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Real-Time Work Hardening Evaluation for Optimizing Hot Rolling Schedules and Power Demand in HSLA Steel Production

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Abstract
The hot rolling mill power requirement depends on several factors, including the material's properties, strain and strain rate schedule, rolling temperature, microstructure evolution and roll-workpiece friction condition. On the other side, the thermomechanical process relies on precisely controlled softening and hardening phenomena to achieve the desired microstructure and tensile properties after rolling and final cooling. In order to optimize both needs (steel quality and energy cost) a novel incremental plasticity approach is introduced to optimize contemporarily the power requirements and the microstructure evolution during hot rolling process. Both deformation energy and microstructure changes are related to the work hardening of workpiece in the roll bite, according with a first-order differential equation, $d\sigma/d\varepsilon = \Omega\sigma$, where the hardening function Ω is independent of stress and is influenced by rolling pass geometry, material properties and roll-workpiece friction condition. The proposed approach allows for the calculation of drive-power requirements in terms of cumulative deformation energy for each rolling pass and enables the prediction of the metallurgical capability of an existing mill to process products of varying dimensions, steel grades, or rolling conditions. This not only to predict steady-state power and torque requirements, but also to estimate the peak values developed under transient conditions. The results of this approach to hot rolling plate mill for HSLA steel grades were quite positive, demonstrating significant potential to achieve optimal microstructure and tensile properties while minimizing both mill power and torque.

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