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Experimental Investigation of Surface Roughness and Tool Wear of Machining Rolled AA7075 Aluminium Alloy using Advanced Cutting Tools

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Abstract: In this present work AA7075 ALUMINIUM alloy was machined by turning operation with different cutting tools such as uncoated- Aluminium grade, WC PVD, WC CVD coated tool insert under dry cutting environment. Effect of spindle speed was studied for each of the cutting tools was regards to the surface finish of the work piece and chip morphology and also experimentally studied the tool characterization while approaching SEM and EDX analysis. It is observed that the surface roughness is decreases with increasing cutting speed. The chip formed were continuous but varied in size and shape depending upon the machining parameters and the formed have been studied under electronic tool maker's microscope. At all cutting conditions WC PVD coated tool insert is the better cutting tool as per the considered machining parameters to achieve better surface roughness and tool wear.

Keywords: AA7075, Dry machining, CVD, PVD, Surface roughness, Toolmaker's microscope, SEM, EDX, Chip morphology.

I. INTRODUCTION

In present era of economic development there is a great need for producing high quality machined components at reduced cost. This can be achieved by using sophisticated machine tools and decreasing the machining time. Some of the methods adopted to reduce the machining times are using higher operating conditions, performing many operations simultaneously, employing jigs and fixtures and employing computer numerical control machine tools. Superior surface finish, higher accuracy, increased productivity, reduced tool wear and having better tool life are the advantages while selecting the proper machining parameters. Even though there are a lot of advantages, still certain inherent drawbacks persists when machining at high speed. Higher investment and maintenance cost, reduced tool life and higher tool wear rates are some of its demerits. Ultimately this has let the researchers to explore some other methods of improving the productivity. An alternate method for increasing the productivity is by engaging more tools at the same time to machine a component. It gives rise to multi-tool machining. It presents a review of available literature on multi-tool machining.

In any machining operation measurement of cutting forces are of paramount importance in order to estimate the power consumption and process efficiency. It is equally important to monitor the cutting temperature as it plays a major role in determining the wear rate for a tool. Therefore surface roughness aspect is reviewed. The cutting tools apart from removing the work material also provide support to the work piece in multi-tool turning. The cutting tool also performs the function of follower rest in case of multi- tool turning process. Hence the diametric error is minimised while turning slender jobs in lathe. From this point of view the review of literatures related to dimensional deviation is presented. The chips that are generated in machining reveal mechanism of metal cutting and in this aspect literature related to chip morphology are reviewed. Cutting tool vibrations also one of the factor influences on the surface roughness and tool life. Excessive vibration leads to chatter. Thus it is very important to maintain the vibration levels to minimum. The research works on cutting tool vibration. The research gaps are given. The detailed scope and objectives of the present work is presented.

A. Cutting Tool Material and its Wear

In the machining, tool wear and its life depends mainly on the following factors:
The material of the machined component
Cutting tool material and its shape
Cutting conditions
The machining process
Mainly, abrasion wear and adhesive wear. When cutting at conventional speeds abrasion wear dominates. When the cutting speed is increased, tool wear happens mainly by diffusion process and hence adhesive wear dominates. It was seen that chipping of tool became dominant which destroyed the cutting edge. Higher plastic deformation increases the temperature that favours

work material gets stick on the nose of a tool. The experiment conducted to find out the tool wear rate along with considered machining parameters.

Generally, cutting forces increases on while varying the speed. It is due to the inertia effects caused by the momentum change of the work piece when it passes through the primary shear deformation zone.
Tool varies thus causing shear localized chips. The fluctuating frictional force reduces the tool life. Apart from this the tool-chip contact length increases. The sticking friction conditions prevail at these interfaces increasing the tool wear rate. Higher chip sliding velocity increases the heat generation and temperature.

II. EXPERIMENTAL PROCEDURE

A. Material used

A cylinder rod of rolled aluminium with diameter 25.4 mm and length 60 mm was used as work piece for experimental purpose. The specimens were initially solutionized at 465℃ for around 100 minutes in a muffle furnace followed by quenching process in a chilled water. Chilled water is used to make the specimen to improve its properties at the particular state.

B. Experimental Setup

CNC machine was used for the dry turning of AA7075 Aluminium Alloy using WC PVD coated, WC CVD coated, ALUMINIUM GRADE tool inserts.

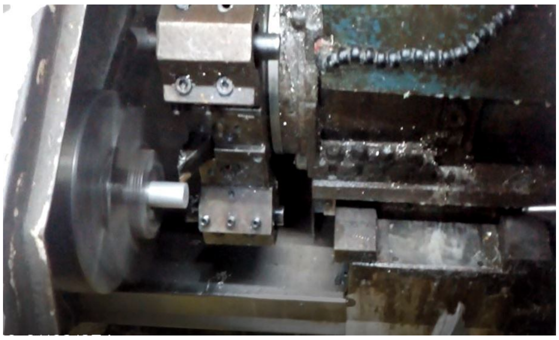

Fig-1: Experimental setup for dry turning operation.

Table 1: Description about tool inserts

Sl	Cutting tool material	Designation	Tool holder
1	WC PVD	VBMT160408 -HMP	SVJBR16-3D
2	WC CVD	VNMG160408 -HM	
3	AL Carbide	VBMT160408 -TH	

C. Machining Parameters used for Test

Turning experiments were carried out at ambient temperature using changeable carbide inserts having TNMG designation with K10 quality degree. A total of twelve experiments were carried out according to cutting parameters and machining levels are shown. The experiments were carried out under dry cutting condition.

Table 2: Machining parameters

Parameters	Values
Speed (rpm)	800,1200,1600,2000
Depth of Cut (mm)	1
Feed rate (mm/rev)	40

Type of tool inserts	WC PVD, WC CVD, AL Carbide
Machining Condition	Dry
Tool holder type	SVJBR16-3D

D. CNC Turning Process

In this CNC turning process the samples are machined by plane turning operation. This plane tuning operation will be done as per the given machining parameters. These values are programmed into the software with the exact values. The software based CNC lathe will done the work with 1.47 sec for every individual sample. The procedure and program is same but the tools and are changed after they are done machining. The door of CNC will be closed if there will be more amount of depth of cut is given.

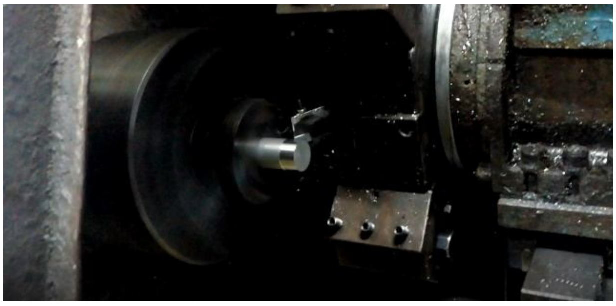

Fig-2: CNC turning of AA7075

E. Chip Morphology

Chip formation is caused by the shearing process. Chip formation depends upon the work material, *viz.*, ductile or brittle material. It also depends on machining parameters, cutting tool geometry and type of lubricant used. The chips are classified into continuous chip, discontinuous chip, continuous with built up edge and serrated chips. Continuous chips are produced while machining ductile metals at high cutting speed and low feed. Discontinuous chips are produced while machining hard and brittle materials like grey cast iron, brass and bronze. The finding of burrs on the material removed from the sample that was inspected in the microscope. The generated chips during machining can give details about machining process efficiency.

III. RESULTS AND DISCUSSIONS

A. Observing the effect of Cutting Speed and Tool insert which influences on Surface Roughness

From table 3, it can be observed that, the effect of cutting for a material is mostly based on the machining parameters. So the main aim is to achieve better surface roughness with minimum tool wear. As per the obtained results machined material get the highest surface roughness at low speeds and lowest roughness at high speed.

The speed is varied in machining every sample. In this the plane turning operation the material is removed as per programed. The WC PVD coated tool insert is the better cutting tool to give low surface roughness at higher speeds. The roughness values are mentioned below.

Table 3: Surface roughness values

Speed (rpm)	Type of tool insert		
	WC PVD	WC CVD	AL Carbide
800	0.904	0.860	0.542
1200	0.422	0.538	0.462
1600	0.404	0.528	0.432
2000	0.352	0.518	0.392

B. Tool Characterization

1) SEM stands for Scanning Electron Microscope. It is the process of finding the tool wear after machining process: It is the examination of tool by using advanced technology where the machining done by the tool. The tool insert is kept in VEGA-3 machine that scans the overall tool and converts it into 3D view. This process helps to know the wear and built up layers on the tool, which find the less tool wear. We can clearly get the tool wear it has done while machining.

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In this SEM method the machined tool inserts are placed inside the machine. Its scans the overall image and it displays. All we need is to test the tool wear at higher speed 2000 rpm because of getting better surface roughness at that speed. This may more useful for identifying the tool wear. The area will be focused by adjusting the inner camera.

This is one type investigation of finding the tool wear. SEM helps to characterize the tool wear after machining and it help to identify the better tool insert.

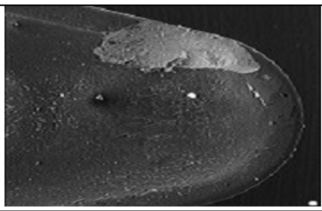
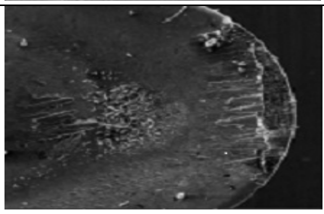
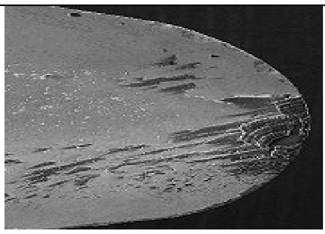
Speed (rpm)	Type of tool wear	Tool Characterization
2000 t=47	WC PVD	
2000 t=45	WC CVD	
2000 t=45	AL Carbide	

Fig-3: Optical micrographs of surface roughness on different cutting tools after machining AA7075 alloy at giving better surface roughness speed and machining time

2) EDX stands for Electron Dispersive X-ray Spectrography: It is an analytical method used to detect the chemical compositions and elemental analysis of certain samples. The beam of X-rays are focused on the samples are to be studied. EDX analysis has to be done on the inserts which are having spindle speed of 2000 rpm as shown in figures 4, 5 and 6 while knowing the chemical characterization and elements present on the face of the tool.

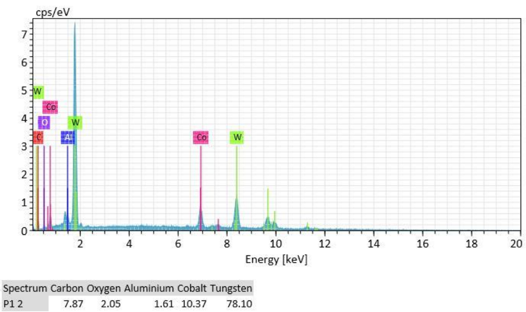
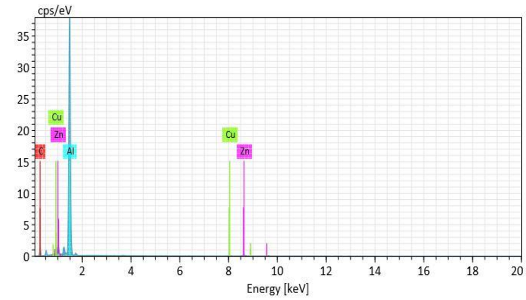
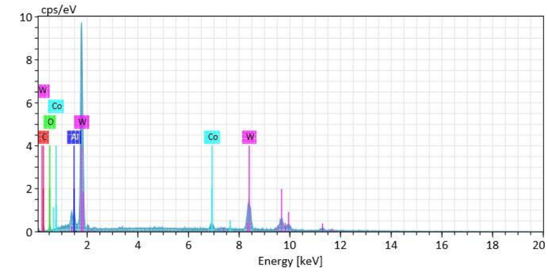


Fig-4: EDX analysis for PVD tool insert



Spectrum	Carbon	Aluminium	Copper	Zinc
C1 3	36.09	59.98	0.90	3.04

Fig-5: EDX analysis for CVD tool insert



Spectrum	Carbon	Oxygen	Aluminium	Cobalt	Tungsten
A1 1	6.65	3.99	2.63	2.72	84.02

Fig-6: EDX analysis for AL carbide un-coated tool insert.

3) Obtaining different chips we can see structures on the chips by using microscope. The experiments conducted with the different rpm that shows various types of tools and chips obtained to find out better surface roughness and good finish. This process is useful to find out the good material and tool wear.

The formation of burrs on the chips are formed due to the required machining parameters of speed 2000 rpm, feed 40mm/rev and constant depth of cut. These parameters were individually varied on the samples that are viewed to be in microscope which will clearly visible in zigzag shapes as shown in the Figure 7, 8, 9 below.

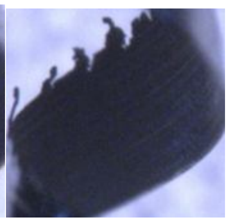



Fig-7: PVD chip Fig-8: CVD chip

Fig-9: Aluminium chip

IV. CONCLUSIONS

A. The experiments were done to find out the better surface roughness and tool wear generated during machining of required Aluminium samples by using cutting tools at a different speed, constant feed & depth of cut condition in a dry environment.

B. PVD tool insert showed better results compared to un-coated tool insert aluminium carbide and CVD tool insert. Uncoated aluminium carbide showed better results compared to coated CVD tool.

C. We have concluded that PVD tool performed best surface finish at higher speed at 2000 rpm. The wear is minimum on the face of the PVD tool. So this results can be found out through SEM and EDX analysis while comparing a tool wear.

D. So, there is little bit of wear found at the nose of the WC PVD coated tool, where as there is a large wear can be observed on the nose of CVD tool insert. This shows that PVD tool showed better tool wear resistance.

E. From the above fig 4, the wear spectrum shows the type of elements found during machining process. As per the results compared to aluminium carbide & WC PVD coated tool, the WC CVD coated tool show the maximum amount of aluminium present. This shows the extent of wear for these tool is more than other cutting tools in fig 5 & fig 6. PVD shows least aluminium present in fig 4.

F. Irrespective of type of tool insert, the surface roughness value decreased with an increases in spindle speed.

G. Study of chip morphology showed that, coated tool insert generate the chips from continuous to discontinuous and burrs were formed in the shape zigzag shape. These results have to be obtained from Tool Maker's Microscope.

H. Finally at all cutting conditions, PVD tool gives better performance in order to achieve good surface roughness and minimum tool wear.

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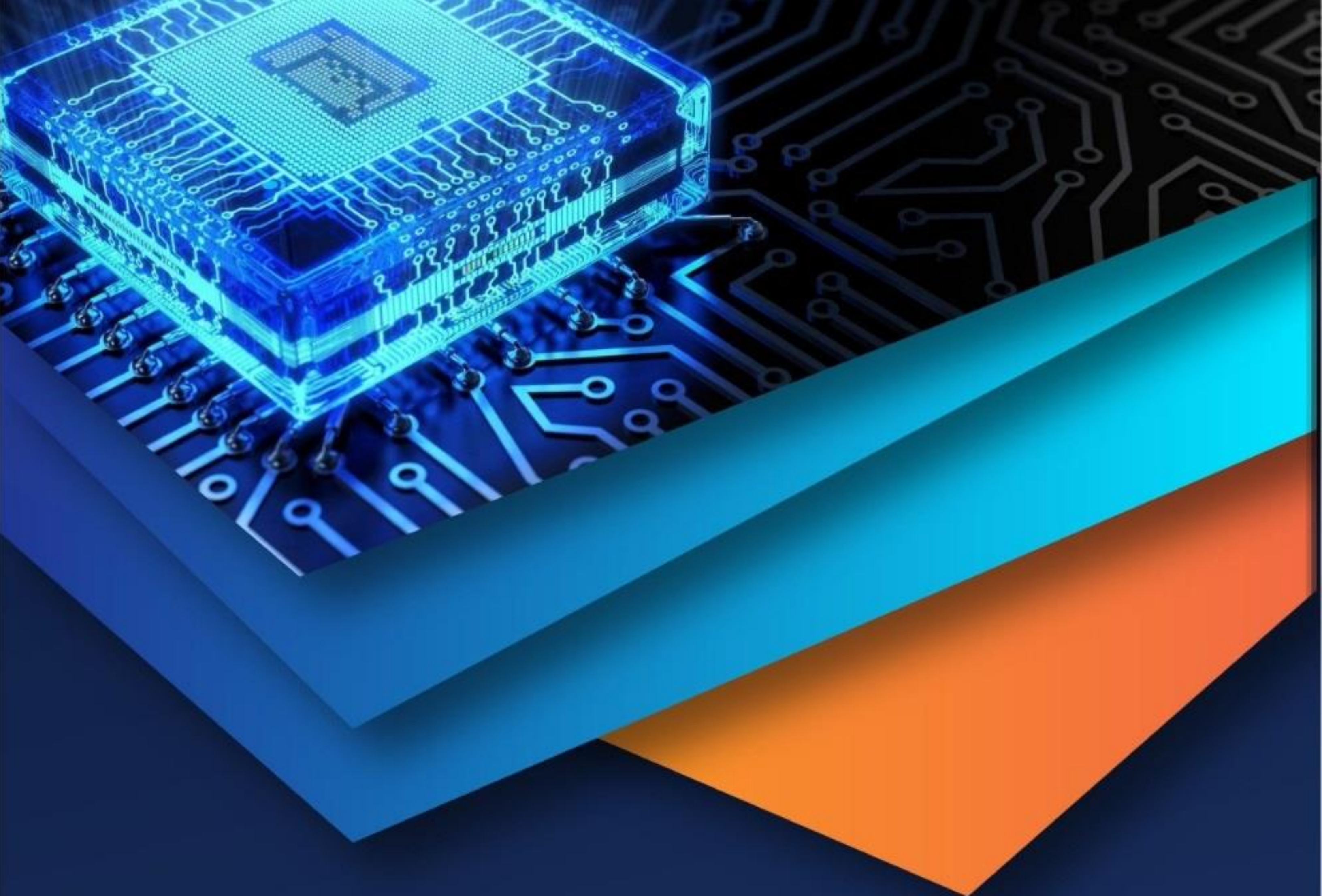

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