

Effect of CNC Lathe Machining Performance by Varying Coolant Nozzle Diameter

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Abstract

Background/Objectives: The cutting temperature is important in machining process. The temperature is a most common effect base on cutting parameters such as cutting speed, feed rate and depth of cut. Optimization of the cutting parameter can also reduce of heat temperature. This way can reduce cost and also can produce a good quality of production. **Method/Statistical Analysis:** In this study focus on effect of machining the aluminum alloy AL6061 by using a various diameter coolant nozzle during CNC lathe process of its inherent advantages. Hence, it also studies the effect of cutting temperature to the surface roughness and dimensional error that will be considered with the parameters to arrive at a conclusive result. Taguchi method orthogonal array L16' was selected as an experimental plan for turning on AL6061 by using CNC PUMA 230 turner with carbide tool insert. The L16' array used 5 factors and 4 levels in conduct the temperature measurement. **Findings:** Results show that the dominant failure mode is the surface roughness and dimensional accuracy when the nozzle orifice size increases during machining of aluminum alloy AL6061. The exploration for dimensional accuracy, productivity and the optimization of cutting speed in the technical and commercial aspects of the manufacturing processes of aluminum AL6061 are discussed in oil and gas components industries for further work. **Applications/Improvements:** Conclusion and recommendations will suggest an enhancement to this application.

Keywords: Cutting Temperature, Dimensional Error, Nozzle Diameter, Surface Roughness, Turning

1. Introduction

The cutting temperature most related to the machining process. Today's in the manufacturing engineering industry, the optimization of metal cutting processes is important to respond effectively to increasing demand of quality production¹ and reduce costing². Knowledge of cutting temperature is also important where it can affect the wear of the cutting tool, induces thermal damage to the machined surface roughness and cause of dimensional error. In machining processes, surface roughness is one of the most important where quality of surface is the most requirements from customer needed³. High temperature can control using cutting fluid. The coolant is applied in machining process can

reduce temperature and also help with disposal of the chip⁴. The aim of this experiment is to achieve the objectives of the experiment to analyze the best parameter and diameter of coolant nozzle in machining on cutting temperature effect to surface roughness and dimension error.

2. Purpose/Motivation/Problem Statement of the Study

Cutting process usually generates heat which depends on the cutting speed, materials and type of coolant. Hence, the study is to investigate the effect of varying coolant nozzle diameter on cutting process that will control the speed and amount of coolant during cutting.

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3. Experimental Method

The experimental method in the study was referred to the flowchart as shown in Figure 1. The main parameter was the coolant nozzle diameter. Once the machine parameters were well set up, the Taguchi Design of Experiment (DoE) was run and three responses of the DoE, i.e., surface roughness, dimensional error and temperature were measured. All data were collected and recorded and DoE was analyzed by using statistical tools.

The parameters and levels selected in this experiment for Taguchi DoE were tabulated in Table 1. Table 2 shows the Taguchi orthogonal array of 5 parameters with 4 levels, which involves 16 experiment runs.

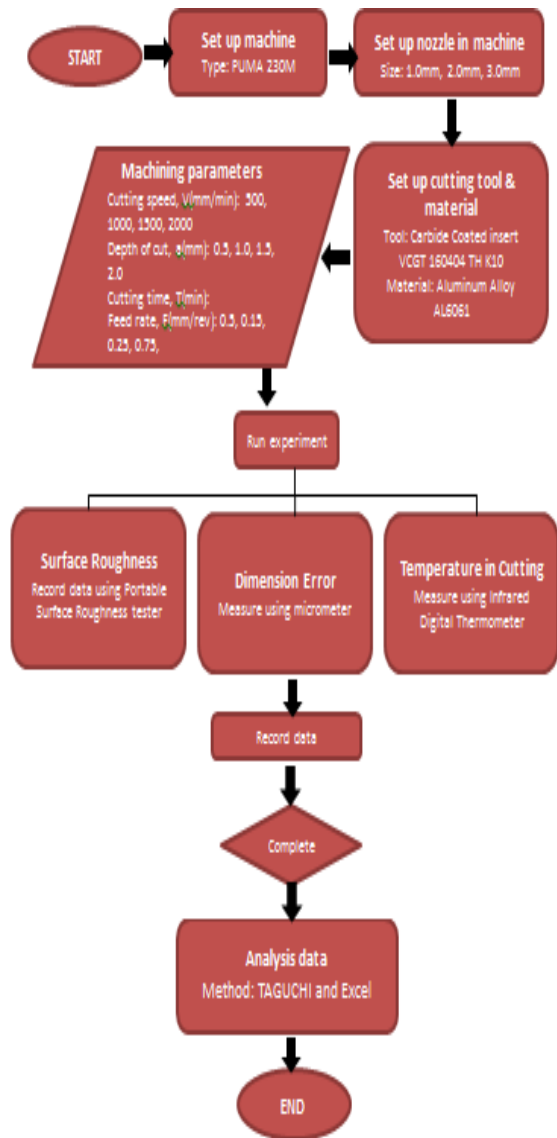


Figure 1. Flowchart of experiment.

Table 1. Experiment parameters and its levels

Factors	Parameter	Level 1	Level 2	Level 3	Level 4
P1	Cutting Speed (m/min)	500	1000	1500	2000
P2	Feed Rate (mm/rev)	0.15	0.25	0.5	0.75
P3	Depth of Cut (mm)	0.5	1.0	1.5	2.0
P4	Diameter of Nozzle (mm)	1	2	3	4
P5	Time (minute)	2	4	6	8

Table 2. Design matrix of orthogonal array L16'(5⁴) of Taguchi DoE

Experiment Run	P1	P2	P3	P4	P5
1	1	1	1	1	1
2	1	2	2	2	2
3	1	3	3	3	3
4	1	4	4	4	4
5	2	1	2	3	4
6	2	2	1	4	3
7	2	3	4	1	2
8	2	4	3	2	1
9	3	1	3	4	2
10	3	2	4	3	1
11	3	3	1	2	4
12	3	4	2	1	3
13	4	1	4	2	3
14	4	2	3	1	4
15	4	3	2	4	1
16	4	4	1	3	2

3.1 Temperature Measurement

An infrared digital thermometer was used to measure the temperature during machining. Figure 2 shows the process of temperature measurement during turning process of aluminum alloy AL6061.

3.2 Surface Roughness Test

The surface roughness is measured by Mitutoyo Surface Roughness as shown in Figure 3, where the roughness value

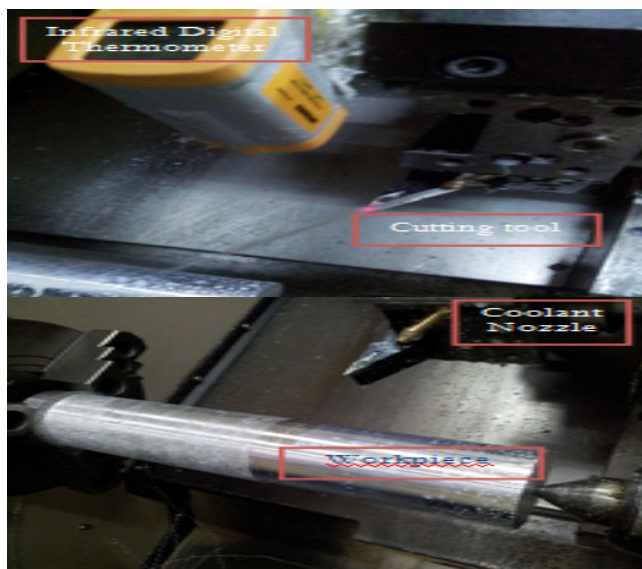


Figure 2. Process of temperature measurement.



Figure 3. Surface roughness test.

is in (Ra). The readings were taken for every each part of the experiment from experiment number 1 until 16.

3.3 Dimensional Error

Dimension error was measured as a function of the experiment cutting parameter, and it also appears on the machined surface in the beginning of the cutting. The tool

elongates as a result of the increase in temperature and the position of cutting tool edge shifts toward the machined surface. This resulted in a dimensional error of about 0.01~0.02 mm. 4 shows the measurement of dimensional error of the experiment.

4. Results and Discussion

The objective of this experiment to study the effect of CNC lathe turning parameters on cutting performance such as cutting temperature, surface roughness and dimensional error by varying coolant nozzle diameter. The target of the Taguchi DoE is to achieve “the smaller the better” characteristics. The temperature response at varying nozzle diameter was shown in Figure 5.

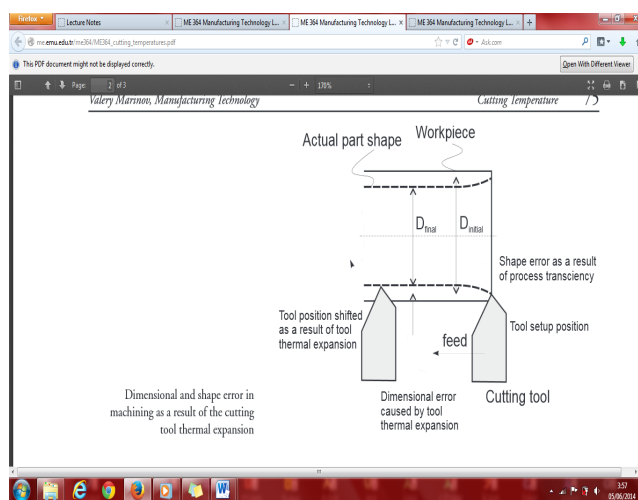


Figure 4. Dimensional and shape error in machining as a result of the cutting tool thermal expansion.

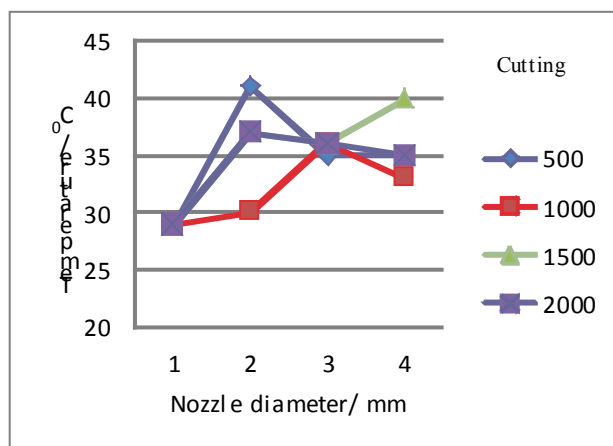


Figure 5. Temperature versus coolant nozzle diameter.

Generally, there is no direct relationship of temperature increase with coolant nozzle diameter. The best coolant nozzle diameter is 1.0 mm for all cutting speed at temperature of 29°C. As the nozzle diameter reduced, the speed of the coolant is increased and the volume of coolant to the targeted point is also concentrated.

Figure 6 shows the effect of surface roughness at various diameters of coolant nozzle. Similarly, there is no direct relationship between surface roughness and coolant nozzle diameter. The lower value of Ra is 1.32 μm at cutting speed of 500 m/min for coolant nozzle diameter of 1mm as shown in Figure 6.

The result of dimensional errors at various nozzle diameters is shown in Figure 7. It was found that dimensional

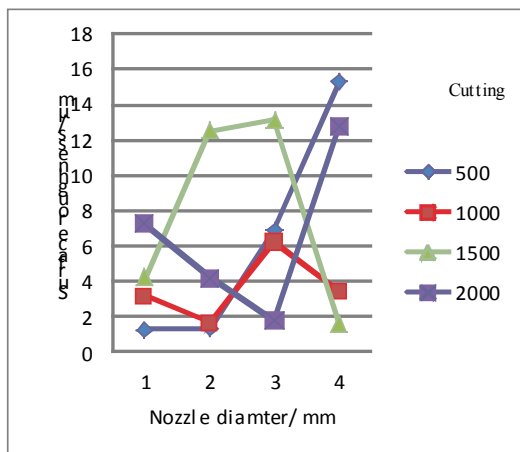


Figure 6. Surface roughness versus coolant nozzle diameter.

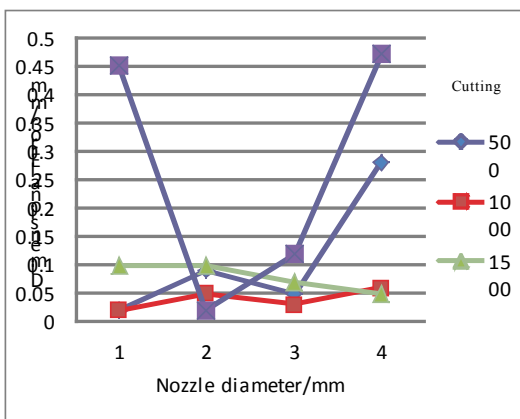


Figure 7. Dimensional error versus diameter of coolant nozzle.

error was not much affected by varying coolant nozzle diameter at cutting speed 500–1500 m/min. High effect was found at high cutting speed of 2000 m/min. The lowest effect of dimensional error was found at cutting speed 500 and 1000 m/min for coolant nozzle diameter of 1 mm. The value of dimensional error at this point is 0.02 mm.

5. Conclusion

The analysis of this study shows that the diameter of coolant nozzle in machining process is the primary influencing factors which affect the temperature, surface roughness and dimension error. The result of using a various diameter of coolant nozzle 1.0 mm produces the best result in experimental, where the high pressure reduces the chip to become good machined surface which the result agreed with previous studies. The results indicate the best optimum parameter for reducing response while parameters also in lower value cutting speed is 500 m/min, feed rate 0.15 mm/rev and depth of cut 0.5 mm.

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