Integration of automated roll pass design and simulation for the development of shape rolling technology

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ABSTRACT

The shape rolling technology is a productive manufacturing process. Meanwhile, its effectiveness is highly dependent on a proper roll pass design and accurate adjusting of the rolling mill which is especially critical for the new products and complicated profile shapes. Traditionally the methods of the roll pass design have been developed relying on extensive experience and knowledge accumulation, resulting in empirical rules expressed by analytical formulae. Some of these design methods nowadays are converted into computer programs to speed up the calculations. Nonetheless, the approach based on empirical rules has limitations especially when implemented to develop the rolling technology for new materials and complex shape profiles. The effectiveness of the roll pass design can be significantly enhanced with the help of finite element (FE) simulation of the material deformation that happens in the stands of the rolling mill. The material flow prediction provided by FE simulation is more accurate compared to empiric formulae which in turn leads to more accurate load, torque, and energy estimations. The presented paper is focused on the integration of the FE simulation of the rolling process with the roll pass design to make it effective and automated for a wide variety of profile shapes.

The first stage of the research was to develop special methods to increase the accuracy of the FE simulation of the rolling process and reduce the simulation time for the long products in continuous rolling mills that may contain more than twenty stands. These methods include a combination of Euler and Lagrange approaches to solve the coupled thermo-mechanical problem in the system “roll-deformed material”, implementation of dual mesh for mechanical and thermal tasks, scaling problem size within the gaps between the stands to reduce the number of elements, and some others which have been integrated into general purpose metal forming simulation program QForm UK. The comparison of the simulation results obtained by such an enhanced FE model with experimental measurement of the temperature, load, torques, and configuration of the intermediate cross sections of the I-beam industrially produced in a rolling mill having 17 stands have shown a good accuracy acceptable for practice.

The next stage was to develop the software system for computer-aided design (CAD) of the roll passes which was called QKaliber. This system is based on analytical methods and empirical rules for groove shape design, but it is tightly integrated with the mentioned FEM program. Thus, the designed roll grooves can be immediately verified for their performance including proper filling with metal, synchronised rolling velocities in all stands of the continuous group avoiding excessive pulling and pushing, and keeping other parameters within limitations applied to the temperature, load, torque, etc. The industrial implementation of the roll pass design developed by the proposed system is presented in the work. It has shown its efficiency in speeding up the rolling technology development and improving productivity of the technological process.