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OPTYMISATION OF EQUIPMENT SETUP PROCESSES IN ENTERPRISES

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Fast equipment setup in a machine on production line is the key precondition to increase the flexibility of the production. Methodology of SMED (*Single Minute Exchange of Die*) is an example which allows reducing the time of setup practically to the minimum. The article presents the theoretical bases and required rules as well as case study conducted in one of chosen enterprises. This paper also answers the question if SMED methodology is applicable in metallurgical sector, presenting the example of shortening the time between the production of various metallurgical products manufactured in the machine for continuous casting of steel (COS in Polish).

Key words: metallurgy, steel, SMED methodology, changeover, internal-external set-up

Optimizacija postupka postavljanja opreme u poduzećima. Brzo postavljanje opreme i alata u stroj na proizvodnoj liniji je ključni preduvjet za povećanje fleksibilnosti proizvodnje. Metodologija SMED Izmjena opreme u jednoznamenkastom broju minuta) je primjer koji omogućava smanjenje vremena postavljanja gotovo na minimum. U članku se predstavljaju teoretske osnove i pravila koje je potrebno poštivati, kao i studija slučaja koji je proveden u izabranom poduzeću. Ovaj rad također odgovara na pitanja da lije SMED metodologija primjenjiva u metalurškom sektoru, predstavlja primjer skraćivanja pripremno završnih vremena između proizvodnji različitih metalurških proizvoda u stroju za kontinuirano lijevanje čelika.

Ključne riječi: metalurgija, čelik, SMED metodologija, promjena, unutarnje-vanjske aktivnosti

INTRODUCTION

Both in the period of prosperity and in time of recession the enterprises want to achieve maximum income, after deduction of all the costs. In each of those periods the enterprise leads a different policy of processes optimisation. In times of prosperity the activities connected with increase of efficiency of manufacturing processes prevail and in times of contraction (recession) the organisations try to introduce changes of saving character [1]. It results from a simple rule: in times of prosperity the enterprises have more capital to introduce technological novelties, modernise production lines etc. In times of crisis they try to save all possible money: the activities then are based on the improvement of production processes and production-related processes in an almost no-cost way. One of methods applied both in the growth period and in downturn period of prosperity is the methodology of Lean Production/Lean Management. The aim of the article is not presentation of techniques which support the mentioned methodology but concentration on only one of them. According to a study of British Institute of Management the labour costs are 20 % of overall costs. The problem then is the cost of other processes, the so-called manufacturing-related processes.

Our publication is concentrated mainly on the third aspect of the mentioned areas. The interesting areas here are: information flow, materials flow and activities connected with setups [2]. Manufacturing companies using SMED achieve a standard 8-minute time of setup. In metallurgical sector the setup period which lasts less than 10 minutes may seem unreal, particularly in reference to machines of continuous casting of steel type (COS). In this article an assumption was made that SMED in metallurgical sector should be understood as way of reduction of break times [3].

TWO AREAS OF WORK

Each activity conducted in the enterprise may, in standard, be divided into two areas of work: basic and auxiliary (Figure 1).

Auxiliary activities support the basic activities. There are also activities which do not bring benefits and which should be underlined here. They are popularly called wasting [4]. The experience of many companies shows that the application of actions which are based on elimination of wasting (Jap.: *muda*) and application of continuous improvement may in the long run bring significant benefits.

One of the examples presented in the paper is the manufacturing company of automotive sector which

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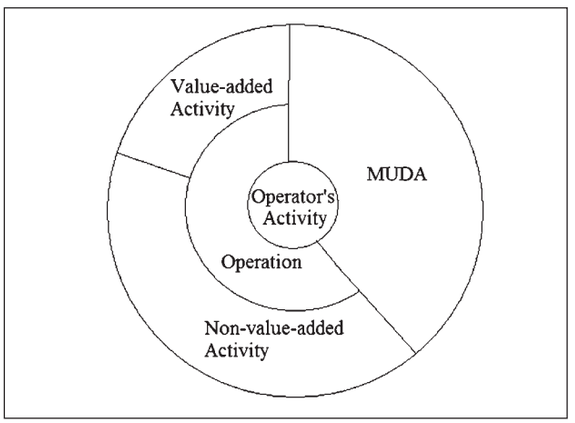

Figure 1 Work and „MUDA" [4]

conducts a *Program of Continuous Improvement*. It is manifested by care about high quality of product in the domain of manufacturing processes and manufacturing-related processes. The program refers to most detailed activities in manufacturing which are influenced by the operators performing them. Even the smallest projects which optimise and rationalise contribute to the increase of productivity, improvement of ergonomics of work stations and the quality improvement of all performed operations. They also influence the pro-ecological activities. As a result they lower the operational costs of the enterprise [5]. Table 1 presents the specification of data concerning the *Program of Continuous Improvement* in the described case.

Table 1 **Program of Continuous Improvement in numbers [5]**

Criterions of research	Period 2005 - 2008
Numbers of workshops	270
Numbers of implemented projects	1 200
Savings	about 2 860 465 EUR

The next example here will be metallurgical enterprise ArcelorMittal Poland (steelworks with full production cycle of metallurgical products) which by application of the saving program and a program improvement of the course of work organisation (TOP – Teraz o Przyszłości – Now About the Future) achieved a reduction of costs of manufacturing 1 ton of steel. In 2008, before the introduction of the program, the cost of manufacturing 1 ton of steel in branches in Poland was 50 EUR higher than in other branches of the capital group ArcelorMittal (this group produces about 100 million tonnes of steel annually in the global scale). Since 2008 the workers have started to be engaged in search of savings on work stations. Until February 2010 19,7 EUR has been saved (Figure 2) [6].

SMED METHODOLOGY

One of the methods supporting the Lean concept is the rationalisations of die exchange – SMED methodology *(Single Minute Exchange of Die*), also known as *Quick Change-Over of Tools*. The setup (changeover) in reference to productivity of manufacturing process is understood as a loss. It results from the fact that during the time when the machine does not produce it does not bring profit [5]. SMED refers to the theory and techniques used for the reduction of equipment setup times [8]. The SMED methodology (technique) is used as an element of Total Productivity Maintenance (TPM) and "continuous improvement process" in various studies to reach lean manufacturing [9]. The SMED allows to reduce the equipment setup to the minimum by separation of internal and external actions. First group is necessary to be done at work station, after switching off the machine, and the second group allow to conduct the equipment setup without the necessity to stop working at work station. The creator of this method is Shigeo Shingo [10]. System of equipment setup improvement according to S. Shingo is possible to be implemented by separating four stages. They are [10]: (1) preparatory operations, which are the detailed analysis of the whole equipment setup process through analysis of production, interviews with workers and video recordings, (2) operations of separation of internal from external setup operations which enable the separation of those external operations which aim at reduction of setup time (which can be reduced by 30-50 %); this stages is the key to achieve success in SMED, (3) activities connected with transformation of internal setup operations into external setup operations which are based on further reduction of idle time resulting from setup operations, (4) activities connected with rationalisation of internal setup operations which allow for standardisation of actions and operations and introduction of conduct procedures.

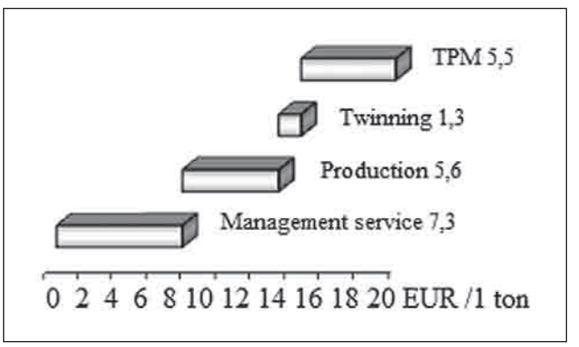

Figure 2 Savings in ArcelorMittal Poland after Program of Continuous Improvement [7]

McIntosh and others give a useful list of actions which support SMED methodology implementation (Table 2). SMED is one of many methods of lean production which aims at lowering the amount of waste in manufacturing process. SMED provides fast and effective setup method (transformation of manufacturing process) from the present to a different one. Fast setup is here the key to reduction of the size of manufacturing batches and at the same time to improvement of material flow [12].

Table 2 **Tools used in the implementation of the SMED methodology [11]**

Phases of the SMED concept	Leveraging tools
Phase A: SMED project kick off	Analyse the Shop Floor activities in order to differentiate internal from external operations
Phase B: Separate internal from external operations	The use of checklists; The definition of functions for each worker; The improvement of tool transportation
Phase C: Convert internal to external operations	The previous preparation of setup operations; The automation of operations; The utilization of different tools
Phase D: Improve all aspects of the setup operation	The improvement of tool transportation and warehousing; Elimination of settings, calibrations and adjustments; The automation of operations

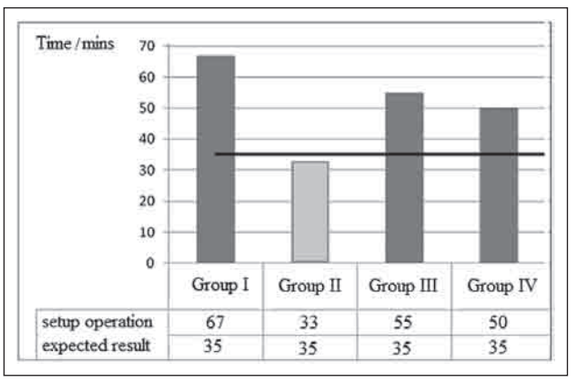

Figure 3 Results of project groups – next phase [13]

SMED IN PRACTICE

Application of SMED is not an easy task. Good preparation is necessary here. A series of steps, which make going through the SMED process easier and help achieve satisfactory results is suggested below. **Action 1** – elaboration of the action plan and responsibilities for the process of equipment setup operation optimisation.

Action 2 – conduction of workshops which introduce the project team who takes part in the controlled setup, it is suggested to conduct workshops in two stages: 1st part is theoretical and led by the project leader – in order to get the workers acquainted with SMED and aims of the project, 2nd part is practical and involves tasks aiming at minimisation of the setup time presented on a simple example. Practical training makes workers aware that the change of internal operations into external operations does not need to be difficult.

Action 3 – phase of SMED project kick off observation which is based on observation of the operations conducted by workers during a real setup. After observation a spaghetti diagram is prepared which shows the movements of the workers. Observations have shown that real setup of the machine lasts from 45-67 minutes.

Action 4 – separation of the internal and external operations which may be based on separation of a few project groups which are to conduct a task which is transformation of internal operations into external ones. Four project groups took part in the described project. It was decided that the time of setup at this stage should not exceed 35 minutes. One of the project groups achieved the following result. The results of project groups should be thoroughly analysed and after a discussion new ideas of setup operations improvement should be put forward. The effect of such debate should also be an action plan which aims at security of workers and organisation of work (re-organisation of work station, application of universal tools, etc.).

Action 5 – Further conversion of internal to external operation concentrated on strengthening the critical points presented in the previous action. Results of that task are presented in Figure 3.

Action 6 – Improvement of all aspects of setup operation which is standardisation of all operations performed during setup, concentrating on those which took too long. Good practices of project group II should be passed on to the remaining workers.

It prevents discrepancies in times of setup and allows the elimination of unnecessary movements of the workers. It is advisable here to work out a *Setup Standardisation Card* which presents detailed description of actions which should be performed during setup. Improvement of preparatory internal actions is based on meeting four conditions as follows: parallel operation completion, application of fixing clamps, elimination of regulation, mechanisation. Before the initiation of SMED project the setup time for a machine lasted from 45 to 67 minutes depending on the abilities of the operators and mechanics. Preparation and conduction of SMED project allowed to reduce the setup time to 30 minutes. It was possible due to:

1. change of some setup operations from internal to external,
2. organisation of work change,
3. improvement of communication among workers,
4. strengthening *5S* on work stations,
5. safety improvements on work station.

SMED IN STEELWORKS

There are some known cases of good practices transfer not only between enterprises from the same trade sector but also among enterprises from different sectors. A question arises then: is it possible to apply SMED in metallurgical sector? The answer to this question is: yes. On Polish metallurgical market SMED can be applied in continuous steel casting process. In the biggest metallurgical enterprise, ArcelorMittal Poland, in March 2011, works have been initiated to introduce SMED (branch in Dąbrowa Górnicza). The aim of the project is reduction of downtime in preparation time of machines to further casting of slabs between first and second order (diversification of the width of casted slabs and the amount of casted elements in a sequence). At present the break between castings lasts about 85 minutes. With the introduction of the project a team was created and its members are: operator of casting process, process

engineer, specialist for production planning, a specialist from finishing bank, foreman and casting process specialist. Working group had analysed the current condition of machine setup and on that basis a project of changes in device steering, organisation and ergonomics of work and investment projects were prepared. The enterprise will install additional device to cut slabs which will allow for fast elimination of band from the cutting region and unblocking roller-tracks. This investment will allow to shorten the time of inserting the steel rod to the machine (estimated time savings of about 10 minutes) [14]. After an interview information was collected that the purchase of machine for cutting and other investment will allow to reduce the setup times on device by about twenty minutes.

CONCLUSION

The foundation of SMED methodology activities is separation of internal setup operations from external (configuration of machines). Another advantage is the application of simple and common sense solutions which are mainly of no-cost type or require little amount of money. Data and guidelines presented here show the practical application of SMED. They also show that it is possible to implement it in real conditions of metallurgy sector.

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Note: The responsible translator for English language is D. Grachal, Katowice, Poland