

Performance Of EN-CBN On Carbide Tool Substrates For Aerospace Material

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KEYWORDS	ABSTRACT
Surface roughness Tool wear Respond surface method Taguchi method	Aerospace materials are hard to machine which can be done by choosing the right tools and methods. There are plenty of coated cutting tools currently used in aerospace industry such as Titanium Aluminium Nitride (TiAlN), Zirconium Nitride (ZrN), and many more. The application of coated tools has become more important in machining process and mostly been done by thermal spraying process such as Physical Vapor Deposition (PVD). The major problems of these processes are that they are costly due to high temperature and complex procedures. Electroless nickel plating is non-galvanic coating method that involves several simultaneous reactions in aqueous solution, which occur without consuming electrical power. By introducing this process, the coating cost and procedure could be simplified. The method used is by comparing tool wear of EN-CBN carbide tools substrates with uncoated carbide tool. The design of experiment is determined base on Taguchi L9 design of experiment. This involves three parameters which are cutting speed, feed rate, and depth of cut. Each of these parameters consist of three level. During the project, equipment used are Mitutoyo Surftest SJ-210 for measuring surfaces roughness, while for flank wear, ZEISS microscope is used with ZEN software. Lowest flank wear measure is 100.469 μm while the highest is 401.341 μm. The surface roughness is not consistent, the lowest roughness is recorded 0.457 μm and the highest is 1.275 μm. In the end of this analysis, the EN-CBN Carbide tool substrate generally able to slightly reduce tool wear.

1.0 INTRODUCTION

The project has focused on the comparison of cutting parameters for cutting tools substrate (coated with Ni-CBN via electroless nickel coating) material using Deckel Maho DMU 50 CNC Milling Machine. Computer Numerical Control (CNC). In industries, milling operation is a very basic type of machining.

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Traditionally, the selection of cutting conditions for machining was left to the manufacturing engineer, machine operator or machine setup technician is often expected to utilize the experience and published shop guidelines for determining the proper machining parameters to achieve a specified level of requirement condition like surface roughness and tool wear. (U. Natarajan, et al., 2014) have examined surface roughness is an important criteria to find the quality of a surface. It is an important response parameter. Surface roughness of work parts plays an important role on mechanical properties.

Specifically, the tool wear and surface roughness are measured in order to assess the surface quality of the workpiece after the milling process. (M. Nurhaniza et al., 2016) said, machining parameters and the process used are important to produce the necessary part for geometrical shapes and dimensional tolerances required. (Kant, Girish, et al, 2014) The optimization of machining parameters for minimum power requirement is expected to lead to the application of lower rated motors, drives and auxiliary equipments and hence save power not only during machining but as well as during build-up to machining, post machining and idling condition. In addition to the machining parameters, the power requirement during machining also depends upon workpiece properties and cutting tool properties.

Machining technique with the combination of high cutting speed, high feed rate and shallow depth of cut using CNC milling machine is one of the wide production technology used (Sutarman et al., 2014). By comparing this high productivity machine with conventional machine has a number of advantages, such as high efficiency, accuracy, quality of final workpieces, eliminate the secondary or semi-finishing process, increase of productivity, cut off of costs and machining time, better surface finish, eliminates the needs of coolant, reduce tool load for finishing operation and last but not least small chips are produced for easy cleaning purposes.

The materials are used in this experiment, namely; Carbide Tool, (Rachmadi Norcahyo, Bobby O.P Soepangkat, 2017) which is widely used in the manufacturing industry. carbide tool is recommended for tool insert which requires a very high wear resistance, combined with moderate toughness (shock resistance). Carbide is versatile tool, which can be used for a wide variety of cold work applications including blanking and other cutting processes, and several forming processes.

The machining parameters need to be considered for this project. For this project, the experiment made are based on the Design of Experiment (DOE) that had been made regarding the variable and parameter needed to be considered in this experiment. The experimental work will be designed using the Minitab 14 and will be analyzed using the Taguchi method. By designing the experiment, a major and minor error such as random error can be minimized and also can be avoided. With this, the data and result that come out from the experiment is reliable and trusted. (Aggarwal et al, 2008) used RSM and Taguchi's technique to investigate the effect of cutting speed, feed, depth of cut, nose radius, and cutting environment during turning of Aluminium Alloy on the power consumption. Results show that the cutting speed is the most significant factor followed by depth of cut and feed.

2.0 EXPERIMENTAL PROCEDURE

This experiment will identify the optimum machining parameters used for machining on tool steel material which is carbid coated with Ni-CBN grade using end mill 3 flutes tool in wet cutting condition. Customer always prefer the quality of product and the quality of work piece cutting surface procedure and the same time prolonged the life of tool. That is one of the main reasons of these project to compare the behaviour of the cutting parameters.

The stages of experimental:

- 1) The data of surface roughness and tool wear will be collected using surface roughness tester and the optical microscope respectively.
- 2) The CNC milling machine will be used is Deckel Maho DMU 50 CNC Milling Machine. Computer Numerical Control (CNC).

- 3) The Material used is Aluminium Alloy 7075.
- 4) The machining parameters for maximum and minimum value be considered are spindle speeds (RPM), feed rate (mm / min) and cutting depth (mm).
- 5) Three flutes end mill be used as a cutting tool and the wear of the cutting tool will be measured using an optical microscope.
- 6) The experimental work will be designed using Minitab14 and will be analyzed using Taguchi method.

The experiment used the Minitab14 to arrange the selected parameters before conducting the process of getting the sample part. For both cutting operations, the machining parameters were set into three variables which were cutting speed, feed rate and depth of cut. The details of the machining parameters are provided in Table 1 below:

Table 1: The parameters considered for conducting the experiment

Machining parameters	Units	Values
Spindle speed	(RPM)	1860 - 3450
Feed rate	(mm/min)	180 - 334
Depth of cut	(mm)	1 – 3

The Minitab14 is exploring the relationships between several explanatory variables and one or more response variables. It is a dynamic, important tool of the design of experiment (DOE) and is based on fitting empirical models with experimental data. These data are obtained from the relationship between the response and input decision variables to maximize or minimize response properties. Minitab14 is a set of statistical technique that employs linear or square polynomial function to describe and explore experimental conditions of a study system until its optimization. This method is useful for any field of engineering.

To run the experiment, the table of machining parameters that needed to be investigated during the experiment should be completed. Table 2 shows of Minitab14 for the experiment. The Table 2 can get from the analysis of variance (ANOVA) after the parameter had been keyed in the software.

Table 2: Table of Minitab14 for the experiment

StdOrder	RunOrder	PtType	Blocks	Depth of Cut	Cross Feed	Ra, μm
1	1	1	1	1	1	0.615
2	2	1	1	2	2	0.457
3	3	1	1	3	3	1.741
4	4	1	1	2	1	0.887
5	5	1	1	3	2	0.478
6	6	1	1	1	3	0.365
7	7	1	1	3	1	0.565
8	8	1	1	1	2	0.632
9	9	1	1	2	3	0.424
10	10	1	1	1	1	0.752
11	11	1	1	2	2	0.567
12	12	1	1	3	3	0.728
13	13	1	1	2	1	0.338
14	14	1	1	3	2	0.466
15	15	1	1	1	3	0.633
16	16	1	1	3	1	0.383
17	17	1	1	1	2	0.601
18	18	1	1	2	3	0.705

3.0 RESULTS AND DISCUSSION

In this section, the full result of experimental work on the machining of Carbide substrate tool using different of cutting parameters in order to assess the surface roughness and tool wear for the best understanding and legitimization.

The machining operation was set up on CNC milling machine (CNC) that is Deckel Maho DMU 50. From this study, the variables investigated was different machining parameter (spindle speed, feed rate and depth of cut) by using 3 flutes carbide end mill substrate tool with diameter of 6 mm on the workpiece. All of the data for the surface roughness and tool wear were recorded for analysis purpose.

This chapter will describe the procedure for this analysis is as stated in the methodology in term of affected on the surface roughness and tool wear on carbide substrate tool. They were measured by using Surftest SJ-210- Series 178-Portable Surface Roughness Tester for the surface roughness shown in Figure 1, while for the tool wear by using Zeiss Stemi 2000-C Microscope Profile Optical Measuring System shown in Figure 2.

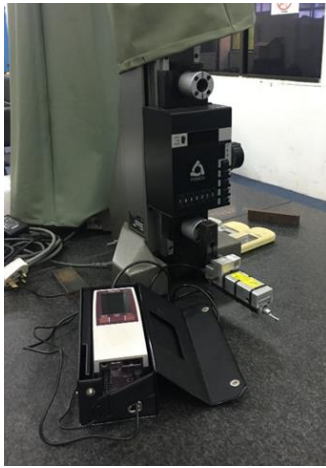


Figure 1: Surftest SJ-210-178 Portable Surface Roughness Tester

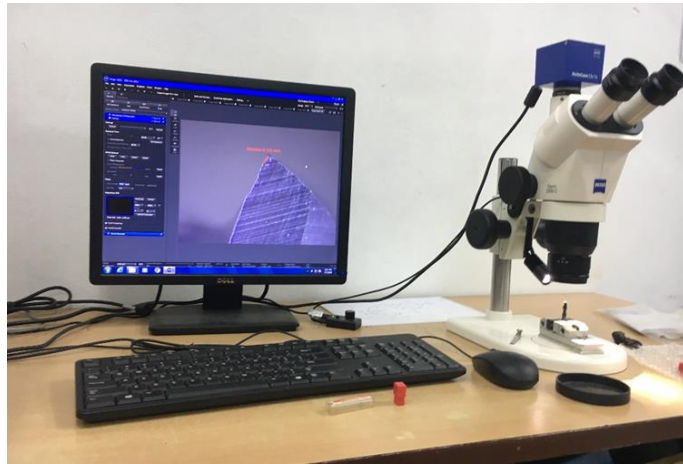


Figure 2: Zeiss Stemi 2000-C Microscope Profile Optical Measuring System

3.1 Surface roughness

The data of surface roughness on workpiece that checked using Surftest SJ-210- Series 178- Portable Surface Roughness Tester (Figure 1). Table 2 showed the design layout and experimental results for surface roughness for this experiment. The unit of surface roughness is micrometer (Ra). From the table, the lowest result of surface roughness is 0.5 Ra. The lowest result were from the machining parameter of (spindle speed: 1860 RPM, feed rate: 180mm/min, depth of cut: 3 mm). The highest result of surface roughness is 1.5 Ra. The highest result were from the machining parameter of (spindle speed: 3450 RPM, feed rate: 334mm/min, depth of cut: 3 mm).

For the analysis, the Taguchi automatically generated from the Design Expert software. Table 3 listed the Taguchi results of the surface roughness for this experimental. The Model F-value of 15.94 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise. The F-value of less than 0.0500 indicates that the selected models are significant, in this case A, C are significant model terms. The lack of fit F-value of 1, 05 implies not significantly relative to the pure error.

3.2 Main effects plot surface roughness

Figure 3 shows the surface response for the surface roughness, according to design parameter of depth of cut and cross feed. It can be seen when cross feed increase to 334 mm/min and spindle speed 2650 RPM.

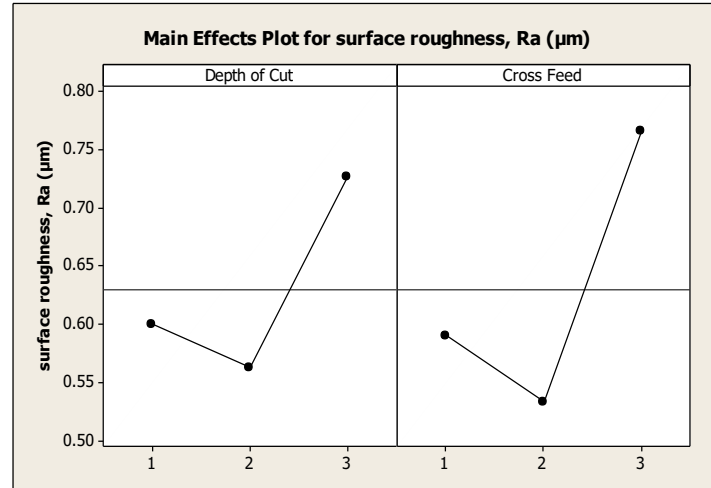


Figure 3: Main effects plot of the surface roughness

The Ra also tends decrease. Meanwhile, the increasing spindle speed 630 RPM can improves the surface Einish with reducing Ra value as the feed rate increase to 334 mm/min. So, interaction between high value of feed rate and high value of spindle speed produce good surface Einish. This is because, when combine high spindle speed and high feed rate will produce cutting force value depending on the material used and depth of cut. That the force decrease continuously due to the less energy required to determined material at higher temperature (Ghani J.A *et al.*, 2004). The interaction between the cutting speed and feed rate is signiEicantly affecting the surface roughness (Mohammed T *et al.*, 2007).

3.3 Response of surface roughness

According to the result, that was obtained from the experiment, it was shown the influenced of using aluminium oxide and machining parameters on the different level of aluminium alloy contributed of surface roughness. In another hand, software MINITAB 14 was used for analyze the influence and also the efficiency range of parameters on the magnitude of surface roughness for aluminium alloy. From Figure 4, the lowest of Ra is 0.5(μm) when the depth of cut is 3 and the cross feed 1 in low movement. The highest value of the surface roughness is 1.5 Ra (μm) when interaction between low the depth of cut 3 and the high cross feed.

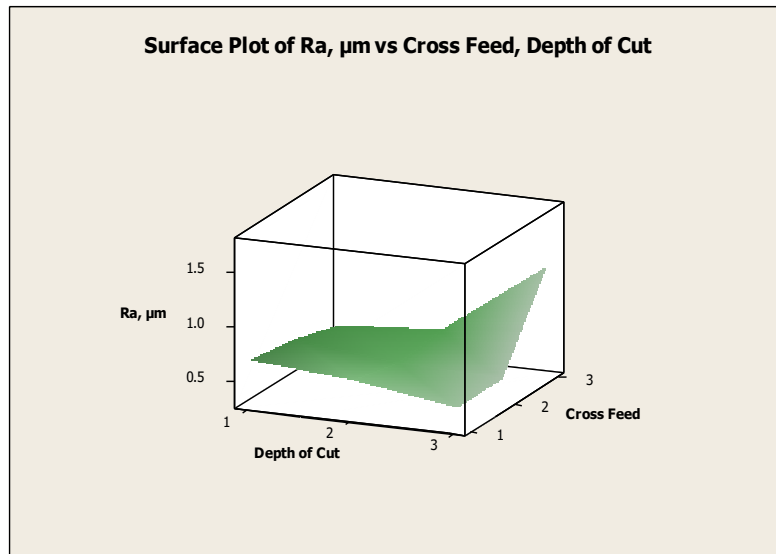


Figure 4: Surface plot

3.4 Tool wear

Test to examine the tool wear is made every 0.2 mm of machining by using the Zeiss Stemi 2000-C Microscope Profile Optical Video Measuring System could prove the presence of tool wear at each running experiment. The results evaluated by the International Standard ISO **8688-2:1989**. Through this standard, the lowest tool wear is the best and most durable. Figure 5a shows low tool wear whereas Figure 5b shows high tool wear.

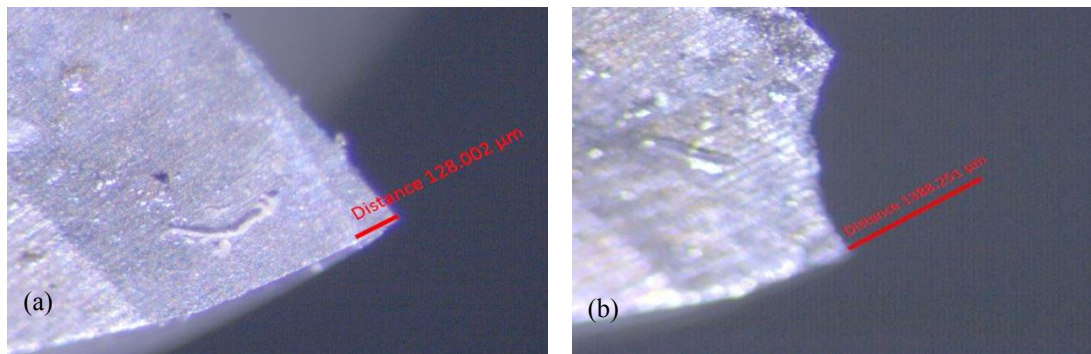


Figure 5: Microscope profile (a) Low tool wear (b) High tool wear

3.5 Flank wear vs Cutting time

Figure 6 shows the flank wear land of each cutting time, according to design parameter of feed rate and spindle speed. The highest value flank wear on coated tools is from 450mm and the cutting time 150 minutes while the higher value of flank wear on coated tools from run 1 is 386.588 mm and the cutting time is 130 minutes. The lowest value flank wear on coated tools is 378.914 μm and the cutting time is 84 minutes. The highest combination parameter and time will produce high cutting force value. This will cause the occurrence of tool wear. The interaction between the cutting speed and feed rate is significantly affecting tool wear.

Lowest flank wear measured is 100.469 μm while the highest is 401.341 μm. The surface roughness is not consistent, the lowest roughness is recorded 0.457 μm and the highest is 1.275 μm. In the end of this analysis, the EN-CBN Carbide tool substrate generally able to slightly reduce the tool wear.

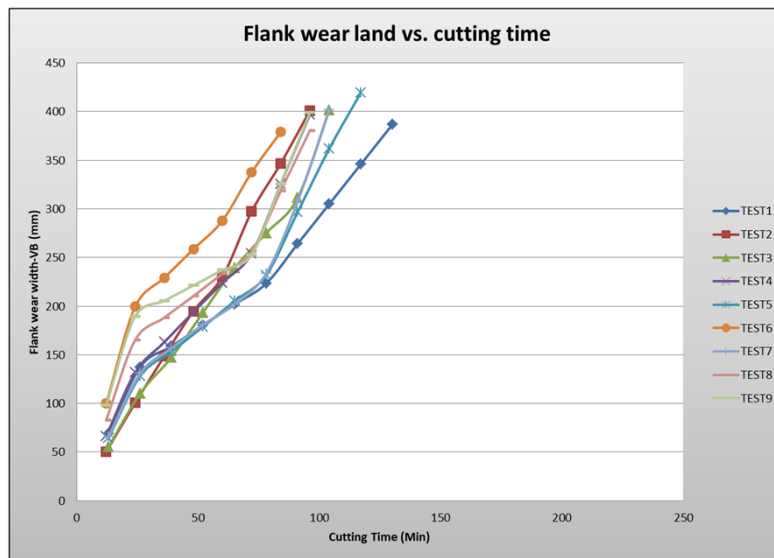


Figure 6: Flank wear vs Cutting time

4.0 CONCLUSION

According to the experiment, the main objective of this final year project were to investigate the performance cutting tools substrate that are coated with Ni-CBN via electroless nickel coating and the most significant parameter i.e. spindle speed, feed rate, depth of cut that influence surface roughness and tool wear of the material. The following conclusions are dawn based on the best result throughout this experiment in end milling operation of aluminium alloy material with coated and uncoated tools.

- I- Result show that coated with Ni-CBN via electroless nickel coating performance is not good enough when machining of aluminium alloy material using the end milling operation.
- II- The spindle speed also gives significant influences in the surface roughness (Ra). As the spindle speed increases, the higher temperature is generated which result in and increase of the surface roughness and reduces tool life.
- III- Tool life depends on the spindle speed and feed rate. The tool life is decrease with the increase of spindle speed and feed rate. The feed rate also dominant effects on the tool life and surface roughness. The optimum value for tool life which corresponds to design variables spindle speed with RPM 1860 and feed rate 180 mm/min.
- IV- Flank Wear (Vb) was increase drastically at run number 6 for coated with medium Value Cutting speed and high feed rate.

After the overall review of the study approach, it is recommended that there are several things can be noted for purposed of modification and improvement of this a better analysis. To achieve a better result in the next study, here are the lists of proposal;

- I) For to achieve better result of tool wear, use the higher optical megapixels of Zeiss Microscope. Besides that, using the SEM (Scanning Electron Microscope) must use to review types several of wear, damage cutting tool or crack.
- II) Variance of cutting method such as plugging cutting and other tools path methods by down milling mode.

III) Using the coolant as to reduce the cutting force at the cutting tool it is also can be prolonging cutting tool life

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