LEAN PRINCIPLES IN METALLURGICAL COMPANIES

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Abstract

Production process of metallurgical enterprises is characterized by high costs and complexity manufacturing. Through the implementation of lean manufacturing principles can be reduced manufacturing costs and complexity of the manufacturing process. Concept of lean manufacturing in metallurgical enterprises can result to increase its effectiveness. One of the aims of lean manufacturing is the elimination of waste in the production process. The aim of this paper is to analyze the sources of waste in metallurgical company and options for their removal.

Keywords: Lean manufacture, metallurgical manufacture, waste

1. INTRODUCTION

At present, companies in all sectors have to focus on rapid production so as to meet the requirements of their customers, on the speed of delivery, their performances during production and added value for their customers. All these aspects represent a way how to remain competitive in this time. Enterprises have to introduce the principles of continuous improvement into their philosophies in order to achieve these goals. The lean philosophy is a tool originally introduced in automotive industry, and it can be the way to succeed. The lean manufacturing principles help companies to achieve significant improvements in their efficiency and economic benefits by improving quality and the manufacturing process [1].

One of the basic principles of lean manufacturing is the identification and elimination of the sources of waste across the enterprise. It's a tool used to improve the quality of the manufacturing process and to reduce costs [2]. Reducing costs is of great importance for the future competitiveness of companies. Its importance for companies lies in lower costs of production reflected in the possibility to reduce the price of the final product for customers [3].

2. LITERATURE REVIEW

Company leanness means doing only those activities that are necessary, doing them right the first time, doing them faster than the others, while spending less money [4]. The current competitive environment puts enterprises under great pressure. However, it is not possible to consistently build your company simply by using cost reductions. Leanness is about improving the performance of the company by producing more than the competitors in the given space, by producing higher addend value than the competitors with the given number of people and equipment, by processing more orders during the given time, and by consuming less time on the individual company processes and activities [5]. It is therefore important to do exactly what the customer wants, with a minimum number of activities and at minimum costs. Being lean therefore means earning more money, earning it faster and with less effort [6]. More and more manufacturing companies realize that without fundamental changes in their processes, their existence in the near future may be at risk.

Lean manufacturing and its principles cannot be understood as a clearly defined and closed system. This philosophy allows you to apply a variety of methods and tools, and it is also possible to use very different approaches during its implementation. The implementation of lean manufacturing is mostly a reaction to some kind of problem in the organization. It is often recommended during the implementation of lean manufacturing principles to use a procedure based on the initial audit of the basic parameters of lean manufacturing, where the values of the selected indicators can be determined. According to contemporary approach, lean manufacturing is a complex system that can evaluate a variety of aspects and parameters, including the indicators assessing the quality of the individual processes, the amount of downtime, but also for example the variability of the production performance. Lean manufacturing uses tens of tools and metrics for this purpose. The most commonly used ones are: the amount of non-conforming production, the OEE of selected workstations, the set-up times, the inventory turnover rate, the hourly stability, the continuous production time, and the C/T of bottlenecks. Their application must, however, always be based on the specific aspects of each organization. A number of parameters which are used to assess the production leanness rely on the principles of mass production, and it is therefore very difficult to apply them for example in individual piece production. That is why it is always necessary to use the individual approach when applying the lean manufacturing tools. Special attention must be paid to the methods and techniques used within the scope of lean manufacturing. Originally, these techniques were applied in the production of automobiles. The application of the principles of lean manufacturing in other areas was also accompanied by an increasing number and scope of the applied methods [7]. There are dozens of different methods used nowadays. The most typical and frequently used ones include, for example: TPM, 5S - a system of good management, visual management, team problem solving, batch production, management of bottlenecks, and many others. The concrete use of the individual methods is again quite dependent on the character of the manufacturing organization in question. A different nature of the production process does not allow a universal application of all the methods.

Taiichi Ohno - a manager of Toyota Company and the father of the philosophy of lean manufacturing has identified seven common sources of waste in companies. These sources of waste are [8]:

1) Inventory - all components, work in process and finished goods, which are not being processed at this time.
2) Transportation - all movements of products that are not necessary during their processing.
3) Motion - people and tools that move more than it is required during the processing of products.
4) Waiting - waiting for the next production operation.
5) Overproduction - production that exceeds the customer requirements.
6) Extra-processing - processing of products using unsuitable tools or poor product design.
7) Defects - effort that is dedicated to the control and elimination of defects.

The above mentioned sources of waste in the company do not have added value for customers, but result in higher prices, since they increase the cost of production. The elimination of waste in the company leads to the reduction of the costs and prices of products and it increases value for customers [8]. The introduction of lean manufacturing principles can also be beneficial for a metallurgical company. Metallurgical enterprises have their specific characteristics that must be taken into account when applying lean manufacturing. The objective of this article is to analyze the sources of waste and to propose ways of their elimination within the scope of a metallurgical enterprise. The focus of this article is only on a specific part of a metallurgical enterprise - a rolling mill that manufactures a wide range of profiles, strips and wires, primarily to the finished products warehouse.

3. EXPERIMENTAL WORK

At the beginning of the analysis of the finished products warehouse in a rolling mill, it is necessary to analyze the input data. The finished products warehouse of the rolling mill is designed for a capacity of around 15,000 tons of finished products. The warehouse is operated by 4 cranes that deal with the loading of finished products during dispatch on one side (for truck transport and rail wagons) and serve production on the other side. The cranes are limited by the production process, and the storage of finished products always takes precedence over loading of finished products in dispatch. The finished product warehouse contains approximately 250 kinds of standard production. Standard production is characterized by standard length, thickness, and it is packaged in bundles of 2.5 tons. Apart from this standard production, the warehouse also contains customized production (different length and thickness from the standard, different bundle size - always up to 2.5 tons). The input data are summarized in **Table 1**.

Table 1 Input data

Warehouse capacity	**15 000 t**
Number of cranes	4 pieces
Range of products	250 standard kinds

When the warehouse capacity, which was designed for 15,000 tons, is not exceeded, the length of the loading of trucks coming into the warehouse is about 45 minutes.

At present, however, the warehouse contains over 25,000 tons of final products. The current state of the capacity of the finished products warehouse is exceeded by almost 67 % in comparison with its original designed capacity. This warehouse overflow has been reflected in the extension of the truck loading time to approximately 4-5 hours. It has therefore caused an extension of the loading of finished products to an unacceptable time.

The following analysis will identify the sources of waste in the finished products warehouse, which have a direct effect on the extension of loading time and warehouse overflow.

3.1. Identifying the sources of waste

It is obvious that there is certain waste taking place in the warehouse. Ohno has defined 7 kinds of waste in companies, and this part of the work will illustrate the sources of waste and their impacts in the finished products warehouse of the rolling mill.

Overproduction

We will not start with the traditional first source wasting according to Ohno - inventory, but with overproduction. The analyzed rolling mill produces about 250 kinds of standard products, on top of which, it subsequently manufactures products according to the requirements of its customers. The production assortment of the rolling mill is as relentlessly wide as the diverse customer requirements are. The mistake is that the standard products are manufactured in large batches, which have to be stored until they are sold. This storage has several consequences that contribute to further sources of waste, such as excess inventory, unnecessary transportation, movements, and defects.

Inventory

In case when the warehouse is designed for 15,000 tons of finished products and it currently contains over 25,000 tons of products in storage, it is associated with waste in the form of money frozen in the finished products until they are sold. The rolling mill produces unnecessarily large batches of standard products that do not have their customers and subsequently lie in the warehouse if there is no interest in them. This high inventory level is good neither for the warehouse capacity nor for the storage costs. Another problem is the unnecessary transportation of the finished products, which is caused by excessive production kept in the warehouse.

Transportation

The overcrowded warehouse of the rolling mill has resulted in unnecessary transport and reloading of the finished products. It is a common situation that it is necessary to load products that have already been covered by finished products intended for another customer, which will be dispatched in another time. For this reason, the crane has to first put away the upper layers of products to be able to load the desired order. It should be noted that this operation will almost certainly cover other products to be loaded later. In such an overcrowded warehouse, the reloading is a daily routine and a cycle that is repeated over and over again.

Motion

Unnecessary reloading of the finished products in the rolling mill has resulted in additional source of waste, the unnecessary movements of the warehouse keepers. Because the bundles are put away throughout the whole warehouse, the warehouse keepers have to look for the products to be loaded by cranes for the ongoing dispatch.

Waiting

There is also certain waste in the form of waiting in the warehouse. This is not waiting for the next operation, but useless unproductive crane idle times, because they must wait for the warehouse keepers who search for the covered bundles to be loaded onto trucks or railway wagons at that time.

Defects

There are frequent defects when large batches are produced. Unfortunately, due to large batches, it is possible to carry out quality control tests of finished products only after a certain time. During this period, however, the products are stored in the warehouse and they take up space. There are situations when quality testing reveals poor quality production, which has to go back into the production process. Given the results of the tests of poor quality products, the products needlessly occupy the place needed for quality products, although it is just a fraction of the total production.

3.2. Summary of the analysis of the sources of waste

The analysis of the sources of waste has revealed that the rolling mill warehouse involves almost all the sources of waste, except for unnecessary processing, which has been eliminated in case of current products in the rolling mill. However, this source of waste has not been eliminated in case of the introduction of new products not manufactured until now.

Almost all the sources of waste are the result of large batches of standard products and their production to storage. This source of waste can be assigned the highest weight and importance for its elimination.

The summary of the sources of waste and the priority of their elimination are included in **Table 2**.

Table 2 Sources of waste and the priority of their elimination

Sources of waste	Priority of elimination
Overproduction	1.
Inventory	2.
Transportation	3.
Motion	4.
Waiting	5.
Defects	6.

3.3. Suggestions to improve the current state of the rolling mill

The highest priority for waste elimination or rectification has to be given to high overproduction of standard products. This priority has been assigned because of its effect on other sources of waste. If the overproduction is reduced and the batches are set according to the customer requirements, there will be free storage capacity and the inventory lying in stock will be reduced as well.

Reducing inventory in the warehouse will go hand in hand with lower reloading of finished products during loading and reduction of the necessary loading time back to the original 40 minutes. This measure will directly improve the delivery times to customers and will result in an increase of the product value for customers.

In case of the elimination of unnecessary reloading, it will also reduce the burden of the warehouse keepers, who must now constantly look for material that is to be loaded for dispatch. This unnecessary searching can also be avoided by introducing a better system of identification of the products in stock, which currently uses barcodes.

If the search time is reduced, the cranes will have a lower share of unproductive time when they have to wait until the products to be loaded are found. In the case of identification of poor quality products, the quality control will have less work as well, provided that it will control thousands of tons of products less, which will speed up the process of quality control.

4. CONCLUSION

Lean production, a concept introduced primarily in the automotive industry, has its place in metallurgical enterprises, which have a number of specifics. Thanks to its versatility, lean philosophy can be introduced in almost any industry. As shown in this article, an analysis of the sources of waste and their elimination has its place in metallurgical enterprises as well, in this specific case; it is in the warehouse of finished products in a rolling mill. If the analyzed rolling mill wants to remain competitive, it has to respond to the current state of its finished products warehouse and eliminate the sources of waste.

The introduction of the elements of lean production does not automatically mean success for a company in today's global market, but it can significantly help to achieve success and competitiveness. Companies have to respond flexibly to the market requirements, they have to develop new products with high added value for the customers, and lean manufacturing can be just the right tool which can help them to achieve this goal with minimal costs. This applies to all industrial enterprises, including metallurgical ones.

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