Implantation of the SMED Technology into an Auto Parts Industry: A Case Study

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Abstract

The SMED methodology - Single Minute Exchange of Die - proposed by Shigeo Shingo was developed in Japan between 1950 and 1969 being referenced in the reduction of costs and times. This work discusses the SMED implantation, the technical and operational questions that involve this methodology within of a production cell in an auto part manufacturing industry. The project of implantation of SMED methodology started up in 2010, within the structural shock absorber area. The operational questions were discussed based the activities on the shop floor before, during, and after the implantation of methodology. The aim is to show that the SMED methodology without support of other tools cannot maintain itself and to reach the proposed goals. A staff during the implementation of SMED was established and trained. Thus, the functions that would be performed by each member within the group for an elaboration of Major Kaizen were established, and each phase during the process was defined since the training until the improvements and standardizations. The results show that after implantation of the SMED methodology, it was observed with comparatives graphics of traditional setup versus Fast Change of Tooling – FCT - that the process acquired significant gains, reducing the time of change, optimizing the trained labor and taking advantage of it in another process.

Keywords: Toyota production system, Single minute exchange of die, Setup.

1 Introduction

Nowadays, the competitiveness is increasing, challenging the worldwide organizations to change or improve more and more the productive processes to continue in the market. The considerable gain in improvements is the creativity, the use of fewer materials, and great ideas.

Based on this, the Fast Change of Tooling – FCT is being very used in the industries due to great profitable feedback, making more flexible the processes, changing the productive environment, attending for a variable demand of diversified molds of pieces in small batches, and consequently, increasing the productivity into the corporations. Moreover, the FCT reduces or eliminates losses and costs of stopping machines, overproduction, large inventories, and other settings.

The Fast Change of Tooling – FCT can be understood as a methodology for the setup reduction of equipments, generating an economic production in small batches. The use of the FCT helps the lead time reduction, allowing the industry a quick answer before the market changes. Another advantage is the economic production of small batches of manufacturing, which generally require low investment in the production process (Shingo, 2000). Furthermore, the FCT reduces the number of errors in the setup of equipments (Harmon & Peterson, 1991).

O Lead Time (the total time required to manufacture an item, excluding the time of purchase of items but including the time of manufacture, preparation of machines, running, movements, inspection, and storage or process) is an important coefficient in the costs of manufacturing processes. The reduction of Lead Time generates lower operation costs and aggregate benefits to the consumer. The time gain from the

Lead Time reduction is an investment in the customer satisfaction and in the reduction of manufacturing costs (Slack, 1999).

The reduction of time in the setup of the process is a necessary requirement to decrease the unit cost. According to (Harmon & Peterson, 1991) the reduction is important based on three statements:

1) High cost of setup provoked great manufacturing batches, increasing the investment in storage;

2) Fast and simple techniques for the tool change decrease the possibility of errors in the regulation of equipments;

3) The reduction of setup increases the time of equipment operation;

The Fast Change of Tooling – FCT is essential to obtain the necessary qualities for a competitive strategy of industries in relation to customers and markets, mainly to reach a Just in Time (JIT) production, where the quality depends on the Lead Time reduction. The Lead time reduction depends on the decrease of intermediary storages, synchronism of production, and size of manufacturing batches. The reduction of size batches is a function of reduction of setup times, and has a high degree of dependence in the FCT.

2 State of the Art

The lean production system has been very discussed in the literature, mainly by the authors, Mondem (1993), Schonberger (1982), Shingo (1985), Hall (1983). According to Bayou and Corvin (2008), in spite of several researches developed in the last decades, this theme isn't completely developed yet. This occurs due to two reasons; in a first place, there isn't a general definition and broadly accepted by the researchers, and second, until the moment, there aren't papers that describe a systematic and relative dimension about the lean production system.

As a result of this, the Production Toyota System (PTS) or Lean Production System (LPS), created by Toyoda and Taiichi Ohno in the 1950s, was, firstly, drawn in the academic literature by the Professor Yasuhiro Monden with the aim of elimination of waste. The seven kinds of waste are considered by Womack e Jones (1998). The waste is eliminated with specific techniques such as: the production in small batches, reduction of storages, high focus on quality, predictive maintenance, and others.

According to Godinho Filho and Fernandes (2004), the production in small batches and the reduction of storages provides great incentives for the reduction of time setup. The SMED methodology (Single Minute Exchange of Die) proposed by Shigeo Shingo is used for the reduction of time setup, and it is based on a long time of experience. The SMED is a scientific methodology that can be applied to any industry and any equipment (SHINGO, 1985).

The application of SMED methodology aiming to reduce the waste and setup time is defined as a reduction process of total time to make a change of one process. This philosophy should be applied from the last part of the product manufactured until the first part accepted with the quality of the new batches following (Marchwinski and Shook, 2003).

The SMED methodology is applied using a strategy of six steps (Shingo, 1985). First, the total time of change is measured. After, the change is analyzed and identified as internal or external operation using the time of specific operations. Afterwards, the internal operations are changed to external after a complete analysis. Thus, the necessary time to perform the operations internal and external is reduced, and finally, the procedure in new change (new setup) is standardized.

The time of change (setup time) allows to reduce the production batches increasing the production capability, flexibility, and the disposal of resources, as well as the improving of the quality of the products and the customer satisfaction. Therefore, the main aim of the time reduction of setup creates a great flexibility of production and gets small and profitable production batches. The process of setup time reduction can also behave as an efficient method to joint operators in the decision-making and problem solution.

The main authority considering the setup time reduction is Shingeo Shingo. During several years, he worked as Toyota consultant and with other Japanese manufacturers. Shingo developed a methodology to analyze the setup time reduction in big mold machines used in the automotive industry. Shingo gave the name to his methodology of SMED that correspond to analysis, time reduction, and tooling change. Applying his methodology, Shingo was capable of reach results very expressive, for example, the setup time reduction decreased from 4 hours to 3 minutes in a machine of 1000 tons of pressure (Shingo, 1985).

Although the Shingo's methodology has been initially developed for the use in the manufacturing of metallic parts of the automotive industry, the main principles of SMED methodology can be applied to other processes where a constant change of tooling occurs in several industries. The time reduction of change of tooling reaches significant results of the implementation of SMED methodology. The application of the six steps of the process and the change from internal to external operations, in other words, the changes the operations that were carried out with stop machine (internal operations) to operations performed with the machine in operation (external operations) can reduce the setup time in a range of 30 – 50%. (Shingo, 2000).

According to SMED methodology there are two classes of setup, external and internal. The internal class of setup concerns the operations that are carried out when the machine is turned off. The class of external setup concerns the operations that are carried out when the machine is working (Marchwinski e Shook, 2003). The important factor in SMED implementation is to make the division between internal and external elements and try to convert the internal elements in external elements.

Fogliatto and Fagundes (2003), proposed in a furniture industry four steps; strategic – with the involvement of all employers; preparatory – corresponding to the elaboration of strategies and analyses of the current system; operational – practical application of the methodologies proposed; and verification – setting of the strategies and used techniques. The authors comment that, after the steps, the environment should be prepared for actions of continuity and focused on reduction of setup times in other processes.

McIntosh et al. (2007) evaluated two fundamental tools, which can best be achieved, independent of the adopted methodology. First, the improvement can occur with the change of when the tasks are carried out, with a better allocation of tasks without changing the essence of them. Second, the tools consist of finding the structural changes existing for the tasks, allowing them be completed more quickly. The authors describe these two tools in relation to the work of Shingo as a method of reinterpreting the SMED methodology.

Sugai et al. (2007) made a critical analysis of the Shingo's methodology for the FCT. According to the authors, although useful, there are several gaps, especially considering the problems associated with the periods of acceleration and deceleration relating to the setup activities. It was observed that the separation, and the conversion of tasks wasn't enough. Another application of the SMED was analyzed by Trovinger and Bohn (2005). The authors used the SMED methodology in setups of the assembly of Printed Circuit Board (PCB) of high-speed. According to the authors, more than 50% of the effective capability can be lost in setups of PCB applications.

Moxham and Greatbanks (2001) discuss the practical application of the SMED in the textile manufacturing operations. The authors suggest prerequisites that need be provided before the implantation phase of the SMED methodology. The SMED technology cannot be affected by cultural problems, procedures, and barriers of management. These problems need to be solved to obtain success. The authors called these prerequisites of zero-SMED. The authors suggest that there are prerequisites that need be provided before of the implantation SMED phase.

Patel, Shaw e Dale, (2001) had good results for the SMED application. The authors studied the time reduction of setup and the methods for reducing errors in little industries, involving mechanic accuracy components in small batches with the great variety for the aerospace industry.

3 SMED Implantation

The methodology SMED applied in Magneti Marelli Cofap at Lavras was started in December 2010 in the cell of shock absorbers structural. The implantation was carried out together with the pillar of costs deployment and improvement focused using a detailed analysis. The stratification by cost unit, there was an evident need to work the reducing of the setup time on the cell 2 that corresponding to a press that produces holes. The project was coordinated by the leader of the pillar of continuous improvement and by an analyst of technology.

4 Objective

The main objective for the utilization of SMED in the place aforesaid was the reduction of waste with movements and activities unnecessary that no aggregate values during the setup operation of the machine. The implementation generates a cost reduction and flexibility in the production with a reduction of 46% of the setup time.

4.1 Development and Organization

After the first action to be developed, the next step was the choice of the team. The team was composed according to the provided necessities and referenced by the coordinators of the project. After the team composed, being included operators and supervisors, the next step was carried out to enable all teams into the SMED methodology.

During the training, the SMED philosophy was taught to the team, since the principles of operation of the SMED methodology until the complex concepts. All steps of SMED methodology were thoroughly studied, and all questions were explained to the correct implementation. Then, the exact activity of each member of the team was defined, and the formulation of Major Kaizen was necessary for the description of each step of the process. The steps of the process were defined not only in the application of continuous improvements but also the standardization of activities (Figure 1 and Figure 2).

WCM Individual performance - Competences - Team projects - Setup - SMED / SR MAGNETI MARELLI

Name	Registry	Function	Function SMED/SR
Carlos Henrique Lara	5007701	Analyst of process	Chrono-Analyst (Time and Method)
Carlos Junior C. Santos	5007089	Operator	Toolworker/Assistant
Elcio dos Santos	5004905	Technical	Follower
Jorge Pizani	5005468	Analyst of process	Technical advisor
Luiz Renato Ferreira	5005382	Analyst of process	Chrono-Analyst (Time and Method)
Marco Calado		Toolworker	Toolworker/Technical advisor
Maycon Alex Moraes Carvalho	5007262	Operator	Operator/Assistant
Maurício Rosado	18525	Toolworker	Toolworker/Technical advisor
Paulo Alacântara	5006604	Analyst of process	Project Leader/Designer
Paulo Moreira Leite	5003355	Master	Facilitator
Raphael Oliveira	900100224	Trainee	Camera man
Vagner Sales	16658	Toolworker	Toolworker/Technical advisor
Wagner Kalocz	3354	Toolworker	Toolworker/Technical advisor
Wilson Fernandez	5002718	Coordinator of WCM	Facilitator
Marcus Ribeiro		Supervisor	Facilitator/Technical advisor
Tainã Barreto	900100227	Trainee	Follower
Éverton S. Tavares	19204	Toolworker	

Figure 1: responsibilities of each member of the team

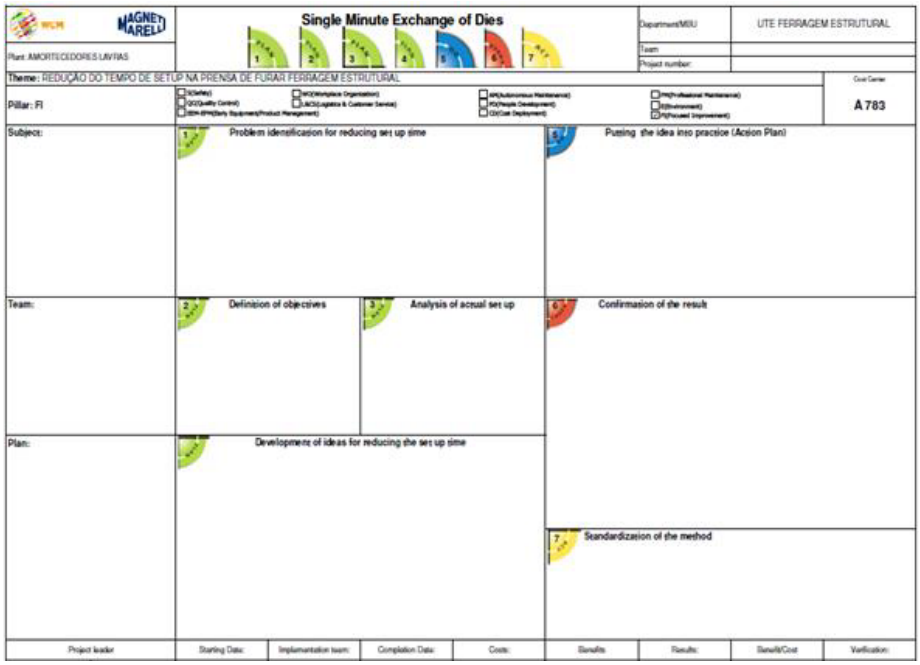

Figure 2: Major Kaizen

After the elaboration of Major Kaizen, was possible create a program of activities that would be developed to reach the proposal gain in the reduction of time setup. The schedule was defined according to (Figure 3)

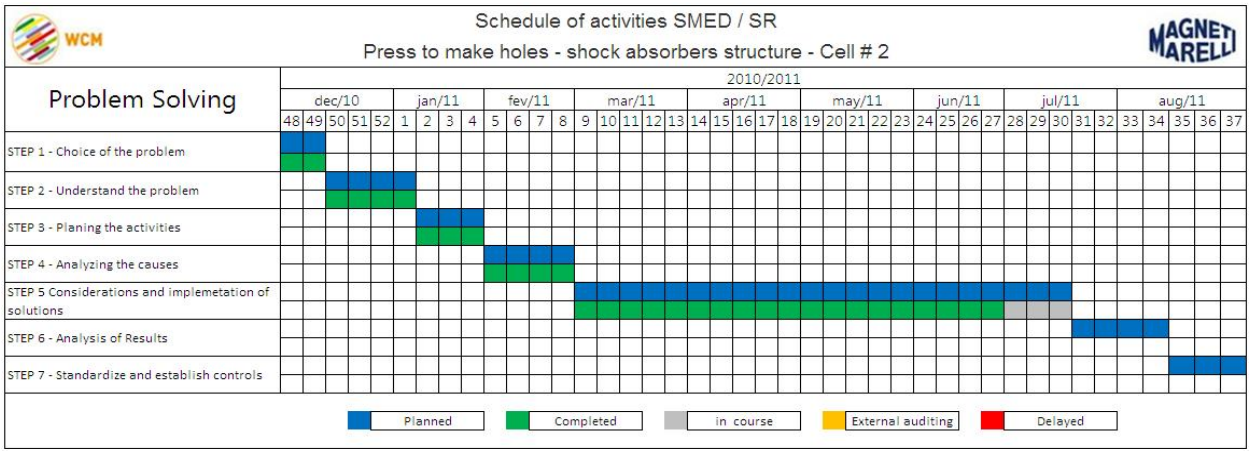

Figure 3: Schedule of activities

In the first step of the SMED was carried out a depth analysis of the problem that would be eliminated. In this step, the implementation of movies of each activity was performed to record each action separately during the setup. These movies were programmed joint with the planning and control of production and without the knowledge of the operators and maintenance team. The aim obtained a result closer to the reality of the day-to-day of operators on the shop floor (Figure 4) and (Figure 9).

Figure 4: Shooting and Figure 5: Registering of the setup

WCM Setup Registration MAGNETI MARELLI		Process number:																Date:____/____/____ Resp.:_____
N°	Activity	Start Time	Step Time	Graphic - Time of each step												Distance	N° of people	
																	Toolmaker	Operator	Auxiliar
1																			
2																			
3																			
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
N-1																			
N																			

Figure 6: Registering of setup information

The shooting was carried out very detailed, and each member on the team was responsible for a specific function, since the registering of time until analysis of each action made by operators and maintenance team. The record of all activities was saved in the precise form of setup according to (Figure 6).

WCM Setup Analysis MAGNETI MARELLI		Process number:													Date:_____/_____/_____ Resp.:_____
N°	Activity	Current		Analysis ECRS				Proposal of Improvement							
											Team			Action	
		Internal Time	External Time	Eliminate	Match	Reduce	Simplify	Internal Time	External Time	Distance	Operator	Toolmaker	Auxiliar		
1															
2															
3															
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
N-1															
N															

Figure 7: Form for registering the setup activities

After the phase of shooting and registering of setup activities, several meetings were carried out to analyze the movies. The meetings had the aim to study the actions of each member responsible by the setup during the operation. Moreover, the more important condition was to understand, if the action aggregated values or not into the process, detaching the setup activities in internal and external, and define whether these activities could be eliminated, matched, reduced or simplified. The form developed for this registered is according to (Figure 7).

WCM	verification ot the setup time press to produces holes MAGNETI MARELLI
N°	**Main problems observed**
1	No standardization of setup activities (methodology)
2	No standardization of wrenchs, nuts, and srews
3	Lack of appropriate place to put wrench and devices
4	No standardization in the displacement of the tooling
5	Lack of setup programming

Figure 8: Setup process deficiencies in Cell 2

Based on the shooting and analysis of data registered, was possible define the main deficiencies of the process in the cell number 2 and elaborate a plan of action to solve the problems. The first deficiencies registered were: no standardization of setup activities, no standardization of wrenches, deficiencies in the transport and handling of tools, and no specific programming of the setup (Figure 8). By detecting the main deficiencies in the process associated with the analysis of the setup, it was possible to establish a reduction goal and develop an action plan with activities to be performed by each member of the team to solve or minimize the major problems registered (Figure 9)

SMED/SF	Schedule the setup monitoring with exchange of interchangeable	Action aborted	Paulo Leite	28/1/2011	4/2/2011	6/5/2011	22/6/2011						
SMED/SF	Painting machines		Élcio/Juarez	28/1/2011	11/2/2011		11/2/2011						
SMED/SF	Check the possibility of painting the shop floor with epoxy paint and the bench in cell #2		Marcus W.	28/1/2011	4/2/2011	1/8/2011							
SMED/SF	Check status of the management board	Delivery in 14/02/2011	Paulo A.	28/1/2011	31/2/2011		3/2/2011						
SMED/SF	Prepare material for head work		Paulo A./Henrique/Raphael	28/1/2011	4/2/2011		3/2/2011						
SMED/SF	Video analysis and analysis setup (31/01 - 13:30 pm)		Grupo	28/1/2011	1/2/2011		1/2/2011						
SMED/SF	Check with Arimathea the possibility of creating the control panel closest to the operator		Raphael	28/1/2011	4/2/2011		4/2/2011						
SMED/SF	Create action plan based on the analysis setup		Paulo A.	25/2/2011	23/3/2011		23/3/2011						
SMED/SF	Carry out training with the basic principles of the pillar AM		Douglas	25/2/2011			25/2/2011						
SMED/SF	Carry out training with the basic principles of the pillar AM with the toolmakers	Toolmakers and training for all operators of the press	Douglas/Pablo	25/2/2011	31/3/2011	1/8/2011							
SMED/SF	Describe the interim standard setup		Paulo A./Henrique	25/2/2011			25/3/2011						
SMED/SF	Fill out the form of Major Kaizen and attach it to the management framework		Paulo A./Henrique	25/2/2011		27/4/2011	24/4/2011						
SMED/SF	Fill in the form 5W, 1H and 5 Whys		Grupo	25/2/2011		11/4/2011	11/4/2011						
SMED/SF	Fill the Spaghetti form		Tainã/Élcio	25/2/2011		25/4/2011	25/4/2011						
SMED/SF	Fill in the registration setup the distances		Raphael	25/2/2011		8/4/2011	8/4/2011						
SMED/SF	management framework provided in the sheet of the eight stages of SMED / SR		Paulo A.	25/2/2011		25/4/2011	25/4/2011						
SMED/SF	Buy A3 and A4 folders for the management framework	request issued on 23/03		10/3/2011			31/3/2011						
SMED/SF	implementation of programming. The major must complete management framework programming, informing the toolmaker what the next setup (cell / product / prediction time)	Bring the framework for the room of toolmakers and charge the update by the majors	Marcus	25/3/2011	1/4/2011	15/7/2011							

Figure 9: Management of the team activities

4.2 Results

The methodology used to monitor and register the setup techniques helped all the team in a widely review of the process. Thus, it was possible to increase the profit in the cell monitored with the reduction of setup time, generating a product more competitive and collaborating with the professional growth within the manufacturing environment. The great challenge to the industry studied was to create a specific sector responsible by the development of systems of Fast Change of tooling – FCT. The creation of an exact sector provided a continuous improvement that generated not only a Fast Change of Tooling but also the increase the process flexibility, decrease of waste, and storage reduction, generating a process more dynamic.

After the performance of the action established, it can be observed that the results were satisfactory, showing a more organized cell, a more efficient layout, standardization of activities, programming and the availability of the tools for the production, generating a time reduction of 46% in setup time according to (Figure 10).

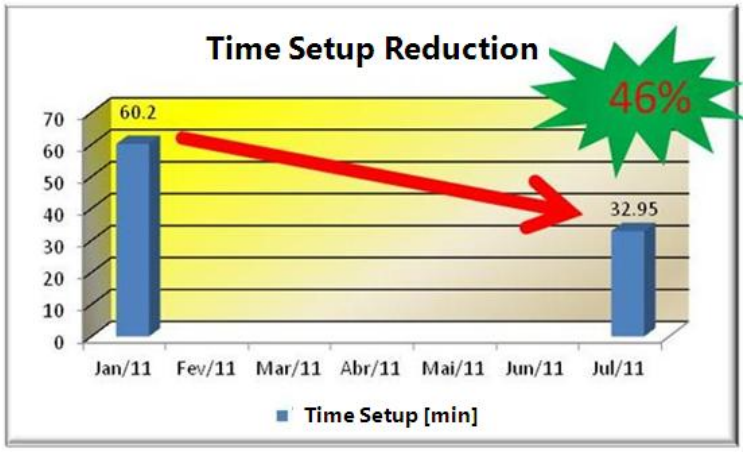

Figure 10: Result of the reduction of time setup

The following figures (Figure 11) and (Figure 12), show the improvement obtained during the realization of the activity proposals and made in the manufacturing cell such as; cabinet organization tool, acquisition of more a device for move high tools, programming of production on the side of the cell, and organization of the tools in the workplace.

(a) (b)

Figure 11: (a) Cabinet organization tool and Device for move high tools (b)

(a)

(b)

Figure 12: (a) Programming of production on the side of the cell and (b) Organization of the tools in the workplace

5 Conclusions

Based on the results, the following points are summarized:

The results show that the gains from the correct application of the SMED reduce the setup times and generate great improvements and expansions with the application of this powerful tool;

In spite of the results observed, the SMED philosophy wasn't achieved completely because the time that exceeds one digit in the setup time is considered a loss;

The work carried out on the shop floor was satisfactory into a preview and according to process conditions. The great problem that is not permitted to reach best results in the time setup reduction is the correct measure of parts produced. This occurs because a robot carried out the measure by sampling of the parts produced is impossible to reduce the time in this operation;

Finally, the aim of this work, considering the complete monitoring the achievement was reached. It can be concluded that the SMED is an excellent tool for reduction of movement time, besides, if properly conducted, it is rallying people for the challenges, facilitating the process of continuous improvement.

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