8306-026

PROCESSING CHARACTERISTICS AND PROPERTIES OF Ti-V-N STEELS

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ABSTRACT

The incentive to develop Ti-V microalloyed steels stems from the desire to combine the excellent grain-coarsening characteristics of Ti-grades with the effective precipitation strengthening derived from vanadium, especially when the latter is combined with nitrogen. The present study has been undertaken to establish the degree to which V and excess N detract from the grain-coarsening resistance of a Ti-steel, and to determine whether or not the presence of Ti modifies the precipitation-strengthening from V(C,N).

It is found that Ti-V-N alloys are, in the as-cast condition (strand), characterized by GCT's only marginally lower than steels based on Ti-only. However, in hot-rolled material, the presence of fine V(C,N) in addition to (Ti,V)N can result in a deterioration of the grain-growth inhibition. The effective elimination of grain growth of austenite both during and following hot rolling renders Ti-V-N grades especially suitable for recrystallization rolling, whereby relatively fine as-rolled ferrite grain sizes can be achieved via conventional schedules with finishing temperatures in the range 900-1000°C. The precipitation-strengthening potential of vanadium and nitrogen is diminished somewhat when, in addition, Ti is present. The reason for this is partly that vanadium is combined as stable (Ti,V)N-particles which are responsible for the limitation of grain growth at high temperatures, and partly that V(C,N) deposits epitaxially on pre-existing (Ti,V)N-particles in austenite following the termination of rolling. Both these effects reduce the amount of vanadium and nitrogen available for strengthening via precipitation in ferrite.

THE USEFULNESS OF SMALL ADDITIONS of Ti (<0,02%) in microalloyed steels stems from the extreme stability of titanium nitride (TiN) precipitates. Particles of pure TiN are resistant to both coarsening and dissolution during reheating and hot rolling, and in association with welding (HAZ). With continuous-casting technology, it is feasible to produce fine TiN-precipitates even in the as-cast condition (average size of particles, 5-20 nm); these remain comparatively stable throughout subsequent processing. Microstructurally, the principal benefit derived from the presence of such a dispersion is an enhanced resistance against austenite grain growth. Hence, Ti-steels can be processed to give relatively fine as-hot-rolled ferrite grain sizes even when the finish-rolling temperature (FRT) is quite high. The reason for this is that a fine austenite grain size is attained via static recrystallization when rolling is finished in the temperature range 900-1000°C, and, most important, that such a fine microstructure can be retained during cooling down to Ar_3 because of the grain-growth inhibition via TiN; furthermore, the latter is effective in limiting grain growth between the individual rolling passes. This type of high-FRT thermomechanical processing is called *recrystallization rolling* and is a realistic alternative only with Ti-microalloyed grades (1).

Another useful effect of the grain-growth inhibition derived from a fine TiN-dispersion is the very pronounced limitation of HAZ-grain coarsening during welding of Ti-microalloyed steels. For a given welding cycle, the resulting austenite grain size is smaller in Ti-steels than for other microalloyed grades and the HAZ-hardness, after transformation, is therefore lower (greater volume fraction of polygonal ferrite as opposed to plate-ferrite products). The low hardness and high proportion of polygonal ferrite in the HAZ confer good impact toughness and superior resistance to hydrogen embrittlement irrespective of whether hydrogen is introduced during welding or in subsequent service (e.g.H_2S-environment).

At the alloying levels which have been found to confer optimum grain-growth inhibition characteristics (<0,02%), titanium does not