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THE PHYSICAL FLOW OF MATERIALS AND THE ASSOCIATED COSTS IN THE PRODUCTION PROCESS OF A ROLLING MILL

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Efficiency of resources use is, in a large extent, determined by the organization of production flow and the way of their control. The optimization of materials flow in the production process requires the identification of physical flows of goods and it cost. In the article the physical flow process of materials stream in the production process in one of Polish rolling mill and also its logistics analysis and cost analysis are presented.

Key words: *flow of materials, rolling mil, associated costs, production process*

Fizički tijek materijala i pridruženi troškovi u procesu proizvodnje u valjaonici. Učinkovitost upotrebe resursa u velikome je dijelu određena organiziranjem toka proizvodnje i načinom njihove kontrole. Optimiziranje tijeka materijala u proizvodnom procesu iziskuje identificiranje fizičkog tijeka roba i njegovog troška. U članku je predstavljen fizički proces tijeka materijala u proizvodnom procesu u jednoj poljskoj valjaonici te njegova logistička analiza i analiza troškova.

Ključne riječi: *tijek materijala, valjaonica, zajednički troškovi, proizvodni proces*

INTRODUCTION

The flow of products through all phases of activity of an undertaking, i.e. supply, production and distribution, is accompanied by logistic costs. Taking into account all aspects and factors influencing the level of those costs is of great practical importance.

This is associated with the proper management of the undertaking. Many undertakings do not perceive the possibilities that are created by logistic management in the process of achieving the company's strategic goals, nor the relevance of logistic processes for the financial situation of the company.

Logistic costs are recorded to a little extent in Polish undertakings, particularly in metallurgical undertakings, as the applicable rules of cost recording and calculation are not adapted for this purpose. It is an obvious fact that logistic (material and informational) processes result in the occurrence of costs which, in practice, are not always identified with the costs of logistics. The recognition of the structure and nature of logistic costs is of key importance for the decision processes in a logistic system. It should be emphasized, at the same time, that the main objective of the identification of these costs is to find the methods and means of their reduction.

THE PHYSICAL FLOW OF MATERIALS IN THE PLATE MILL

The basic feedstock for plate rolling are slab ingots from the Continuous Steel Casting (CSC) line of the Steelmaking Department of the Steel Mill under discussion. The feedstock used may include also:

- slabs or CSC slab ingots owned by the customer who has ordered the plate,
- uphill cast slab ingots,
- returns from the rolling line,
- own slabs (rough-rolled uphill cast slab ingots or CSC slab ingots).

The majority of slabs coming from CSC is fed to furnaces in a hot state at a temperature of about 400 °C.

The physical flow of material in the production process encompasses the supply zone, the heating furnaces zone, the rolling mills, the heat treatment zone, the cutting line and the finished product storage.

The supply material delivery zone is composed of the following areas:

Hall I - uphill cast slab ingots.
Hall II - SCS slab ingots and a possible feedstock from

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external suppliers, either purchased or in service, SCS slab ingots requiring to be divided prior to being loaded to the heating furnaces and own slabs.

Hall III - the basic storage area of the ongoing deliveries of continuous castings.

In each hall, the first fields on the western side are intended for the storage of nonconforming stock that is the stock in which defects have been detected. Whereas, the fields situated in the close vicinity of the roller table are designed for the preparation of the stock to be loaded on the roller table [1].

The heating furnaces area includes 5 pusher furnaces for the soaking of slabs or slab ingots and 3 chamber furnaces. After the material has passed through the preliminary scale breaker, part of the slabs, particularly those of large mass, being preliminarily "singed" on the steel continuous casting line, is subject to cutting into two parts by means of a special cutting device, intended for the rolling of plates within low thickness ranges. The pusher furnaces are divided into heating zones of different heating capacities.

The rolling mills area is made up of the following:
- a vertical rolling mill for squaring of the side edges of slabs and for levelling out of slab ingot tapers,
- a four-high roughing mill with a scale breaker, serving for the rough-rolling of slabs and slab ingots into plates of a thickness above 40 mm,
- a four-high finishing mill with a scale breaker, equipped with stand rollers before and after the mill and a roll changing rig.

The heat treatment area enables the following heat treatment operations to be carried out:
- hardening,
- toughening,
- normalizing.

The hot finishing bank area includes:
- a normalizing furnace,
- a hot straightener,
- a stepper cooler.

The cold finishing bank area includes:
- cutting lines,
- control grids,
- plate ultrasonic examination units,
- plate painting and marking stands [3].

The finished product storage (shipping storage) is divided into the three following parts:
- commercial plates - plates stored according to major customers,
- small-format plates - (so called processing) small-format piece-plate, long piece-plate,
- redundant plates - to be recycled [1].

The physical flow of materials in the WBG (Plate Mill) has been drawn up on the basis of technological stands, supplementary data and relevant literature [2].

The Sankey chart (Figure 1.) of material flow in the Plate Mill does not allow for the method of transporting stock materials and finished products. The plate shipment storage is called the finished product storage.

The locations, where production wastes are generated and are subsequently transported to the Steelmaking Shop to be reused are marked with a dotted line in Figure 1.

The plate shipment storage is treated as a finished product storehouse of a very high material flow dynamics. The plate is transferred to the cutting line stand, where it waits for the positive results of laboratory testing; it will remain there until the shipping specification is prepared.

Plates in which defects have been detected in laboratory testing are put at the disposal of the Engineer, whose task is to reclassify them for another purpose.

In terms of their destination, plates are divided into the three following groups:
- plate intended for shipment - the shipment storage,
- plate in "inter-operations" - the inter-operation storage,
- plate to be utilized [3].

THE COSTS OF THE PHYSICAL MATERIAL FLOW

Logistic processes, covering both material and informational processes, as well as some elements of financial processes, result in the occurrence of specific costs which, in economic practice, are not always identified with the costs in the strict sense. They have, however, an influence on the overall performance of an undertaking by shaping its financial outcome.

The costs of logistics can be represented in various profiles. The division of the cost structure may have different purposes, both cognitive and practical. From the point of view of the basic components of logistic processes, three primary logistic process components have been distinguished, namely: the physical flow of material goods and information and stock-keeping. On this basis, the following groups of costs can be isolated:
- the costs of the physical material flow,
- the costs of stocks, and
- the costs of information processes [5].

The costs of the physical flow of material goods in a metallurgical undertaking belong to the basic group of logistic costs, being dependent on:
- the size of the infrastructure involved in the physical flow,

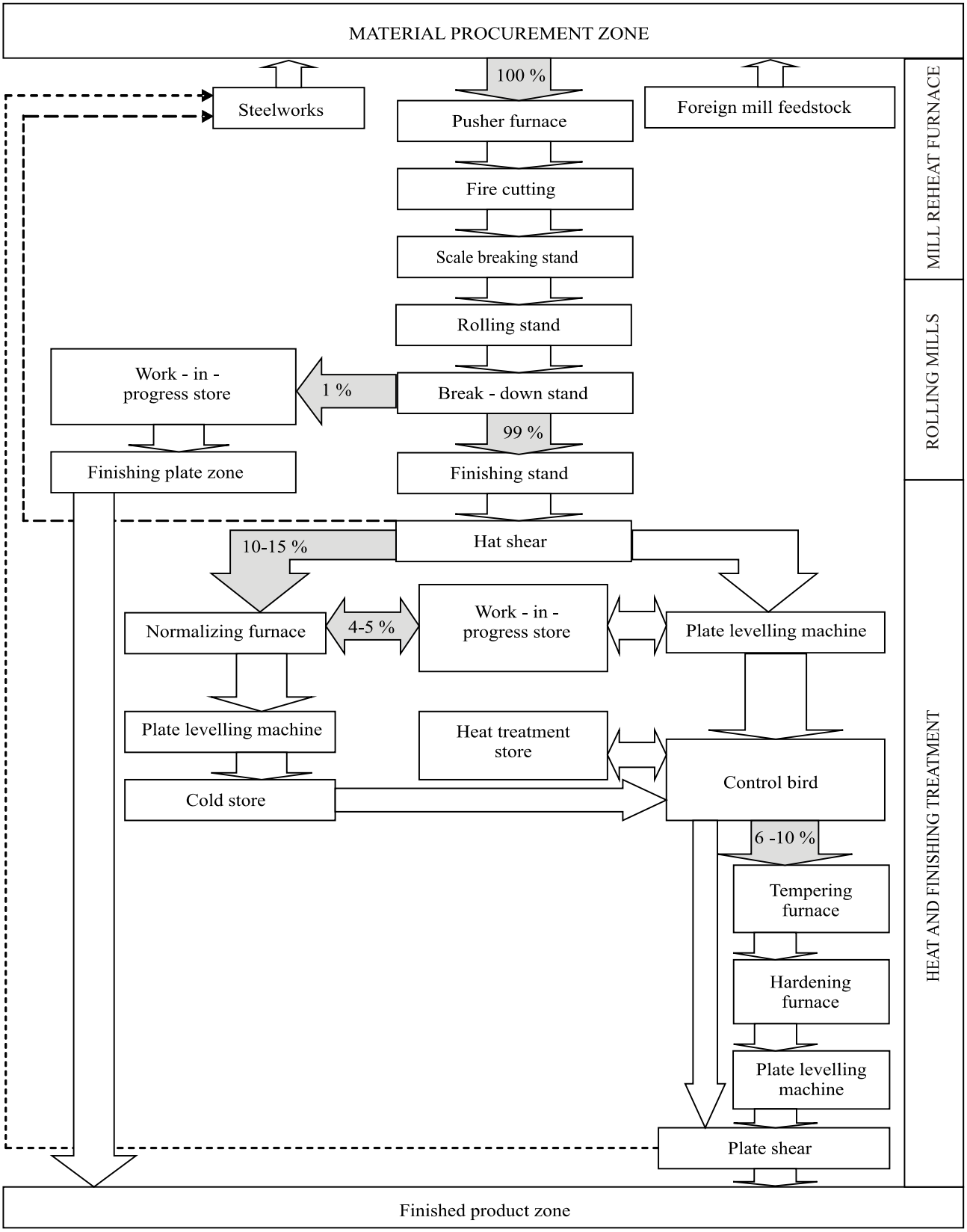

Figure 1. **Sankey chart of physical material flow**
Slika 1. **Sankey dijagram fizičkog tijeka materijala**

- labour resources involved in the flow processes,
- the consumption of materials, fuels and energy.

The costs of the physical flow of materials include [5]:

1. The costs of depreciation of fixed assets involved in the logistic processes (K_a):

$$K_a = M_t \overline{s}_a,$$

where:

M_t - initial value of the fixed assets in the logistic processes,
$\overline{s}_a$ - average fixed assets rate;

2. Labour costs (K_p):

$$K_p = L\overline{p},$$

where:

L - number of employees engaged in the logistic process,
$\overline{p}$ - average remuneration, including any surcharges;

3. Costs of the consumption of materials, fuels and energy (K_m);
4. External services (K_{uf});
5. Other flow costs.

The equation for the overall costs of the physical flow of goods has the following form:

$$K_{pf} = K_a + K_p + K_m + K_{uf}. \quad (1)$$

ANALYSIS OF THE PLATE MILL'S COSTS

The division of costs in terms of their relationship with production volume allows fixed costs and floating costs to be distinguished. They can be considered in the aspect of an undertaking's overall costs and the unit costs of product manufacture.

The structure of self-costs in the Plate Mill under examination is shown in Figure 2. The main cost component is the production input, which accounts for 87,75 % of the total costs. In the Plate Mill, the value of raw materials, basic materials and semi-finished products used in the production process is classified under the production input. The fixed costs account for 4,16 % of the overall self-costs. The fixed costs in the Plate Mill include, among other things, auxiliary pays, lease charges, the costs of auxiliary materials, electricity, Health & Safety measures, etc.

The structure of floating processing costs is shown in Figure 3. The floating costs account for 8,45 % of the metallurgical undertaking's self-costs.

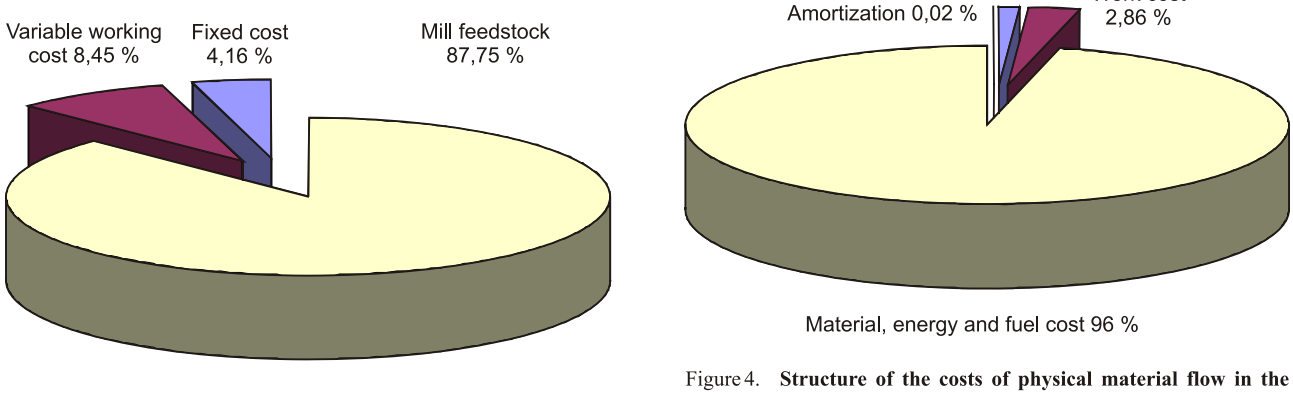

Figure 2. **Structure of self-costs in the Plate Mill under examination [3]**
Slika 2. **Struktura vlastitih troškova u valjaonici limova u kojoj se provodi istraživanje [3]**

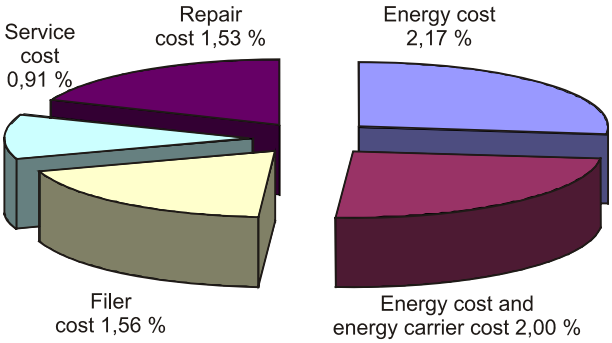

Figure 3. **Structure of processing floating costs in the Plate Mill under examination [3]**
Slika 3. **Struktura prerade, plivajući troškovi u valjaonici limova u kojoj se provodi istraživanje [3]**

The structure of physical flow costs in the Plate Mill of the Steel Mill under study is shown in Figure 4. The following have been classified into the costs of physical flow:

Figure 4. **Structure of the costs of physical material flow in the Plate Mill of the Steel Mill under study [3]**
Slika 4. **Struktura troškova fizičkog tijeka materijala u valjaonici limova u sklopu valjaonice čelika koja je predmet studije [3]**

- the costs of productive and auxiliary labour,
- the costs of materials, fuels and energy, including: feedstock, fuels, energy and energy media and auxiliary materials, etc.,
- the costs of external services, including: technological services, part refurbishment, motor transport, equipment services, etc.,
- depreciation.

It can be found from the data presented in Figure 4. that the main component of both the physical flow costs and the overall costs in the Plate Mill metallurgical undertaking are the costs related to materials, fuel and energy. These costs account for 96 % of the costs of the physical flow of the undertaking's goods, while 87 % of the costs classified as materials, fuels and energy being the input. The depreciation is practically invisible in Figure 4. due to its very small percentage share.

Using Equation (1), the costs of the physical flow of goods have been calculated for the metallurgical undertaking under consideration and then related to the overall costs in the period examined and to the production volume (Figure 5.).

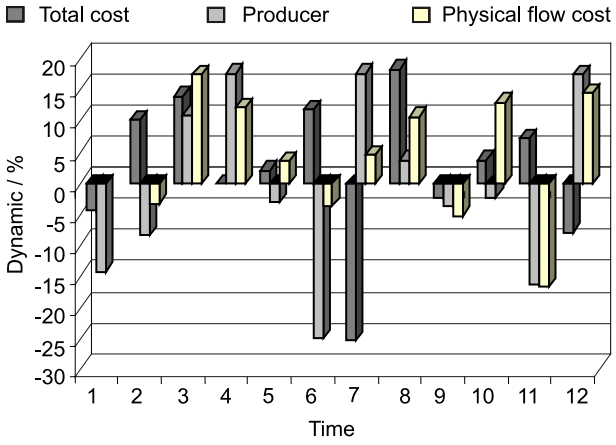

Figure 5. **Dynamics of physical flow costs in relation to the dynamics of production and overall costs [4]**
Slika 5. **Dinamika troškova fizičkog tijeka u odnosu na dinamiku proizvodnje i ukupne troškove [4]**

On the basis of the data shown in Figure 5. it can be stated that the logistic costs are largely determined by the production volume; it is so, because 96 % of the costs of the physical flow of goods fall into materials, fuels and energy, which belong to the undertaking's floating costs.

CONCLUSION

The current considerations have indicated that logistic processes have a comprehensive effect on the economics of an undertaking and, in the end, they determine its financial result. From the structure of costs it can be concluded that the material costs play a key role in the overall costs of a metallurgical undertaking and in the costs of the physical flow of goods.

The actual quantities determining the sizes of material costs, apart from the amount and price of the materials, may include:

- number of orders for the materials,
- number of material supplies,
- number of material inspections,
- number of receipts to or expenditures from the store,
- utilization of the storage area,
- value of the inventories [5].

The comprehensive and systemic formulation of logistic costs is not an end in itself; it must not only serve the understanding of the level and structure of the costs of logistic processes, but also enable the creation and implementation of appropriate instruments of acting on the reduction of costs [4].

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