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CRYOGENIC TREATMENT OF EN SERIES OF TOOL STEELS TO IMPROVE WEAR RESISTANCE

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ABSTRACT

Tools for gears, crank shafts, rollers, crane shafts etc which require low tensile strength (En Series of tool steels) were subjected to cryogenic treatment. Each type of the above tool was studied in detail about its performance versus the hardened and tempered tools.

KEYWORDS: Cryogenic Treatment, Cold Treatment, Heat Treatment, Wear Resistance, Martensite

INTRODUCTION

Cryogenic hardening is a cryogenic heat treating process where the material is cooled to approximately −185 °C, usually using liquid nitrogen. It can have a profound effect on the mechanical properties of certain steels, provided their composition and prior heat treatment are such that they retain some austenite at room temperature. It is designed to increase the amount of martensite in the steel's crystal structure, increasing its strength and hardness, high-carbon, and high-chromium steels to obtain excellent wear resistance. Recent research shows that there is precipitation of fine carbides (eta carbides) in the matrix during this treatment which imparts very high wear resistance to the steels[1]. Through hardening of steel involves heating the steel to a temperature at which it becomes austenite and then cooling rapidly enough to produce martensite, a hard and strong, but brittle structure. Tempering at moderately elevated temperatures reduces this brittleness. Generally austenite phase may be retained in small amounts in low-alloy steels and in appreciable amounts in high-alloy steels, because of the austenite stabilizing effect of various alloying elements.

In general, the martensite starting point is slightly above room temperature in most of the tool steels. The transformation end point in some tool steel s is well below the room temperature, which leads to retaining some amount of austenite, The retained austenite percentage depends on the chemical composition of the tool steel and its hardening and quenching procedure. To arrest the retained austenite transformation it is necessary to quench the tool steel not less than its critical cooling velocity, and allow the tool steel to cool down to temperature well below the martensite transformation end point. Here, practically all the austenite will be transformed into martensite. Sometimes this transformation is not complete, because the velocity of the tool steel quench is lower than the required, or the temperature to which the steel is cooled is well above the martensite transformation end point. Treatment to optimize its service quality, it should be comparable with the tool in which the transformation of martensite is complete.[4,5]. In this study the performance of En series of tool steels studied. En 19 tool steel is used for making the Components of mediums & large cross section, requiring low tensile Strength, as well as heavy forging in the normalized condition for automatic engineering and gear & engine construction such as crane shafts steering knocking connecting, EN 24 tool steel is used for Components of mediums & large cross section, requiring low tensile Strength, as well as heavy forging in the normalized condition for automatic engineering and gear & engine construction such as crane shafts steering knocking connecting, En 31 tool steel is used for roller bearing components such as blanks, cylindrical, conical & needle rollers and En 36 tool steel is used for making Components with large cross section, requiring high toughness & Score strength such as gears, crane shafts & heavy duty gear shafts in aircrafts & truck construction & mechanical engineering.

EXPERIMENTATION

In the Pin-on-Disk apparatus the maximum size of pin that can be accommodated is held as 6 mm diametere and 50 mm length. The specimens were machined to 5mm diameter and a length of 30mm. Then the pieces were faced flat and made to contact fully on the disk (grinding wheel GC 320 K5V). Finally the specimens were finished by centreless grinding to avoid irregularity in their diameters. Cold treatment and Cryotreatment were introduced after completion of hardening process. In case of cold treatment, one part of hardened and stress relieved samples were cooled from room temperature of 30^{o}C to -40^{o}C and another set of samples were cooled from room temperature to -80^{o}C in 2 hours and 4 hours respectively then soaked at this temperature for 24 hours. Subsequently the samples were slowly heated to room temperature in 1 hour and 2 hours respectively. In case of Cryotreatment, one set of hardened and stress relieved samples were cooled from room temperature of 30^{o}C to -150^{o}C and another set of samples were cooled from room temperature to -190^{o}C in 6 hours and 8 hours respectively then soaked at this temperature for 24 hours. Subsequently the samples were slowly heated to room temperature in 4 hour and 6 hours respectively. On completion of all the Heat treatment process, Treatment conditions considered for wear resistance are recorded as:

- Untreated **[NORMAL]** (Hardened & Tempered)
- Coldtreated - I **[C1]** (Hardened + Coldtreated at -40^{o}C (233K) + Tempered)
- Coldtreated - II **[C2]** (Hardened + Coldtreated at -80^{o}C (193K) + Tempered)
- Cryotreated - I **[CR1]** (Hardened + Cryotreated at -150^{o}C (123K) + Tempered)
- Cryotreated - II **[CR2]** (Hardened + Cryotreated at -190^{o}C (83K) + Tempered)

Pin-on-disk tests were conducted using approximately 5.00 mm diameter metal sample pins, at three different speeds of 130rpm, 200rpm and 280rpm, at three different loads of 20N, 30N and 50N and for three different periods of abrasion of 5min, 10min and 15min.[2,3]

RESULTS

It is observed that the wear resistance of the materials tested is improved with reduction in temperature. The improvement shown has steady growth up to -150^{0} C, and little improvement is seen after -150^{0} C treatments. Hence the Cryogenic Treatment for EN series of tool steels can be limited to -150^{0} C which gives substantial saving in economics of tool treatment.

Table 1

Overall % Improvement of Specific - Wear Resistance at Different Temperature						
Sl. No.	**Material**	**Normal Treatment**	**-40 ^{0} C**	**-80^{0} C**	**-150^{0}C**	**At - 190^{0} C**
1	EN 19	100	117	167	193	226
2	**EN24**	**100**	**124**	**159**	**214**	**223**
3	**EN31**	**100**	**118**	**142**	**184**	**195**
4	**EN36**	**100**	**129**	**172**	**187**	**192**

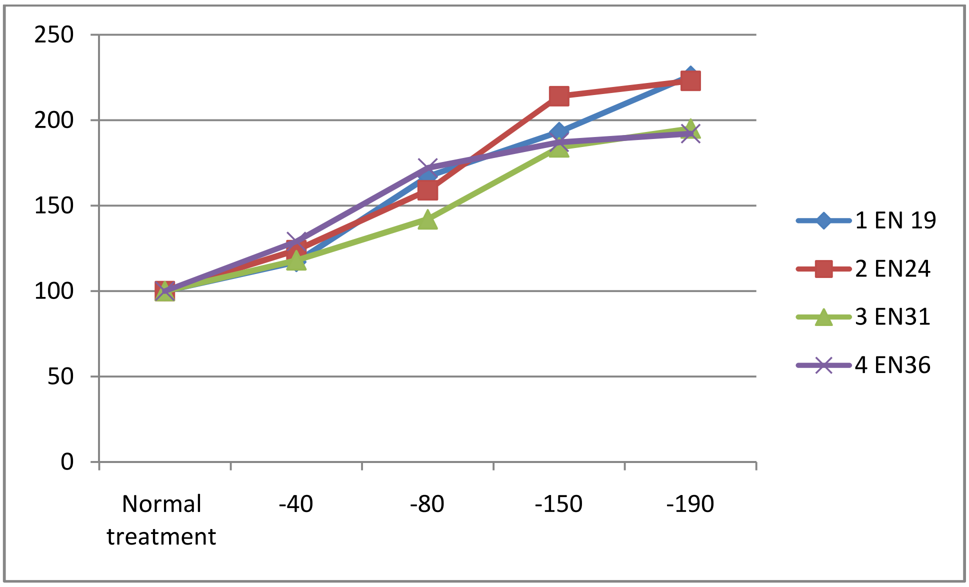

Figure 1

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