant. The operator affirmed to be more than willing however to be transferred to the laser department that he really likes. If an operator is not willing to work and does not enjoy what he or she is doing, the outcome results in a bad quality work. All this is related to the pleasure, as it could be compared to an athlete performance. If the pleasure is very low for someone competing to become world champion of any sport, the final result will not be the first place.

It was the kind of discussion entertained with the operator in one hand and the production manager Richard Miles. He claimed that the operator had his personal reasons to be in such a bad mood, and the production manager knows how skilled this worker is. However, according to the press operator, he never heard such a pleasant saying and felt to be left aside.

After a couple of weeks, the production manager had a long conversation with this employee, and finally found agreements. The operator has been transferred to the laser department and is "borrowed" to train people working on the press or to solve technical problems happening on the machine as he is really skilled. When discussing later on with this operator, it felt like he was much better physically and especially mentally.

Communication within the whole organization is not the strong point, many employees are aware of this problem, but only a real opposition could make change happen. Indeed, it is linked with the situation of emergency presented, to lead change. As long as no one will say that communication is bad and prevents to go ahead as planned, the same state will remain, and the progression is slowed down.

5.2 Technical solutions around OEE improvement

That part aims to transfer what is exposed by the theoretical part to the technical and internal requirements that compose the machine presented through the case study. In this section are listed the eventual suggestions available to get around or to solve the different problems in addition to the ones mentioned under paragraph “4.4 The main reasons for a low OEE”. Once analyzed, these suggestions are the main manner used to give an answer to the three research questions exposed among the aim of this project. A detailed answer to them will be given in chapter “6 ANALYSIS”.

Research question number 3: What are the major issues when developing and implementing a higher OEE?

Technical solutions as the ones previously presented are essential to be developed and implemented to improve the OEE. Refreshing equipment and performing focused maintenance are highly important as well, so all those new features give power to equipment to be more effective. It could be related to a Formula one team, because even if already leading a championship, the car is continuously improved and developed by many actors to stay on top of the ranking.

Regarding the thirty previous suggestions of improvement given, a summary is available from the next Figure 74.

Category	Improvement number	PAGE	Cost estimation	Improvement summary	Rating
5 S's	1	58	Mainly time + negligible training tools purchasing	Strong basis to go through continuous improvement.	+++
	2	59	Between 10 000 and 20 000 SEK	Higher security, 5 S's improvement and time saved since operators does not have to move to observe	+
	3	60	Between 15 000 and 25 000 SEK	5 S's highly improved (operator does not need to get into the machine), time saved	++
	4	60	Between 50 000 and 150 000 SEK	5 S's improved through the whole factory, few time saved	++
	5	61	Between 5 000 and 10 000 SEK	Most accurate feedback for future work, constitute 5 S's and continuous improvement basis	+
	6	62	Between 1 500 and 5 000 SEK	Higher security, 5 S's improvement that could be standardized to the whole workshop	+
	7	62	Between 15 000 and 150 000 SEK according to the option	5 S's improved since the operator does not require to mix the parts, time spent so the machine does not stop.	++
	8	63	Between 15 000 and 40 000 SEK	5 S's highly improved, time saved by less cleaning and better operator involvement	+++
	9	64	Between 20 000 and 50 000 SEK	5 S's by standardization improved, which can be extended to the whole factory	++
	10	66	175 000 SEK	5 S's improved, time saved, money saved (130 000 SEK of oil on one part type per year)	+++
	11	67	Between 10 000 and 30 000 SEK	5 S's improved , time saved and space saved so the operator can work in a more pleasant surrounding	+++
	12	68	Mainly time + negligible tools purchasing	5 S's improved, higher security, maintenance is made easier to perform	+++
	13	69	Mainly time required to clean	5 S's are improved since only what is useful remains close to the machine	+++
	14	71	Between 10 000 and 25 000 SEK to move the feeder	5 S's improved by saving space mainly	+/++
	15	72	Mainly time + negligible training tools purchasing	Strong basis to go through continuous improvement.	+++
	16	73	Between 15 000 and 30 000 SEK	5 S's imprved through the whole workshop	++
	17	74	Mainly time + negligible training tools purchasing + few technical investments	Strong basis to go through continuous improvement.	+++

Category	Improvement number		Cost estimation	Summary	Rating
Maintenance	18	78	Mainly time and between 50 000 and 150 000 SEK	Basis for continuous improvement and better employees involvement (training mandatory)	+++

Category	Improvement number		Cost estimation	Summary	Rating
Changeover	19	80	Between 50 000 and 250 000 SEK according to the option	Changeover improved, time saved and workshop waiting decreased	+++
	20	81	Between 10 000 and 30 000 SEK	Changeover improved, time saved and cart maintenance reduced	+++
	21	82	Between 100 000 and 250 000 SEK	Setup time reduced and quality improved by less scrap.	+++
	22	84	Between 10 000 and 30 000 SEK	Setup and changeover time improved, and good basis for continuous improvement	+++
	23	86	Mainly time required	Changeover improved and space saved. 5 S's improved as well	+++
	24	87	Between 15 000 and 250 000 SEK	A lot of time saved, 5 S's highly improved by less screws and tools	++++
	25	88	Between 5 000 and 15 000 SEK	5 S's greatly improved and strong basis for continuous improvement	+++
	26	89	Mainly development costs	Changeover greatly improved and 5 S's as well	++++
	27	90	Mainly development costs	Changeover greatly improved and 5 S's as well	++++
	28	92	Between 10 000 and 30 000 SEK	TPM and changeover improved if no need to fiw the sensor. Continuous improvement basis as well	+++
	29	93	Between 500 and 10 000 SEK	Improves the OEE, and gives more time to the operators	+++
	30	93	Between 5 000 and 15 000 SEK	Changeover improved, 5 S's as well and maintenance problems are limited	++++

Figure 74: Improvements summary including costs estimation

Of course, the whole layout could have been changed in order to directly improve OEE in one shot. To do so, the finances of the company need to be solid, and more affordable steps should be done before, since small improvements can be sufficient to progress a company’s results in a close future.

To develop the OEE, more manpower to run the machine – especially during the changeover – could have been appropriate. However, it was the case before, so the top management is not willing to come back, and would prefer to improve their equipment instead of hiring new people. By renewing equipment and applying the SMED system, results as good or close to what was achieved with two operators should be equalized by a single operator.

The changeover parts are the most negative points since they are performed in average twice a day, and require in average 2 hours to be realized. An important focus related to this part has been dedicated through the study, and some results about what could be saved concerning the changeover time and its impact on the OEE are presented thereafter in the coming sections.

5.2.1 Internal and external setup operations

Distinguishing internal and external setup operations is crucial and is the starting point to implement the SMED system according to (Shingo, 1985) as mentioned in the theoretical framework. The succession of observations, video recordings and discussions with the operators led to the establishing of the following Table 10 and Table 11 which are an overview of the different operations performed to change a die within the machine. The two tables are based on one observation just to give an example, but could be employed as a spreadsheet template for any other tool changing. The aim would be to get a standard template that shows the minimum mandatory operations required to perform a die changeover (provided by Appendix B - Changeover template).

Operator:	xxxxxxxxxxxxx
Date:	xxxxxxxxxxxxx
Between part n°:	xxxxxxx and xxxxxx

Changeover time operations

1. Die attachement

Operation description	Time (s) actual	Time (s) after imp.
Put the front spacers in the die	60	0
Walk back the machine	20	20
Put the rear spacers in the die	50	0
Loosen the front die	85	40
Loosen the rear die	80	40
Lock the rear table	60	30
Lock the front upper die	230	40
Lock the rear upper die	500	40
TOTAL	1085	-
AFTER IMPROVEMENT	-	210

2. Scrap material in machine

Operation description	Time (s) actual	Time (s) after imp.
Loosen the ramps	60	20
Walk to the ramp storage	15	0
Walk to the machine	30	0
Clean the ramp	35	20
Walk to the ramp storage	15	0
Walk to the machine	10	0
Clean the ramp	20	20
Walk to the ramp storage	10	0
Walk to the machine	10	0
Clean the ramp	25	20
Walk to the ramp storage	20	0
Walk to the machine	10	0
Measure for which ramp to take	20	0
Choose a ramp	55	0
Walk to the machine	10	0
Install the ramp	35	5
Walk to take a ramp	10	0
Choose a ramp	55	0
Walk to the machine	15	0
Install the ramp	75	5
Measure for which ramp to take	30	0
Walk to take a ramp	10	0
Choose a ramp	15	0
Walk to the machine	10	0
Install the ramp	25	5
Walk to take a ramp	10	0
Choose a ramp	40	0
Walk to the machine	10	0
Install the ramp	70	5
Move the scrap conveyor ramp	10	10
TOTAL	765	-
AFTER IMPROVEMENT	-	110

3. Transport

Operation description	Time (s) actual	Time (s) after imp.
Toe empty trailer to the machine	120	0
Fit the trailer on the machine	130	130
Unfit the trailer	105	105
Toe the loaded trailer to the storage	155	0
Toe the next die to the machine	210	0
Fit the trailer on the machine	190	130
Unfit the trailer	150	105
Toe the empty trailer	120	0
TOTAL	1180	-
AFTER IMPROVEMENT	-	470

4. Removing die

Operation description	Time (s) actual	Time (s) after imp.
Extract the die	170	100
TOTAL	170	-
AFTER IMPROVEMENT	-	100

5. Positioning die

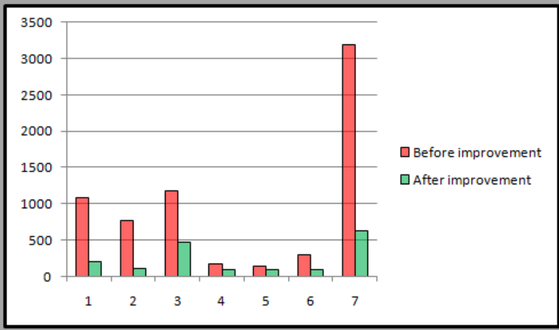
Operation description	Time (s) actual	Time (s) after imp.
Insert the die	135	100
TOTAL	135	-
AFTER IMPROVEMENT	-	100

6. Raw material handling

Operation description	Time (s) actual	Time (s) after imp.
Walk to raw coil	15	15
Prepare the coil	60	0
Load the coil on the cart	60	0
Load the coil on the axle	60	30
Fit the coil stoppers	45	20
Setup the plate	20	20
Cut the straps	10	10
Scrap the straps	35	0
TOTAL	305	-
AFTER IMPROVEMENT	-	95

Table 10: Changeover time operations including improvements – 1st part

7. Miscellaneous		
Operation description	Time (s) actual	Time (s) after imp.
Open the door	10	10
Walk to the front of the machine	25	20
Walk back to start engine (he forgot)	30	30
Wait for engine to start	50	50
Lift down the press	60	30
Walk back the machine	15	15
Walk to the front of the machine	15	15
Wait for engine to start	200	50
Move up the press	5	5
Walk to the tool storage	60	0
Wait for an available forkilft	450	0
Walk back to the machine	60	0
Prepare the paper	30	30
Lower the upper part	30	20
Walk to the back of the machine	30	20
Walk to the front of the machine	15	15
Wait for engine to start	60	50
Wait for the engine to reverse	205	0
Lift up the upper part	10	10
Setup the die	60	60
Lower the upper part	35	30
Adjust the die heigh	180	0
Take the file to check the heigh of ground	45	0
Walk to the grounder	15	10
Set the ground	50	5
Walk and order the file	30	0
Miscellaneous	120	100
Wait for the engine to reverse	650	0
Lift up the upper part	15	15
Adjust the shut heigh	300	30
Flatten the sheet start and feed	120	0
Enter the sheet in the die	200	0
Run the first parts	10	10
TOTAL	3190	-
AFTER IMPROVEMENT	-	630



Time before improvement	1	hours	54	minutes
Time after improvement	0	hours	29	minutes

Table 11: Changeover time operations including improvements – 2nd part

From the upper tables – especially the graph mentioned in Table 11 – it is clear to see how much time could be saved to perform a die changing for the Manzoni press. The time saving is mostly based on estimation about what could be done externally instead of internally, and a combination of all the other improvements that could be done to improve the changeover time. New estimated times for internal to external setups are mentioned by a red number in the column “time after improvement”.

The vertical axis of the graph in Table 11 represents the time spent in second for each operation type determined by the horizontal axis. Once summed up, the total amount of time required before improvement to perform a die changeover is 1 hour and 54 minutes. When getting rid of the useless transportation, or by eliminating or reducing long time consuming operations, the total changeover time drops down to 29 minutes which is about 75% less than the actual time. This result is obtained only based on some feasible improvement regarding the scale of the company, and could probably be improved even more by investing on more material.

5.2.2 Remove the screws to optimize the fastening method

From the theoretical part, it is known that screws and nuts are the enemies of SMED, due to the time required to fasten them. The idea to improve the OEE for the Manzoni press is to establish a strategy aiming to get rid of all the screws and nuts for a “one turn” device. In the best case, no screw would be required to install a device, but the manner employed to get around the use of screws should be poorly time consuming to fulfill the SMED requirements.

To do so, general technical solutions given previously should be used as a basis. Later on, continuous improvement needs to take place to always improve the necessary operations that need to be performed, to replace fastening equipments.

5.2.3 OEE Improvement

In this section are presented the final OEE results. The calculations obtained thereafter through different scenarios are once more all based on estimations, and provide the OEE that could have been achieved in 2012 with the corresponding data, especially the ideal run rate which is the actual one over 2012.

SCENARIO 1: Changeover time reduced by 50%

- Achievable in about 6 to 18 months (according to estimations)
- Relatively affordable

OEE calculation						
Production data						
Shift length	4030	hours =	241800	minutes		
Short breaks	448	breaks of	18	minutes each	8064	minutes in total
Meal break	448	breaks of	24	minutes each	10752	minutes in total
Down time	55260	minutes				
Ideal run rate	9,6959	PPM (part per minute)				
Total pieces	850885	pieces				
Scrap pieces	700	pieces				

Support variable	Calculation	Results
Planned production time	Shift lenght - breaks	222984
Operating time	Planned production time - down time	167724
Good pieces	Total pieces - scrap pieces	850185

OEE factor	Calculation	AQ OEE%
Availability	Operating time / Planned production time	75,22%
Performance	(Total pieces / Operating Time) / Ideal run rate	52,32%
Quality	Good pieces / Total pieces	99,92%
Overall OEE	Availability x Performance x Quality	39,32%

OEE factor	Wolrd class	AQ OEE
Availability	90,00%	75,22%
Performance	95,00%	52,32%
Quality	99,90%	99,92%
Overall OEE	85,00%	39,32%

Change-over reduced by 50%

Table 12: OEE improvement – changeover reduced by 50%

The upper Table 12 represents what OEE could have been obtained in 2012 after implementing some of the ++ and +++ rated technical suggestions proposed earlier, without involving a lot the human factor by training operators, it could improve the changeover time by 50%. 7.15% is the rate by how much could have been improved the OEE following those suggestions.

SCENARIO 2: Changeover time reduced by 75%

- Achievable in about one to two years (according to estimation)
- Higher investment required

OEE calculation

Production data						
Shift length	4030	hours =	241800	minutes		
Short breaks	448	breaks of	18	minutes each	8064	minutes in total
Meal break	448	breaks of	24	minutes each	10752	minutes in total
Down time	47280	minutes				
Ideal run rate	9,6959	PPM (part per minute)				
Total pieces	928258	pieces				
Scrap pieces	700	pieces				

Support variable	Calculation	Results
Planned production time	Shift lenght - breaks	222984
Operating time	Planned production time - down time	175704
Good pieces	Total pieces - scrap pieces	927558

OEE factor	Calculation	AQ OEE%
Availability	Operating time / Planned production time	78,80%
Performance	(Total pieces / Operating Time) / Ideal run rate	54,49%
Quality	Good pieces / Total pieces	99,92%
Overall OEE	Availability x Performance x Quality	42,90%

OEE factor	Wolrd class	AQ OEE
Availability	90,00%	78,80%
Performance	95,00%	54,49%
Quality	99,90%	99,92%
Overall OEE	85,00%	42,90%

Change-over reduced by 75%

Table 13: OEE improvement – changeover reduced by 75%

Still in the same spirit than scenario 1, Table 13 gives an idea about the achievable OEE after investing a bit more. This second scenario implies more the operators in order to develop ideas and to sustain what has been achieved so far. This is why it would require more time to implement according to approximate estimation, so the changeover can drop and be reduced by 75%. The result compared to the original OEE of 32.17% could have been higher by about 10%.

SCENARIO 3: Changeover time reduced by 75% and unplanned stops reduced by 50%

- Achievable in about 18 months and 3 years (according to estimation)
- Not much more expensive than scenario 2, but more time required

OEE calculation

Production data						
Shift length	4030	hours =	241800	minutes		
Short breaks	448	breaks of	18	minutes each	8064	minutes in total
Meal break	448	breaks of	24	minutes each	10752	minutes in total
Down time	23640	minutes				
Ideal run rate	9,6959	PPM (part per minute)				
Total pieces	1157469	pieces				
Scrap pieces	700	pieces				

Support variable	Calculation	Results
Planned production time	Shift lenght - breaks	222984
Operating time	Planned production time - down time	199344
Good pieces	Total pieces - scrap pieces	1156769

OEE factor	Calculation	AQ OEE%
Availability	Operating time / Planned production time	89,40%
Performance	(Total pieces / Operating Time) / Ideal run rate	59,89%
Quality	Good pieces / Total pieces	99,94%
Overall OEE	Availability x Performance x Quality	53,50%

OEE factor	Wolrd class	AQ OEE
Availability	90,00%	89,40%
Performance	95,00%	59,89%
Quality	99,90%	99,94%
Overall OEE	85,00%	53,50%

Change-over reduced by 75%
Unplanned stops reduced by 50%

Table 14: OEE improvement – changeover reduced by 75% and unplanned stops by 50%

Table 14 is a last estimation about the result that could be obtained based on the 2012 results. To get this result, it implies to implement SMED system to a rather good level, and to get involve into a good TPM development by the 5 S's training for example. It would reduce the unplanned stops by 50% compared to scenario 2. By comparing this result to the original one, it is possible to see that OEE could have been improved by about 20%.

To come back on those results, the overall OEE calculated could seem low due to the particularly bad results from 2012. To get a better overview, is could be fair to realize the same study considering the results over 2013. It would provide better results for the performance factor especially, by optimizing the ideal run rate.

5.2.4 Cost consideration

To develop the Manzoni press OEE, some investments need to be done. Those investments could be more or less important according to the expected outcome, and the budget that can be allocated per year to develop this machine. The following Table 15 could be helpful for any decision making.

Part number	Price/part (SEK)	Annual volume	Total price (SEK)
14635352	64,49	6535	421442,15
14635372	75,23	515	38743,45
14635382	73,55	19032	1399803,6
14635392	94,7	250	23675
14635412	83,25	28470	2370127,5
14635432	81,98	4665	382436,7
1463867	17,79	44575	792989,25
1529244	18,53	8783	162748,99
15200981	8,69	15224	132296,56
17330380	12,89	47558	613022,62
17330390	12,89	47977	618423,53
17422661	24,82	250	6205
17423701	20,86	19017	396694,62
17920381	8,67	19621	170114,07
17920391	8,67	16011	138815,37
18548781	23,11	60597	1400396,67
18548792	27,56	5792	159627,52
18648872	12,39	15986	198066,54
211920171	71,48	52446	3748840,08
219174121	48,99	328	16068,72
218255191	74,38	427	31760,26
307228191	9,5	35845	340527,5
30742463	18,06	31096	561593,76
82451629	8,56	31016	265496,96
82451635	8,56	30657	262423,92
82451637	8,56	30313	259479,28
82451639	8,56	30686	262672,16
82451643	7,05	41447	292201,35
82451645	7,05	40692	286878,6
82451647	7,05	41022	289205,1
Total sales over 2012 (in SEK)			16042776,83

Table 15: Total sales over 2012 for Manzoni press

From the above Table 15, it is possible to get the total sales for the production of parts by the Manzoni press over 2012. It represents a total amount of 16042776 SEK for the whole year. A review about how much money can be saved by the OEE improvement can hence be established:

It has been presented by Table 8 (p.56) the costs to operate the Manzoni press which corresponds to 1094 SEK per hour. The several scenarios presented above can hence be analyzed in order to know what could be the strategies to use in order to make the most profitable investment.

The scenarios can also be a support to some costs application examples, as presented in the following Table 16.

		Scenario	Quantity produced	Difference with original	Average cost / unit (SEK)	Saving over 2012 (SEK)
Production	Parts	Original	696139	0	23,00 SEK	- SEK
		Scenario 1	850 885	154 746	23,00 SEK	3 559 158,00 SEK
		Scenario 2	928 258	232 119	23,00 SEK	5 338 737,00 SEK
		Scenario 3	1 157 496	461 357	23,00 SEK	10 611 211,00 SEK
		Scenario	Downtime (hours)	Time saved (hours)	Average machine cost per hours	Non-wasted amount of money
	Machine	Original	1 187	0	1 094,00 SEK	- SEK
		Scenario 1	921	266	1 094,00 SEK	291 004,00 SEK
		Scenario 2	788	399	1 094,00 SEK	436 506,00 SEK
		Scenario 3	394	793	1 094,00 SEK	867 542,00 SEK

Table 16: Production cost consideration related to scenarios

This table gives how much money could be saved when implementing some improvements to get a higher OEE. Once more, those results are only estimations, but give an overview regarding the costs evolution related to the machine. The results would be much different for 2013 for example because the quantity produced would not be the same.

6. ANALYSIS

Suggestions and solutions related to the main problem statements have been presented in the previous parts. Those solutions are taken out from observations, general understanding, interviews, theoretical knowledge, company's background and my personal background. This part is dedicated to the analysis of what has been suggested, weighting the relevant aspects, and comparing the empirical statement with the case studied in one hand and the scientific fundaments emphasized by the theoretical part in the other hand. From this will come out the answers to the different research questions exposed thereafter.

6.1 Solutions around leading change

When any company is about to implement a new process, a new system or a new vision, the organization needs to change to a more or less important level. In any cases, the steps described by the theoretical part related to leading change are crucial to have in mind. To emphasize the scientific degree of the answers to the research questions, analysis and comparison to the case study in a general manner will be provided.

Research question number 1: How important are the operators when improving OEE?

After the interviews and different discussions driven, it is possible to link the case study to the general manufacturing industry. Indeed, differences between operators and bureaucrats exist, which creates a negative-tending working atmosphere. For any type of action conducted between operators and bureaucrats within a company, relationship between every actor has to be strong enough so everyone is aiming towards the same goals. Operators should be involved within the guiding coalition so change can occur more easily. An operator against the guiding coalition will build himself against the coalition in order to slowdown or even to make fail all the planned steps to change.

In a general manner, operators like to be recognized for the work they provide. So this is why it is crucial for the good expenditure of any company to communicate when it is good and also when it is not. It could be linked according to me to any life where having a positive feedback especially is encouraging. Operators in this case also have to admit negative feedback, but have to accept them as an evolution opportunity. This is the reason why a leader endowed by good social skills can be more easily accepted by a bench of operators.

All what is said previously is valid when implementing new tools, especially when improving OEE. Operators like and need to take part of the journey as they are the ones dealing with the actual problems daily. It puts them into a grateful situation, so they are not compared only with the bottom of the company. This aspect is central for the respect of people. Indeed, operators get the satisfaction to stand on a higher level which reduces the differences between operators and bureaucrats. However, it is better to stay prudent so operators and bureaucrats in general do not become close friend, which might slowdown any conversation.

To summarize the answer to the research question number one, it could be said that weaker is the difference between operators and bureaucrats, easier, faster and better is the implementation of OEE. However, it is important to keep in mind that bureaucrats are not much compared to operators and vice versa. Operators and their ideas are fundamentals for any company to stay competitive.

Research question number 2: How important is a good communication and change management through all the steps?

The answer to this second research question is in some ways linked with the previous one. To make change happen successfully – as in everyday's life – communication is a vital aspect. The eight steps presented under the theoretical part are the ones to follow to expand and lead change within any kind of small, medium or large scale organization.

Once more, even if there are some lacks of communication observed through the case study, it joins the average level where most companies are standing. Leading change takes some time to be implemented, but on the long-term can show results which is crucial to have in mind.

A good communication with every employee especially will result in a higher quality work produced. Indeed, if the communication level is rather advanced, operators will not be scared to admit and to expose their failure to the top management. This is a really important step to be able for a company to perform continuous improvement. Quality of goods in general as well could be improve since if a good communication level is set in an organization, employees are more willing to work. More willing to work indirectly means more careful to do things right, so the quality of the work can be improved. It is however important for managers and leaders to stay a minimum strict to the rules so no chaotic situation is reached.

Discussions between the two sides – operators and bureaucrats – are crucial to the right development of any organization. Nevertheless, it is probably not the best place for the production manager to spend some time just talking individually to every employee as many other technical problems need to be solved, but it is hopeful to see that change can happen due to communication.

To conclude this answer, top management of any organization needs to have great communication skills before implementing any change. Communication learning and transfer goes from the top to the bottom of hierarchy first, and then constructive discussions are foreseeable.

6.2 Technical solutions to improve the OEE

Improving OEE of pressing equipment is technically specific. To improve OEE, rules need to be followed as well, and some general concepts are the keys to success. Research question number three is accurately answered thereafter by analyzing core concepts and the case study.

Research question number 3: What are the major issues when developing and implementing a higher OEE?

OEE is a tool that many bureaucrats at least are aware of nowadays within the worldwide industry. This tool is well-known, but not so many persons know how to properly use it in an efficient manner. This research question clarifies the tricks to avoid and what are the prerequisites to use the OEE as a powerful improvement tool, to develop pressing equipments especially as not so many studies have been previously conducted within this domain.

- **Time and OEE:**

To improve OEE for any companies, time is required. It is not possible to say that OEE can be improved within a couple of days, principally for an obsolete machine. It takes time to investigate all the actual problems, and to investigate the different alternatives to get around them. Time should overall be dedicated once solutions can be proposed to decide which ones need to be implemented, and what will be the outcome. To do so, it is important to have a good theoretical knowledge as proposed in this present report, but a strong technical knowledge is more than welcome as well. Having those two skills make faster any OEE improvement to occur.

In anyways, OEE is a tool to measure how is used a machine, it needs to be employed over a long period to check that a continuous improvement process is on-going to optimize the equipment utilization.

- **Data collection:**

When coming to OEE calculation – for pressing equipment or any other machine type – data collection is of great importance. Indeed, many companies gather and store data for administrative and statistics reasons, but to get accurate OEE calculation, the way data are collected is crucial. Once more, it is really important to know the analyzed system. Interpretation of maintenance reports counts to insert the preventive maintenance time in the planned stops and corrective maintenance in the unplanned stops for example. To exactly know what is the shift length and how long the studied machine is down over a certain period, also strongly act to the accuracy of OEE.

When calculations are done to analyze any equipment, data need to be collected following the same way for every calculation. Hence, it could be relevant to establish a template on how should be gathered data and which ones in order to get the best results.

- **Limits of resources:**

Through the previous case study – as for many other cases – OEE can be improved by changing the layout of the company for example. Moving a press as the Manzoni would be a very important operation, time consuming and rather expensive. This is why in many situations the goals need to be carefully established so they can be reached in order to provide short-term results.

A strong knowledge of studied material like the machine, parts and the production type helps a lot to have a strong basis on developing a system. Human resources are also essential. Indeed, knowing the operators makes easier the data collection, and makes them more willing to get involved into the machine development. As mentioned previously, having social skills could be useful to analyze behaviors and motivations.

The last crucial resource is the budget that can be allocated to the machine development. Without any money spent, an OEE cannot be highly improved. By having a close relation with top management to find agreements about what could be done or not, it enables the OEE to be improved smoothly.

- **Generalities:**

In a general way, to improve a machine, a good analysis of the system is required, and an efficient communication with every actor, are key elements to the success. When implementing the different action steps or to propose results to top management, solutions have to be well structured so comprehension by everyone becomes easier.

7. CONCLUSION AND RECOMMENDATIONS

That conclusion part is dedicated to the overall analysis about the work done. It contains a more general and personal approach concerning the project that has been presented through this report.

7.1 Project achievements

During the period spent to lead this projects, mainly all the goals have been achieved. Some obstacles came onto the way to realize what I really wanted, but the main targets are reached. Indeed, the data collection to get an initial OEE calculation has not been the easiest part. However, by investigating and getting really involved in the actual problem, it became possible to obtain data or to make some estimation in order to get the most accurate regarding OEE calculations. In any cases, a degree of uncertainty remains, and need to be considered through all the steps to get an outcome as accurate as possible.

Listing the maximum suggestions of improvement was a part of my goal which has been mainly completed as well. The best to me would have been to have time for implementation so the results could be verified. This verification will hopefully come in the coming years by following my begun investigation, even by another person.

No suggestion has been directly implemented to the company since it takes a long time to perform. It was a bit tricky to stop a whole production for a while to implement some changes, but without being sure that they will sustain, especially for a 200 employees organization. That is why I opted for giving technical solutions especially and advices so they can be deeply thought by more than one or two persons. After that deep thinking, the team in charge to implement the suggestions could check and follow the operators through continuous improvement phases. The results in term of OEE improvement should be more accurately supervised, which will induce a best development for the Manzoni press, which could be extended to the whole presses area, to finish to the whole company. This would be a long-term investment, and would have – on the long-term – a more efficient outcome than the one I could have produced over a period of 6 months.

More time has been spent to the SMED development, and 5 S's. However, from the results, I think that improving the changeover time will of course improve the OEE, but not as much as expected. To improve this project, considering more in details the unplanned stops related to the machine could be great, in order to aim towards the most efficient system as possible.

7.2 Summary of results

Results are mainly filled-up with some technical solutions regarding the machine in order to get a higher OEE. Those results are principally focused on the case study led during the project's period, but some ideas could be extended to similar cases meeting the same kind of problems.

More general results as the template to get the time spent to perform a changeover can of course be employed in a common way, if the operations observed and written are carefully analyzed and recorded as a data.

The different scenarios exposed through the “results” part compose a summary of how OEE could be improved, by implementing more or less technical suggestions and/or operators training to lean production, especially the wastes, 5 S’s and other general lean aspects. The company should develop a lean culture in a long-term. This when dealing with the development of this culture that the lead of change mainly interacts, and the steps presented earlier should be followed to secure the sustainability.

A cost consideration related to the case study once again, takes place as well among the “results” parts. As it comes from the OEE, those costs calculation should only be used as an example to get an idea on how could be the impact when improving a stamping press OEE.

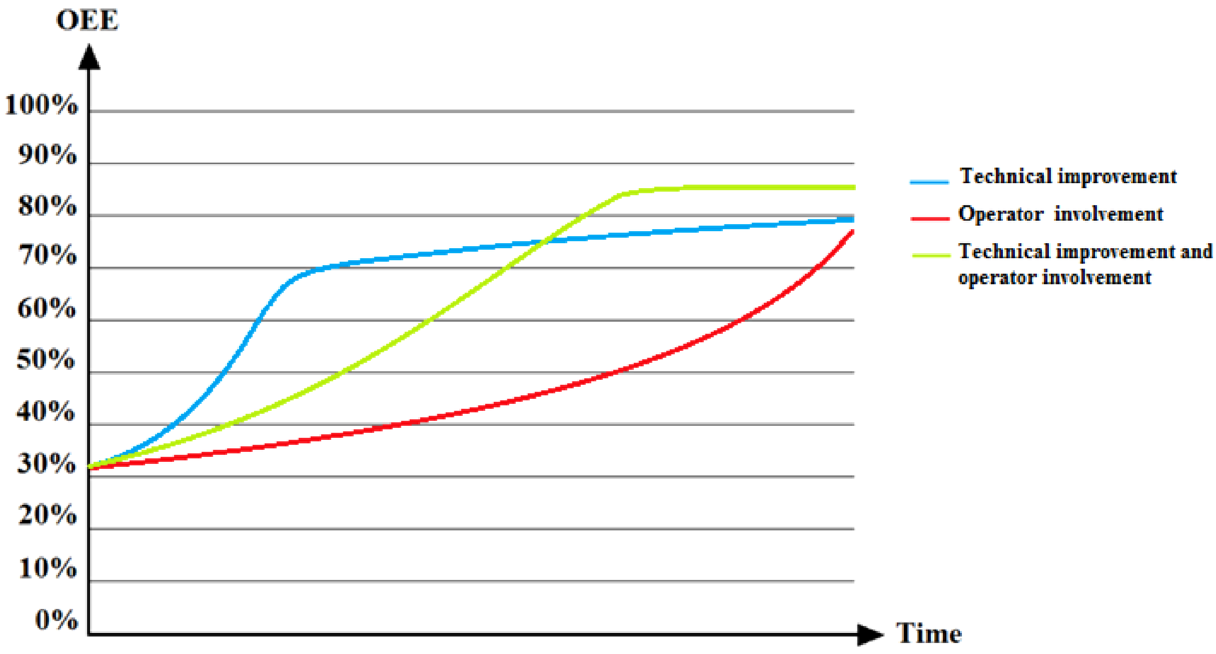


Figure 75: OEE evolution related to several factors

Lastly, I would like to present the Figure 75 shown above. After this study, I could understand more in details what could be the links between every factor around improving OEE. I could from that point of view, create the graph mentioned in Figure 75. To explain a bit more this latter, I realized that developing and implementing technical improvements to rise up a low OEE is relatively quick, and results come respectively. Contrarily, when developing only the human factor by training for example or improving the relationship, OEE will grow up as well, but will take more time to get on track. Both of them reach a quite satisfying level, but do not reach the OEE World class since one can really hardly work properly without the other.

It is obvious that combining both the technical improvements and the operators’ involvement lead to better results, still in a satisfying period. This period cannot be fixed in advance. It actually depends on the size of the company, its place on the market, its original OEE level, and some others parameters.

7.3 Future relevant investigation

Stamping presses like the one described through the case study, are performing the first manufacturing operation to make parts within a factory, as those machines are fed with raw material. When this kind of machine OEE is improved, it has an impact on the whole downstream, so the next steps where parts should be processed need to be ready before improving a press OEE so it can absorb the overload produced. To perform a successful OEE improvement, all the required resources like machines, operators and budgets mainly, should be prepared in advance to the kind of work that is about to be realized.

From this point of view, I would think relevant to investigate how ready is the downstream to receive more parts to produce. Indeed, it is fair to think that many bottlenecks could occur later on among the production chain. It seems interesting to link the already existing theory around this domain with the presented case study.

Concerning the organization itself, I would suggest having a deep thinking concerning the lead of change. Reinforce the communication within the company will drive some actors to develop a sense of urgency. By doing so, it will be a really good start to make change happen, and any further work can take place much quickly, and results could be properly observed.

7.4 Supervisors and personal opinion regarding the project

When the project was tending to its end, a meeting has been arranged gathering the plant general manager Leif Plate and the production manager Richard Miles. This meeting had for goals to present them the different steps that have been studied to lead my study, what were the final suggestions possible in term of improvements and to get a feedback from their point of view about the work done.

The main reaction that came out was that no actual results of improvements have been achieved. This negative point is mainly clarified by the fact mentioned under section "7.1 Project achievements". The company is willing to grow and has to grow-up to fulfil the AQ group objectives. Of course, the organization is allowed to use the suggestions exposed through this report. However, I would greatly recommend developing the sense of urgency in the company, so good results can much easily be reached. I think that I could provide some neutral opinion that the company could use to get into continuous improvement.

Concerning the results, I would like to have been able to produce more actual results as well, but I did not want to leave an unfinished work that could lead to a disaster. My concern is that the company now has a useful support to start a real lean thinking implementation journey. In anyways, this project has been a really pleasant work to lead, and has a lot reinforced my interpretation regarding the studied fields.

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9.APPENDICES

APPENDIX A: AQ SEGERSTROM & SVENSSON VISION

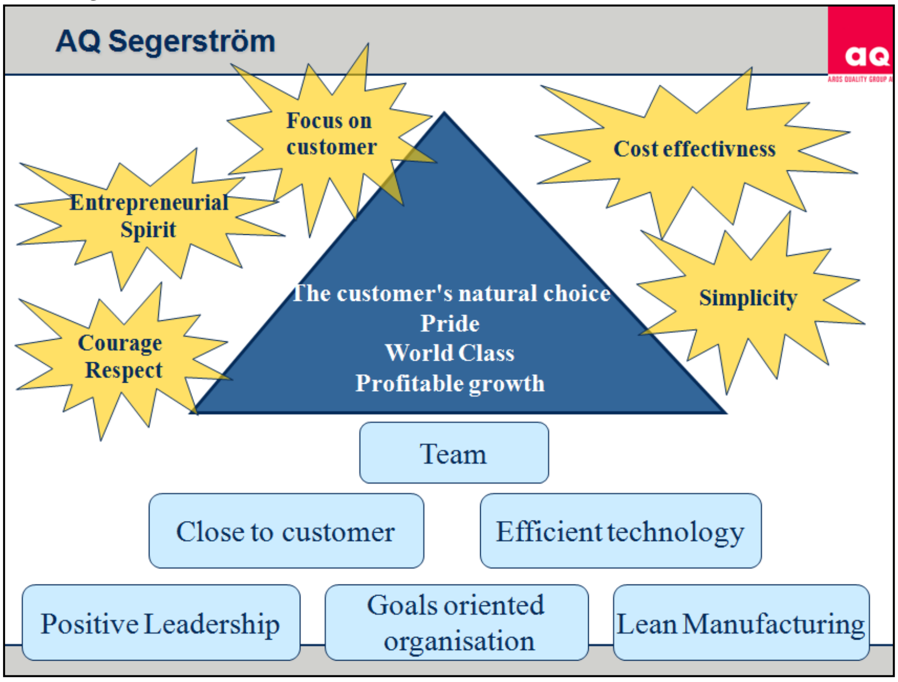

Figure 76: Appendix A - AQ Segerstrom & Svensson vision

VISION

- The customer's natural choice
- Pride
- World Class
- Profitable growth

MATERIAL AND LOGISTIC VISION

- World-class in customer satisfaction
- World-class delivery in and shipping out
- Fully motivated employees
- Quality in everything we do

MATERIAL AND ARTICLE STRATEGY

- Lean concepts in everything we do
- Developing objectives at each group level
- Develop employees, processes and equipment

STRATEGIES/BUILDING BLOCKS

- Close to customers
- Positive Leadership
- Team
- Efficient technology
- Lean Manufacturing
- Targeted organization

CUSTOMER PROXIMITY

- Leading Partners

- Continuous customer contact
- Understand the customer's products, employees
- See the entire system

POSITIVE LEADERSHIP

- Leader is not a chief
- Do what you preach-model example
- Clarity
- Clear and simple communication
- Develop employee

TEAM

- The team is stronger than the individual
- All add value based on their needs
- Complement each other
- Create trust and expectations of the group
- Working across borders / flexibility

EFFICIENT TECHNOLOGY

- Partners
- Process - participate in the development
- Product knowledge – involve the customer
- Total Productive Maintenance

LEAN MANUFACTURING

- Quality in everything
- Remove waste of resources
- Flow Orientation

GOAL ORIENTED ORGANIZATION

- Visually
- All must belong to a group / team
- Flat - customer-oriented organization

VALUES

- Customer in Focus!
- Simplicity!
- Entrepreneurial spirit!
- Cost!
- Courage and Respect!

FOCUS ON CUSTOMER!

- Appreciate demanding customers!
- Be available for customers
- Quality and delivery performance is a prerequisite
- Acting as a unified team to customers!

SIMPLICITY!

- The simple is beautiful
- Limit the number of goals
- Right from me
- Workshops and offices shall be cleaned and orderly
- Gut feeling can be sufficient for decision
- Differences can make us more effective
- Take responsibility for own development

ENTREPRENEURIAL SPIRIT

- Production is what we sell
- All companies in the AQ group driven entrepreneurial basis
- Working on continuous improvements
- Profitable growth, both organically and through acquisitions
- First, we make money, then we invest

COSTS

- The financial results are the yardstick
- When we see something that needs to be done, do it now
- Be proud to conserve our resources
- Ask yourself: is the customer willing to pay for what I do now?
- Competitive and reliable suppliers is crucial
- Reduce waste
- Question the need for external help

COURAGE AND RESPECT

- It is good to be honest
- Welcome straightforward communication and opposition
- Dare to stand up for yourself
- Fun at work
- All employees are equal
- Report bad news as fast as you can
- Call a mistake for a mistake
- Dare to be unconventional

APPENDIX B: Changeover template gathering mandatory operations

Changeover template		
Mandatory internal operations	Time (s) actual	Time (s) after imp.
Stop the machine		
Scrap the coil end		
Unplug the sensor		
Remove the ramps		
Shut the die (lower the upper part)		
Unclamp the upper die		
Lift up the press		
Unclamp the lower die		
Fit the cart		
Remove the die		
Unfit the cart		
Carry the new die on another cart		
Fit the cart		
Insert the die		
Unfit the cart		
Lock the table		
Lower the upper part		
Clamp the lower and upper part		
Insert the ramps		
Plug the sensor		
Load new coil on the axle		
Roll the coil		
Set the ground flatter		
Set the oil sprayers		
Eventually adjust the shut height		
TOTAL	0	-
AFTER IMPROVEMENT	-	0

Table 17: Appendix B - Changeover template