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Impact of Cutting Speed on Tool Life of Coated and Uncoated Cemented Carbide during Turning of S31700 Grade Stainless Steel

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Abstract: Here, we found and observed different results of experimental work in dry turning of S31700 grade stainless steels using coated and uncoated cemented carbides. The turning tests were conducted at three different cutting speeds (150and 200m/min) while feed rate and depth of cut were kept constant at 0.3 mm/rev and 1 mm, respectively. The cutting tools used were ISO P30 uncoated and TiN-TiCN-Al_2O_3-ZrCN coated cemented carbides. We found the influences of cutting speed on the average flank wear. The worn parts of the cutting tools were also examined using optical microscopy and SEM. Here we concluded that cutting speed significantly affected the average flank wear. The multilayer effects superior resistance to tool wear compared to its uncoated counterpart in the entire range of cutting speeds during turning of S31700 stainless (AISI317) steel.

Keywords: S31700 stainless steel, turning, Carbide tool, SEM, Cutting speed, turning.

I. INTRODUCTION

AISI 317 stainless steel is an austenitic stainless steel. 317 is the AISI designation for this material. S31700 is the UNS number. Austenitic stainless steels have high work hardening even at low deformation rates and low thermal conductivity. These two characteristics make austenitic stainless steels (γ-SS) more difficult to machine than different carbon steels and alloy steels.The austenitic stainless steel have high toughness and high ductility which leads to the formation of long continuous chips and to the intensive sticking of the work piece material to the cutting tool surface which results in an

Adhesive wear enhancement. Moreover, high temperatures at the tool-chip interface result in an increase of diffusion and chemical wear[2].Coated carbides are basically a cemented carbide insert coated with one or more thin layers of wear-resistant material, such as titanium carbide (TiC), titanium nitride (TiN) and/or aluminum oxide (Al_2O_3). It is well known that thin, hard coatings can reduce tool wear and improve tool life and productivity.Therefore , most of the carbide tools used in the metal cutting industry are coated though coating brings about an extra cost. The objective of the present investigation is to study the effect of cutting peed on the tool life of uncoated and TiN-TiCN-Al_2O_3-ZrCNmultilayer coated cemented carbide insert during dry turning of AISI 317 grade austenitic stainless steel.

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II. EXPERIMENTAL WORKS

Mechanical properties of AISI 317-

From Brinell hardness test We found Hardness- 200 BHN

From tensile test using UTM Ultimate Tensile strength- 600GPa

From Fatigue test Fatigue strength- 305 MPa

From tensil test we found Poisson's Ratio-0.29 and Yield strength-300 Gpa.

Hardness (BHN)	Ultimate Tensile Strength(Gpa)	Fatigue Strength (Mpa)	Poisson's Ratio	Yield Strength (Gpa)
200	600	305	0.29	300

The machining experiments were carried out using the tungsten carbide cutting tool inserts and turning operations were performed using a HMT NH26 lathe. The machining experiments were performed with a constant depth of cut (t) of 1 mm and feed rate (f)of0.2 mm/rev while three different cutting speeds (V_c) was varied 150 and 200 m/min, under dry environment. The tool holder used for turning was ISO PCLNR 2525M12. The cutting conditions and tool geometry were held constant for all the experiments. The flank wear was measured using a optical microscope. The average width of flank wear (VB) was measured.

The work piece material used for present work was AISI 317 stainless steel of diameter 80 mm and length 100 mm. Table 1 shows composition of AISI 317 steel from XRF test. Fig.1. shows Photographs of Experimental Setup for Turning of AISI 316 grade austenitic stainless steel.

Table1-Composition of AISI317 stainless steels From XRF test

Element	Fe	Mn	Si	P	C	Cr	Mo	Ni	Mo
Weight %	65.12	2	0.752	0.045	0.083	18	3.0	10	1

Fig.1.Experimental Setup for Turning.

III. RESULTS

EDS Analysis and Microstructure

Fig.2.shows optical microscope images of (a) Flank surface (b) Rake face (c) top view of coated carbide insert before machining. The surface morphology of both uncoated and coated carbide inserts were first studied using SEM. The SEM micrographs have been depicted in Fig.3. A particular region on the rake surface of the inserts has been magnified and shown in Fig.3 (a) and (b). The top surface of ISO P30 uncoated insert (Fig. 3 (a)) shows gray region with black and white spots dispersed all over it. The gray region consists of WC and Co while the black and white spots have been found to be TiC and TaC as confirmed by energy dispersive spectroscopy (EDS) through X-ray. Fig. 3 (b) shows the surface morphology of ZrCN coating of multilayer coated carbide insert.

Tool Wear

Fig. 4 shows the growth of average flank wear (VB) with machining duration (T) for different cutting speeds (V_c= 150, and 200 m/min.) during dry turning of 317 grade stainless steel with uncoated and coated inserts. It may be seen from Fig. 4 (a) that progression of flank wear was more favorable for uncoated insert .

Fig.2. optical microscope images of (a) Flank surface (b) Rake face (c) coated carbide insert

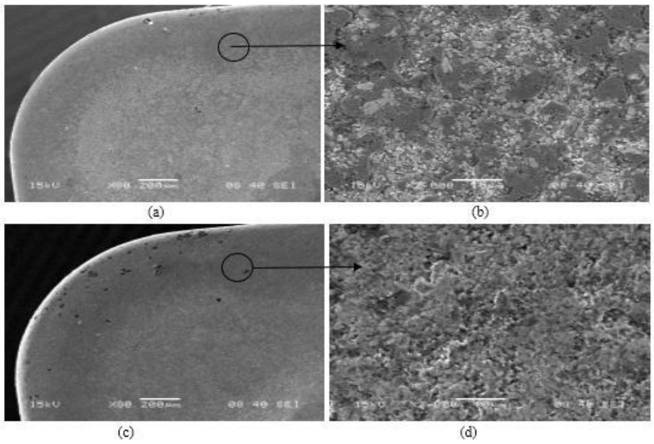


Fig.3. SEM micrographs showing surface morphology of (a),

(b) uncoated and (c) ,(d) coated cemented carbide turning insert

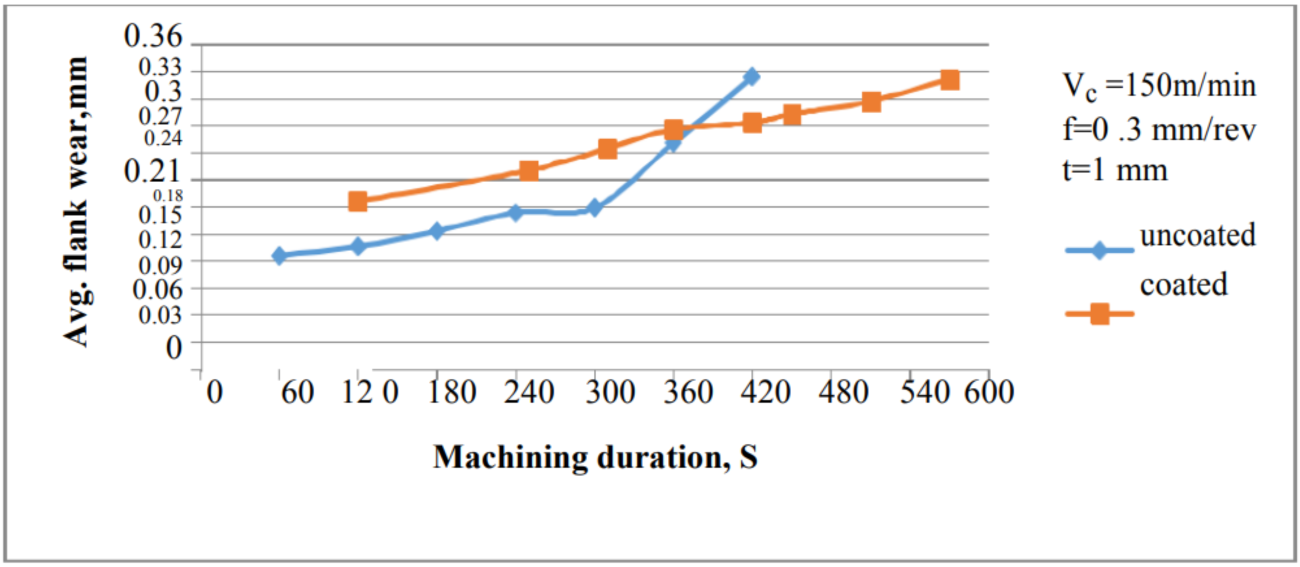
However, after 300s the uncoated insert suffered from catastrophic failure and its tool life was over after around 400 s as evident from the graph. The multilayer coated insert, on the other hand, demonstrated much stable development of flank wear during machining and the tool life was extended to 560 s.

Therefore, multilayer coated tool resulted in around 33% increase in tool life when machining with a cutting speed of 150 m/min. Similar observation was also noted for cutting velocities of 200 m/min. when there was improvement in tool life of around 40% and 25% respectively for coated insert over its uncoated counterpart. This may be evident from the graphs in Fig. 4 (b). Improved performance of multilayer coated tool may be ascribed to the super hardness and wear resistance of the multilayer coated carbide insert over uncoated cemented carbide insert. This is important particularly when work hardening characteristics of stainless steel is considered. It may also be noted from Fig. 4 that with increase in cutting speed from 1500 to 200 m/min., there is decrease in tool life for both uncoated and coated tools.

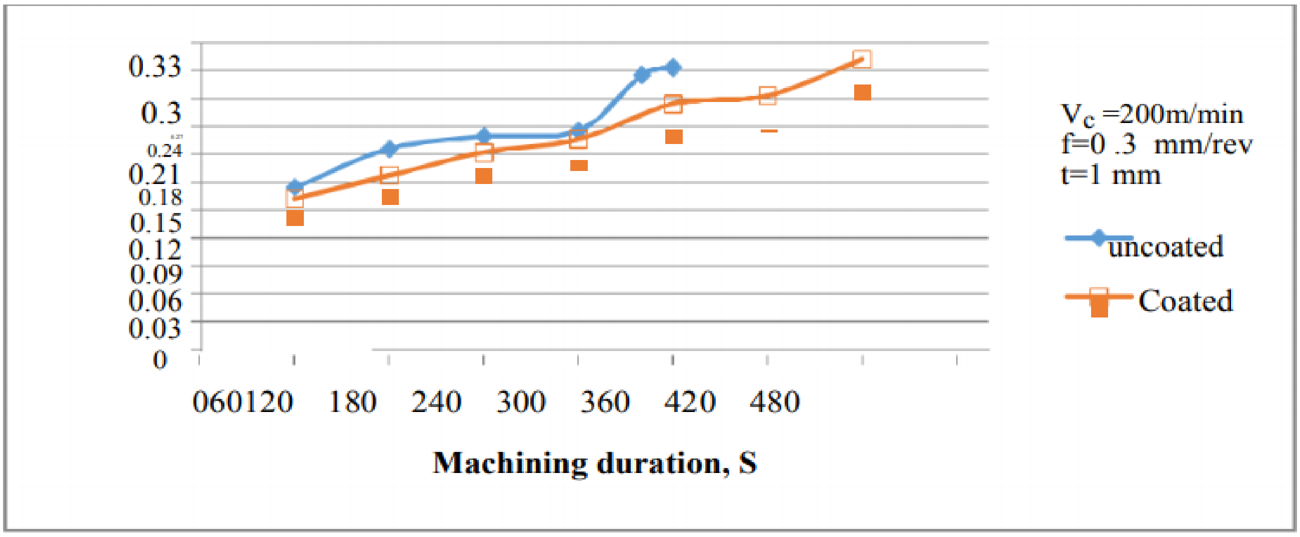
This may be attributed to- increase in cutting temperature with cutting speed combined flank surface of uncoated and coated tools after machining.

with a lack of ability of stainless steel to dissipate heat Both the figures clearly demonstrate more severe degree of effectively owing to its poor thermal conductivity. Severe wear that took place on rake, nose and flank surface of the damage of uncoated tool was observe d particularly for uncoated carbide insert compared to those for multilayer uncoated carbide insert. Fig.

5 shows th e SEM images of coated carbide insert during dry turning of 317 grade rake surface whereas Fig. 6 depicts optical micrographs of stainless steel.



(a)



(b)

Fig.4. Effect of cutting speed:(a) Vc=150m/min (b)Vc=200m/min and machining duration on average flank wear

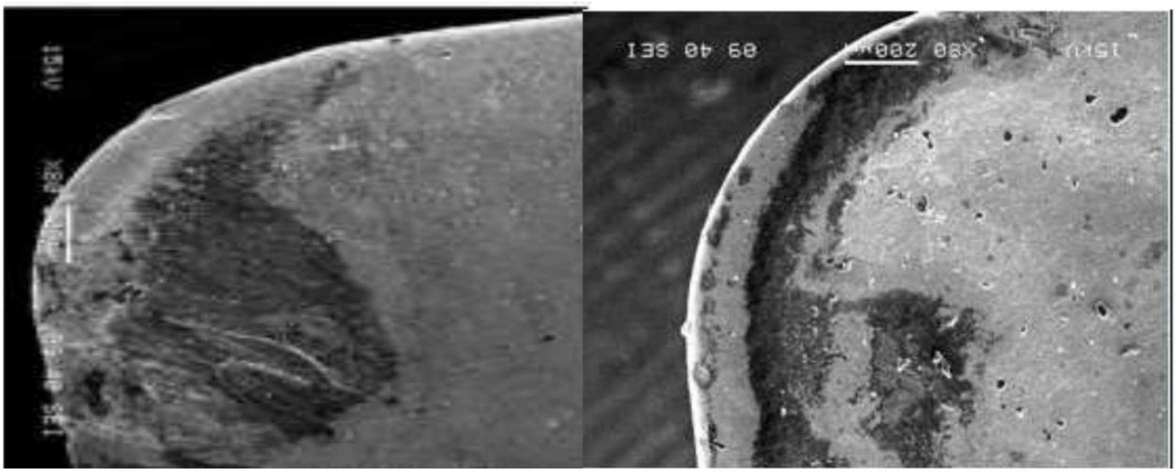
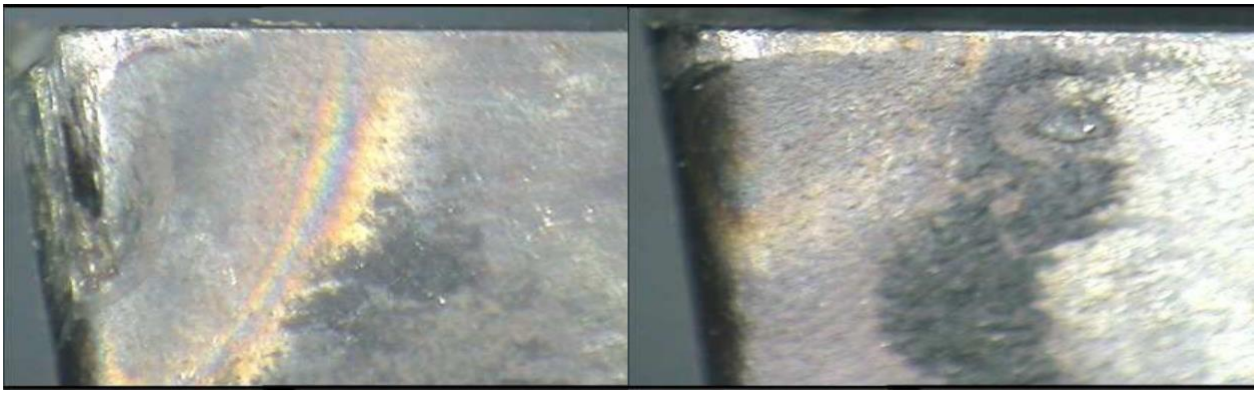


Fig.5. SEM micrographs showing the condition of rake surface of (a)uncoated and (b)coated tools after machining with cutting speed Vc=150m/min and machining duration of T=410 s and T=550 s respectively



(a) (b)

Fig.6. Optical microscopic image showing flank surface of (a)uncoated and (b)coated tools after machining with cutting speed Vc=150m/min and machining duration T=410 s

IV. CONCLUSION

Following are the observations from the current research work:

(i) Cutting speed has significant influence on the tool life during dry machining of AISI 317 grade stainless steel. When cutting speed increases, tool life of both uncoated and coated cemented carbide decreases.

(ii)The multilayer coating consisting of $TiN\text{-}TiCNAl_2O_3\text{-}ZrCN$ has good impact in dry turning of 317 grade stainless steel. Such coated tool consistently resulted in improvement in tool life.

Such increase in tool life has been observed to be in the range of 25%-40%.

(iii)Crater, nose and flank wear have been found to be less for multilayer coated tool compared to its uncoated counterpart.

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