The International Journal of Engineering And Science (IJES)
||Volume|| 2 ||Issue|| 01 ||Pages|| 246-249 ||2013||
ISSN: 2319 – 1813 ISBN: 2319 – 1805

Deep Cryogenic Processing After Heat Treatment: A New Approach

S.N.Chaudhari[1], Dr. G.J. Vikhe patil[2]
[1, 2]Amrutvahini College of Engineering, sangamner, Ahmednagar, Maharastra.

Abstract

Abstract- Generally cryogenic treatment for tool steel is performed after quenching but cryogenic treatment after completion of total heat treatment was hardly studied. This work compares the performance of untreated (HTTT) M2 tool with cryogenically treated after heat treatment (HTTTCD) tool on the basis of tool life, flank wear, power consumption, surface roughness and microstructure. The result shows that cryogenically treated M2 tool after heat treatment (HTTTCD) tool exhibit better performance during operation than untreated (HTTT) M2 tool steel.

Key word- *M2 tool steel, HTTT, HTTTCD.*

Date of Submission: 22th December, 2012 ⟺ Date of Publication: Date 20th January 2013

I. Introduction

Jelenkowski et al. [2010] “Effect of Deep Cryogenic Treatment on Substructure of HS6-5-2 High Speed Steel” compares microstructure of cryogenically treated HS6-5-2 steel with conventional treated tool. Transmission electron microscopy and scanning electron microscopy observations were carried out. Studies of thermal stability in range of temperatures from -196^{0}C to 400^{0}C were performed using differential scanning calorimetry (DSC). The HS6-5-2 high speed steel was heat treated in a conventional mode for secondary hardness or was processed in a mode with use of DCT, with and without next tempering.

1. In first mode, Austenitizing (1200^{0}C) + Quenching + Tempering (550^{0}C, 2 hour) sequence was carried out.
2. In second mode Austenitizing (1200^{0}C) + Quenching + DCT (-180^{0}C, 24 hour) carried out.
3. In third mode Austenitizing (1200^{0}C) + Quenching + DCT (-180^{0}C, 24 hour) + Tempering (550^{0}C, 2 hour) sequence was carried out.

Transmission electron microscopy and scanning electron microscopy observations were carried out. Studies of thermal stability in range of temperatures from -196^{0}C to 400^{0}C were performed using differential scanning calorimetry (DSC).The result shows that deep cryogenic treatment doesn’t alter the amount, size and distribution of special carbides, whereas it refines the substructure of martensite laths and plates.

Firouzdor et. al [2008] in their work “Effect of deep cryogenic treatment on wear resistance and tool life of M2 HSS drill.” Investigate effect of deep cryogenic treatment on M2 tool steel. The austenitizing temperature of drills selected was 1100^{0}C and gas quenching was performed in a cool nitrogen gas and consequent tempering was done at 600^{0}C for 2 hour. Cryogenic treatment was performed by placing drills in an isolated alumina chamber immerged gradually in a liquid nitrogen reservoir by means of an electric motor. The isolated chamber was designed according to heat transfer equations to estimate the thermal gradient of the chamber. Deep cryogenic treatment consisted of slowly cooling drills to approximately −196^{0}C and holding at this low-temperature for 24 hour and gradually bringing the specimens back to room temperature. In order to avoid thermal shocks from rapid cooling and heating, the specimens were cooled down and heated up slowly, to and from the cryogenic temperature (−196^{0}C), over an 8 hour period with the temperature being monitored by a thermocouple attached to the specimen. This gives an average heating/cooling rate of 0.5^{0}C/min. Three types of drills were tested, reference drills (R) with no extra treatment, cryogenic-treated drills (CT) and cryogenic with a 1 hour temperature 200°C treated drills (CTT).The heat treatment cycle of each drill category. Drilling test was performed on a rigid instrument-drilling bench. Blind holes were drilled in normalized CK40 carbon steel blocks. Hole depth; feed rate and cutting speed were kept constant at 50 mm,0.11 mm/rev and 350 m/min, respectively. Five drills were tested for each group. One can notice the influence of cryogenic treatment on hardness values which are 2 and 1 points higher in CT and CTT drills in comparison with R one, respectively. It is also noticeable that drill life increases approximately 77% in CT drills whereas it improves about 126% in CTT ones. Comparison of the flank wear width developed on the flank surface after drilling of 10, 15, and 20 holes. It was observed that the wear width enhances with increasing in the number of drilled holes. It is also imperative to note that CCT drills show the least wear rate while Reference drills show the most.]

Sendooran et. al [2011] their work "Metallurgical Investigation on Cryogenic Treated HSS Tool" investigated about change in microstructure and hardness of the AISI M2 (or) HSS 6-5-2 tool before and after the deep cryogenic treatment (DCT).In this method called deep cryogenic tempering, subjects tools placed in a specially constructed tank to temperature around (-196^{0}C) for thirty minutes using liquid nitrogen as the refrigerant. Slowly cooling the tool steel to deep cryogenic temperatures and soaking it at this low temperature for 20 minutes changes the material's microstructure is to improve mechanical property of material. Transformation of retained austenite at low temperatures in tool steels generally is believed to be dependent only on temperature, not on time. Thus, merely reaching a suitably low temperature for an instant would produce the same effect as holding for several days. Cryogenic treatments can produce not only transformation of retained austenite to martensite, but also can produce metallurgical changes within the martensite cryogenic treatment of high alloy steels, such as tool steel, results in the formation of very small carbide particles dispersed in the martensite structure between the larger carbide particles present in the steel. This strengthening mechanism is analogous to the fact that the concrete made of cement and large rocks is not as strong as concrete made of cement, large rocks and very small rocks, (Coarse sand). The small & hard carbide particles within the martensite matrix help support the matrix and resist penetration by foreign particles in abrasion wear. The reported large improvements in tool life usually are attributed to this dispersion of carbides in conjunction with retained austenite transformation. It was found that Cryogenic treatments can produce not only transformation of retained austenite to martensite, but also can produce metallurgical changes within the martensite and this offer many benefits where ductility and wear resistance are desirable in hardened steels.

Flavio J.da Silva [4] investigated the performance of cryogenically treated M2 high speed steel tools. The tools were cryogenically treated at −196^{0}C followed by three cycles of heating to temperatures in the order of +196^{0}C for tempering, lasting a total of 43h. The hardness and the microhardness of the M2 HSS samples were not significantly affected by the cryogenic treatment. The cryogenic treatment increased the performance of the M2 HSS twist drills. The gain observed during drilling steels adopting catastrophic failure as the end of tool life criterion varied from 65% to 343% depending on the cutting conditions used. Depending on the application the cryogenic treatment may be a good alternative for having productivity enhancement.

Rupinder singh [5] et al. studied enhancement of tool material machining characteristics with cryogenic treatment..Cryogenic processing is a supplementary process to conventional heat treatment of tool steel for industrial applications like HSS centre drill, carbide insert for CNC turning, U drilling, face milling and keyway milling. The cryogenic process conducted at -184^{0}C.After ramping down to -184^{0}C, material is soaked at 18 hour and brought up to room temperature in 9 hour. Total duration of cryogenic treatment was about 36 hour. Then material is tempered at 150^{0}C.This temperature is achieves in 1.5 hour and kept this temperature at 4 hour. Then it brought back to room temperature in next 1.5 hour. Cryogenic treatment improves mechanical properties like wear resistance, toughness and resistance to fatigue cracking. This is due to the, transformation of retained austenite into stable martensite. The phase transformation leads to the increase in density of dislocations and vacancies which in turns enhance the diffusion coefficient of carbon. This microstructure evolution induces the precipitation of very tiny carbides during the cryogenic treatment. The result of cryogenic treatment shows enhancement of tool life HSS centre drill, carbide insert and HSS cutter by 5% to 22.2%.

II. Experimental Work

The experimental work was carried out in Indian Tool Manufacturers Ltd. and Cryonet Company, Surat. The drilling operation was carried out on work specimen using cryogenically treated and conventionally treated HSS drill. Conventional heat treatment was carried out at 1200^{0}C hardening temperature and 560^{0}C tempering temperature.

Cryogenic treatment was carried out at -185^{0}C temperature for 24 hour in liquid nitrogen tank after hardening at 1200^{0}C, quenching and triple tempering.

TABLE I.EXPERIMENTAL CONDITION M/C TOOL AND EQUIPEMENT SPECIFICATION

Parameter/Item	**Experimental condition M/C Tool and Equipment specification**
Machine tool	Witzig & Frank make Drill machine, 3phase, and 18KW motor.
Cutting Tool	HSS M2 Twist drill Untreated (HTTT)) HSS M2 Twist drill CryogenicallyTreated(CT)
Chemical composition of cutting tool material	C-0.954,Mn-0.450 Si-0.411,P-0.030 S-0.003,Cr-4.045 Mo-5.65,Ni-0.225 V-1.790,W-6.45
Tool Geometry	Flute Length-120mm,overall Length-220mm,Point Angle 118^0 ,Helix angle 30^0
Work Material	EN 8(75x75x20 mm)
Chemical Composition of Work Material	C-0.410,Mn-0.807 Si-0.132,P-0.025 S-0.024,Cr-0.009 Ni-0.004,V-0.002
Cutting Speed	22m/min
Feed Rate	0.13mm/rev
Depth of Cut	8mm

III. Methodology

Following heat treatment sequence was selected for study.

TABLE II HEAT TREATMET SEQUENCE

Sr. No	Heat Treatment Sequence	Heat Treatment Sequence Detail
	HTTT	Hardening+Tripple Tempering
	HTTTCD	Hardening+Tripple Tempering+Cryogenic Treatment at -196^0C Temp.

Following steps are involved in evaluating the performance of cryogenically treated M2 drill. Samples of M2 tool steel were subjected to three different heat treatment processes.

Step 1.

Flank wear of both untreated (HTTT) and cryogenically treated (HTTTCD) M2 drill was measured by height gauge with conjunction with dial indicator.

Step 2.

Power consumption of both untreated (HTTT) and deep cryogenically treated (HTTTCD) M2 drill was measured by display of ammeter and voltmeter directly on machine tool.

Step 3.

Surface roughness of hole drilled by work specimen (EN8) of both untreated (HTTT) and deep cryogenically treated (HTTTCD) M2 drill was measured.

IV. Paratemer Measuring Techniques And Equipements

Surface roughness was measured by surface roughness tester, model Supercom 130 roughness tester. Flank wear was measured by height gauge with dial indicator of least count 0.01mm.Power consumption was calculated by measuring the current (amperes) and voltages (volt) directly on display of drilling machine. Microstructure of both untreated (HTTT) and deep cryogenically treated (HTTTCD) M2 drill was taken using Metallurgical microscope, magnification X100.

V. RESULTS AND DISCUSSIONS

The microstructure analysis was carried out to study the microstructure changes in M2 untreated (HTTT) and deep cryogenically treated (HTTTCD) drill due to cryogenic treatment.. Microstructure shows that due to cryogenic treatment, well distributed carbides in the matrix of tempered martensite observed.

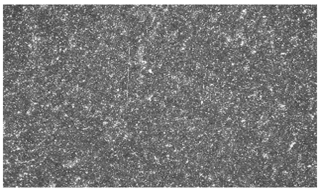

Fig. 1.1 Microstructure of untreated (HTTT) M2 tool

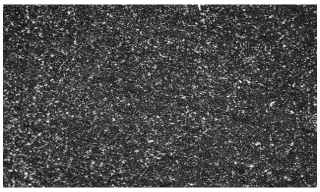

Fig. 1.2 Microstructure of cryogenically treated (HTTTCD) M2 tool

The parameter chosen to study the performance of CT M2 drill were change in flank wear, power consumption by drilling machine and surface roughness of work material

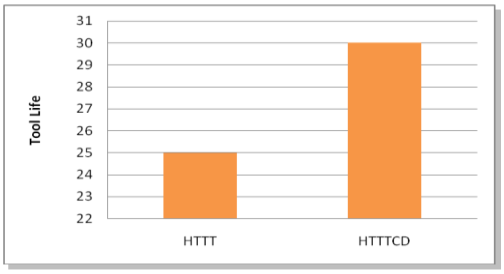

Fig. 1.3 Variation of tool life against untreated and cryotreated tool

As shown in figure 1.3 tool life of cryogenically treated tool after heat treatment (HTTTCD) is more than untreated tool (HTTT).

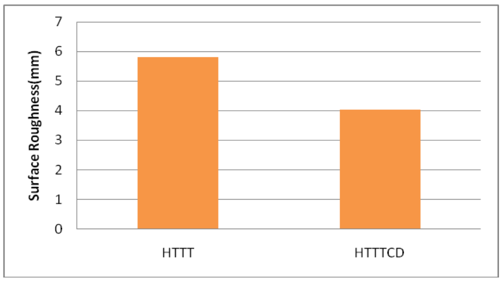

Fig. 1.4 Variation of surface roughness against untreated and cryotreated tool

As shown in figure 1.4 Surface roughness of cryogenically treated tool after heat treatment (HTTTCD) is less than untreated tool (HTTT).

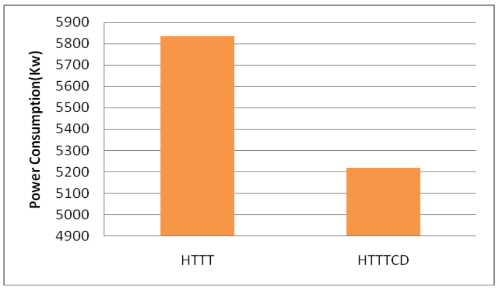

Fig. 1.5 Variation of Power Consumption against untreated and cryotreated tool

As shown in figure 1.5 cryogenically treated tool after heat treatment (HTTTCD) consume less power than untreated tool (HTTT).

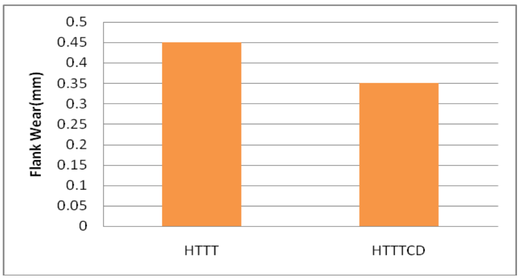

Fig. 1.6 Variation of flank wear against untreated and cryotreated tool

As shown in figure 1.6 flank wear of cryogenically treated tool after heat treatment (HTTTCD) is less than untreated tool (HTTT).

V. Conclusion

The experimental result shows that cryogenic processing enhances the performance of tool after heat treatment also. Less wear , more uniform distribution of metal particles, less power consumption of cryogenically treated (HTTTCD) tool and lower value of surface roughness of workpiece machined with deep cryogenically treated (HTTTCD) M2 tool (Twist Drill)represents the positive scope of cryogenic treatment after hardening.

ACKNOWLEDGMENT

I am very thankful to Indian Tool Company and Cryonet Company Surat for allowing me to do project. I earnestly express my sincere thanks to my guide Prof. Dr.G.J.Vikhe Patil for his valuable help and guidance also I express sincere thanks, to Prof. A. K. Mishra, Prof.V.S. Aher, Prof.V.D. Wakchuare and Prof. for their kind co-operation.

I highly obliged to entire staff of Mechanical Engineering and my friends for their kind co-operation, help & encouragement me for present this paper in International Conference.

References

[1] Jelenkowski,A.ciski,T.babul“Effect of Deep Cryogenic Treatment on Substructure of HS6-5-2 High Speed Steel “Journal of Achievement in material and manufacturing Engineering,Vol.43,2010,Pp 80-87.

[2] Firouzdor E. Nejati, F. Khomamizadeh “Effect of deep cryogenic treatment on wear resistance and tool life of M2 HSS drill.” Journal of materials processing technology Vol.206 2008, Pp 467–472.

[3] Flavio J. da Silva,Sinesio D. Franco b,Alisson R. Machado,Emmanuel O.Enugu,Antonio M. Souza Jr.“Performance of Cryogenically Treated HSS Tools” Journal of wear,Pp-674-685,2006

[4] Sendooran “Metallurgical Investigation on Cryogenic Treated HSS Tool” International Journal of Engineering Science and Technology (IJEST) Vol. 3, 2011, 3992-3996.

[5] Rupinder Singh, and Kamaljit Singh “Enhancement of Tool Material Machining Characteristics with Cryogenic Treatment: A Review” Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management Dhaka, Bangladesh Pp- 1-5, 2010.

[6] Alam M. Bayer, Bruce A, Becere R and Teledyne vasco “High Speed Tool Steel” ASM Handbook, Volume16, 1989, Pp- 51-59.