© 2016 IJSRSET | Volume 2 | Issue 3 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Experimental Investigation to Minimize Tool Wear by Cryogenic Treatment

Dr. N Nandakumar

Department of Mechanical Engineering, Government College of Technology, Coimbatore, Tamilnadu, India

ABSTRACT

The high speed steel is used as a cutting tool, since it has good quality and reliability at cheaper rate when compared to other cutting tools. So it is very important to increase the ability of the tool further for its reliability. So the best way is to increase the hardness. We have brainstormed to find out alternate tool materials. One novel method namely dipping the ordinary tool bit in a cryogenic solution, which improves the wear properties of the cutting tool consequently machining time is also reduced. Cryogenic treatment of high speed steel is one of the developments in manufacturing field. It offers much better wear resistance and hardness for the high speed steel. The conventional cryogenic treatment process involves cooling down the samples to 93k (-180°c) soaking for 12 seconds and then slowly heating back to room temperature. In this experimental investigation a sequence of methodology is adopted to arrive at an optimum solution having two sample pieces of round of EN8 & EN19. A method called deep cryogenic process, subjects steel components placed in a specially constructed tank to temperature around 77k (196°c) for half an hour using liquid nitrogen as the refrigerant.

Keywords: Cryogenic treatment, sub-zero temperatures, tool wear

I. INTRODUCTION

In persistent investigation for cost effectiveness in manufacturing, there is a continuous need to reduce tooling costs to meet economic requirements. Tooling cost includes the cost of new tool and loss in production time due to tool changing and tool wear regrinding Tooling cost can be minimized by improving tool life or wear resistance. Deep Sub-zero treatment of metals and alloys is a deep stress relieving technology. Whenever material is subjected to any manufacturing operation, it is subjected to stresses. The stress manifests itself in the nature of defects in the crystal structure of materials. As the level of stress increases, the density of these defects increases, leading to increase in inter atomic spacing. When the distance between the atoms exceeds a certain critical distance, cracks develop and failure takes place. The third law of thermodynamics states that entropy is zero at absolute zero temperature. Deep sub-zero treatment uses this principle to relieve stresses in the material. The materials are subjected to extremely low temperatures for a prolonged period of time leading to development of equilibrium conditions. This leads to ironing out of the defects in the material and also attainment of the minimum entropy state. A more recent approach to address this issue is the application of cryogenic treatment.

II. METHODS AND MATERIAL

Cryogenic treatment involves the following sequence:

1. Slow cooling to predetermined low temperature
2. Soaking for predetermined amount of time
3. Slow heating to room temperature
4. Tempering

Before proceeding for cryogenic treatment the batch of conventionally heat treated specimens were cleaned to remove the dirt, impurities and traces of salt layer found on their surface. The machining materials also chosen and hardness is done on that material after that machining is done on the materials using the machining tools.

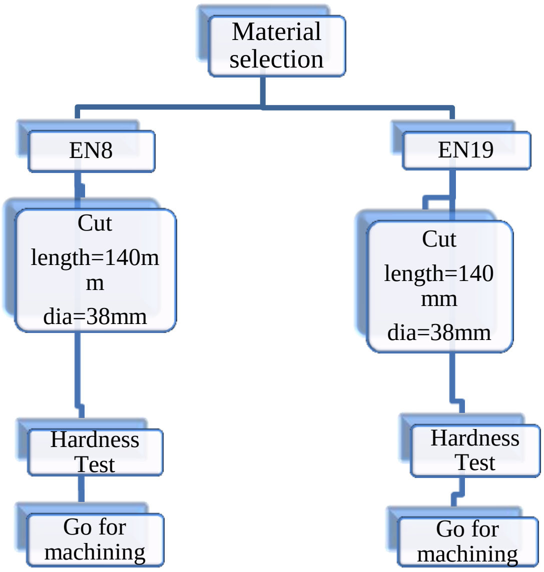

Figure 1. Experimental methodology adopted

Deep cryogenic treatment has been carried at -195° C with a soaking time of 24 hours. Specimens were cooled at the rate of - 0.5°C/min until they reach the final soaking temperature of -195° C. Soaking time of 24 hours was adopted to allow for complete phase transformation to take place. Then the cycle was reversed such that temperature ramp up at the rate of 0.5° C/min up to room temperature.

- Carbide tipped tool: The tool is costly, suitable for high feed rate and material removal. Not suitable for low speed application.
- Diamond tipped tool: Not economical for machining low carbon steels.
- Ceramic tool: Suitable for harder material. For machining high carbon steel work pieces only, tool material would suffice. Not for low speed operation or interrupted cutting, not for machining Al, Ti alloys**.**
- Cryogenic treatment of tool: A novel method which improves the hardness of the tool material, thereby the machining time can be reduced.

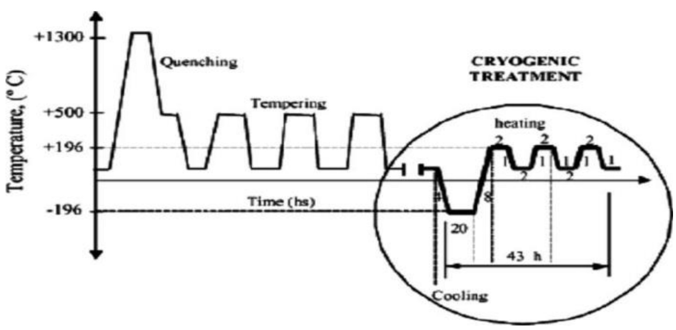

Figure 2. C.T cycle

III. RESULTS AND DISCUSSION

In this first machining process we selected the machining material as En8 and performed the machining by reducing the material for various diameters of the desired length. The material is removed by turning operation performed in the lathe for a constant speed and feed. The depth of cut is given as 3mm for the metal removal for various diameters. In this shaft of 100mm length, the first 40mm is used for holding the shaft in the lathe.

A. Procedure - I

Table 1. EN8 Machined with Untreated HSS tool

Dia. Of Shaft (mm)	Tool Travel length (mm)	Tool Wt.		M.R.R (gm)	M/C time (sec)
		Initial	Final		
38-32	35	49.26	49.25	87.47	143.23
32-26	35	49.25	49.23	164	130.07
26-20	30	49.23	49.21	46.48	61.91

Table 2. EN8 Machined with Treated HSS tool

Dia. Of Shaft (mm)	Tool Travel length (mm)	Tool Wt.		M.R.R (gm)	M/C time (sec)
		Initial	Final		
38-32	35	54.24	54.24	106	38-32
32-26	35	54.24	54.24	94.20	32-26
26-20	30	54.24	54.24	83.31	26-20

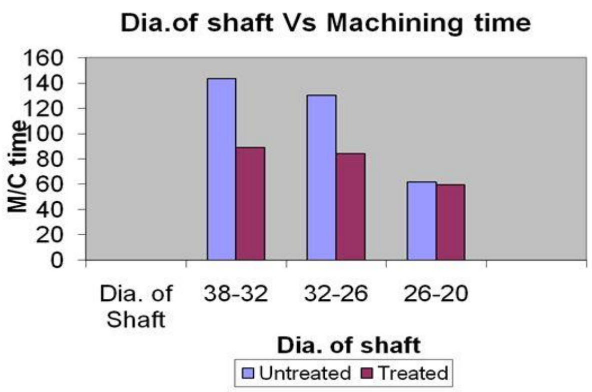

Figure 3. Diameter of the shaft Vs machining time

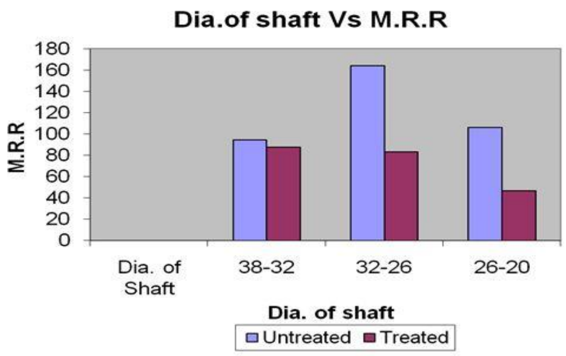

Figure 4. Diameter of shaft Vs MRR

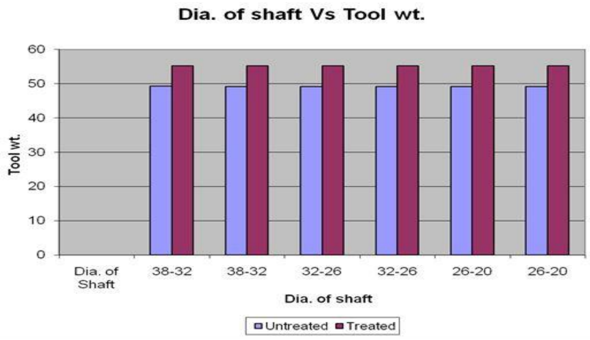

Figure 5. Diameter of shaft Vs Tool weight

A. Procedure – II

In this second operation we selected the machining material as En48 and performed the machining by reducing the material for various diameters of the desired length. The material is removed by turning operation performed in the lathe for a constant speed and feed. The depth of cut is given as 3mm for the metal removal for various diameters. In this shaft of 140mm length, the first 40mm is used for holding the shaft in the lathe.

Table 3 EN19 Machined with Untreated HSS tool

Dia. Of Shaft (mm)	Tool Travel length (mm)	Tool Wt.		M.R.R (gm)	M/C time (sec)
		Initial	Final		
26-20	30	50.40	50.38	59.50	60.46
32-26	35	50.38	50.36	65.92	139.6
38-32	35	50.36	50.35	73.48	146.77

Table 4 EN19 Machined with Treated HSS tool

Dia. Of Shaft (mm)	Tool Travel length (mm)	Tool Wt.		M.R.R (gm)	M/C time (sec)
		Initial	Final		
26-20	30	55.31	50.31	62.16	56.75
32-26	35	55.31	55.30	69.43	120.98
38-32	35	55.30	55.29	75.88	102.99

It may be concluded from these tests that treatment at -196°c improves wear resistance and reduces the machining time greatly.

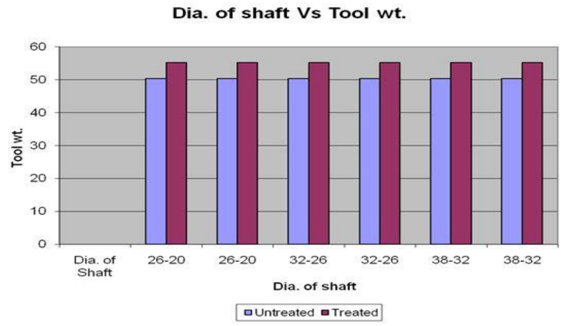

Figure 6. Diameter Of shaft Vs Tool weight

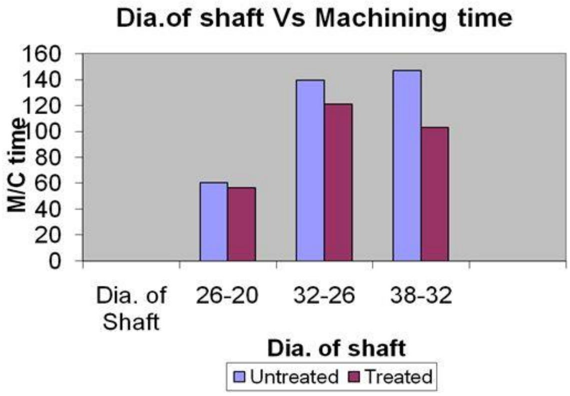

Figure 7. Diameter Of shaft Vs Machining time

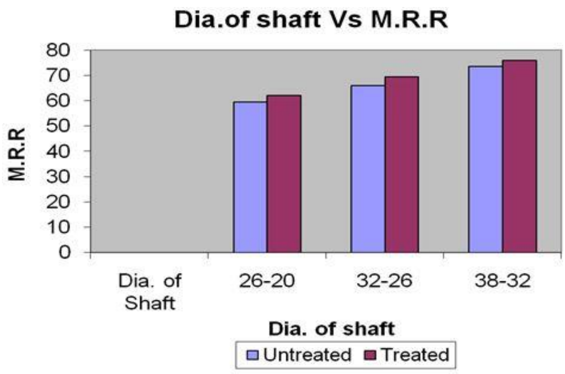

Figure 8. Diameter of shaft Vs.MRR

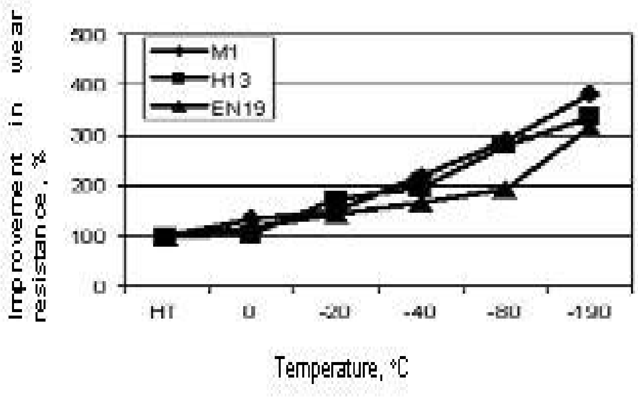

Figure 9. Wear Resistance Analysis

IV. CONCLUSION

It will be evident experimental details, for EN8 there is 44.04% of reduction in machining time and 200% increase in tool wear resistance and for EN19 there is 23.55% of reduction in machining time and 150% of increase in tool wear resistance. Presence of retained austenite from 17 – 19% in case of conventional heat treatment has been reduced to 4-5% by shallow cryogenic treatment and finally it was brought down to less than 1% by deep cryogenic treatment. Deep cryogenic treatment has shown to result in significant increase in the wear resistance and correspondingly reduces machining time of steels such as EN8 and EN19. The benefit of this process includes; reduction of abrasive and adhesive wear, improved machining properties resulting from the permanent change of the structure of the metal. Increase in hardness and wear resistances attributed only to these fine precipitates formed during cryogenic treatment.

V. REFERENCES

[1] Dhar NR, Paul S, Chattopadhyay AB, "Machining of AISI 1045 steel under cryogenic cooling – tool wear, surface roughness and dimensional deviations", Journal of Materials Processing Technology, 2002, 123, 483-489.

[2] Seah KHW, Rahim M, Yong KH, "Performance evaluation of cryogenically treated tungsten carbide cutting inserts", Proc. Inst.Mech.Eng. Part B: J Eng Manuf. 2003, 217: 29-43

[3] Jha, A.R. "Cryogenic Technology and Applications" Butterworth-Heinemann: Oxford, UK, 2006; 1–21.

[4] Timmerhaus, K.D.; Reed, R.P. "Cryogenic Engineering" Springer: New York, USA, 2007; 3–27.

[5] Baldissera, P.; Delprete, C. "Effects of deep cryogenic treatment on static mechanical properties of 18NiCrMo5 carburized steel", Materials and Design, 2009, 30, 1435–1440.

[6] Gordon, P.; Cohen, M. "The transformation of retained austenite in high speed steel at sub atmospheric temperatures" Transactions of the ASM 1942, 30, 569–588

[7] A.A. Khan, M.Y. Ali and M.M. Haque "A new approach of applying cryogenic coolant in turning AISI 304 stainless steel" International Journal of Mechanical and Materials Engineering , 2010,Vol.5, No.2, 171-174

[8] Das, D.; Dutta, A.K.; Ray, K.K. "Influence of varied cryo-treatment on the wear behavior of AISI D2 steel" Wear 2009, 266, 297–309.

[9] Moore, K.; Collins, D.N. "Cryogenic treatment of three heat treated steels" Key Engineering. Material. 1993, 86–87, 47–54.

[10] Collins, D.N.; Dormer, J. "Deep cryogenic treatment of a D2 cold-worked tool steel" Heat Treat. Met. 1997, 24 (3), 71–74.

[11] S.S. Gill, R. Singh, H. Singh, J. Singh, "Wear behaviour of cryogenically treated tungsten carbide inserts under dry and wet turning conditions", Int. J. Mach. Tools Manuf. 2009, 256–260

[12] Pellizzari M., Molinari A., Girardini L., Maldarelli L. "Deep Cryogenic Treatment of AISI M2 High-speed Steel", Int J Micro- struct Mater Prop, 2008, 3(2-3), 383-390.

[13] A. Akhbarizadeh, A. Shafyei, M.A. Golozar; "Effects of cryogenic treatment on wear behavior of D6 tool steel"; Materials and Design , 2009, pp 3259–3264.

[14] Yong, A.Y.L., Seah, K.H.W., Rahman, M., Performance evaluation of cryogenically treated tungsten carbide tools in turning, Int. J. Mach. Tools Manuf., vol. 46, 2004, pp. 2051–2056.

[15] Seah,K.H.W, Rahman, M., Yong, K.H.,Performance evaluation of cryogenically treated tungsten carbide cutting tool inserts, Proc. Inst. Mech. Eng. Part B: J. Eng. Manuf., vol. 217, 2003, pp. 29-43.

[16] Reddy, T.V.S., Sornakumar, T., Reddy, M.V., Venkataram, R., Senthilkumar, A. Turning studies of deep cryogenic treated p-40 tungsten carbide cutting tool inserts. Technical Communication .J. Mach Sci tech. vol. 13, 2009, pp. 269- 281

[17] F. Farhani, K.S. Niaki "Cryogenic treatment of metals–a review of experimental studies, underlying mechanism and process equipment" Proceedings of the 4th BSME-ASME International Conference on Thermal Engineering, Dhaka, Bangladesh, 27-29, 2008.

[18] Muammer Nalbant, Yakup Yildiz "Effect of cryogenic cooling in milling process of AISI 304 stainless steel" Trans nonferrousMet soc.China 21,72-79, 2011.