HÖGSKOLAN VÄST

Effect of heat treatment on microstructure and mechanical properties of a 5 wt.% Cr cold work tool steel

MUHAMMAD ARBAB REHAN

AKADEMISK AVHANDLING

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Opponent: Professor Reinhold Schneider,
University of Applied science, Upper Austria

Abstract

Title: Effect of heat treatment on microstructure and mechanical properties of a 5 wt.% Cr cold work tool steel.

Keywords: Cold work tool steel; Hardening; Tempering; Microstructural characterisation; Retained austenite; Martensite; Bainite; Hardness; Impact toughness.

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This work presents investigations related to phase transformations occurring in the 5 wt.% Cr cold work tool steel Caldie during hardening and tempering treatments. The influence of austenitisation temperature, cooling rate, sub-zero cooling, isothermal treatment during cooling, tempering temperature and holding time on the microstructure and mechanical properties were investigated.

The hardened microstructure of the investigated steel consisted of a mixture of plate and lath martensite, minor amounts of bainite, blocky and thin retained austenite and M_7C_3 carbides. Increasing austenitisation temperature from 1020°C to 1050°C was found useful as it provided higher hardness, good compressive strength and sufficient toughness. However, a further increase to 1075°C resulted in large prior austenite grains which produced coarse martensite containing somewhat increased carbon content. This was found to reduce the impact toughness of the steel.

Significant amounts of retained austenite were present after tempering for 2x2 h between 200°C and 500°C while tempering at 525°C or higher, reduced retained austenite content to below 2%. During holding at tempering temperature carbides precipitated in martensite and possibly in retained austenite. The retained austenite was thereby destabilised and transformed to martensite on cooling. This fresh martensite was tempered by following tempering treatments. It was concluded that tempering at 525°C for 2x2 h was suitable to achieve a good combination of hardness, compressive strength and impact toughness.

Retained austenite was also found to transform during holding at 600°C for longer times. Initially, carbides formed in the austenite and after some time transformation of retained austenite to ferrite and carbides took place.

Results were used to discuss alternative heat treatment procedures for the 5 wt.% Cr cold work tool steel Caldie and some changes of current heat treatment recommendations were suggested.