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Comparative Analysis of the Implementation of the SMED Method on Selected Production Stands

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Abstract: Nowadays, companies are looking for newer and newer methods in order to increase their efficiency and effectiveness. Many of them decide to implement Lean Manufacturing philosophy because the benefits of the introduction of this philosophy apply not only to the industrial but also to the financial and commercial areas. These changes can increase the efficiency of production realized with small investments, improve product quality, reduce inventory as well as material consumption. This philosophy can shorten the delivery time and product quality what leads to the increased customer satisfaction and enhances the competitiveness of enterprises. One of the tools of Lean Manufacturing is the Single Minute Exchange of Die (SMED) method. The implementation of this method reduces machines changeover time, which is a waste. This method makes it possible to implement a continuous flow of the product without long waiting times and, most importantly, without any performance loss. The results of the implementation of the SMED method on several different production work stands are presented in this work. The selected stands differ in type (conventional, semi-automatic, automatic) and their role in a production process (bottlenecks, support process). The work, by means of indicative evaluation, assesses the ability to increase the efficiency of machines for the analysed production work stands. The work indicates the effects a company may expect having decided to implement the SMED method for the production areas that are a part of either the main or support processes.

Keywords: changeover; Lean Manufacturing; maintenance; performance of machines; SMED method

1 INTRODUCTION

A difficult situation of many companies forces them to seek new ways to improve their efficiency and effectiveness. Recently, many companies have decided to implement the tools and methods of Lean Manufacturing. Lean Manufacturing is a philosophy based on the resource-efficient economy. It shows how important it is to eliminate waste that appears in a production process. It allows eliminating the losses that occur most frequently in a production process, e.g. long retooling, overproduction, failures, inventory, scrap, unnecessary movement and transport. The elimination of wastes is realized with the tools such as 5S, TPM, SMED, VSM [1, 2] and many other. In this paper, the possibility of improving the changeover of machines using the SMED method (Single Minute Exchange of Die) is presented. The aim of the study was to determine what effects might be expected by the company after the implementation of SMED on various production work stands. The selected stands differ in type (conventional, semi-automatic, automatic) and in their role in a production process (bottlenecks, support process). The work, by means of indicative evaluation, assesses the ability to increase the efficiency of machines for the analysed production work stands. The work indicates the effects a company may expect having decided to implement the SMED method for the production areas that are a part of either the main or support processes.

In the last century, Toyota factories noticed the necessity of fast changeovers. It was the result of the used Toyota Production System, which indicates a necessity of over-production elimination and inventory minimization. In order to achieve this, it was essential to transform the production system from the mass production to the small series production. Long changeovers were an obvious obstacle in the short series production. In addition, each changeover is certainly only a waste because it does not add any value. The time, which is consumed, for a changeover could be consumed for production [3]. Improving changeovers should be one of the best manufacturing practices [4]. The development of SMED was a natural consequence of the necessity of short changeovers. Shigeo Shingo is the author of the method. According to Shigeo Shingo, SMED as a technique was born in 1969 when he used it for the first time to shorten the changeover time of a press in one of Toyota plants – Honsha. However, in 1950 in Toyo Kogyo (Mazda), Shigeo Shingo discovered that activities realized in a changeover process consist of internal and external operations. In 1957, he used this observation in the shipyard of Mitsubishi Heavy Industry in Hiroshima. He encouraged doing external activities before beginning the real changeover. It resulted in the increased productivity of 40% and in shortening the time for building a ship from 4 months to 2 months [5] When the costs reduction is considered, for example in the work [6], after SMED implementation the authors achieved the cost reduction equal to 2% of the company sales volume. Nowadays, the SMED method is one of the methods used in lean manufacturing systems [7]. Companies try to reduce the changeover time for example by a focused maintenance activity [8]. However, for many years this method has been also effectively used in many companies. The cases can be found in the literature. In the paper [9] the results of the changeover time decrease in various companies are presented. The authors also show the areas in which changeover time is important for the process planning. Many cases of the use of this method can be observed e.g. in pharmaceutics industry [10], in casting machines changeover [11], in metallurgical area [12], in the changeover reduction of a press [13], in the carton company [14] as well as in order to develop a continuous flow of stamped parts into AC disconnect assembly line in an electric plant [15]. Furthermore, in the article [16] instructions for a good equipment design are presented. Some authors also proposed to use computer systems. In the papers [17, 18], the researchers propose combining MTM and SMED analysis in order to improve standard documents in MTM-UAS. Moreover, the paper [19] proposed to use the computerized information system in process implementation of the SMED method. It is also possible to decrease the changeover time using a right planning system [20, 21]. An enterprise can be more effective and flexible when the changeover time is shorter [22]. Summarizing the results of the literature review - the SMED method is well known in manufacturing [23]. The difficulty is that enterprises are often not aware what effects shall be expected after implementing this method on different work stands. In particular, it considers the companies, which have just learned about this method. Many of them expect immediate remarkable effects after its implementation. This work allows evaluating the effects of the SMED method in the real production conditions.

2 THE METHODOLOGY OF IMPLEMENTING THE SMED METHOD

The SMED method is a set of techniques used to reduce the time of preparation and finishing in order to make the exchange of technological equipment or to set a production line in less than 10 minutes. The author of the method, Shingeo Shingo, was a Japanese engineer who specialized in the manufacturing process improvements [5]. The SMED method is implemented in four steps:

- Step 0 - Lack of differentiation between internal and external preparation (registration retooling course).
- Step 1 - The division of the changeover into external activities (performed when the machine is in motion), internal activities performed only during technological machines standing) and unnecessary activities (wrongly executed operations during the changeover).
- Step 2 - Elimination of unnecessary operations and transforming internal into external operations.
- Step 3 - Streamlining preparatory operations through new design solutions in order to facilitate the determining and installing the handles and machine tools [24].

A theoretical training precedes the introduction of the SMED method, during which workers are familiarized with the assumptions of the method and its steps. The advantage of the training is the provision of examples of such solutions for instance in the form of images.

3 THE SELECTION OF WORK STANDS FOR THE ANALYSIS AND THEIR CHARACTERISTICS

For the analysis, five work stands from the Polish companies from the Podkarpackie Voivodeship (Podkarpackie Province) were selected. Three of them are large enterprises, two are small businesses. They are companies from different sectors: furniture industry, production of screws, manufacture of aircraft and automotive parts, and home electronics appliances. For the analysis, five production work stands were selected. In the selection process, the following criteria were used: its role in a production process (bottlenecks (B), support process (SP)) and difference in type (conventional (C), semi-automatic (SA), automatic (A)). The changeovers were analysed in the following work stands: Screw-cutting lathe, CNC milling machine, rolling mill, ram extruder, injection-moulding machine. Tab. 1 shows the work stands in accordance with the selection criteria. The data obtained during the study as well as the data from the works [25-29] were used for the analysis. For each work stand the type of a changeover was selected. The process selection was based on a changeover matrix. When choosing the analysed process two criteria were applied: a number of changeovers during a month and the time of the changeover.

Table 1 The characteristic of the chosen work stands

Work stand	The role in a production process (B, SP)	Type (C, SA, A)
Screw-cutting lathe	B	C
CNC milling machine	SP	A
Rolling mill	SP	SA
Ram extruder	B	SA
Injection moulder	B	A

For each work stand, the type of a changeover was selected. The process selection was based on a changeover matrix. When choosing the analysed process, two criteria were applied: a number of changeovers during a month and the time of the changeover. The changeover chosen for the analysis was based on the developed matrix of the changeovers which occurred most frequently or which had the longest duration.

Table 2 Changeover matrix

	C1	C2	C3	C4		C1	C2	C3	C4
C1	-	2	4	2	C1	-	45	30	10
C2	**20**	-	8	9	C2	**15**	-	10	8
C3	6	20	-	12	C3	25	2	-	6
C4	5	10	6	-	C4	3	4	5	-
1 - a number of changeovers during a month					2 - the duration of changeover				

The example of a changeover matrix is shown in Table 2. In order to protect the company's data, changeovers are marked with the letters: C1, C2, C3, and C4. In this case, the changeover from C2 to C1 was analysed: the rate of changeovers (20 per month) and their duration (15 minutes). The estimated changeover is 300 minutes in a month.

4 THE ANALYSIS OF A CURRENT STATE –PROPOSALS FOR IMPROVEMENTS

The methodology of the SMED method implementation for all the analysed stands was the same. Before using the SMED method trainings for leaders and managers in the area were conducted. An employee working on the stand was acquainted with the principles and actions of the SMED method that would be used. It was important to explain to the employee that they should perform all the steps in their ordinary pace. Each of these steps was recorded with a video camera. In order to conduct a thorough analysis by the appointed team, developed SMED control charts, rope graphs of an employee’s movement through the hall as well as the forms recording each of the activities performed by the operator with regard to the exact duration were used. The operations performed were divided into internal, external or unnecessary. After recording, each changeover was analysed in detail. In the analysis, the following data were collected: the total duration of the operations performed, the duration of external actions, duration of internal actions, a number of internal operations, a number of external operations, a number of operator’s movements during the changeover. In Tab. 3, the detailed data for all the analysed stands are shown.

The longest time of the changeover was recorded on the stand 1, and the shortest on the work stand 2. This fact is due to the specificity of work on these machines. A lathe is a conventional machine tool and a CNC milling machine is an automatic machine tool. In this relation one can see a certain regularity. Certainly, this requires dedicated research, which would take into account the diversity of the operations performed. The largest number of external actions was recorded on the work stand 4. The work stand 3 did not carry out any external activities. This fact may indicate the specificity of the CNC machine tool, as it can also be a sign of a well-organized production process. Slightly less because 45 internal operations were realized by an operator on the work stand 3. The least number of movements was performed by an operator on the stand 4. The highest number of movements was performed by an operator on the stand 5.

Table 3 The changeover data for all the stands before implementation of the SMED method

Changeovers information	Total changeover time [h:min:s]	Duration of external actions [h:min:s]	Duration of internal actions [h:min:s]	The number of internal actions	The number of external actions	The number of operator’s movements
Screw cutting lathe (1)	04:21:46	00:04:36	04:17:10	26	3	23
CNC milling machine (2)	00:34:44	00:00:00	00:34:44	23	0	22
Rolling mill (3)	01:58:00	00:40:25	01:17:35	45	11	12
Ram extruder (4)	01:08:11	00:58:58	00:09:13	9	31	43
Injection moulder (5)	02:17:00	00:48:00	02:29:00	56	22	250

The analysis of the changeover times and the number of activities shows different starting positions for the SMED method. Companies that want to implement this method have a lot of responsibility for the comprehensive preparation for the implementation. Each implementation of the SMED method may show a specific difference.

Additionally, the changeovers analysis led to the identification of the number of non-conformities. Tab. 4 shows the list of examples of non-conformities identified on the analysed work stands as well as the proposals for improvement activities.

Table 4 Proposals for improvement activities

Non- conformities	Proposals of improvement activities
Searching tools on the other work stand.	Changing the organization of the work stand - an extra shelf for tools.
Incompatible product delivered from the supplier.	Increasing the control while taking parts from the supplier.
Failure to apply safety rules by an employee.	Appropriate task marking. Reminders for the use of safety goggles.
Long waiting times for quality control.	Installing the informing system about the operation. Types of lights: - Green - duration of the operation, - Yellow - waiting time for quality control, - Red - the existence of non-compliance, failure of a machine.
An employee needing tools must cover a great distance to another stand.	Most necessary tools and instruments should be closer to the work stand, which is under changeover.
Failure to apply the principles of 5S.	Implementing the principles of 5S on the work stand.
Leaving the work stand by the worker in order to assist the operator on another stand.	Training the worker from another stand.

Table 5 The changeovers information for all work stands after implementation the SMED method

Changeovers information	Total changeover time [h:min:s]	Duration of external actions [h:min:s]	Duration of internal actions [h:min:s]	The number of internal actions	The number of external actions	The number of operator’s movements	The number of improvements proposals	The time saved
Screw cutting lathe (1)	04:04:00	00:04:36	04:17:10	26	3	27	7	00:17:46
CNC milling machine (2)	00:15:08	00:01:29	00:13:39	14	4	17	5	00:19:36
Rolling mill (3)	01:14:40	00:11:40	01:03:00	42	5	5	11	00:43:2
Ram extruder (4)	00:48:58	00:40:09	00:08:49	9	28	33	26	00:19:47
Injection moulder (5)	01:48:00	00:12:00	01:36:00	7	101	150	38	01:29:00

The number of improvements proposed for different work stands is shown in Tab. 5. Most improvements were suggested for the work stand number 5.

5 THE CHANGEOVER ANALYSIS AFTER THE IMPLEMENTATION OF IMPROVEMENTS

After the implementation of the proposed actions a thorough analysis of the changeover was made by the same team. The SMED checklists, spaghetti diagram of the operator’s movements through the hall and record forms for each of the activities performed by an operator with their duration were used. Again, every changeover was analysed in detail. In this analysis, the following data were collected: the total duration of the operations performed, the duration of external actions, duration of internal actions, a number of internal operations, a number of external operations, a number of operator’s movements during the changeover. The detailed data for all the analysed stands are shown in Tab. 5.

After the implementation of the SMED method the longest duration was identified at work stand 1, and the shortest at work stand 3. As in the case before the implementation of the SMED method, the longest changeover time was for a conventional machine (1). The largest number of external activities was identified at the work stand 5. As it can be observed, the implementation of the SMED method increased the number of external activities on the work stand 5. It is 4.5 times more of external activities. In this case, we can see that high potential was wasted on this machine. The largest number of internal operations was performed on the work stand 3. It is interesting that on the conventional machine tool (1) the number of external and internal activities (being a result of the implementation of the SMED method) has not changed. The largest number of operator's movements was performed on the stand 5. Most time was saved on the work stand 5 where many improvements were proposed.

6 THE EFFECTIVENESS EVALUATION OF THE IMPLEMENTED ACTIONS

The application of a few simple and not very expensive solutions led to tangible benefits. The implemented improvements allowed reducing the changeover time on all work stands. In addition to assessing the effectiveness of the improvements, the following indicators evaluating the effectiveness of SMED were used:

ERS indicator determines the effectiveness of reducing the waste that results from the implementation of redundant activities,

EPZ indicator indicates the efficiency of operations conversion,

EUT indicator of the efficiency of determining technical improvements,

CESMED indicator shows the total efficiency of the implementation of the SMED method. In order to determine these indicators the following formulas were used [28]:

$$ERS = \frac{T_{\mathrm{w}} + T_{\mathrm{uz}} + T_{\mathrm{z}}}{T_{\mathrm{w}} + T_{\mathrm{ut}} + T_{\mathrm{z}} + T_{\mathrm{zb}}} \tag{1}$$

$$EPZ = \frac{T_{\mathrm{w}} + T_{\mathrm{ut}}}{T_{\mathrm{w}} + T_{\mathrm{ut}} + T_{\mathrm{z}}} \tag{2}$$

$$EUT = \frac{T_{\mathrm{w}}}{T_{\mathrm{w}} + T_{\mathrm{ut}}} \tag{3}$$

$$CESMED = \frac{T_{\mathrm{w}}}{T_{\mathrm{w}} + T_{\mathrm{ut}} + T_{\mathrm{z}} + T_{\mathrm{zb}}} = ERS \times EPZ \times EUT \tag{4}$$

Where: T_{w} - is the duration of internal actions, T_{z} - is the duration of external actions, T_{ut} - is the time savings related to the implementation of improvements, T_{zb} - is the duration of unnecessary actions.

The value of *CESMED* index shows the percentage of changeover times reduction. The defined indicators allow us to assess the effectiveness of the SMED method as a tool for shortening the machine changeover time. They also help to evaluate the efficiency of particular technological stages of this method. Large values of the defined indicators *EPZ* and *EUT* identify the areas of the *EUT* (the SMED method stages) in which there is a need to seek additional solutions in order to improve the process of a changeover. Tab. 6 shows the values of these indicators for particular work stands. In addition, the table shows the level of the performance increase of work stands and the value of the estimated savings per year.

Table 6 The values of the analysed indicators for all work stands after the implementation of the SMED method

Indicators	*ERS*	*EPZ*	*EUT*	*CESMED*	Increase of performance / %	Simulation of changeover cost savings in 1 year / PLN
Screw cutting lathe (1)	0,86	0,99	0,96	0,88	0,67	7200
CNC milling machine (2)	0,87	0,98	0,41	0,68	0,89	4800
Rolling mill (3)	0,97	0,83	0,34	0,58	0,59	4000
Ram extruder (4)	1	4,16	32,4	42	15	80000
Injection moulder (5)	0,86	0,72	0,83	0,51	46	100000

Table 7 Simulation of changeover cost savings - Work stand performance

Savings				
Changeover time	Before SMED	After SMED	Profit	Production price per hour
	00:34:44	00:15:08	00:19:36	125 PLN
The number of changeovers in a month	12			
Time saved within a month	3 hours 55 minutes 12 seconds			
Money saved in a month	about 400 PLN			
Money saved in a year	12 × 400 = 4800 PLN			
Profit				
Number of items produced		Efficiency		
Before SMED 1450	After SMED 1920	32,4%		

The highest value of the *ERS* indicator is the effectiveness of reducing losses and which results from the implementation of unnecessary activities. It is on the work stand 4. The rate of conversion efficiency (*EPZ*) has the highest value for a conventional machine station (1).

The most effective technical improvements were observed on the work stand 2. For this work stand the *EUT* ratio is 0.41, what means that saving of the changeover time as a result of technical improvements was at the level of 59%. It is a very interesting result that reveals new possibilities of implementing the SMED method. The largest effect of the SMED method implementation was observed for the work stand 2. The *CESMED* ratio is 0.34, what means that the changeover time was reduced by 64%. The least effective changeover time reduction took place for the stand 1 with *CESMED* index value of 0.83. In addition, in order to confirm the expected efficiency of the changes, the costs simulation and performance changes of a work stand were run. This simulation was designed to show how to change the work stand of the analysed performance within one month. Tab. 7 presents the sample simulation changeover cost for a CNC milling machine.

Production efficiency, due to the implementation of SMED, was increased by 32.4%. The simulation of costs saving shows the amount of money saved because of the implementation of this method.

The estimated amount per month is 4800 PLN. The money saved this way may be spent on workers' trainings, investments improving the quality of the manufactured products as well as on the modern machines and equipment. Tab. 8 shows the average indicator values with the account of the role and type of the analysed work stand.

The best results were achieved on the work stands of support processes. The average value of *CESMED* indicator was 0.46, and for the *CESMED* automatic stands it was 0.34. The highest average increase of performance was observed for the support stands (the average of 37.2%) and for the semi-automatic stands it was 28.5% on average. The lowest increase of performance was noticed for the conventional stands. Despite the lowest increase of performance for the conventional stands, the highest costs savings were achieved for these stands.

Table 8 The average values of indicators for the selected stands of a different type (conventional, semi-automatic, automatic) and a role in a production process (bottlenecks, support process)

Work stands		Bottlenecks	Support process	Conventional	Semi-automatic	Automatic
Average values of indicators	ERS	0,90	0,92	0,86	0,98	0,87
	EPZ	0,79	0,92	0,99	0,77	0,96
	EUT	0,90	0,55	0,98	0,78	0,41
	CESMED	0,64	0,46	0,83	0,585	0,34
	Performance increase / %	21,72	37,2	4,16	28,5	32,4
	Simulation of changeover cost savings in 1 month / PLN	8400	4400	7200	6000	4800

7 GENERALIZED INDICATOR OF THE QUALITY OF CHANGEOVER

Calculation of the indicators allows estimating a changeover in a relevant way and, at the same time, emphasizing one chosen criterion. It is more convenient to use one general indicator for the comparison of the changeover efficiency. Such generalized indicators of the changeover quality (of satisfying the expectations) are the following: CESMED and the simulation of changeover cost savings in 1 year. However, they are two separate indicators. In order to form one indicator, it can be created based on those two. This indicator could express a generalized assessment of a changeover and be labelled as W. It might be based on the simulation of changeover cost savings in 1 year and the SMED efficiency (*CESMED*). This indicator could be used for comparing the set ups quality both in one enterprise as well as in those performed on different machines in different enterprises.

The comparative analysis of the changeovers done so far could be a good example for providing an indicator of a generalized changeover assessment. For calculating this indicator, the methodology used in the price-quality analysis (*PQA*) described in the literature [29] was applied. The calculation of the indicator would come down then to determining the changeover efficiency *E* in the first place:

$$E = 1 - CESMED \tag{5}$$

and

$$C = \text{Simulation of changeover cost savings in 1 year} \tag{6}$$

After having calculated the indicators (5) and (6) for each of the compared changeovers, other indicators should be calculated based on the literature [30]. The methodology of the calculation is as follows:

Calculation of the changeover cost savings:

$$c_p = \frac{1}{E \cdot C} \tag{7}$$

The lower the indicator, the more favourable are the effects of the carried changeover.

Calculation of relative savings:

$$p = \frac{P_a - P}{P_a - P_i} \tag{8}$$

Where: P is ad hoc savings for the case, P_a is the highest saving for the *PQA*, P_i is the lowest saving for the *PQA*.

Calculation of the indicator of the cost savings and effects proportionality:

$$e = \frac{p}{E'} \tag{9}$$

Where: P is the relative saving, E' is the efficiency expressed in decimal.

Calculation of the decision making function:

a) for $e = 0 \div 1 \quad d = 0.5e$ (10)

b) for $e > 1 \quad d = 0.5 + 0.5\left(1 - \frac{1}{e}\right)$ (11)

Calculation of the relative savings indicator:

$$c = \frac{c_{pa} - c_p}{c_{pa} - c_{pi}} \tag{12}$$

Where: c_{pa} is the highest indicator of savings efficiency in the *PQA*, c_{pi} is the lowest indicator of savings efficiency in the *PQA*, c_p is the indicator of the savings efficiency for the analysed changeover,

Calculation of the resolution indicator for technical preferences:

$$w_t = 0.0667(8E' + 4d + 2c + k) \tag{13}$$

The resolution indicator for economic preferences:

$$w_e = 0.0667(8k + 4c + 2d + E') \tag{14}$$

Calculation of the averaged indicator of the decision-making resolution:

$$R_d = 0.5\left(R_t + R_e\right) \tag{15}$$

The higher the W indicator, the changeover occurred more favourable.

The results of the comparative calculation for the changeovers improved with the SMED method and presented in Tab. 6 are shown in Tab. 9.

Indicator W shows that in the comparison of the five analysed changeovers, the best changeover is the one done on the ram extruder (4).

Table 9 Calculation of the generalized comparative indicator of changeovers from tab.6, improved with the SMED method

Measure	Screw cutting lathe (1)	CNC milling machine (2)	Rolling mill (3)	Ram extruder (4)	Injection moulder (5)
CESMED	0.83	0.34	0.58	0.59	0.51
C / PLN	7200	4800	4000	80000	100000
E	0.000138889	0.000208333	0.000250000	0.000012500	0.000010000
c_p	0.000008	0.000003	0.000006	0.00000030	0.00000020
p	0.463	0.174	0.000	0.990	1.000
e	2.723	0.263	0.000	2.414	2.041
d	1.362	0.132	0.000	1.207	1.020
c	0.000	0.629	0.278	0.987	1.000
w_t	0.540	0.480	0.257	0.773	0.753
w_e	0.483	0.469	0.210	0.966	0.924
W	0.512	0.475	0.233	0.870	0.838
Rank according W	3	4	5	1	2

8 CONCLUSION

In today's fast-changing world, companies are introducing changes to their own organization, which allow them to respond to the customer’s demand in the shortest possible time. The flexibility of the manufacturing process is increased by the use of organization methods and production management. An essential tool to increase the flexibility of the production is to shorten the duration of the changeover. One of the most effective methods to shorten changeovers is SMED - Single Minute Exchange of Die. The study analyses comparably the implementation of the SMED method on the selected work stands. The SMED implementation for the analysed stand eliminated unnecessary activities. Simultaneously, the production flexibility and performance of the machine were increased. On account of the thorough analysis of the presented results, significant effects for particular stands can be noticed. The analysis of indicators and the costs savings simulation showed the results achieved.

An interesting result of the indicator of the total effectiveness of the SMED implementation in the case of a conventional machine tool (lathe) was observed (1). The number of internal activities before the implementation of SMED was the largest among the analysed work stands. However, the implementation of SMED resulted in a significant reduction in the number of these activities. It turned out that they are now the least among the same work stands after the implementation of SMED. The largest effect of the implementation of the SMED method was noticed on the CNC machine tool work stand (2), where the value of the *CESMED* index is 0.34. That means that the changeover time was shortened by 64%. What is interesting, the greatest efficiency of technical improvements was also noticed on this machine. For assessing the efficiency of the implementation of the SMED method, the price and quality analysis can be used. In this case, the comparison of implementations on different machines proved that for a hypothetical company considering SMED methods implementation on these work stands, it would be best to implement them on machine 4. Obviously, the obtained results are the result of adopting a case study aimed at inspiring the implementers to skilfully use the SMED method. Actual results require dedicated research, which would take into account the diversity of operations carried out.

This work presents SMED as a very flexible tool and it shows what effects are to be expected when implementing it for different stands. This method can be used for every stand, irrespective of its purpose in a production process or of its type. However, it is important to be prepared properly for the implementation of this method, i.e. to collect detailed data, to run analyses precisely and to identify the improvement actions skilfully. It should be noted that the final effect is largely dependent on the cooperation and engagement of all employees, starting from an operator up to the middle level and top management. The result may be compared to other changeovers. The indicator (W) proposed in this paper, and based on the changeover efficiency (E) and expected costs saving (C), may be a generalized indicator of comparison. Due to this indicator, one may compare measurably and objectively the changeovers performed.

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