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METHODOLOGY OF DESIGN OF THE THIN STEEL STRIP COLD ROLLING ENERGY EFFICIENT TECHNOLOGY

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The article states basic principles of the methodology of design of the thin steel strip production energy efficient technology, according to which the design process is structurally divided into seven interrelated modules of certain functions. Implementation of the represented approach resulted in the efficient technical mode of rolling providing reduction of overall power consumption subject to compliance with the requirements to quality parameters of the strip.

Key words: steel strip, cold rolling technology, methodology of design, energy efficient

INTRODUCTION

Operational tools for automation of production preparation and development of technologies for receiving new types of products, as well as for improvement of current production processes are required to ensure the efficient operation of steel works and high quality of made products under ever-changing external and internal factors. Among such tools, there should be different standards, product quality requirements, methods of search for a comprehensive solution with high reliability, and software providing implementation of the design process. The problem of identification and implementation of methods of rolling technologies effective design in the area of thin strips cold rolling is rather urgent, since the resolution of this problem influences acceleration of realisation and implementation of developments helping to increase the efficiency of existing production facilities and competitiveness of the products made, as well as to set up production of modern types of rolled products.

The thin steel strip cold rolling technology is based on the processing method the effectiveness of which is determined, firstly, by set parameters of the mill, and secondly, by rolling process control from the mill. Setting of the mill is regulated by process instructions and process charts developed by subdivisions and services responsible for product quality. Control of the mill operational modes helps to minimize deviations of technological process actual parameters from set parameters, and depends on technical level of automation means and systems used at the mill, on availability of credible and reliable tools for measurement and control of technological process parameters, on quality and lifetime of mill rolls, equipment for their lubrication and cooling, and on properties of the coolant.

Design of the technological mode belongs to the mill setting stage, and if operational tools are available it helps to determine the mill settings (set points), which would ensure compliance with the finished product quality requirements specified in the technical specifications for its supply with as little power consumption as possible.

Technological advances in equipment and technology of cold rolled sheet production, as well as in the area of information technologies resulted in significant changes in the approach to selection of individual elements of technological modes, which was reflected in numerous papers. Thus, the paper [1] demonstrates the influence of high quality emulsols application on distribution of reductions by stands of continuous mills and on the tension level in interstand space during cold rolling of strips made for the automotive industry and strips of structural steel due to significant reduction of friction factors in deformation zones of work stands. The paper [2] evaluates the possibility to grip during the initial contact and equipment load with respect to energy and power parameters when developing cold rolling modes; the paper [3] considers limitations on metal formability; the paper [4] discusses the lack of rolls' slip; the paper [5] addresses the limitations on metal heating in the deformation zone. The paper [6] is devoted to development of the system of automated design of cold rolling modes, but the model behind it does not consider the dynamic component of the cold rolling process. The detailed description of the dynamic model enabling calculation and study of geometry of the deformation zone, kinematic, technological and energy-power parameters of the cold rolling process under non-steady conditions, is provided in papers [7, 8]. It is clear that the existing deep knowledge of methods and

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ways to study parameters of the rolling process and the strip, including under conditions of their objectively existing variation, constitutes the basis for development of the methodology of design of cold rolling technological modes, defining the innovative activity of scientific and technical personnel of the iron and steel industry aimed at a new result related to output of flat rolled products with high competitiveness indicators and to development of manufacture of rolled products of higher technological maturity. Within this framework, development of methods for rapid advance of rolling modes with resolution of tasks of resources and energy saving, improvement of product quality and expansion of the product range is of high scientific and practical importance for improving the efficiency of thin steel strip production technology.

METHODOLOGY

When developing the methodology of design of the cold rolling energy efficient technology, the modular approach (Figure 1) was applied, which simplified the design process by dividing it into individual parts called modules. A certain function or several interrelated functions are implemented by each module.

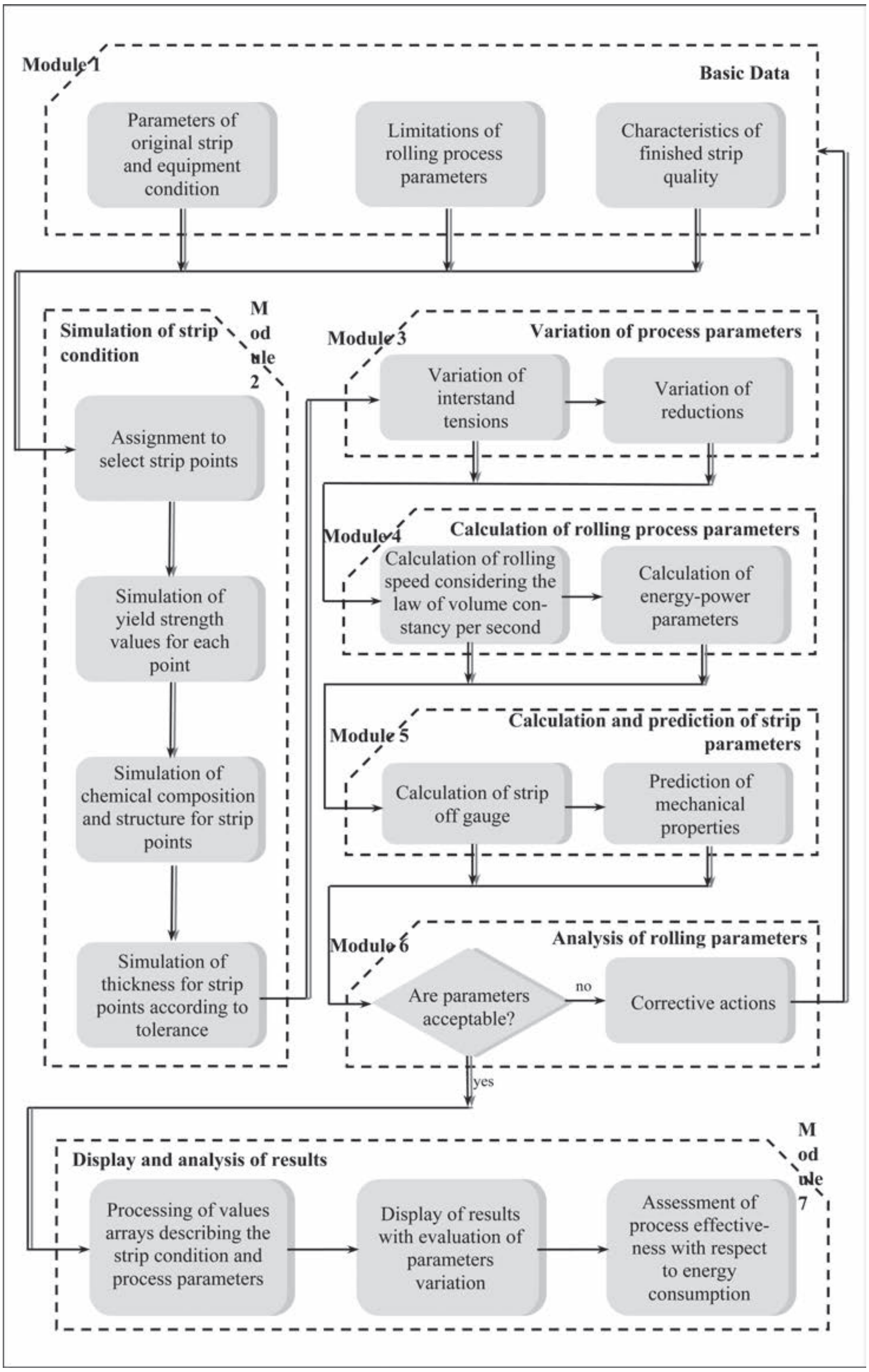

Figure 1 Methodology of design of the steel strip cold rolling energy efficient technology

Table 1 **Modes of reductions and specific tensions during rolling of the strip 0,5 x 1 250 mm made of steel 08 ps (Rus. '08пс')**

Mode #	Relative Reduction in Stands / %					Specific Tensions / MPa					
	No. 1	No. 2	No. 3	No. 4	No. 5	Before Stand 1	Interstand Space				After Stand 5
							No. 1	No. 2	No. 3	No. 4	
1	29	27	27	29	2	57	145	147	174	172	45
2	30	28	26	28	3	67	132	164	190	198	45

The Module 1, which is a description of basic data for the rolled strip, enables setting characteristics and size of the work piece and the finished strip, parameters of the mill equipment, ranges of technological parameters, such as interstand tensions, reductions, rolling speeds, ranges of strip condition parameters, as well as energy-power values and quality indicators of finished cold rolled strip. At the same time it is possible to use the existing experience of formalized recommendations on selection of initial values of parameters describing the rolling mode.

The Module 2 imitates the strip condition, considering non-uniformity of the yield strength, chemical composition and structure, thickness lengthwise based on use of the random number generation procedure according to the law of normal distribution.

The Module 3 provides the possibility to go over all possible options of distribution of reductions by stands of the continuous mill and interstand tensions according to the limitations set in the Module 1.

Modules 4 and 5 calculate parameters of stand interaction with the strip checking the condition of constant metal volume per second at each point of the strip. It results in generation of values arrays being random numbers in relation to simulation of disturbances as implemented in Modules 2 and 3.

After calculation of process and strip parameters, the Module 6 checks the rolling process with respect to power and kinematic characteristics, and the finished strip quality indicators are evaluated.

In case of successful check, the Module 7 processes the values arrays describing the strip condition and process parameters for selection of the technological mode responsible for efficiency criteria set in the Module 1. If non-fulfilment of set requirements is observed for any parameter, the respective corrective measures are taken in the Module 1 in accordance with the methodology of design, and calculation is repeated.

RESULTS AND DISCUSSION

The described methodology of design of the energy efficient technology was implemented based on the example of rolling of the strip 0,5 x 1 250 mm made of steel 08ps (Rus. "08пс") on the 5-stand mill 1700 of PAO Severstal. The received result was evaluated compared to the strip rolling mode recorded on the production site. Simulation of the strip condition was performed with the standard deviation of 10 % for the yield strength, 0,012 % for carbon content, 0,05 % for manganese, 0,001 mm for grain diameter, and 2 % for thickness.

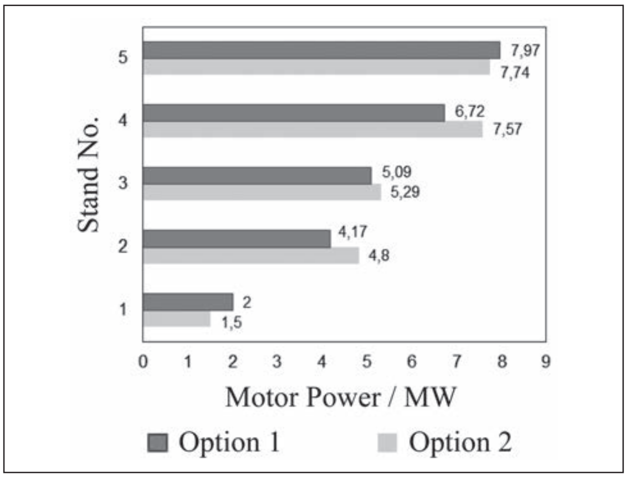

Figure 2 Comparison of total motor power by stands

Table 1 provides modes of reduction and tension for two options: the option 1 represents actual reductions and tensions taken from the automated system of measurement and data control during rolling; the option 2 is developed in accordance with the stated methodology.

In both cases, the work piece thickness was 1,8 mm, and the original yield strength was 265 MPa, the rolling speed was 21 m/s. Table 1 demonstrates that in the second option the reduction is redistributed between the stands (within 1% in each stand compared to actual reductions) with parallel growth of specific tensions before stand 1, in the 2nd, 3rd and 4th spaces, and reduction in the 1st space. Distribution of values of energy-power parameters for options 1 and 2 indicated that stands No. 1, No. 2 and No. 5 received additional load during rolling according to the developed mode, and the total motor power reduced by 0,95 MW during rolling according to the developed mode (Figure 2), which ensures 3,5 % of energy saving during rolling. When evaluating longitudinal off gauge and yield strength of the strip after rolling, it was found that both modes provide compliance with the requirements to quality indicators of structural cold rolled sheets. It confirms the possibility to use the suggested methodology for developing modes ensuring effectiveness with respect to a number of process and strip characteristics.

CONCLUSION

The stated methodological principles of design of thin steel strip cold rolling energy efficient technology represent the possibility to achieve the result not only through process parameters correction, but through strip condition control, and stabilization of processes occurring in electromechanical systems of continuous mill stands under conditions of dynamic load.

Based on the developed methodological procedures, it is planned to create an automated system for design of the thin steel strip cold rolling efficient technology purposed for operational simulation, design, analysis of process parameters and prediction of finished strip characteristics.

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Note: The person responsible for the translation of the paper into the English language is Natalia Skrobot, Cherepovets, Russia