FIVE STEPS OF THE SMED SYSTEM APPLICATION IN DEEP DRAWN STAMPING

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Abstract

The paper describes 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 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 this paper is to describe the process of SMED methodology application within the production of deep drawn parts for automotive industry. The instrument used to achieve the intended aim is detailed analysis of above defined sequence of SMED system steps.

Keywords: Deep drawn stamping, SMED system, external activities, internal activities, changeover time

1. INTRODUCTION

The world around us is constantly changing and developing, and so are the enterprises and business environment. Nowadays, it is not enough to capture new trends in marketing, technology and information systems for enterprises. Companies increasingly 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 realized outputs. One of the tools used for process analysis is the SMED methodology. SMED is an acronym for Single Minute Exchange of Die. The term 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] This concept of reducing setup and changeover times is not new; it arose in the late 1950s and early 1960s. It originated from the work of Shigeo Shingo, a Japanese industrial engineer, who significantly reduced the setup and changeover times in case of large presses in the Toyota Production System. Focusing on the increase of production capacity without purchasing new equipment, he realized that the critical point is reducing setup and changeover times. His pioneering work led to significant reductions in setup and changeover times and became a basis of today’s SMED. The essence of the SMED methodology is to make as many internal changeover activities of as possible external. What is the changeover time? It is the time taken to stop the production of a product A and start of the same product A, or another product B. What are internal and external activities? Internal activity is 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). [2] The submitted paper deals with application of SMED in deep drawn stamping used to produce airbag components. 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. [3]

2. PROCEDURE OF SMED IMPLEMENTATION IN THE CHOSEN ENTERPRISE

SMED usually defines two fundamental goals - to obtain a part of the machine capacity which is lost due to long tool changeover and to enable production in small doses by ensuring fast transition from manufacturing one type of product to another. The subject of this study in the chosen enterprise were both mentioned goals, thus to ensure increasing company output by reducing setting times during frequent changeovers of either tools or versions. The practical SMED application was implemented according to the following steps:

1) analysis of current changeover process,
2) identification of internal and external activities,
3) transformation of internal activities to external,
4) reducing of 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 chosen industrial enterprise were preceded by a very important preliminary step - to build a SMED structure. SMED structure of a company can be understood as a creation of a SMED team consists of representatives from chosen departments (project engineer, process engineer, shift leaders, toolmakers, 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. Real SMED system application in the chosen company proceeded in accordance with the synthesis - from part to a whole. In other words, a single workplace was chosen for SMED system application within the project. Subsequently, a SMED system was implemented on the rest of the workplaces of the company. The selected master workplace had to meet several conditions: a) its layout represented a typical company workplace, b) company core products were manufactured within 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 first phase of implementation, therefore it contains a description of the five most important steps of the SMED application in case of chosen workplace.

2.1. 5S application in the model workplace

Before the actual SMED system implementation it was necessary to put into the practice another significant method of organization of working environment. This method was 5S. 5S can be described as 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) [4]. The main goal of 5S implementation was the creation of 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 to add 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. In the first phase, the subjects on the model workplace were divided into three groups - those which must be on the workplace, those that do not have to be in immediate proximity and those that must be completely removed (Seiri). As a next step, a suitable location was found and a visualization (horizontal and vertical) was performed for each subject which remained at the workplace after the first step of 5S implementation - i.e. all the necessary subjects (Seiton). During the third implementation phase the model workplace was cleaned up. This does not mean simply "sweep the floor", but it is a deep cleaning of the workplace, including all its components. In this step was important to record what needs to be cleaned up, in which way, which aids are used and how long the cleaning process takes etc. This information served as a basis for standardization (Seiso). The establishment of standards followed up previous 5S phases (Seiketsu). Finally, the last step of 5S implementation was performed to prevent the workplace from returning into the original disordered status. All activities in this step were therefore aimed to meet the established standards (Shitsuke).

2.2. Analysis of the original changeover process (STEP 1)

Describing the initial status - the analysis of all the steps of production tool changeover was a key point of SMED application in the chosen company because only perfect knowledge of real operational conditions can lead to an effective adoption of corrective measures. The tool used for manufacturing deep drawn airbag components consists of several manufacturing stations (shear, drawn, test etc.), through which the formed material passes and acquires its final form. The number of stations determines the tool complexity and affects the time needed for its changeover. The changeover process includes activities such as tool preparation and check, disassembly and assembly, tool setting or testing and subsequent tool tuning. Changeover time is measured as the time elapsed between the last piece in the run just completed until the first good piece from the process after the changeover [5]. In this study, the changeover from tool A to B of tracked product line was analyzed. The description of current process tool changeover was based on the observation of working activities in the workplace using time study tools, such as workday survey and spaghetti diagram. However the most important instrument during this stage was usage of video recordings, which were used for analysis of individual changeover activities. Significant differences between ways of performing the same tasks by other workers were often revealed in this step.

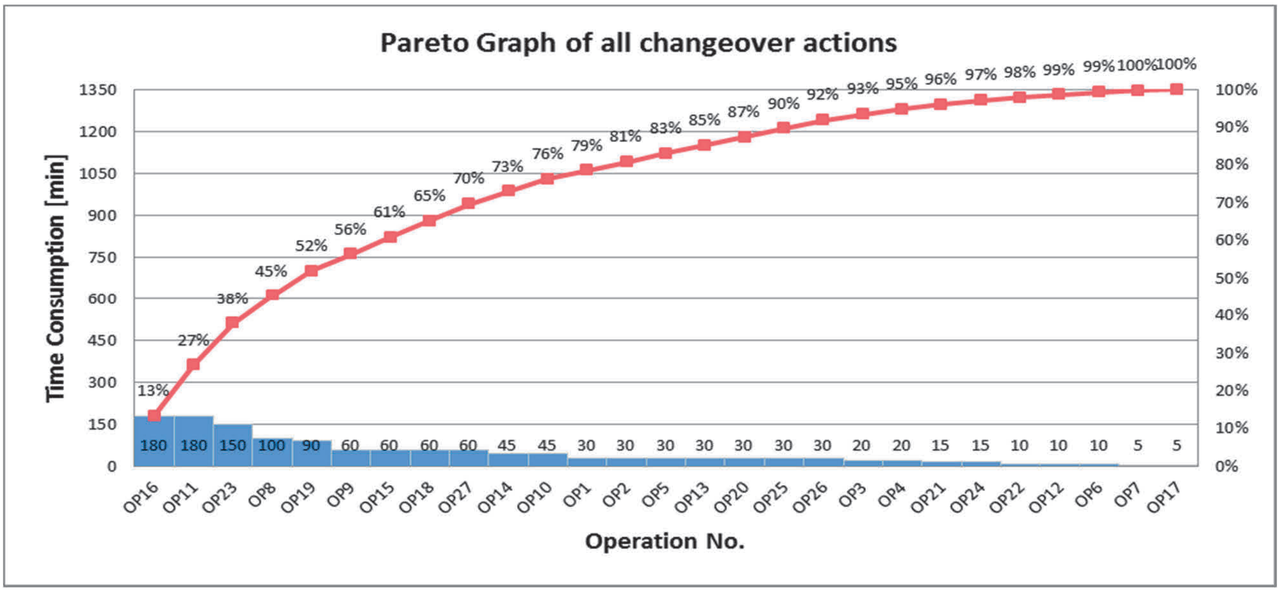

Fig. 1 Pareto graph of all changeover actions

Output of this analytical phase was a list of activities with corresponding time consumption. Pareto chart (see **Fig.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 totally took 1350 minutes. This time 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. The time or even the current process of tool changeover has not changed after this phase of SMED system application. The whole process is now well described and ready for the reduction of the potential waste of time.

2.3. Identification of internal and external activities (STEP 2)

In the second and the most important step of SMED application, it was necessary to distinguish and separate internal (IED) and external operations (OED). A checklist which contained information required for preparation and execution of all operations was used for this purpose. The result was defining the following operations as external:

- OP13 (transfer and preparation of new tool for inserting to the press) - a transfer is generally considered as an external activity. The same also applies in this case because the tool may be prepared for next production already during production of previous product A.
- OP24 (preparation of measuring gauges and necessary documentation for product B) - this operation was previously done as internal by a setter. However, the operation is external due to its nature, because it does not affect the smooth run of the machine. Gauges or documentation preparation can be provided after machine start or in simultaneously by an operator.
- OP25 (release of the first piece of product B production) - similarly to OP24, this operation was carried out as internal by a setter. However the operation also has an external character, since it does not affect smooth run of the machine. The first box can be provided with a special status and released after measuring the first pieces.
- OP26 (workplace cleaning) - external activity that includes activities that do not affect machine run.
- OP27 (unexpected repairs or additional adjustments) - external activities, which are not essential in most cases. However, there may be situations when the operation has the nature of the internal activity. If this situation arises, it is mainly caused by errors in previous internal operations or by a failure in following established procedures and work organization.

When this phase of SMED system application is complete, the time needed for tool changeover has already changed. In practice, this means saving of 165 minutes in comparison to the original tool changeover process, because activities identified as external are performed while the machine is running.

2.4. Transfer of chosen internal activities to external activities (STEP 3)

Although there are significant time savings in the previous step, it is followed by a phase of shifting some internal activities to external. This transformation of selected activities brings further significant savings. When 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) - a part of internal operations was moved among the externals, since shims can be prepared on a special auxiliary cart in advance. In practice, there is a time saving of 5 minutes.

- OP11 (cleaning of the new tool) - this part of internal operations has the nature of an external operation, because it can be performed by a setter within machine run (i.e. in case of product A production). That was possible due to establishing working teams consisting of a setter and an operator for each shift. At the moment, when the setter was preparing the tool B for production, the operator managed the machine. In practice, a 60 minute time saving was ensured by this.
- OP20 (preparation of a new steel coil for product B production) - transfer is generally considered as an external activity. The same also applies in this case because the raw material can be prepared for next production already during production of the previous product A. After putting this idea into practice, there was a 5 minute time saving.

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.

2.5. Reducing of internal and external activities (STEP 4)

While it is possible to reduce the time needed for tool changeover significantly by implementation of the previous steps, in most cases it is appropriate (sometimes even necessary) to do one more step of SMED application which consists in strong concentration on single operations, their detailed analysis with following improvements and investments in technological modifications. It is not possible to perform this step without additional time and mainly financial investments in case of the chosen enterprise (e.g. change of tool clamping technology, modification of individual tool stations, purchasing new warehouse space etc.). One of the main goals of this study was to ensure the increase in company output without having to significantly invest into a new production equipment or tools. Therefore reduction of internal and external activities were carried out for instance by optimizing storage and preparation of tools, gauges and instruments, staff distribution between operators and setters, spare parts identification etc. The most significant time saving was realized in case of OP16, where 60 minutes from the initial 180 minutes (see Pareto analysis) were saved by change of setter´s technical facilities (purchasing of new pneumatic tools and preparation of all necessary tools into auxiliary trolley). In total, 170 minutes were saved by this reduction of time wasting. It is planned by the company to realize this step in more details (including additional investments if needed) in a long-term period.

2.6. SMED compliance supervising and evaluation of its application benefits (STEP 5)

The modified process of tool changeover and setting was verified during the following three tool changeovers. Single steps were again monitored (video of all thee verifying changeovers was captured and analyzed), needed corrective actions were taken in next step and all the working teams (setters and operators) were trained again. All the steps taken were recorded into detailed working instructions, named “Prescription of Tool Changeover and Setting” after verifying of SMED system implementation. Sub-task photographs were added into this brief and structured text of the prescriptions. It was ensured that the “lesson learned” (Yokoten) or troubleshooting guides were implemented as well. In fact, these "live" documents are updated within each tool changeover. 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 study - to ensure an increase in the company outputs (see **Table 1**). Total time savings during tool changeover and setting after implemented changes are 30%. This means saving of 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 equal to 18 630 pcs per month (products are manufactured with the same machine cycle). Annual increase in production volume is then 223 560 pcs.¨

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 mention nonfinancial benefits, i.e. the benefits which are not immediately expressible in money. Despite initial negative attitudes of setters or shift leaders, the entire SMED application process was widely accepted. Involving workers as soon as during project planning and subsequently in the analysis of process, making core decisions or practical SMED application was a strong motivating factor.

3. CONCLUSION

Implementation of SMED system in the chosen enterprise represented primarily nonphysical investments - it means possibility for increase in company output implemented immediately and with minimal financial requirements. Nonphysical investments are not only cheaper, but their implementation is also immediately visible and measurable. And that was the goal of this study - to ensure an increase the enterprise output without investing in new manufacturing equipment or tools. The above-mentioned evaluation of the SMED application benefits shows that the goal was met. Saving resulting from real SMED application at the chosen workplace were up to 30% of time spent on one tool changeover. This saving or rather, this real increase in outputs relates only to 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 this paper was to describe the process of SMED methodology application within the production of deep drawn parts for automotive industry. This intended aim was achieved by analyzing above-defined SMED methodology steps which were performed within real project of SMED implementation in the chosen enterprise.

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