ORGANIZATION OF INTERNAL TRANSPORTATION AS AN ESSENTIAL ELEMENT OF THE PROPER COURSE OF LOGISTICS PROCESSES IN THE SUPPLY CHAIN OF A STEEL COMPANY

KULIŃSKA Ewa[1], ODLANICKA-POCZOBUTT Monika[2]

[1]Opole University of Technology, Faculty of Production Engineering and Logistics, Department of Logistics, Poland, EU

[2] Silesian University of Technology, Department of Organization and Management, Poland, EU

Abstract

The article the processes of flow of material goods and information in the transportation system of a steel company were analyzes in terms of their impact on the entire supply chain, including the processes of internal transportation. The aim of this publication was to develop a model for assessing organization and internal transportation costs with regard to the supply of materials and raw materials between different sources (inlets) and outlets in the steelmaking process. The model was verified based on a case study conducted in the Huta Małapanew steel plant, in Ozimek. The simulation was concerned on the possibilities for improving transportation in terms of organization and in terms of reducing the overall costs.

Keywords: Metallurgy, steelmaking, internal transportation, assessment model

1. INTRODUCTION

Iron and steel industry is the oldest branch of the metallurgical industry in Poland. By the middle of the nineteenth century, it was concentrated in the Staropolski Basin (the oldest industrial and metallurgical district in Poland, now a remanufactured steel industry). In the middle of the 19th century, a new metallurgical technology was introduced on Polish soil, which consisted in the use of hard coal, which enabled steel production to increase. At that time, iron and steel production concentrated in the Upper Silesian Industrial District (GOP), where there were rich coal deposits. After the Second World War the metallurgy was expanded by opening two large mills - Katowice Steelworks in Dąbrowa Górnicza and Huta Sendzimir in Cracow. In 1965, iron ore investment was abandoned due to its scarcity of resources. At that time Poland was dependent on imports from the USSR. At present, iron comes mainly from Ukraine and from Russia. In Poland there are 25 mills, of which 18 come from the period before WWI. The average age of metallurgical equipment is 40 years. In recent years there has been a decline in metallurgical production, which is due to the lack of demand and unprofessionality of this industry. Currently, Poland produces long products, ie rails, bars and semi-finished products of steel. Huts are located in the vast majority of the GOP and its neighborhood. The largest steelworks are located in: Dąbrowa Górnicza, Świętochłowice, Siemianowice, Zabrze, Cracow, Czestochowa, Zawiercie and Mała Panew in Ozimek. In addition, the steelworks are located outside the GOP and its vicinity: Ostrowiec Świętokrzyski, Stalowa Wola and Warsaw.

Steel plants (also known as “steel mills”) in which final products of the steelmaking process are manufactured usually form part of a larger steel company and its production is intended for further processing. This is the case in sectors such as metal sheet rolling plant or pipe rolling plant, for which steel is an input and only at this stage occur the manufacturing of steel and production of metal sheets, pipes and other steel structures. In terms of types of production (manufacture) processes and applied technological solutions, a steel company can be classified as an appliance industry, i.e. the one in which manufacture processes are differentiating. Full production cycle of a steel company is implemented in the logistics system according to the following steps: unloading of scrap metal, storage and classification of steel scrap in the scrap hall, loading scrap metal into the vat using cranes, transportation of steel load with the vat from the scrap hall to the furnace hall,

transportation of the vat with scrap to the furnace level, loading the scrap into the furnace, furnace operation (smelting time of approx. 50 min.), drainage of liquid steel into the vat, transportation of the vat using funnel crane to the ladle furnace, ladle furnace operation, enriching the smelting, steel refining, transportation of the vat with liquid steel to the position of continuous steel casting, pouring steel by piece, storage of steel pieces in the warehouse, transportation with the use of cranes and roller conveyors. The production cycle requires a smooth flow conditioned by internal transportation. As known, the primary task of transportation in the company is to move, in a given spatial area, load from its place of origin to the place of its reception (pick-up). The essence of this process lies in a conscious and coordinated, man-controlled movement of loads with the help of relevant equipment. The term transportation system refers to the system which is the structure of elements with specific characteristics, where the movement of objects is expressed in a stream of traffic flowing through the elements of that structure.[1,7,9,13] The transportation system should be considered in technical, economical and organizational terms.[2] A comprehensive grasp of the internal transportation system allows for identifying the problems involved in the proper course of logistics processes in a steel company.

The aim of the publication was to develop a model for assessing organization and internal transportation costs with regard to the supply of materials and raw materials between different sources (inlets) and outlets in the steelmaking process. The proposed model was verified on a case study conducted in the Huta Małapanew steel plant, in Ozimek. The simulation was concerned on the possibilities for improving transportation in terms of organization and in terms of reducing the overall costs. The authors analyzed the processes of the flow of material goods and information in the transportation system of a steel company in terms of their impact on the entire supply chain, including the processes of internal transportation.

To verify the objective, the following theoretical research tools were used: analysis, synthesis, generalizations, comparisons. In terms of practical methods as logistical audit and interviews with employees have been applied. The key achievements of the research described in the article include a draft model of the steel plant's internal transportation which determines the decision-making process with regard to functional interferences and reduction of additional costs.

2. ORGANIZATION OF INTERNAL TRANSPORTATION SYSTEM IN STEEL COMPANIES

Internal transportation (i.e. within the facility), as the subject of the analysis, supports the flow of materials, raw materials and semi-finished products within the company through handling processes of loading and unloading of goods during storage and production, as well as their movement between different stages of the technological process. The transportation and loading processes in warehouses are usually performed by trucks, pallet jacks, conveyors, cranes, etc. The production stage is served by production transportation, which is closely linked and subordinated to the technological processes characteristic to a particular industrial establishment. Depending on the structure of the company, production transportation can be divided into intra- and inter-facility transportation. The former supports various posts and maintains the continuity of the flow of materials and raw materials between these posts, whereas the latter provides the connection between departments, storage sites, warehouses and transshipment points, shuttling between them raw materials, semi-finished products and finished goods. Proper organization of transportation should ensure the movement of as many goods as possible, within the shortest period of time and at the lowest cost, to the appropriate reception points (also known as "pick-up points").[3,4,12] In terms of economics and organization of the above-mentioned transportation types, the best solution is peripheral transportation. In reality, however, one can come across more sophisticated systems. When planning transportation, one should strive for a system that, under given circumstances, indicates the best factor since the level of costs per unit of cargo depends on the use of transportation that has been opted for.

Organization of internal transportation system in a steel company depends on many factors characterizing heavy-industry companies and specific metallurgical processes. These include: system of inventory maintenance (network of warehouses, department warehouses, on-time delivery), production technology (flow

of goods), amount and distribution of inputs and outputs of the internal transportation system, condition of the owned transportation infrastructure, altitude differentiation of terrain, distribution of goods loading and unloading points, network of roads, railways and other systems of transporting raw materials and their connections with the departments, posts or warehouses of the steel plant, intensity of material flows between departments and warehouses, system of flow and processing of information.[2,5,11] Internal transportation in a steel company is determined by its organizational system of production. It comprises: rail transportation, road transportation, pipelines transportation, departmental transportation.[6, 10, 11]

Modeling of internal transportation also requires analyzing the process tasks in the operation of a steel plant. The tasks of internal transportation include: handling railway siding that forms input to and output of the system for rail transportation, handling inputs and outputs of the road transportation system, handling road and rail scales for external transportation, coordinating the flow of internal and external sources of transportation in the company's internal system of rail tracks, handling transshipment points, evaluating costs of transportation services for each department (internal control of cost levels).

Since the steel plant has a stabilized nature of production that is also "plannable", while the fixed connection with Poland's national railway network (PKP) - via railway siding - as well as the need for technical supervision of rail vehicles and rail tracks due to the rules of safety and rail traffic, rail transportation must be centralized. In this respect, it is subordinate to the head of the department of transportation who governs all issues related to the cooperation with the PKP, and in particular the ordering of railway carriages. Rail transportation serves individual departments plus warehouses and storage sites according to the plan and delivery schedule.[11, 13] Road transportation, due to the continuous nature of production in steel companies and also due to financial and organizational reasons (central service database, disposition and organization of traffic) is usually centralized and managed from above.[8, 11]

3. RESEARCH RESULTS-PROPOSITION OF A MODEL

Huta Małapanew Spółka z o.o. was founded on 1 July 2001 and operated formerly as Huta "Małapanew" S.A. in Ozimek. The steel plant is one of the largest manufacturers of steel castings in Poland and its main product range consists of: crude and refined castings, metallurgic rolls, machine parts (road wheels, roll equipment). The castings are made of approx. 200 grades of cast steel and cast iron in accordance with the PN/EN, DIN, ASTM, GOST, BS standards or based on the requirements of the client. Weight of a single rough casting ranges from 5 to 12,000kg. The products are ordered by all industries, in particular those that deal in mining, metallurgy, cement and lime, engineering, energy, shipbuilding, etc. The plant can run either unit or mass production. The castings are available rough (raw) or refined by means of mechanical treatment.

The basis for the creation of a logistics chain is to define and identify its potential links. As far as industrial enterprises are concerned, these links can be isolated on the basis of the analysis of various stages of production processes and spatial distribution of the points of their implementation.

In a steel company running a full production cycle, departments of raw materials are the initial source of the flow in the distribution channels and they form the first link of the internal logistics chain. These departments include coking plants and agglomerating plants (ore sinters) which are a source of fundamental raw materials for steelmaking. Coking plant is the department constituting an elementary link in the logistics chain with the blast furnace department. It is powered, mostly from outside, with the basic raw material, namely coking coal.

Blast furnaces are the outlet for the channel of distribution of the coking department's basic product, thus creating the initial link in the internal logistics chain. Movement of coke between the above-mentioned departments takes place by means of transportation. This process must take account of the storage site (buffer), which acts as a factor regulating the flow rate of this raw material in response to changing production capacity of the source and the demand of the outlet of distribution channel. Due to mass and volume production, mode of transport serving the distribution channel needs to be suitable for transporting raw

materials with high intensity. The bandwidth parameter of this channel, meanwhile, must include a surplus flow resulting from the need to restock. Such criteria are met chiefly by rail transport, provided adequate minimum distance between the source and the outlet or the place necessary in maneuvering long carriages. An alternative to rail may, in this case, be belt conveyors capable of conveying solids in a continuous manner, which makes it possible to obtain a continuous stream flow of material. Agglomerating plant - this second division of raw materials is the recipient of iron ore. In its production process takes place pre-treatment of the raw material. As in the previous case, mass production of this department also determines the choice of means of transportation. For the production process of ore sintering, coke is consumed as an energy resource, and its supplier (source) is most often its original coking plant. This gives rise to the interdependent system where the coking plant is the raw material base for almost all elements (departments) of the steel company's production system, with coke -raw material requiring transportation by the relevant means and handling equipment - is mainly used by agglomerating plants and blast furnaces. Transportation of these media is automatized, with high flexibility in intensity, by transfer transportation. In the case of consuming large amounts of the above-mentioned media and a small distance from the source to the outlet, the best option is the pipeline transportation. The above-mentioned departments, through their relationships resulting from the production process, may form the first links of the internal logistics chain.

Each link as an integral part of the logistics chain requires control of flows. To specify the control and its methods, one should adopt appropriate assessment criteria. The basic criterion, here, could be the time or cost of flow, although one should also account for its impact on the entire logistics chain and total costs.

Another potential link in the internal logistics chain Is found in the department of blast furnaces as the source and the steelmaking department as an outlet of the distribution channel. The specificity of this channel is determined by the type of raw material and technical conditions that must be satisfied during transportation. Such requirements are met by rail transportation in conjunction with the hardware and specialized equipment to perform handling activities and transportation of liquid metal. When transporting a vat of hot crude iron, it is required to comply with safety regulations and applying the just-in-time rule. This is due to the difficulty of maintaining a sufficiently high temperature of the crude iron in the long term. This comes with additional costs. Another reason for employing the above rule is sequentially of the steelmaking process, on the basis of which one can predict the time of receipt of the next batch of liquid crude iron without unnecessary storage. Managing flows of raw materials between the supplier and the recipient comes down to synchronizing this process. This requires a continuous flow of information in order to determine the optimal timing of transporting the vats through deliberate slowing down or speeding up the technological process, both at the sender and the recipient's end.

Depending on the steel plant's production capacity, size of one-time delivery and dimensions of the vat, it may be needed to store an appropriate amount of crude iron so as to meet the demand for the one-time delivery. The initial product of the steelmaking process, depending on the technological level of steelmaking as well as the company's structure at the basic processing level, may be sequential or flat ingots, with the former meant for processing in metal sheet rolling mills and the latter - for pipeline rolling mills. If these rolling departments form part of the steel company in question, we then have to deal with two further links of the internal logistics chain. Transportation of hot ingots between the plant and the native rolling mill must meet the conditions of speed and efficiency. This is due to the degree of synchronization of production processes of the source and the outlet of the distribution channel, as well as to the technical conditions resulting from technical parameters (i.e. temperature, dimensions) of the transported load. Loss of heat by ingots increases the cost of production in terms of energy consumed in the process of heating up the load to an adequate temperature. Factors influencing the heat loss include: distance, process time, environmental conditions (atmospheric conditions). The existence of subsequent links in the internal logistics chain depends on the degree of vertical diversification of the steel company in the sphere of complex processing (profilers, welded constructions, tanks etc.).[1, 2, 10]

Put it in more general terms, the system of materials' flow can be analyzed using the network model. The system in question can be considered at two different levels - between different companies and between different regions. If we were to assume that the company's departments are independent enterprises, then the system of materials' flow between these entities can be compared with the modified X-system. Streams of materials from several companies (departments of raw materials) consolidate here within the steelmaking process between two points (blast furnace and steelmaking department) only to subsequently deconsolidate into smaller streams, dispersing and heading toward the enterprises (departments) processing the raw material into the finished product offered to consumers. The processes of raw materials' flows in the presented network, regarding internal transportation between various links of the logistics chain, implemented by the transportation department, must be coordinated. In order to coordinate the processes of transportation (flows), there must be potential streams, and one must additionally take into account a number of factors described on **Figure 1**.

Internal transportation is designed to service flows between departments which result from the production process. Most of these processes are carried out by means of rail transportation due to the technical conditions of production, physical characteristics of goods and thee fact they are mass-produced. This last feature is common for supplies of raw materials to departments located at the start of the internal logistics chain.

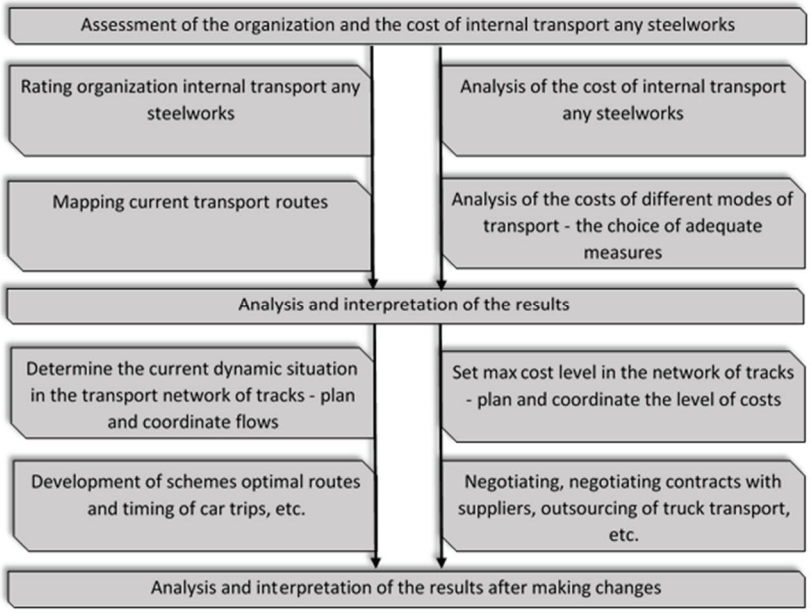

Figure 1 Assessment model of logistic processes in the steel company in terms of organization and costs of the company's internal transportation

Source: own study

The department of transportation, responsible for the railway flows within the company and cooperation with carriers, acts as the-so called third participant in the internal logistics chain. Here, one should note the inability to define all the links of the company with the environment. To plan activities of the company, one selects from the environment these signals or data that are believed to be essential. The company's environment is always more complex and relations with it are less known and understood than relations within the company itself. Between the enterprise, as a system of action, and the environment there is always certain reduction of complexity (data selection) representing a conventional boundary of the enterprise.

The boundaries of the research area, as defined by the authors, are marked by the processes of loading and unloading of raw materials transported into and out of the steel company, carried out by road transportation. In the case of rail transportation, the border point is considered to be the railway siding, serving the drop-off and pick-up function of the transportation into and out of the company, or an external company located at the

plant's site. Border processes of the research area, for rail transportation, are transportation to and from the siding. If the rail transportation to or from an external company located at the plant's site, the border processes are loading or unloading conducting in the steel plant's department. Internal processes of internal transportation are loading in the source, transportation and unloading in the outlet, including buffer warehouses. The functioning of the model of the system is carried out by extracting data from the outside through the boundary flows and their subsequent conversion into output data. This action activates along the way the decision-making processes relating to internal transportation. All the processes involving selection (i.e. decision-making) are based on iterative procedures (algorithms in the form of mini-specification). The way the model and its processes are constructed abstracts from the type and organizational structure existing in a particular company. This allows for verification of the model based on the actual system and in the process of improving its functionality in the context of e.g. costs and assessment of process organization.

4. CONCLUSION

The steelmaking industry is highly susceptible to transportation. This fact directly affects the existence of a closed-cycle flow of raw materials and steel products, where the company acts as the connecting link. All objectives currently implemented in the Polish steel plants, in accordance with global trends, ultimately strive to achieve lower manufacture costs of steel products. One cannot here ignore the fact that logistics costs make up for significant share of the total costs in the steelmaking industry. Polish steel companies in the process of restructuration and reorganization simultaneously need to reorganize the logistics processes, including transportation ones. This becomes necessary since these processes significantly affect operating costs of the enterprise, especially that in most cases these systems were designed at a time when logistics costs were not deemed particularly important.

In this situation, it becomes helpful to form logistics chains that will globally, via the organizer of the chain, the so-called "third participant", transport raw materials and final products to the end user. In order to improve the efficiency of transportation processes in manufacturing companies, it is necessary to build such a transportation system which, combined with the flow of information, will be the basis of logistic chains serving the internal flows of material goods and information, and will ensure the effective integration with transportation of suppliers of materials and raw materials from outside by external means of transportation (e.g. scrap transportation by rail). Consideration of the proposed model will improve the flow of information and material goods in the transportation of the internal logistics chain and it will also reduce interferences occurring at the interface between organizational systems and logistic units participating in the logistics chain.

Organization of internal transportation in the enterprise should provide transportation of a certain amount of load along the shortest possible routes, at the highest rate - and at the same time with the lowest possible consumption - of usage of means of transportation. With a comprehensive look at the processes taking place in the company, one can make the right decisions relating to the constituent parts of the company, that will also be optimal across the entire scope of its activities. This approach is particularly important for internal transportation as an essential element of the logistics chain. It will enable to implement the cost-reduction plan for transportation and analyze this process in terms of the consequences for the logistics system of the steel company. The proposed model optimizes the flow of processes in the transportation system across the company in terms of its organization. The algorithm of process occurrence in internal transportation models the processes of transportation including loading and unloading in each link of the internal logistics chain. It is possible to develop a mathematical model based on the algorithm of the processes and calculate the total costs associated with internal transportation, what would be desirable.

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