RESOURCE COSTS OPTIMIZATION AND ENERGY CONTAINMENT REDUCING IN ROLLING PRODUCTION

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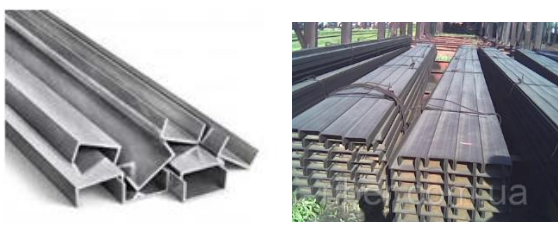
Introduction. Compliance with the Sustainable Development Goals of Ukraine for the period up to 2030 involves ensuring the transition to rational models of consumption and production (UkrSDGs, 2019). A necessary prerequisite for stable national economic growth is the sustainable industrialization of our country and the introduction of innovative technologies into production.

In modern conditions of metallurgy development, the main task for the enterprise becomes the search for internal reserves for the decrease in expenses, the use of energy, resource-saving technological modes. The enterprise's economic activity is the development of such production programs, which much attention would be paid to reducing the specific costs of raw materials and energy resources; maximum use of stocks of raw materials.

In this paper, we consider the enterprise, which produces rolled products of a wide range. Figure 1 shows an example of such products. To justify the enterprise's operation program quantitatively, we use mathematical modeling, system analysis and optimization methods.

Figure 1

Rolled products: a) channel; b) shipment of products



a) b)

Presentation of the main research. The exclusivity of the issue is because a significant part of metal losses at the enterprise falls on the final operations of the technological cycle when the manufactured metal already laid a lot of energy resources. One of the main criteria of the rolling production efficiency is the cost ratio of metal, which equals the ratio of the metal weight used to fulfill some order to one of all the order's products. The closer this ratio is to the unit, the more efficiently the enterprise performed the whole technological operations from steel smelting to shipment of finished products.

The technological process of manufacturing rolled products, regardless of the type of smelting unit, contains several operations, each of which significantly affects the performance of the following (Hnatushenko et al. 2021). Traditionally, we adjust each of them to some technological optimality criterion based on the already known results of previous stages. Mostly we solve the problem of minimizing the cost of metal in rolling production at the cutting finished products and (partially) cutting ingots into blanks. Therefore, we propose a mathematical model of the problem of finding such a plan for forming ingots, which would allow subsequent operations to cut blanks and finished products the minimum of possible scraps, thereby minimizing the cost factor of the metal.

Thus, the technological process of rolling production includes the following operations: 1) steel smelting, 2) casting of ingots in the mold, 3) heating of ingots, 4) rolling of blooms, 5) cutting of blooms with a steam hydraulic knife, 6) rolling of preform billet, 7) cutting of a preform, 8) heating of rod blanks, 9) rolling of profiles of finished products, 10) cutting of profiles of finished products, 11) final processing of finished products. Each of the operations significantly affects the performance of the following. From the above sequence, it is seen that the cutting of the ingot is carried out in two stages. On the first - the whole ingot is divided into redistribution blanks, the length of which can lie in the range from 2.4 m to 3.2 m with a step of 0.05 m. On the second - each redistribution blank is rolled into a finished product (channel, corner, beam, lunch ...) and divided into measuring rods with a length of 12, 11.7, 9 or 6 m according to the order (determined by the customer's logistics requirements).

We formulate the mathematical model under the following assumptions. Firstly, we know the number of blooms of a cross-section, which must use to manufacture products according to plan. Secondly, there is a correspondence between the moulds and blooms, i.e. it is known from which mould we roll the metal into ones of a given cross-section. Thirdly, we cut each redistribution blank into bars of only one size. This division we carry out taking into account the pre-calculated by the brute force method of the optimal length of the workpiece for each type of product, i.e. for each partition rod length. Since some sections of blooms involve the manufacture of not only one finished product type but several, combining blank lengths in different quantities, we can use the maximum length of the resulting bloom (the entire mass of the ingot). We solved several model problems of minimizing the amount of metal used to make orders, the size of which does not exceed the volume of one smelting. The computational results indicate that the proposed mathematical and software introduced into the production process will reduce metal losses to 4-5%, which is almost twice lower than the losses now (Zheldak et al., 2021).

Conclusions. A feature of the proposed approach is the formulation of the problem of the available metal distribution between the moulds cutting of the ingots obtained from them for processing blanks provides a minimum number of scraps at this and subsequent stages of rolling shaped profiles.

References

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