Effect of Microstructure on Room-Temperature Work Hardening Behavior of Eutectoid Steel (Postprint)

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Abstract

Eutectoid steels with four different microstructures—lamellar pearlite, spheroidized pearlite, ultrafine (+) duplex microstructure, and fine-grained (+) duplex microstructure—were obtained through different thermomechanical treatment processes; the effects of these microstructures on the room-temperature work hardening behavior of eutectoid steel were investigated by means of room-temperature uniaxial tensile testing, SEM, and TEM. The results show that the lamellar pearlite microstructure is characterized by high tensile strength, low yield ratio, and low uniform elongation, which is directly related to its high initial work hardening rate and the degree of decline in work hardening rate with increasing strain. The other three ferrite/cementite particle duplex microstructures exhibit lower initial work hardening rates, but with a more gradual decreasing trend, demonstrating better plastic deformation capacity. Compared with spheroidized pearlite, microstructural refinement endows the ultrafine (+) duplex microstructure and fine-grained (+) duplex microstructure with a better combination of strength and ductility.

Full Text

Mechanical Properties and Work Hardening Behavior

The high initial work hardening rate, which decreases rapidly with strain, is directly related to the high tensile strength, low yield ratio, and low uniform elongation. Although the three ferrite/cementite particle duplex structures exhibit a lower initial work hardening rate, their work hardening rate decreases much more slowly with strain compared to lamellar pearlite. Consequently, these three types of ferrite/cementite particle duplex structures demonstrate excellent plastic deformation capability. Compared to spheroidized pearlite, both the ultrafine (+) duplex structure and the fine-grained (+) duplex structure exhibit a better balance between strength and ductility due to microstructural refinement.

KEY WORDS eutectoid steel, different microstructure, mechanical behavior, cementite particle, work-hardening

Dislocation Morphology Analysis

Figure 7 illustrates the dislocation morphology of different ferrite/cementite particle duplex structures at various strain levels: (a) ultrafine (+) duplex structure at 4% strain, (b) fine-grained (+) duplex structure at 3% strain, (c) ultrafine (+) duplex structure at 10% strain, and (d) fine-grained (+) duplex structure at 11% strain.

Geometrically Necessary Dislocation Densities in Different Microstructures

Table 2 presents the geometrically necessary dislocation densities (×10¹ m ²) in various microstructures contributed by different microstructural constituents at a strain of 0.04. The table includes values for L (lattice dislocations), D (dislocation density), gb (grain boundary dislocations), ig (intragranular dislocations), and total (total dislocation density).

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Note: Figure translations are in progress. See original paper for figures.