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Lean Management Implementation in Small and Medium Sized Companies – A Success Case Study in a Manufacturing Process

ABSTRACT

Objective: The aim of this paper is to understand a production system of a forging and presses structure of a centenary factory in terms of a cultural change on the management approach.

Methodology: The study was focused on many aspects such as the pieces production lead time, a time study of the setups, the Overall Equipment Effectiveness determination for the Computer Numeric Control machinery and an analysis of the production cells operational flow.

Findings: For the aspects that were analysed during the study, the problems are identified, and the root causes determined. At the end of the assessment stage Lean tools and concepts for fixing the problems were proposed, like new rules for production planning, setups procedures, 5S toll usage and a Lean implementation plan that is adapted to the company.

Value Added: The high industrial competitivity has dictated the development for this sector that – allied with the inconstant and unstable economic environment – makes the companies very vulnerable and highly dependent of the global market. This is a concern of special relevance for the Small and Medium Size companies that are increasingly adopting Lean solutions to continuously improve their operational value chain and the management approach, for a more systemic way of thinking.

Recommendations: For some of the solutions an impact study with their implementation was made. An analysis of the success factors proposed in the literature that were verified during the assessment stage of the case study was performed as well.

Key words: Lean Management, SME, OEE, Lean Implementation Plan, Production Planning

JEL codes: L11, L23, L25

Introduction

Small and medium sized companies – are increasing their presence in the manufacturing activity, his – allied with the unstable economic environment – makes this kind of companies highly dependent of competitiveness factors, as the constant improvement of the production systems, to produce more with less resources and with better quality levels is a concern for most of the management teams. Continuous improvement makes the companies better prepared to face the changes of the industry, enabling them to face daily problems and getting a long-term vision (Madaleno, 2018).

Lean philosophy is well recognized by top managers as strategy, in order to archive their goals, both in management and production areas, Lean implementation needs a total understanding of the system, identifying the added value chain and the waste sources, minimizing or eliminating them. Although, due to lean birth relate to large enterprises, its application in Small and Medium Sized Companies is often questioned by some researchers (Almanei, Salonitis, & Xu, 2017).

To understand the limitations of a lean implementation within SMEs, a literature review was made, extensive research approached the subject, and a convergent analysis of the findings was made.

This case study defines the main objective as the assessment of a production system of a forging and presses structures production company a Lean assessment was performed for the manufacturing sectors, such as product lead time, setup procedures, OEE (Overall Equipment Effectiveness) factors identification and calculation.

An analysis for workplaces was also done, at the end of the diagnosis stage several lean solutions were proposed and for some of them an impact study was made (Madaleno, 2018).

The implementation of the lean management philosophy in all types of companies, or other organizations, is also related to aspects of an intercultural nature, which is a factor influencing the success of possible implementation processes (Alkhoraif & MacLaughlin, 2018).

In the specific case, as a starting point, a new management aspect was formalized in the company, moving from a family philosophy to a professional management team. It strongly transformed the basic cultural notions, as Portugal is frequently associated with low levels of productivity and competitively. Those are often related to its corporate structure and form of management and leadership. It was deemed interesting to situate the study in terms of analysis of the organizations' leadership on an Internal perspective and its influence in the direction and future development of companies, taking in consideration the high-level changes promoted by the LEAN Management Philosophy implementation, considering a Portuguese Small and Medium sized company with a family management style (Romana, 2020).

Literature review

The case study focusses on SMEs, it is important to understand this kind of companies, by definition the concept varies from place to place. European Commission issued a recommendation for the member states to define SME as a company that has between 10 and 250 workers and a business volume up to 50 million euro. Portuguese government followed the recommendation, but the German for instance, states that SME has up to 499 workers and a business volume up to 50 million euro. Outside Europe, the Chinese government states that SME may have up to 999 workers (Madaleno, 2018; Tetteh & Burn, 2001).

The significance of contemporary discourse on leadership, practical aspects of managerial work, and ambiguity as a central dimension of organization and leadership (particularly in knowledge-intensive settings) are highlighted. We examine the presumed leadership in a company with respect to the three 'moral' and 'aesthetic' positions or aspects of leadership: the good, the bad and the ugly leadership. We define how managers incoherently move between different leadership positions (Quinn & Quinn, 2015).

The study undermines some of the dominant notions of leadership, for example, the leader as a consistent essence, a centred subject with a particular orientation to work. We suggest a less comfortable view of managers aspiring to adopt, but partly failing to secure leadership identities and a coherent view of their work.

Value commitments appear as disintegrated and contradictory, which indicates a need to radically rethink dominant ideas about leadership on the normal and fundamental state (Quinn & Quinn, 2015), as LEAN Management can help on this change by using better operational tools, continuous improvement plans and following better key performance indicators (Romana, 2020).

Lean in Small and Medium Sized Enterprises

Lean is a well-known key factor in repetitive production companies for improving their operations. However, because lean implementation relates to large companies, so many researchers question its applicability in low size companies or processes, stating that it is dependent on the company's dimension and volume of activity (Pakdil & Leonard, 2014). The research processes about lean implementation in SMEs are increasing, mostly due to the increasing number of companies applying it to their production structure (Matt & Rauch, 2013).

Studies show that SMEs implement lean principles mostly at manufacturing level (Pettersen, 2009) and that this type of enterprises often choose to select techniques that carry less investment effort (Hu, Mason, Williams, & Found, 2015).

The modern competitive context is pressuring companies to achieve higher levels of productivity with the lowest resources' usage (Kokubu & Tachikawa, 2013). Thus, a few alternative methods have emerged to support management decisions in terms of operational and economic results.

At the same time, considering the product quality impact and production volumes (Kokubu & Tachikawa, 2013; Sygulla, Bierer, & Götze, 2011), some tools have been developed to support manufacturing companies to increase the effectiveness of their Value Chain and to support management decisions by presenting the effective added value activities.

Lean Management is recognised as a solution for waste elimination. Its main goal is the identification and elimination of several types of non-added value tasks allowing companies to achieve an efficient customer demand (Spear, 2019). The competitiveness of small and medium sized enterprises (SMEs) is vital for the European economy.

Also, manufacturing is most of the times the main focus of Small and Medium Enterprises, so by implementing lean philosophy is a possible way in order to develop better production practices and to create a better environment for continuous improvement (Majava & Ojanpera, 2017).

The methodology is applied to an industrial system in a Portuguese traditional company, in order to support our study in practical terms.

Success factors for Lean Implementation

It is very important to understand what drives this kind of companies to implement a management model based in the Lean principles to their operational processes, so an analysis of the success and failure factors of such implementation must be identified (Almanei, Salonitis, & Xu, 2017).

A study published by Hamid (2011) states that the success or failure factors must be categorized as one of the following:

External:

- Customer – relation with the customer and their feedback;
- Governmental – applied legislation, government changes.

Internal:

- Top management – support and resources availability;
- Training – for the workers to understand lean principles;
- Workers – involvement and motivation issues;
- Work culture;
- Communication – ability to spread information within the organization;
- Resources – financial and human;
- Development of continuous improvement thinking.

The decision for the application of lean principles in an area of the organization is directly related to the experience of success and failure. A study published by Almanei, Salonitis and Xu (2017), proposes that success or failure factors can be categorized in some of the categories shown above and adds others like organization awareness, commitment of top management, external consultants support, adoption of a strategic approach and realistic milestones (Samantoroy, 2017).

A study conducted by Antosz and Stadnicka (2017) groups the failure factors in a different manner. It states that the most common failure factor is the excessive work experienced by operators, followed by the lack of commitment by workers, the resistance to change, lack of knowledge of lean principles, lack of motivation, shortness of investment and the top management's lack of involvement. Some researchers prefer to refer to this factor as facilitators or inhibitors for lean implementation, calling them CSF – Critical Success Factors (Hu, Mason, Williams, & Found, 2015). Despite the differences in nomenclature, these authors confirm that companies with better performance are those who can adopt a proactive thinking in problem solving (Hermawati & Mas, 2006).

Lean Implementation Strategies

The best way to implement lean principles in SMEs is doing it step by step according to authors, due to lack of resources (Matt & Rauch, 2013). A plan proposed by literature is called "Lean Staircase" (Almanei, Salonitis, & Xu, 2017). This plan is divided in two phases: an investment phase and an improvement phase.

In the investment phase the priority is given to a strategic implementation, regarding the definition of specific goals the company wants to archive. During this phase, it is expected of the company to spread lean thinking among its structure, not only at top management positions, but also at operations level. It is a phase where funding and support must be found from external sources, as the strategic and investment plans need to be reformed (Womack, Jones, & Ross, 1990). The investment phase corresponds to the time gap between lean principles adoption and obtaining results from the techniques implemented. The last steps from the performance investment phase are the diagnosis of the production system and the application of some of the basic lean tools, like 5S or VSM (Dennis, 2015).

The performance improvement phase relates to a more operational intervention, corresponding to the phase where results can be obtained. It starts by developing change support mechanisms such as performance metrics. It is succeeded by the application of more complex lean tools, like TPM, Kanban or Kaizen. This phase ends with the adoption of other supporting initiatives, like IT systems and the integration of suppliers in the lean initiative. For continuous improvement the implementation plan suggests that the company has to continuously reset its goals and review them with time (Hu, Mason, Williams, & Found, 2015).

There are other implementation plans suggested in literature. The one defined by Sunder (2016) suggests that the implementation should start by defining milestones for the goals the company wants to archive and simultaneously do the Value Stream Map and diagnosis of the full production system. The author then suggests the implementation of lean tools, like cell production, SMED, Kanban. The process will be supported by a continuous improvement plan, which will allow the management to define better and more ambitious objectives.

Every plan analysed has the diagnosis stage in common, this diagnosis can be made in two ways: with a lean assessment tool (LAT) or by performing an in-place diagnosis on the shop floor, some aspects included in lean initial assessment are related with the part numbers lead time, with Overall Equipment Effectiveness factors and Value Stream Map calculation.

In some cases, the (LAT) – Lean Assessment tool has some limitations for its usage like the unavailability of accurate statistical data (Pakdil & Leonard, 2014).

Suitability of Lean techniques in SMEs

Due to some of the characteristics of SMEs, involving some resources limitations and lack of skills of some operators, some lean techniques are not suitable to be implemented in SMEs. Studies published refer that the Six Sigma, Failure Model Evaluation Analysis and Total Quality Management are not suitable and the most suitable are 5S, JIT, pull system, visual management, or Poka Yoke, so the most sophisticated lean techniques should be used in larger companies that may have a typology of more powerful resources allowing their use (Nagavarapu, 2013).

In SMEs it is understood that the use of the most elementary tools, such as 5S and visual management, would be of great use for the creation of more favourable conditions for the understanding of Single Minute Exchange Dies and later for the development of Overall Equipment Effectiveness implementation in order to perform a better follow up on the operational results, as a high-level Key Performance Indicator (Nagavarapu, 2013).

Case study and methodology

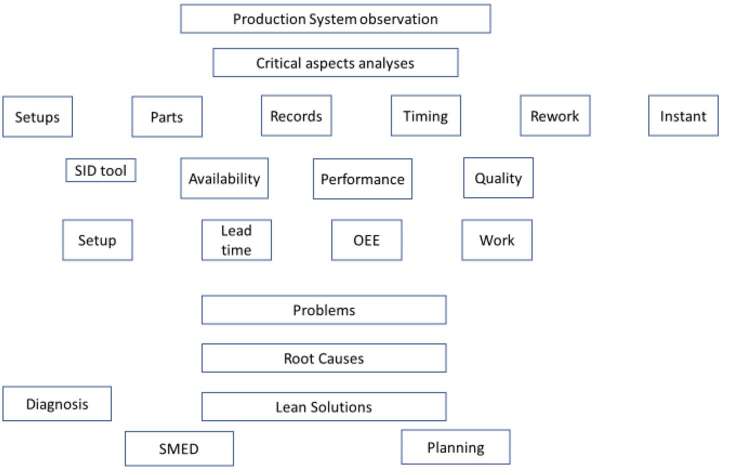
In order to study this aspect and describe it in this paper, a management position of several years was accomplished.

The company under study was founded in 1920 and since then has produced machined pieces for forging and presses elements. In order to perform the initial assessment/diagnosis a plan flow chart was designed that is represented in Figure 1.

The first step was to understand the production system, identify critical aspects and decide which analysis to perform for each aspect. Once that is done, the diagnosis contemplated timing of setups, machining parts were monitored, the existing records were analysed, some machining programs were monitored, and instant observations were conducted.

With gained information, an analysis of the setup procedures, lead time determination, OEE determination, and a workstations analysis was performed. By the end of the collecting period, the problems associated with every aspect analysed were identified and the root causes determined. That allowed to propose some lean solutions that had the objective of minimizing the impact of the problems identified during the diagnosis.

Figure 1. Assessment Plan Flow Chart



Source: own elaboration.

Initial Assessment/Diagnosis phase

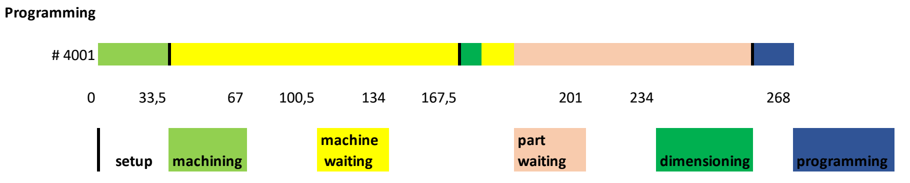
Lead Time

All parts produced by the company are made by order and each order is identified by the prefix "GL", which means Galucho (company name). Two orders were monitored, each comprising three pieces. These two orders were requested in duplicate, so they had the exact same pieces, each containing a GL100, a GL200 and a GL300 as an internal code for the workplace.

The two pieces GL100 were machined at the same time and in the same equipment, with the lead time represented in figure 2. The detailed data for the lead time of these two pieces is in table 1. The production of the parts took 268 hours, and 51,9% of them were with the machine waiting due to lack of information from the customers regarding specific conditions that had to be drilled in the bottom of the pieces.

There were also 32,5% of waiting time for the dimensioning operations to control the pieces. In general, the production of these two pieces had an added value contribution (AV) of about 15,1% and non-added value contribution of 84,9%.

Figure 2. Parts Lead Time



Source: own elaboration.

Table 1. Lead Time impact factors GL100

Lead Time	**268 hours**	
Programming	***9 h***	***3,40%***
Setup	***1,4 h***	***0,50%***
Machining	***34,7 h***	***13,00%***
Machine Waiting	***139,0 h***	***51,90%***
Part Waiting	***87,2 h***	***32,50%***
Dimensioning	***5,7 h***	***2,10%***
Total	***268 hours***	***100%***
Total AV	***40,4 h***	***15,10%***
Total NAV	***227,6 h***	***84,90%***

Source: data collected from company reports.

A similar analysis was performed for the GL200 and GL300 pieces and the detailed data can be found in table 2.

Table 2. Lead Time impact factors GL200 & GL300

	GL200	GL300
Lead Time	539 hours	
Programming	***6,50%***	***1,00%***
Setup	***1,70%***	***1,70%***
Machining	***16,50%***	***17,00%***
Machine Waiting	***11,00%***	***23,00%***
Part Waiting	***70,40%***	***58,10%***
Dimensioning	***0,40%***	***0,20%***
Total	***100%***	***100%***
Total AV	***16,90%***	***17,20%***
Total NAV	***83,10%***	***82,80%***

Source: data collected from company reports.

The lead time value related to these two parts – numbers archive 539 hours to finish all the tasks. The part waiting stands out of the remaining lead time contributors with an incidence of 70,4% and 58,1% for GL200 and GL300 pieces, respectively, so the operating time for these parts is very low, representing about 17% of total lead time for all pieces. The non-added value contributors represent about 83% of the lead time.

The lead time analysis concluded that the waiting time while the pieces were in production was very high. There was a huge difference between the time expected for the machine to conclude the work and the real one verified, and the ratio Added Value/Non-Added Value promote a really low rate result.

Using some Lean tools as the 5 Why's analysis some of the problems main causes were well raised: lack of production, non-Total Productive Maintenance planning and low level of people motivation in the team.

Setup process and time

The setup process analysis was performed by monitoring 9 procedures comparing the results for the Computer Numeric Control and Conventional equipment. The data for the Computer Numeric Control are represented in figure 3.

The setups analysis was been accomplished using the SID tool, which allows the comparison of different setup process and procedures. It categorizes all tasks done by the operator in categories like movement, transport, cleaning, tool, adjust, positioning, program, and unsuitable operation (Madaleno, 2018).

According to the analysed values it´s very clear that there is an important variation in the several kinds of verified operation time, total time and splited for the SID activities.

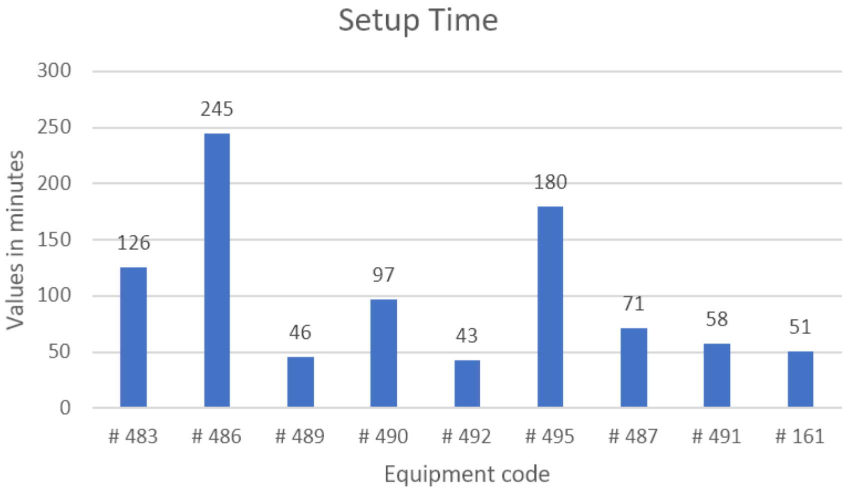
By example, taking in consideration setup 2 (equipment #486) it can be verified that it lasted for 245 minutes, as for setup 5 (equipment #492), it took only 43 minutes, this is an important difference considering that it´s the same, process, procedure, machine and the very same type of piece operated for the proposed verification.

The variation of SID operations is also relevant, the variation of cleaning operations varies from 8% to 24%, movement operation varies from 8% to 46%, transport varies from 1% to 25%, positioning operation from 3% and 20%, adjust from 4% to 40%, tool from 0% to 23%, and program operation from 8% to 72%, considering Computer Numerical Control equipment, of course the same situations were verified in the conventional machinery.

The setups analysis allowed to determine the problems that were causing the high level of time waste in non-added value tasks that were performed by operators during the time that the machines are stopped, so to determine the higher timing for SID operations, the 5 Why's analytic toll was been used.

The main results of the a.m. analysis are related with, the lack of tools kits in quantity and variety to equip all the machines, the lack of organization of the space available around the machines, the inexistence of a standard setup procedure, the lack of organization of the storage of tooling.

Figure 3. Computer Numeric Control Machinery – Average Setup Results



Source: data of the surveyed company.

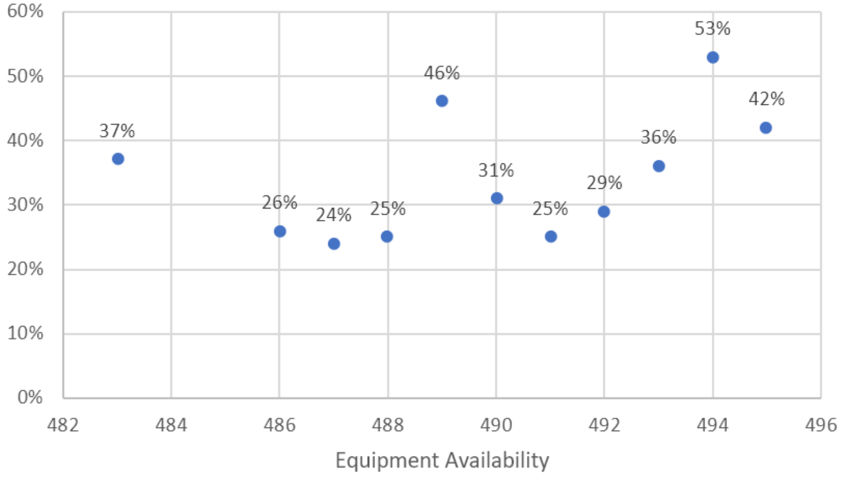
Overall Equipment Effectiveness

The Computer Numeric Control equipment was the one analysed because of its relevance in the manufacturing process. The Overall Equipment Effectiveness (figure 5) is calculated taking in consideration three main factors: availability, performance, and quality.

For the total time available it was considered that the equipment was able to work 24 hours per day and every day of the week. This time constituted the time available which was referred to as SA (Shift Availability).

For the availability, the results showed that in average the machines were being used 37% of the time, or about one third of the time available. The availability of machines varied from 24% to 53%. Values above 33% are in line with the usage of machines after operators leave the factory, as they are only there for one third of the time available in the 8 hours shift. The results for availability of equipment are shown in figure 4.

Figure 4. Computer Numeric Control – Equipment Availability



Source: data of the surveyed company.

The classification of the available time is machine running, machine in setup, machine waiting, machine in maintenance, machine broken, and machine in idle. The importance of this components in the time available has huge variation depending on the analysed process.

It was verified that there were no maintenance incidence pattern and a high incidence of broken time in some machines like the CNC 1, CNC 2 and CNC 3. The low values of availability are caused mainly because of the equipment idle times.

The Computer Numeric Control performance varied from 45% to 90% and only two of them had values above 80% and about half lower than 65%. The average performance was about 67%. Once again, a 5 why's analysis was made to conclude the root causes of the problem of low performance values caused by the lowering of machining speeds by the operators, it was verified that the root causes were the lack of motivation of team members and supervisors, training program provided to the operators was not sufficient to assist the equipment and no total productive maintenance strategy is implemented.

The equipment quality performance was considered in general for the all factory, as the lack of information and data registered in the production management information systems is not reported by workplace.

The quality value was calculated analysing the rework processes related with the pieces not produced as good, on the first time, it was calculated that in one year a quantity of 38 parts were rejected in a range of 1400 pieces produced.

This ratio resulted in the value of 97,3%. The Overall Equipment Effectiveness results are shown in figure 5.

The analysis of the workplaces are aligned with some of the problems of the global analysis, considering, the low values of capacity available are in line with the presence of operator in the workstation, which is very low considering that this analysis was only performed as theoretical forecast.

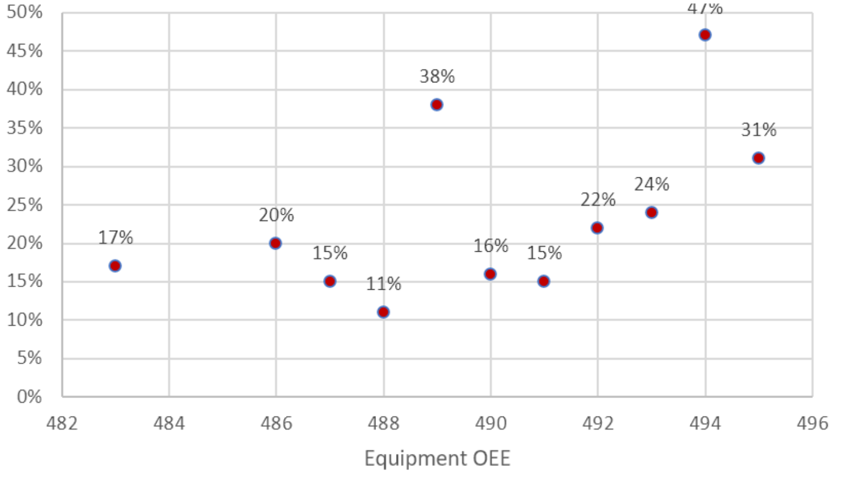
The equipment setup time is very high with an of 18%, as the production plan can not prevent the huge number of exchanges dies at all the processes.

Considering maintenance rates of the equipment and tools we can report they are very low with an average of 1%, this could be a good result if the maintenance activities were performed during the night shift, although this is not the case.

As far as the on-hold machine times are concerned, it was verified that in some equipment this incidence had values of over 50%. The running machine effective time obtain values from 29% to 79%, depending on the more or less process and workstation stability on the production plan.

Considering the operators allowed to verify that they were out or the workstation about 49% of the 8-hour shift, in 12% of that time they were doing transport operations, 2% of time they were in the supervisor´s office, and 86% locking for lost raw materials in the factory shop floor.

Figure 5. Computer Numeric Control – Equipment Overall Equipment Effectiveness



Source: data of the surveyed company.

Solutions

After determining the root causes for the identified sources of waste, this work proceeded with the developing of solutions that aim to minimize them.

Implementation Plan

As verified in literature review, lean transformation needs to be supported in a very robust actions plan and is supposed to act as continuous improvement process, along the time.

So, a lean implementation plan was defined by adapting the Lean Staircase plan reviewed. From the first to the fifth stage referred in Lean Staircase, it is crucial that the company revise their organizational structure and rightly divide the responsibilities between top management and production supervisor (Madaleno, 2018).

It´s also needed that the company seek for new ways of funding to support some of the solutions suggested in this work.

The sixth stage of Lean Staircase suggests diagnosis, and that was already done by this work. The plan proposed by this work is about the last stage of the Investment phase of Lean Staircase and the first and second stage of the second phase. It is scheduled to last twelve months divided in three phases. The plan is schematically represented in figure 6 (Madaleno, 2018).

In the first phase the factory is expected to implement the logic of the 5S method. In order to achieve that, is necessary for the capital to be invested in purchasing some tools and accessories for all the machines that are missing. Hence, it is mandatory that inventories are made to determine what is necessary.

This implementation is to be made during the first phase but should be audited periodically in the remaining phases of the plan. Also, during the first phase the factory should implement visual planning and standardization of filling production records. This standardization needs the operators to be taught about how to use the software in the most effective and easy way.

It is suggested to the factory to do workshops about the software and if necessary, involving the software developer in this training sessions. The daily kaizen could be progressively introduced in the first phase but there will not be the necessary rigorous and trustworthy results obtained with the standardization of records to discuss.

Nevertheless, it can be implemented during the first phase to discuss the progress of the other actions to be introduced. In the second phase is expected of the factory to implement Single Minute Exchange Die and strategies of problem solving, like the A3 report and 8D, the strategies of problem solving can be discussed during kaizen events following the sequence of defining a purpose, identifying the adequate processes and involving people.

They are a good tool to discuss problems that can be identified during implementation and to come up with solutions. This allows to increase the motivation of operators and delegate in them some of the responsibilities. The kaizen, which must be fully implemented at this phase, needs to happen in both daily period and occasionally with kaizen events.

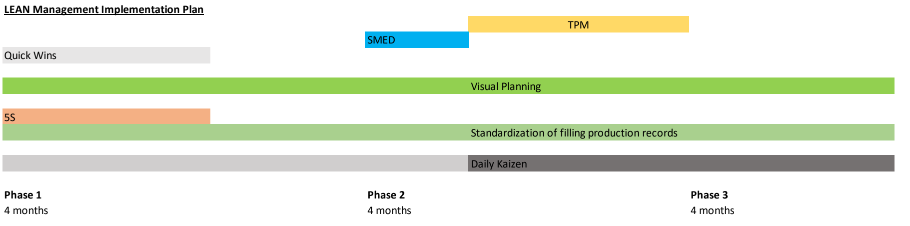
The kaizen events can be used to define the necessary Key Performance Indicators to visually expose to the factory in the daily information board. Also, during the daily kaizen events it is suggested to expose the planning of production or maintenance schedule, the setup standard time, equipment availability, and part lead time (Nordin & Adom, 2016).

In the third phase the top management is expected to implement Total Productive Maintenance, relying to external maintenance services. It is suggested to introduce the concept of self-maintenance among operators for the simplest actions once again this allows to increase motivation of workers and the delegation of responsibilities.

The remaining solutions proposed in first and second phases are supposed to be continued and to be assessed frequently. This implementation plan aims to optimize the performance of setup time using the Single Minute Exchange Die technique and at the same time work in order to decrease the production part – numbers lead time by improving the planning process and consequently promoting a better result on the Added Value/Non – Added Value ratio.

These set of operational actions will also contribute to increase the Overall Equipment Effectiveness, by the long-term improvement in production planning and total productive maintenance processes. Concerning the organizational culture, the plan predicts the dissemination of lean philosophy and continuous improvement. The success of the actions plan implementation will be dependent on the management cultural change (Hermawati & Mas, 2006).

Figure 6. Implementation Plan



Source: own elaboration.

Single Minute Exchange Dies

The implementation of a standardized setup procedure aims to minimize the total time the machine is stopped to change any piece, the setup processes monitored during the initial assessment were analysed with the Single Minute Exchange Die, which is represented in figure 7.

The method allowed to distribute the tasks performed by the operator in direct and indirect, meaning that all activities that could be done with the machine running were indirect and those who are performed with the machine stopped are direct, corresponding to the first and second phases of Single Minute Exchange Die process.

Due to the kind of direct activities analysed, some of them were categorized as indirect that could be minimized, this corresponded to the third phase of Single Minute Exchange Die process. In order to eliminate the time of indirect activities from the setup procedures and minimize the directs, three setup related procedures were defined: a pre-setup, a setup, and a post setup procedure (Madaleno, 2018).

The pre-setup is related to the preparation of all the things a setup requires. It involves the information about the setup and materials gathering like cleaning items and fastening devices. It also involves the preparation of the piece to be loaded into the machine, like verifying its position, defining clamping system and verifying if the dimensions are correct.

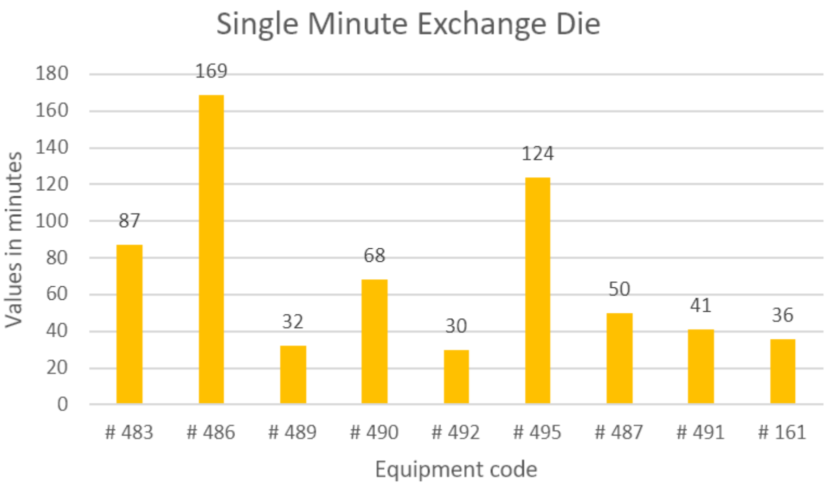
Moreover, during the pre-setup, it is crucial that the operator responsible for transporting the piece from its location to the workstation to perform the cleaning of the piece to be put in the machine, prepare all related tools, and verify the Computer aided Manufacturing program.

The setup procedure is done with the machine stopped, during this time, the operator must control the dimensions of the piece that will exit the machine, remove its clamping fixtures and the piece, clean the interior of the machine, position the new piece, and define centres of the new piece to introduce this information in the Computer aided Manufacturing program.

Also, during this time, it is required to insert the dies prepared during the pre-setup and select machining programs, after the setup, the operator must perform a post-setup procedure that aims to do storage of the items used during the process.

The implementation of the new processes would result in a decrease of an average of 23 minutes with the strong reduction of indirect tasks represented in figure 7, corresponding to the second phase of Single Minute Exchange Die process, in general, a reduction of 31% of total setup time was forecasted, with an interval of values from 10% to 2%.

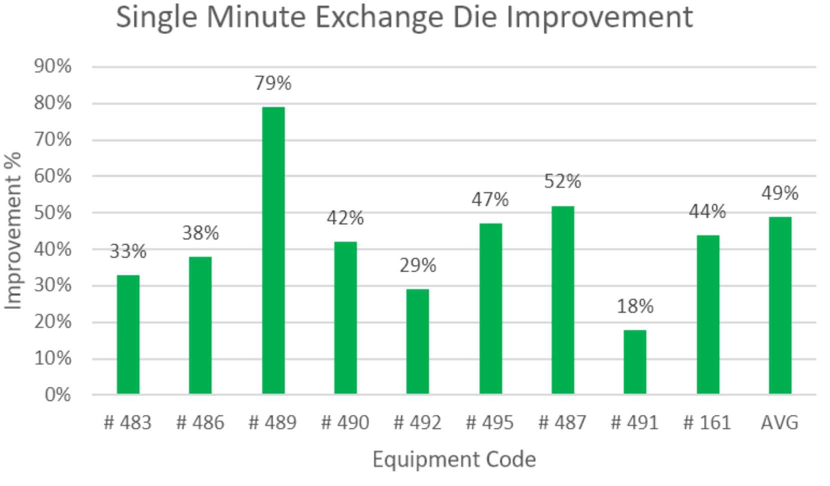
Figure 7. Single Minute Exchange Die – average analysis results



Source: data of the surveyed company.

The improvement of the direct operations related to the third phase of Single Minute Exchange Die, is expected to minimize total setup time by 18% to 79% with an average of 49%, all the key elements are reported in figure 8.

Figure 8. Single Minute Exchange Die – average implementation results



Source: data of the surveyed company.

Production Planning

As verified during the assessment, planning decisions were a major reason to much of the wastes identified, both in production and maintenance level. Because maintenance planning is a subject for Total Productive Maintenance, this solution shows only the approach to the production planning, in order to do that, two planning situations were compared: one with the practices used by the factory, and other with new procedures proposed by case study research.

To compare the two situations, it was required that a skills table (competencies mapping) be defined, that can be used to have 16 parts (pieces) and two possible machining operations, roughing and finishing. The time available to complete the machining of each part is named AT – Available Time. Skill Table used is defined in table 3.

Table 3. Skill Table (competencies mapping)

Part	Roughing (h) Machine 483	Finishing (h) Machine 495	AT (h)
1	8	3	24
2	4	5	24
3		15	84
4		8	36
5	7	4	36
6	8	7	96
7	10	6	48
8	10	9	48
9	1	9	108
10	3	3	60
11	3	1	60
12	9	4	120
13	1	8	72
14	1	8	72
15	8	8	132
16	4	5	132

Source: data of the surveyed company.

Due to the purpose of this case study the idea, is only to compare the decision priorities during production planning definition, some assumptions were raised:

- The Setup processes would only happen during the time frame of day-shift with operator, from 8am to 5pm, and not during lunch time between 1 pm and 2 pm.
- Setup times are equal for both cases, lasting 1h.
- Operating length time is aligned with the standard defined by the engineering department.

Note: it is not considered the Total Productive Maintenance improvements of the equipment.

To compare the results for each case, some Key Performance Indicators were defined, for instance part lead time (LT), average lead time (LTM), availability of equipment's (Ava.), ratio between nightshift usage and nightshift available (blind shift), ratio of pieces delivered with delay, difference between TD and LT (Difference) and ratio between LT and TD (TD usage) (Madaleno, 2018).

At the moment, the plant management had just one decision planning rule, which was the time available to complete process tasks for the piece and a process principle, roughing in machines with lower performance and finishing in machines with higher performance.

Values for main Key Performance Indicators for the decision rules used by the plant management are reported in table 4.

Table 4. Key Performance Indicators – Results for the production planning

Part	LT (h)	Difference (h)	TD usage
1	*28*	*-4*	*117%*
2	*33*	*-9*	*138%*
3	*166*	*-82*	*198%*
4	*9*	*27*	*25%*
5	*53*	*-17*	*147%*
6	*176*	*-80*	*183%*
7	*61*	*-13*	*127%*
8	*82*	*-34*	*171%*
9	*186*	*-78*	*172%*
10	*100*	*-40*	*167%*
11	*102*	*-42*	*170%*
12	*149*	*-29*	*124%*
13	*111*	*-39*	*154%*
14	*129*	*-57*	*179%*
15	*207*	*-75*	*157%*
16	*198*	*-66*	*150%*
Average	**112**		**149%**

Source: data of the surveyed company.

Defining planning with plant management decision rules resulted in LTM of 112 hours and a delay in 15 pieces, or 94%. Also, the usage of available time (TD) is about 149%, which means machining of parts usually takes more 49% than the available time.

In relation of machine results, this planning resulted in 48% and 50% of availability for equipment 483 and 495, respectively. Effective time reported is 31% for 483 and 29% for 495.

The processes change in order to support management actions plan, raised the goal of increasing availability of equipment, assuring its maximum usage considering the skills table and the available time to operate the products. The List of proposed procedures, were as follow:

1) Maximization of setups performed in dayshift (giving priority to low volume operations during dayshift).
2) More Effectiveness on shift occupation.

3) Standard time reduction to complete parts, promoting a productivity increase.

These procedures consider the operation process to be performed in one single equipment, eliminating the need of a second setup for the same part, the second decision idea is the best one out of two possibilities, namely the maximization of daily setups and the usage of nightshift and the last decision step is based on the time available to operate each piece.

Once these procedures are based on the operation on a single machine, it is necessary to calculate the time necessary to perform the complete process in both machines for each piece. So, an evaluation indicator needs to be calculated, based on the performance values analysis, related with Overall Equipment Effectiveness reporting.

The indicator of the equipment 483 performance and the equipment 495 performance results in the value of 0.59, this value needs to be confirmed when performance improvements will be obtained from Total Productive Maintenance, strategies and operations.

The time to perform the single process on each machine for each piece was calculated based on the results of Equation 1 and Equation 2 (Madaleno, 2018).

Equation 1 – total time for equipment 483

Total time 483 = Machining time 483 + (Machining time 495/Performance Ratio)

Equation 2 – total time for equipment 495

*Total time 495 = Machining time 483 * Performance ratio + Machining time 495*

The updated job matrix with both possibilities of machining for each part is shown in table 5.

Table 5. New version of Skills table (competencies mapping)

Part	Total time 483 (h)	Total time 495 (h)	TD (h)
1	13	8	24
2	12	7	24
3	24	15	84
4	13	8	36
5	13	8	36
6	19	12	96
7	20	12	48
8	25	15	48
9	16	10	108
10	8	5	60
11	5	3	60
12	15	10	120
13	14	9	72
14	14	9	72
15	21	13	132
16	12	7	132

Source: data of the surveyed company.

The results of the Key Performance Indicators for the management actions are represented in table 6.

Table 6. Key Performance Indicators results for the effective management actions

Part	LT (h)	Difference (h)	TD usage
1	*105*	*-81*	*438%*
2	*8*	*16*	*33%*
3	*46*	*38*	*55%*
4	*110*	*-74*	*306%*
5	*129*	*-93*	*358%*
6	*26*	*70*	*27%*
7	*69*	*-21*	*144%*
8	*24*	*24*	*50%*
9	*65*	*43*	*60%*
10	*30*	*30*	*50%*
11	*6*	*54*	*10%*
12	*83*	*37*	*69%*
13	*87*	*-15*	*121%*
14	*135*	*-63*	*188%*
15	*48*	*84*	*36%*
16	*56*	*76*	*42%*
Average	**64**		**124%**

Source: data of the surveyed company.

Production plan done with proposed procedures have obtained results in LTM of 64 hours and a delay in 6 pieces, or 38%. Also, the usage of available time (AT) is about 124%, which means machining of parts usually takes 24% more than the available time. In terms of machine results, this planning resulted in 76% and 67% of availability for machine 483 and 495, respectively, blind shift usage is 68% for 483 and 55% for 495.

Models Validation

It was verified that some of the external and internal factors proposed by Hamid (2011) had some influence on the diagnosis results obtained, the problems related with the top management can be categorized in the Hamid's proposal as far as the planning and decision-making process are concerned.

Another evidence of Hamid's factors is the existence of operator issues related to the assistance of the machines resulting in the decrease of the performance value for the equipment, the resources availability is also a concern that was verified, and it is in line with Hamid's proposal (Madaleno, 2018).

For the implementation plan, it was verified that the proposed solution tools had to be adapted to the company as predicted, like Single Minute Exchange Die and implemented with realistic milestones (Almanei, Salonitis, & Xu, 2017).

The involvement of operators is also considered, assuring their motivation and development of a lean thinking philosophy (Matt & Rauch, 2013), the top management involvement is also a concern, assuring its elements to be completely focused on the objectives and committed with the results achievement (Antosz & Stadnicka, 2017).

Conclusion and Future Research Lines

Conclusion

The current paper was been developed based on a presentation of a review of some models which tried to categorize the factors that a possible lean management philosophy implementation in Small and Medium Sized Companies is on dependence, a practical project case analysis was conducted, comparing each model and its categorization, revealing common aspects and their differences, the adaptability of lean tools in this category of enterprises was tested as well.

A lean production and management case study plan was followed, of course, according and verified in the literature review, that stated that it was necessary to perform a lean assessment to evaluate a manufacturing system and to be able to identify its added value levels, non-added value tasks and waste sources in the processes.

In order to support the analytic model, the main monitored processes were the setup of equipment, the lead time of parts, the Overall Equipment Effectiveness of Computer Numeric Control equipment and a detailed analysis of the processes workstations was been done.

According to the above-mentioned research actions we could identify the major categories of issues that were related with the high incidence of waiting time in the lead time parameter, huge amount of time for performing the equipment setup and low values of equipment availability and performance.

After that and to minimize the impact of some of the situations identified during the initial assessment, a practical approach supported in the lean management solutions were implemented, like a lean implementation plan, a Single Minute Exchange Die tool, and a production planning based on the pull system for the better allocation of pieces and machines.

The goal for Single Minute Exchange Die implementation was to decrease total setup time and increase the organizational level of the production areas.

The new production planning philosophy aimed to increase machine availability and in consequence to obtain better results on the Overall Equipment Effectiveness indicator, as this was one of the most important factors for the calculation.

A check verification was performed for each of the proposed solutions obtaining much better results than the previous ones. The implementation plan was adapted to the company and its reality, assuring the minimization of the failure risk according to the failure factors proposed by models of various researchers addressed (Madaleno, 2018).

So, the main conclusions of the case study, can be addressed in two main categories, first related to the need to simplify the lean implementation process in SMEs. The second was considered in terms of being compared with large companies (Dennis, 2015).

In addition to that we can refer to the first aspect, we can understand that the implementation will be consolidated using base tools of the lean philosophy, 5S and Single Minute Exchange Die in particular, for improvements in the Setup time performance and Overall Equipment Effectiveness results.

The biggest difference found for large companies is that in reality, the creation of an integrated management system becomes more complex, with most of the potentialities of the lean management philosophy.

The opinion is that the levels of lean implementation will not be uniform in all organizations and that holistic functioning systems may be possible in organizations with greater capacity to maintain them as their fundamental management model (Basu, 2019).

The final approach, supported by the LEAN management philosophy, promotes a cultural change in the management style of companies in general, and SMEs in particular, because it creates a context of professionalization to the detriment of family operation and based on empirical and social situations that are not supported in a scientific thinking of professional management.

The cultural change established and supported by professionalism comes from the creation of a sequence of thought, through the development of a purpose for the decision process change, generation of knowledge about the elements and tasks to analyse, a behaviour supported by the example and creating expectations in the face of results, supported on a philosophy of management by objectives (Romme, 2016).

Future Research Lines

Naturally, we understand some limitations in the study, as it is a specific case with a strong capacity and opportunity for improvement. Thus, we defined two fundamental and converging options as future lines of research (Romana, 2014; 2016a), which would be the possibility to compare the results over time with other industrial organizations and apply the study methodologies to companies in non-industrial sectors, such as logistics and services (Romana, 2016b).

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