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INFORMATION-MEASURING SYSTEMS FOR MONITORING THE TECHNOLOGICAL PARAMETERS OF ROLLING MILLS

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Abstract. *Rolling mill process control systems require a wide variety of sensors that operate under the extreme conditions of heating plants. This reduces the accuracy and reliability of the results obtained and causes significant material losses, the occurrence of emergencies, and a decrease in overall work efficiency. The paper analyzes the methods and means of generating primary production information in information-measuring systems for monitoring the technological parameters of rolling mills. As an example, the system of automatic tracking of slabs in the furnace area is considered, where one of the tasks of the control system is to automatically set the moments when the pushers start to work in accordance with the specified rolling rate. The information-measuring system for tracking slabs is implemented on the basis of an optical locator.*

Key words: *control system, rolling mill, information measuring system, slab, furnace area, optical locator.*

Introduction.

Metallurgy and hot rolling of metals are distinguished by the complexity and variety of technological processes. This predetermines the nature of their automation. Currently, the main directions in the integrated automation of rolling mills are the hierarchical construction of a production control system as a whole, the creation of local automatic control systems through the integrated automation of individual sections of the technological line of the mill, the organization of microprocessor control of the entire complex of mechanisms, from the slab warehouse to the coilers and the coil warehouse (for the production line of a rolling mill), as well as the creation of an information-measuring system for collecting, processing, storing and issuing control and statistical information *[1,2]*.

The class of rolling production management tasks, the solution of which is implemented almost immediately, and the necessary information is received as the production process develops, is solved by local workshop information systems. These systems are located near information sources and perform the functions of operational and technological management. Such local information systems, within the limits of production, are combined into a single information-measuring system (IMS), built according to a hierarchical principle.

An analysis of the technological processes of rolling production showed that the most significant technological task is to control the presence and position of blanks on the production line - the organization of an information support system for metal on the mill line. The tracking of the movement of each slab, up to the transfer of the rolled and rolled strip to the cooling conveyor, takes place with the help of primary converters, mainly of the photoelectric type *[3]*.

The organization of uninterrupted, on the one hand, and efficient (with a small proportion of defects), on the other hand, the course of the technological process of rolling is ensured at its initial stage - in the furnace area. The variability of the heating time of the ingots and the time of their rolling on the mill significantly complicates the work of the furnace area, making it difficult to predict the time of the end of the heating of the ingots and the time of the release of the furnaces for planting new ingots. An increase in the time spent by ingots at a high temperature contributes to an increase in metal waste, while emergency situations inside the furnace itself due to insufficient noise immunity of measuring transducers are not excluded. The poor organization of production in the furnace area thus leads to a decrease in the productivity of the entire mill. To improve the situation caused by the shortcomings in the organization of production, until recently the practice was to increase the capacity of the furnace section by increasing the number of furnaces and transport vehicles, which led to a significant increase in capital investments.

The heated slab released from the furnace is fed by roller tables to the roughing group of stands, in front of which a scale breaker is installed. Crushed scale is removed from the surface of the slab by hydraulic descaling. At the same time, the variability of the temperature of the slabs fed into the mill determines the variability of the forces acting on the rolls, the fluctuations in the values of the force deformations of the stands, and, as a result, the fluctuations in the geometric dimensions of the rolling profile, the mismatch of the metal speeds in certain sections of the technological line of the mill *[1,4]*.

The above tasks can be solved by creating an automated information system for tracking slabs in the furnace area.

Studies of the state of automation of hot rolling mills and a number of similar industries have shown that the existing photoelectric measuring converters of the analog and pulse type, when operating under conditions of intense optical and electromagnetic interference, providing the probability of a control error at the level of 10^{-3}, do not fully meet the requirements of high noise immunity and reliability of the generated information. This leads to emergency situations in the operation of the rolling mill (drilling, jamming of slabs in actuators, equipment breakdown) and, as a result, to significant material losses [*1,5,6*].

On rolling mills, the speed of the strip within each group of stands (or sections of the mill) increases as its thickness decreases and can change along the length of the strip during its rolling in the stand. Therefore, the speed regime should be considered as a function of the rolling time, which varies depending on the technological operation: transportation of the strip at the rolling speed in the last roughing stand; transportation of the strip at high speed along the intermediate roller table to the roller table in front of the shears; transporting the strip by a roller table in front of the shears in the braking mode to a cutting speed of 0.4…2.8 m/s and further reducing the speed to the speed of rolling into the first finishing stand *[3]*.

Due to the presence of transition zones between the indicated sections, the duration of which depends on a number of random factors, the value of the time of transportation by rolling can be considered as a random variable that obeys the normal distribution law. This statement is valid and confirmed experimentally for mills with uncontrolled rolling speed in the last roughing stand – mills 1680, 1700, 2000 *[1]*.

The probabilistic nature of the slab (rolled) transportation time between sections of the rolling mill determines the great importance of primary measuring transducers for the implementation of information support of the metal on the mill and the organization of rolling speed control.

Various high-speed rolling modes should contribute to the reliable capture of the strip by the working bodies of the stands, the coiler, to produce reliable cutting of rolled products, ensuring high productivity of the mill. It should be noted that an increase in the productivity of a rolling mill is possible due to an increase in the rolling speed (more than 20 m/s on thin-sheet mills), and reliable gripping of the front end by coilers is still possible only at a strip speed of no more than 10…11 m/s, and cutting of rolled – at 0.4…2.8 m/s. The fulfillment of these requirements determines the use of optimal speed modes in certain sections of the mill, adequate to the quality indicators of the used primary measuring transducers, which in most cases leads to a decrease in productivity due to the low speed of the used measuring transducers.

The solution of the problem in favor of productivity is possible by creating or improving the IMS for controlling the technological parameters of the rolling mill by increasing the reliability of the measurement information and the speed of the metal information tracking system on the rolling mill production line *[7]*.

The change in speed during the rolling process, especially in the automatic mode of operation of the mill, imposes increased requirements on the speed of reaction of the system to changes in the technological parameters of rolling and the reliability of the information obtained.

The decisive role is played by the reliability of the primary information obtained and the speed of the control system when eliminating pre-emergency and emergency situations at the mill (“wrapping” the front end after the roughing stand, extremely high strip speed, “drilling” the metal during transportation and jamming it in the mill equipment), which ensures increasing the efficiency of the mill, saving resources and material resources.

To prevent emergencies and improve the efficiency of the mill and production control system as a whole, it is necessary to increase the response rate of the information-measuring system to the dynamics of changes in the technological process, to reduce the time for polling a plurality of measuring transducers, which is possible by increasing the speed of their measuring channels.

These circumstances predetermined the priority solution of the problems of increasing the reliability of measurement information and the speed of the IMS for monitoring the technological parameters of rolling mills in order to increase the efficiency of the control system and the productivity of the rolling mill.

Thus, providing control systems for technological parameters of rolling mills with highly reliable non-contact measuring transducers capable of operating in extreme conditions of metallurgical production with high reliability and speed of control is an urgent task *[8]*.

It has a particularly important role for heating furnaces, where there is a limited arsenal of methods and technical means for monitoring the presence, movement or achievement of a given position of metal of various thermal states under conditions of extreme temperature and other interfering factors, in particular optical interference. They allow solving transport, technological and regime automation of both the entire line and individual sections of rolling mills *[3]*.

Material of research.

Let's analyze the methods and means of generating primary production information in information-measuring systems for monitoring the technological parameters of rolling mills *[9]*.

In the technological scheme of rolling production, the processed metal is repeatedly subjected to the heating process, as a result of which the operating conditions of the means that form the primary production information deteriorate sharply. Further improvement of technological processes of rolling necessitates the improvement of the quality of control based on the rapid and reliable provision of the information-measuring system with the necessary production information generated by primary converters in extreme conditions *[8]*.

Functional diagram of the complex automation system of the hot rolling state is shown in Figure. 1.

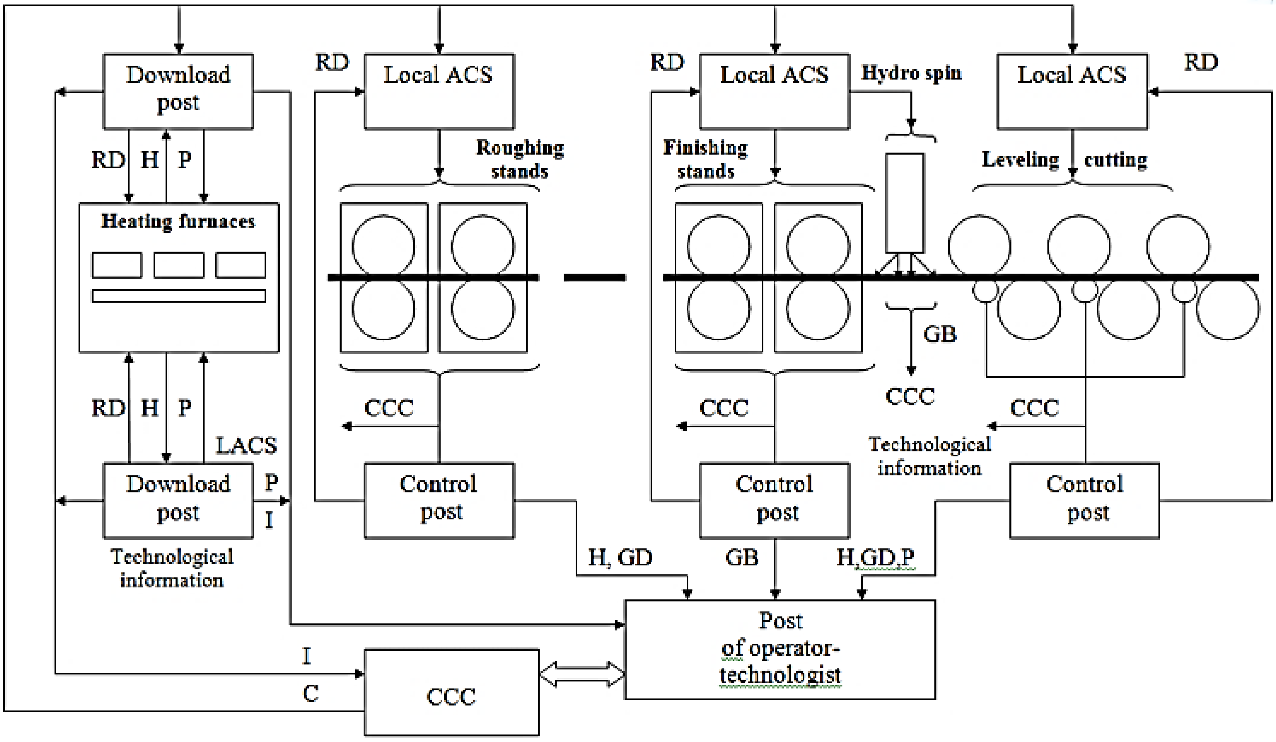

Figure 1 - Diagram of the complex automation system of the hot rolling state

In the Figure. 1 are marked: H - presence, P - position, GD - geometric dimensions, GB - hydraulic breaker quality, I - information, C - commands, LACS - local automatic control system, RD - regulating devices, CCC - control computer complex.

An analysis of the functional diagram of the integrated automation of a rolling mill (Figure. 1) shows that the amount of necessary production information is determined by the technical tasks of monitoring objects (presence - H, position - P, quality of hydraulic breaker - GB and measurement of their sizes - GD). The implementation of these tasks is currently carried out using primary measuring transducers (sensors for presence, position, length and thickness measurements), based on various physical principles of operation. For example, on radioisotope radiation – when controlling the position of slabs in continuous furnaces and measuring the thickness of rolled products and using the rolling method - when measuring the length of rolled products, using optical radiation – when detecting and measuring dimensions.

A significant part of the technological and metrological support of information-measuring, and exactly, as well as the entire control system of a modern rolling mill, is made up of control and measuring devices. Thus, when automating broadband mills (BBM) for hot rolling, up to a thousand units of such devices are used, and more than 20% of them are of the photovoltaic type *[3]*.

As an example, the system of automatic tracking of slabs in the furnace area is considered.

Automatic control of technological processes on the technological lines of rolling mills, in particular in the areas of heating and thermal furnaces of rolling production, requires the mandatory use of information about the metal. The presence of a large number of blanks on the objects of control, the need to identify them, increased requirements for the reliability of information and the complexity of its recovery in case of distortions are the specifics of the task of information support of metal. A characteristic feature here is not only the need to identify the state of the object, but also the fact of its transition from one state to another. This determines the importance of the task of developing methods and means to improve the efficiency of providing information-measuring systems of rolling mills with information about the spatial arrangement of the heated metal. It also becomes necessary to take into account the operation of local control systems with initiative sources of information for which delay or loss of information is unacceptable, as this leads to failures in the operation of the mill control system, which leads to significant material losses due to emergencies *[6,7]*.

The importance of non-contact, highly reliable measuring transducers is especially evident in the area of heating furnaces. The main functions of the means of collecting information here are tracking the location and advancement of slabs in furnaces, the order of seating billets in furnaces, and controlling the delivery of heated slabs. At the same time, more than ten positions for monitoring the presence and position of slabs are required, especially in places with very difficult (extreme) conditions for collecting information due to high temperature and the presence of optical and electromagnetic interference - at the landing of slabs in front of a process furnace, when monitoring the edge of slabs on gliding pipes in the welding area. Thus, photoelectric position sensors are an important integral part of the metal information tracking system on the rolling mill production line.

The use of such means of primary control of the technological parameters of a rolling mill leads to an increase in the efficiency of these systems.

Let us consider the features of building such automation systems for rolling processes *[5,6]*.

From the analysis it is known that the poor organization of production in the furnace area leads to a decrease in the productivity of the entire mill. The solution of this problem seems to be possible by creating a local automated information system for tracking slabs in the furnace area. The use of the workpiece control system in conditions of intense optical interference in the furnace area makes it possible to increase the productivity and energy efficiency of the mill as a whole.

The functional diagram of the automatic tracking system for slabs in the furnace area based on optical radars is shown in Figure. 2. In the Figure.2 are marked: ACS – automatic control system; H - presence indicator; P – position indicator; Pos – control position number.

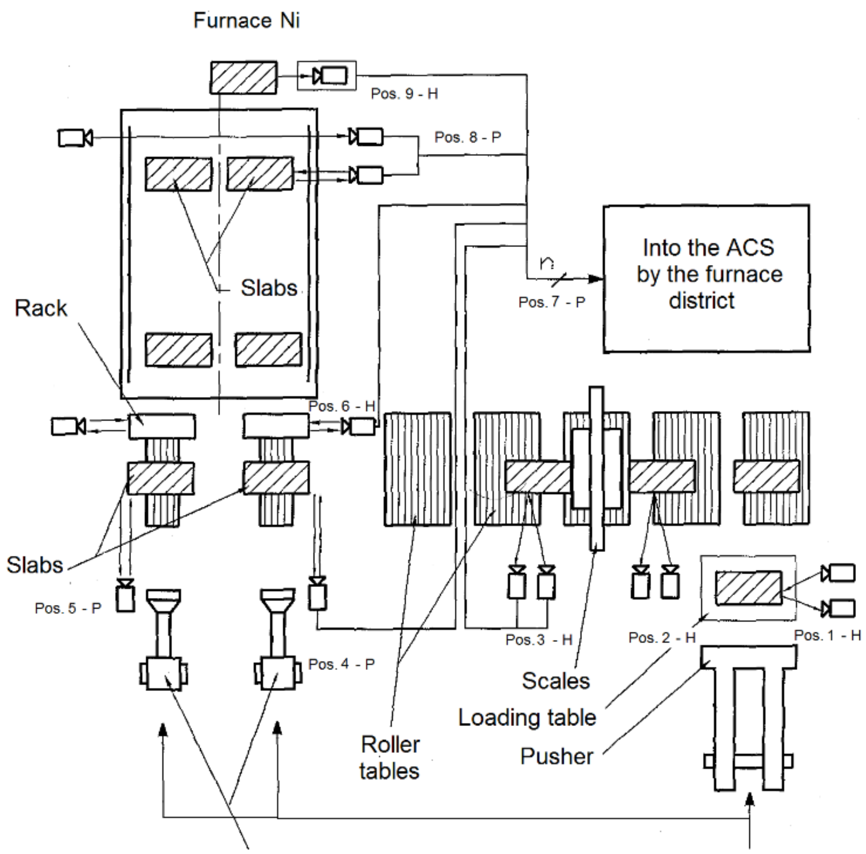

Figure 2 – System of automatic tracking of slabs in the furnace area

As required, the slabs from the stacks are transferred by cranes to the receiving racks of the mill (position 1), from where they are transported by loading roller tables to the scales (control positions 2 and 3), after which they are transferred to the loading windows of the methodical heating furnaces (position 6). Slabs are loaded into the furnace and pushed through the furnace by a pusher (position 4 and 5). When the next slab rests against a row of planted slabs (position 7), the pusher pushes this row through the furnace. The end slab, from the side of the furnace dispensing window, moving towards the furnace box (position 8), rolls down the inclined plate onto the furnace roller table of the mill (position 9), which connects the furnace with the first lash of the mill. At control positions, photoelectric sensors are installed, and at position 8, not a locator, but a photoelectric measuring transducer is used *[8,10]*.

During normal operation of the mill, heating furnaces must produce slabs at regular intervals with the minimum possible temperature fluctuations of individual slabs, which is due to the requirement of constancy of the geometric dimensions of the finished strips. Thus, one of the tasks of the control system for the landing and delivery of slabs is the automatic setting of the moments of the start of the work of the pushers in accordance with the specified rolling rate.

IMS for tracking slabs in the furnace area based on an optical locator is shown in Figure.3, there are marked: E – emitter; R – signal receiver; MS – means of communication; CD – computing device; ODE – operational and dispatching equipment; DAC – digital-to-analog converter; MO – management object *[7]*.

The core of the system is a computing device (microprocessor unit), which stores information about the time of heating and emptying the furnaces, about the steel grades of each heat, orders based on which the ingots of this heat should be rolled, and about the final dimensions of the metal after rolling. Information about the position of the ingots in the furnaces is transmitted to the dispatcher and to the mechanisms for controlling the supply of ingots and information about the actual state of the furnaces, their readiness, the number of remaining not yet dispensed, but heated ingots, the position of the dispensed ingot until it is transferred to the receiving roller table of the first stand, the position of all pushers and ingots to the furnace.

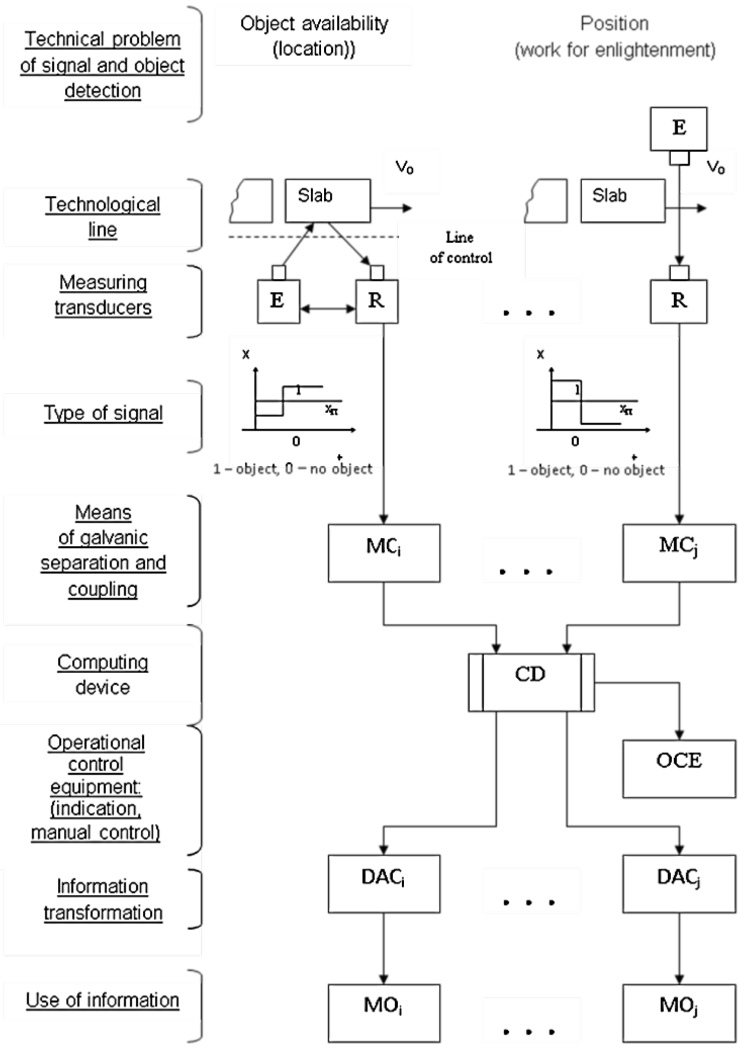

Figure 3 – Information-measuring system for tracking slabs in the furnace area

The information part of the system ensures that with each new ingot, all the initial information necessary to determine the further processing of the ingot on the rolling mill line is transferred to the mill control system.

Summary and conclusions.

An analysis of the state of the issue under study made it possible to formulate the following conclusions.

1. Systems for monitoring the technological parameters of rolling mills require a significant range of primary measuring transducers of various functional purposes for operation in extreme conditions of heat engineering shops. These conditions adversely affect the quality of control, reducing the accuracy and reliability of the results obtained, which causes significant material losses and the occurrence of emergencies during the operation of the mill. This, in turn, reduces the efficiency of the mill as a

whole.

2. The creation of modern complexes with control means with high noise immunity and speed for control systems of complex heat engineering processes is an urgent task from an economic, scientific and technical point of view. This is due to the inadmissibility of delay or loss of information at the stages of control, transmission and storage of production information for organizing an efficient and trouble-free rolling process.

The analysis made it possible to formulate the task of this study - the analysis of existing and the identification of new methods for obtaining primary information about the state of the rolling process in order to improve the efficiency of the equipment and the mill as a whole.

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Анотація. *Системи керування технологічними процесами прокатних станів вимагають широкого спектру датчиків, що працюють в екстремальних умовах теплових установок. Це знижує точність і достовірність отриманих результатів і спричиняє значні втрати матеріалів, виникнення аварійних ситуацій та зниження загальної ефективності роботи. У статті аналізуються методи та засоби формування первинної виробничої інформації в інформаційно-вимірювальних системах моніторингу технологічних параметрів прокатних станів. Як приклад розглянуто систему автоматичного відстеження слябів у пічній зоні, де одним із завдань системи керування є автоматичне встановлення моментів початку роботи штовхачів відповідно до заданої швидкості прокатки. Інформаційно-вимірювальна система відстеження слябів реалізована на основі оптичного локатора.*

Ключові слова: *система керування, прокатний стан, інформаційно-вимірювальна система, сляб, пічна зона, оптичний локатор.*

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