www.ijiarec.com

ISSN:2348-2079

Volume-6 Issue-1

International Journal of Intellectual Advancements and Research in Engineering Computations

Enhancement of mechanical properties of EN 31 steel by cryogenic treatment

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Abstract-This work has focused on the effect of the Deep Cryogenic Treatment on the wear behaviour, micro structuralchange, retained austenite percentage and hardness of EN31 alloy steel. The analysis are conducted using the scanning microscope to get the microstructure change, a pin on disk wear testing machine to analyse the wear behaviour, as well as hardness testing machine to compare the hardness change. It was shown that the deep cryogenic treatment eliminated the retain austenite and made a more uniform carbide distribution with higher percentage. It was also observed that the deep cryogenic treatment improved the wear resistance and hardness of the substance. Moreover, the hardness and wear resistance decreased in longer austenitization duration due to the grain growth and the dissolution of carbides in the structure. There are many types of heat treatment we are using hardening heat treatment method which means heat to a definite temperature and cooling or quenching. After this process tempering is done to lower the brittleness and increase in ductility.

Keywords-Bearing steel, Deep cryogenic treatment, Microstructure, Wear resistance, Hardness

I. INTRODUCTION

The heat treatment of steels is one of the most important developments of the industrial era. The ability to attain high strength and toughness by conventional heat treatment process is a major benefit for alloy steels. The addition of carbon to steel, helps in the heating and quenching of steel to make martensite had been mastered over 3000 years ago. Still, research effort continues in the process of producing steel components into a stronger and more wear-resistant than the earlier ones. In alloy steels, a low percentage of austenite is retained after the conventional heat treatment process. The retained austenite as a soft phase in steels could decrease the life of the component and can be transformed into martensite under certain working circumstances. This new martensite could cause some problems such as micro cracks thereby reducing the life of the component. It is found that this martensite causes micro cracks and decreases the product life. Moreover, this type of martensitic transformation provides

instability.Concerning the problems stated above, the controlled transformation of the retained austenite into martensite is necessary to develop many types of durable component. For this controlled transformation of retained austenite to martensite, cryogenic treatment technique is adopted. This is a modern process used to manufacture highly durable components. It is an affordable supplement process to conventional heat treatment process of steel. As a result, the retained austenite is decreased and development of wear resistance is attained.This project discusses the influence of conventional heat treatment (CHT) and deep cryogenic treatment (DCT) of EN31 alloy steel through various mechanical and characterization test.

II. LITERATURE SURVEY

K. Clemons (2007), studied the processing-structure-property relationships in the new bearing steels (REX20 and CRU80) and are compared to the baseline 52100 and 440C steels. Even though the hardness values are widely used as a qualitative measure of the load capacity of bearings, it is shown that the compressive yield strength is a better indication of the load capacity, and that the amount of retained austenite affects the load capacity. For each steel, four different heat treatment schedules were developed to produce different microstructures with varying retained austenite contents to study the interrelationships of hardness, compressive yield strength, and the retained austenite.

Ibrahim Guns (2014), analysed which the cryogenic treatment contributes to wear resistance

is through the precipitation of fine Eta carbide, which enhances the strength, and toughness of the martensite matrix, rather than the removal of the retained austenite. As a result of cryogenic treatment, the retained austenite is reduced, fine Eta-carbides are formed and a homogeneous distribution of carbides is provided. Therefore the wear resistance is significantly improved in steels.
D. Umbrello (2011), objective of its formation is mainly due to the rapid heating and quenching which produce un tempered martensitic structures.
Thus, it was generally believed that to reduce or avoid the white layer formation and, consequently to improve the surface integrity, it is necessary to decrease the temperatures; this is mainly done with the application of coolants. Also, the convective cooling effect of cutting fluids on this affected layer has not yet been clarified.
H. Paydar1 (2013), discussed the martensite and austenite endure a high degree of contraction. This contraction together with the different expansion coefficient of martensite and austenite produces some new dislocations in the steel structure. The contracted structures make the highly deformed martensite unit cells in which the carbon atoms cannot be stable in their places. In other words, carbon atoms prefer to jump to the nearby defects containing the newly formed dislocations, old dislocations, twins and other defects, due to a highly contracted martensite structure which forces the carbon atoms to jump. These carbon atoms act as preferential sites for carbide nucleation in the following tempering These newly formed carbides are eta carbides rather than the regular epsilon ones and are bigger than 20 nm in diameter These carbides make a more homogenous distribution and increase the carbide percentage.

III. MATERIALS

A commercial EN 31 steel rods with diameter of 20mm and height of 15mm was used to prepare the sample. The samples were subjected to convectional and cryogenic treatment in separate batches. The CHT consisted of hardening and tempering.

Two kinds of treatments namely shallow cryogenic treatment (SCT) and deep cryogenic treatment (DCT) are adopted by the researchers. The shallow cryogenic treatment is otherwise termed as sub-zero treatment or cold treatment. By Shallow Cryogenic Treatment the conventionally quench hardened steels are directly put in a freezer kept at -80ºC and soaked for 5 hours to attain thermal equilibrium. By Deep Cryogenic Treatment, the conventionally quench hardened steels are slowly cooled from room temperature to -196ºC at 1.24 ºC/ minute, soaked at -196ºC for 24 hours and finally heated back to room temperature at 0.62 ºC/ minute. This technique has been proved to be efficient in improving the mechanical and physical properties of materials such as alloys, metals, composites and plastics. During the last decade, cryogenic treatment techniques have been developed and are now broadly used by industry to improve the mechanical properties of steel components. The cryogenic treatment was carried out by gradual cooling of the samples to -145C and holding this samples for different duration, followed by gradual heating to room temperature. The contents of the retained austenite and martensite were measured using XRDA. The bulk hardness was measured using a Rockwell hardness tester with a load of 1.5kN. the micro structure was characterized by a Leo 1430VP scanning electron microscope.

Table.1 Chemical composition of EN31 steels

Materials	Percentage (%)
Carbon	0.96
Chromium	1.09
Manganese	0.57
Silicon	0.21
Sulphur	0.023
Phosphorus	0.031
Iron	Remaining

IV. METHODS

1. Wear Behaviour

The wear of steel components used on machinery, which is operating in a wide range of industrial circumstances can cause sudden breakdowns, serious inefficiencies, and significant financial losses. These losses can be reduced by means of cryogenic treatment on steels. The frequently referred scientific literature results from Barron (1974)[3] are given in Table 1.1. However, wear is not a simple one to measure in the laboratory, where testing parameters significantly affect the results. The actual wear experienced by a component may be quite different in practice. It has been found that a few machine elements, such as slitting blades used in paper cutting, have lasted six times longer after deep cryogenic treatment. Results from field trials on stamping dies, milling cutters and punches have also shown noteworthy improvements, given in Table 1.1. The improvement in wear for various tool steels after deep cryogenic treatment is as shown in Figure 1.1. The preliminary test to determine the influence of deep cryogenic treatment on end mills, zone punches, lathe tools was conducted and concluded that an increase in tool life from 50% to more than 200% were observed for the tools which had been soaked in liquid nitrogen for 12 hours.

Table.2 Field Trial of Wear Improvements in Deep Cryogenic

Tool Type	Tool Material (AISI no.)	Improvement in Wear Rate (%)
Stamping die	D-2	1000
Punch	M-7	600
End mill	M-42	450
Drills	C-2	300
Milling cutters	M-7	250
Drill	M-42	200
Punch	M-2	100

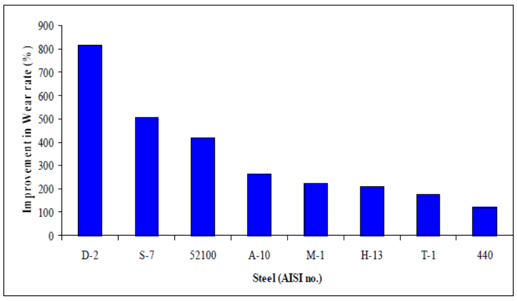

Fig .1 Improvement in Wear Rate due to Deep Cryogenic

2. Microstructural study

Themicrostructures of all the samples were studied with Leica DM version optical microscope. Bakelite moulds are prepared and the moulds are polished by using emery paper of grit 400, 600, 800, 1000, 1200, 1500, 2000 and 2500, followed by polishing using diamond paste on rotating linen disc and finished with polishing on velvet cloth using white kerosene as a suspension medium. These samples are etched with 2% nitric acid and ethanol and dried in air. The etched samples were studied using optical microscope at a magnificationof500x.

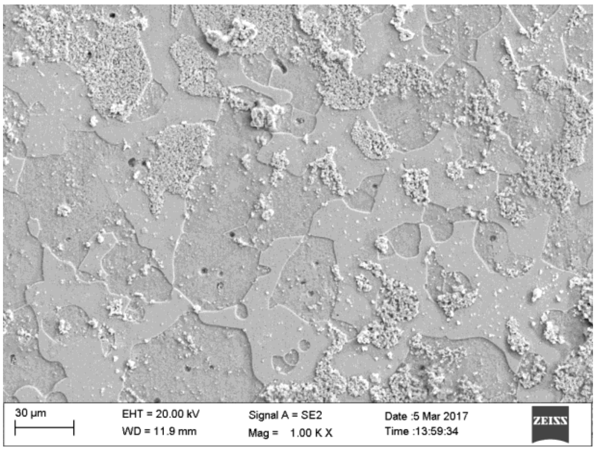

Fig. 2 Microstructure of CHT at a magnification of en31 steel

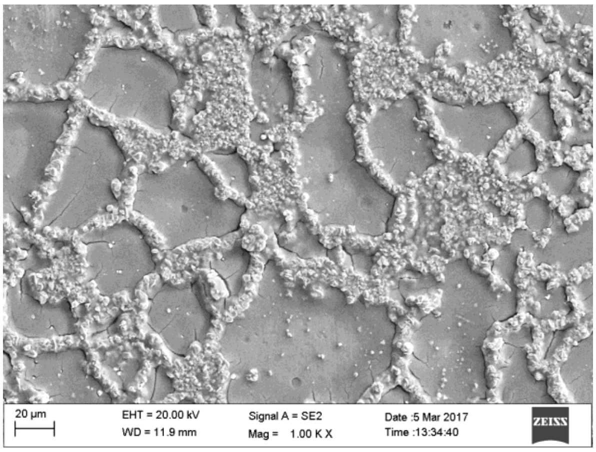

Fig.3 Microstructure of DCT at a magnification of en31 steel

3. Rockwell hardness test

The Rockwell hardness test was done on the samples prepared as per the process. The hardness measurement was made with a 100N load with a dwell time of 15sec. The indention was made on a circular faces and care was taken that there is distance more than three times the diagonal intention between center of two impressions. three samples are taken for each type of treatment and three readigs are taken for each sample.

V. CONCLUSION

Deep cryogenic treatment is found to reduce the quantity of retained austenite from 15% to less than 3%. Formation of grain boundary carbides was observed for samples subjected to deep cryogenic treatment. As a result, 4.76 % improvement in bulk hardness and was obtained. Wear resistance improved by over 50% compared to the conventional heat treated samples. The improvement in hardness and wear resistance is attributed to the increased transformation of retained austenite and the precipitation of secondary carbides

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REFERENCE

[1] Barron, R. F. "*Effect of Cryogenic Treatment on Lathe Tool Wear*", Progress in Refrigeration Science and Technology, Vol. 1, pp. 529-531, 1974.

[2] Collins, D.N. and Dormer, J. *"Deep cryogenic treatment of a D2 cold work tool steels*", Heat Treatment of Metals, Vol. 24, pp. 71-74,1997.

[3] George Krauss. "*Deformation and Fracture in Martensitic carbon steels tempered at low temperatures*", The 2000 Edward DeMille Campbell Memorial Lecture, Metallurgical and Materials Transactions B, Vol. 32, pp.205-221, 2001.

[4] Mohan Lal, D., Renganarayanan, S. and Kalanidhi, A. "*Cryogenic treatment to augment wear resistance of tool and die steels*",Cryogenics, Vol. 41, pp.149-155, 2001.

[5] Molinari, A., Pellizzari, M., Gialanella, S., Straffelini, G. And Stiansy, K.H. "Effect of deep cryogenic treatment on the mechanical properties of tool steels", Journal of Materials Processing Technology, Vol. 118, pp.350-355, 2001.

[6] Suchanek, J. and Kuklik, V. "Influence of heat and thermo chemical treatment on abrasion resistance of structural and tool steels", Wear, Vol. 267, pp. 2100-2108, 2009.