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Analysis of CH_4 - C_4H_{10} Cryogenic Treated Tungsten Carbide Insert

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***Abstract*— Deep Cryogenic Treatment was confirmed to be crucial in order to maximize the hardness of the tool to reduce the tool wear and economic considerations which affects the production. Because of its high precision and high reliability tungsten carbide inserts have been broadly used worldwide for significant productivity improvements. Liquid nitrogen, oxygen are commonly used cryogenic treatment. The aim of this research is to examine the effect of cryogenic treatment of the uncoated carbide inserts with mixture of methane (CH4) and butane (C4H10) gases and observed with varying temperatures of -130°C, -150°C, -170°C. In general, machining with carbide tool is characterized by steady state conditions. Except at the beginning and end of the cut, the forces on the cutting tool and the tool tip temperature are essentially constant. For the special case varying cutting speed will affect the tool tip temperature. Where during machining, the carbide tool should provide reliable performance only with the parameters of higher hardness, bending strength, resistance to crater wearing and oxidation. Thus, it is necessary to provide high quality carbide turning inserts with excellent cutting capability. The specimens from both cryogenically treated and untreated conditions were subjected Rockwell Hardness Test and Metallurgical Analysis to obtain results that the cryogenic treatment has improved the hardness and strength.The experimental result was compared with Ansys.**

***Keywords*— cryo treatment, uncoated carbide tool, hardness test,finite element analysis**

I. Introduction

Over the past few years cryogenic processing is capable of treating a wide variety of materials such as metals, alloys, polymers, carbides, ceramics and composites. Deep cryogenic is the ultra-low temperature processing of materials to enhance their desired metallurgical and structural properties. This is a temperature is easily achieved using computer controls, a well-insulated treatment chamber and cryo fluids. Generally the cryogenic treatment is classified into two types and they are as follows: One is Shallow Cryogenic Treatment and another is Deep Cryogenic Treatment.

In Shallow Cryogenic Treatment, the material is subjected at -110°C and held at this temperature for 18- 25 hours and gradually brought back to the room temperature. Mohd Touseef Nauman, S. Rasool Mohideen & Nasreen Kaleem (2012) presented Material Characterization of 316L Stainless Steel After Being Subjected To Cryogenic Treatment. This study aims at investigating the properties of stainless steel of grade 316L after being subjected to deep cryogenic treatment. The specimens from both cryogenically treated and untreated conditions were subjected to Tensile Test, Charpy Impact Test, Rockwell Hardness Test, Microstructure and Percentage Shear Area Analysis and the results thus obtained are discussed in this paper. The results have shown that cryogenic treatment has improved the hardness and strength. S.Sendooran, P.Raja (2011) presented, Metallurgical Investigation on Cryogenic Treated HSS Tool. In their research they described deep cryogenic treatment (DCT) is to improve mechanical property of material. The DCT was applied to HSS tool top improve their mechanical properties. DCT always improves the wear resistance of the tool steel. The specimen was emerged in liquid nitrogen for 20 minutes for deep cryogenic treatment after austenitizing and the following tempering temperature was varied. The influence of heat treatment and deep cryogenic treatment on HSS tool was investigated by means of retained austenite transformation to martensite consists of uniformly distributed fine carbide particles in a matrix of the tempered martensite, hardness of the treated material. In this process retained austenite structure was completely converted into martensite structure and hardness was improved 17% BNM.

D. Candane1, N. Alagumurthi, K. Palaniradja (2013) presented, Effect of cryogenic treatment on microstructure and wear characteristics of AISI M35 HSS.Changes in the microstructure were studied using SEM. Fine precipitates of carbides of size 0.3-0.5µ were observed in cryogenically treated samples. Variation in mechanical properties such as toughness andhardness has been studied. There was no change in toughness due to cryogenic treatment and it corroborates well with the results of fractography.

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Wear characteristics were studied using pin on disc wear tester. The operative modes and mechanisms of wear have been identified as severe delaminative and mild oxidative from the morphology of worn surface of pin. The results unambiguously confirm enhancement in hardness and wear resistance of cryogenically treated specimens. There is a marginal improvement in hardness from 64HRC to 64.5HRC for shallow cryogenic treated specimens. And it improved further after DCT to 65.5HRC. 3. Also the micro hardness measured in Vickers scale shows an increase in hardness value from 920 to 934 in case of shallow cryogenic treatment and it was 980 in case of DCT.

II. Experimental Procedure

1. Cryogenic Treatment

Where the cryogenic treatment involved with mixture of methane and butane gases three varying temperature. Each gas contributed as 1 litre quantity. The running hour provided for the cryogenic treatment is 18 hours and that of the mixing flow is 1 hour. The maximum cryogenic temperature considered in this research is -170°C. Each carbide insert has different temperature values as follows:

Table 6.1
Cryogenic Temperatures

Insert	Temperature
Insert A	-130 °C
Insert B	-150 °C
Insert C	-170 °C

2. Hardness Test

Many hardness tests about CT are reported here because this property is related to the wear resistance. Hardness properties are usually measured through indentation tests and they are expressed in different scales depending on the penetrator shape. The most used methods are the Rockwell and the Vickers ones. While the first method is a macro indentation test, the second one can be performed both as macro or micro-indentation, depending on the applied load. According to this, the wear resistance improvement has been correlated to the enhanced toughness of the CT material. Thus suggests that playing on carbides fraction and dimension and on retained austenite allows achieving an optimized ratio between hardness and toughness.

After cryogenic treatment the tool is annealed to atmospheric temperature. Then the hardness test done on each tool with load characteristics of 60Kgf in a Rockwell Hardness testing process having scale A od indenter diamond involved.

The obtained result shows the increase in hardness values rather than that of the untreated carbide inserts. Where thise process also describes the hardness values with that of liquid nitrogen based cryogenic treatment.

Analysis work done with ANSYS to develop the thermal distribution and deformation – stress values for the treated tool as a couple – field analysis of thermal and of structural analysis.

III. Experimental Results

1. Rockwell Hardness Test Results

Table 8.1
Hardness Test

Load (Kgf)	Rockwell Hardness (HRA)	
	Untreated Insert	Treated Insert
60	88	95
60	87	96
60	89	97

2. Analysis Results Using ANSYS

Both thermal and structural analysis done on each model carbide insert which has varying temperature values of -130 °C, -150°C and -170°C. The obtained results were; Temperature Distribution, Total Heat Flux, Total Deformation, Directional Deformation, Equivalent Stress.

Structural Analysis	Dierctional Deformation, mm		Total Deformation, mm		Equivalent Stress, MPa	
Temp.	Min	Max	Min	Max	Min	Max
-130°C	-0.304	0.304	0	0.402	0.684	943.54
-150°C	-0.344	0.344	0	0.454	0.762	1067.7
-170°C	-0.384	0.384	0	0.507	0.843	1191.8

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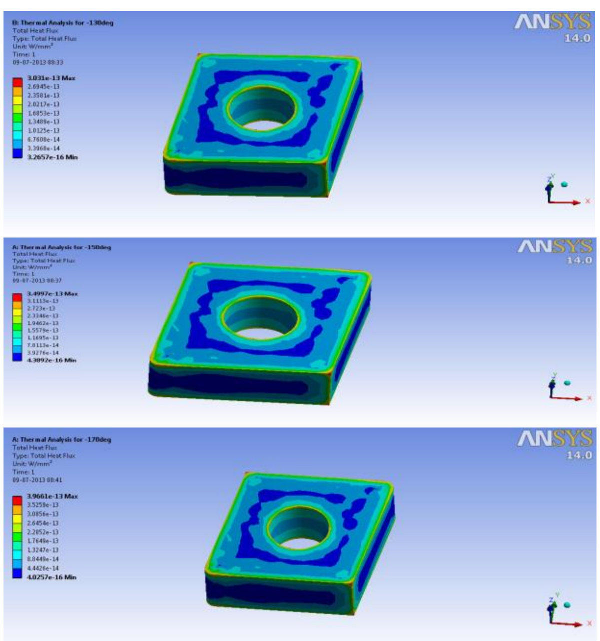
Thermal Analysis	Cryogenic Temperatures					
	-130°C		-150°C		-170°C	
	Min $x10^{-16}$	Max $x10^{-13}$	Min $x10^{-16}$	Max $x10^{-13}$	Min $x10^{-16}$	Max $x10^{-13}$
Total Heat Flux, W/mm^2	3.27	3.03	4.39	3.5	4.03	3.97

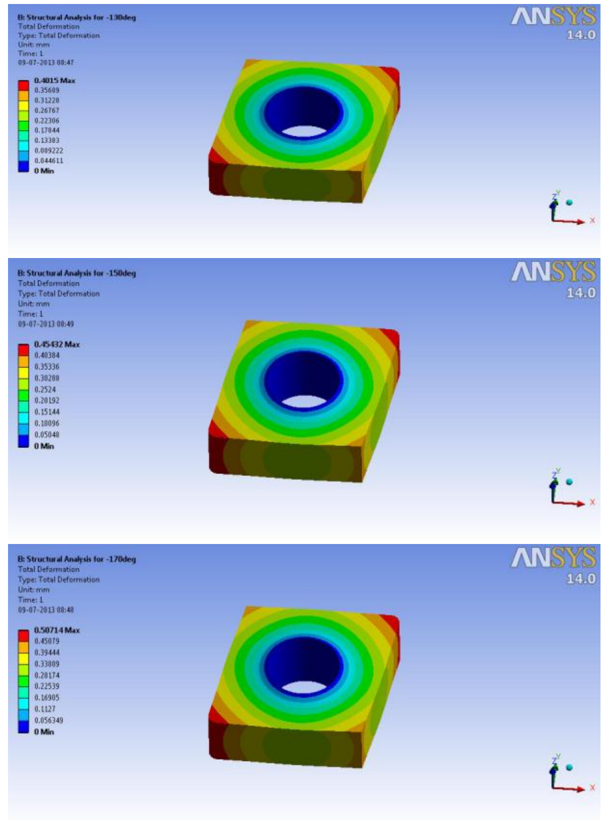
Commonly used cryogenic fluid is liquid nitrogen is replaced with this research of to provide a better optional to its performance. Thus a mixture of gases methane (CH4) and butane (C4H10) is applied as a cryogenic fluid. Also, to provide varying temperatures regards to hardness test.

The main objective of the research is to improve the hardness values cryogenically treated carbide inserts against untreated inserts and to understand cryogenic treatment improves the wear resistance of tungsten carbide tools. The responses of the mechanical testing will be validated by means of couple field analysis using ANSYS

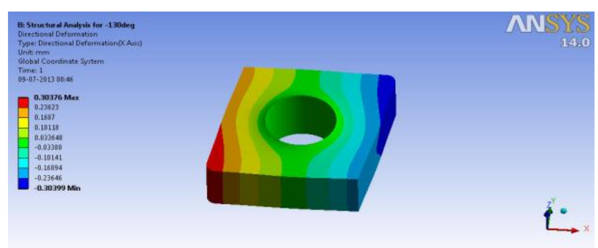
1. TotalHeatFlux



2.Total Deformation



3. DirectionalDeformation



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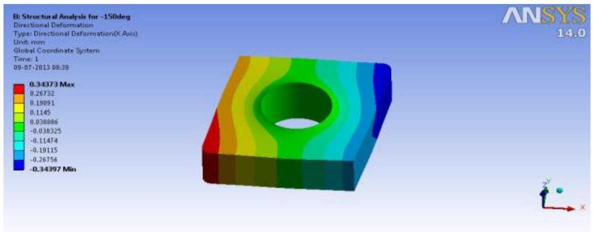

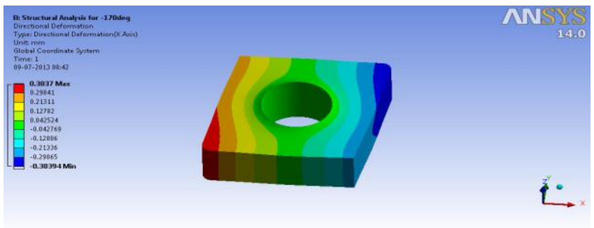

IV. Results And Discussion

The hardness value of CNMG 120408 LH BU810 specimen is heat treated with a mixture of methane and butane gases. After that a load 60 Kgf is applied with Rockwell Hardness Test to find the hardness values of each treated carbide inserts.

Comparing the results of the hardness test it was found that the hardness value increased tremendously after cryogenic treatment. Initially before heat treatment the hardness value was very low. After the analysis is performed in two load step groups: the first load step is to apply the cryogenic temperatures to the carbide insert model. And thus the temperature distribution is developed. Thereafter a static load value of 60Kgf has been applied in a node of each carbide insert model. Thus, stress and deformation results developed. Result got in ansys and result got in experimental work is related to provide the better performance could be developed from cryogenic treated tool.

V. Conclusion

The application of Cryogenic treatment on the carbide insert hardness values is increased which leads to the mechanical properties like wear resistance, toughness and resistance to fatigue cracking.

Overall, cryoprocessing has significant favourable influence on the performance of cutting tool steels and carbides. Hence, cryoprocessing is a good alternative for having productivity enhancement.

The improvement in wear resistance and hardness by cryoprocessing is attributed to the combined effect of conversion of retained austenite to martensite and precipitation of η-carbides.

The phenomenon responsible for improved wear resistance in carbide cutting tools is the combined effect of increased number of η phase particles and increase in bounding strength of binders used.

Cryoprocessing is an inexpensive one-time permanent treatment affecting the entire section of the cutting tool unlike powder coatings; therefore, similar lives can be expected after each regrinding of tools.

Both types of cryogenic treatments substantially decrease the wear rate of the insert compared to the conventional treated ones. However, the improvement in wear rate by deep cryogenic treatment is significantly higher than that achieved by shallow cryogenic treatment.

From the case study it can be said that the cryogenic treatment if applied properly can significantly reduce the cost of production of any mechanical component.

REFERENCES

[1] D. Candane1, N. Alagumurthi, K. Palaniradja, Effect of cryogenic treatment on microstructure and wear characteristics of AISI M35 HSS, International Journal of Materials Science and Applications 2013; 2(2) : 56-65.

[2] S. Sendooran, P.Raja, Metallurgical Investigation On Cryogenic Treated Hss Tool, ISSN: 0975-5462 Vol. 3 No. 5 May 2011

[3] MohdTouseefNauman, S. RasoolMohideen&NasreenKaleem, Material Characterization of 316L Stainless Steel After Being Subjected To Cryogenic Treatment, International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN No. 2231 – 6477, Vol-2, Issue-1, 2012

[4] B.R. Ramji,Analysis Of Forces, Roughness, Wear And Temperature In Turning Cast Iron Using Cryotreated Carbide Inserts, International Journal of Engineering Science and TechnologyVol. 2(7), 2010, 2521-2529

[5] A.A. Khan, M.Y. Ali and M.M. Haque, A New Approach Of Applying Cryogenic Coolant In Turning Aisi 304 Stainless SteelInternational Journal of Mechanical and Materials Engineering (IJMME), Vol.5 (2010), No.2, 171-174.

[6] AejazMasood, MujibUllahZuberi&Ekram Husain, Estimation of Breakdown Strength of Solid Insulating Materials in Liquid Nitrogen Indian Journal of Cryogenics Vol. 33. No.1, 2008

[7] SandipB.Chaudhari, Prof. Sanjay P. Shekhawat, Mr.Ambeprasad S. KushwahaAdvanced Technology of Cryoprocessing for the Enhancement of Tool Material Machining Characteristics International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, Volume 2, Issue 4, April 2012) 612

[8] Harold A. Stewart,Cryogenic treatment of tungsten carbide reduces tool wear when machining medium density fiberboard Forest Products Journal Vol. 54, No. 2 March 2003

[9] HemantB.Patil, Prashant B. Chavan, Shoeb H. Kazi, Effects Of Cryogenic On Tool Steels-A Review, International Journal of Mechanical and Production Engineering, ISSN (PRINT): 2320-2092, Volume – 1, Issue – 1, 2013.