Microstructure evolution and heterogeneous deformation of pearlite steels

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Thesis Summary

The microstructure evolution and heterogeneous deformation of pearlite steels were studied in this thesis. Plastic deformation of multi-phase structures can generate significant amount of internal stresses between the hierarchically multi-scaled heterogeneous microstructures due to the different mechanical properties. In pearlite steels, the main heterogeneous microstructures are the polycrystalline ferrite matrix and the cementite particles. Although the mechanical behaviour of pearlite steel has been investigated in the past few decades, our knowledge is far from complete, when the cementite phase is considered, particularly.

It was found that the internal stresses generated during pearlite transformation accompanying some stress relaxation mechanisms. This results in larger diffraction profile line broadening. Additionally, the thermal misfit strain between ferrite and cementite upon heating and cooling also affect diffraction line broadening of ferrite peaks.

The occurrence of discontinuous yielding in pearlite steels is unclear. In this dissertation, the critical stress from elastic to plastic deformation is lower near the semi-coherent interface than the incoherent one or in the grain interior. This suggests easier emission of dislocations at the semi-coherent interface compared with the incoherent one.

The work hardening behavior is governed by the interplay between the ductile ferrite matrix and the brittle cementite. Three kinds of stress partitioning behavior are found, i.e., between ferrite and cementite, <*hkl*>-oriented grain families and colonies with different lamellar orientations.

By considering the load reversal, the internal stress of ferrite also plays some roles in macro mechanical properties. The ferrite phase stress hinders forward plastic deformation but assists backward plastic deformation. In addition, the softening of ferrite phase stress results in macro cyclic softening.