THE SMED SYSTEM - CASE STUDY IN THE METALWORKING INDUSTRY

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Abstract

The paper describes a case study of the application of SMED methodology in a chosen enterprise dealing with production of deep drawn steel parts for automotive industry. Acronym SMED stands for "Single Minute Exchange of Die". The main goal of SMED methodology is to reduce the time needed for tool exchange and adjustment. Radical shortening of these times, for instance from several hours to a few minutes, is achieved progressively by changes in the tool exchange organization, standardization of the tool exchange procedures, staff training, special aids and technical modifications of the tool or of the press machine. The aim is to move as many internal activities as possible into external. The internal activities are those that are done during machine shutdown, the external activities are done while the machine is running. The goal of the paper is case study of SMED system application in the case of the chosen product series running on a specific machine. It means an introduction of concrete steps taken to reduce the time required for tools changeover and setting.

Keywords: Deep drawn stamping, SMED methodology, external activities, internal activities, changeover

1. INTRODUCTION

The world around us is constantly changing and developing. Today customers want a variety of products in the precise quantities they need. They expect high quality, speedy delivery, and of course, a good price. To meet these requirements, companies more often turn their attention to the needs, methods and approaches to managing and optimizing internal processes. And here is where downsizing comes into play. Lean processes are free from all the activities that increase costs without increasing the added value of the realized outputs. One of the tools used for process analysis and optimizing is the SMED methodology. SMED is an acronym for Single Minute Exchange of Die. The submitted paper deals with application of SMED in deep drawn stamping.

2. LITERATURE REVIEW

2.1. SMED methodology

SMED ("Single Minute Exchange of Die") is based on the notion that it is possible to perform the setup operations in under ten minutes, i.e., in a number of minutes expressed in a single digit. Although not every setup can literally be completed in a single digit number of minutes, this is the goal of the system, and it can be met in a surprisingly high percentage of cases. Even in the cases where it cannot, dramatic reductions in setup time are usually possible. [1] SMED changes the assumption that setups have to take a long time. When setups can be done in short time, they can be done as often as needed. It means that companies can then make their products in smaller lots. This brings companies advantages like higher productivity, quicker deliveries, flexibility and also better quality. In other words, shorter changeover and setting processes reduce downtime, which means a higher equipment productivity rate, less inventory storage with fewer storage-related defects, production of small lots bring less lead time and company ability to meet changing customer needs without the expense of excess inventory. The essence of the SMED methodology is to make as many internal changeover activities as possible external. Changeover time is measured as the time elapsed between the last good piece in the run just completed until the first good piece from the process after the changeover. [2]

Internal activity is then an activity that does not require the machine/line to be stopped, on the contrary, external activity is an activity that requires the machine/line to be stopped (it cannot be performed if the machine/line in not stopped). [3] As stated above the paper deals with application of SMED in deep drawn stamping. Deep drawing can be defined as the process by which a punch is used to force sheet metal to flow between the surfaces of a punch and a die. A flat sheet is formed into a cylindrical, conic or box-shaped part. With this process, it is possible to produce a final workpiece - using minimal operations and generating minimal scrap - that can be assembled without further operations. [4]

2.2. 5S application - an important input for SMED implementation

For successful SMED implementation is considered as very important to put into practice another significant method, 5S, which can be described as a Japanese approach to the organization and layout of the workplace. The name 5S comes from five Japanese words all beginning with S. They are: Seiri (Sort), Seiton (Set in Order), Seiso (Shine), Seiketsu (Standardize) and Shitsuke (Sustain). [5] The main goal of its implementation was to create a well arranged, clean, safe, visualized and standardized workplace free of unnecessary items so that the faultless production could run and excessive waste would be eliminated. 5S does not mean just “clean up your workplace”, it is set of rules related to the work itself within the workplace and as well as staff discipline in complying with this order. The main goal of 5S is to create a “lean workplace” where there are only the subjects needed for product fabrication, in other words, those which add or allow adding value to the product. Practical 5S implementation in the chosen company took place in several steps and with the participation of all SMED team members.

3. CASE STUDY - SMED IMPLEMENTATION AT THE CHOSEN WORKPLACE

It is important to point out that it may not be possible to reach the single minute range for all setups, but SMED dramatically reduce changeover and setup times in almost every case. In other words, SMED ensures increasing company output by reducing setting times during frequent changeovers of either tools or their versions. Practical SMED application was implemented in a chosen company in accordance to the following steps:

1) Analyze current changeover process.
2) Separate internal and external activities.
3) Convert internal setup activities to external.
4) Reduce internal and external activities.
5) SMED compliance supervising and evaluation of its application benefits.

The above core stages of the practical implementation of SMED method in the chosen industrial enterprise were preceded by a very important preliminary step - to build a so-called SMED structure. The SMED structure of a company can be understood as creation of SMED team representatives from chosen departments (project engineer, process engineer, shift leader, toolmaker, setters and operators) and arrangement of regular SMED meetings. Practical SMED application was launched by SMED workshop which was attended by all team members. As part of this meeting, team members were trained and their responsibilities were clearly defined. An important step was a creation of Key Action Plan, i.e. a tool for planning single milestones of the project, particular steps or use of financial sources. Implementation process, taking corrective actions and creation of documentation based on project requirements were analyzed by all team members within the regular meetings. The real SMED system application in the chosen company proceeded in accordance with the synthesis (from part to a whole). It practically means a single workplace was chosen for SMED system application within the project. The workplace had to meet several conditions: a) its layout represented a typical company workplace, b) company core products were manufactured at this workplace, c) changeovers were lengthy and relatively frequent compared to the rest of the workplaces. The project of SMED system application was divided into three main phases: a) preparation phase - this contained SMED method implementation (including 5S application) in case of the chosen workplace, b) realization phase - this part included gradual extension of SMED approach from the model workplace to the entire enterprise, c) evaluation of the total SMED application contribution. This article focuses on the practical SMED implementation in case of chosen workplace and contains a description of the five most important steps of the SMED application in case of chosen workplace.

3.1. Analysis of the original setup conditions

Analysis of actual shop floor conditions in details was a key step of SMED application in the chosen company because only a perfect knowledge of the real operational conditions can lead to an effective adoption of corrective measures. The tool used for manufacturing deep drawn parts consists of several manufacturing stations (drawn, shear, test etc.), through which the formed material passes and acquires its final form. The number of the stations determines the tool complexity and affects the time needed for its changeover. The changeover process then includes activities such as tool preparation and check, disassembly and assembly, tool setup or testing and subsequent tool tuning. Description of current process tool changeover was done by observation of working activities in the workplace using time study tools, such as workday survey, stopwatch, spaghetti diagram, work sampling study or videotape. The usage of videotapes seemed to be the most important instrument. It was very effective if the tapes were shown to the workers immediately after the setup had been completed. Giving workers the opportunity to see what they do led to surprisingly good cooperation during regular SMED workshops. They thoughts and explanations brought important insights into analysis of individual changeover activities. Significant differences between ways of performing the same tasks by other workers were often revealed in this step.

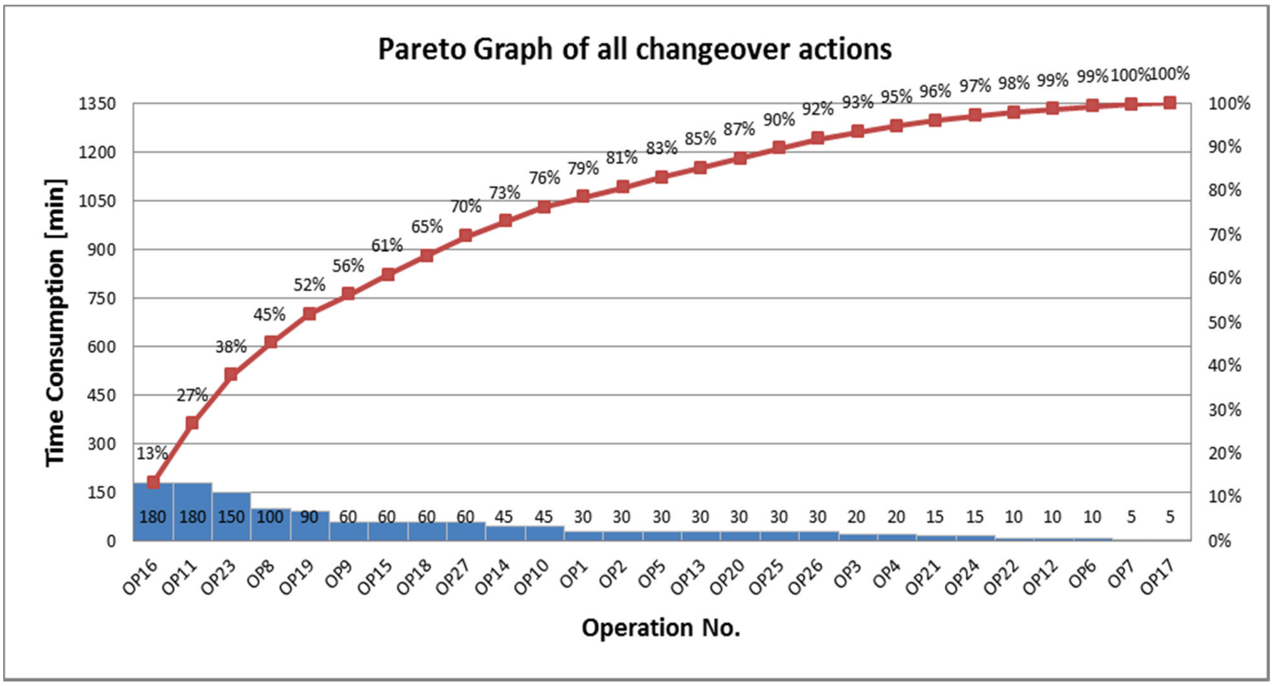

Figure 1 Pareto graph of all changeover actions

The output of this analytical phase was a list of activities with corresponding time consumption. Pareto chart (**Figure 1**), which served for its deeper analysis, shows a proportion of time consumption in case of individual operations in terms of total time fund of the changeover. Original changeover process of observed production range took 1350 minutes in total. This time span basically represents three working shifts. In the chart above, 52 % of consumed time corresponds to the five most time intensive operations. The entire tool changeover process is composed of 27 basic operations.

3.2. Separating internal and external setup activities

Second and actually the most important step in implementing SMED was distinguishing between internal (IED) and external setup operations (OED). In other words, tasks that can be carried out while the press is operating are separated from tasks that must be performed while the press is stopped. In practice, it is surprising how often some tasks are done after the press has been stopped instead of while it is still running the previous lot. In this step, mainly one of well-known techniques was used - operation checklist for describing each setup operation, tool, specifications and workers required. In our case study, the checklist was created for changeover from tool A to tool B in case of defined model workplace. Existing working instructions (i.e. tool setting instructions) served here as an input. The checklist included proper values for operation conditions (e.g. pressure, SPM, diverter setup etc.) and correct measurements and dimensions required for each operation (i.e. mainly critical characteristic in case of samples from the first tool station to a complete part produced at the last tool station). It was very important to divide the checklist into two parts - internal and external setup operations (IED/OED). This helps prevent oversights and mistakes that might come up after internal setup has begun (when the press is stopped). Using a checklist also generally helps setters avoid errors and multiple test runs later during setting. But initial goal of the described checklist was to use it as an instrument for defining what are the IEDs and OEDs during changeover from tool A to tool B. The following operations were then identified as external:

- OP13 - transfer and preparation of tool B for inserting to a press
- OP24 - preparation of measuring gauges and necessary documentation for product B
- OP25 - release of the first piece of product B production
- OP26 - workplace clean up
- OP27 - unexpected repairs or additional adjustments

To establish a functional check was another step within this stage. This type of inspection tells whether a tool, its stations, dies, jigs etc. are in perfect working order before these items are mounted. Functional test helps cut down setup time significantly. When this phase of SMED system application is completed, the time needed for tool changeover had already changed. In practice, there was saving of 165 minutes in comparison to the original tool changeover process.

3.3. Converting internal setup activities into external activities

Although there are significant time savings in the previous step, it alone cannot reduce internal setup time into the required single-minute range. For that, the previous stage must be followed by a phase of shifting some internal activities to external. There can be used two basic steps in this stage: a) look at the true functions and purposes of each operation in current internal setup; b) find ways to convert these internal setup steps to external setup. [6] Following these steps and looking for ways to carry out the transformation, the possibilities of all procedures which are otherwise performed during machine stop were analyzed. Consequently, the actions which can be implemented as external were identified as follows:

- OP6 - inserting of shims under stripper plates
- OP11 - tool B clean up
- OP20 - preparation of a new steel coil for product B production

The above-mentioned points mean saving further 70 minutes compared to the original tool changeover process, because activities which were identified as external are performed without a machine stop. The key activity to achieve such time saving was simple - preparing operating conditions in advance. This preparation basically means getting all the necessary items (i.e. tool, stations, diverter, decoiler, material web feeder etc.) and conditions (i.e. position of steel coil, coolant etc.) ready before internal setup begins.

3.4. Reducing internal and external activities

In this fourth step, in practical implementing SMED, all of the remaining IEDs and OEDs should be improved. External setup improvement mainly consists in streamlining transport and storage of tools, tool versions, tool stations or spare parts, preparation of gauges, working tools and aids. The most significant time saving was achieved in case of OP16, where 60 minutes from the initial 180 minutes (see Pareto analysis above) were saved by change of setter´s technical facilities (purchasing of new pneumatic tools and preparation of all necessary tools into an auxiliary trolley). On the contrary, internal setup improvements include implementing for instance parallel operations or steps leading to eliminating adjustments. In practice, parallel operations consisted in staff distribution between operators and setters. The large 300T press requires operations at both the front and the back side during changeover and setting process. The spaghetti diagram showed that one-setter changeover means additional movements because the same person had to constantly walking from one side of the press to the other. Parallel operations approach divides the setup operations between two people (in this case setter and operator), one at each side of the press. Both workers were given concrete tasks and trained on how to continue and communicate when a single task is done. Correct communication was very important because just the appropriate safety signal (i.e. flashlight in this case) could avoid accidents of damage of the tool. Sometimes it is not possible to perform this step of SMED implementation without additional time and financial investments. This mainly applies in the realized step dealing with eliminating adjustments. As described above, tool used for deep drawing consists of several manufacturing stations (drawn, shear, test etc.), through which the formed material passes and acquires its final shape. The number of the stations determines the tool complexity and affects the time needed for its changeover and setup. Eliminating adjustments depends on how accurately setters performed all the setting conditions in the earlier phases of setup. In case of the analyzed tools changeover and setup, it was found that it is possible to reduce the number of tool stations which have to be adjusted and then eliminate part of setting (i.e. possible issues with centering etc.). The solution was to design and build a so-called multi-die station. Multi-die station replaced a few single stations (they were gathered into one) and therefore eliminated the time needed for their setup. This main practical advantage saved further almost 70 minutes. In total, all the improvements realized in this step of SMED implementing saved 170 minutes.

3.5. Evaluation of SMED implementation

The modified process of tool changeover and setting was verified during the following three tool changeovers. Single steps were again monitored (video of all the verifying changeovers was captured and analyzed), the necessary corrective actions were taken in the next step and all the working teams (setters and operators) were trained again. All the steps taken were recorded (including sub-task photographs) into detailed working instructions after verifying SMED system implementation. It was ensured that the lesson learned or troubleshooting guides were implemented as well. In fact, these "live documents" are updated within each tool changeover. Therefore implementing SMED in the chosen company runs continuously. When standardization process of tool changeover and setting was finished, implementation of the last step of SMED methodology application in the chosen company took place - evaluation of its practical benefits. Evaluation criterion was derived from the defined goal of this case study - to ensure an increase in the company outputs. Total time savings during tool changeover and setting after implemented changes are 30 %. This means saving one shift during changeover from tool A to tool B. If we recalculate these savings as increasing indicator of observed product series, we will achieve an increase in production volume of both products A and B equal to 18 630 pcs per month in total (products are manufactured with the same machine cycle). Annual increase in production volume is then 223 560 pcs. More detailed values are stated in the **table 1**.

Table 1 SMED contributions

Changeover time savings	30	[%]
Changeover time savings	405	[min]
Increase in output (monthly)	18 630	[pcs]
Increase in output (annually)	223 560	[pcs]

If we evaluate the benefits of SMED application, we should also point out to the non-financial benefits. Despite initial negative attitudes of the shift leaders and the setters, the entire SMED implementation process was widely accepted. To involve workers already in analysis phase, project planning, making decisions or SMED practical application phase itself was significant motivation for them.

4. CONCLUSION

The SMED approach is simple and universal. It works with some modifications in companies all over the world. Its basic principles were also used at the model workplace in the chosen company to reduce changeover and setup time. Practical implementing SMED was done within five main steps. In the first step, the actual shop floor conditions were analyzed in detail because only perfect knowledge of real operational conditions could lead to an effective adoption of corrective measures. This initial step was followed by separation of internal and external setup tasks. In other words, the tasks that can be carried out while the press is operating are separated from the tasks that must be performed while the press is stopped. These steps were followed by phases of shifting some internal activities to external and improving all these activities with following evaluation of the SMED implementation benefits. Savings resulting from its real application at the chosen workplace were up to 30 % of time spent on one tool changeover (from tool A to tool B). These savings or rather, this real increase in output, relates only to the model workplace. This means that overall benefits can have a multiplying effect for the chosen enterprise. In addition to this absolute indicator, SMED system implementation had a significant impact on simplification of work, reducing labor intensity of setting, eliminating of tool searching etc. The goal of the paper was case study of SMED system application in case of the chosen product series running on a specific machine. Practical benefits show that the goal - reduction of changeover and setup time by SMED implementation - was fully met. Now SMED helps the chosen company meet customer needs with less waste by making it cost-effective to produce things in smaller quantities in case of analyzed product series.

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