A Novel Approach in Minimizing the Process Duration of Deep Cryogenic Treatment of Cold Work Tool Steel

Venu Yarasu[a, *], Bojan Podgornik[a], Marko Sedlacek[a]

[a]*Institute of Metals and Technology, Lepi pot 11, SI-1000, Ljubljana, Slovenia*

Email: venu.yarasu@imt.si

Abstract

D2 steel is widely used in cold work applications due to its low cost and good combination of mechanical properties. Further improving the mechanical properties of cold work tool steels over conventional treatment, deep cryogenic treatment (DCT) has proven to be beneficial. However, the longer processing times required for optimal results limit its industrial application. This study investigates a novel approach via cyclic deep cryogenic treatment (CDCT) and compares conventional treatment, DCT 24-h, and 2-cycle CDCT after low- and high-temperature tempering treatments. Scanning electron microscopy coupled with energy dispersive spectroscopy, electron backscattered diffraction, and transmission electron microscopy were applied to analyze the microstructure, phase composition, size and distribution of carbides. Tensile bar specimens that had been circumferentially notched and fatigue-pre-cracked were used to evaluate fracture toughness, and hardness. The results show that CDCT treatment significantly improves fracture toughness over DCT and conventional heat treatment after high-temperature tempering at a similar hardness level, while at low-temperature tempering DCT and CDCT treatment increase the hardness and reduce the fracture toughness by 13% over conventional treatment. Both the DCT and CDCT treatments produced comparable levels of hardness and fracture toughness at low-temperature tempering treatments. This suggests that the CDCT treatment achieved better or similar performance in a shorter time, which might allow manufacturers the possibility of lowering production costs.

***Keywords**:* Cold-work tool steel, conventional treatment, cryogenic treatment, cyclic cryogenic treatment, hardness, fracture toughness.