Synopsis

Twinning Induced Plasticity (TWIP) and Transformation Induced Plasticity (TRIP) steels possess excellent combination of high strength and high ductility. Deformation twinning and strain induced martensitic phase transformation are the dominant deformation mechanisms in TWIP and TRIP steels, respectively. The TWIP and TRIP effects are strongly dependent on stacking fault energy (SFE), which essentially decides the operating deformation mechanisms. In TWIP steels, which are characterized by SFE in the range 18 - 45 mJ/m2, deformation takes place primarily by twinning, whereas in TRIP steels where the SFE below 18 mJ/m2, deformation is by martensitic transformation. TWIP steels contain very high amount of manganese (Mn) for the stabilization of austenitic phase and to keep the SFE within the prescribed range. In TRIP steels, the Mn content is rather low.

The present thesis primarily deals with the evolution of the microstructure, texture and mechanical properties in TWIP/TRIP steels for a range of Mn content. Chapter 1 of the thesis presents the general introduction of the TWIP/TRIP steels and an extended review of published literature on these materials. The experimental procedures and the methodology of data analysis are presented in chapter 2.

Chapter 3 deals with the effect of deformation on the evolution of microstructure and texture in a high Mn steel. The evolution of microstructure and texture has been examined for deformation up to very large strains.
In chapter 4, two medium Mn steels with 18 and 12 wt. pct. Mn have been studied about evolution of microstructure and texture, hence the associated the deformation mechanisms have been explored. For both the materials deformation texture has been characterized by the evolution of Bs-type texture. Deformation twinning has been identified as main mechanisms in the early stages of deformation and shear banding at intermediate to large deformation. Thermal stability of the deformed microstructure has been examined and recrystallization mechanisms have been identified. Chapter 5 deals with the effect of Al addition on deformation mechanisms, texture evolution and mechanical properties in medium Mn TWIP steels. The effect of Al addition has been studied more comprehensively. It was found that different Al containing alloy led to different mechanical response in terms of yield strength and strain hardening, which has been attributed to different propensity of twinning.

In chapter 6, the basic principles of alloy design, deformation mechanisms and mechanical properties have been investigated for low Mn steels (<10 wt. pct. Mn), exhibiting TWIP/TRIP effects. It has been found that in these materials, microstructural development takes place on elemental partitioning during inter-critical annealing. The phase fraction of austenite in the microstructure depends on the inter-critical annealing temperature, annealing time, chemical composition and rolling conditions before annealing. An elaborate study on possible alloying additions and their consequences have also been discussed.

Overall conclusions pertaining to the investigations carried out in the entire thesis have been summarized in chapter 7 along with the suggestions for the future work.