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Evaluation of wear characteristics of ultra high carbon steel

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Abstract : In this modern era high wear performance materials are necessary components in machinery and equipment's especially in automobile sectors. One of the developed high wear resistance material is the investigation of Ultra High Carbon Steel to study with 1% carbon transformed from cementite to Spheroidite shape. This assignment aimed to study of wear behaviour of Ultra High carbon Steels using computerized Pin on Disc wear testing machine. The amount of wear could identify by scanning the materials in microscope analysis. The annealed, quenched and forged test samples to four different load variation of 0.5kg, 2kg, 4kg and 6kg shows that with increase in load, the wear rate decreases as there is increase in friction at the contact surface. Result of this project goes to good wear rate of spherodized shape, of quenched specimen compare to other samples. Observed that, volumetric wear rate of one wt. % C of Spheroidite shape wear for all the operational conditions. Scanning Electron Microscope observation of the worn surface showed that three body and surface confinements were the prevailing to sliding wear mechanisms.

Keywords : spheroidite, microstructure, SEM analysis, volumetric wear rate, normal pressure, sliding speed.

Introduction

The tribological as subject is relatively modern. But attention, in the constituent element of tribological is alleged to be grown-up then recorded history [1]. The issue of friction, lubrication and wear was sensibly understood were afraid with reducing friction in relative motion, and in this respect records show the use of wheels from 3500 B.C. There are many well documented examples of how early civilization developed bearing and low friction surfaces[2]. The interactions among wear and corrosion could considerably reduce the total weight loss. In order to decide whether choose materials according to their mechanical properties or corrosive characteristics, for any particular applications, sufficient information will be necessary [3].

Investment of Wear

Friction and wear cost in the form of energy loss and material loss can decrease national productivity and quality of life. Wear can also lead to accidents. A five tone truck is whispered to be completely worn out, when it has lost 3 kgs of its weight due wear. Thus, the knowledge of tribology can lead to various substantial and significant savings without deployment of large capital investment. The world economy rests on energy efficiency and thus tribology is supremely important subject today [4,5].

Wear properties have been finding improve with the increase in martensite volume fraction in dualphase steels. Among the investigated of steel has very high-quality combination of mechanical properties which is a major obligation for a better wear resistant material attractive the time of machine parts and reducing the effective cost. An understanding of these properties is essential to facilitate the application of low-carbon weld steel doped with minor and trace elements to tribological products [6]. About this studies gives to, depth of strain hardened zone under the sliding surface was observed to increase with load[7,8].

The oxidation wear behaviour weakened and the size of the debris particles became larger. As the slippage increased, the mainly wear mechanism transformed from the oxidation wear to the fatigue wear and then into the abrasive wear accompanying de-lamination. Many microstructures develop from phase transformations, the changes that take place between phases when the temperature is altered ordinarily upon cooling. It may involve the transition from one phase to another or the appearance or disappearance of a phase.

Experimental Setup

Material and processing

The UHCS considered too includes (as weight percentage of) C - 1, Mn – 0.25 to 0.40, Si – 0.20 to 0.40, P – 0.025, S – 0.025, Cr – 1.3 to 1.6 and balance Fe.

Transformation from cementite to Spheroidite

Spheroidite can be produced by heating a pearlite or bainite microstructure to and leaving at a temperature below the eutectoid for a sufficiently long period of time-for example at about 723°C for between 18&24 hours.

Instead of alternating ferrite and cementite lamellae or the microstructure observed for bainite the Fe_3C phase would transform into sphere like embedded in a continues α matrix. The driving force for this transformation is the reduction in α-Fe_3C phase boundary area [8].

Properties Analysis

Wear

Wear is allied to relations between surfaces and specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. The wears properties of friction force, co-efficient of friction, volumetric wear rate and weight loss were examined on the ultra high carbon steel. For the wear test specimens are prepared with a 10 x 32 mm each of all.

Mechanical

The hardness is a precise resistant of solid matter is to different varieties of permanent shape change after a compressive force is applied. The hardness specimens ASTM E10 standard made to were indented with a 5mm diameter hardened steel ball subjected to a weight of 250 kgf applied for 15 seconds [9].

Result and discussion

Microstructure analysis

Observe the details of microstructure fig. (a-c), e microstructures obtainable had to study in a computerized microscope under a magnification of 500X.Shown that the microstructure indicates Spheroidite structure, fly ash and carbon content 100% compose to other materials. (Fig. 1) Microstructure annealed specimen consists of thin network of ferrite along the grain boundary of Pearlite. (Fig. 2) Microstructure consists of fine Tempered martensite as Quenched. (Fig. 3) Microstructure consists of fully pearlite structure with traces of ferrite. Very well Globular carbides dispersed in matrix.

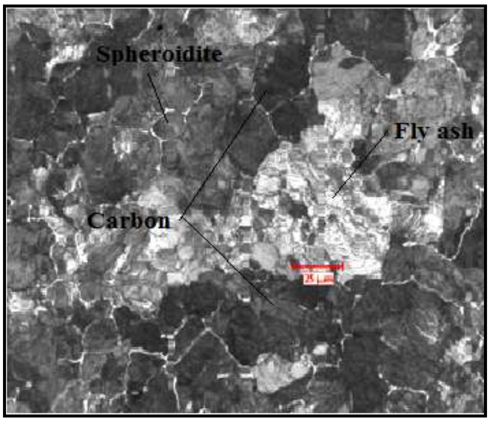

Figure 1 1wt. %C of Annealed Specimen

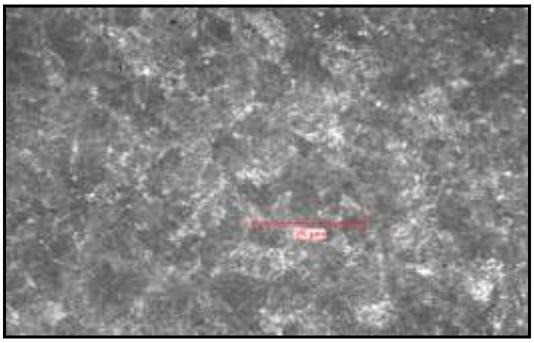

Figure 2 1 wt. %C of Forged specimen

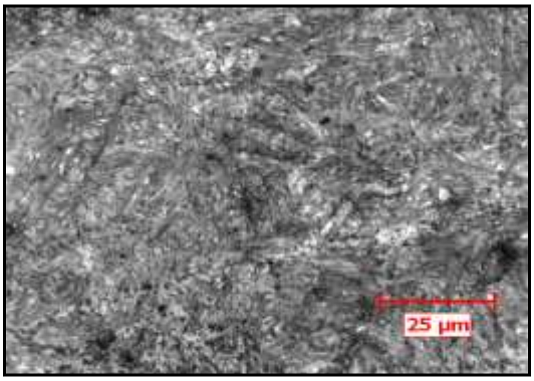

Figure 3 1wt. %C of Quenched Specimen

SEM image Analysis of UHCS's

Above the figures prove the SEM image of one weight percent of Carbon steel for 6000x magnification. (Fig 4,5,6) The dark lines are indicates to composition of 1wt. % C added in this steel. In that phase the fly ash and Si particles and white gray line Cr, and some oxides are noticeable. The Quenched specimen was indicating good wear improvement could visible to 1wt % C and it does prove that good wear strength.

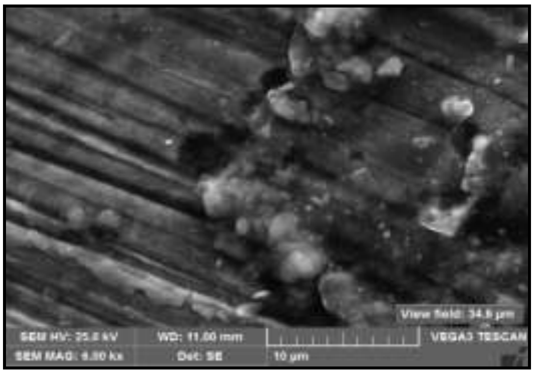

Figure 4 After wear SEM image view of Annealed sample

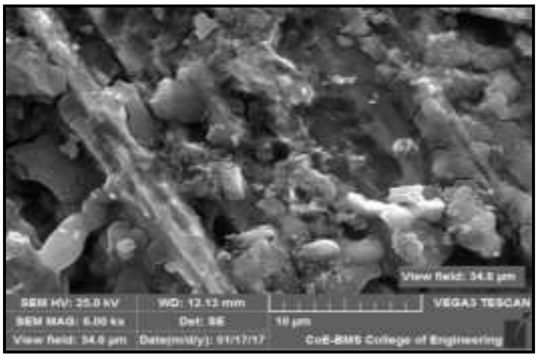

Figure 5 After wear SEM image view of Forged sample

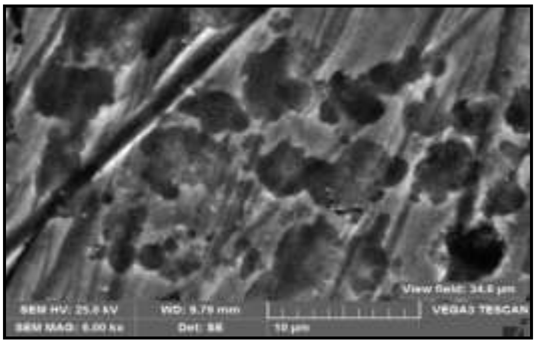

Figure 6 After wear SEM image view of Quenched sample

Hardness test

The hardness bar chart of present steel (UHCS) with one weight percent of carbon shown under the Fig 7. Expose from hardness test of annealed, quenched and forged specimens with added the carbon content to increase the hardness values (61.7 BRC) in quenched specimens. The Quenched specimen Brinell hardness is better than annealed and forged. Often, after quenching, an iron and carbon steel alloys will be excessively hard and brittle due to an overabundance of Spheroidite shape. it is observed under the room temperature the average hardness of the worn out surface is increased almost with sliding speed (Fig-7) With increase room temperature of physical properties of material goes down due to this reduced physical property, hardness of worn out surface fall down with increased in normal temperature.

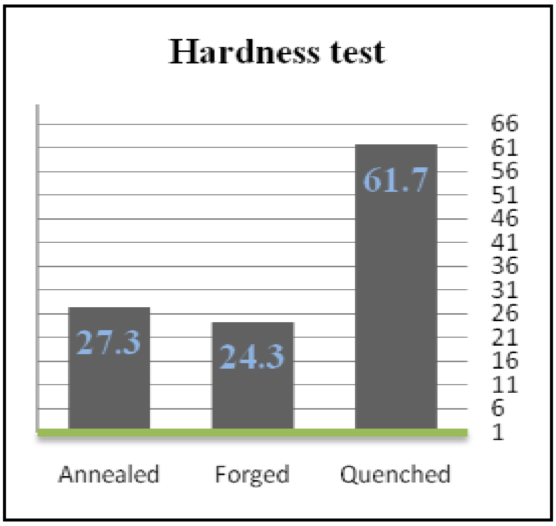

Figure 7 Graph of Hardness test

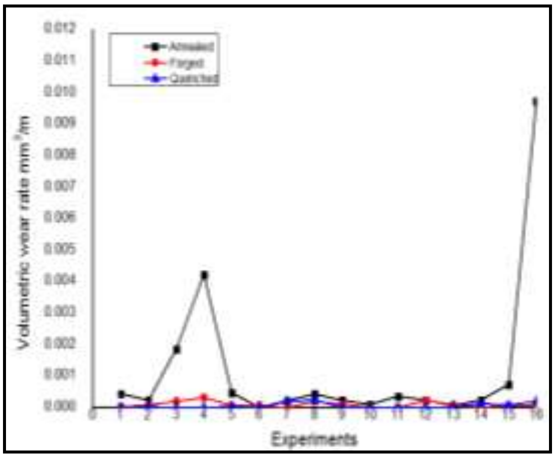

Figure 8 Volumetric Wear rate in all samples

Wear analysis of Annealed, Forged and Quenched Specimens for Ultra High Carbon Steel

Shown the present table indicates to the present investigation generally relates to understand the volumetric wear rate, frictional force, and effect of operational conditions like sliding speed, and wear pressure. The effect of Chromium, silicon and to optimize the wear resistance material among annealed forged and quenched specimen of Ultra High Carbon steel. The size of transformed fragment decreases as the speed increases as sufficient time is not available for the junction growth. (Fig-8) The general effect of increasing sliding speed under low wear pressure is to cause reduction in the wear rate, because during the wear in the metal is first transferred to the disc from the wear pin and wear debris is produced from this deposited layer. This means that the frequency of metal transfer will decrease with increase of sliding speed resulting in a progressive fall in the wear rate. The spheroidite structure has been hardness then the pearlite due to the residual stress free and cementite spheroidite.

Table 1 Volumetric wear rate of Annealed, Forged and Quenched Samples

Exp	Annealed	Forged	Quenched
1	4.41578E-4	2.5003E-5	0
2	2.26265E-4	7.768E-5	3.32464E-5
3	0.00185	1.99478E-4	0
4	0.00423	3.14186E-4	0
5	4.72357E-4	6.33553E-5	4.16346E-5
6	0	6.528E-5	0
7	2.19092E-4	0	2.00671E-4
8	4.2809E-4	1.89595E-4	2.35668E-4
9	2.20198E-4	1.04414E-4	6.40768E-6
10	1.01367E-4	4.80576E-6	1.56778E-5
11	3.60327E-4	0	0
12	2.39001E-4	2.21012E-4	4.71122E-6
13	5.36118E-5	9.37911E-5	1.09173E-5
14	2.40721E-4	2.46197E-6	1.25856E-4
15	7.32248E-4	7.11016E-5	7.87436E-5
16	0.00974	4.78606E-5	1.95579E-4

Conclusion

Under the room temperature of volumetric wear rate is low at high wear pressure and sliding speed. In severe volumetric wear rate is observed at low wear and roughness at 0.75 MPa and 4m/s. It is show the graph volumetric wear rate decreases with the wear pressure for all the sliding speed under the room temperature. The frictional force might increase to reduce the volumetric wear rate and sliding speed. The hardness of worn out surface is increased with the wear pressure. The worn out surface roughness is minimum at the sliding speed of 4 m/s. The abrasive wear mechanism is learned on the worn surface. The sliding distance and normal load are directly proportional to the volumetric wear rate. With increase the volumetric wear rate is reduced. That is wear resistance would increase.

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