DEVELOPMENT OF ALUMINUM ADDED MEDIUM MANGANESE STEEL FOR AUTOMOTIVE APPLICATIONS

ABSTRACT

Lightweight materials with the best possible combination of high strength and ductility are vastly preferred in automotive research where challenges to passengers' safety and emission control need to be assessed circumspectly. Modern research on the Fe-Al-Mn-C system with low carbon, medium Al (1-6 wt. %) and medium Mn (5-12 wt. %), for locomotive applications, is of soaring importance due to its significant weight reduction capabilities, superior strength and good ductility. In the present work, a medium manganese steel (MMnS) with a composition of Fe-6.78Mn-3.92Al-0.18C (weight percent) was prepared using the melting and casting route and subjected to hot rolling followed by intercritical annealing at various temperatures (700, 750 and 800 °C). The influence of microstructure, texture, and mechanical stability of austenite on the tensile properties is studied. The scanning electron microscopy (SEM) and transmission electron microscopy (TEM) analyses reveal the development of a complex microstructure comprising of blocky and lath type reverted austenite (RA) with fine polygonal and blocky type intercritical ferrite (IF), coarse elongated ferrite (EF) and lath martensite (M). The significance of volume fraction and mechanical stability of austenite on the transformation-induced plasticity (TRIP) effect is inferred from the X-ray diffraction (XRD) and electron back-scattered diffraction (EBSD) analyses. The sample annealed at 750 °C for 1hr shows an ultimate tensile strength of 802 MPa, total elongation of 61% and impact energy of 26 J which is attributed to the enhanced TRIP effect and low mechanical stability of RA. Further, the effect of annealing time (30, 60 and 180 min) on the microstructure, mechanical properties and impact behavior of the steel annealed at 750 °C is investigated. The steel annealed at 750 °C for 60 min shows better strength-ductility balance and impact properties as compared to others. This is attributed to the high volume fraction of austenite, improved TRIP effect, and low mechanical stability of austenite. In addition, the effect of strain rate on the microstructure evolution, tensile behavior and mechanical stability of austenite of intercritically annealed (at 750 °C, 1hr) steel is investigated. The experimental outcomes show that the ultimate tensile strength, tensile elongation and dislocation density decrease with an increase in the strain rate. The mechanical stability of austenite increases at a higher strain rate which primarily depends on the transformation ratio of austenite. Further, the intercritically annealed (at 750 °C, 1hr) steel is subjected to interrupted tensile tests to evaluate the microstructure, the role of mechanical stability of RA on the TRIP effect, coefficient of mechanical stability *(k*-parameter), and the micro-mechanical behavior of RA during tensile deformation. Lastly, the electrochemical behavior of intercritically annealed (700, 750 and 800 ºC for 60 min) Fe-0.18C-7Mn-4Al (wt. %) steel is studied. The intercritically annealed samples are exposed to a splash and static corrosion environment. Both electrochemical impedance spectra (EIS) and potentiodynamic polarization analysis suggest the higher corrosion resistance of sample annealed at 800 ºC as compared to other annealed samples.

Keywords: *Medium manganese steel; Intercritical annealing; Reverted austenite; Tensile properties; TRIP effect; Mechanical stability*