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Optimization of Stainless Steel Cold Rolling Lubrication Through Thermal Modeling

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In cold rolling, the mixed lubrication regime is needed e.g. to avoid skidding. In fact, low viscosity oils are used as lubricants to set lubrication at the frontier of the boundary regime, promoting strip surface smoothing by finely ground rolls. This poses a risk of boundary regime interface degradation, including adhesive transfer, which may harm final strip surface quality. On the other hand, heat is generated at the contact region between the strip and the roll under two forms: friction dissipation and plastic deformation, increasing the roll and strip temperatures (up to 200 ℃ depending on the rolling conditions). In turn, temperature influences the lubricant behaviour and therefore the coefficient of friction (dual relation), especially when it exceeds the desorption temperatures of polar additives (~150 ℃). The effect is twofold: 1) High upstream temperature reduces lubricating film thickness, worsening boundary lubrication and dependence on additives. 2) Excessive temperature hampers friction-reducing additives, while extreme-pressure additives need significant film-forming time. In classic mixed lubrication regime theory, to predict friction in the roll bite, the mean lubricant film thickness and fractional contact area evolutions from the entry to the work and exit zones are evaluated using Reynolds equation integrated together with the theory of plastic asperity crushing. The goal of this study is to enhance these lubrication models with a roll and strip thermal model. The proposed model predicts key phenomena, including a decreasing in viscosity within the contact region, a reduction in lubrication film thickness, and an indication of transition into the boundary lubrication regime. In the latter, an estimate of the risk of loss of lubricity, adhesion and strip surface degradation is proposed, based on interface temperature and superficial plastic strain. An example of application to a typical stainless steel cold rolling schedule will be presented.

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