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THE USE OF LEAN MANUFACTURING (LM) TOOLS IN THE FIELD OF PRODUCTION ORGANIZATION IN THE METALLURGICAL INDUSTRY

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This article presents the possibility of using Lean Manufacturing (LM) tools for the identification of waste occurring in individual areas of the production activity of steelworks in Poland. The issue of waste reduction and improvement of the organization of production contributes substantially to cost reduction and effective implementation of production tasks. This study identifies waste, and then presents the process of its reduction based on the available methods and tools of the LM concept. Given the above, the aim of this study is to assess the possibility of adapting LM tools in the steel industry in the context of waste reduction and improvement of the organization of production.

Key words: steel industry, waste, lean manufacturing tools, Poland

INTRODUCTION

The basis for the improvement of production processes is the optimal combination and use of available production resources due to the necessity to meet customer requirements and adapt to changing market conditions or cost pressure. The measures taken by enterprises in the steel industry to improve production processes and their organization are foreseen to ensure that such enterprises achieve economic and production effects such as, inter alia, cost reduction, increase in efficiency, timely execution of tasks, improvement of work quality, increase in production quality, shortening of inter-operation times or reduction of inventory [1,2]. Various concepts, methods and techniques of the organization and management of production processes play an important role in ensuring improvement – among others, the Lean Manufacturing concept merits particular attention. The LM concept consists in the use of solutions suitable for a given enterprise so that the best possible results are obtained under given technical and organizational conditions with the least possible cost [3]. The system is referred to as lean because it uses less of everything compared with mass production, i.e. half the human effort, half the production space, half the investment in tools, half the engineering work necessary to develop a new product, in twice as short a period of time [4]. The application of solutions within the LM concept entails the improvement of the functioning of the entire production system by the elimination of all kinds of waste [5]. Waste is defined as any action identifiable in production processes that does not add value to the product from the customer's point of view. Pursuant to the LM concept, the following categories of waste may be distinguished [6,7]: overproduction, inventory, unnecessary motion, unnecessary transport, over-processing, defects, waiting, as well as unused potential of production workers. Waste disrupts the implemented processes, it is therefore necessary to properly identify it and adopt measures to reduce or eliminate it entirely. The use of properly selected LM tools or selected quality tools facilitating the solution of problems in the production hall can lead to waste reduction and, consequently, improve the organization of production in various areas of enterprises in the steel industry [8]. The solutions that will promote the achievement of the above goal include: 5S method, visual management (VM), value stream mapping (VSM), SMED method, TPM system, standardization, kaizen, kanban, poka-yoke, Ishikawa diagram (5M analysis).

METHODOLOGY

A three-stage methodology was developed in order to achieve the objective pursued in this study consisting in the adaptation of selected Lean Manufacturing tools to reduce waste and improve the organization of production in enterprises in the steel industry.

The first stage involved the identification of wastes occurring in production areas, taking into account the causes of their occurrence (in line with the 5M analysis).

The second stage consisted in the determination of the impact of a given waste on the organization of production. For the purposes of this study, a three-grade scale of the impact of waste on the organization of production was adopted, i.e. low impact (L), medium impact (M), high impact (H). The choice of the impact

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scale was made on an individual basis depending on each identified waste.

The third stage involved a presentation of methods of reducing the compiled wastes by means of a selection of solutions within the LM concept whose implementation will contribute to the improvement of the organization of production.

IDENTIFICATION OF WASTES AND SELECTION OF LM TOOLS

The selection of solutions within the LM concept that facilitate the improvement of the organization of production in enterprises in the steel industry necessitated the identification of the following categories of waste: overproduction, inventory, waiting, motion, over-processing, defects, transportation. The impact of each waste within a given category on the organization of production was determined, and subsequently the areas where the causes of such waste exist were identified – in compliance with the 5M analysis (Table 1).

Overproduction waste arises from the production of a greater number of goods at the work station in order to avoid problems caused be a possible failure of the machine. It also results from production completed in advance of the delivery time. Overproduction waste leads to the build-up of inventories generating costs and it produces other waste. The identified overproduction waste has a high (H) impact on the organization of production tasks. In order to reduce it, the following solutions are recommended:

use of VSM to graphically present the flow of materials and information in the process, allowing for the identification of problems and taking corrective measures,

kanban (in selected areas of a steelworks) as a control mechanism for the implementation of production tasks and flow of materials,

implementation of the TPM system to ensure the continuity of production by means of the efficient use of machines;

application of and compliance with procedures, work instructions to stabilize and standardize processes, which may contribute to a reduction of overproduction waste.

The identified inventory waste (as a protection against a loss of the continuity of production, work-in-progress inventory, delays in the flow of materials) has a high (H) impact on the organization of production – it disrupts material flows, generates storage costs, or poses the risk of loss in product quality. The same solutions as for overproduction waste are also recommended for the reduction of inventory waste.

The waste of waiting included: workers waiting for material, tools, or documents, waiting due to a failure of machines or changeover, material waiting for processing, as well as an uneven workload of machines. The applied methodology leads to the conclusion that waiting waste has a high (H) impact on the implementation of production tasks, it is therefore proposed that the following solutions are adopted:

VSM – to graphically present the flow of materials and information in the process, allowing for the identification of waste and taking corrective measures,

Red Tags – to identify and remove problems (failures, machine defects) within the TPM system,

work standards in compliance with the Training Within Industry (TWI) program as regards work methods and instructing workers,

cleaning, lubrication and control standards for operators within TPM;

machine manuals, control standards, checklists, OPL in matters of SMED for operators,

involvement of operators in kaizen training projects to reduce waste.

The waste of motion is connected with excessive motion of workers caused mainly by an improper organization of workplace in the production hall. It was determined that motion waste has a medium (M) impact on the organization of production. The recommended measures to reduce it are to follow the principles of the 5S method and use VM in the form of designation and marking of the working space and places where materials and tools are stored. The adoption of a kaizen suggestion scheme may also be a solution to the problem.

The waste of over-processing concerned the problem of synchronization of processes in some production areas as well as the use of wrong procedures or failure to understand them due to their complexity or lack of clarity. The result was a failure to satisfy customer requirements and loss in quality. Given that the waste of over-processing had a high (H) impact on the organization of production, the adoption of the following measures is recommended:

VSM to graphically present the problems in the production hall and undertake actions to facilitate the effective material flow in the process,

clear, visual standards, procedures and work instructions: one point lesson (OPL), TWI standards, standard operation procedure (SOP).

The identified defects waste (products that do not meet customer expectations, poor quality of materials supplied to the process, errors in documentation) had a high (H) impact on the organization of production – it entails additional costs of repeated processing or repair. In order to reduce defects waste it is recommended that poka-yoke solutions be applied in selected areas of processes and in every case of control standards. It is also proposed that SOP or OPL are adopted in order to prevent errors. Quick kaizen projects submitted by workers as a suggestion system can be an additional solution.

Transport waste included: unnecessary movement of parts in certain areas of the enterprise (high impact), transport of materials over long distances (medium impact), errors in marking of transport routes (medium impact), which can affect the flow in the value stream and generate costs, in particular in case of damage to

Table 1 **Identification of wastes in the aspect of the improvement of the organization of production [own research]**

No	Type of waste	Examples of wastes in steel companies and their impact on the organization of production	The area where the causes of wastes occur (5M analysis)	Proposed LM solutions
1	Waste of overproduction	- production of a greater number of goods in order to avoid problems caused be a possible failure of the machine (H) - production completed in advance of the delivery time (H)	Man Method	VSM kanban standardization TPM
2	Waste of inventory	- inventory to ensure the continuity of production (H) - work-in-progress inventory (H) - delays in the flow of materials (H) - large warehouse spaces (H)	Method Material Machine	VSM kanban standardization TPM
3	Waste of waiting	- operator waiting for materials, tools, documents, decisions of superiors (H) - operator waiting while the machine is working (H) - waiting due to a failure of machines (H) - waiting due to changeover (H) - material waiting for processing (H) - uneven workload of machines (H)	Man Method Machine	VSM standardization SMED TPM kaizen
4	Waste of motion	- excessive motion between work stations and production halls (M) - difficult access to work tools (M)	Man Method	5S VM kaizen
5	Waste of over-processing	- problem of synchronization of processes (H) - failure to satisfy customer requirements, resulting in additional control and increased costs (H) - the use of wrong procedures, complicated procedures, lack of clarity (H)	Man Method Management	VSM standardization VM
6	Waste of defects	- products that do not meet customer expectations (H) - poor quality of materials supplied to the process (H) - errors in documentation (H)	Man Method Material	standardization poka-yoke kaizen
7	Waste of transport	- unnecessary movement of parts for the production in certain areas of the enterprise (H) - transport of materials over long distances (M) - possibility of damage of materials during transport (H) - errors in marking of transport routes (M)	Method Material	VSM standardization VM

material and products in transport. The following measures are recommended to reduce transport waste:

VSM to visualize the material flow,
visual marking of transportation roads (VM),
standardization of actions concerning the movement of parts for the production process.

The key element of the process of waste reduction is the ability to identify the reasons for the occurrence of waste. Given the above, for each of the listed wastes (Table 1), the areas of their occurrence were identified. The reason for wastes most often occurred in the areas related to: production methods (7 in 7 wastes), worker (5 in 7 wastes), material and machines (2 in 7 wastes). The actions related to the reduction of wastes should therefore be prioritized depending on the frequency of their occurrence in a given area of a steelworks.

CONCLUSIONS

The conducted analysis focusing on waste reduction in enterprises in the steel industry led

to the conclusion that the use of LM tools can significantly affect the improvement of the performed production tasks. A high impact on the organization of production is exerted by waste arising from: overproduction, inventory, waiting, over-processing, defects and transport. In view of the above, it is recommended that LM tools such as VSM, kanban, kaizen, 5S, VM, standardization, poka-yoke be applied. The use of LM tools in one area of the occurrence of waste will also lead to a reduction of waste in the remaining areas.

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Note: Marcin Gorgol is responsible for English language, Katowice, Poland