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Web Application for Calculating Roll Calibrations in the Production of Curved Rolled Sections and Tube Stock

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Abstract: A computer program complex is described for calculating roll calibrations, energy-force parameters and stress-strain state of the metal in the production of curved rolled profiles of practically any real configuration, as well as the formation of a wide billet tube assortment. The system also includes a database of domestic and foreign ferrous and non-ferrous metals and alloys, containing chemical compositions of materials, their technological, mechanical and physical properties. The programs allow you to get a complete set of drawing documentation, the distribution of stresses across the width and thickness of the strip, the forecast for the level of residual stresses. The software package was created as a Web application for use on the Internet and is posted on econom.misis.ru. Previous versions of the program in the form of Windows applications, as well as this option were used by a number of organizations to calculate roll calibrations in preparation for the production of curved profiles. The program for calculating the formation of tubular billet, predicting changes in the stress-strain state of the metal across the width and thickness of the strip, springback and residual stresses, was tested when analyzing the production process of welded longitudinal pipes of a wide profile range of stainless steel on the Olimpia 80 production line.

Keywords: Computer program complex, production of curved rolled profiles, prediction of changes in the stress-strain state of the metal.

INTRODUCTION

The development of information technologies is proceeding along the path of creating dynamic models, including for the global Internet. One of the applications of computer programs that implement mathematical models of technological processes of production, is the production of curved profiles by rolling in rolls and forming tubular blanks. At the same time, special interest is due not only to the calculation of process parameters and tool sizes, but also to the preparation of technological and design documentation (drawings), which under normal conditions is a very time-consuming process and requires highly skilled performers who combine knowledge of how the strip behaves during plastic deformation and design skills.

Another important feature of this direction is a wide profile and brand assortment of products produced, as well as, in many cases, small-scale production. The latter does not allow to count on significant costs in the design and preparation of production.

An effective solution to these problems is the creation of computer systems that allow the development of optimal technological processes and to simplify the preparation of production as much as possible. In terms of billet molding, taking into account the simplicity of the shape of the final profile and the volume of production, quite effective profiling schemes, calculation methods and types of equipment used have been developed [1, 2]. Although new trends, for example, multi-roll forming of a whole range of

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core pipe mix, require further development of the theory and technology of the process, and with it, computer software design and preparation of production.

Until recently, the production of curved profiles substantially lagged behind pipe production, characterized by the diversity and, in many cases, complexity of the geometry of the required products. This explains the much smaller development of process theory, mathematical and computer software.

The development of roll calibration when rolling, both varietal, shaped, and curved profiles, is a creative process requiring high qualification and experience of a specialist. The presence of a computer program does not eliminate this completely, but it can greatly facilitate the solution of such a task [3].

MATERIALS AND METHODS

One of the developments for calculating technological parameters, roll calibrations, estimating the stress-strain state of the strip, energy and process parameters in the production of billets, as well as curved profiles of arbitrary configuration with the issuance of a set of drawings, is a Web application for the Internet with a modern interface, embedded in “Dist” distance learning system, hosted on the website econom.misis.ru.

The technology of bending largely depends on the material of the strip. In this regard, it became necessary to create a database of ferrous and non-ferrous metals and alloys, which includes chemical compositions, purpose, technological, physical and mechanical characteristics, as well as a number of other data on domestic and foreign materials. The program shell of the database also allows you to identify the material by its chemical composition, to find analogues.

RESULTS

Starting the development of the technological process and tooling design, it is necessary to evaluate the manufacturability of the profile, taking into account the characteristics of the deformable material, to determine the dimensions of the workpiece. In the presence of relatively small radii of curvature, it is necessary to take into account the hood along the strip width.

The adopted shaping scheme and the profiling mode (angles and radii of rounding) should create such a stress-strain state of the strip in each pass, which, along with the high-quality production of rings and roll adjustment, will ensure not only the required final profile geometry, but exclude the formation of defects, first of all, such as wave formation on strip edges, risks on its surface.

When the strip moves from one stand to another, the length of the path of different sections along the width of the strip due to changes in its geometry may differ significantly. At the points of the strip with an extended trajectory of movement (usually on the edge of the strip), longitudinal tensile stresses arise. To prevent the formation of residual longitudinal deformations, the so-called corrugations (waves), it is necessary that the stresses do not exceed the elastic limit of the material. Usually, for this it is necessary to reduce the hem angles in separate passages, which inevitably leads to an increase in the number of stands. That is, when profiling each profile, it is necessary to find the optimal distribution of the hem angle along the aisles, which ensures the greatest economic efficiency of production.

When rolling asymmetrical profiles, it is necessary that the twisting moment in one half of the profile is balanced by the twisting moment in the other half. Otherwise, the final profile will have a helical shape and this defect, as a rule, is very difficult to correct.

In order to better, control the shaping of the strip, in many cases vertical, usually non-driven rolls are used, as well as inclined rollers. The calculation of their geometry also should considered in the program.

The difficulty in the development of technological processes also adds the need to predict strip formation in areas where it is not possible to control the instrument (rolls). As a rule, these are the last passages in the production of pipes, closed or other complex profiles.

When calculating the geometry of the outgoing strip after each pass, a certain complexity is caused by the determination of springback (restoration of the shape) due to elastic deformations. In addition to the characteristic properties of a deformable steel or non-ferrous alloy, it also depends on the state of the original billet - its degree of hardening.

Increased requirements to the quality of products imply control of the level of residual stresses in the metal in order to prevent premature destruction of products at loads less than intended. First, this applies to pipes and building structures of critical purpose.

Essential in the development of technology are also the power parameters of the process, which are checked for the strength of the rolls and the bed, as well as the drive power.

The program also analyzes the obtained roll calibration by a number of parameters (exceeding permissible hem angles, possible formation of waviness, strip twisting, exceeding allowable loads on equipment, etc.) with issuing messages about possible deficiencies, which allows making changes to parameters, recalculating and thus achieve the best results.

The result of calculating the roll calibration at the first stage is the roll profile geometry, which in many cases is quite complex. In the production of curved profiles, the rolls are usually not turned out entirely, but they are made into composite ones - shrouded in the form of an axis with rings attached to it. The relatively small mass of the rings makes it possible to use rolled metal rather than forgings as a blank in their manufacture, which is much cheaper. The division of the rolls into separate rings is also an important task, the solution of which depends both on the capabilities of the equipment used for their manufacture and on economic considerations. At the same time less loaded and idle rings can be made of cheaper steel, which is more expedient from an economic point of view.

The arbitrary nature of the form of rings and their complexity creates additional difficulties in programming the preparation of their drawings. Considering that while in many cases drawing of drawings onto paper carriers is required, it is necessary to provide a rational layout of several rings of the same type on one drawing. In addition to the drawings of the rings provides for the preparation of the assembly drawing rolls. A summary table of the rings is also calculated, with the calculation of their mass and the size of the proposed blanks for their manufacture.

The graphic capabilities of the program, ranging from inputting the geometry of the desired final profile, displaying the configuration of the strip and calibers during molding in each pass, up to transferring the developed drawings to one of the well-known drawing graphics systems (in particular, AutoCAD, Compass), greatly simplify the design process snap and reduce the likelihood of errors. The issuance of additional information in the form of graphs and tables also ensures the visibility of the data obtained and facilitates the analysis of the results.

Accompanying text information in the form of hints to each screen form contains instructions for the program, as well as recommendations for developing roll calibrations.

DISCUSSIONS

Operation of the program in the form of a Web application requires, of course, the presence of a fairly powerful server, but it allows you to give access to remote users and quickly update the data and make changes to the program as it is improved.

Previously, the program for calculating roll calibrations in the production of rolled-up rolled sections was distributed as a Windows application, acquired by many enterprises and organizations in Russia and neighboring countries. With its help, roll calibrations were calculated and implemented in the production of profiles of various configurations. The program for calculating the formation of tubular billet, predicting changes in the stress-strain state of the metal across the width and thickness of the strip, springback and residual stresses, was tested when analyzing the production process of welded longitudinal pipes of a wide profile range of stainless steel on the Olimpia 80 production line.

Over the past few years, the created software package has been provided to Internet users on the econom.misis.ru portal.

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