

The rolls calibration development and caliber drawings preparation with the computer software for the bent profiles production and straight-through pipes formation for laser welding

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Abstract. A computer program has been created for selecting the profiling route, calculating the rolls for the manufacture of bent symmetrical and asymmetric profiles of virtually any real configurations with the issuance of a complete set of drawings. The algorithm of the program is based on the mathematical model of the strip profiling process, which allows geometric and energy-strength parameters calculation. To create an algorithm for designing roll calibrations to produce curved profiles, a unified description of the shape of the profile was proposed. The left and right halves of the cross section of the profile are treated as separate sets of alternating straight sections and rounds. The configuration of each of them for one and the other profile half is entered separately, starting from the middle. For each point of conjugation (the beginning and end of the section), the coordinates, the rounding radius and the rotation angle are specified (or calculated in the future). The accepted profile shape description makes it possible to compile a general algorithm for calculating the roll calibrations of virtually any profiles, and not to develop an algorithm for each profile or group of profiles.

1 Introduction

The next stage in the development of networked information technologies is, along with the improvement of methods for providing unstructured information and structured data, the widespread use of computer systems in global networks that implement mathematical models of phenomena and technological processes. Such systems, in contrast to local programs, allow the provision of services to a greater number of users and make improvements quickly and update the data. Networking creates additional programming challenges and requires specialized, powerful servers to host such Web applications.

One of the promising areas is the computer design of technological equipment to produce bent rolled profiles, the production of which has recently increased significantly.

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Creation of large specialized production centers is hampered by low profitability of transportation of such products and small, for the most part, consignments. In this regard, many relatively small firms are created to produce profiles for the construction industry, engineering and other purposes. It is often difficult for such organizations to maintain a staff of highly skilled calipers. In addition, the complex configuration of most profiles requires working out several options for choosing the optimal solution and performing a large amount of calculations in each of them. Using a computer program allows you to significantly reduce work and design time, as well as reduce the number of errors. In this regard, the creation of intelligent computer-aided design systems, allowing with a minimal human participation to obtain a full range of technological, including design documentation for the organization of production of any profile is very in demand.

Many years ago, the computer program "Gnut" was created in NITU "MISiS" to calculate roll calibrations for the production of bent symmetrical and asymmetric profiles of virtually any real configurations with the issuance of a complete set of drawings. The program to date has no analogues in our country.

In recent years, work is underway to improve the network version of this program in the form of an Internet application for selecting the profiling route and calculating the rolls.

2 Algorithm description and usage

The algorithm of the program is the realization of the mathematical model of the process of strip profiling with horizontal and vertical rolls, which allows calculating the geometric and energy-force parameters of the process. A unified description of the cross section of a profile consisting of two halves is proposed, each of which is considered in the form of alternating straight sections and curvatures. Such a description of the shape of the profile makes it possible to compile a general algorithm for calculating the roll calibrations of virtually any bent profiles, eliminating the need to develop algorithms for individual profiles.

Initial data for the calculation are: the equipment parameters, strip material and its characteristics, profile shape and dimensions, profiling conditions. The data can be entered in dialog mode and saved in a file on disk. To enter information about the strip material, you can use the built-in database. The profile of the resulting profile is defined using a specially designed graphical editor.

As examples, the user is offered several examples of source data, each of which can be completely modified.

The general profiling scheme can be worked out during the calculation or entered in advance in the form of a table of angles of the sub-graphical interpretation.

Drawing of the required profile, as all subsequent drawings and diagrams can be transferred to AutoCAD or Compass for control checks and subsequent work.

At the initial stage, the program evaluates the processability of the profile, gives recommendations on dimensional tolerances and determines the required width of the workpiece, considering the peculiarities of forming and drawing the metal at bending points.

Bending points can be formed with constant radii of curvatures to better fix the profile or with a constant arc length for less band thinning.

In the detailed dialogue mode during the calculation, the program offers the options for profiling, which you can, if desired, adjust. Based on the analysis of the configuration of the finished profile, the overall molding strategy is determined (to the center, from the center, along the entire length, a pairwise bend for the "snake" type profiles or a combined one) [1,2]. The angles of bending along the aisles are chosen on the basis of the limit values determined from the data on the geometry of the profile and the characteristics of the

process. taking into account the type of caliber, the pass number, the forming method (continuous or piece), the shape of the strip.

When profiling the unequal profiles due to different bending conditions in individual parts of the strip, if the profile mode is incorrectly chosen, the bending moments are not balanced and there may be a twisting moment, which leads to a screw-like course of the strip. To prevent the formation of this defect, the corresponding correction angles in both halves of the strip are made on the basis of an analysis of the stress-strain state of the metal.

The received mode of bending allows to pass to designing of calibers. The outline of the profile is described after the next pass - the upper and lower part (for vertical rolls - left and right), on the basis of which a drawing of the caliber is formed. At the same time, the configuration is refined to eliminate thin protrusions, pinching, etc.

The peripheral section (caliber type) on the left and right in each pass is determined on the basis of analysis of profile configuration features, tolerances on workpiece dimensions and equipment features.

As the basis for the calculation of individual elements of different types of calibers, the relations given in [1] were used. Later, the corresponding analytical expressions were obtained for the calculation of various gauge elements for an arbitrary strip configuration.

When calculating the power-law parameters of the process, the configuration of the strip in each caliber was considered as a combination of four basic elements - with one bend point and a free edge (shelves of angles, channels and other profiles), with two bending points when the adjacent elements were bent one way (walls of channels, troughs and other profiles), with two bending points when the adjacent elements are bent in different directions (the walls of the z-profiles, the side walls of the troughs and other profiles), and also the actual bending points.

The caliber drawings, contours of the incoming and outgoing profiles for each pass are displayed and transmitted to the AutoCAD system.

The general characteristic of the developed calibration of the rolls is shown in the form of a summary table and contains energy-strength parameters, deflections of the shafts, limiting angles of the bend, longitudinal extensions and other parameters. In this case, the maximum permissible and unacceptable values are allocated, respectively, in yellow and red.

As a rule, in the production of bent roll profiles for economic reasons, the rolls are not wholly welded, but made composite (banded), consisting of an axis and a set of rings. Based on the analysis of the swath geometry, the program offers a certain variant of dividing the roll into individual rollers, which can be adjusted taking into account its capabilities for their production.

After the breakdown of the rolls into individual rings, materials for their manufacture are selected, depending on the nature of their work - for the manufacture of heavily loaded rings that perform band folding for less loaded rings holding the strip and for idle rings.

When preparing and outputting drawings, the search and summation of repeating rings is performed, grouping rings by types. Working drawings of the rings and assembly drawings of the rolls, which are the main result of the program, can be transferred directly to production. At the same time, the developed method of placing dimensions on the drawings excludes the creeping of one size to another. In addition, a summary table of the sizes of rings is given with the calculation of the approximate mass of blanks for their manufacture.

On each screen form, the program has a link to a hint, which explains the program's operation and provides recommendations for profiling.

The Internet application for the calculation of roll calibrations for the production of bent roll profiles is posted on the portal http://econom.misis.ru/P/Gnut/_HGnut_.aspx [3]. The

guest entry allows you to familiarize yourself with a more detailed description and its work with a few limited possibilities.

Summarizing the experience of the Internet application, it is possible to note a number of its advantages in comparison with the locally installed program:

- Saving time: the user's costs for accessing the application are minimized - no need to install, configure the program and solve other emerging problems;
- automatic update of the application: an improved version of the program becomes available immediately after it is installed on the server;
- mobility: the ability to work with the application on any computer that has access to the Internet;
- Low requirements for the working computer: saving the RAM of the end user allows it to work in several programs at the same time.
- data security: the reliability of data storage on the server is higher than on the local computer.

The program is registered in the State Register of Databases by the scientific and technical center "Informregistr" under the State Committee of the Russian Federation for Communications and Informatization, acquired and used by a number of organizations of Russia and Ukraine. With its help, roll calibrations have been developed and implemented to produce all kinds of symmetrical and asymmetrical bent rolled profiles [4].

Further development of the computer system is the calculation of the calibrations of the rolls and the stress-strain state of the metal in the manufacture of the pipe billet. The strip forming in this case has some features and, in addition, the geometry of the tool differs significantly. Requirements for the quality of products, primarily the mechanical characteristics of the metal, in this case, as a rule, is much higher. In connection with this, along with the design of the tool design and the geometry of the obtained profile, special attention was paid to the determination of the stress-strain state along the section of the strip and the prediction of residual stresses.

The created computer program complex in the form of a Web application in the Visual Studio environment in C # language with a modern interface that implements the developed calculation methods is placed in the educational environment "Dist" on the portal econom.misis.ru. The software package can be recommended for use in the development of technological processes for a new profile and brand assortment. The programs are registered by the Federal Service for Intellectual Property under No. 2018614644 and No. 2018614645.

3 Conclusion

The developed methodology and programs were tested in the calculation of the process for the production of welded, straight-seamed pipes on the Olimpia 80 production line, which consists of an uncoiler, a roll opening machine, a sheet straightening machine, a dock splitter, a spiral tape drive and a main deforming section that includes molding and calibration mill.

The research and analysis of the process of production of tubular billets of a characteristic assortment have been performed. The results of calculating the stress-strain state showed that the maximum level of longitudinal tensile deformations and stresses lies in the region of the elastic state, which indicates that there is no danger of corrugation at the edges of the strip. The prediction of residual stresses also showed that they are at a sufficiently low level.

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