On the Optimization Procedure of Rolling Mill Design — A Combined Application of Rolling Models

A procedure to optimize the rolling mill design is discussed in this article. This procedure has been programmed into a software package, which standardizes the design, reduces the design cycle time, saves material cost and, most importantly, provides optimal mill performance.

The rolling mill is a solid hardware to perform metal thickness reduction with mechanical, electrical, hydraulic and control devices to meet the target geometric and metallurgical requirements. The pass schedule (or the level 2 model) is a knowledge-based software package to direct the designed mill to reduce the material thickness in a certain sequence, with calculated setpoints for control means to achieve desirable metallurgical and geometric targets. The geometric target extensively embraces the gauge, profile (crown) and shape controls. The gauge control includes the rolling feasibility and achievable gauge tolerance. The crown/shape control largely influences the downstream operation, and frequently affects productivity as well. In designing the mill, the rolling feasibility must be considered; namely, the work roll (WR) diameter must be suitable for the entire product mix. The crown/shape control capability has to be taken into account so that the designed mill can provide the control range for the entire product mix.

The development of the servo-operated hydraulic system and the concept of automatic gauge control (AGC) solve most of the gauge variation problems.1,2 The system can provide even quarter-gauge tolerance, thanks to modern rolling technology. The crown/shape control was resolved later due to its natural complexity of two-dimensional displacements and the coupled correlations between crown and shape changes. In the 1980s, the crown/shape control devices were invented, tested, and installed in the lab and production mills,3–7 including the dynamic adjustment of roll bending,4 roll shifting,3 roll crossing7 and roll crowning5 devices. The contoured roll shifting8 was developed to further enhance the crown/shape control range. The control concept and theory lag behind the developing pace of control devices. The mill may be equipped with multiple crown/shape control devices to increase the control range. However, the end user has difficulties coordinating and optimizing these control devices for the best mill performance.

Besides ample control devices, selecting the mill type (2-high, 4-high, 6-high or cluster mills) is also a major task in the industry. The mill type selection relies more on the end user’s preference than technical aspects. In fact, there is a lack of technical knowledge to optimize the mill design with suitable mill type and crown control device(s).

This article introduces an optimization procedure by combining the results of the force model, the crown/shape model, the pass schedule model, the roll slippage model and the mill design model. The force model

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