Advances in Materials Science and Mechanical Engineering Research
Volume 1, Number 1 (2015), pp. 1-7

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Effect Of Deep-Cryogenic Treatment On Uncoated Cemented Carbide Turning Inserts

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ABSTRACT

This paper presents the results of an experimental investigation that has been carried out on uncoated carbide inserts of types TTR and TTS against C-40 job comparing with the untreated and deep-cryo-treated inserts. Experiments were carried out to evaluate the cutting forces and tool tip temperature under different machining conditions. Results indicated much improvements in cutting forces and tool tip temperature thereby increasing tool life and cutting performance in deep cryo-treated inserts. It has been observed that cutting forces increase/decrease with increase in cutting feed, depth of cut but decrease/increase with increase in cutting speed.

Keywords: Deep Cryo-Treatment (DCT), cutting forces, tool tip temperature.

1. Introduction

The study of metal cutting focuses on the features of the behaviour of tool and work materials that influence the efficiency and quality of cutting operations. Development of cutting has been improved by contributions from all the branches of industry with an interest in machining. Productivity has been increased through replacement of carbon tool steel by high-speed steel and cemented carbide which allowed cutting speeds to be increased by many times. The main parameters to be controlled are cutting speed, selection of cutting tool, feed rate and depth of cut to give the desired tool life for tools.[14]

Instead of just seeking out new tool materials, researchers showed interest into areas like coating of the tool by different physical or chemical vapour deposition methods to improve the performance of the parts. The thermal treatment of metals must certainly be regarded as one of the most important development of the industrial age. After more than a century, research continues into making metallic components stronger and more resistant. One of the more modern processes being used to treat metals is Cryogenic tempering.

Cryogenic technology on the whole is not a new process and has been used on several types of materials like plastics and composites to improve their performance in various applications. In cryogenic treatment, the tool bits are cooled down to cryogenic temperature and maintained at this temperature for a required length of time and then brought back to room temperature. [5][6][7][11][13]

Some investigators have drawn a distinction between Cryo-Treatment (CT) at temperatures down to -80^{o}C and Deep Cryo-Treatment (DCT) which is down to -196^{o}C, liquid nitrogen temperature, as these two temperature ranges result in different effects.

It is not a surface treatment but a thorough treatment with changes occurring at molecular level. It is also relatively economical and cost effective. Cryogenics have been successfully applied on steels to improve its mechanical properties. This occurs due to the transformation of almost all the retained austenite in steel to martensite thereby making the steel more wear resistant.

The present investigation has been carried out to understand the effect of Cryogenic treatment on cemented carbide inserts.

2. Experimental details

The work piece used in our experiments is C-40 steel. Single point cutting tools of types TTR and TTS uncoated cemented tungsten carbides (procured from Kennametal industries) were used in our experiments. These inserts were treated cryogenically in a cryogenic refrigerator. The procedure of which is given as follows [6][8][11]

1. Tool Inserts are placed in a cryogenic cooling chamber.
2. Temperature is gradually lowered at a rate of 1°C/min over a period of 6 h from room temperature to -196 °C.
3. Temperature is then held steady for about 18 hours (Cold stabilization).
4. Temperature is gradually raised at a rate of 1 °C /min, over a period of 6 hour to room temperature.
5. Temperature is gradually raised at a rate of 1 °C / min for 6 hours till 190 ^{o}C which is the tempering stage.
6. Temperature is gradually lowered over a period of 2 hours to room temperature.

In case of steels, the benefits are usually attributed to the reduction or elimination of retained austenite from hardened steel and accompanied by the precipitation of small finely dispersed carbides in the martensite. The effect in the tungsten carbide is yet to be ascertained and there are live experiments going around the globe.

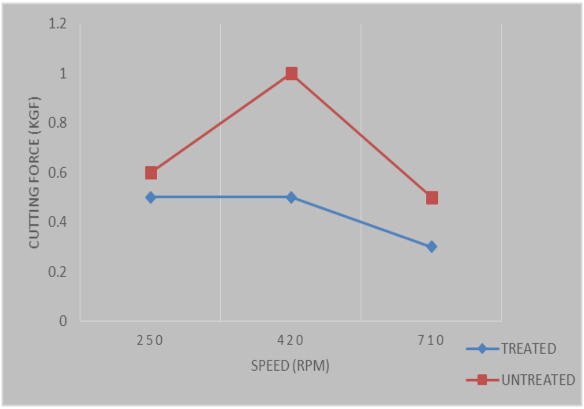
Before the cryogenic treatment the tools have previously been submitted to conventional thermal treatment to obtain the secondary hardness (conventional quenching and tempering). This sequence was chosen following the work developed by Baron et al. According to them the cryogenic treatment in cutting tools can be applied either after quenching and tempering or straight after the machining. Their results with tools cryogenically treated straight after the quenching was apparently better than those obtained with the tool cryogenically treated after quenching and tempering. Regardless of the method, the materials can usually have their properties improved with cryogenic treatment. A high power HMT lathe was used for this research. The cutting forces and tool tip temperatures are recorded for different speed, feed and depth of cut while turning different work pieces. Cutting forces were recorded using a lathe tool dynamometer and tool tip temperatures were recorded using a laser temperature gun.

3. Results and Discussions

Effect of cutting speed

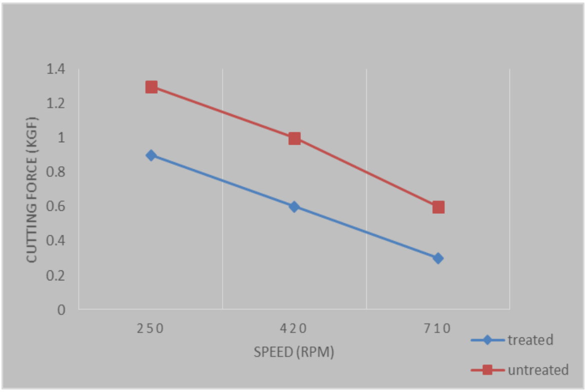
The cutting force decreases in case of both untreated and treated tool as the speed increases from 250 rpm to 710 rpm.[1][2][10]

1. TTR with C-40 job



It was found that the cutting force of the treated tool decreased by an amount of 44% in comparison with the untreated tool.

2. TTS with C-40 job

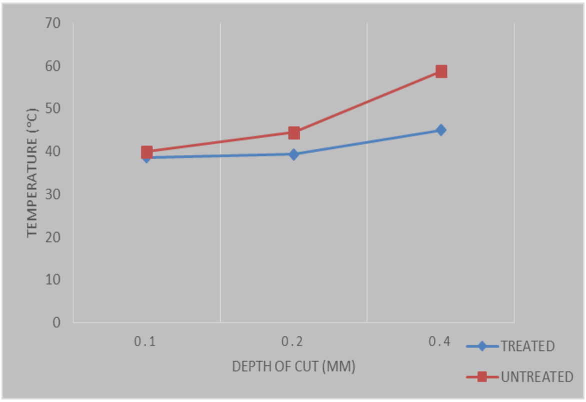


It was found that the cutting force of the treated tool decreased by an amount of 40% in comparison with the untreated tool.
Hence an improvement has been taken place in cryo-treated tool due to heat bearing capacity.
The same behaviour has been observed by earlier investigations. Hence the outcome of the experiment is in concurrence with the earlier investigators.

Effect of depth of cut

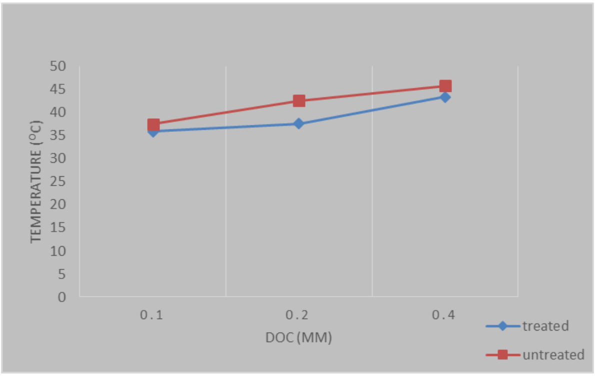
It has been observed from table that as depth of cut increases from 0.1 mm to 0.4 mm, there is an increase in tool tip temperature for both untreated and treated tool. [12]

1. TTR with C-40 job



It was found that the tool tip temperature decreased by an amount of 13% in comparison with the untreated tool.

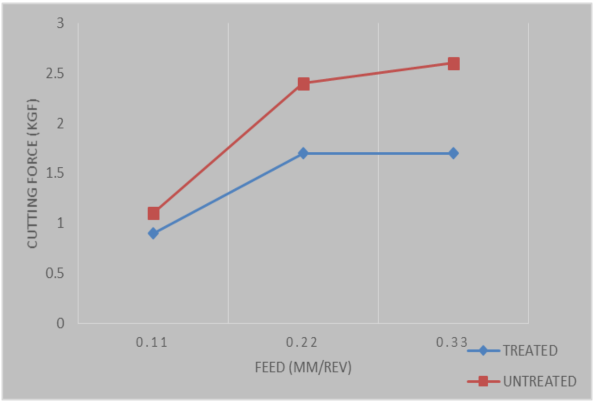
2. TTS with C-40 job



It was found that the tool tip temperature decreased by an amount of 8% in comparison with the untreated tool.
As depth of cut increases, the increase in friction is responsible for increase in temperature.
Cryogenic treatment has improved thermal conductivity property which is responsible for reducing friction.
Hence cryo-treated tool is capable to decrease tool tip temperature due to improvement in its thermal conductivity.
The trend of results is in concurrence with the earlier investigators.

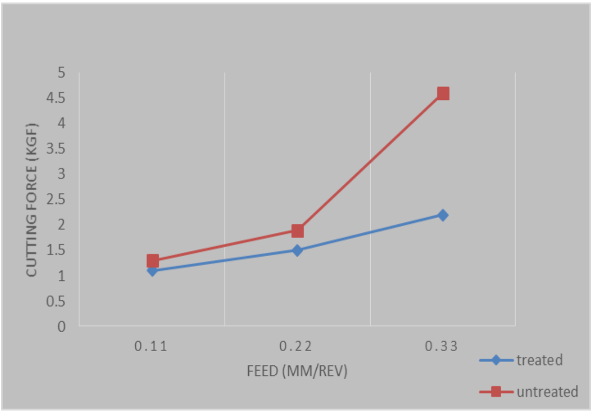
Effect of feed
It has been observed that as the feed increases from 0.11 to 0.33 mm/rev the cutting forces has been increased in both treated and untreated tools.[1][2][10]

1. TTR with C-40 job



It was found that the cutting force of the treated tool decreased by an amount of 35% in comparison with the untreated tool.

2. TTS with C-40 job



It was found that the cutting force of the treated tool decreased by an amount of 30% in comparison with the untreated tool.
As the feed rate increases the chip breaking efficiency increases the shape of chip formation (ribbon shape) on account of higher thermal conductivity due to cryogenic treatment which is responsible for decrease in the tool tip temperature.

Effect of cryogenic treatment

From our observations it was seen that as speed, depth of cut and feed increases the decrease in tool tip temperature is about 16% in favour of treated tool. The forces corresponding to untreated and treated tool is approximately 50% in favour of treated tool with the increase in speed, feed and depth of cut.

4. Conclusion

From the outcome of the experiment, the following conclusions have been drawn.

1. Lower cutting forces have been observed in case of cryogenically treated TTR and TTS tools compared to that of untreated tools.
2. The tool tip temperature of the cryo-treated tool is found to be lower than that of untreated tool for the same cutting conditions.
3. The cutting forces increased with increase in both feed and depth of cut but decreased with increase in speed.
4. The tools has favourably responded to cryogenic treatment by means of which cutting performance has been increased.

Acknowledgement

We are indebted to The HOD, mechanical department, Bangalore Institute of Technology and non-teaching staff of machine shop, department of mechanical engineering, Bangalore Institute of Technology.

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