ABSTRACT

of the thesis work for conferring PhD scientific degree
in specialty 6D070900 –«Metallurgy» by

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Research and development of production technology of metals with nanostructure and high mechanical properties during the rolling in the back-taper rolls

Relevance of research.

Currently, materials with nano- and ultrafine grained structure produced by severe plastic deformation (SPD) have attracted particular attention of the scientific community and industry. The interest in such materials, which differ from the traditional ones with their enhanced mechanical properties (tensile strength, hardness, elongation, etc.) is connected not only to their properties, but also to the possibility of using SPD technology to obtain nano- and ultrafine grained structure of bulk materials.

Rolling is a promising way to produce bulk ultrafine-grained (UFG) and nanostructured (NS) materials at relatively low homologous temperatures. When asymmetric rolling introduce severe shear in one direction. At the moment, there is no process of deformation in two or more directions, allowing to make long articles with UFG and NS.

Since, for obtaining the materials with UFG and NS it is required to increase individual degree of deformation of more than 50%, there is a risk of manifestation of cracks and breaks, failure of equipment, due to high deformation forces and the manifestation of deformation texture. In this context, the development of the processes of SPD without any noticeable load increase and excluding one-directional flow of the material is an urgent task.

Purpose of work - development of technology of rolling in the back-taper rolls and its experimental investigation for ultrafine grained and nanostructured metals production.

Tasks of research. To achieve this goal it was necessary to solve the following problems:

- analysis of existing methods for obtaining the UFG and NS materials;
- investigation of stress-strain state of the strip and the mathematical modeling of the rolling in the back-taper rolls to develop design tools, ensuring maximum efficiency of the treatment process;
- determination of the pressure and the full force of the rolling in the back-taper rolls;
- determination of dependence of the grain size and the angle of misorientation of their boundaries on the parameters of the rolling in the back-taper rolls;

Scientific novelty. For the first time the following results are obtained:

- the ratio of the largest to the smallest roll diameter D/d =1,5 is determined, wherein the effective shear strain is increased by 1.5 - 2 times higher than with conventional and asymmetric rolling respectively;

- the total amount of deformation of 50-60% at the rolling in the back-taper rolls is determined, allowing to obtain billets of carbon steel with a tensile strength of 585 MPa, which is 1,5 times higher than in conventional rolling;

- the roll diameter ratio D/d = 1,5, can cut the rate of Lankford value of 1,5 times as much as possible and bring it to unity, i.e. to eliminate the anisotropy of the strength properties of low carbon steel in contrast to the conventional rolling;

- it is found that deformation starting temperature of 900 °C and the ratio D/d=1,5, and the total degree of deformation of 50% of the resulting structure comprises grain sizes from 92 to 200 nm in the surface and central parts of the billets, and the microhardness increased from 1284 MPa to 2305 MPa;

The practical value. On the basis of the results obtained in the thesis:

- basic theoretical positions and research results related to the solution of the scientific problem are introduced in the learning process of undergraduate and graduate of specialties of 5B070900 «Metallurgy» and 6M070900 «Metallurgy»;

- the design of rolls and rolling technology for the production of low carbon steel billets with high mechanical properties, nano- and UFG structure are developed, tested in industrial conditions and proposed to use.

Provisions for the defense.

- geometrical factors and technological conditions affecting the stress-strain state and deformation force during the rolling in the back-taper rolls are identified;

- dependence of formation of nano- and UFG structures and high angle grain boundaries of low-carbon steel on the parameters of the rolling ro in the back-taper rolls is derived.

Reliability and validity of the research results presented in the thesis are confirmed by:

- positive results of the industrial validation of the developed techniques and a method of rolling technology and tools configuration under JSC «ArcelorMittal Temirtau»;
- high reproducibility of analytical and experimental studies.

Implementation of the work. The technological process has passed industrial tests at JSC «ArcelorMittal Temirtau» (Temirtau). The technological process is adopted for the production program of the plant.

The main provisions the dissertation work reported and discussed on 5 international scientific-practical conferences (5 abstracts)

According to the results of the work there four articles published in journals recommended by CCES (1 article – «Vestnik of KazNTU», Almaty, Kazakhstan, KazBC IF - 0,078; 3 article – «Proceedings of the University», Karaganda, Kazakhstan, KazBC IF – 0,062) and 1 article in the journal which is a part of the database information agency Thomson Reuters and Scopus («Metalurgija», Zagreb, Croatia, IF – 0,77), and there are also received 2 innovation patents of RK.

Structure of the dissertation. The thesis consists of content, normative references, list of abbreviations, introduction, main part of 6 chapters, conclusion,

three applications. The volume of the dissertation is 127 typewritten pages, contains 70 figures, 12 tables, a list of references, including 121 names.