Australian Journal of Basic and Applied Sciences, 7(4): 90-93, 2013
ISSN 1991-8178

Effect of Dry Machining on Tool Wear During Turning Al 6061 by Using Different Type of PVD and CVD Coated Carbide Inserts

S.A. Syed Azuan

Universiti Kuala Lumpur Malaysia France Institute 43650 Bandar Baru Bangi, Selangor, Malaysia

Abstract: Industries and researchers are trying to reduce the use of cutting fluids in metal cutting to obtain safety, environmental and economical benefits. Machining without the use of any cutting fluid so called dry machining is becoming increasingly more popular, especially in machining Al 6061 for the automotive application. This paper deals with experimental investigation on the effect of dry machining on the tool wear by doing the comparative dry machining experiments using five commercial coated carbide available inserts: 3 PVD coated carbide inserts and 2 CVD coated carbide inserts. Tool wear during dry machining was compared for each of the inserts. The results showed that the CVD coated carbides inserts have shown lower tool wear when compared to PVD coated carbide inserts.

Key words: Dry machining, Al 6061, PVD, CVD, turning, tool wear

INTRODUCTION

The increase in environmental pollution and problems relating to waste disposal of cutting fluids is forcing manufacturers to reduce the volume of oil-based cutting fluids used in large-scale metal-cutting operations even to the point of machining dry. For the latter to become widely adopted in industry as a commercially viable alternative to wet machining then the main advantages of cutting fluids, namely, they act as coolants, lubricants and transfer medium for chip removal, need to be obtained in other ways. Dry machining has been proposed as an alternative to conventional wet machining. In addition dry machining will significantly reduce the use of metalworking fluids and can be potential reduce the amount of particulate emissions (Sreejith, 2008).

Al 6061 has been studied extensively because of their benefits such as medium strength, formability, weld ability, corrosion resistance and low cost comparing to other aluminium alloys (Alcoa, 2011). This standard structural alloy one of the most versatile of heat treatable alloys is popular for medium to high strength requirement and has a good toughness characteristic. It has been used in the automotive industry for the fabrication of several types of automobile parts, such as wheels, panels and even in the vehicle structure (Demir and Gunduz, 2009). It is expected that substitution of such aluminium alloys for steels will result in great improvements in energy economy, recyclability and life-cycle cost.

In all machining processes, tool wear is a natural phenomenon, and it leads to tool failure. The growing demands for high productivity of machining need use of high cutting velocity and feed rate. Such machining inherently produces high cutting temperature, which not only reduces tool life but also impairs the product quality. To effectively and safely machine these materials, high performance cutting tools that high hardness, high hot strength and high toughness are required (Kamata and Obikawa, 2007; Khan et. al., 2009) Coating technologies have developed rapidly to produce several types of coated tools for machining lighter non ferrous material such as Al 6061. Coating provided better results like longer tool life and better surface finish.

The use of hard wear resistant physical vapour deposition (PVD) coatings on cutting tools is now widespread in global manufacturing for reducing production costs and improving productivity, all of which is essential if industry is to remain economically competitive. Since the late 1980s, titanium aluminium nitride (TiAlN) PVD coatings have provided manufacturers with opportunities to improve cutting tool performance in aggressive machining operations (Munz, 1986). For CVD coated carbide is applicable for low to high speed machining and finishing to roughing. Stable machining is obtained due to high toughness and crack resistance.

Thus, this work is undertaken with the aim to evaluate the tool wear of PVD and CVD coated carbide insert when dry machining Al 6061. It also concentrates on the influences of cutting speed, feed rate and workpiece materials in this case is Al 6061.

Experimentation:

Turning operations were performed on Al 6061. Machining test was performed using conventional lathe machine RAMO C33. Cutting speeds 50m/min and 150m/min were employed. In addition, the feed rate used is 0.1 mm/rev and 0.4 mm/rev; depth of cut is fixed to 2 mm. The tests were performed using a different type of CVD and PVD coated carbide inserts and one PVD coated carbide inserts specially design for cutting aluminium alloy as a reference.

Corresponding Author: Syed Azuan Syed Ahmad, Department of Mechanical and Manufacturing , Universiti Kuala Lumpur Malaysia France Institute , Malaysia.
Email: syedazuan@mfi.unikl.edu.my

Table 1: PVD Cutting tool specification

Type	TN 6025	TN 6010	HC-K10
Coated Carbide	TiAIN Nano multi layer	TiAIN Nano multi layer	TiAIN-AL2O3 on micro-grain carbide
Code	(TNMG160408-AP) T : Triangular 60º N : 0º 16 : cutting length 04 : 4.76 mm thickness 08 : 0.8 for radius AP : Near net shape	(TNMG160408-22) T : Triangular 60º N : 0º 16 : cutting length 04 : 4.76 mm thickness 08 : 0.8 for radius 22 : Finishing	VCGT160404-AL3 V : Rhomboid 35º N : 7º (clearance) 16 : cutting length 04 : 4.76 mm thickness 04 : 0.4 for radius AL3:High positive
Specialization	Extremely wear resistance. Light machining. For steal or nodular cast iron in non interrupted cuts.	Light and medium machining. For difficult to machine alloys and stainless steels.	Light and medium machining. For aluminium alloys.

The cutting tools were commercial-grade PVD and CVD coated carbide supplied by WIDIA. CVD –TN 7125 and CVD-TN 7135 both have TiAIN nano multi layers. PVD –TN 6025 and PVD-TN 6010 both have TiAIN nano multi layers. For PVD-HK10, it has been coated with TiAIN-AL_20_3 micro grain carbide. Table 1 and 2 shown the technical specification for each PVD and CVD cutting tool been used. The PVD and CVD coated carbide inserts were tested under dry cutting condition.

Table 2: CVD Cutting tool specification

Type	CVD - TN7125	CVD - TN7135
Coated Carbide	TiN-TiCN-Al2O3-TiN	TiN-TiCN-Al2O3-TiN
Code	TN MG 16 04 08 - 49 N : 0º (insert clearance angle) 16 : 16mm (cutting edge length) 04 : 4.76 mm thickness 08 : 0.8 for nose radius 49 ; medium stainless steel	TN MG 16 04 08 - 5 N : 0º (insert clearance angle) 16 : 16mm (cutting edge length) 04 : 4.76 mm thickness 08 : 0.8 for nose radius 5 : medium roughing
SSpeciali zzation	Good toughness prosperity Medium and heavy machining For steel	All roughing and heavy roughing operation, wet or dry Interrupted or non-interrupted

Tool wear was measured during each machining test using a MOTIC toolmakers microscope. Average Flank wears (VB_B=0.3mm) was taken as tool wear criteria. The measurement of tool wear was carried out at regular intervals during 300 s machining time.

RESULT AND DISCUSSION

Figure 1-4 show the change in the flank wear VB_B with machining time in the machining of Al 6061. It can be seen the flank wear increases significantly when increasing feed rate from 0.1 mm/rev to 0.4 mm/rev.

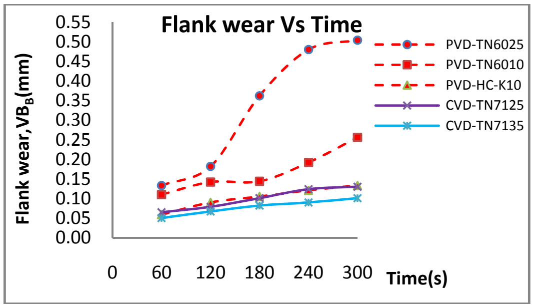

Fig. 1: Average Flank Wear at cutting speed 50 m/min, feed rate 0.1 mm/rev and depth of cut 2 mm

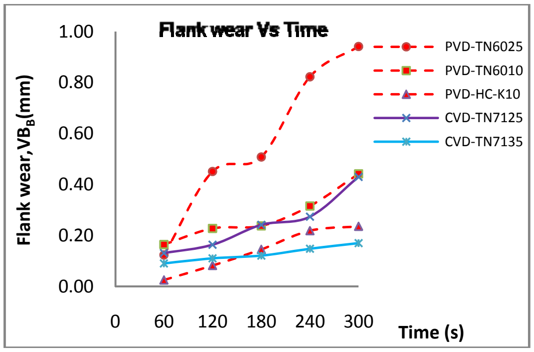

Fig. 2: Average Flank Wear at cutting speed 50 m/min, feed rate 0.4 mm/rev and depth of cut 2 mm

It was found that increasing cutting speed from 50 m/min to 150 m/min resulted in a not significant increase in the flank wear since the result maintained at the average VB_B 0.05 mm – 0.4 mm. PVD- TN6025 showed the highest flank wear compared to other coated carbides.

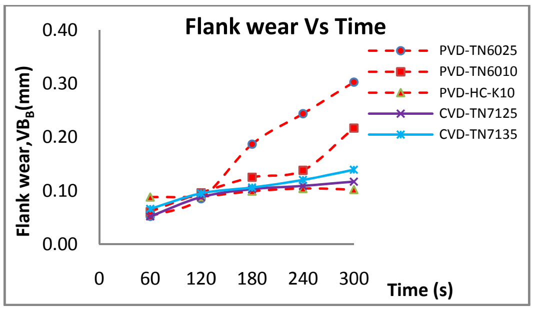

Fig. 3: Average Flank Wear at cutting speed 150 m/min, feed rate 0.1 mm/rev and depth of cut 2 mm

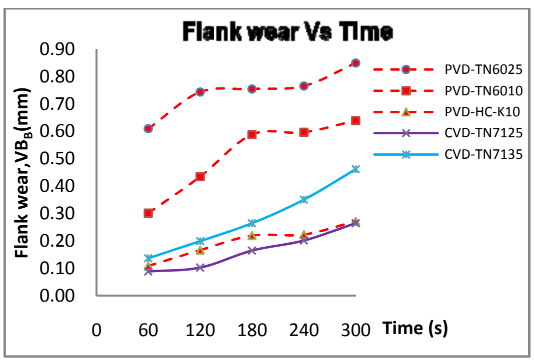

Fig. 4: Average Flank Wear at cutting speed 150 m/min, feed rate 0.4 mm/rev and depth of cut 2 mm

Overall CVD coated carbide has the same flank wear with PVD HK-10 coated carbide specially design for machining aluminium alloy. During dry machining, work material adhered to the edges of the tool. As the speed of machining increased from 50 m/min to 150 m/min, the adhesion between the tool and the chip also increased correspondingly. This could be due to the increase in thermal softening of the chip as the temperature increased with the increase in cutting speed. The formation of built-up edge (BUE) and adhesive layer on the tool rake face degrades, on the one hand, the shape and efficiency of cutting tool and on the other hand, the surface quality and dimensional accuracy of the finished product.

Conclusion:

Turning operation was performed on Al 6061 by using dry machining cutting condition. The influence of Al 6061, PVD and CVD coated carbide inserts, cutting speed and feed rate on tool wear was investigated. Based on the results obtained, the following conclusions can be drawn:

a. Material adhered when machining using dry condition.

b. Cutting speed was not the influential parameter on the tool wear. The value of tool wear is remaining the same for both cutting speed.

c. The effect of feed rate is the most influential parameter. Higher feed rate produced higher tool wear range.

d. The CVD coated carbides tools have shown lower tool wear when compared to PVD coated carbide tools.

e. The CVD coated carbide tool has shown the same performance like PVD (HC-K10) in terms of tool wear.

ACKNOWLEDGEMENT

The author is grateful to the Department of Mechanical and Manufacturing, UniKL MFI for providing the facilities to carry out the research.

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