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DIE CASTING PROCESS ASSESSMENT USING SINGLE MINUTE EXCHANGE OF DIES (SMED) METHOD

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Die casting process uses high productive level machines. Machine capacity utilization is a key goal in achieving minimum time consumption. Changeover procedure during die casting process is recognized as possible area for reducing time consumption. The SMED method has been improved by additional procedures simultaneously applying the 5S method. Their contribution is evident in recognition of internal and external activities, particularly while transferring internal activities into external ones in as many numbers as possible, by minimizing at the same moment the internal ones. The validity of the method and procedures are verified by an example application of die casting foundry for casting automobile parts. Significant time savings have been achieved with minimum investment.

Key words: die casting, automobile industry, the SMED method, changeover of tools

Unapređenje procesa tlačnog lijevanja primjenom SMED metode. Proces tlačnog lijevanja složenih dijelova u mnogim granama industrije danas koristi strojeve visoke produktivnosti. Oslobađanje kapaciteta strojeva je glavni cilj u postizanju minimuma utroška vremena izrade. Postupak izmjena alata kod procesa tlačnog lijevanja područje je moguće vremenske uštede. Primjenjena je i dodatnim koracima unaprijeđena *SMED* metoda, uz istovremenu primjenu 5S procedura. Doprinos se očituje u prepoznavanju unutarnjih i vanjskih aktivnosti, pretvaranju što većeg broja unutarnjih u vanjske, uz istovremenu minimalizaciju unutarnjih. Metoda i procedura su provjerene na primjeru ljevaonice automobilskih dijelova, a postignute su značajne vremenske uštede uz minimalne investicije.

Ključne riječi: tlačno lijevanje, automobilska industrija, SMED metoda, izmjene alata

INTRODUCTION

The automobile industry changes refer to manufacturing different parts in increasingly small series which have to be produced with minimal time consumption. These very strict requirements are creating a lot of problems in automotive industry world wide. Generally, additional time is needed for setup caused by poor design of equipment [1]. The solution can be achieved both by fast responding on market demands and with early application of new methods and technologies. Continuous process improvement and SMED (Single Minute Exchange of Dies) can fix this problem [2, 3]. The SMED method has originated from production workshops out of necessity to minimize tool exchange time due to frequent tool exchanges and is one of the methods presented in Japan production philosophy. The motto "Less is more" comprehends the basic idea of Japan production philosophy that is how to produce more, to wasting less time, to using less production area, as well as less material and human resources, simultaneously keeping quality and quantity constant as required by the costumer [4].

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LP (Lean production) [5], is an organizational concept that emphasizes the importance of technology improvement grounded on cross referenced organizational elements, methods and tools. LP was founded on Massachusetts Institute of Technology to improve the competitiveness of USA Automotive industry as response on Japan production philosophy and their success.

PROBLEM FORMULATION

Die casting process is a technological process of under pressure alloy casting where the melt under high pressure fills the mould with great velocity. When manufacturing some die casting products in large series, several tool exchanges take place for the same product. A rapid changeover is widely acknowledged as an essential prerequisite to flexible, responsive small batch manufacturing [1].

The SMED system is a method that make possible to perform equipment setup and changeover operations under 10 minutes, and is also used as an element of Total Productive Maintenance - TPM. Some case studies about setup and changeover at different manufacturing environment are presented in [1, 6, 7].

In [1], author use the MINITAB 14 software to investigate the relation between SMED method and equipment design. The results of this study indicated that SMED is suitable not only for manufacturing improvement but also for equipment/die design development.

In [6], author research the sustainability as important factor to keep desired point of time reducing in changeover process achieved by SMED method. To reach aimed sustainability well-arranged standard procedures must be prepared. Optimal changeover procedure is constituted with aid of predetermined time system (MTM-UAS) to standardize and preserve the improved changeover operations.

In [7], author assesses two fundamental mechanisms by which better changeovers might be achieved. Better allocation of tasks to the resources necessary to conduct them is sought, where the tasks themselves remain essentially unchanged. The second mechanism is to seek structural change to existing tasks, thereby intrinsically enabling them to be completed more quickly. These two mechanisms are described in relation to use of the SMED method where greater of potential improvement options can be gained.

NEW APPROACH IN IMPROVING DIE CASTING PROCESS

New approach to improving die casting process is realized in 10 steps integrating the SMED method and 5S techniques. The 5S technique is integrated into step 7. The naming 5S originates from the following Japanese words: Seiri (organization), Seiton (tidiness), Seiso (cleaning), Seiketsu (standardization), Shitsuke (discipline).

1. Implementation Team Forming

Having responsibility in their own sector, production personnel, i.e. executors and professional team members, represent the best choice for team members. The purpose behind the 5S techniques is to increase to efficiency through the expansion of knowledge and skills of the workers, and their responsibility. Workers become more committed to their work, they are able to understand properly a given situation and make the right decisions. So, implementation team members should be machine, production, tool and design technologist.

2. Training

Maintenance workers have to perform changeover and machine set-up have to be introduced into and trained in implementing new methods and procedures into changeover procedure minimum once a week. Training is foreseen to be done per team, clarifying all misunderstandings and questions as well as giving clear instructions to enable faster and easier tool exchange (SMED).

3. Survey and screening of the situation prior to the method implementation

All changeover details are video recorded and complete work activity sequence is written down. Every operator's move and all activities have to be recorded in detail, since any unnecessary activity contributes to obtaining even worse results. The same recording procedure should be done after implementing the method to establish the efficiency in both applying the method and achieving the result (SMED).

4. Activity classification

This step is comprised of recorded material analyses and activities divided into two groups: the internal and external ones. External activities are all the set up activities that can be preformed while machine is in operation. Internal set up activities are the ones that can be performed only if the machine is not in operation. Internal activities refer to the dismantling of used tool, to the mounting of new ones and establishing communication in line machine–tool (SMED).

5. Transforming internal into external activities

Transforming internal into external activities as much is possible. It is the most efficient procedure ever for decreasing machine outage rates (SMED).

6. Improvement, internal activities minimization

- Visually set the tools, at hand of operator (5S)
- Using connectors that may be rapidly exchanged for all tool power sources (5S)
- Using as many locating pins for accurate tool positioning as possible (SMED)
- Cranes with sliding transporters (SMED)
- Using cranes for heavy tools only (SMED)
- Using standard tools as possible (SMED)

7. External activities improvement

- Placing visual markings for easier and faster identification (5S)
- Using check list to prevent unpredictable events in resources preparation (5S)
- "At hand" tool organization (5S)
- Work place organization that decreases tool search time (5S)
- Using appropriate tool preheating machine along with adequate device (SMED).

8. Standardization and forming the SMED procedures

9. Save quantification of savings reached by SMED

10. CIP (Continuous Improvement Process)

PROPOSED PROCEDURE PREPARATION

In order to reduce time consumption in changeover procedure and capacity release, foundry in Buzet has applied the proposed procedure. When die casting in foundry was started, neither activities necessary for the changeover procedure nor their sequence order were regulated. This situation entailed the fact that 463 min-

utes were needed for one tool exchange, table 1. By recording the process' details, overall activities are separated into external and internal ones. In accordance with the basic idea of proposed method, all possible internal activities were transferred into external ones, improving them in this way by using the following resources: SMED stations, consisting of the parts and devices are shown in Figure 1.

There are: die casting and boundary cutting tool fixing clamps, wire ropes for lifting weight, robot clamps, and ejecting pins. Within the station there is also a SMED table.

All necessary tools and parts are organized by 5S method on the table, Figure 2.

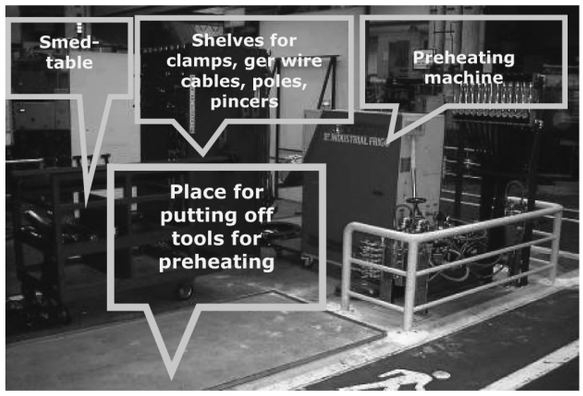

Figure 1. SMED – station

Figure 2. SMED – table

To accelerate tool exchange standardized machines and tools are used. Thus, they have the same connectors for hydraulics, pneumatics, tool heating and cooling, electrical connectors, and cutting tool positioning controllers (5S). Markings are placed on all the tools and machines which accelerate connecting i.e. communication machine – tool, Figure 3.

Prior to tool mounting, all signals and functionalities of hydraulic and electrical tools components are checked, via simulation test, by device on Figure 4 (SMED).

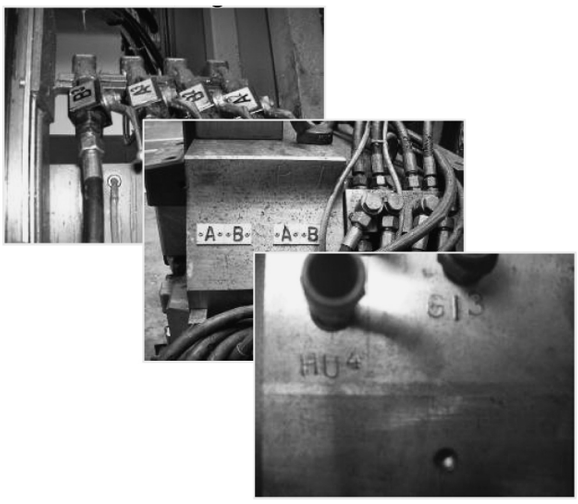

Figure 3. Markings for:
a) cutting machine hydraulics
b) die casting tools hydraulics
c) tool heating and cooling circuits

Figure 4. Device for check-testing hydraulic circuits and electric signal

In this manner, possible errors as well as any eventual delay during the tool mounting on the machine are avoided. After equipping the SMED station and putting all necessary resources in function, instruction manual for rapid changeover was elaborated and tool exchange operators were trained. As the attachment to this Manual, Check lists, before and after tool exchange, were made as an essential help during changeover procedure, Figure 5.

C4000574 SE				
	Pieces	Unit	Size	Attestation
Machine				
PISTON DIAMETER	1	mm	80	
PLUNGER ROD	1	mm	800	
CHAMBER	1	mm	100	
CLAMPS				
Stationary platen	4	Pieces	A	
Ejector (movable) platen	4	Pieces	B	
GUT COLD WATER	2	Pieces		
1 circle stationary	2	m	1,5	

Figure 5. Check list details before tool exchange

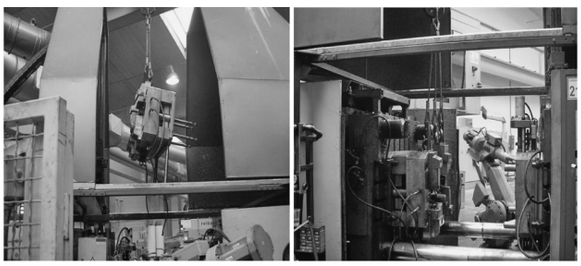

Figure 6. Tool exchange using bridge crane

Furthermore, some other improvements are introduced as shown in Figure 6.

The SMED method combined by 5S techniques improved die casting process applied in the casting foundry in Buzet and resulted in time consumption saving, shown in Table 1.

Table 1. **Activities duration before and after implementation and time savings**

Activity	Duration of activity before improvements (SMED)	Improvements	Duration of activity after improvements (SMED)	Time saving / min
transportation	35	instructions (order)	15	20
heating	90	preheating	0	90
auxiliary tools	49	smed table	9	40
dismantling of cutting tool	37	instructions (order)	27	10
mounting on cutting tool	64	signs, standardization, procedure, locating pins	49	15
dismantling of die casting tool	58	instructions (order)	44	14
mounting on die casting tool	115	signs, standardization,procedure, locating pins	89	26
starting	15	instructions (order)	7	8
TOTAL	**463**	TOTAL	240	**223**

CONCLUSION

A key parameter to achieving minimal production time is machine capacity release. A new approach to improving die casting process is to integrating the SMED method and 5S techniques as presented in this article. The proposed method application has resulted in the following improvements: average tool exchange time period is decreased, machine flexibility is raised due to reduced tool exchanges in controlled time period increasing in this way different parts production possibilities. There is a rise in production process in the parts of time periods that were previously used for tool exchange, work place and its surroundings are tidier and more organized than they used to be.

Presented improvements are not the final ones, since implementation of new and innovative tools give the space for further improvements. Besides, this new approach uses methods independent of industry fields which make them applicable to other complex technological processes.

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Note: The responsible for English language is Ksenija Mance, TFR Rijeka, Croatia.