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PREDICTION OF MICROSTRUCTURE DEVELOPMENT DURING RECRYSTALLIZATION HOT ROLLING OF Ti-V STEELS

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ABSTRACT

In recrystallization hot rolling of plate, the static recrystallization of austenite at moderate rolling temperatures is used to engender fine as-hot-rolled ferrite grain sizes and concomitantly attractive as-rolled properties. The advantages of the procedure in comparison with controlled rolling are shorter throughput times on conventional mills and lower rolling loads. In the present paper, the essence of a computer model for predicting microstructural evolution during recrystallization hot rolling of a Ti-V microalloyed steel is given. The model is shown to forecast a behaviour which is in acceptable accord with practical rolling experience. Furthermore, the effect of the principal rolling variables on the degree of microstructural refinement during processing via recrystallization rolling has been investigated theoretically in a systematic way. Low finish-rolling temperatures and heavy reductions, especially during the final passes, promote fine as-rolled ferrite grain sizes; the austenite grain size created during reheating has no bearing on the final as-rolled microstructure. In addition, a suggestion is given regarding the design of rolling schedules which fulfill the conflicting requirements of efficient microstructural refinement (large reductions in the final rolling passes) and satisfactory plate flatness (small reductions).

RISING ENERGY COSTS have motivated attempts to obviate normalizing as a step in the production of constructional steel plates for applications specifying moderate to high toughness levels. *Controlled rolling* is one possibility, but this is an expensive production method unless the plant available is specifically designed for the process; on conventional, low-capacity mills the production rate with controlled rolling is often unacceptably low. Another method of enhancing toughness of as-hot-rolled plates is via *accelerated cooling*; however, many mills lack the necessary facilities to take advantage of this procedure. In recent years, increasing interest has been centred upon obtaining small as-hot-rolled ferrite grain sizes after finish rolling at relatively high temperatures, so-called *recrystallization rolling*. This procedure, which constitutes the principal substance of the present paper, is attractive in that it is relatively uncomplicated and can be applied on conventional mills.

In recrystallization rolling, the basic philosophy is to make use of the grain refinement accruing from the static recrystallization of austenite at moderate finish-rolling temperatures (FRT), typically 900-1000°C. However, in order to maintain the fine recrystallized grain size during cooling between the FRT and the temperature at which the steel starts to transform to ferrite, it is necessary that grain growth be restricted in some way e.g. by particles. It is known from earlier work that TiN is a suitable candidate for such grain-growth inhibition. With continuous-casting technology, it is possible to induce a fine distribution of TiN-particles which are formed in association with and immediately following solidification of the steel. This dispersion is then extremely stable during reheating at normal temperatures and under rolling. The small TiN-inclusions existing after strand casting of Ti-microalloyed steels, not only engender effective grain-growth inhibition between rolling passes and during cooling following the termination of rolling, but are also useful for restricting HAZ-grain coarsening in association with subsequent welding.

Properly performed with an appropriate steel analysis, recrystallization hot rolling is capable of yielding as-rolled ferrite grain sizes small enough to meet moderate toughness requirements. In addition, the method offers a considerable potential for attaining high production rates on conventional mills combined with