Fracture Toughness in a High Carbon Steel

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ABSTRACT

Tensile data and the critical stress intensity factors were obtained for a high carbon steel containing 0.94 C, 1.70 Cr, and 1.66 Mn. The tensile ductility increased to 1.2 pct on tempering at 500°F and the K_{Ic} to 14 ksi$\sqrt{in.}$ Refrigeration immediately after the hardening quench drastically reduced both parameters and the effect was ascribed to the transformation of the retained austenite during the refrigeration. It is also suggested that a small amount of retained austenite may be beneficial in promoting the ductility and the toughness.

1. Introduction

The mechanical properties and fracture toughness have been measured for a deep hardening bearing steel (ASTM 485, grade 2) with the composition 0.94 C, 1.70 Cr, 1.66 Mn, 0.72 Si, 0.01 N and 0.009 S, all in weight pct. This steel is used in large rolling contact bearings at hardness levels in the vicinity of Rockwell C 60. This steel was taken from an electric furnace vacuum-poured heat, and it exhibited a very low inclusion content in terms of the JK rating. This steel met all of the criteria designated by the term bearing quality.

Despite a wide usage, data on the tensile properties, and particularly on the fracture toughness, are not generally available. The property which is frequently measured is the rolling contact fatigue life, and this is usually evaluated in full-sized bearings. However, attempts are now being made to interpret this type of load-life data in terms of the crack propagation laws which have been utilized in recent approaches to fatigue life. As a first step in this direction, we report here on the tensile properties and on the critical stress intensity factors, K_{Ic}, which have been measured here as a function of the tempering temperature.

The tensile properties at these high hardness levels are difficult to measure reliably because of problems in gripping and uncertainties in achieving axiality. With care, however, it is possible to make tensile measurements with sufficient reproducibility to justify an interpretation of the data. The ductility appears to be the most significant property, and although the values are small, generally less than 2 pct, the data are sufficiently consistent to distinguish clearly between various tempering temperatures. The effects of introducing a refrigeration cycle between the quench and the tempering are particularly evident.

We relied on the compact tension specimen for measurements of K_{Ic}. Valid K_{Ic} values were finally