The effects of cryogenic processing on the wear resistance and microstructure of manufacturing materials

Rob Thornton MEng AMIMechE, Department of Mechanical Engineering, rob.thornton@sheffield.ac.uk

Cryogenic processing is a heat treatment technique that affects the whole cross-section of materials and components. In tool steels it has been shown to offer substantial improvements in wear resistance, hardness and ultimately in tool-life. This PhD project aims to measure and explain those effects.

Introduction

Cryogenic processing has been used by various industries for a number of decades to enhance the lifespan of tooling, automotive, aerospace and industrial components. Preventing greater exploitation of this technique is a lack of understanding of the effects of cryogenic treatment on materials, and the underlying microstructural mechanisms at work.

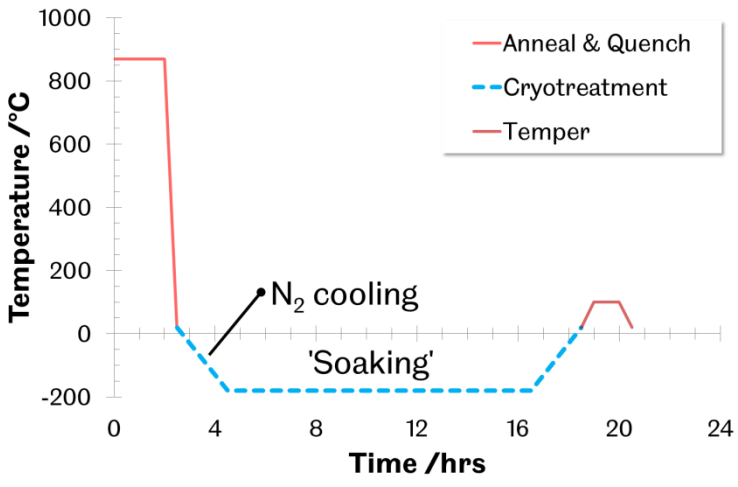

Figure 1 - A cryogenic treatment cycle for a typical carbon steel. Materials are gently cooled in an N_2 atmosphere before being 'soaked' at cryogenic temperatures.

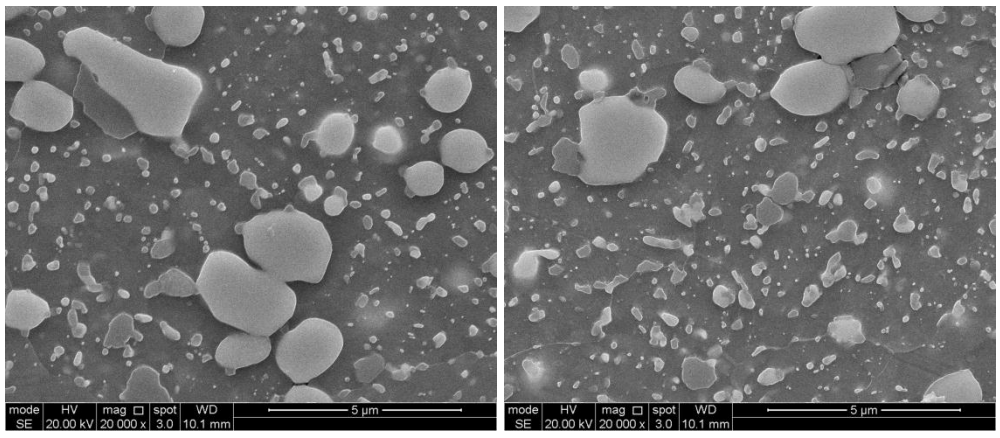

Figure 3 – 10x10µm electron micrographs of AISI M2 tool steel before (left) and after (right) treatment. More, smaller carbides (white) are seen in the cryotreated sample.

Industrial impact

More comprehensive understanding of cryogenic treatment would allow industry to:

- Reduce tooling costs and material usage through enhanced tool life;
- Sustain machining tolerances for longer during tool life;
- Reduced downtime for tool changes and greater productivity.

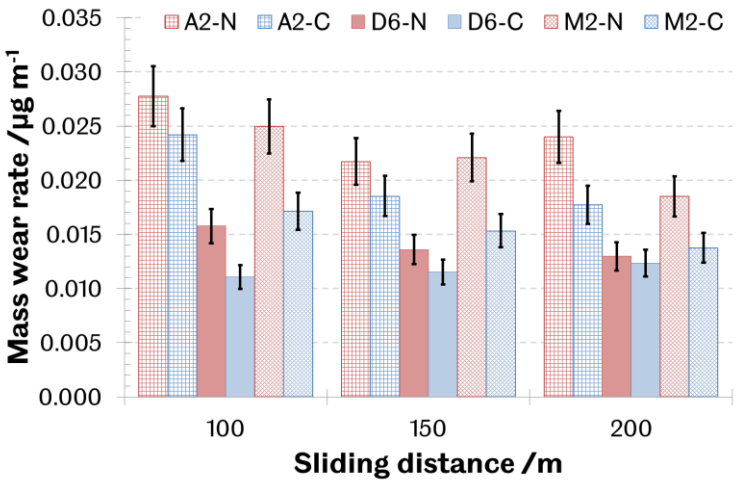

Figure 2 - Wear test results from AISI A2, D6 & M2 tool steels before (-N) and after (-C) cryogenic treatment. Significant improvements in wear resistance were observed.

Results

Significant increases in the wear resistance of AISI A2, D6 & M2 tool steels have been demonstrated as a result of cryogenic treatment (Figure 2). Cryotreatment causes a more complete transformation of softer austenite to harder martensite, and the refinement of carbides within the matrix (Figure 3), which both lead to greater wear resistance.

Future work

More realistic tool-life testing will be conducted to indicate the 'real' benefits cryogenic treatment can bring in manufacturing, supported and corroborated by more detailed microstructural analyses.

Supervisors:

Dr. Tom Slatter, Mechanical Engineering, tom.slatter@sheffield.ac.uk
Dr. Roger Lewis, Mechanical Engineering, roger.lewis@sheffield.ac.uk

Industrial partner:

Andy Priscott
Cryogenic Treatment Services Ltd., http://www.195below.co.uk/