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Experimental Analysis and Effect of Coating on HSS Cutting Tool

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ABSTRACT

In this paper the wear behavior of High Speed Steel (HSS) Single Point Cutting tool and Titanium Nitride (TiN), Aluminium chromium nitride (AlCrN) coated by physical vapor deposition method (PVD), HSS single point cutting tools in dry condition of simple turning process is investigated and compared with respect to its chip tool Interface temperature, turning time, upcoming forces, on each tool is studied and analyzed. The present work involves the study of tool wear caused by the change in hardness of single point cutting tool for a turning operation to predict the tool life in turning process based on temperature and force, stress analysis using Ansys workbench 14.0. Experiments were performed with M.S bar as work piece and HSS coated, uncoated tool bits as a tool material and the single point wear of tool has been measured experimentally.

Keywords: *Titanium nitride (TiN), Aluminium chromium nitride (AlCrN),coating of tool, Turning, Coated tool, hardened steel*

I. INTRODUCTION

Titanium nitride(TiN) structured is a golden yellow refractory compound of low density (5.22 g/cm3) and high melting point (2930°C) also the another coating material which is used for this experimental study is Aluminum chromium nitride (AlCrN) of having Bluish grey in color. Titanium nitride as a coating for tool steels has been available widely since the last decade and is enjoying increasing attention and application in tool industries. The reasons are simple yet important the advantages of TiN, AlCrN coatings of tool steels include a noble appearance, excellent adhesion to substrates, high chemical inertness, resistance to elevated temperatures, a low coefficient of friction with most work piece materials which increases lubricity, results in excellent surface finish, decrease of horsepower requirements, improved ability to hold tolerances, high temperature stability, low maintenance cost and high productivity.

II. OBJECTIVES AND METHODOLOGY

The aim of this paper is to predict the temperature and stress distribution among region of failure of tip point of HSS single point cutting tool and hence to carry out force and temperature carrying capacity of the tool also the following points mention below,

1. To check performance of HSS tool with different temperature readings.
2. To carry out the analysis of HSS tool with different temperature, force readings in Ansys workbench 14.0 Software.
3. To check the performance of all three tools as uncoated, TiN coated, AlCrN coated.
4. To carry out the analytical calculations for coated material removed from each tool after experimental working of each tool.

To meet with above mentioned objectives and for carrying out analysis, different models have been prepared as mentioned below,

1) **Model 1:**High Speed Steel Single Point Cutting Tool of without coated structure of size (1/2"x 6"), length 122 mm, width 13 mm, Weight before turning 164 mg, Weight after turning 160 mg.
2) **Model 2:**High Speed Steel Single Point Cutting Tool of coated structure with Titanium nitride (TiN) of size (1/2"x 6"), length 138 mm, width 13 mm, Weight before turning 157 mg, Weight after turning 155 mg.
3) **Model 3:**High Speed Steel Single Point Cutting Tool coated structure with Aluminium chromium nitride (AlCrN) of size (1/2"x 6"), length 140 mm, width 13 mm, Weight before turning 165 mg, Weight after turning 164 mg

III. EXPRIMENTAL OBSERVATION

Table No.1 Properties of Coated and Uncoated Tools

Properties of Material	HSS Uncoated Tool	TiN Coated Tool	AlCrN Coated Tool
Length ,L	122 mm	139 mm	140 mm
Width, w	13 mm	13 mm	13 mm
Thickness, t	13 mm	13 mm	13 mm
Tip Point Radius, R	0.5 mm	0.5 mm	0.5 mm
Weight of Tool, W	164 mg	157 mg	165 mg
Color	Silver-Grey	Golden Yellow	Bluish- grey
Hardness Value	915.8 HV	1072 HV	1160.2 HV
Top rake angle,α_b	07°	07°	07°
Side rake angle,α_s	07°	07°	07°
End relief angle,θ_e	07°	07°	07°
Side relief angle,θ_s	07°	07°	07°
End cutting edge angle,C_e	15°	15°	15°
Side cutting edge angle,C_s	15°	15°	15°
Modulus of elasticity, E	210 Gpa	110 Gpa	290 Gpa
Poisson's ratio, ν	0.30	0.33	0.29
Thermal Conductivity, K	11.5 W/mK	21.9 W/mK	29.5 W/mK
Melting Point Temperature, T	1425°C	1668°C	1750°C
Actual Photo of Tool			

III. ANALYTICAL CALCULATION

1. **Weight of the Tool before and After Machining Initial weight of the tool is nothing but the weight of the tool before machining or turning is to measure by weighting machine.**

Type Of Tool	Weight Before Machining (mg)	Weight After Machining (mg)
Uncoated	164	160
TiN	157	155
AlCrN	165	164

2. **Weight Loss Calculation after Machining**

1) Uncoated tool weight loss % $= \frac{\text{Loss in weight}}{\text{Initial Weight}} \times 100\% = \frac{04}{164} \times 100\% = 2.4389\%$

2) TiN Coated tool weight loss % $= \frac{\text{Loss in weight}}{\text{Initial Weight}} \times 100\% = \frac{02}{157} \times 100\% = 1.2738\%$

3) AlCrN Coated tool weight loss % $= \frac{\text{Loss in weight}}{\text{Initial Weight}} \times 100\% = \frac{01}{165} \times 100\% = 0.6067\%$

3. **Efficiency of the Coated Tool Compare with Uncoated Tool**

1) Uncoated Vs TiN $= \frac{\text{Loss \% of uncoated tool}}{\text{Loss \% of TiN coated tool}} = \frac{2.4389}{1.2738} = 1.5316$ times stronger

2) Uncoated Vs AlCrN $= \frac{\text{Loss \% of uncoated tool}}{\text{Loss \% of AlCrN coated tool}} = \frac{2.4389}{0.6067} = 4.0199$ times stronger

IV. RESULTS AND DISCUSSION

1. **Experimental values of tool**

Tool Specification	Weight Loss Percentage After Machining or Turning (mg)	Maximum Rise in Temperature in 20 minutes In (°C)	Hardness Value In HV	Remark (Efficient And Economic Cutting Tool Based On Life)
HSS Uncoated Cutting Tool	04	65	915.8	Wear rate and Temperature rise is more as compare to coated tools
TiN Coated Cutting Tool	02	54	1072.5	Wear rate is less as compare to uncoated tool
AlCrN Coated Cutting Tool	01	42	1160.2	Very less wear rate hence more efficient than other tools

2. Cutting Time Vs Temperature

Graphical representation of results is plotted in between two parameters as temperature rise of single point of HSS tool with the time required for machining or turning for all three tools is as given below,

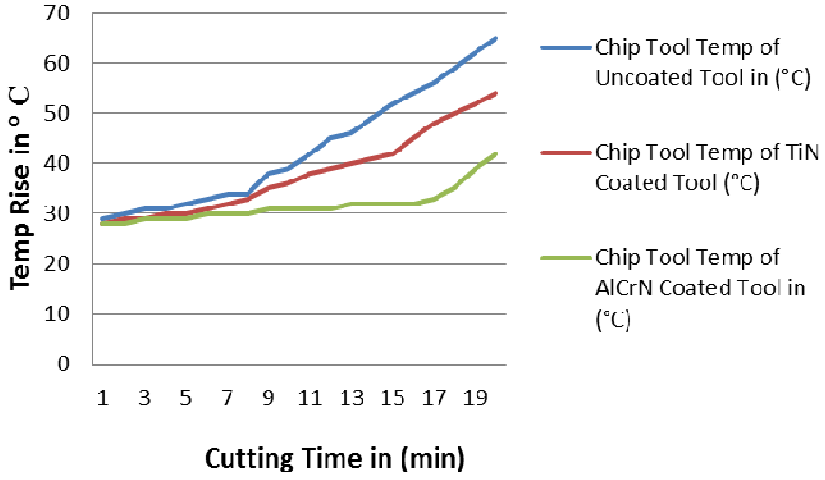

Fig Representation of Cutting Time Vs Temperature

3. Tool Material Vs Percentage Weight loss

Graphical representation of results is plotted in between two parameters as tool material with the percentage weight loss of all three tools is as given below,

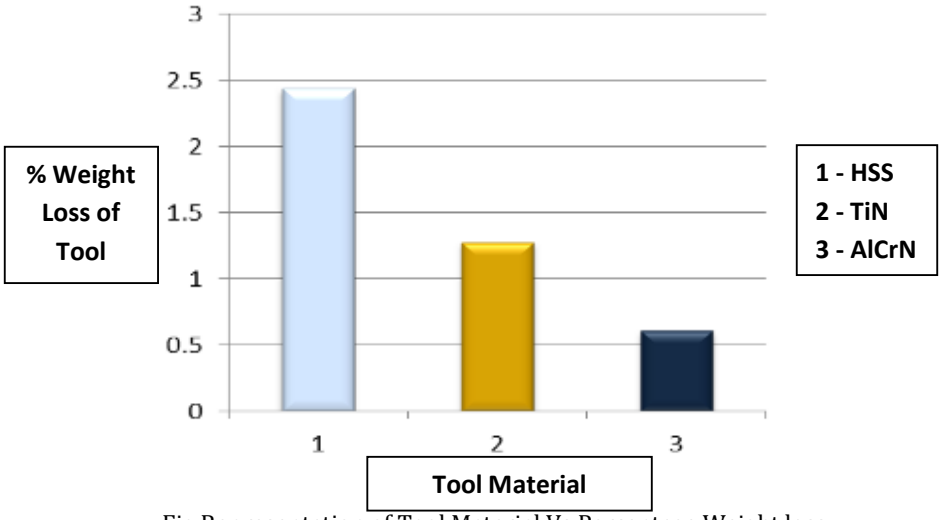

Fig Representation of Tool Material Vs Percentage Weight loss

V. Conclusion

In this paper we have studied three tools in which two tools are coated with TiN, AlCrN and one tool is uncoated and its comparative points of tip point wear rate, rise in chip-tool interface temperature is calculated and measured by calculations and observations. The hardness value for each tools have been taken under same conditions. The weight loss in the tool after each machining has been measured using standard equipment's. It is found that the rise in temperature, wear rate of uncoated tool is more as compare to coated tools when it is working on lathe machine for turning operation also the performance of coated tool is more as compare to uncoated tool.

The results obtained from the experimental work of this project is as follows, wear or percentage weight loss of uncoated tool is 2.4389%, TiN coated tool 1.2738%, AlCrN coated tool 0.6067% should be noted from present investigation. The present work also calculate the tool efficiency of each tool comparatively with other tool as Uncoated Vs TiN coated tool is 1.5316 times stronger also Uncoated Vs AlCrN coated tool is4.0199 times stronger is to be found by performing the experiment.

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