Abstract

The present work has been conceived to explore the development of advanced high strength steel (AHSS) having light weight, ecofriendly and most importantly to provide safety. Its applications are widely broaden with the usage in structural applications. The present work systematically correlates the strength–ductility relationship of Mn-modified Fe-Mn-Al-Si-C steels with its microstructural characteristics such as grain size, type and morphology of precipitates, and the transformation-induced plasticity (TRIP) effect during hot deformation. The invstigated steels developed through melting and casting route are subjected to thermo-mechanical processing such as hot forging, which is common for all the developed alloys at 1373K. Subsequent hot rolling was performed at various temperatures for all the three alloys in the range of 1073K-1273K.

In case of Fe-12Mn-0.6C-3Al-7Si-0.2Ti (wt.%), an excellent combination of the ultra-high tensile strength (UTS~1700 ± 20 MPa), reasonable ductility (elongation ~ 11%) and high work hardening behaviour (n ~ 0.89) are achieved in the hot-rolled specimen as compared to the hot-forged one (UTS~ 824±9 MPa, n ~ 0.07) with negligible change in the elongation. Similarly, in case of Fe-15Mn-0.17C-2Al-3Si-0.6Ti (wt.%), ultra-high tensile strength (UTS~ 2181±53 MPa), good ductility (elongation ~ 51%) and high work hardening behaviour (n ~ 0.7) are achieved in the hot-rolled specimen (1173K-HR). In case of Fe-19Mn-0.6C-3Al-4Si-0.04Nb (wt.%), unique combination of ultra-high tensile strength (UTS~1994 ± 11 MPa), excellent ductility (elongation ~24%) and high work hardening behaviour (n ~ 0.5) are achieved in the hot-rolled specimen (1173K-HR 30% red.). The unique tensile properties of the hot-rolled specimens in contrast to the hot-forged one are due to the combined effects of grain refinement during rolling, twin-twin interactions (TWIP effect), and precipitation strengthening by mixture of Ti rich and Nb-rich precipitates and most significantly the enhanced TRIP effect. The martensitic transformation instigates the TRIP effect during tensile testing which resulted in the enhanced hardness and strength of the hot-rolled specimens. The above observation offers strong support to the proposition that TRIP effect is the dominant plasticity enhancing mechanism that has been activated during the deformation of the low-stacking fault energy in the developed multicomponent steels.