International Journal of Engineering Research And Advanced Technology (IJERAT)
ISSN: 2454-6135 [Special Volume. 02 Issue.01, May-2016]

STUDY OF MECHANICAL AND TRIBOLICAL PROPERTIES OF DEEP CRYOTREATED M2 TOOL STEEL

Satish kumar[1], Ujjwala Sharma k[2], Puneeth Kumar M[3], Chaitanya J R[4], Shreyas S[5]
ASSISTANT PROFESSOR[1], Student [2,3,4,5]
Department of Automobile Engineering Technology
The oxford College of Engineering
Bangalore, Karnataka
India.

ABSTRACT: *Cryogenic treatment has been acknowledged by some as means of extending tool life of many cutting tool materials, thus improving productivity significantly. However real mechanisms which guarantee better tool performance are still dubious. This implies the need of further investigations in order to control the technique more significantly. Studies on cryogenically treated HSS tools show microstructural changes in material that can influence tool lives. However little research has been done on other cutting tool materials. Performance of cryogenically treated tools largely depends upon the cutting conditions. Hence design of experiment was employed to study the effect of cutting parameters on tool wear and tool life equations were developed illustrating the significant factors that affect performance of cryogenically treated tools*

Key Words: Cryogenic treatment, Tool steel , DCT, HT

---

1. INTRODUCTION

Every known type of material in the world today must be considered for use for various applications by the engineer and certainly there is very wide variety of them. For example there may be as many as 2000 types of steel, 5000 types of plastics, and 10000 kinds of glass and so on. In addition, several hundred new varieties of materials appear on the market every year. The engineer, therefore, has a large number of choices for the fabrication of the components of any new product being designed. Availability of materials and their costs are important considerations, but it is the performance which is the most important criterion for the selection of any engineering material for a specific application. the performance of any material depends on its set of properties and the properties in turn depends on its internal structure. in other words, the properties of a material originate from the internal structure of that material. Since performance is inspired by the properties of the materials, engineers must understand their internal structure that govern those properties. as far as metals and alloys are concerned, their internal structure(macro and micro -structure) depends principally on the composition, solidification mechanism and heat treatment which can be independently varied for desired structure.

As manufacturers continually seek and apply new manufacturing materials that are lighter and stronger and therefore more fuel efficient it follows that cutting tools must be so developed that can machine new materials at the highest possible productivity. The most important elements in the design of cutting tools is the material construction and there judicious selection.

The properties that a tool material must process are as follows:

- Capacity to retain form stability at elevated temperatures during high cutting speeds.
- Cost and ease of fabrication
- High resistance to brittle fracture
- Resistance to diffusion
- Resistance to thermal and mechanical shock

2. SELECTION OF MATERIAL

M2 tool steel is the most commonly used material for tools in small and medium scale industry. M2 is a tungsten-molybdenum high-speed steel and is a popular grade for general purpose cutting and non-cutting applications. It has a wider heat-treating range than most of the molybdenum high-speed steels, coupled with a resistance to decarburization that is characteristic of tungsten types. M2 offers an excellent combination of red hardness, toughness, and wear resistance. M2 is available in a wide variety of shapes and sizes. Cryogenic treatment can be used to enhance the tool life. Studies on cryogenically treated (CT) cutting tools show micro structural changes in the material that can influence the life of the tools significantly. In the continual search for cost effectiveness in manufacturing we turn our focus to an attempt to reduce tooling cost by improving the life of cutting tools. There has been continued research conducted to increase cutter tool life with various applications of cutting fluids, speed and feed rates, and the use of coated cutters. One newer approach, cryogenic processing. M2 is a matrix type high speed tool steel available for warm and cold forging tools where critical performance is required. M2 prolongs service life due to its higher hardness and toughness than those of conventional grades.

They are commonly used for applications such as broaches, boring tools, chasers, cold forming rolls, cold heading inserts, drills, end mills, form tools, hobs, lathe and planer tools, punches, milling cutters, taps, reamers and saws.

2.1CHEMICAL COMPOSITION:

CONTENT	PERCENT	SPECIFICATIONS AISI M2
Carbon	0.864	0.85-1.05
Silicon	0.262	0.20-0.45
Manganese	0.241	0.15-.040
Phosphorus	0.028	0.025 MAX
Sulfur	0.022	0.025 MAX
Chromium	4.19	3.75-4.50
Molybdenum	4.549	4.50-5.50
Vanadium	1.912	1.60-2.20
Tungsten	6.404	5.50-6..75

2.2Physical Data:

Density (lb / cu. in.)	0.295
Specific Gravity	8.16
Melting Point (Deg F)	2600
Modulus of Elasticity Tension	28

3. TESTING

3.1Rockwell hardness test:

The Rockwell method measures the permanent depth of indentation produced by a force/load on an indenter. First, a preliminary test force (commonly referred to as preload or minor load) is applied to a sample using a diamond indenter. This load represents the zero or reference position that breaks through the surface to reduce the effects of surface finish. After the preload, an additional load, call the major load is applied to reach the total required test load. This force is held for a predetermined amount of time (dwell time) to allow for elastic recovery. This major load is then released and the final position is measured against the position derived from the preload, the indentation depth variance between the preload value and major load value. This distance is converted to a hardness number.

Fig 3.1: Rockwell Hardness Setup

Wear test:

- Immediately prior to testing, and prior to measuring or weighing, clean and dry the specimens. Take care to remove all dirt and foreign matter from the specimens. Use non chlorinated, non flim forming cleaning agents and solvents.
- Dry materials with open grains to remove all traces of the cleaning fluids that may be entrapped in the material .Steel (ferromagnetic)specimens having residual magnetism should be demagnetized .Report the methods used for cleaning.
- Measure appropriate specimen dimensions to the nearest 2.5µm or weigh the specimens to the nearest0.0001g.

- Insert the disk securely in the holding device so that the disk is fixed perpendicular to the axis of their solution.
- Insert the pin specimen securely in its holder and, if necessary adjust so that the specimen is perpendicular to the disk surface when in contact, in order to maintain the necessary contact conditions.
- Add the proper mass to the system lever or bale to develop the selected force pressing the pin against the disk. Start the motor and adjust the speed to the desired value while holding the pin specimen out of contact with the disk. Stop the motor.
- Set the revolution counter (or equivalent)to the desired number of revolutions. Begin the test with the specimens in contact under load. The test is stopped when the desired number of revolutions is achieved. Tests should not be interrupted or restarted.
- Remove the specimens and clean off any loose wear debris. Note the existence of features on or near the wear scar such as: protrusions, displaced metal, discoloration, micro cracking, or spotting.
- Remeasure the specimen dimensions to the nearest2.5 µm or re weight specimens to the nearest0.0001g, as appropriate. Repeat the test with additional specimens to obtain sufficient data for statistically significant results. Model of the tabular column is shown in table(3.2)
- Hence wear rate can be calculated from equation given below

$$\mathbf{w=V_w / D}$$

Where w= Wear rate.
V_w = Wear volume.
D= Distance travelled.

Fig 3.2: Pin on Disc Setup

4. RESULTS AND DISCUSSION

4.1Microstructure discussion:

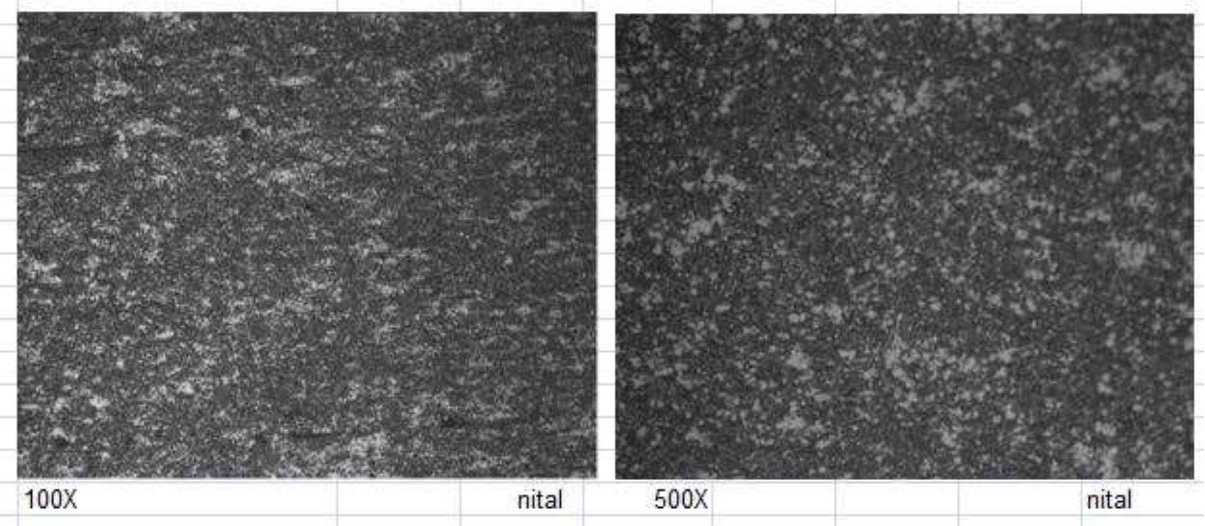


Fig 4.1: Before Cryogenic Treatment

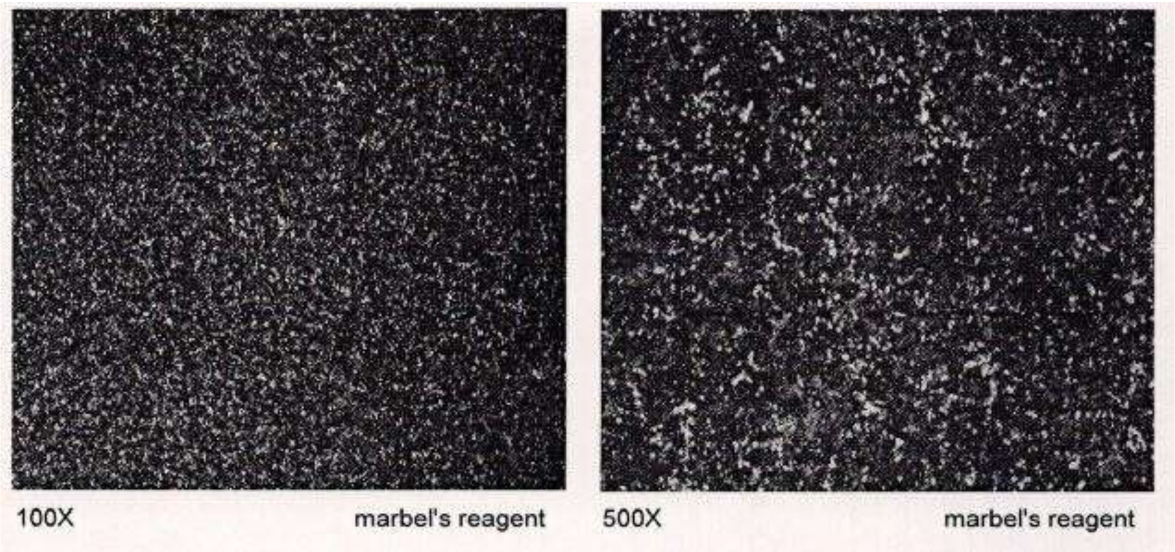


Fig 4.2: After Cryogenic Treatment

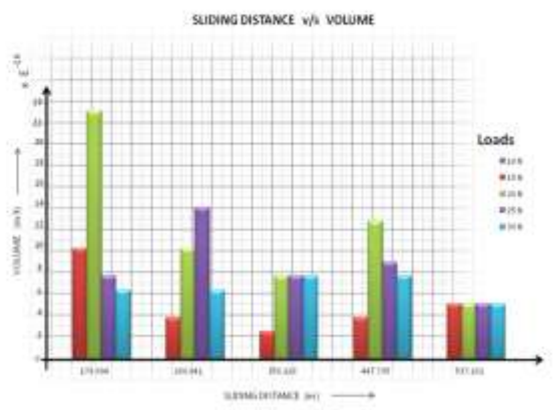
Microstructure consists of uniformly dispersed fine spheroidized cementite (carbide) in a ferrite matrix. Spheroidization appears complete in fig 4.1 ie before cryogenic treatment in fig 4.2 ie after cryogenic treatment Microstructure consists of fine spheroidal and elongated carbides in the matrix of martensite.it is in hardened and tempered condition.

4.2 HARDNESS TEST

It was observed that initially the hardness falls sharply at the cryogenic cycle and when the tool is heated to the room temperature the hardness is totally recovered.

Specimen type (M2)	Hardness (HRC)
Heat treated	60
DCT	60

4.3 WEAR TEST



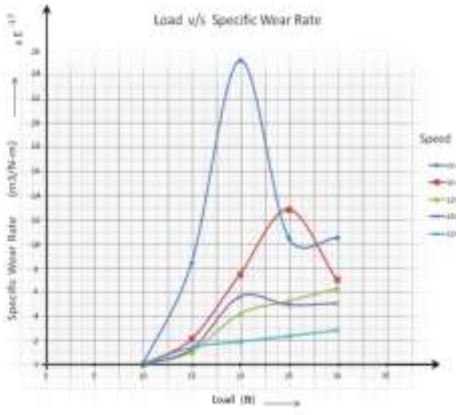


Fig 4.3 sliding distance vs volume

Fig 4.4 load vs specific wear rate

Relation between sliding distance and volume loss is shown in the fig (4.3). There will be no volume loss when the load is 10N. When the load is 15N the volume loss will be 1.02564E-15 m3, 3.84615E-16 m3, 2.5641E-16 m3, 3.84615E-16 m3, 5.12821E-16 m3 with sliding distance of 179.094m, 268.641m, 358.188m, 447.735m, 537.282m. When the load is 20N the volume loss will be 2.30769E-15 m3, 1.02564E-15 m3, 7.69231E-16 m3, 1.28205E-15 m3, 5.12821E-16 m3 with the sliding distance remaining the same. Similarly the volume loss for 25N, 30N is calculated with same sliding distance.

Relation between load and specific wear rate is shown in the fig (4.4) for different speed. Wear rate will be zero until the load increases above 10N for all speeds. When the load is 15N the wear rate will be 8.59025E-17 m3/N-m, 2.14756E-17 m3/N-m, 1.07378E-17 m3/N-m, 1.28854E-17 m3/N-m, 1.43171E-17 m3/N-m for the various speed (60rpm, 90rpm, 120rpm, 150rpm, 180rpm). Similarly when the load is 20N, 25N, 30N the wear rate is calculated for the various speed and the graph is plotted.

5. Conclusion:

- The cryogenic treatment has been used effectively to enhance the mechanical properties like wear resistance, hardness of various grades of steel.
- The underlying mechanism involves conversion of austenite to martensite structure and reduction of retained austenite structure. The tool life also gets enhanced through increased wear resistance caused by the deeper distribution of carbide particles in the material.
- Unlike conventional heat treatment, cryogenic treatment is not a superficial method; it affects the entire material. It enhances the toughness and hardness values of cutting tools by homogenizing the carbide distribution within them.
- Optimization of tool performance and reduction of the cost of tools can be achieved by using different cryogenic process parameters when necessary in order to determine the effect of the cryogenic process.
- Contribution of DCT to improve the wear resistance is due to martensite, carbide formation, and homogeneous distribution of produced carbides rather than only removal of retained austenite.
- Hardeness of the material is not affected by DCT only the Residual Stress are being relived

- Wear rate of the material is very negligible by that the tool life is increased.

6. REFERENCES

1. Machado,M.B. da Silva, Metal Machining. Brazil : MG, (2003)
2. Paulin, Frozen gears, Gear Technol. (1993), pp. 26–28.
3. Smolnikov, Kossovich, “Cold Treatment of Cutting Tools” Volume No. 10, (1980): pp. 5–7
4. Tseitlin,. Kolensnichenko, Karnaushenko, Umanets, Zhmud, “Tool Life Of High Speed Steel Cutters After Cold Treatment". Volume No. 10, (1980):pp. 7–9.
5. Zhmud E.S,"Improved Tool Life after Shock Cooling". Volume No. 10,(1980):pp.3–5.
6. Gulyaev A.P., “Improved methods of heat treating high speed steels to improve the cutting properties", Metallurgy. Volume No. 12, (1937):pp. 65.
7. Reasbeck, “Improved tool life by the cryotough treatment". Metallurgia. (1989):pp. 178–179.
8. Zamborsky D.S.,"Control of distortion in tool steels". The Heat Treating Source Book,(1986):pp. 73–79.
9. Heberling J.M., Tool steel tutorial, Heat Treating, (1992)
10. Barron F.R., “Yes—Cryogenic Treatments can save your money! Hear's Why",. Tapi Volume No. 57,(1974):pp. 35–40
11. Popandopulo, Zhukova, “Transformations in high speed steels During Cold Treatment". Volume No. 10,(1980):pp. 9–11.