Effect of Deep Cryogenic Treatment on Tribological Properties of Molybdenum Based M-2 tool steel.

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ABSTRACT— *Cutting tool industries are striving hard to increase the life of the tool by different methods. Cryogenic treatment is one among that which improves the tool life by morphological changes in the tool material. Conversion of retained austenite into martensite in case of tool steel may be responsible to increase the life of the tool .Cryogenic treatment improves the tool life of a tool by increasing the hardness and wear resistance of a tool.*

This paper describes a study on the effects of Deep Cryogenic treatment on tribological properties of M-2 tool steel. Tool life of a cutting tool is dependent on Wear of the tool material, which in turn depends on tool material, machining conditions and material of the job to be machined. The main aim of this study is to analyze the effect of Deep Cryogenic treatment (-193^{0}C) on sliding wear characteristics of M-2 tool steel under different sliding conditions, load, and speed using pin on disc wear testing machine. The structural analysis with the help of optical microscope helps in knowing the effect of deep cryotreatment on M-2 tool steel.

Decrease in wear rate, frictional force, temperature due to friction and increase in hardness on deep cryotreated M-2 tool steel may be responsible for improving the tool life.

Key words— Cryogenic treatment, M-2 tool steel, wear, Tool life.

1 INTRODUCTION

Cryogenic process is a controlled thermal process which modifies the crystal structure of materials at Cryogenic temperatures. The major results of these changes are to enhance the abrasion resistance and fatigue resistance of materials [1].The cutting tool industry has recognized the benefits of the cryogenic processing of materials. Cryogenically treated High speed tool steel will last about 2 to 3 times longer than untreated tools [2].

Cryogenic treatment has also found favorable results in Auto racing sporting goods, Metal forming tools and Plastic molding components. Several investigations have been carried out to optimize the parameters in machining process. The control of the parameters assuming importance while machining Ferrous and non ferrous materials.

The main parameters to be controlled are Cryo temperature, selection of cutting tool, cutting speed, feed rate, and depth of cut, to give the desired tool life for tools [3].

Very few published information is available on the effect of Cryogenic treatment on tool steel, which is used in small scale industries. In view of this an investigation has been carried out to know the effect of Deep Cryogenic treatment on Tribological properties Molybdenum based M-2 tool steel.

2. EXPERIMENTAL DETAILS

2.1 Tool material

The tool material used in this study is Molybdenum based High Speed Steel (M-2) tool steel. The chemical composition of tool material is shown in table1.

TABLE: 1

Element	C	Mn	Si	Cr	Ni	Mo	W	V	Co	P	S
Weight%	0.78-1.05	0.15-0.40	0.20-0.45	3.75-4.50	0.3	0.45-5.50	5.50-6.75	1.75-2.20	---	0.03	0.03

2.2 Wear test specimen

The samples of the required sizes as per ASTM standards were prepared (10Φx20mm)

2.3 Cryogenic Treatment

The tool samples in this work were subjected to cryogenic treatment with the following parameters

- Cooling time: 8 hours at the rate of2^{o}C/min.
- Soaking time: 24 hours at -193^{0}C.
- Medium used: Liquid Nitrogen.
- Warming time: 8 hours at the rate of 2^{o}C/min.

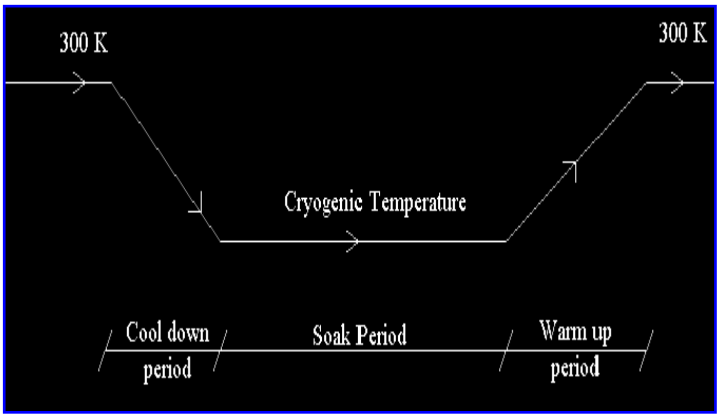


Fig1. Cryogenic treatment cycle

3. TESTING

3.1 Pin on disc tester

A pin on disc tester was used to measure wear, frictional force, and temperature. Tests were carried in accordance with ASTM standard has been shown in table2.

Table: 2

Sliding distance	0.5-3.0 Km
Load	20-80N
Speed	200-600RPM

3.2 Hardness test

Hardness test was conducted by using Rockwell hardness tester.

3.3 Microstructure

The microstructure of both treated and untreated samples were examined under NIKON optical microscope.

4. RESULTS AND DISCUSSIONS

4.1 Effect of Cryogenic treatment on the hardness of M-2 tool steel

Improvement in hardness of M-2 tool steel has been found by 33% when subjected to deep cryogenic treatment.

***4.*2** Effect of Cryogenic treatment on wear, frictional force, temperature and wear rate.

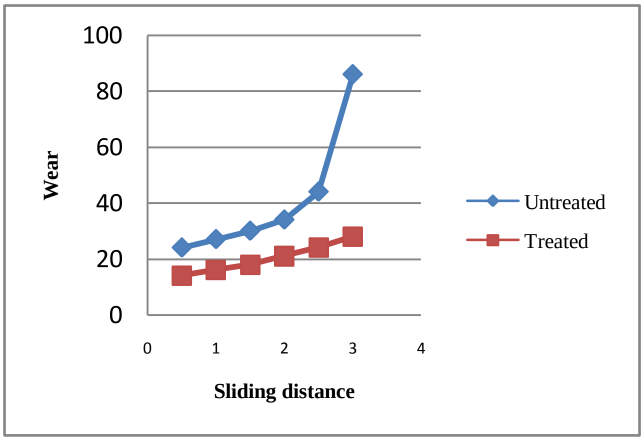


Fig.2 Wear (Microns) as a function of sliding distance (Km) at applied load 80N and 200rpm

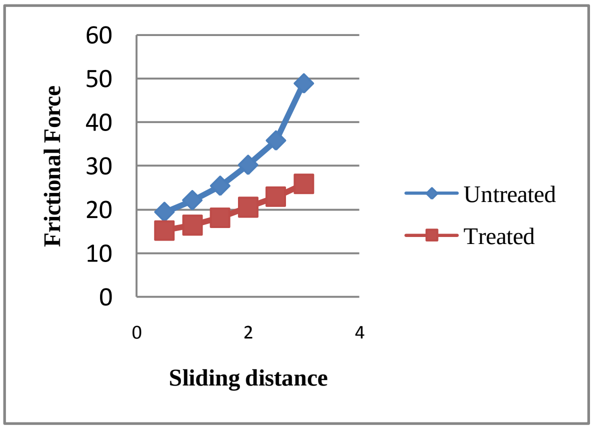


Fig.3 Frictional force (N) as a function of sliding distance (Km) at applied load 80N and 200rpm

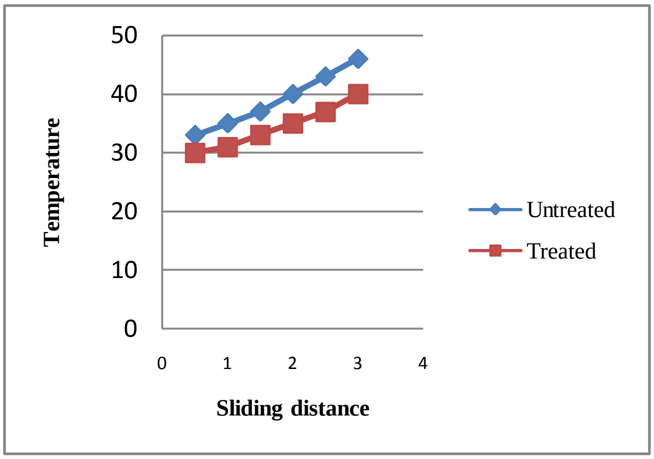


Fig.4 Temperature (ºC) as a function of sliding distance (Km) at applied load 80N and 200rpm

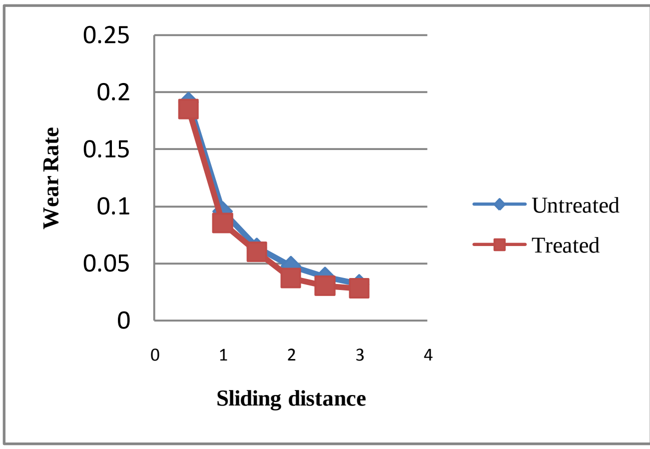


Fig.5 Wear rate (mm^3/N km) as a function of sliding distance (Km) at applied load 80N and 200rpm

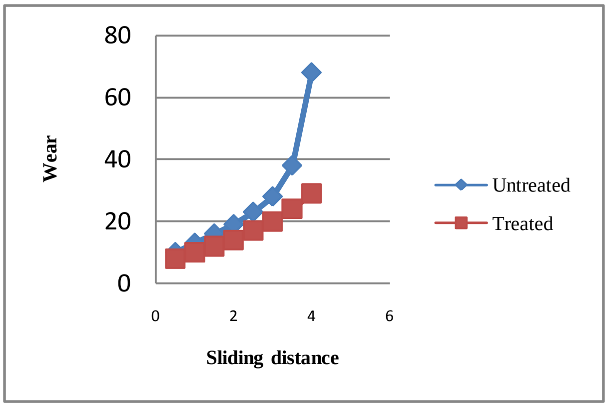


Fig.6 Wear (Microns) as a function of sliding distance (Km) at applied load 40N and 600rpm

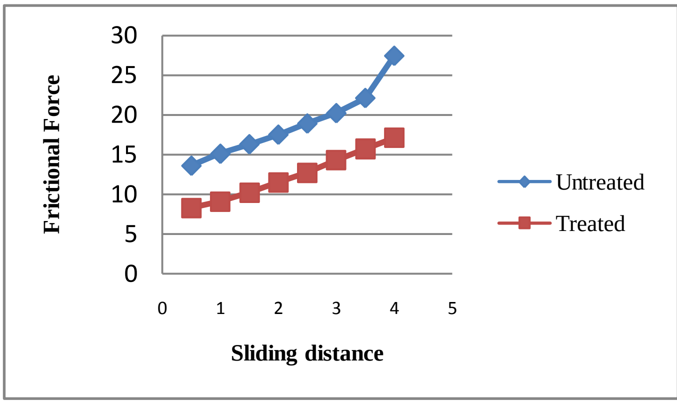
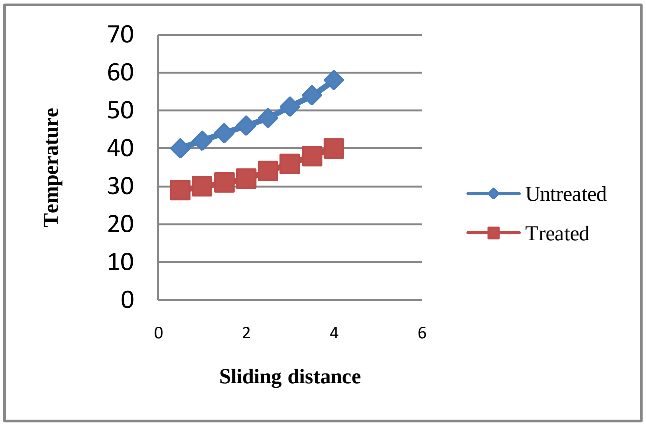


Fig.7 Frictional force (N) as a function of sliding distance (Km) at applied load 40N and 600rpm



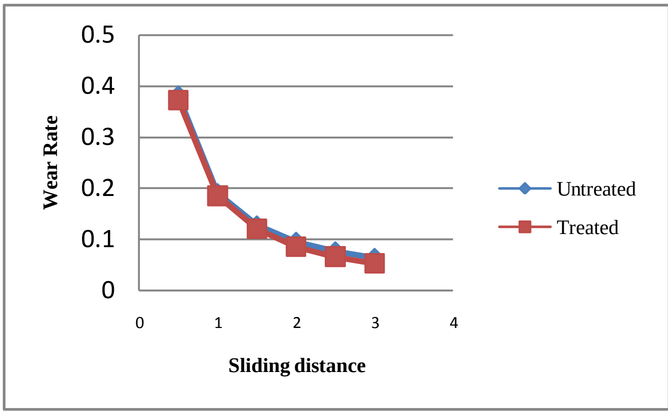


Fig.8 Temperature (ºC) as a function of sliding function of sliding distance (Km) at applied load 40N and 600rpm and 600rpm

Fig.9 Wear rate (mm^3/N km) as a distance (Km) at applied load 40N

4.2.1 Effect of speed

It has been observed from fig 2 to fig 9 that as the speed increases from 200rpm to 600rpm, there is an increase in the wear of the tool, increase in frictional force, increase in temperature and decrease in wear rate of the M-2 tool steel material.

4.2.2 Effect of load

It has been observed from fig 2 to fig 9 that as the load increases from 20N to 80N, there is an increase in the wear of the tool, increase in frictional force, increase in temperature and decrease in wear rate of the M-2 tool steel material.

4.2.3 Effect of sliding distance

It has been observed from fig 2 to fig 9 that as the sliding distance increases from 0.5Km to 3.00Km, there is an increase in the wear of the tool, increase in frictional force, increase in temperature and decrease in wear rate of the M-2 tool steel material.

4.3 Microstructure

Photo micrographs of untreated and treated samples are shown in figure 10 & 11. The following are the salient observations

- Larger number of alloy carbides has been observed on structure of deep cryo treated M-2 tool steel in comparison with untreated tool.

- The alloy carbides are more uniform and slightly denser.
- Martensite matrix appears to be more homogenous.

Decrease in wear rate, reduced frictional force and reduced temperature in case of deep cryo treated M-2 tool steel has been observed in this investigation may be due to refinement of carbides as compared to that of untreated condition.

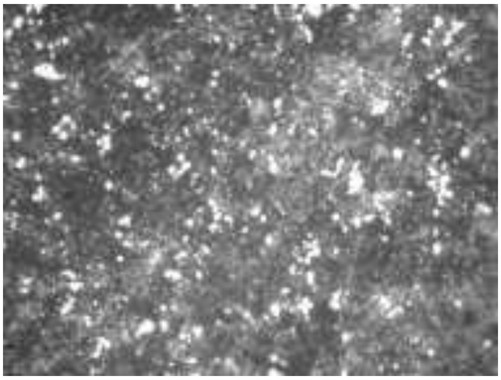


Fig.10 Untreated

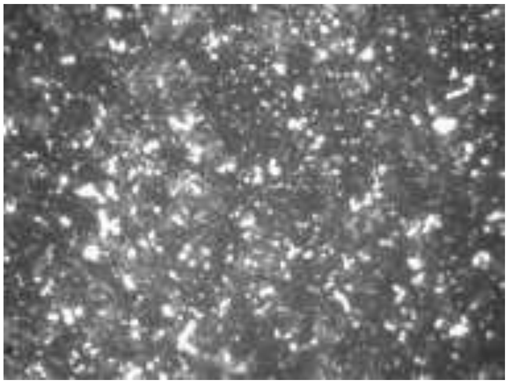


Fig.11 Treated

15. CONCLUSIONS

Within the scope of this investigation, the conclusion of the research work carried out in the area of deep cryogenically treated M-2 tool steel has been presented.

- Deep Cryo treatment on M-2 tool steel improves the structure by enhancing carbides in place of retained austenite.
- Improvement in microstructure is responsible for decreasing wear rate, frictional force temperature, wear rate and increase in hardness as compared to that of untreated molybdenum based M-2 tool steel .
- Hence it can be concluded that Deep Cryogenic treatment is more effective for M-2 tool steel.

To sum up this research work it indicates that the findings of this research work may be useful for small or medium machining industries having conventional machining facilities.

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