International Journal of Engineering and Management Research e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume- 9, Issue- 2 (April 2019)
www.ijemr.net https://doi.org/10.31033/ijemr.9.2.05

Comparative Analysis of Coated and Non Coated HSS Tool with Zinc, Nickel, and Chromium

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ABSTRACT

Machining is the heart of any manufacturing process so coating material have been used in the coating of tool steels. The tool used is high speed steel and are coated with Zinc, Nickel and Chromium separately. The various reasons to coat cutting tools are to increase tool life and improve the surface quality of the product, and to increase the production rate. The advantage of Zi, Ni, Cr coating include high hardness, good ductility, excellent lubricity, high chemical stability and tough resistance to wear, corrosion and temperature. In this paper, the principle, advantage and limitation of various Zn, Ni, Cr coating processes are summarized. This paper involves of machining hardened steel using Zi, Ni, Cr, coated HSS cutting tool is studied. This paper discussed about the wear and also hardness factor after coating compared with conventional cutting tool(high speed steel)

Keywords-- High Speed Steel, PVD Coating, Hardness Test, Wear Test

I. INTRODUCTION

High-speed steel (HSS) is a subset of tool steels, commonly used as cutting tool material. It is often used in power-saw blades and drill bits. It is superior to the older high-carbon steel tools used extensively through the 1940s in that it can withstand higher temperatures without losing its temper (hardness). This property allows HSS to cut faster than high carbon steel, hence the name *high-speed steel*. At room temperature, in their generally recommended heat treatment, HSS grades generally display high hardness (above Rockwell hardness 60) and abrasion resistance (generally linked to tungsten and vanadium content often used in HSS) compared with common carbon and tool steels. HSS tool is the easily available and inexpensive. Small scale industries and educational institutions are still using HSS tool for machining mild steel work piece. So that HSS tool is taken as substrate material. HSS tool has higher heat resistance and wear resistance properties than that of the high carbon steel. To increase the wear resistance of the tool and thereby increasing tool life surface coating is needed. To improve surface roughness and increase the corrosion resistance the PVD coating is applied. The Zi, Ni, Cr is coated separately and whose performance competes with that of more advanced coated tools could be achieved at much lower cost. High Speed steel (HSS) single point cutting tool (specification 5/16"*4") is used in engineering industries. Physical vapor deposition (PVD) describes a variety of vacuum deposition methods which can be used to produce thin films and coatings. PVD is characterized by a process in which the material goes from a condensed phase to a vapor phase and then back to a thin film condensed phase. Chemical Vapor Deposition (CVD) is an atmosphere controlled process conducted at elevated temperatures (~1925° F) in a CVD reactor. During this process, thin-film coatings are formed as the result of reactions between various gaseous phases and the heated surface of substrates within the CVD reactor. In addition of thin layer can be deposited on tool edge. The range of deposition temperature is between 450^{0}C to 950^{0}C. The Zi, Ni, Cr coating process is well known low coefficient of friction, higher hardness and high oxidation resistance.

II. MATERIALS AND METHODOLOGY

High-Speed Tool Steels and their requirements are defined by The American Society for Testing and Materials in Specification A600-79 as follows: High-speed tool steels are so named primarily because of their ability to machine materials at high cutting speeds. They are complex iron-base alloys of carbon, chromium, vanadium, molybdenum, or tungsten, or combinations thereof, and in some cases substantial amounts of cobalt. The carbon and alloy contents are balanced at levels to give high attainable hardening response, high wear resistance, high resistance to the softening effect of heat, and good toughness for effective use in industrial cutting operations.

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The Knoop hardness test is a micro hardness test - a test for mechanical hardness used particularly for very brittle materials or thin sheets, where only a small indentation may be made for testing purpose. This is not strictly true for loads of 100 grams or less the concluded that the applied load should always be reported with the hardness number. The Tukon tester is provided with several weights corresponding to loads from 100 grams up. The, for an indentation 100 microns (0.1 mm.) long, the penetration is only about 3 microns. The smallness of the penetration was demonstrated by Peters and Knoop (1940) when they showed that a valid reading of the hardness of electrolytic chromium plate can be obtained, Regard less of the nature of the base metal upon which the chromium was deposited, if the thickness of the plating is greater than 0.001 inch or 25 microns. Surface engineering point of view, wear test is carried out to evaluate the potential of using a certain surface engineering technology to reduce wear for a specific application, and to investigate the effect of treatment conditions (processing parameters) on the wear performance, so that optimized surface treatment conditions can be realized. In a pin-on-disc wear tester, a pin is loaded against a flat rotating disc specimen such that a circular wear path is described by the machine. The machine can be used to evaluate wear and friction properties of materials under pure sliding conditions. This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus. Materials are tested in pairs under nominally non-abrasive conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined.

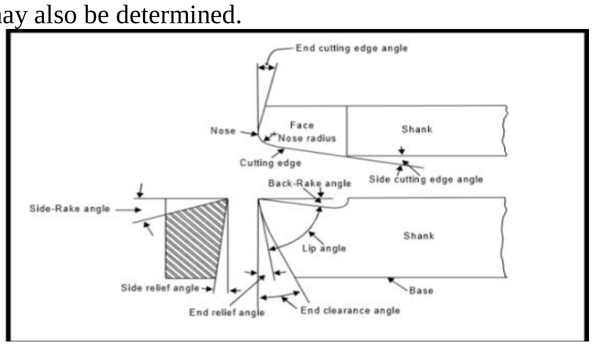

Fig. No 1Single point Cutting Tool Nomenclature

Elements	Composition (%)
C	0.78-1.05
Mn	0.15-0.40
Si	0.20- 0.45
Cr	0.20-0.45
Ni	0.3
Mo	4.5-5.5
W	5.5-6.75
V	1.75-2.2
Cu	0.25
P	0.03
S	0.03

TABLE No1 COMPOSITION OF HSS TOOL

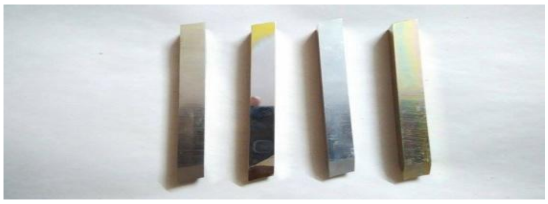

Fig. No 2 Single Point HSS cutting Tool (*Left to right: Uncoated, Zn coated, Ni coated and Chromium Coated tool*)

The properties of high speed steel as follow them all possess a high-alloy content. They usually contain sufficient carbon to permit hardening to 64 HRC. They harden so deeply that almost any section encountered commercially will have a uniform hardness from center to surface. They are all hardened at high temperatures, and their rate of transformation is such that small sections can be cooled in still air and be near maximum hardness hardened high-speed tool steel. Ability to absorb (impact) energy the relative importance of these properties varies with every application. High machining speeds require a composition with a high initial hardness and a maximum resistance to softening at high temperatures. Certain materials may abrade the cutting edge of the tool excessively; hence, the wear resistance of the tool material may well be more important than its resistance to high cutting temperatures. Hardness is necessary for cutting harder materials and generally gives increased tool life, but it must be balanced against the toughness required for the application.

III. RESULT AND DISCUSSION

The hardness test and wear test results are tabulated below

S.No	Materials	Value(HK)
1	Non Coated HSS	298
2	Zinc coated HSS	332
3	Nickel coated HSS	358
4	Chromium Coated HSS	324

TABLE No 2 HARDNESS TEST

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S. No	Materials	Sliding speed (m/s)	Load (N)	Wear rate (mm^3/m)
1	Non Coated HSS	2	20	0.0028
		2	40	0.0031
2	Zinc Coated HSS	2	20	0.0016
		2	40	0.0018
3	Nickel Coated HSS	2	20	0.0014
		2	40	0.0016
4	Chromium Coated HSS	2	20	0.0019
		2	40	0.0022

TABLE No 3: WEAR TEST

The results shows that the coated tool perform better as compared to uncoated cutting tool. The effect of cutting is to reduce wear and tear of tool tip point as well as more heat dissipation to surrounding hence the increase in tool life and surface finish of the product to be machine. The nickel coated HSS tool is given better performance compared to other coating HSS tools, so the Nickel coated HSS tool is best for machining purposes.

IV. CONCLUSION

In the present work the performance of coated HSS tools by using Chromium, Zinc and Nickel conditions is studied. The results shows that the coated tool perform better as compared to uncoated cutting tool. The effect of cutting is to reduce wear and tear of tool tip point as well as more heat dissipation to surrounding hence the increase in tool life and surface finish of the product to be machine. With increase in depth of cut the surface roughness is increased. Here experimental results shows by selecting the proper cutting parameters the coated tools are suitable to produce fine surface finished components.

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