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Study & Experimentation about machinability of Al-7075 composite

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ABSTRACT

Metal matrix composites have received considerable attention due to their excellent engineering properties. These materials are difficult to machine because of their hardness and abrasive nature of reinforcement particles. This paper presents experimental work from a series of turning tests in which carbide tool and polycrystalline diamond (PCD) tools were used to machine E-glass and tungsten carbide reinforced Al-7075 hybrid composite. The influence of machine parameters e.g., cutting speed, feed, and depth of cut on the surface roughness, cutting forces, tool wear and tool life were investigated. In the present study, an attempt has been made to investigate the influence of cutting speed, depth of cut, and feed rate on surface roughness during machining of 7075 Al alloy and 4% tungsten carbide and E-glass reinforced particulate metal-matrix composites. The experiments were conducted on a CNC Turning Machine using tungsten carbide and polycrystalline diamond (PCD) inserts.

Keywords : Composite, Fly ash, Al - 2024, Wear, Hardness, Tensile, Microstructure.

I. INTRODUCTION AND LITERATURE REVIEW

Metal matrix composites are formed by combination of metal matrix and stiff and hard reinforcing phase. These materials are difficult to machine because of their hardness and abrasive nature of reinforced particles.In the last decades, WC/Al composites have been increasingly used in the aerospace industry and advanced arm systems such as satellite bearing, inertia navigation system, and laser reflector. Particulate metal-matrix composites (PMMCs) are most commonly manufactured by a stir-casting technique or powder metallurgy technique [1]. Stir casting is the simplest and the most commercial technique. The development of MMCs by stir-casting technology has been one of the unique and feasible processes because of producing better matrix–particle bonding, easier control of matrix structure, simplicity, higher production rate, and low cost [2]. It involves stirring the melt along with solid silicon carbide particles and then allowing the mixture to solidify. Due to the addition of reinforcing materials, which are normally harder and stiffer than matrix, machining becomes significantly more difficult than those of conventional materials [3].

LM 25 aluminum alloy reinforced with green bonded silicon carbide particles of size 25 µm with different volume fractions was used for experimentation. The machining experiments were conducted on the lathe using tungsten carbide tool inserts (K10). It was concluded that feed rate has the greater influence on surface roughness, followed by cutting speed and percent volume fraction of WC [4]. Investigation on the wear of polycrystalline diamond (PCD) and polycrystalline cubic boron nitride (PCBN) tools in the machining of Al-WC MMC (9.27 Si, 0.15 Fe, 0.55 Mg, Al balance) 5% volume WC, particle size 12.8

μm was carried out by turning. The binder less PCBN tools showed the highest fracture resistance. PCD tool exhibited higher wear resistance than PCBN tools and lower propensity for work material adhesion. During machining with PCBN tools without coolant, the severity of transfer material on the tools increased significantly with cutting speed. The adhesion property of the tool and the work material, apart from the tool wear, appeared to have a major influence on the surface finish [5].

LM6 Mg15 WC-Al-metal matrix composite, as casted with average particle size 23 μm, was used as composite material. Different sets of experiments were performed on a combination turret lathe. Uncoated tungsten carbide (WC; HW-K10) insert was used for turning. Results indicated that cutting speed, feed rate, and depth of cut are having equal influence on the surface roughness characteristics, i.e., Ra and Rt. High speed, low feed rate, and low depth of cut was recommended for achieving better surface finish during turning of Al/WC-MMC using tungsten carbide insert [6].

Rods of Al Si 7 Mg2 material reinforced with 5, 10, and 15 wt.% of WC of particle size 30–60 μm were produced, 90 mm in diameter and 150 mm in lengthInfluence of feed rate was not as effective as cutting speed on tool wear, but as the feed rate increased, the wear of cutting tool also increased. In turning of AlSi7Mg2-MMC samples, surface quality improved when cutting speed decreased. Surface roughness increased due to increasing feed. It was found that increase in particle ratio affects roughness negatively [7].

An experimental investigation was conducted on the machinability of fabricated aluminum metal matrix composite LM-25 (A356/WC/10p) during continuous turning of composite rods using medium grade polycrystalline diamond (PCD 1500) inserts. Cutting conditions and parameters such as surface roughness, specific power consumed, and tool wear were measured. The steady low values of Ra and Rz at a cutting speed of 400 m/min over the entire tool life span makes high speed finishing of MMC possible [8]. Work dealt with the surface integrity of machined Al 4% WC PMMCs. Dry high-speed turning tests at different cutting speeds, feed rates, and depths of cut were conducted in order to investigate their effect on the surface quality and the extent of the sub-surface damage due to machining. The cutting tests were carried out using PCD tools. It was found that machining of this type of composite is most economical and safe at a speed of 894 m/min, a depth of cut of 1.5 mm, and feed rates as high as 0.45 mm/rev, when the surface roughness (R_{max}) did not exceed 2.5 μm [9].

In this study, A356 homogenized 5 wt.% WC (average particle size 24 μm) aluminum MMC material was selected for an experimental investigation of tool wear and surface roughness. Two types of K10 cutting tool (uncoated and TiN-coated) were used at different cutting speeds (50, 100, and 150 m/min), feed rates (0.1, 0.2, and 0.3 mm/rev), and depths of cut (0.5, 1.0, and 1.5 mm). In dry turning condition, tool wear was mainly affected by cutting speed. It decreased tool wear and provided smoother surface finish. Homogenized heat treatment affected material adversely, it increased tool wear and surface roughness [10].

From the available literature on particulate metal-matrix composites, it is clear that the morphology, distribution and volume fraction of the reinforcement phase, as well as the matrix properties are the factors that affect the overall cutting process. So far no work has been reported about the machining of 7075 Al alloy and 4 wt.% WC and E-Glass composite using tungsten carbide and PCD inserts to assess surface roughness and tool wear.

The cost of PCD tools increase the cost of production so it is necessary to carry out basic machinability studies in order to find cutting conditions using tungsten carbide tools, which can result in high productivity at low cost. In the present work, optimum values of cutting speed, feed rate, and depth of cut have been found out to attain minimum surface roughness during the turning of 7075 Al alloy with 4 wt.% WC and E-glass composite using tungsten carbide inserts and PCD inserts. Wear of tungsten carbide and PCD inserts have been found out and the causes of wear have been analyzed.

II. Experimental Setup

Stir casting process was used to fabricate the 7075 Al alloy and 4 wt.% WC and E-glass composites. Figure 1shows the microstructure of the cast Al alloy and WC and E-glass composite before the machining operation was performed.

The experiments were performed on 7075 Al alloy and composites. The diameter and length of the workpiece material are 27 and 100 mm, respectively.Details of inserts and tool holders are given in Table 1.

Table 1: Cutting tools used in experiment

Turning tool Holder	Type of insert	Clearance angle (degree)	Back rake angle (degree)	Nose radius (r; mm)	Feed (f; mm/rev)	Depth of cut (mm)
PCLNL 2525 M12 KT 809	Carbide insert CNMG 120408EM grade 6630	0°	7°	0.8	f_{min}=0.15; f_{max}=0.60	a_{pmin}=1.0; a_{pmax}=6.0
SVJBL 2525 M16 WIDAX	PCD Insert VCMW 160404 FN	7°	0°	0.4	f_{min}=0.10; f_{max}=0.14	a_{pmin}=0.4; a_{pmax}=2.0

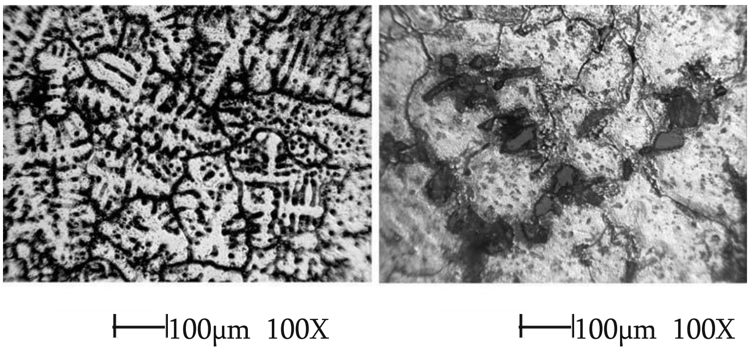


Fig. 1. a, b Microstructure of 7075 aluminum alloy and reinforced composite

CNC Turning Machine (Model TC 20) was used for experiments. The machine parameters are given in Table 2.

TABLE 2.CNC TURNING MACHINE PARAMETERS

Parameter	Specifications
Distance between centers	575mm
Swing over telescopic cover	500mm
Spindle speed range	40–4,000rpm

Positioning accuracy X-axis	±0.005 mm
Z-axis	±0.0075mm
Main motor	7.5KW

After turning, the surface roughness was measured using the Gippan SRT-6210, a portable surface roughness instrument. The cut-off and sampling lengths for each measurement were taken as 0.8 and 4 mm, respectively. Driving speed of stylus was taken as 0.5 mm/rev. ISO 4287 standard was followed during measurement. On each specimen, three surface roughness measurements were made along the machined surface and an average of these values was taken as a response. A small portion of size 12 mm ×12 mm was cut with a hacksaw from each specimen to analyze the machined surface microstructure using a LEICA DFC 420 optical microscope.

TABLE 3: VALUES OF SURFACE ROUGHNESS OF THE WORK PIECES MACHINED USING CARBIDE INSERTS

Material	**Feed (mm/rev)**	**Depth of Cut (mm)**	**Cutting speed (m/min)**	**Average rurface roughness (R_a; μm)**
7075 Al alloy	0.1	0.5	180	4.015
			200	3.921
			220	3.869
			240	3.619
	0.2	1.0	180	4.198
			200	3.917
			220	3.825
			240	3.722
	0.3	1.5	180	4.809
			200	4.713
			220	4.605
			240	4.524
	0.4	2.0	180	5.967
			200	5.858
			220	5.746
			240	5.639
7075 Al alloy 4 wt.% WC and E-glass composite	0.1	0.5	180	4.327
			200	4.172
			220	4.069
			240	3.926
	0.2	1.0	180	4.439
			200	4.287
			220	4.176
			240	4.053

	0.3	1.5	180	5.347
			200	5.234
			220	5.128
			240	5.019
	0.4	2.0	180	6.217
			200	6.131
			220	6.018
			240	5.911

Material	Feed (mm/rev)	Depth of Cut (mm)	Cutting Speed (m/min)	Average surface roughness (R_a; µm)
7075 Al alloy	0.1	0.5	180	2.729
			200	2.605
			220	2.521
			240	2.402
	0.2	1.0	180	2.837
			200	2.726
			220	2.618
			240	2.509
	0.3	1.5	180	3.215
			200	3.107
			220	2.987
			240	2.876
	0.4	2.0	180	3.625
			200	3.519
			220	3.427
			240	3.318
7075 Al alloy 4 wt% WC and E-glass composite	0.1	0.5	180	2.838
			220	2.652
			240	2.507
	0.2	1.0	180	2.941
			200	2.835
			220	2.739
			240	2.618
	0.3	1.5	180	3.538
			200	3.441
			220	3.322
			240	3.214

	0.4	2.0	180 200 220 240	3.987 3.851 3.728 3.611

TABLE 4: VALUES OF SURFACE ROUGHNESS OF THE WORK PIECES MACHINED USING PCD INSERTS

III. Results And Discussion

Surface roughness:

Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy. Many factors affect the surface condition of a machined part. But machining parameters such as cutting speed, feed rate, and depth of cut have a significant influence on the surface roughness for a given cutting tool and workpiece setup. Values of surface roughness at different cutting speed, feed rate, and depth of cut using carbide and PCD inserts are shown in Tables 4 and 5, respectively.

Figures 2and 3show the values of surface roughness at different feed rates, cutting speeds, and depth of cuts while turning Al alloy and WC and E-Glass composite, respectively, using carbide inserts. Surface roughness of Al alloy decreases by 5.49% with the increase of cutting speed from 180 to 240 m/min at a feed rate of 0.4 mm/rev. Surface roughness of Al alloy is almost same at cutting speeds of 200 and 220 m/min when feed is increased from 0.1 to 0.2 mm/rev. On the other hand, surface roughness of WC and E-Glass composite decreases by 4.92% with the increase of cutting speed from 180 mm/min to 240 mm/min at feed rate of 0.4 mm/rev. Surface roughness of WC and E-Glass composite is higher than Al alloy at all machining parameters.

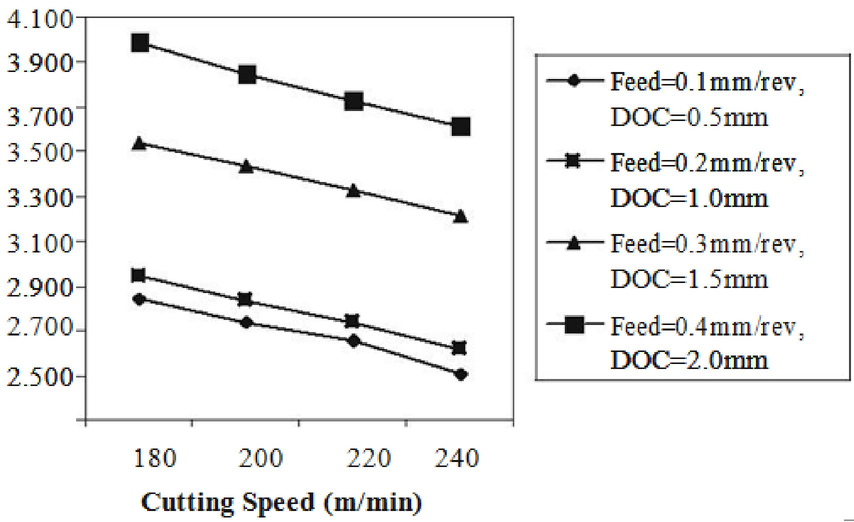


Fig. 2. Variation of surface roughness WC and E-Glass composite using carbide insert

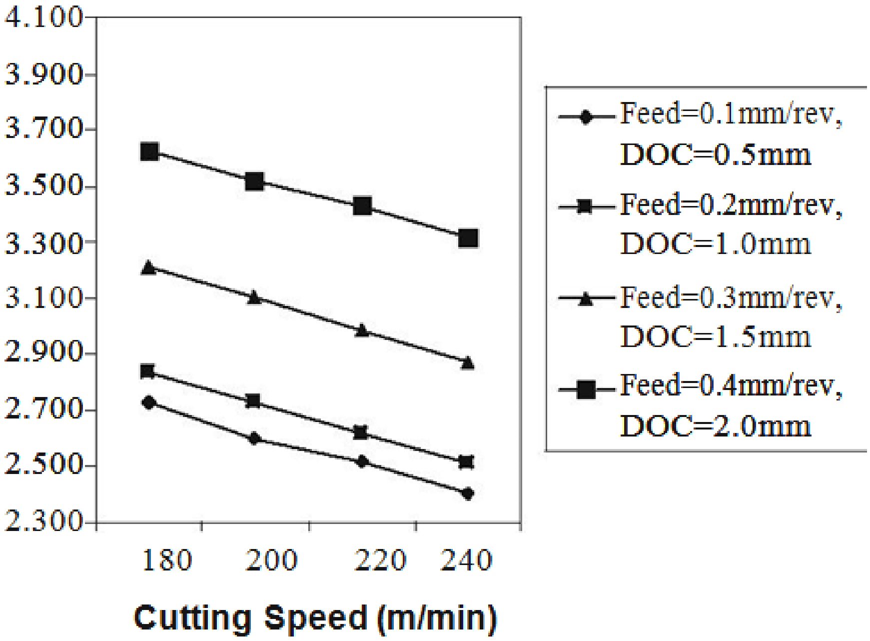


Fig. 3. Variation of surface roughness of Al alloy using carbide insert

Figures 4and 5indicate the value of surface roughness at different feed rates, cutting speeds, and depth of cuts while turning Al Alloy and WC and E-Glass composite, respectively, using PCD inserts. Surface roughness of Al alloy decreases by 8.46% with the increase of cutting speed from 180 to 240 m/min at a feed rate of 0.4 mm/rev.

Decrease in surface roughness is gradual for Al alloy at all feed rates and depth of cuts considered in the experiments, when cutting speed is increased from 180 to 240 mm/min. Surface roughness of composite decreases by 9.43% with the increase of cutting speed from 180 to 240 mm/min at feed rate of 0.4 mm/rev. Surface roughness of both Al alloy and WC and E-Glass composite decreases when using PCD insert as compared to the carbide insert.

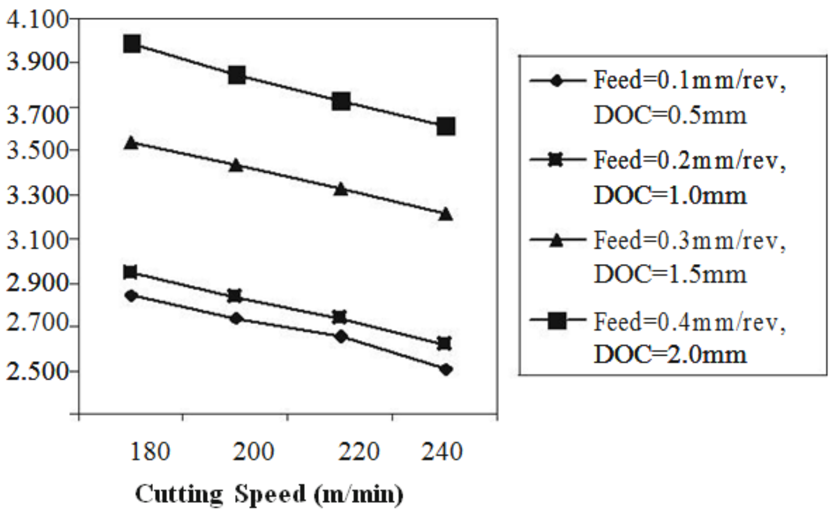


Fig. 5. Variation of surface roughness of WC and E-Glass composite using PCD insert

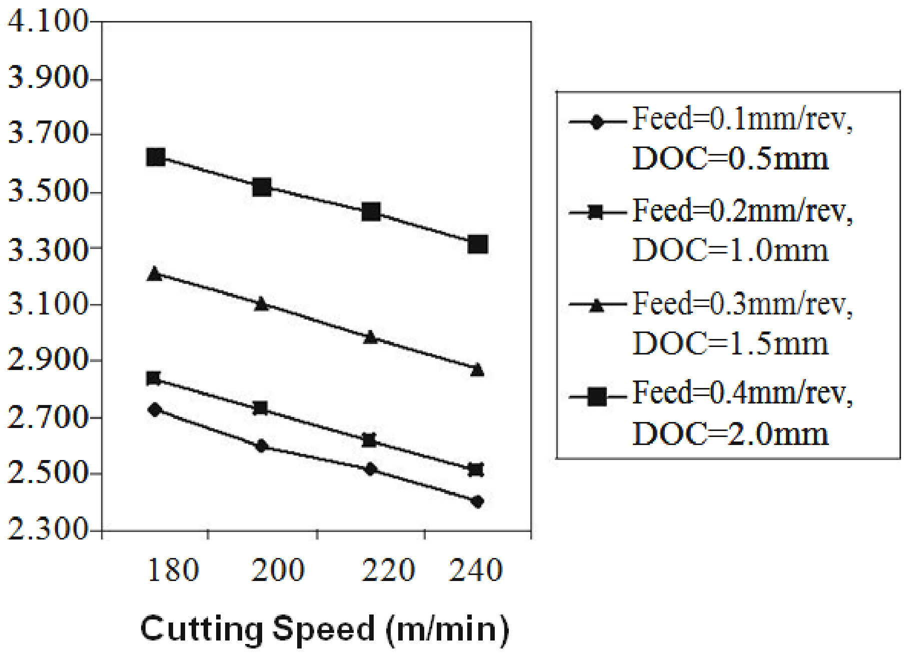


Fig. 4. Variation of surface roughness of Al alloy using PCD insert

In Figs. 6and 7, surface roughness is examined during turning of Al alloy and WC and E-Glass composite, respectively, by using carbide inserts at feed rates of 0.1, 0.2, 0.3, and 0.4 mm/rev. Surface roughness of Al alloy is almost constant at cutting speed of 200 and 220 mm/min when feed is increased from 0.1 to 0.2 mm/rev and DOC from 0.5 to 1.0 mm. Surface roughness of Al alloy increases by 55.81% with the increase of feed from 0.1 to 0.4 mm/rev and DOC from 0.5 to 2.0 mm at cutting speed of 240 m/min. Surface roughness of WC and E-Glass composite increases gradually with the increases of feed from 0.1 to 0.2 mm/rev and DOC from 0.5 to 1.0 mm at all cutting speeds. Surface roughness of WC composite increases by 50.56%, with the increase of feed from 0.1 to 0.4 mm/rev and DOC from 0.5 to 2.0 mm, at cutting speed of 240 m/min.

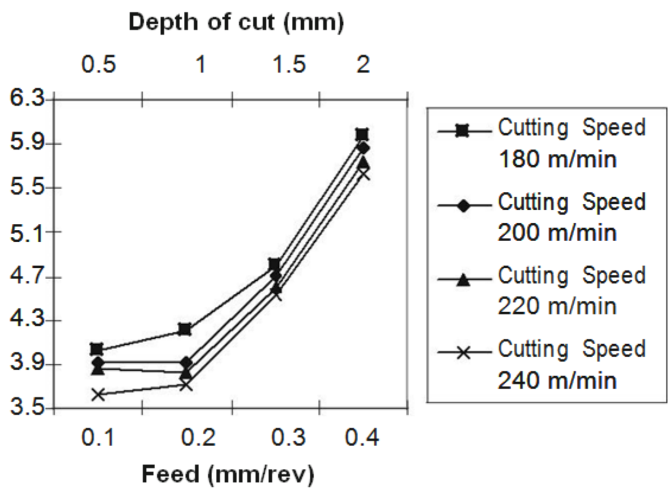


Fig. 6. Variation of surface roughness of Al alloy using carbide insert

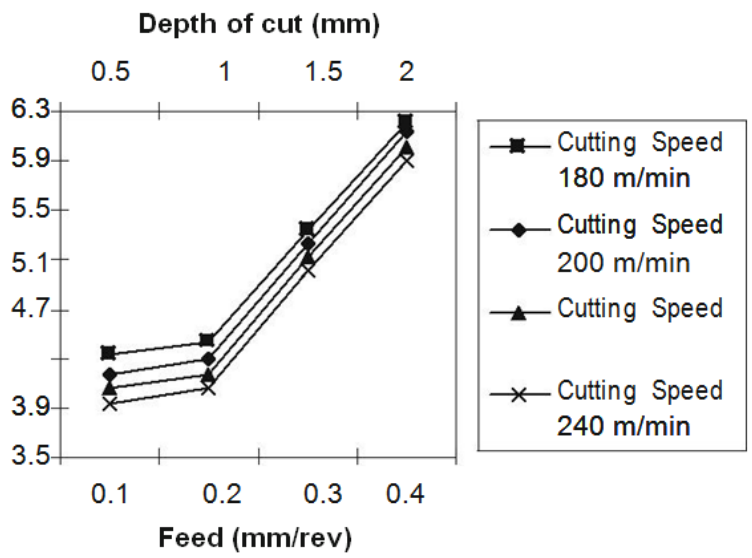


Fig. 7. Variation of surface roughness WC and E-Glass composite using carbide insert

Figures 8and 9show surface roughness during turning of Al alloy and WC and E-Glass composite, respectively, by using PCD inserts at feed of 0.1, 0.2, 0.3, and 0.4 mm/rev. Surface roughness of Al alloy increases sharply with the increase of feed from 0.2 to 0.4 mm/rev at all cutting speeds. Changes in feed rate from 0.1 to 0.4 mm/rev and DOC from 0.5 to 2.0 mm at cutting speed of 240 m/min caused increase in surface roughness of Al alloy by 38.13%. Surface rough-ness of composite increases sharply with the increase of feed from 0.2 to 0.4 mm/rev and DOC from 1 to 2.0 mm at all cutting speeds. Surface roughness of composite increases by 44.03% with the increase of feed from 0.1 to 0.4 mm/rev and DOC from 0.5 to 2.0 mm at cutting speed of 240 m/min.

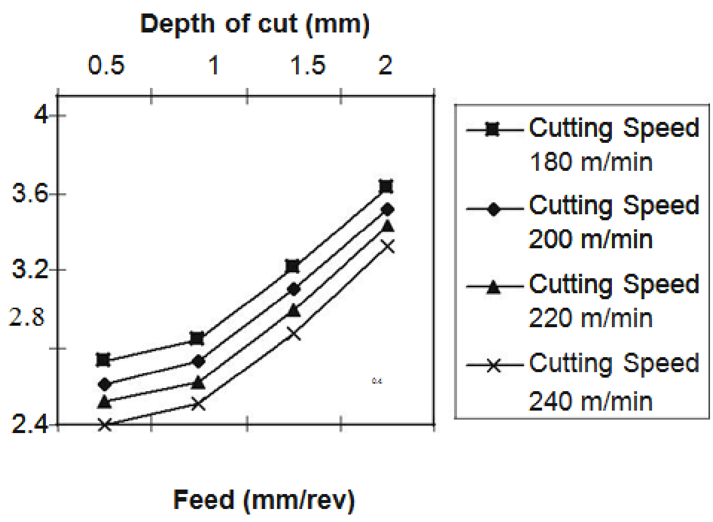


Fig. 8. Variation of surface roughness of Al alloy using PCD insert

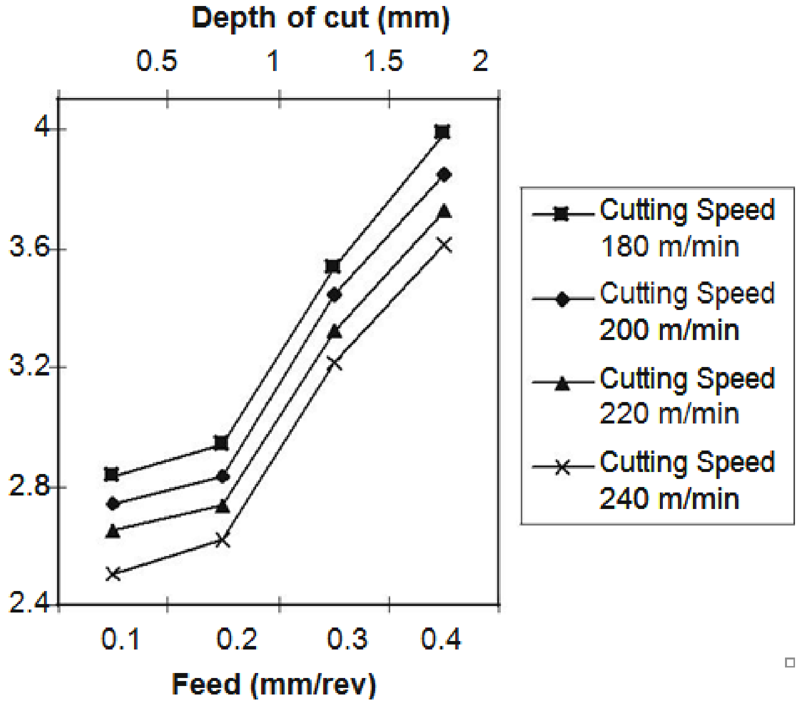


Fig. 9. Variation of surface roughness of WC and E-Glass composite using PCD insert

As can be seen from above figures, the surface roughness produced by carbide insert is more as compared to PCD insert, while machining Al alloy and WC and E-Glass composite at all feed rates and DOCs selected in the experiment. Fracture of the carbide insert cutting edges was higher than PCD cutting edges. This is due to the fact that hardness of diamond is more than the silicon carbide. It was considered that the fracture of the cutting edges of carbide insert caused these significantly high Ra values. Surface rough-ness (Ra) values measured on machined surfaces of WC and E-Glass composite were much higher than the Al alloy during the machining as the removals of WC and E-Glass particles cause some small gaps in machined surface. It is estimated that this condition caused an increase in surface roughness of WC and E-Glass composites as compared to Al alloy. The cutting speed plays an important role in deciding the surface roughness. At high cutting speeds, the surface roughness decreases. At low cutting speeds, the built up edge (BUE) is formed and also the chip fracture readily producing the rough surface. As the cutting speed increases, the BUE vanishes, chip fracture decreases, and hence the roughness decreases. The surface roughness increased with using higher feed rates in all machining conditions. This was attributed to high temperature in the cutting zone. Higher feed values increase temperature and this cause to decrease bonding effect between WC and E-Glass particles and Al alloy matrix.

The PCD inserts performed a lot better than the carbide inserts and were able to remove a greater amount of material. PCD inserts maintained a good surface finish on the workpiece throughout the experiment. No major degradation of workpiece surface quality was observed even at the end of the tests.

Surface roughness of WC and E-Glass composite during machining by the carbide insert is less in the feed range of 0.1 to 0.3 mm/rev and DOC range of 0.5 to 1.5 mm. These values of feed and DOC are recommended for machining by carbide tool in the cutting speed range of 180 to 220 m/min. Surface roughness of WC and E-glass composite during machining by PCD insert is more below cutting speed of 220 m/min. Machining by

PCD insert is recommended at cutting speed more than 220 m/min but at feed rate of less than 0.2 mm/rev and DOC less than 1.0 mm.

Tool Wear:

Flank wear is the measure most often used to assess tool condition. It occurs on the flank or relief face of the tool below the cutting edge. Flank wear is caused due to the abrasive action of the reinforced particles present in the metal matrix composite. A tool can be considered to have reached the end of its useful life when flank wear reaches a specified dimension. The extent of flank wear (V_B) can be measured as the distance between the top of the cutting edge and the bottom of the area where flank wear occurs

Carbide turning tools are usually replaced when the width of the flank wear area reaches some pre-defined limit. The 1993 international standard (ISO 3685) stipulates that a flank wear width of 0.76 mm width for rough turning and 0.38 mm for finish turning (Fig. 10) [7].

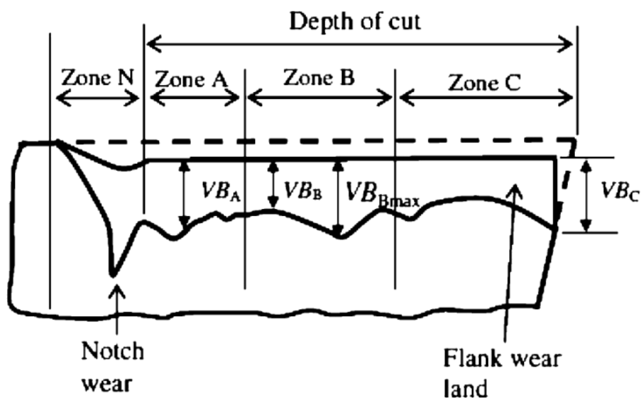


Fig. 10. Side view of cutting tool showing flank wear (ISO3685)

The worn out cutting inserts were examined under both optical and scanning electron microscope. ISO 3685 was followed for measurement of flank wear. Machining was continued for 7 min for carbide and PCD inserts for all the parameters considered. Each experiment was repeated three times and average value of readings was taken. Flank wear of carbide and PCD inserts while machining 7075 Al alloy with 4 wt.% WC and E-Glass composite is shown in Table 6. The carbide insert has 0.54 mm maximum flank wear (V_B) and PCD insert has 0.0102 mm maximum flank wear (V_B) when turning 27 mm diameter composite at a cutting speed of 240 m/min, a feed rate of 0.4 mm/rev, and a depth of cut 2 mm.Figures 11and 12indicate wear of carbide inserts during turning of 7075 Al alloy composite with change in cutting speeds and feeds, respectively.

Flank wear increases gradually with the increase of cutting speed, feed rate, and depth of cut. Flank wear increased by a factor of 2.4 with the increase of cutting speed from 180 to 240 m/min at feed of 0.1 mm/rev and DOC 0.5 mm. Increases in the flank wear is more at feed rate of 0.4 mm/rev and depth of cut of 2.0 mm as compared to other values of feeds and DOCs. Flank wear increased by a factor of 2.5 with the increase of feed from 0.1 to 0.4 mm/rev at cutting speed of 240 m/min. As can be seen from figures, lowest tool flank wear values were recorded at cutting speed of 180 m/min and feed rate of 0.1 mm/rev. In order to examine the tool wear in detail, the worn cutting tools were investigated using metallurgical microscope. Workpiece material adhered to the cutting edges at 180 and 200 m/min cutting speed. In this speed, range adhesive wear is the dominant wear mechanism. When the cutting speed was increased beyond 200 m/min, abrasion and adhesion were the mechanisms dominating the tool wear.

TABLE 5: FLANK WEAR OF CARBIDE INSERT AND PCD INSERTS

Feed (mm/rev)	Depth of cut (mm)	Cutting Speed (m/min)	Flank wear (mm) using carbide insert	Flank wear (mm) using PCD insert
0.1	0.5	180	0.08	0.0040
		200	0.11	0.0044
		220	0.14	0.0046
		240	0.19	0.0052
0.2	1.0	180	0.16	0.0056
		200	0.18	0.0058
		220	0.22	0.0062
		240	0.28	0.0068
0.3	1.5	180	0.23	0.0068
		200	0.26	0.0070
		220	0.31	0.0076
		240	0.38	0.0084
0.4	2.0	180	0.41	0.0086
		200	0.45	0.0090
		220	0.48	0.0094
		240	0.54	0.0102

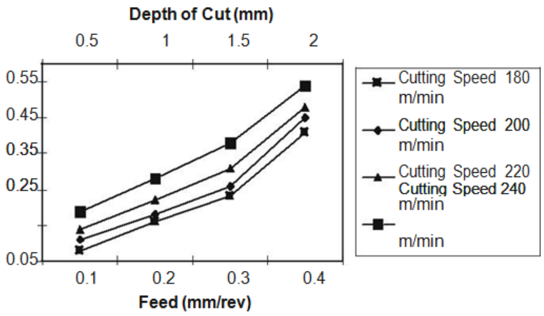


Fig. 12. Wear of carbide insert with feed

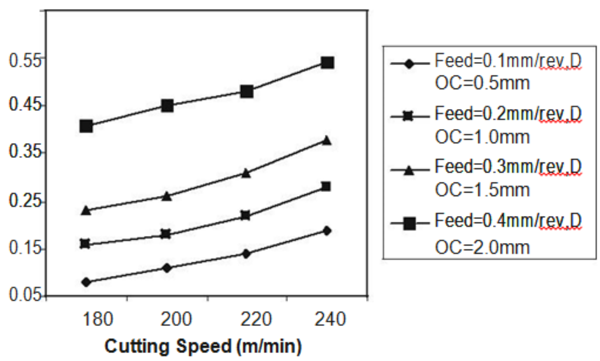


Fig. 11. Wear of carbide insert with cutting speed

PCD insert was monitored using a scanning electron microscope for normal types of tool wear namely crater wear, flank wear, and the nose wear as machining progressed. The wear on the PCD insert is caused by the abrasive nature of the hard particles present in the work piece material. As diamond is harder than the WC and E-Glass, this abrasive wear may be associated with micromechanical damage rather than with micro-cutting [8].

Figures 13and 14indicate wear of PCD inserts during turning of WC and E-glass composite with respect to cutting speed and feed. Flank wear increases gradually with the increase of cutting speed, feed rate, and depth of cut. Flank wear increased by only a factor of 1.3 with the increase of cutting speed from 180 to 240 m/min at feed of 0.1 mm/rev and DOC 0.5 mm. At low cutting speeds, the worn flank encourages the adhesion of the work piece material and was therefore often covered with an aluminum film due to the high pressure generated. At same feed rate and depth of cut, the effect of cutting speed on flank wear was little. At same cutting speed, flank wear was higher when higher feeds and depth of cuts were used. Higher feed rates and depth of cuts at high cutting speed resulted in increased flank wear.

Flank wear increased by a factor of 1.96 with the increase of feed from 0.1 mm/rev to 0.4 mm/rev at the cutting speed of 240 m/min. In machining, Al-WC composites using PCD inserts, the predominant mode of tool wear is by abrasion [9].

Andrewes et al. [10] reported that when machining MMCs using PCD cutting tools, the initial flank wear starts with the abrasive effect of the hard particles and the workpiece material adheres to these abrasive grooves strongly due to the high pressure generated at the tertiary cutting zone as machining progresses. Each time a workpiece film adheres and breaks off as a result of the hard abrasive particles present in the workpiece, small diamond particles are also removed from the PCD cutting tool surface. This cyclic process leads to progressive loss of the PCD tool material. Wear of PCD inserts is less as compared to carbide inserts at all ranges of cutting speed, feed rate, and depth of cut studied. Since diamond has an extremely low coefficient of friction and high thermal conductivity, crater wear is not a significant wear mode of tool failure in PCD inserts.Figure 15indicates carbide insert before machining. Figure 16represents carbide insert after machining for 7 min at cutting speed of 180 m/min, feed rate of 0.4 mm/rev, and DOC 2 mm.

The optical inspection of the flank face of the cutting inserts revealed the beginning of the flank wear. No substantial groove wear was observed; insert experience relatively wider, but shallower nose deformation with mild erosion of material over the tool.

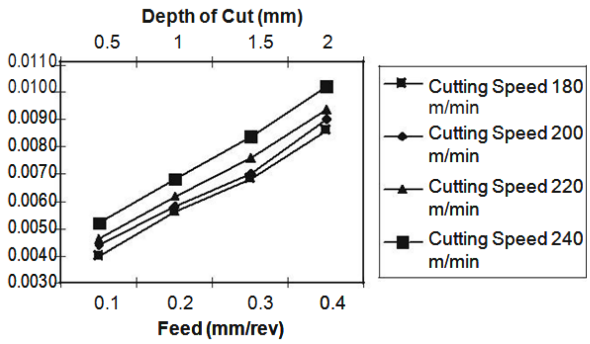


Fig.14. Wear of PCD insert with feed

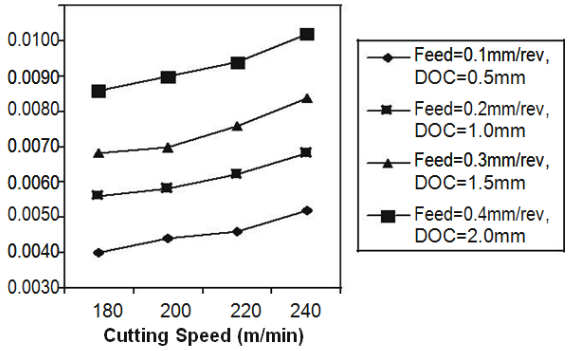
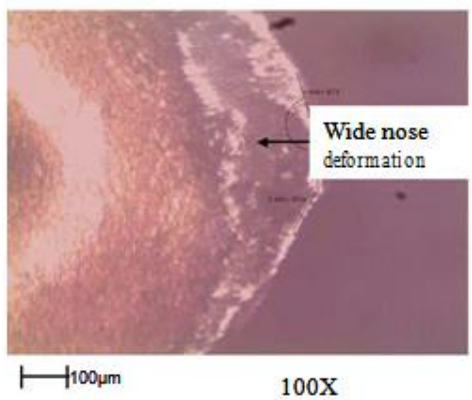


Fig. 13. Wear of PCD insert with cutting speed



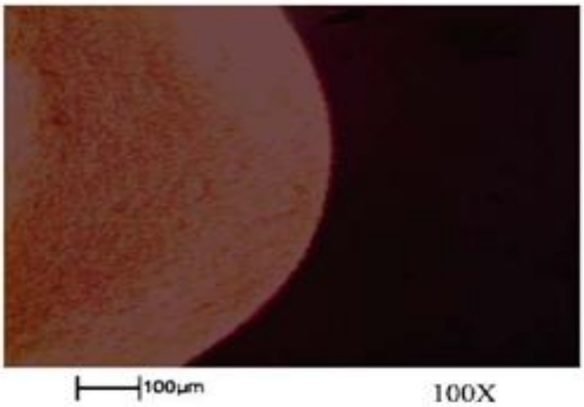


Fig. 16 Carbide insert after machining atFig. 15. Carbide insert before machining

cutting speed of 180 m/min

Figure 17shows carbide insert after machining at cutting speed of 240 m/min, feed rate of 0.4 mm/rev, and DOC 2 mm. It is seen that cutting insert experiences wide, deeper nose deformation with localized chipping over the cutting edge. Under the combined action of cutting force and temperature acting over the cutting edge, the tool experienced deformation of nose and consequent chipping.

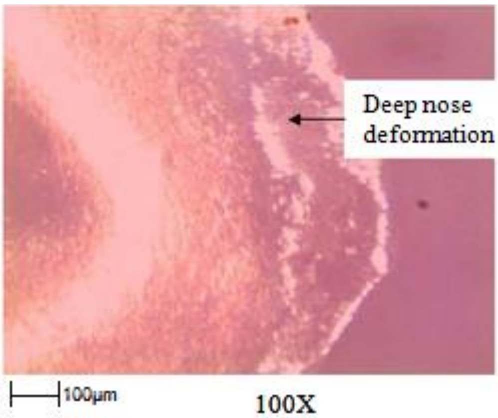


Fig. 17 Carbide insert after machining at cutting speed of 240 m/min

Figure 18shows scanning electron microscope micro-graph of PCD insert. The main wear pattern observed is flank wear. Flank wear is associated with abrasion wear tracks. Figures 19and 20shows the microstructure of WC composite after machining by carbide and PCD insert, respectively. It appears from these figures that WC particles are properly bonded with aluminum matrix at most of the places. The white particles indicate the transformation of aluminum powder during machining of composite. Dark spots in Fig. 19show that machining of composite by the carbide insert is non-uniform. Less number of dark spots in Fig. 20is an indication of uniform machining by PCD insert as compared to machining by carbide insert. The WC particle has high yield strength and its elastic modulus is very high, whereas the 7075 Al alloy has low yield strength and good plasticity. Under force, the stress of the matrix is unequal to that of reinforcing particles. Thus, in the cutting process of WC and E-Glass composites, when the Al alloy matrix deforms plastically, the WC and E-Glass particles may only deform elastically to break. In addition to this, the boundary of the Al alloy matrix and the WC and E-Glass particles may break between the tool and reinforcing particles, which causes severe abrasive wear on the tool flank of carbide insert. This is the reason of non-uniform machining of WC and E-Glass composites by carbide insert.

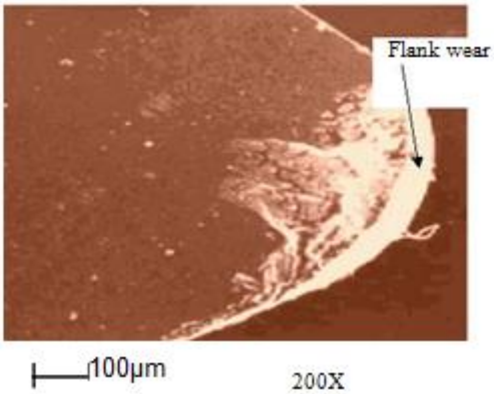


Fig. 18. SEM micrograph of PCD insert

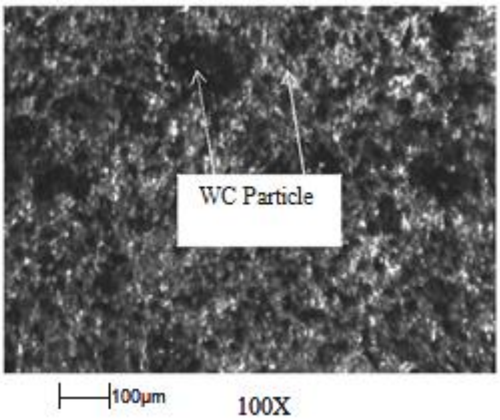


Fig. 19. Microstructure of WC and E-glass composite after machining by carbide insert.

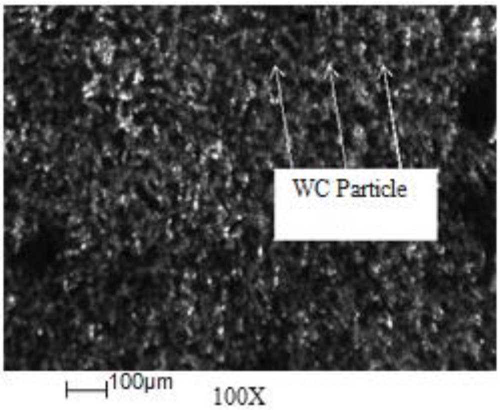


Fig. 20 Microstructure of WC and E-glass composite after machining by PCD insert

IV. Conclusion

In this work, effects of tungsten carbide and E-glass reinforcement to 7075 Al alloy on surface roughness and tool wear during turning have been investigated in terms of selected parameters such as cutting speeds, feed rates, and depth of cuts. The following conclusions are drawn based on the above experimental work:

1. Surface roughness of Al alloy is less as compared to Al alloy composite during turning by carbide as well as PCD inserts.
2. Wear of carbide and PCD inserts is less during turning of Al alloy as compared to Al alloy composite.
3. Wear of PCD insert is less as compared to wear of carbide insert during turning of Al alloy composite.
4. For optimum surface roughness in the workpiece, it is recommended that turning operation on Al alloy composite by carbide insert should be carried out at, cutting speed within the range of 180 to 220 m/min, feed rate within range of 0.1 to 0.3 mm/rev, and DOC within range of 0.5 to 1.5 mm. For minimum flank wear in the carbide insert, machining should be carried out at cutting speed of less than 200 m/min, feed rate of 0.1 mm/rev, and DOC 0.5 mm.
5. Based on the results of surface roughness in the work piece and flank wear in the tool, it is recommended that turning operation on Al alloy composite by PCD insert should be carried out at cutting speed higher than 220 m/min but at a feed rate of less than 0.2 mm/rev and DOC less than 1.0 mm.

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