THE PRINCIPLES OF LEAN MANUFACTURING IN METALLURGICAL PROCESSES

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Abstract

Production of metallurgical enterprises requires high costs and the production process in blast furnaces is among the most complex manufacturing processes. Blast furnace process is energy intensive and, since the prices of input raw materials have been constantly rising, companies must look for possible ways how to reduce their costs. Metallurgical enterprises are not capable of reducing the prices of input raw materials, which is why the reduction of production costs is the way to go in order to produce cheaper than the competitors. Cost saving is the way to remain competitive in a global scale. One of the potential methods to reduce costs and to simultaneously increase the efficiency of the production process is the application of lean manufacturing principles. This concept was originally introduced in the automotive industry in car production in Toyota Company. Lean production concept has proved to be a very effective tool to improve the manufacturing processes, which is the reason why this concept has been applied in other industrial fields. Lean production in metallurgical processes may contribute to savings and to cost reduction in metallurgical production. This article is focused on the application of lean manufacturing principles in metallurgical processes.

Keywords: Lean manufacturing, metallurgical production, principles

1. INDTRODUCTION

Metallurgical production as one of the most demanding manufacturing processes requires expensive material and energy inputs. The goal of every company is to reduce its manufacturing costs and to remain competitive on a global scale. Metallurgical companies can use their communication mix for in the process of customer acquisition [1]. Companies cannot influence the global prices of raw materials or energies, and the way to reduce the production costs is to produce in a more efficient way. One of the ways to achieve higher efficiency is the application of lean production principles [8, 9].

The concept of lean production originally implemented for the mass production of automobiles leads to improvements of the process of production in the company, thus reducing costs [10, 11, 12]. The application of lean production in a company means doing only those activities that are necessary, doing them right on the first occasion and faster than the competitors, while maintaining lower costs. This philosophy is based on maximizing the added value for the customer, while trying to shorten the time between the customer and manufacturer by eliminating wasting in the chain between the two sides [2]. It is a concept of continuous improvement. The basic principle of lean production is to identify and eliminate the sources of wasting [3]. The term wasting is a key word in lean production, and it includes all the aspects that increase the cost of product without increasing its value. The most common sources of wasting in enterprises are [4]:

1) Overproduction - wasting means producing more products than required by the customer, resulting in costs incurred for storage of this production.
2) Waiting - a case when there is no activity of a machine or a worker, because they are waiting for the completion of the previous process step [13].
3) Stocks - the accumulation of semi-finished products [5].
4) Process wasting - all surplus process operations in production.
5) Transport - a resource of wasting caused by improper arrangement of the production plant, which leads to handling and transportation between the individual workplaces.

6) Unnecessary movements - movements of workers or machines during production that are caused by improper arrangement of workplaces.
7) Rejects - wasting due to production of rejects and their repairs.

Lean production takes advantage of various tools to improve the production process in the company and to eliminate the sources of wasting. The most commonly used tools of lean production are: Method 5S, Kaizen, TPM, SMED. Selected tools are mainly used in the original area which lean production was implemented for - automotive industry. Metallurgical production has many specific features in comparison with automobile production, which is why the aim of this article is to analyze the possibility of introducing lean production principles in the production of pig iron and other follow-up metallurgical and finishing processes.

2. EXPERIMENTAL WORK

The selected tools of lean production in the automotive industry should achieve the elimination of the above-mentioned sources of wasting and increase production productivity and, on the other side, they should reduce its expensiveness. To see if it is possible to introduce the analysed lean production tools in metallurgical production for the same purpose will be the subject of this research.

2.1. 5S Method

5S Method has, as well as the entire philosophy of lean production, its origins in Japan, which is why the abbreviation of 5S stands for 5 Japanese words that start with S. The meaning of 5S is as follows:
1) Seiri (sort) - sort all the items and keep only those that are necessary and important, you must get rid of everything else.
2) Seiton (straighten) - means order, everything has its fixed position and everything has to be in its place.
3) Seiso (shine) - cleanliness, or the cleaning process acts as a certain controlling mechanism revealing abnormal conditions that could lead to reduced product quality or damage to the machine.
4) Seiketsu (standardization) - development of rules in the form of systems and procedures allowing you to keep and continuously follow the first three S rules.
5) Shitsuke (sustain) - self-discipline in maintaining a stabilized workplace, which is a continuous improvement process.

In **Fig. 1**, you can see how 5S together create a continuous process of improvement of the working environment.

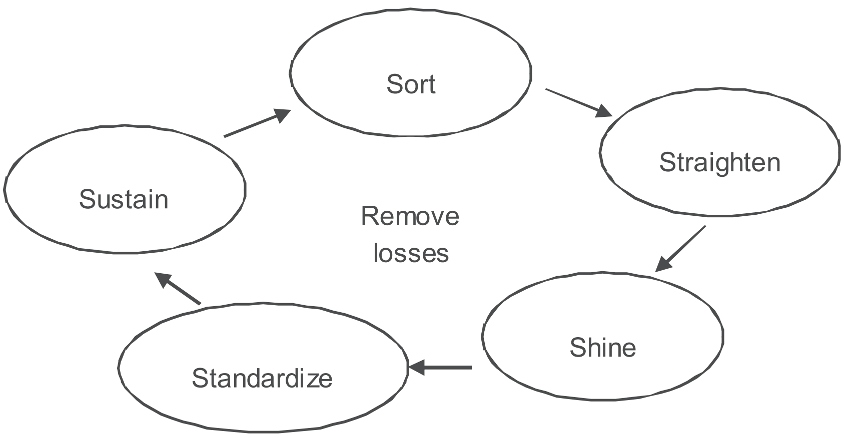

Fig. 1 5S Method [4]

The 5S Method also has its place and use in metallurgical enterprises, especially in identifying positions, transportation routes, safety signs in buildings and protection of workers, and marking of the exact location of the individual tools. You can see an example of the visual signs at workplaces in **Fig. 2**.

Fig. 2 Visual signs at workplace

2.2. KAIZEN

KAIZEN means continuous improvement in the company. It is one of the most effective approaches improving company performance by means of continuous improvement in small steps. In Japan, KAIZEN is considered to be one of the most important steps of management, which plays a key role in the competitive struggle in the market, and it is used by a number of Japanese and other global companies [14, 15]. It is a method in which improvement takes place in all aspects and is done by all people, i.e. continuous improvement involves every single employee of the company. KAIZEN consists of a range of tools and approaches that should be used in the enterprise. The most important methods include especially: customer care, automation and mechanization of processes, quality circles, work discipline, suggested continuous solutions, cooperation between managers and workers, improving quality, creative teams, productivity improvements, etc [6].

Due to the universal use of continuous improvement of processes, there is also space for the introduction of KAIZEN in metallurgical enterprises. In high-cost production, such as metallurgical one, even seemingly small improvements can deliver significant cost savings [16]. It is necessary for metallurgical enterprises to search for these possible ways of cost reduction and to improve them. That is why it is imperative to involve every employee in this process, regardless of the position at work, since it is possible to look for savings in all areas of the production process, starting from the company management and up to the actual production.

2.3. Total productive maintenance

TPM is a part of the philosophy of lean production, and it involves all departments of the company and represents the interconnection of maintenance and production. Sometimes, the concept of TPM is incorrectly understood only as company maintenance. However, TPM is based on preventing the division of workers into those who repair it and those who work on it. TPM says that an employee working on a given machine is more likely to be the first person to identify any abnormality or potential sources of future breakdowns of the machine. TPM therefore transfers maximum diagnostic and maintenance activities on the workers. The aim of TPM is to prevent machine stopping and its downtime due to a malfunction or an accident. Another area covered by TPM is the operation of machines with damaged parts or the use of incorrect methods.

TPM uses 5 basic activities to eliminate work stoppage of production facilities [6]:

- using optimal conditions for the operation of the equipment,
- compliance with the prescribed operating conditions,
- early diagnostics and repairs of damaged parts,

- elimination of imperfections in equipment design,
- improving the skills of workers.

Overall, TPM consists of partial areas and they are: program of autonomous equipment maintenance, program of scheduled maintenance, program of education and training of staff, and program of planning of new equipment and spare parts.

For metallurgical enterprises, and blast furnaces in particular, TPM approach is applicable only to a certain extent. Metallurgical processes are mostly continuous and this is the reason why it is possible to use this approach only to a limited extent. However, more extensive application of TPM can be found in follow-up processes, such as moulding, rolling and treatment of steel products. In these areas, workers can perform small maintenance interventions and implement certain prediction of equipment damage.

2.4. SMED

SMED is a method of rapid changes or rapid conversions of equipment to another product. Cutting the time for equipment conversion is a key step to eliminate time wasting as a result of equipment downtime necessary to perform its conversion. The reduction of set-up time makes sense in places where production equipment is frequently converted and equipment downtime causes great losses of available production equipment capacities. SMED method principles are based on the distribution of activities required for equipment conversion to perform external and internal activities. External activities are such operations that can be performed while the equipment is running. The aim is to try to shift as many activities as possible from the internal to the external group, so that the lowest number of activities has to be done while the production equipment is stopped. However, this is not the entire scope of SMED Method, and it also requires cutting the times necessary to perform the individual internal operations. A typical benefit of the introduction of SMED Method includes radical shortening of the equipment adjusting time, reduced production capacity losses, shortening of the continuous production time, elimination of the errors during set-ups and overall improvement of the production process. All these results achieved by SMED Method have a direct impact on reducing the costs of production.

The course of the application of SMED Method is shown in **Fig. 3**.

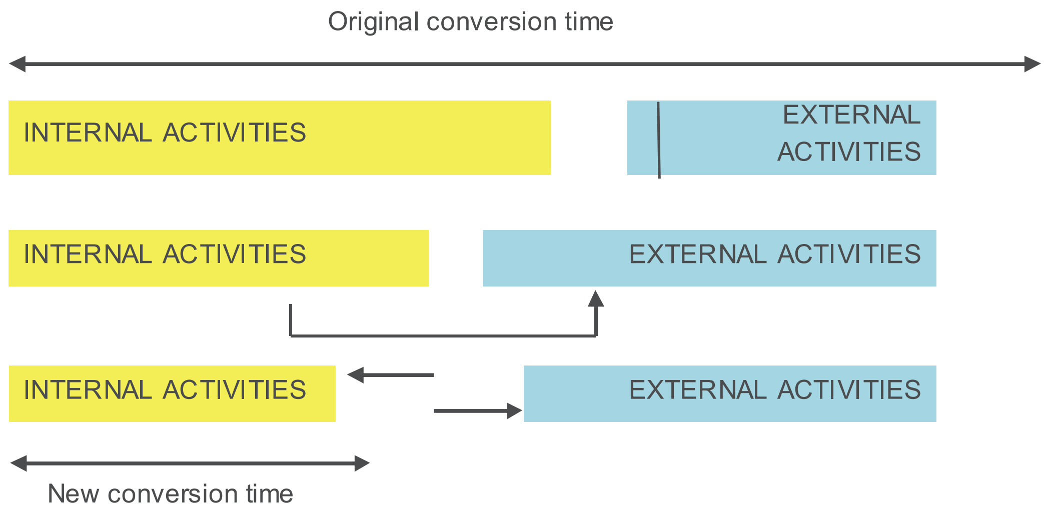

Fig. 3 SMED principle [7]

The application of SMED Method in metallurgical industry makes sense. Its application cannot be found in the production of iron, but SMED makes sense especially in the follow-up processes, such as moulding, rolling and other machining operations, especially in case of equipment capable of producing various ranges of products. Rolling and other product treatments can serve as a typical example here.

3. CONCLUSION

The aim of this article was to analyze the possibilities of implementing and using the tools of lean production in metallurgical processes. Based on the research, it can be stated that the chosen tools of lean production - 5S Method, SMED, KAIZEN and TPM can be applied in metallurgical production. Each tool has its application in a different part of the metallurgical production.

There are no practical restrictions of 5S Method, and its universal character allows its application in various sectors. This method has a wide application in metallurgical enterprises, from the production of pig iron, through other treatment activities up to the final products. The necessary tools at their designated place, marking of passages through production facilities, maintaining cleanliness and other factors can serve as typical examples.

The same conclusion applies to the KAIZEN Method, which can help companies with extensive manufacturing capacities to reduce their production costs to a large extent, as a result of relatively small savings in partial operations. Substantial savings arise from a large volume of production. It is vital for the KAIZEN Method to involve all the employees of the company in this philosophy of continuous improvement. This condition is mainly due to the fact that every single employee performing his/her daily routine work can bring improvement proposals to perform this activity more efficiently. KAIZEN can therefore be applied in metallurgical productions in its entire scope.

TPM and SMED methods have limited use, since they are specific tools related to production equipment. TPM tool is particularly suitable for subsequent treatment production processes, where the final product treatment is performed using a higher number of devices. These devices represent exactly the points of suitable application of the SMED Method, if the devices are capable of producing a wider range of products. SMED makes sense only in places where it is necessary to make conversions between the individual final products.

It can be concluded that the philosophy of lean production originally introduced for mass production of automobiles can also find its application in other industrial fields. On the basis of the analysis, metallurgical production is one of the fields where lean tools can be used as well.

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