Mapping of the carbide precipitation sequence and the in-situ transformation of cementite in medium carbon low alloyed tool steel with Scanning Precession Electron Diffraction

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Abstract

Precipitation of carbides after tempering at 600 °C of a medium carbon low alloyed tool steel was studied with scanning precession electron diffraction (SPED). The precipitation sequence was evaluated by mapping the carbide distribution on carbon extraction replicas. This gave detailed information about formed precipitates which could be identified based on electron diffraction. The experimental work was compared to equilibrium calculations and energy dispersive x-ray spectroscopy (EDX). It was found that precipitates ε-Fe₂C within laths during quenching via auto-tempering. During reheating to tempering temperature ε-Fe₂C was dissolved and replaced by cementite, θ-M₃C, which predominately form on martensitic lath boundaries. Vanadium and molybdenum are known from literature to form cubic MC or hexagonal M₂C carbides, respectively. In this work it was found that the small carbides in the early stage of tempering have predominantly a cubic MC structure, even if the V/Mo-ratio the studied steel was only 0.12. Later during tempering more stable carbides, such as M₇C₃ and M₂₃C₃, also form, and it was concluded that the M₇C₃ form both by separate nucleation and in-situ transformation on cementite. The latter phenomenon was seen as particles with a core of cementite and shell of M₇C₃ after 24 h at 600 °C of tempering.