Austenite Stabilization through Reverse Transformation and Intercritical Annealing in Medium Manganese Steel

Austenite stabilization through reverse transformation and intercritical annealing of 8 Mn steel was investigated. A minimum austenite grain size of 2 μm was achieved with 5 cycle reverse transformation. Austenite stabilization was obtained in a short period of intercritical annealing of lean alloy of 8 Mn steel having small grain size, which is obtained by 5 cycles of reverse transformation.

Lean alloyed steel containing 5 to 8 wt. % manganese refers to as the third generation advanced high-strength steel (AHSS) comparing to the second generation AHSS which requires high manganese level for the stabilization of the fully austenitic structure. Third-generation AHSS developments are focusing on stabilizing retained austenite in an ultrafine ferritic matrix such as martensite or bainite. Although austenite stabilization is obtained through diffusion of interstitial carbon in most processing strategies, diffusion of substitutional elements such as manganese has also been shown to be effective. Significant austenite fractions resulting from prolonged holding (24hr, 1 week) at an intercritical temperature allowing for manganese partitioning from ferrite into austenite have been reported [1].

Austenite stability is increased not only with increasing austenite stabilization element such as Mn and C, but with reducing grain size and increasing dislocation density [2]. Repetition of austenite to martensite transformation through thermal cycling of rapid heating and quenching would results in fine grained structure [3]. The medium manganese content steel having fine prior austenite grain size which is obtained by reverse transformation, would results in stabilized austenite at room temperature in reduced time period when it experiences intercritical annealing, as the manganese atoms do not need to go far for achieving equilibrium concentration of austenite.

Fe-8Mn-0.2Mo-0.04C alloy was prepared by vacuum induction melting furnace. Cast slab was hot rolled to the thickness of 14mm(80% reduction) at 1200°C. Homogenization was carried out for 86.4ks at 1150°C in a vacuum furnace followed by water quenching. Solution treatment was performed for 1.8ks at 850°C followed by water quenching for obtaining initial microstructure having a lath martensite structure. For the reverse transformation cycle, the specimens were re-austenized at 730°C for 60s and quenched. The reverse transformation cycle was repeated up to 5 times. Intercritical annealing was performed for 3.6ks at 600°C followed by air cooling.

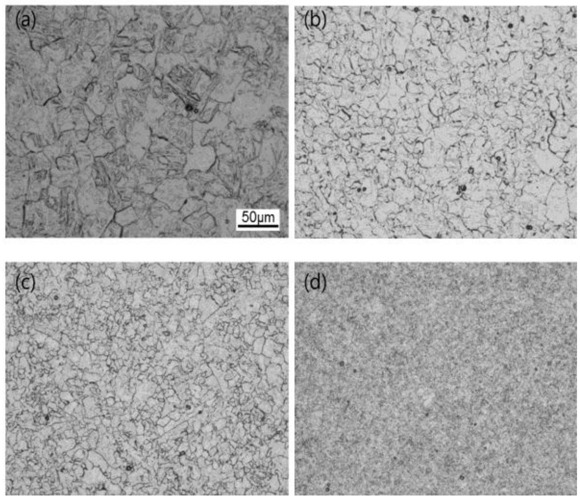

Fig. 1 Optical microstructures obtained by reverse transformation at 730°C. (a) 0 cycle; solution treated at 850°C for 1.8ks and followed by water quenching, (b) 1 cycle, (c) 2 cycle, (d) 5 cycle

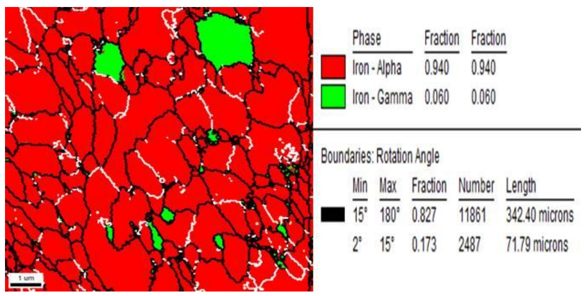

Fig. 2 EBSD phase map; 5 cycle reverse transformed at 730°C and followed by intercritical annealing at 600°C for 3.6ks.

Fig. 1 shows microstructures obtained by reverse transformation at 730°C. The initial austenite grain size is 26 μm(Fig. 1(a)). Austenite grain size decreases with increasing thermal cycle. The austenite grain size decreases sharply after the first cycle, and finally prior austenite grain size 2 μm was achieved with 5 cycles of reverse transformation.

Fig. 2 shows the EBSD phase map obtained from the intercritical annealing at 600°C for 3.6ks.

6 percent of the stabilized austenite was confirmed at room temperature with intercritical annealing of the specimen treated 5 cycle reverse transformation. The amount of stabilized austenite was reduced with decreasing reverse transformation cycle. It is thought to be due to the fact that the prior austenite grain size is decreased with reverse transformation cycle and resulting in the martensite structure having smaller packet and block sizes, thereby the distance need to move for achieving equilibrium concentration of austenite during intercritical annealing is reduced.

The results obtained in present work were summarized below.

A minimum austenite grain size of 2 μm was achieved with 5 cycle reverse transformation. Austenite stabilization (6% austenite fraction) was obtained in a short period of intercritical annealing (600°C, 3.6ks) of lean alloy of 8 Mn steel having small grain size, which is obtained by 5 cycles of reverse transformation.

References

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