Indian Journal of Science and Technology, Vol 9(9), DOI: 10.17485/ijst/2016/v9i9/88713, March 2016 ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Effect of Coolant Nozzle Sizes on Turning Aluminum Alloy AL319

Zainal Ariffin Selamat[1*], Nor Bahiyah Baba[1], Mohd Alias[1], Ahmad Razlan Yusoff[2] and Md. Mustafizur Rahman[3]

[1]Faculty of Manufacturing Engineering Technology, TATI University College, Kemaman, Terengganu, Malaysia; zainal@tatiuc.edu.my, bahiyah@tatiuc.edu.my, aliasmohd@tatiuc.edu,
[2]Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, Gambang, Kuantan, Pahang, Malaysia; razlan@ump.edu.my
[3]Faculty of Mechanical Engineering, Universiti Malaysia Pahang, Gambang, Kuantan, Pahang, Malaysia; mustafizur@ump.edu.my

Abstract

Background/Objectives: The paper discusses about the optimum cutting parameters with combination of various sizes of nozzle coolant to optimize the surface roughness, chips deformation and dimensional accuracy in the turning process based on the selected setting parameters. The selected cutting parameters for this study were the cutting speed, feed rate, depth of cut and various diameters of nozzle coolant. **Methods/Statistical Analysis:** Experiments were conducted and investigated based on Design of Experiment (DOE) with Taguchi method. The research of the aggressive turning process on aluminum alloy (A319) for automotive applications is an effort to understand the high speed machining concept, which widely used in a variety of manufacturing industries especially in the automotive industry. **Findings:** The results show that the dominant failure mode is the surface roughness and dimensional accuracy when the nozzle orifice size increases during machining of the A319. The exploration for dimensional accuracy, productivity and the optimization of cutting speed in the technical and commercial aspects of the manufacturing processes of A319 are discussed in automotive components industries for further work. **Applications/Improvements:** The result of this study shows that the effectiveness and efficiency of the system can be identified and helps to solve potential problems.

Keywords: Aluminum Alloy (A319), Nozzle Coolants, Turning Operation, Taguchi Method

1. Introduction

The challenge of modern machining industries is mainly focused on the achievement of high quality in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving, increase the performance of the product with reduced environmental impact[1,2]. A significant methodology was adopted to conduct these experiments in organized the procedure which based on Taguchi L9 (4^3) method for Design of Experiment (DOE). It is a statistical tool which adopted experimentally to investigate the influence of surface roughness, chips deformation and dimensional error by using cutting parameters such as cutting speed, feed rate and depth of cut. From Figure 1, it uses three different sizes of nozzle orifice which are 2 mm, 3 mm and 4 mm internal diameter with two extension nozzles of 31 mm and 17 mm. The function is to deliver different pressure directly to the cutting area. The tool holder allows the cutting fluids to flow through the chip area via special designed of nozzle orifice. It is to prove that the differences in nozzle diameter are the key factor that affects the pressure and flow rate, as shown in Figure 1.

* Author for correspondence

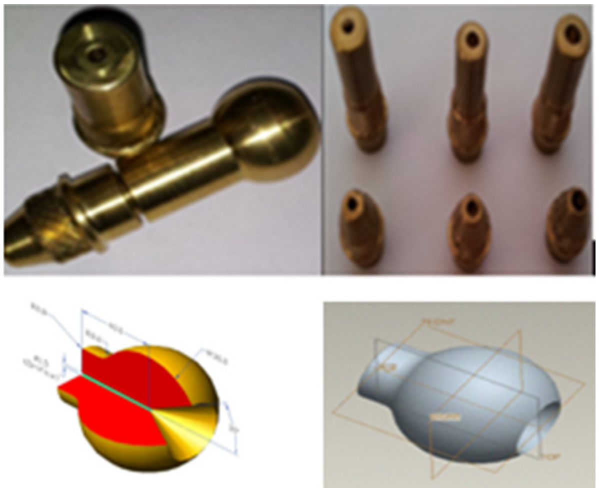


Figure 1. Design of various types of nozzle coolants.

2. Methodology

2.1 Machine Tool and Equipment

All experiments were carried by MORI SEIKI NL2500 CNC turn mill machine, as shown in Figure 2(a). Different size of nozzle coolants were attached to the insert of VCGT160404 FK10 Computer Numerical Control (CNC) carbide turning[3].

(a)

The experimental work was carried out based on the interchangeable with various of nozzle orifices by using 2.0 mm, 3.0 mm and 4.0 mm size. The material used was aluminum alloy (A319). The work piece has a hardness of about 95 to 97 BHN, the Brinell hardness number. It was used in the form of round bar with 50 mm in diameter and 250 mm in length.

The flow rate and inlet temperature of the cutting fluid soluble oil used is 10 liters/min and 27˚C respectively, as shown in Table 1(a).

Table 1. (**a**) Parameters of the cutting fluid (**b**) Design of experiment parameters and its levels

Cutting Fluid	Soluble Oil
Fluid oil concentration	5%. (vol.)
Cutting fluid flow rate	10 liters/min
Fluid inlet temperature	27°C

The machined workpiece was measured in terms of its surface roughness, dimensional accuracy as well as type of chip formation[4]. The surface roughness (Ra) was measured by using a portable surface profilometer, Mitutoyo SJ-301. The dimensional error was measured by using Mitotuyo micrometer. This process was to check the diameter accuracy of the work piece.

The type of chip produced depends on the material which being machined and the cutting conditions at that time. These conditions include the type of tool used, rate of cutting condition of the machine and the use or absence of a cutting fluid. Besides, the chip formation was significantly different with the variation of process parameters[5]. All chips will be classified according to ISO3685-1977(E) and ANSI/A SME B94 55M-1985.

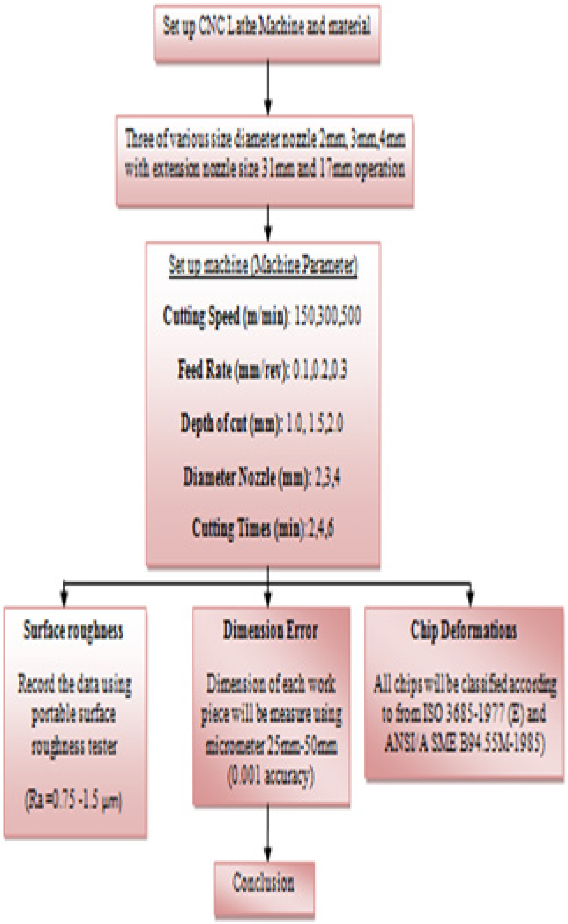
2.2 Design of Experiment Taguchi Method

The experimental design was according to L9 array based on Taguchi method. It was designed to investigate the effect of different size of coolant nozzle on turning process parameters. Orthogonal array L9 is divided into 4 parameters[6,7]. Each of them has 3 levels with different value parameter in each range, as shown in Table 1(b).

(b)

Factors	Parameter	Level 1	Level 2	Level 3
P1	Cutting speed (m/min)	150	300	500
P2	Feed rate (mm/rev)	0.1	0.2	0.3
P3	Depth of cut (mm)	1.0	1.5	2.0
P4	Nozzle size (mm)	2	3	4

The overall working procedure is simplified in Figure 2 (b).



(b)

Figure 2. (**a**) Experimental procedures with simplified tool and work piece model. (**b**) Flowchart of the overall experimental procedures.

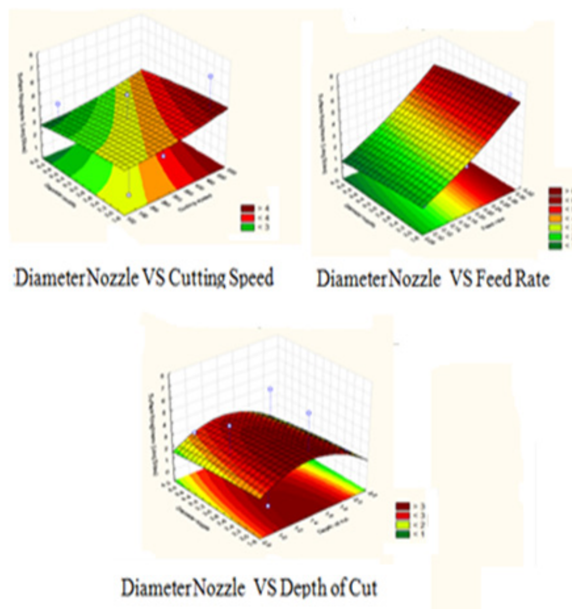
3. Results and Discussion

The study discusses on the effect of varying different sizes of coolant nozzle and machining parameters on turning A319. The surface roughness, dimensional error and types of chip formation as a result of turning process by using CNC turn mill was evaluated and analyzed. The effect in different diameter of coolant nozzle size on these three responses is investigated and justified.

3.1 Surface Roughness

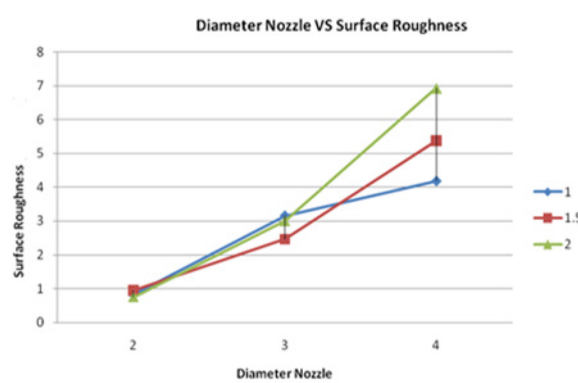
The three dimensional representation of machining parameters on the surface roughness was illustrated in Figure 3(a). It shows the coolant nozzle diameter of 2.0 mm which produces the best performance with an average surface roughness of 0.75 Ra. The parameters used are cutting speed of 500 m/min, feed rate 0.3 mm/rev and depth of cut is 2 mm.

The surface roughness for 0.83 Ra also provide the same results with coolant nozzle of 2.0 mm, but the surface roughness of 0.75 Ra used is a small amount of 0.63.



(a)

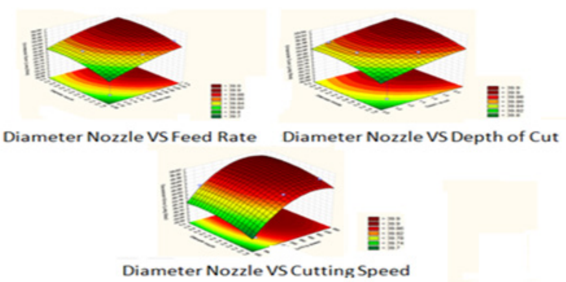
Figure 3(b) shows the relationship between various diameter nozzles on surface roughness. The experiment shows that by using 2.0 mm diameter nozzle size, the minimum surface roughness can be achieved at 0.75 µm as compared with the other size nozzle diameter. Therefore, 2 mm diameter nozzle is the best suited to achieve an optimum surface roughness.



(b)

3.2 Dimensional Error

As shown in Figure 3(c), when cutting speed increased at 500m/min the value of dimensional error is also increasing to 39.89 as compared to the cutting speed at 150 m/min with the value of 39.67. With nozzle diameters of 2.0 mm together with cutting parameters such as feed rate value of 0.1 mm/rev and depth of cut 1.0 mm, the cutting speed of 150 m/min could achieve a lower dimensional error.



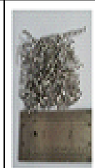
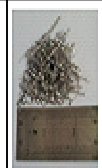
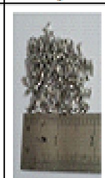
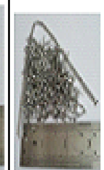
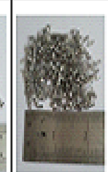
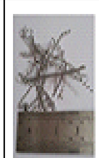
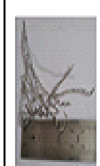
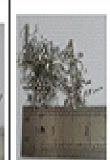
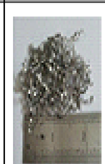
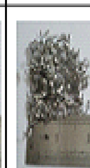
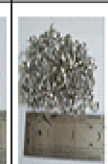
(c)

3.3 Chip Formation

Figure 3(d) shows the type of chips produced during machining depending on the cutting conditions. It includes the rate of cutting condition of the machine and the use or absence of a cutting fluid[6]. The mechanism of chip formation and separation is due to the extreme strain rate that occurs during the machining process. The shape of chip deformation produced like ribbon, tubular, spiral, washer and conical helical chips are regularly formed during cutting process especially in turning operation.

4. Conclusion

The following conclusions are drawn based on the results throughout the research on aluminum alloy AL6061 coated with carbide Al_2O_3 that inserted by using various sizes of nozzle with internal orifice nozzle of 2.0 mm, 3.0 mm and 4.0 mm. The optimum and suitable parameter setting also plays an important role in determining the surface roughness, dimension error and chip deformation. Cutting at high cutting speed is the optimum situation for aluminium alloy (AL319). Increasing the cutting speed and feed rate, produces better surface roughness. Based on the analysis of this study, the diameter of coolant nozzle in machining process is the primary influencing factor which affects the type of chip deformation, surface roughness and dimension error. The result is shown by using various diameters of coolant nozzles of which 2.0 mm produces the best result.

EXP.	PARAMETER				CHIP DEFORMATION		
	Cutting speed	Feed rate	Depth of cut	Diameter nozzle	2 MIN	4 MIN	6 MIN
1	150	0.1	1.0	2	 Elemental Chips	 Elemental and Conical Chips	 Washer Type Helical Chips
2	150	0.2	1.5	3	 Arc Chips	 Elemental and Conical Chips	 Conical Chips
3	150	0.3	2.0	4	 Washer Type Helical Chips	 Washer Type Helical Chips	 Ribbon Chips
4	300	0.1	1.5	4	 Arc Chips	 Arc Chips	 Arc Chips

(d)

Figure 3. (**a**) The effect of various diameter sizes of nozzle on surface roughness and cutting speed, feed rate and depth of cut. (**b**) Effect of various diameters of nozzles on surface roughness. (**c**) The effect of various diameter sizes of nozzle on dimension error, cutting speed, feed rate and depth of cut. (**d**) Comparison chip formation between parameter with experiment.

5. Acknowledgment

Firstly, I wish to express my sincere appreciation to TATIUC for a short grant number of 9001-1201 and UMP. Last but not least, I would like to thanks to anyone who contributes to my final research directly or indirectly.

6. References

1. Cerri E, Evangelista E, Spigarelli S, Cavaliere P, DeRiccardis F. Effects of thermal treatments on microstructure and mechanical properties in a thixocast 319 aluminum alloy. Materials Science and Engineering: A. 2000; 284(1):254–60.
2. Prakash S, Mercy JL, Goswami K. A systemic approach for evaluating surface roughness parameters during drilling of medium density fiberboard using Taguchi method. Indian Journal of Science and Technology. 2014; 7(11):1888–94.
3. Feng CX. An experimental study of the impact of turning parameters on surface roughness. Proceedings of the Industrial Engineering Research Conference; Norcross, USA, Bradley University, Institute of Industrial Engineers. 2001. p. 1–11.
4. Abhang LB, Hameedullah M. The measurement of chip-tool interface temperature in the turning of steel. International Journal of Computer Communication and Information System. 2010; 2(1):1–5.
5. Ozel T, Karpat Y. Predictive modeling of surface roughness and tool wear in hard turning using regression and neural networks. International Journal of Machine Tools and Manufacture. 2005; 45(4):467–79.
6. Lawal SA. A review of application of vegetable oil-based cutting fluids in machining non-ferrous metals. Indian Journal of Science and Technology. 2013; 6(1):3951–6.
7. Roy RK. A primer on the Taguchi method. Michigan: Society of Manufacturing Engineers; 2010.