Estimation and Operating IMPROVEMENT

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Chapter 6

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REDUCING THE TIME SPENT ON CHANGEOVERS USING THE SMED METHOD, IN THE COMPONENT PRODUCTION PROCESS USING HYDRAULIC-PRESS

Abstract: Lean Manufacturing is believed to be the most effective way of significantly increasing productivity, limiting waste and shortening the production cycle. The wide range of tools and techniques used in this method results in a very good outcome for the companies using it. We can observe that it increases their competitiveness in comparison to the companies which did not decide to apply the above mentioned methods. The goal of the research is to apply one of the crucial elements of the Lean Manufacturing, namely SMED (Single minute exchange of die- changeover of the machine under ten minutes). The object of the analysis is the hydraulic-press used in the manufacturing plant. For the aim of the research the changeover process was analysed and improving actions that could result in shortening the time needed to change the components were suggested.

Key words: Lean Manufacturing, SMED, changeovers.

6.1. Theoretical basics of SMED method

SMED method is one of the basic tools used in Lean Manufacturing, its' aim is to optimise the production process. Its' name is an abbreviation of words Single Minute Exchange of Die. It is a set of tools and technics allowing the tools and the set-up of the machine to be changed in time shorter than ten minutes. Reduction of the changeover time to singular number is not always possible nonetheless the application of SMED

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method results in substantial decrease of time needed to perform that action. Primarily this method was used in the motoring industry to reduce the changeover times on different kinds of presses, but its' rules can be effective in any kind of manufacturing, from production companies and the ones taking care of packing to airlines (SHINGO S. 1985).

To understand the issue it is important to define what the term 'changeover' means. Changeover is the time needed to change the settings of the machine to prepare it for production of the new product and more precisely it is the time between producing the last old product (of required quality) to the time the first new product (of required quality) is produced. This process if performed traditionally comprises of the following steps (SHINGO S. 1985):

a) preparation, after-process regulation, verification of tools and materials,
b) exchange and set up of new devices and grips,
c) measurements, settings and calibration,
d) practice rounds and regulation (SHINGO S. 1985).

In this model, changeover comprises of two stages:

- knowledge- referring to the way the machine is built and how it works as well as knowledge about the equipment, tools, devices, forms, dies and so on,
- skills- to assemble and dissemble of the elements as well as ability to measure, centre, regulate and calibrate after the practice rounds (HOHMANN C. 2012).

The result of that is that the changeover requires a very skilled employee, even though a simple machine can be straightforward to use, expert knowledge about changeovers is required when dealing with a more complicated machine. During the time the person responsible for changeovers is supervising one of them; the operator of the machine should serve as an assistant to him or should be delegated to operate another machine. Most times the operator is left waiting for the process to be over. All of the above are ineffective. It is generally believed that the most effective way of dealing with changeovers is to constantly increase

qualifications of employees. Many companies deal with the problem in that way, but not many of them try to lower the qualifications required by the changeover (SHINGO S. 1985). Typical type of changeovers requires for the machine to be turned off. In SMED method the main emphasis is on the fact that the changeover process can be divided into internal and external actions:

- internal actions: they require stopping the machine to be performed,
- external actions: they can be carried out while the machine is still working.

The main aim is to change as many actions as possible from internal to external (Shingo S. 1985).

6.2. Stages of introducing SMED method

Guidelines mentioned above are a starting point of the whole philosophy used in this method. Improvement of changeovers using SMED method requires following four main stages. These are:

a) 0 stage- introductory stage encompassing analysis of the current state of changeovers.

To effectively plan the introduction of SMED method, it is essential to look carefully with the present course of the process. It is necessary to define all of the performed actions and the amount of time they last. All of this information can be gathered using suitable technics and methods such as Picture of the Day or OEE indicator (SHINGO S. 1985).

b) stage 1-dividing actions into external and internal.

The most important stage when introducing the SMED method is the stage of dividing the actions into external and internal. Actions related to preparation and transportation of necessary tools and devices should not be performed after the machine is stopped. It is highly important to try to move as many actions, involved in changeover, from internal to external. In result the time necessary to perform the actions while the machine is

turned off can decrease from circa 30% to 50%. This attitude is the basis to introducing the SMED method. The tools that we can find helpful at this stage are (SHINGO S. 1985):

- checklists- that should entail information on everything that is necessary in the changeover process and during the production of the new element. The following elements can be named: necessary tools, correct value of parameters of the machine and correct measurements and values required for every action (QUICK 1996, SHINGO S. 1985),
- functional control- which provides information on the technical state of used devices and tools before starting the changeover. (SHINGO S. 1985).
- analysis and improvement of transport of parts and devices from the warehouse to the press and subsequently after dissemble back to the warehouse. This action should be performed as the external action (QUICK 1996, SHINGO S. 1985).

c) stage 3 –changing internal actions into external ones.

In this stage it is necessary to convert as many actions as possible from the ones performed after the machine has stopped to the ones that can be performed before the beginning of changeover. The key to positive outcome of this stage is to look at the internal actions as if they were performed for the first time. It should not be allowed for the old habits and attitudes to come in the way of introducing those changes. Three methods of transforming internal actions into external ones can be highlighted. They are as follows (QUICK 1996, SHINGO S. 1985):

- advanced preparation of work, it means that all the necessary parts, devices ad tools as well as required conditions of work are prepared before the start of changeover,
- standardization of the basic functions based on unification of montage parameters as well as the parameters related to tools, devices and materials. Standardization can then be concerned with measurements, centring, attaching, dissembling or gripping. Standardization of the function does not have to mean that the tools should be replaced only that they should be adjusted to new conditions,

- use of the indirect binding devices that allow changing the actions from internal to external. Indirect devices that are usually used are plates or frames (of typical measurements) to which tools with changeable sizes are attached (QUICK 1996, SHINGO S. 1985).

d) stage 4- streamlining all of the actions related to changeover.

Introduction of this stage should result in attaining lasting changeover that could be performed in less than ten minutes. Still both the internal and external actions should be constantly improved and the introduced changes should be kept up and further developed (QUICK 1996, SHINGO S. 1985).

Improving the external actions comes down to improving the warehousing of all the parts and tools. To reach the set goal it is very important to introduce suitable methods of managing them (QUICK 1996, SHINGO S. 1985).

Improving internal actions can be achieved by using one of the four ways:

- introducing parallel operations,
- use of the fixing grip,
- elimination of regulation,
- mechanization (QUICK 1996, SHINGO S. 1985).

Keeping up and bettering of the introduced improvements is the deciding element in obtaining lasting results.

6.3. Characteristics of the researched object

Specification of production in the researched company influenced the decision to analyse the process of changeovers at the hydraulic press work station (Fig. 6.1) in the 'Press' unit of the factory producing the home appliances. This press produces parts that are then installed in the end-product. Variety of the products makes it necessary for the press to produce a wide variety of components in the shortest possible time. This fact became a very important trigger for the management to take action reducing the time the press undergoes changeover since it is one of the main reasons causing the standstills. It was decided that the SMED

method will be introduced. It is one of the most used methods applied by the companies world-wide. Examples of SMED being used show how effective it can be. A very important factor during the process of introducing the method was the fact that it had a full support of management, which was an additional motivation to introduce it.

Fig. 6.1. A part of hydraulic press

Source: personal research

6.4. Analysis of the current situation

The first step that was supposed to be taken, according to the SMED methodology, was to create a team responsible for introducing this research project. The unit chosen to be responsible for managing the whole project was the unit of Industrial Engineering (IE), however the leadership of the project was given to the technologist who is the engineer that supervises the processes undergoing in the press unit on every day basis. Employees from various units became the members of the team, but mainly they are a part of the maintenance, warehouse and production units. More over the more experienced operator also became a part of the group. It was also decided what type of changeover will come under analysis. After choosing the type and the date of the project, the created team gathered to watch the whole process 'live' as it was happening.

Changeover was also recorded using a video camera, to be able to analyse it step by step later on. Next a detailed analysis of the video was performed. The complete time of registered changeover amounted to 110 minutes. Changeover was divided into three characteristic parts (Table 6.1):

- exchange of tools: disconnecting the unnecessary devices, removal of the tool table, arrival of the table with the new tools and their installation on the press, introduction of the new programme into the steering panel,
- change of drum, change of the used material, regulation of grips: adjusting the grips to suit the new element transferring the form between particular operations.

Table 6.1. Division of changeover time

110:20min		
30:19	22:16	57:445
Tools	Drum	Grips
27%	20%	52%

Source: personal research

Obtained data, gathered in Table 6.1 shows that the regulation of grips takes up 52% of the whole changeover time.

Further analysis was based on careful highlighting of every action performed by the operator. The time each of them lasted was diligently recorded, in order to pin-point the ones that took the most time. Better visualisation of the process was possible thanks to grouping all of the actions performed into main categories of actions, demonstrating the most important stages of changeover. This division was performed taking into consideration the actions performed by the main operator as they are the decisive ones for the process. In this way stages visualised in Fig. 6.2 were created.

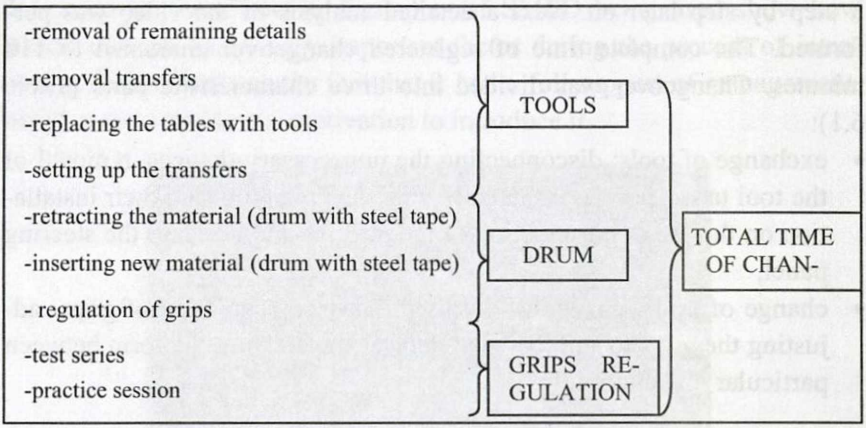

Fig. 6.2. Actions performed during the changeover

Source: personal research

Grouping of the actions (Fig. 6.2) allowed visualising in an easy way which stages of changeover take the most time, and that serves in the further research as the basis of applying the SMED method.

6.5. Attempt at implementing the SMED method in researched company

After the analysis of the current state of changeovers was performed, the next step was to start the process of improving the whole process according to the subsequent stages of SMED introduction (description in theoretical part). Thanks to the careful division of changeover into single actions (Table 6.1, Fig. 6.2), they could have been divided into the external and internal ones as well as particular actions and resources, could have been identified, that will allow for the effective introduction of changes improving those actions. The following solutions were introduced in particular actions:

a) removal of leftover materials,

b) assembling and dissembling of transfers,
c) replacing the tables and attaching new devices,
d) withdrawal and introduction of the new material.

Removal of leftover materials

It was decided that removal of waste from underneath the tool will be performed by other workers not before the table with old tools was removed and after the changeover in finished, as an external action. Before this action was performed differently as there was fear that during the removal of the table waste will fall on the floor and block it. However it was never put into practice and after testing the idea it turned out that it can be done without any issues occurring. The same thing can be applied to the waste trolleys- operator should only remove the trolley out of the press's area enabling to continue with the changeover and taking it to the unloading place should wait until the process is over (external action).

Assembling and dissembling of transfers

In the whole process of assembling and dissembling there were a lot of unnecessary actions related mostly to the unneeded movements of operators. A number of improvements could have been introduced in this stage that minimised the time to perform both of them. Firstly it was decided that the transfer trolley, before they are dissembled, should be placed next to the press before the changeover has started and not as it was before, during the process (external action). After dissembling the transfers operators were putting away the trolley next to the shelves and followed with assembly and then were bringing the trolley back to change grips. It was decided that right after the transfers are dissembled operators put the trolley next to the regally and exchange the old set of transfers with grips into the new set of transfers with grips already attached to it. It is though related to the necessity of choosing correct grips before the changeover has started, as the external action. After putting the new transfer on the trolley, it should be brought as close to the press as possible to also be able to change the tool tables. Due to the fact that the trolley with new transfers is placed close to the press the whole process is much quicker.

Suitable organization of work and proper use of already existent resources can make the whole process of dissembling and assembling transfers much simpler. The actions that were eliminated were mostly excessive moving about of the operators which resulted in substantial decrease of time needed to perform those stages.

Replacing the tables and attaching new devices

After dissembling the transfers the next step is to disconnect the tools from the press and replacement of tables. After the press is off the first step is to remove the top tool bindings. Hydraulic, opening and closing, grips that are controlled by the control desk of the press are used. This allows for the quick disconnection and connection of new tools without the need of using special screws or wrenches. Next, the operator, using the control panel removes the table with the old tools and brings the table with the new ones. This process is very quick since the devices used are in the form of cartridge containing two operations. Before the start of changeover the table is provided with a set of suitable tools (external action). In result the only action performed during the changeover is replacement of the tool table. After approaching the press with the new table the operator loads a programme, suitable to the element to be produced, into the control panel. After the programme is loaded the next thing is to attach the new set of tools. At this stage many inconsistencies were observed. The main issue here is attaching the lover devices to the table, which is performed using screws. It turned out that the operators do not have enough of them to supply both of the tables. The result is that part of the screws has to be taken from one table to attach to the other. Another problem was the size of the screws as three sizes were in use, one of which was a Hexagon Socket Head Cap screw (which is used to remove waste accumulated during pressing and located in the channels underneath the machine). In effect three types of wrenches had to be used by the operators which lead to another problem of not having two full sets of wrenches which meant that the operators had to exchange them between each other during changeover. It resulted in wasting time while waiting for the right wrench. The solution to the problem was to stan-

dardize the size and type of all screws (all of them should be of same diameter and shape), whereas in place of the Hexagon Socket Head Cap screw, shorter length screw was introduced. Thanks to that operators need only one wrench. Moreover it was decided to purchase such amount of screws to be enough for both tables. It will allow for them to be screwed on to the table during the process of preparing it for the new set of tools, before the changeover has started. Those improvements allow for the screws not to be moved between the tables and prevents from the need of exchanging wrenches which leads to considerable time savings.

Withdrawal and introduction of the new material

After attaching the new tools operators start the replacement of the suitable material. They have to withdraw the old material from the whole administering system and the metal sheet cutting system which cuts metal into pieces of suitable measurements, thanks to the system of various rollers which straighten the sheet and reduce all kinds of **tightness** created during unrolling it from the drum (Fig. 6.3)

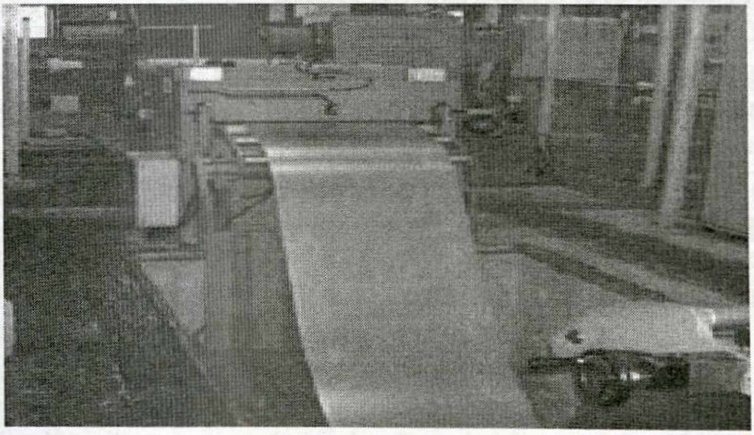

Fig. 6.3. System responsible for administering the metal sheet

Source: personal research

At this stage the problem with finding the right tools to bind the drum and wrenches used to unscrew the arms of the unroller. The operators had

to look for the necessary tools in cupboards. Next the metal sheet is transported using the fork-lift to the place where it is stored. The next step is to load a new drum with metal sheet on the table. The sheet coming from the producers is packed for protection reasons in foil or cardboard that has to be removed before loading the drum. At the time being the unpacking process was performed by the operators which took a lot of their time. It was decided that the whole process of unpacking has to be performed before the changeover takes place and it will be performed by the fork-lift driver as the external action. The stage of withdrawal and introduction of the new material was the stage that decided on involving two extra employees in the process. Looking at the whole process it was easy to see that this stage could be performed along the stage of exchanging the tools. The actions in this stage are still internal actions but due to parallel actions being performed a considerable time savings can now be observed. Using extra workers has also led to reduce the time necessary to perform other stages.

- **Regulation of grips and practice session**

This stage is the one that takes the most time during the whole changeover process (table 6.1). All the actions to do with adjusting and setting up the whole system that transfers the steel sheets between particular operations are performed in this stage.

The first action performed by the operators is setting grips, attached to the form, in such a way that they would not get caught the devices while the metal sheet is being transported between the operations. It is the result of the fact that the grips have been used to produce a different element before. Because of that the operator has to manually move the transfer and check the location of each grip with second operator. There are ten grips on every transfer and each of them has to be checked. As it can be seen in Fig. 6.4, construction of such grip is quite complicated as it has a lot of screws all of which need to be regulated.

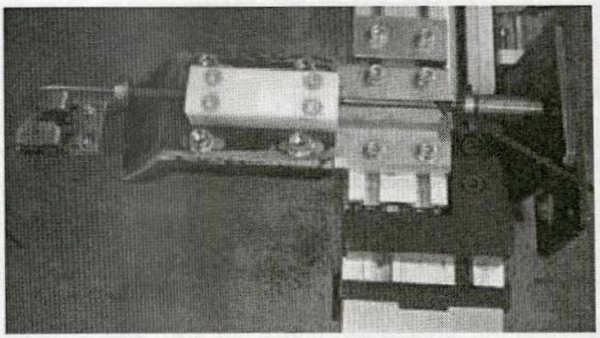

Fig. 6.4. Grip attached to the transfer

Source:personal research

Moreover they have sensors installed that detect the metal sheet while it is transferred between the operations. It is required due to the safety reasons, not to cause any damage to the press in case of sheet falling out of grips during the transfer.

Another action that has to be performed is setting the 'zero' position on which the steel sheet is put after being transferred using hydraulic grips from the cutting stage. The 'zero' position is permanently located on the press table, and the elements that have to be regulated are mandrels that position the sheet, they have to be adjusted since different sizes of pressed forms of steel are being used. Operators have to unscrew them and regulate it according to the new sheet. After all of the adjustments are performed the next step is to start a practice sessions and after they are over everything has to be adjusted once again until press can be started using automatic work mode. The whole process of adjusting is a huge waste of time, each of the actions takes a very long time as a lot of precision is required when performing them. This stage was the longest one in the whole changeover and at the same time it required for the changes to be performed the quickest. The main decision that was taken here to facilitate the whole process was that a separate set of grips should be created for every type of component family being produced (Fig. 6.5).

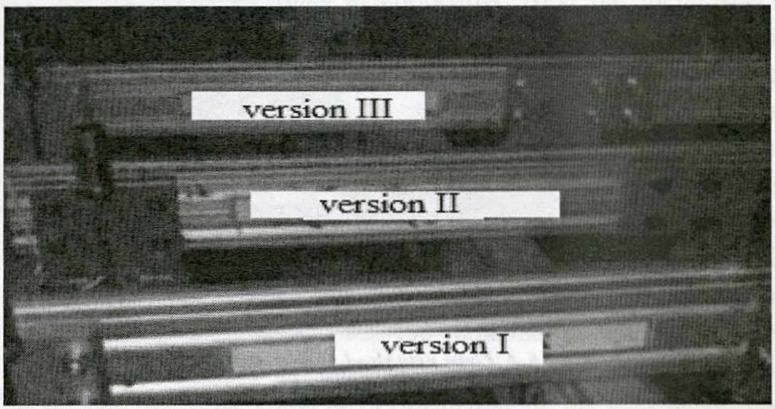

Fig. 6.5. Separate set of grips for every component family

Source:personal research.

Thanks to that idea operators will not have to adjust the grips to the new component on the press as they will be already prepared and installed by the second operator on the other set of transfers (which was talked about in the part devoted to assembling and dissembling of transfers). Having grips for every component family allows for minor regulations of transfer that result from having various versions of it. Those regulations can be performed outside of the changeover time as the external actions.

Improvements of the operators work station

During the analysis of changeover another important aspect caught the attention of the team, that aspect was the state of the operators work space located next to the press. It turned out that a lot of imperfections can be found that have an influence on the operators work and what is related to that on the whole changeover process.

The first thing noticed was the way the employees collect the tools and wrenches. It turned out that they have to go through the drawers of a cupboard to find them. To make matters worse it turned out that the

drawers were very messy which led to the operator looking for a tool longer then it was required and necessary to. To improve the situation the board of shadows for all of the wrenches and tools was created. By the means of it, worker can easily find the thing he is looking for and check before starting changeover if everything is located in its' designated space (Fig. 6.6).

Another alarming matter was a way of storing screws and elements that were to be attached to the table of the press. Most of them were scattered all over the table or was placed in all kinds of boxes without any sense and order. To resolve the situation special holders were made to store the screws and other elements were placed on the newly installed shelves.

Next problem was keeping order, or rather the lack of order, in desks located near the press. The desks were found to be really messy with documents, filed in by the operators, in disarray without division into different types of documents. It was noted that operators had sometimes issues with finding paper work necessary during the changeover. All of the documents were separated into groups according to their purpose and marked. Instead of using big desks shelving was introduced that carries only the most necessary items and documents.

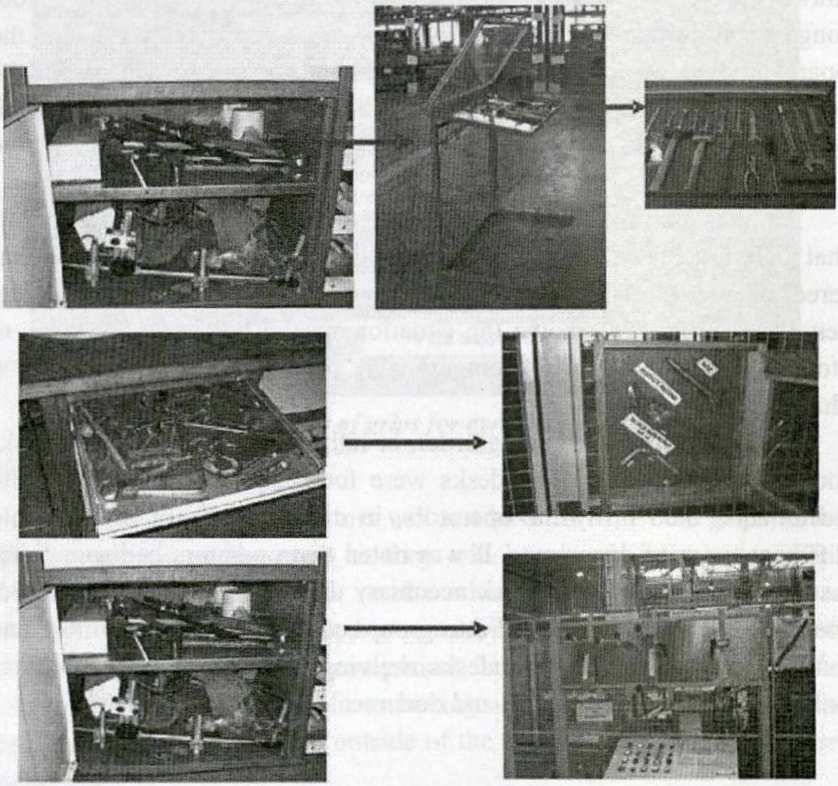

Fig. 6.6. Shadow board

Source:personal research.

6.6. Conclusions

After all of the improvements and changes regarding the process of changeovers were introduced, a practice changeover was done. Introductory scenario was created that defined the order of the actions to be performed and the people responsible for each action were selected. To check if all of the elements were planned in the right way and to analyse what else can be improved the changeover was registered using video

camera. Before the start of the changeover a quick training for the operators and two additional workers was organised. Training was supposed to clarify who is responsible for what action and when should each action be performed. After the above preparations the changeover has started. The final result was very satisfactory. The whole process went very smoothly. The changeover time which was 110:20 minutes to begin with was minimised to 34:00 minutes (Table 6.2). This means that the time saved came up to 76 minutes. When divided into three main groups of performed actions the minimised time comes to:

I. Tools: from 30.32 to 26 minutes,
II. Drum: from 22.16 to 18:30 minutes,
III. Grips regulation: from 57.45 to 8 minutes.

Table 6.2. Division of the changeover time after applying the SMED method

34:00 min*			
Time	26 min	18:30 min	8:00 min
Time saved	4:19 min	38:56 min	14:16 min
Group	Tools	Drum	Grips

*the change of the drum and tools preparation are carried out at the same time

Source: personal research

Based on Table 6.2 it can be concluded that the main influence on the overall result was the improvement of the grips' regulation and at the same time reducing the number of practice sessions.

The end results were satisfactory to the whole team as well as the management. Everybody was convinced that the changes went in the right direction. Next step, that should be taken, is making sure that the obtained result will be repeated every time thanks to keeping up and improving the system, that being one of the pillars of the SMED method.

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