

IDENTIFICATION OF CAUSES OF WASTE IN THE EXPEDITION PROCESSES OF A METALLURGICAL ENTERPRISE

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Abstract

The expedition processes of the metallurgical enterprise are characterized by the high complexity that results from wide product portfolio, considerable size of products or the ever-increasing complexity of individual orders. Expedition centers of metallurgical enterprises are historically adapted to the formerly prevailing rail transport, instead of the currently prevailing road transport, and during the development there was not implemented a continuous improvement system that would allow them to adapt effectively to changing conditions. The aim of the article is to analyze the causes of waste in the expedition processes of metallurgical enterprises and to present possible approaches to their elimination, which will lead to efficient planning of the expedition or storage of products in the warehouse and to shortening the loading time.

Keywords: Metallurgy, expedition process, properties, applications, testing methods

1. INTRODUCTION

The aim of the study is identification of the causes of wasting within the expedition process of a metallurgical enterprise, representation of possible approaches to their removal and solving of invoked problems, which will lead to efficient planning of the expedition or storage of products in the warehouse and to shortening the loading time. Although the aim of this study is not direct implementation of the Lean Manufacturing principles, the conception of the leanness served as a base for the generalization of knowledge obtained during the study. The basic sources of wasting described in the original model of Lean Manufacturing [1] are herein extended and used for the classification of the causes of wasting within the expedition process. As presented in literature, the aim of the successful company is to provide added value of all inputs by connecting all the value-adding steps to a continuous flow. Other activities that do not add value to the inputs and are not necessary, we refer to as the waste or inefficiency. [2] Lean Manufacturing does not mean purposeless reduction of costs. Its purpose is, above all, to provide maximum added value for customers. Lean approach is the way to higher production of a company, lower overhead costs, more efficient utilization of its area and production machinery. Lean Manufacturing cannot work without close contact with product development and technical preparation of production, logistics and company administration. [3] A lot of studies attending to the implementation of the Lean Manufacturing principles or summarizing benefits of this approach can be found in the current literature [4]. As the expedition process studied in this article can be very well perceived as a logistic activity, study on hourly stability analysis by Besta [5] should be mentioned, because it represents one point of view on analysis and improvement of manufacturing process. Samolejová also deals with the causes of wasting in her study. She characterizes the causes of wasting going from four specifics of the metallurgical production [6]:

- Technological and technical basis of metallurgical processes,
- Material and energy demandingness,
- Large production batches and volume processed in a single cycle,
- High demandingness for organization and operational planning and control.

There is a series of methods for the identification of the causes of wasting, whereas one of the most significant methods is Value-Stream-Mapping, which is an improvement technique allowing visualization of an entire

production process, representing information and material flow, improvement of the production process by identifying waste and its sources [7]. The parameters involved in VSM can be inventory, cycle time, changeover time, uptime, number of operators and shifts, scrap rate, pack, pallet and batch size and distance travelled [8]. Sá et al. [9] presents a new method referred as Waste Identification Diagram, which comprises of three basic types of waste, namely inventory, overproduction and transport and should provide a visual outcome easy to understand by management, which overcomes some limitations of VSM method. In the context of the specifics of the metallurgical production and historical development, especially regarding the increase of complexity of the portfolio of the manufactured products and a transfer from the railway transport to the road transport, it is possible to assume that the expedition process plays a key role in the satisfaction of customers' needs and increasing of effectiveness of the entire enterprise. The herein presented analysis of the expedition process of a metallurgical enterprise is a base for a proposal of a diagram serving as a methodical utility for carrying-out of the expedition process analysis in a metallurgical enterprise in general. The use of the diagram will enable systematical analyzing of the expedition process with regards to the main types of wasting and identification of separate causes of wasting for their next analysis and consequential removal.

2. METHODOLOGY

The subject of the study of wasting was the expedition process of a metallurgical enterprise, respectively of an expedition center of a middle-fine rolling plant. Arrival of a truck to the road transport gate of the company area was selected as the start of the investigated process, while departure of the truck to a customer was set as the end of the process. Controlled interviews with participation of employees across the hierarchal levels of the enterprise from workers to the top management served as a fundamental method of obtaining knowledge for the presumed analysis and consequently for its methodical generalization. Structural correspondence questionnaires were also used for the collection of information; and group brainstorming were realized as well for this purpose. The first step of the analysis of the processes of the expedition center focusing on the identification of the main causes of wasting was process mapping, which was performed in cooperation with the managerial staff according to the BPMN methodology. The output of the expedition process mapping was a model performed in a graphical BPMN notation, which was compared with the actual process schemes used in the enterprise for identification of deviations and inconsistencies of real and assumed realization of the process. Based on the process map, outputs of the controlled interviews and structural questionnaires, main problem areas and causes of wasting were identified, which were used as inputs for the group brainstorming, the purpose of which was to identify a maximum possible spectrum of the problem areas, process weaknesses or causes of wasting in the expedition process. The base for the generalization of the outputs of the performed analysis of the processes was a Lean Manufacturing philosophy. Basic types of wasting coming from the original, respectively by 8-type-of-wasting extended, Lean Manufacturing philosophy were used for the construction of the modified Ishikawa causes-and-consequences diagram, in which - instead of original, standardly used - it creates the main branches of the diagram or main groups of the causes of the problem, by which the wasting in the expedition process was indicated. The Ishikawa diagram, within generalization of the obtained knowledges, was completed with auxiliary branches of causes falling into separate main categories.

3. RESULTS

Metallurgical enterprises are, as a rule, big complex enterprises, the operation of which is linked to a big volume of logistics operations. Metallurgical enterprises produce within big manufacturing campaigns by technological and economic reasons with the aim to minimize production costs and to fully utilize production capacities of the metallurgical aggregates. That's why it is necessary to be especially careful with the inventory management and make sure that wasting in the logistics doesn't exceed savings from the production. Customers at the present time continue to impose more and more individual requirements towards their suppliers, and that is both in the production sphere (quality, sizes, modifications, types of products) and in the logistics sphere

(package, JIT, marking, method of transportation). These individual customers' requirements result in more and more expanding portfolio of the manufactured products and more and more growing complexity of the expedition processes.

Metallurgical enterprises were also historically fitted to the railway transport, which predominated in the past. The road freight transport, however, prevails at the present time, and expedition processes, thus, cannot be effectively performed in the company's area. As was found out from the analysis of the actual state of the expedition processes of the metallurgical enterprise, although there are internal regulations and other standards defining how the expedition has to be performed, controlled and implemented, the real expedition process is often proceeded in absolutely different way. This discordance between the required and real state of the expedition processes is caused by a series of factors such as out-of-date standards, insufficient familiarization of employees with the regulations and methods, insufficient information flow between workplaces, extern influences (suppliers, customers, forwarders), incorrect presumptions, bad organization and coordination of the expedition processes.

Inadequacies and deviations were identified in the study of the expedition processes compared with the required state, which influence the quality of the expeditions process and result in the origination of below-described cases of wasting, see **Table 1**.

Table 1 Main causes of waste in expedition process of metallurgical enterprise [own study]

Shortage area	Waste type	Cause	Consequences	Solution
Expedition warehouse layout	Inventory Waiting Motion	Over fulfillment, Overproduction, Non-systematic warehouse management, storage of products regardless of future expeditions	Increasing load time, unnecessary motion, Ineffective space utilization	Dynamic layout system, expanding warehouse
Information systems	Over processing Transportation Motion	Obsolesce, Incompatibility, Historical development, insufficient server capacities	Insufficient info/data flow, errors in expedition planning	Increase of server capacities, integrating of IS
Transport infrastructure	Motion Transportation Waiting	Historical development, Need of high investments	Complicated truck manipulation, Ineffective space utilization	Redesign and reconstruction of expedition center
Expedition planning and coordinating	Waiting Motion	Insufficient info/data flow, Non-integrated ITS, Expedition planning regardless of delivery specs.	Unnecessary movement of trucks, unnecessary manipulation with supplies, Increasing load time	Increasing info/data flow, Expedition planning regard of delivery specs. Dynamic system for truck loading organization
Expedition center capacity utilization	Unused potential Waiting Correction	Carriers prefer certain day times, Drivers working mode	High waiting times of trucks, unused capacity in unpopular day times	Efforts to fulfill the unused daily times
Workforce of expedition	Motion Waiting Unused potential	Insufficient staffing	Increasing load time, Overworked workers	Increasing expedition workforce, Effective shift planning regard of daily peaks
Manipulating devices	Waiting Correction	Obsolesce, Need of high investments, Disturbance, Unplanned maintenance	Increasing load time, Blocking of expedition center in case of breakdown	Regular maintenance, device modernization

Possible approaches for the elimination of the main causes of origination of wasting and recommendation for their solving were proposed for the most significant problem areas:

- 1) **Expedition warehouse layout** - An analysis of the portfolio of the stored products from the point of view of their volume and turnover rate is recommended to eliminate wasting in the sphere of the products storage in the expedition warehouse. Based on the analysis, a methodology for products positioning and a new layout of the storage areas will be created. With regards to an extensive portfolio of products manufactured by a metallurgical enterprise, it is necessary to create a dynamic algorithm for employees of the expedition warehouse, which must take into consideration not only the turnover rate of the products, their volume and sizes, but also a dead-lines of their planned expedition. A benefit of implementation of this recommendation is a functional system for products positioning and effective utilization of the spatial capacities, which leads to the decrease of the average loading time and to a reduction of the average waiting time of the trucks.
- 2) **Information systems** - A frequent inadequacy is unavailability of data and information necessary for the employee for expedition planning and organization. The solution consists in setting of simple export groups or assignation of an access to the given system. Insufficient integration of a factory information systems, which causes irrelevance of information and discordance of data in separate systems, can be solved with IS suppliers in a form of an integrating project, by increasing server capacities for the provision of more frequent data exchange or by implementing a unique complex IS. A benefit of the growing integration of factory information systems is accessibility of all necessary information, relevance of data and information as well as improvement of the information flow between separate workplaces, by which occurrence of errors and misunderstanding in planning and expedition organization will be reduced.
- 3) **Transport infrastructure** - By reason of historical development, expedition centers in most of metallurgical enterprises do not comply with the freight transport. To optimize functionality of the expedition center, it is necessary to optimize movements and routes for the trucks and to use effectively the space in the expedition center. Thanks to its investment demandingness, mostly an impracticable solution is a complete reconstruction of the expedition center so that it complied with the needs of the road freight transport. A real solution consists in organizational or minimal structural modifications, optimization of the utilization of the capacities and possibilities of the expedition center, which ensure easier and safe movement of the trucks inside the expedition warehouse, optimization of the routes of arrival and departure of the trucks.
- 4) **Expedition planning and coordinating** - To eliminate wasting in expedition planning, it is advisable to pay attention especially to the information flow, which accompanies planning, and provide - on the basis of the performed analysis of the process - the accessibility of necessary information for all touched employees. To enable optimization of the expedition coordination process in the expedition center, it is necessary to analyze data on expeditions and classify different types of expedition cases by their average loading time and other optional specifications. Based on the analysis, it is then recommended that a dynamic algorithm to be created, which coordinates the course of expedition and determines the order of the dispatched trucks on the basis of specifications of separate deliveries. A benefit of the implementation of the above-mentioned recommendations is optimization of the entire organizational and planning process, leading to the minimization of excessive movements of the trucks, storing operations and to the decrease of the average waiting time and loading time of the trucks.
- 5) **Expedition center capacity utilization** - It is necessary to achieve uniform exploitation of the EC. The base is the analysis of the volume of the dispatched trucks and their distribution within a day and week. Afterwards, it is necessary to try to fill up the unused times and, on the contrary, to discharge so called picks (daily/weekly). Expedition centers, as a rule, are in operation uninterruptedly in connection with continuous operation of the metallurgical aggregates. Non-uniformity in utilizing capacities of the expedition center is caused by external influences, for example, by a market force of the forwarders

which, using the actual market situation, can choose orders and determine conditions of transportation. Because of a series of reasons, forwarders give priority to the day-time for dispatching instead of the night-time. A forwarder can be motivated to use non-exploited time-windows by financial bonuses or by a preferential position among forwarders. The uniform utilization of the expedition center capacities enables increasing a number of loaded truck, decreasing the average waiting time of the truck and limitation of wasting by the non-usage of the capacities.

- 6) **Workforce of expedition** - To eliminate wasting in the expedition process caused by ineffective planning of work-shifts, it is necessary to evaluate whether the number of employees in a usual work-shift is enough for the smooth course of the expedition processes and whether it is suitable to have a stable number of employees in each work-shift or whether it is the most suitable to adapt the number of employees in the work-shift dynamically with regards to daily and weekly picks in the expedition. Implementation of work-shift planning depending on the exploitation rate of the expedition center brings shortening of loading times and shortening of the load rate of the employees of the expedition in daily and weekly picks. On the contrary, when the capacity of the expedition center is not fully used, this flexible planning brings savings of personnel costs and decreasing of wasting caused by non-utilization.
- 7) **Manipulating devices** - Elimination of wasting caused by a bad state or insufficient performance of manipulating devices has to be initiated by an analysis of data on operation of these devices both for a number and exploitation rate of the device, wearing and obsolescence, a failure rate, an average time between reparations and an average duration of reparations. After having performed the analysis, it is necessary to go on depending on recognized facts by modification of the number of manipulating devices as well as by optimization of maintenance or renewal. Implementation of the above-mentioned actions increases the general effectiveness and capacity of the expedition center. The optimal number and state of the manipulating devices reduces the average waiting and loading times of the trucks. Improvement of the maintenance system prevents from failures requiring unplanned repairs, which invoke wasting from non-activity of the expedition center and wasting from waiting of the trucks.

4. GENERALIZATION OF THE STUDY RESULTS

On the basis of the realized study, we can - based on the identification of wasting in the expedition process, which serves as a base for the proposal for their removal - recommend a general procedure consisting of the following sequence of activities:

- Expedition processes analysis - processes mapping, controlled interviews, measurement in operation, analyses of data.
- Expedition processes evaluation - evaluation of effectiveness and maturity of the processes.
- Identification of weaknesses - with help of the model Ishikawa diagram.

Using the principles of the Lean Manufacturing philosophy, a model Ishikawa diagram was compiled for the identification of wasting in the expedition processes of metallurgical enterprises, which is a suitable method for the initiation of a process of gradual improvement of the expedition processes in the metallurgical enterprises; it conducts the assigned employees by separate types of wasting and warns of their main causes. Based on a concrete state of the expedition processes, it is possible to adapt the diagram and complete it with other causes of wasting for the specific conditions of each enterprise. The diagram, see **Figure 1**, is compiled from 8 main branches, which carry the marking of the main types of wasting according to the Lean Manufacturing philosophy. Auxiliary branches of each main branch carry marking of the main causes of wasting discovered on the basis of the realized study.

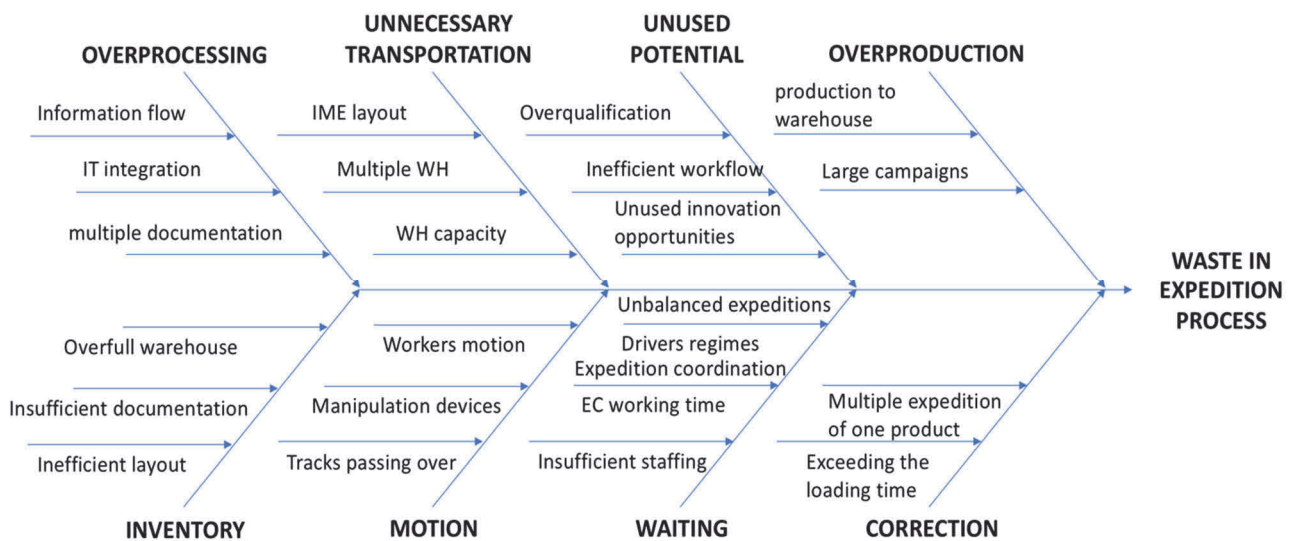


Figure 1 Ishikawa diagram of causes of waste in expedition process

5. CONCLUSION

On the grounds of the expedition process analysis of a concrete metallurgical enterprise, main causes of wasting were identified, and frame approaches of their solution were proposed. Based on the performed process analysis, a model Ishikawa diagram was created with the use of ideas of the Lean Manufacturing conception, which can be used at identification of the causes of wasting in the expedition process of the metallurgical enterprise. The proposed approach will enable performance of the first fundamental step to the employees of metallurgical enterprises without implementation of complicated methods and approaches on the route to continual improvement of the factory processes, respectively the expedition processes, in which in the case study there were discovered a lot of occasions for the improvement and removal of wasting, which resulted in considerable costs. The proposed structure of the causes of wasting should serve as a base for the iterative investigation of the expedition processes of metallurgical enterprises, which will enable systematical work related to the removal of the causes of wasting and increase of the effectiveness of the expedition process, which significantly influences the effectiveness of the entire enterprise.

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