THE PRINCIPLES AND SPECIFICS OF LOGISTICS OF METALLURGICAL PRODUCTION

Dušan MALINDŽÁK a, Andrzej GAZDA b

a Logistic Institute of Industry and Transport, Faculty BERG, Technical University of Košice, Slovakia, dusan.malindzak@tuke.sk

b The Faculty of Management, Rzeszow University of Technology, Poland, agazda@prz.edu.pl

Abstract

The metallurgic production is characteristic for its continuous – discrete types of production processes form the side of material flow and also from the side of equipments and machines. Logistics of these production processes has specifications like: long production cycles, great inertia (thermal processes), tree structure (from roots up to the leaves), high price of construction etc., and from these it resulted the of Feed Forward management. In this article there are described these specifics and their impact to the production logistics. Application of the principles of logistics is explained in the production process of continuous slab casting, their heating for rolling temperature and rolling itself in hot wideband line.

Keywords: logistics, metallurgical production, continuous slab casting

1. INTRODUCTION

Logistics is a science of management, implementation and assurance of flows and chains with the target of their globalisation and optimising [1]. Logistics is universal and sectional science that is why the specification of the logistics of metallurgical production is followed on mainly from the object of management i.e. metallurgical production processes. The production processes of metallurgical production have several specifications, which have to be accepted while managing them [10].

Metallurgical production process is a chain of continuous and discrete technological operations which have to be transformed into a discrete first at modelling these processes. Then, there are a long production cycle and also great inertia especially for thermal processes, long delivery cycles of supplied material (even several months), typical tree structure of the production process [1] and from these it resulted the strategy of Feed Forward management [1]. Metallurgical companies are huge companies it means very high investments (even mld. of Euro) and it resulted into long return of investments and high lifetime [7]. Metallurgical products are at the beginning of a product chain. These products are materials like metals, semi-products (plates, pipes, wires) that is why a product with the different than planned quality do not need be a scrap (as it is e.g. in machinery or electro industry) and it can be still used for lower quality purpose. The output of these production processes is the only one or narrow assortment of products.

These and other characters of metallurgical production processes – chains classify these production processes into a so called Homogenous production processes. The costs for atomizing, informatics, logistics are relatively low compared with the costs for building-up technology and equipments, but if all of these approaches bring minimal 5% of savings, in absolute value these savings are high for the certain companies. That is why the metallurgical companies are leaders in these applications that mean also leaders of logistics as well as production logistics. [1], [3].

2. TRANSFORMATION OF CONTINUOUS – DISCRETE PRODUCTION PROCESS INTO DISCRETE

Production process is a system - chain of production, transport, manipulation and storage operations which contribute to the production of a product at a certain production section. Production operations can be mechanical, thermal, chemical etc., are processed in one machine, equipment, workplace. Mechanical
operations can be discrete but chemical or thermal are running continuously. This complicates modelling, simulation and managing of production process. That is why the process has to be changed.

2.1 Transformation of continuous production operations into discrete

Production operation can be passed through a machine which works discrete (e.g. slabs to pusherer furnaces are pushed in certain time) or continuously (e.g. blast furnace processes of slab casting). Material flow can be also continuous (slab casting) or discrete (pusherer furnaces, rolling line). Theory of managing of these chains, methods of modelling, simulations [8] needed for managing and optimising are not sufficient elaborated. That is why this type of chains is transformed to discrete first and then they are modelled, managed. It is used the method of black box – the application of the input – output standpoint for the discretization of these processes. If individual pieces of equipment and operations in any production process are viewed from the input - output standpoint, it is possible to consider every production process a discrete one, i.e. equipment is to be imagined as a “black box” in which is not progress of operation but the external display is of interest, i.e. duration time, start of operation, finish of operation, etc.

2.2 Discretization of continuously operating equipment

Operation of continuously operating equipment such as crushers, blast furnaces, transport conveyor belts, etc. is made discrete by calculating the time in which they treat material flow unit, e.g. 1 ton. For example: The performance of a jaw crusher is 30t/hr, i.e. it treats 1 ton in 120 seconds. This way the performance of all continuously operating equipment in the production process is to be calculated.

2.3 Transformation of production processes with changing structure

Production processes with changing structure are transformed into processes with fixed structure by considering the moving elements (vehicles, wagons, etc.) as a static. Transport time of a certain number of material flow units which are transported by these elements is then the time of operation duration. (Time is calculated from the means of transport speed, transport distance and bearing capacity). This way a continuous - discrete production process with changing structure is transformed into a discrete production process with fixed structure.

3. THE LOGISTICS OF METALLURGICAL PRODUCTION PROCESSES

3.1 The basic philosophy of management

The basic approach to management of homogenous processes results from the previously mentioned characteristics. If a feedback approach to management were used as a basic philosophy, as shown in figure 1, the result would be that the system starts to eliminate an aberration only after a breakdown appears at the output end or in case the "e" aberration is discovered respectively i.e. a breakdown occurred in the production process.

$$e = w_z - y \neq 0$$

$$\tau_{por} = \tau_z + \tau_y + \tau_o + \tau_u + \tau_N$$

The result of this is that the production process must operate in the breakdown regime during $\tau_{por}$ time. From the standpoint of large productions of homogenous production processes it is possible that a production of great value is produced in a short period of time.

Another problem is great inertia of homogenous processes. This means that the transfer of the system into the required pre-breakdown condition can also last for hours (e.g. a blast furnace). The philosophy of feedback management as the basic philosophy is therefore not appropriate for homogenous production processes. Feedback management is not capable of ensuring the invariability of a homogenous production process output.
Feedback management with negative feedback is, however, of global sensibility, i.e. if a breakdown occurs in any element of production process management system or in the production process itself, it shows at the output end at all times and management works in its counter-direction.

Let us investigate the second basic way of management - feed-forward management (compensation management). Figure 2 shows a block diagram of feed-forward management according to the breakdown. Selected most important breakdowns which affect the production process are at the same time an input for the model of production process M. Quantity $y^*$ as a result of the breakdown effect on the model M is an image of how the breakdown shows at the output $y^*$ after $\tau_z$ time. The value of $y^*$ is compared to the planned values of $w_z$ and an aberration $e$ is calculated, based on which the management system develops the “u” management which affects the production process in counter-direction to the breakdown effect. In this management diagram a principle of double channelling is fulfilled, which is a necessary condition of accomplishing a complete invariability. This system of management is very speedy in many cases. Principal possibility of developing an invariant system resides in the fact that the inertia of a canal in which the breakdown occurs $z \rightarrow PP \rightarrow y$, can be significantly higher than of the canal $Z \rightarrow M \rightarrow y^* \rightarrow P \rightarrow e \rightarrow MS \rightarrow u \rightarrow PP \rightarrow y$, i.e. the following formula must be valid:

$$\tau_z \leq \tau_M + \tau_e + \tau_u + \tau_n$$

The basic problem is the development of a speedy M model. That is why a great attention is therefore dedicated to discretization of homogenous production processes because well - designed methods for discrete production processes modelling. The result form the above mentioned facts is that the basic philosophy of the managing – logistics of metallurgical production processes is feed-forward management. A disadvantage of feed-forward management resides in its local sensibility, i.e. the management system designed by the feed-forward principle of feed-forward management is sensible only of breakdowns located through the M model. Logically, global sensibility of the feed-forward management system and double channelling of the feed-forward management system within a single management system is offered for utilisation.

3.2 The principles of logistics

Logistics is a way of management in which the following is applied:


- system approach;
- co-ordination;
- planning;
- algorithmic thinking; and
- global optimization.

Any company has its own structures, rules, objectives- is unique and it has also unique logistics. Slabs of required sizes are cast by two pieces of equipment for continuous steel casting (ZPO I. and ZPO II.). The diagram of material flows is in Figure 3. The cast slabs are transported either to the slabs preparation plant where they are adjusted before rolling and from there to the cold slabs storehouse (cold storehouse) or are directly transported to four push furnaces (NP 1 to NP4). After heating up to the rolling temperature they are pushed out from the push furnaces and transported by a roller table for rolling at hot rolling mill (TŠP 1700). The field stock yard serves to balance the differences in production at times of regular repairs on TŠP 1700 or of operation shut downs of ZPO I. or ZPO II.

The three main elements i.e. TŠP 1700, NP1 - NP4 and ZPO I. and ZPO II. have their own system of operating planning. Each single unit is understood as units of one system, their mutually relations create material flows, but also information relations in the way of operative plans.

One of the goals of Steel division production management is to coordinate production operating plans of TŠP 1700, NP1-NP4 and ZPO I. and ZPO II. in order to accomplish the maximum portion of slabs in direct sequence (ZPO - NP - TŠP) thus solving the problem between the difference production capacity of slabs preparation plant (approx. 1.5 million tons yearly) and production of ZPO I. and ZPO II. and TŠP 1700 (approx. 3 million tons yearly) but at the same time the more slabs there are in the direct sequence the less is the energy consumption for their heating up in the push furnaces (cold slabs are of outer temperature i.e. approximately 10 degrees Celsius, the temperature of hot slabs is from 400 to 600 degrees Celsius).

The fact that every hour a material flow of several million Slovak crowns flows through these aggregates requires very precise systems of short-term time planning. At TŠP 1700 it is a so called schedule of TŠP 1700, 24 hour and 7 days plan, at NP has a schedule of charging and at ZPO I. and ZPO II. has a schedule of casting.

Planning, system approach and processes coordination must be ruled by global optimization [9]. Individual elements of the production process have different criteria of optimization. For example, for TŠP 1700 slabs groups of the same type in the amount of 20 to 40 are beneficial for rolling from the standpoint of rolling technology because with such amounts the best exploitation of operation and support rolls of roll stands is achieved when changing the slabs groups according to certain rules.

It is therefore an effort of operating planning of TŠP to form groups with these amounts of slabs. From the standpoint of characteristics of production processes at ZPO I. and ZPO II. it is necessary to readjust the
crystallizer through which slabs are cast with every change of their size. However, the readjustment of the crystallizer means idle time of ZPO I. or ZPO II. and also a creation of a reducing slab which must be adjusted before rolling (if we know how to sell it in the final product) or it becomes scrap. The goal of ZPO I. and ZPO II. is therefore to cast the greatest series of the same slabs possible.

It results from the previously mentioned that local criteria of optimization must adopt to the superior global criteria, for example maximum profit, minimum energy consumption, keeping the confirmed terms of order etc. One of other characteristics of logistics is logical organization of individual operations of the production process and the algorithmic consistency of their effectuation. Algorithmic thinking ensures logical order of steps, activities continuation, activities repeating, compatibility in communication and realization. Likewise in algorithm, it can be a definite activity sequence, cycle, alternative selection-decision-making, etc.

3.3 The relations of management, logistic and technological operation control in the conditions of metallurgical process

Inner enterprise processes can be divided into three levels (see figure 5):

- economic processes;
- production, transportation and cumulation processes;
- technological processes (production operation).

![Fig. 5 An example of activities of these specific management levels](image-url)
These three groups of processes are characterized by other variables, other managing variables, other managing criteria. While technological process control is managing physically, mechanical, thermal and chemical variables like pressure, temperature, liquid level, speed of rotation, ratio among the variables etc. The management criteria are for example to find out optimal curve of heating with the aim defined economically e.g. minimal heating costs.

If the managing of production, transformation, transportation, cumulative processes are considered as the flow or network then it is the logistics. There are managing variables of time, place and capacity in the logistics.

Management – management of economical processes of an enterprise is based on the principle of hierarchic managing i.e. the logistics have to respect aims of a management, as the supervising level (if whole enterprise should work optimal) and aims of the logistics are moved behind the base level on the technological process management.

4. CONCLUSION

In the 60s – 70s of previous century, automation was the basic dynamic factor of production industry. The dynamic factor till the end of the century was information system, where systems like Steel man, SAP R/3 etc. include partly a logistics. The dynamic factor of early 21st century is the logistics.

From the logistic point of view each production process is different, each has its specifications and this is the reason why logistic systems are needed to be developed and implemented as the unique, “made-to-order” systems, based on the present conditions of modelling, simulation and information technology and applied their knowledge into heuristic models and expert systems.

Metallurgical companies, especially by reason of fast return of investments, are always the leaders of implemented automation, information technologies and they are also the leaders of the companies implemented the logistics in their production.

REFERENCES