APPLICATION OF SMED METHODOLOGY 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 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 this paper is to define the main contributions of SMED methodology application in the case of the chosen product series running on a specific machine. The instrument used to achieve the intended aim is the above defined sequence of SMED methodology steps.

Keywords: deep drawn stamping, SMED methodology, external activities, internal activities, tool exchange.

1. INTRODUCTION

The world around us constantly changes and develops, as well as 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 directly here is placed emphasis on the downsizing. 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 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 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. SMED APPLICATION 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 was mainly the first goal, i.e. to ensure increasing company output without having to invest into a new production equipment or tools. SMED application in the chosen company was based on a detailed analysis of the current tool changeover process. The analysis was done by observation in the workplace. Subsequently, a SMED workshop took place, a SMED team was created (Process Engineer, Quality Engineer, Setters and Shift Leaders) and regular SMED meetings were set up. In these meetings, procedure of SMED implementation was analyzed, corrective actions were taken and documentation based on project requirements was created by all the team members. The entire SMED application was implemented in accordance with the following steps:

- analyze current changeover process
- identify internal and external activities,
- transfer internal activities to external,
- decrease internal activities,
- decrease external activities,
- evaluate benefits of the SMED application.

Given the nature of the stated goal, our attention was mainly focused on the first three above-listed steps. Shortening the time needed for tool changeovers was reached by a gradual change in working organization, standardization of procedures and by staff training.

2.1 Analysis of current changeover process

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 a 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 (typically stainless steel) passes and acquires its final form. The production tools used for the stated product line are made of 20 stations. 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 itself or testing and subsequent tool tuning. The time required for its changeover and setting then simply represents a period from end of the last part A production to start of the first part B production. 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. A video was recorded and analyzed together with the setters in both cases. This procedure identified the time needed for execution of all activities during tool changeover –see table 1 for more details. The table below shows further phases of SMED application, which will be described below.

Table 1 List of all changeover actions

Operation	Operation Description	Time [min]	Operation Type (I/E)	Time Savings [min]	Time after SMED [min]
OP1	End of production (parts transport, waste removal, documentation completation).	30	**IED**	5	**25**
OP2	Binding and dismounting of steel coil used for previous production.	30	**IED**	0	**30**
OP3	Pumping of emulsion into container.	20	**IED**	0	**20**
OP4	Dismounting of trimmed chips chute.	20	**IED**	0	**20**
OP5	Dismounting of transfer, sensors, cables.	30	**IED**	0	**30**
OP6	Inserting of shim under stripper plates, removal of 4 pcs bumper supports.	10	**IED > OED (partly)**	5	**5**
OP7	Inserting of 8 pcs tool supports.	5	**IED**	0	**5**
OP8	Dismounting of the top part of the tool, Dismounting of the bottom part of the tool. Blank pusher dismounting.	100	**IED**	20	**80**
OP9	Dismounting of the highest parts of the tool, dismounting of air cables.	60	**IED**	15	**45**
OP10	Removal of the tool from the press and its transport to the tool shop.	45	**IED**	0	**45**
OP11	Cleaning - tool, transfer, ram, table, space under the press, emulsion sump, waste container. Old filter dismounting and new one assembly, new emulsion pumping.	180	**IED > OED (partly)**	60	**120**
OP12	Control programme change.	10	**IED**	0	**10**
OP13	Transfer and preparation of new tool for inserting to the press.	30	**OED**	30	**0**
OP14	Inserting of the new tool to the press, blank pusher assembly.	45	**IED**	0	**45**
OP15	Assembly of the highest parts of tool and air cables.	60	**IED**	5	**55**
OP16	Assembly of the new tool as a whole.	180	**IED**	60	**120**
OP17	Bumper support assembly.	5	**IED**	0	**5**
OP18	Assembly of the transfer, sensors, cables.	60	**IED**	15	**45**
OP19	Transfer and transfer fingers setting.	90	**IED**	20	**70**
OP20	New steel coil setting/new material inserting and feeder wheels setting.	30	**IED > OED (partly)**	5	**25**
OP21	Setting of the feeder as a whole.	15	**IED**	0	**15**
OP22	Setting of the emulsion spray nozzles.	10	**IED**	0	**10**
OP23	Trial punching and setting of the tool as a whole.	150	**IED**	30	**120**
OP24	Preparation of measuring gauges and needed documentation.	15	**OED**	15	**0**
OP25	Release of the first piece.	30	**OED**	30	**0**
OP26	Cleaning of workplace (no lost time - press running).	30	**OED**	30	**0**

OP27	Dealing with unexpected repairs and adjustments (possible lost time)	60	**OED**	60	**0**
	Total Time needed for SOP	**1350**		**405**	**945**

Based on the description of the initial tool changeover status of the monitored product line, it is clear that the current process took 1350 minutes in total. This time means three working shifts. 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.

2.2 Identification of internal and external activities

In the second and the most important step of SMED application, it was necessary to distinguish and separate internal (IED) and external operations (OED). The nature of individual operations from the list above was analyzed by the SMED team. 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 nor 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.

2.3 Transfer of specific internal activities to external activities

Although in the previous step there are significant time savings, it is followed by a phase of shift 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 analysed. 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 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 thanks to establishing working teams (pairs) 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 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.

Summary of the above mentioned means saving 70 more minutes as compared to the original tool changeover process, because activities which were identified as external are performed without a machine stop. After the completion of this phase of SMED system application, it can be said that all possibilities of time savings which could be implemented without any additional investments in production technology have been exploited.

2.4 Decrease of the external and internal activities

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.). Due to the above defined goal of this study – to ensure increasing company output without having to invest into a new production equipment or tool – this point was not examined in detail. However, the "basic" reductions of internal and external activities were carried out for instance by optimizing of storage and preparation of tools, gauges and instruments, staff distribution between operators and setters, spare parts identification etc. For the company, this reduction of time wasting meant saving 170 minutes. It is planned by the company to realize this step in more detail (including additional investments if needed) in a long-term period.

It was necessary to discuss and plan all the prepared steps with the shift leaders, setters and operators within implementation of SMED system. Using their knowledge and experience was the key to practical application of the agreed steps. 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), corrective actions were taken in next step (PDCA used) and the particular working teams were trained (setters and operators). All the steps taken were recorded into detailed working instructions – so-called prescription of tool changeover and setting after verifying of SMED system implementation. To the brief and structured text of these prescriptions sub-tasks photographs were added. It was ensured that the “lesson learned” (Yokoten) was implemented as well. In fact, this "live" document is updated within each next tool changeover.

2.5 Evaluation of the benefits of SMED application

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 criteria were derived from the defined goals of this study – to ensure an increase in the company outputs. Total time savings during tool changeover and setting after implemented changes were 405 minutes. If we recalculate these savings in case of the products A and B, we will achieve an increase in production volume of both products of 18,630 pieces per month and 223 560 pieces annually. Sales increased 47 134 CZK monthly, which means. 563 371 CZK annually, in case of product A and 43 035 CZK monthly, or. 516 424 CZK annually, in case of product B. Overview of the benefits of SMED system application in the company are shown in the following table:

Table 2 SMED contributions

Changeover time savings	405	[min]
Increase in output (monthly)	18 630	[pcs]
Increase in output (annually)	223 560	[pcs]
PRODUCT A		
Increase in sales (monthly)	47 134	[CZK]
Increase in sales (annually)	563 371	[CZK]
PRODUCT B		
Increase in sales (monthly)	43 035	[CZK]
Increase in sales (annually)	516 424	[CZK]

If we evaluate the benefits of SMED application, we should mention also the non-financial benefits, i.e. the benefits which are not immediately expressible in money. Despite initial negative attitudes of the shift leaders and the setters, the entire SMED application process was widely accepted. To involve workers already in analysis phase, project planning, making decisions or SMED practical application phase itself was good motivation for them.

3. CONCLUSION

SMED system represents nonphysical investments – it means possibilities realized immediately with minimum temporal and 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 a new manufacturing equipment or tools. Above-mentioned evaluation of the SMED application benefits shows that this goal was met. In total, the financial benefit resulting from reducing time of tool changeover and setting was 1 079 795 CZK per year. In addition to these absolute indicators, SMED system implementation had a significant impact on simplification of work, reducing labor intensity of setting, eliminating of tool searching etc. in the chosen company. Another benefit is the standardization of all setting activities and particularly ensuring the same quality of setting done by each setter.

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