Abstract

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Studies on the deformation microstructure in some coarse-grain high-Mn steels using X-ray and electron diffraction

High-Mn steels are broadly categorized into three types, namely Fe-Mn-C, Fe-Mn-Al & Fe-Mn-Si-Al, wherein each having the own merits and demerits. Deformation microstructure in some coarse-grain high-Mn steels is studied by using X-ray and electron diffraction. The study involved with the investigations of mechanical properties in terms different deformation microstructures in different high-Mn steels with & without Al alloying. Al-free steel manifested maximum strain hardening rate under tensile deformation as compared to other steels with different Al content (1, 3 wt. %). The corresponding deformation microstructure of the steels were interpreted in terms of different microstructural parameters, such as: dislocation density, stacking fault energy, planar fault probability, critical twinning stress etc. Lowest value of critical twinning stress was obtained for 0Al steel and it increases with Al content, while the dislocation density decreased with increasing Al. Deformation induced ε-martensite was detected only for Al free steel, whereas twinning and dislocation substructures were predominant in both 1Al and 3Al steel. Critical shear stress-based deformation study revealed an adaptation in deformation mechanism from: $(\gamma \rightarrow \varepsilon)$ transformation $\rightarrow$ deformation twinning $\rightarrow$ dislocation plasticity – which was also verified by transmission electron microscopy studies. Another study involving a different steel with slightly higher carbon content revealed a gradually decreasing three-stage strain hardening behavior, and the corresponding early deformation microstructure was comprised of dislocations configurations; like Taylor lattice and stair-rod dislocations while dislocation cells and fine twin bundles were observed at high strain. Instead of hardening being a concomitant effect of deformation twins and dislocation substructure, the contribution of dislocations seems to overwhelm the contribution from twinning. Lastly, a Fe-Mn-Si-Al steel was also considered, wherein, a competition of the dislocation plasticity and deformation twinning was noticed during tension and compression loading which created an asymmetry in their flow stress behavior. Formation of Sessile Lomer-Cottrel lock (LC) in highly tangled dislocation for tensile deformed sample introduced the yield asymmetry while asymmetry in intermediate to high strain was controlled by deformation twinning. Due to secondary twinning and formation of twin bundle, flow curve of the compressed specimen remains higher than the tensile sample and leads to a high asymmetry in the plastic flow behavior.

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