8306-090

ACHIEVING GRAIN REFINEMENT THROUGH RECRYSTALLIZATION CONTROLLED ROLLING AND CONTROLLED COOLING IN V-Ti-N MICROALLOYED STEELS

Yang-Zeng Zheng, A. J. DeArdo, Robert M. Fix, Guillermo Fitzsimons
Dept. of Metallurgical and Materials Engineering
University of Pittsburgh
Pittsburgh, Pennsylvania USA

ABSTRACT

A new thermomechanical processing route, labeled recrystallization controlled rolling (RCR), and the alloy design philosophy corresponding to this processing are proposed. RCR avoids the high mill loads and low productivity associated with conventional controlled rolling (CCR) and is based upon (i) achieving a very fine as-reheated austenite, (ii) repeated deformation and recrystallization above the recrystallization temperature of austenite and (iii) accelerated cooling to some intermediate temperature, followed by air-cooling to room temperature. Steel compositions which are ideal for this processing should have a relatively high grain coarsening temperature during reheating, T_{GC}, a relatively low recrystallization temperature during rolling, T_{RX}, and a low grain coarsening rate after deformation, R_{GC}. In addition, the steels should exhibit an adequate capacity for undercooling and precipitation hardening of the ferrite.

Experiments conducted on .13V and .13V-.017Ti steels have shown that a very small addition of Ti to V steels markedly raises the T_{GC}. The T_{GC} of the V-Ti steels in the as-slabbed condition increases with increasing N content while the T_{GC} of the same steel in the as-cast condition is insensitive to N content. Nevertheless, in all cases, the former is much lower than the latter. In both the .13V and .13V-.017Ti steels, the lowest temperature at which austenite completely recrystallizes in a short time after a 50% reduction, the T_{RX}, increases with increasing N level; however, the T_{RX} of the V-Ti steels is much lower than that of the V steels if the processing parameters are the same. The temperature difference (T_{GC}-T_{RX}), the temperature range of RCR, is at least 175°C higher in the V-Ti steels than in the V steels. In the .13V-.017Ti-.012N steel, an effective austenite interfacial area, S_V, of approximately 160 mm^{-1} can be generated by rolling in the range of 850 to 1080°C. This S_V is remarkably temperature insensitive and resulted from recrystallized austenite in all cases. The hot strength in the second hit of interrupted compression tests at 850°C and a strain rate of 5 s^{-1}, to which mill loads are directly related, is 60% higher in the .13V-.025N steel than in the .13V-.017Ti steels. In addition, the V-Ti steels show strong inhibition of grain growth after hot rolling due to the pre-existing fine TiN particles. Uniform and fine ferrite grain sizes to 6 microns can be achieved using RCR. The precipitation potential in α of V and V-Ti steels increases with increasing N content as well as cooling rate. An addition of .017 wt% Ti to V steels decreases the precipitation potential; however, the loss can be reduced by using a relatively high N level and accelerated cooling.

While extensive grain refinement is achievable using CCR, the high mill loads and low productivity have kept this process from being widely applied in North America as well as in most of the rest of the world. The attractiveness of RCR is that it is a rolling procedure which can result in extensive grain refinement, and, which at the same time, can be immediately employed on existing rolling facilities.

IT IS WELL KNOWN that a fine ferrite grain size in the final product can be achieved by proper hot rolling. Recent work has focused on the ferrite grain refinement which results from the conventional controlled rolling (CCR) of austenite. As much of the deformation in CCR takes place below the recrystallization temperature, T_{RX}, high ferrite nucleation rates are promoted. This is due to the high effective interfacial area, S_V, which results principally from the