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Influence of Soaking Periods in Cryogenic Treatment of Tungsten Carbide

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Abstract

Improvement in wear resistance and hardness of cutting tool material is one of the most important challenges in machining operation. This issue can be overcome by improving the wear resistance and hardness by cryogenic treatment of tungsten carbide. In this work it is tried to study the effect of different soaking periods in cryogenic treatment of tungsten carbide. The experiments were conducted at temperature of 88K at different soaking periods of 8hrs, 16hrs, 24hrs and 30hrs on commercially used tungsten carbide. Further efforts were made to quantify and confirm the effect of different soaking period along with the mechanism responsible for change in the hardness and wear resistance by measuring Rockwell hardness and weight loss during wear test. In addition to this OM, SEM, EDX and XRD tests were also conducted to support the results..

The obtained result shows that there is a significant decrease in weight loss of 8hr soaked sample out of different soaking periods but, there was no change in bulk hardness. In addition to this the formation of carbide and change in particles size was observed in SEM and XRD after cryogenic treatment. The weight loss during sliding wear test indicates the cryogenically treated tungsten carbide is more wear resistance due to increase in population density of carbides. Microstructure analysis of worn surface reflects the mechanism behind the improvement of mechanical properties.

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1. Introduction

Nomenclature

CT Cryogenic treatment
UT Untreated sample
CT1 Cryogenic treated sample at 8hr soaking period
CT2 Cryogenic treated sample at 16hr soaking period
CT3 Cryogenic treated sample at 24hr soaking period
CT4 Cryogenic treated sample at 30hr soaking period
OM Optical Microscope images
SCM Scanning electronic microscope
EDS energy dispersive spectrometry
XRD X-Ray Diffraction method

The tool material life plays important role in machining process [1]. It depends on wear characteristics of cutting tool material [1]. Use of CT for improving wear characteristics of various materials was well studied by various researchers [3-7]. Cryogenic treatment process involves gradual cooling of material below zero degree Celsius temperature, holding it for certain period of time called soaking period and then progressively warming it back to room temperature.

Barron reported improvement in wear characteristics of steels after CT [8]. Improvement in wear characteristics was observed due to presence of iron (Fe) in steels [3-7]. The CT of ferrous alloys such as tool steels and nonferrous materials is well studied by researchers in past decade [3]. Sing [7] observed improvement in tool life by 9% to 22% in deep cryogenic treatment of various materials. Stewart [9] observed reduction in normal tool force by 25% as well as parallel force by 20% after cryogenic treatment of tungsten carbide tools in machining of medium density fiberboard. For this work cryogenic treatment was carried out at 86K for 24hrs soaking period [9]. Yong et al. [10] performed face milling operation on medium carbon steel by treated and untreated tungsten carbide milling tools. They observed an increase in flank wear resistance by 38% in cryogenically treated WC-Co tools. The CT was carried out at 88K for 24hrs soaking period and flank wear was measured as per ISO standard (0.5mm flank wear criteria for tool life) [10]. A. Y. L. Yong [11] evaluated the performance of cryogenically treated tungsten carbide tool in turning of carbon steels and found 20% reduction in flank wear after the CT. Gill et al. [12] applied CT to tungsten carbide inserts and found 27% reduction in flank wear at cutting speed of 110m/min in dry and wet turning operation. During this study CT was carried out at 77K for 24hrs [12]. Ramji et al. [13] have worked on performance analysis of cryogenically treated carbide drills in drilling white cast iron. The Cryogenically treated drills has improved the results in terms of reduced tool forces, improved tool wear resistance and improved surface finish of the drilled holes. It was observed that the carbides were formed after CT. For this study CT was carried out at 94K for 24hrs [13]. Gill et al. [14] have studied the effect of shallow CT (SCT) and deep cryogenic treatment (DCT) on WC-Co tool. It was observed that there is improvement in bulk hardness by 4.75 % at SCT for 18hr soaking period at 163K [14]. Kalsi et al. [15] have studied the effect of tempering cycle after CT on cobalt bounded tungsten carbide inserts. Significant improvement in tool life was observed when CT was carried out at 77K for 24hrs. Also, hardness of material improves after the first tempering cycle of treated sample [15].

In the literature survey few attempts have been made on effect of different soaking periods in CT of WC-Co tool material. The commercial used tungsten carbide (WC-Co) tool material manufactured by powder metallurgy process. It consists cobalt as binding material. The position of Iron and cobalt are in VIIB group of periodic table [8, 9]. Hence, hypothetically it was stipulated that WC-Co which contains cobalt as binder will show similar response to CT as that of the steels. Also, the mechanism responsible for the improvement in wear characteristics remains to be unanswered. Therefore in addition to these studies, the gape to the survey effect of different soaking periods in CT on WC-Co material was carried out. The efforts are made to understand the mechanism behind the change in wear characteristics due to CT.

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