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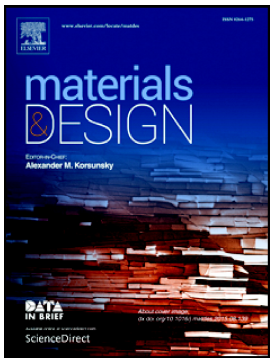

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Microstructure engineering by dispersing nano-spheroid cementite in ultrafine-grained ferrite and its implications on strength-ductility relationship in high carbon steel

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Abstract

Thermo-mechanical processing is performed to engineer the microstructure comprising of nano-spheroidized cementites in ultrafine-grained ferrite in high carbon steel to enhance strength-ductility relationship. Spheroidization is achieved through heavy warm rolling (4-passes of 30% reduction at 823K and 873K) followed by extended annealing (1h and 2h) at the respective deformation temperatures. The influence of annealing temperature and time on the evolution of carbide precipitates, the extent of spheroidization and ferrite softening is investigated employing scanning electron microscopy, electron back scatter diffraction and transmission electron microscopy techniques. A near-complete spheroidization is achieved following heavy warm rolling and subsequent annealing for 2h at 873K (WR873K-2H). Although ferrite grain size increases with time and temperature of annealing, it ceases to cross the ultrafine regime (470-750 nm) due to the pinning effect of the carbides that restricts the migration of ferrite grain boundaries. A simultaneous increase in strength and ductility is achieved following heavy warm rolling and subsequent annealing for 1 to 2h at 873K. Maximum elongation (~30%) is achieved in the WR873-2H specimen in contrast to ~20% elongation in as-received specimen. Such an increase in ductility is due to the near-complete spheroidization as revealed by the ductile mode of fracture in fractrographic analysis.

***Keywords*:** High carbon steel; Heavy warm deformation; Ultrafine grains; Spheroidized cementite; Tensile properties