International Journal of Engineering Research and Advanced Technology (IJERAT)

DOI: http://doi.org/10.31695/IJERAT.2018.3347

E-ISSN : 2454-6135

Volume.4, Issue 12
December -2018

Investigation of the Effect of Different Working Mediums on Turning Al7075-T6 Alloy

Suleyman Cinar Cagan[1] and Dr. Berat Baris Buldum[1]

Research Scholar[1]

Department of Mechanical Engineering[1]

Mersin University, Engineering Faculty

Mersin

Turkey

ABSTRACT

The surface quality of the manufactured parts is an important factor affecting the functional properties such as corrosion resistance, the fatigue strength of the part. For this reason, this study aims to develop surface roughness of Al 7075-T6 alloy material which is generally used in the aviation and manufacturing industry. In this study, the machinability of Al 7075-T6 alloy with different high speed turning parameters was investigated. Two different mediums (Dry and boron oil), three different cutting speeds (400, 800 and 1600 m/min) and three different feed rates (0.1, 0.2 and 0.4 mm/rev) were determined as parameters in the experiments. The optimum parameters for the determination of surface roughness values of Al 7075-T6 alloy were determined. The most important parameters affecting the surface roughness of the Al 7075-T6 alloy have been found out to be the feed rate. It appears that the medium and cutting speed examined have not had a significant effect on the surface roughness. When the test results are taken into consideration, the best surface roughness value is reached with parameters: medium: boron oil, cutting speed 400 m/min and feed rate: 0.1 mm/rev.

Key Words: *Al 7075-T6 alloy, Turning, Taguchi method, Surface roughness.*

1. INTRODUCTION

Aluminum and its alloys have become increasingly industrialized due to their lightweight as well as their strength and easy forming ability [1-3]. Aluminum alloys play a significant role in the development of space, aviation, automotive, weapons and defence industry due to their mechanical properties as well as their lightweight (density is 2.81 g/cm3). Within these alloys, the importance and application areas of 7075-T6 grade aluminum alloys are increasing especially in the defence and aerospace industry [4, 5].

Machinability, the material is expressed as a convenience or difficulty in machining in a chip removal process involving cutting conditions such as cutting speed, feed rate, cutting force, number of passes, and chip depth [6, 7]. Machinability of a material can be defined by measuring components such as tool wear, chip formation, tool life, surface roughness and cutting force [6, 8]. Surface roughness is one of the most important characteristics affecting the product quality and is of great importance in the functional behaviour of the machined parts [9-11]. The manufacturing process is the process of converting the raw materials planned to be used for various purposes into finished products [12]. Products with poor surface quality cannot meet the functional requirements and cause extremely high production costs [13]. Therefore, the improvement of the surface quality of the products and the economics of the production processes become a very important issue for the production of finished products [14, 15]. Although there are studies about the machinability of aluminum alloys, it is observed that there is the limited number of studies on the effect of the turning process of Al 7075-T6 on the surface quality.

In this study, the effect of surface roughness on the different parameters (mediums, cutting speed and feed rate) of the Al 7075-T6 alloy turning process was investigated. Also, the experimental design was planned by selecting L_{18} Taguchi method. In this study, it is aimed to determine the optimum parameters of Al7075-T6 alloy material, which is a limited number of studies in the literature.

2. MATERIALS AND METHODS

2.1. Material and Experiments

In the experiments, Al 7075-T6 filled cylinder was used as the workpiece. This workpiece material's dimensions were Ø50 x 280 mm. The chemical content of the workpiece as Al 7075-T6 is presented in Table 1. The roughness value of the workpiece surface was measured as 0.501 μm before starting the turning tests.

Table 1. The chemical composition of Al 7075-T6 workpiece material (wt. %)

Material	Zn	Mg	Cu	Fe	Si	Mn	Cr	Ti	Al
Al7075-T6	5.63	2.71	1.94	0.45	0.37	0.25	0.21	0.19	Balance

The turning experiments have performed a lathe as shown in Figure 1. According to the determined parameters, each sample was subjected to separate turning process and the surface roughness of the samples was determined by means of the surface roughness measuring device. CCGT 431-AS IC20 was used as cutting tool insert. This tool insert has good performance in machining Aluminum alloys.

Figure 1. The experimental setup

The Taguchi method is an easy and efficient method for determining the optimization of parameters [16]. This method is cheap, easy and is used widely in the manufacturing sector due to the decrease in the number of experiments. Table 2 depicts the parameters used in the experiments. In this study, the turning process was performed in 2 different mediums, 3 different cutting speeds and feed rate parameters. For this reason, the L_{18} design of the Taguchi method was used (Table 3). For the analysis of the experimental results, the interactions between the main factors were not taken into consideration and the S/N ratio was calculated for each experiment. The S/N ratio is defined as a measure of the sensitivity of system performance to design parameters to the sensitivity of system performance to noise factors. “Smaller is better” was preferred for calculating the S/N ratio to achieve the best performance result of the factors in this study, ‘Smaller is better’ was computed by the undermentioned equation (1).

$$S/N = -10\log\left(\frac{1}{N}\left(\sum_{i=1}^{n} Y_i^2\right)\right) \quad (1)$$

Y_i is the surface roughness value, n is the number of tests and N is the total number of data points for equation (1).

Table 2. Turning process parameters and levels.

DOI : 10.31695/IJERAT.2018.3347

Parameters	Units	Levels		
		1	2	3
Medium	-	Dry	Boron oil	-
Cutting Speed	m/min	400	800	1600
Feed rate	mm/rev	0.1	0.2	0.4

Table 3. Taguchi experimental design

Experiments	Medium	Cutting Speed	Feed rate
1	1	1	1
2	1	1	2
3	1	1	3
4	1	2	1
5	1	2	2
6	1	2	3
7	1	3	1
8	1	3	2
9	1	3	3
10	2	1	1
11	2	1	2
12	2	1	3
13	2	2	1
14	2	2	2
15	2	2	3
16	2	3	1
17	2	3	2
18	2	3	3

2.2. Measurements

The surface roughness is used as a measure in determining the surface properties of the workpiece materials [17]. After any test procedure applied to the workpiece, changes in the surface topography of the material occur at the micro level. The determination of these changes is vital in terms of the mechanical properties of the workpiece materials [17]. Surface roughness helps to determine the performance of any mechanical component as having the strategic designation because surface irregularities can cause cracks or corrosion initiation. The surface roughness value is generally calculated by taking into account the arithmetic mean values of the absolute values (Ra) [18]. Referring to Figure 2, the Ra value can be expressed by the following equations:

$$\mathrm{R_a} = \frac{1}{L}\int_0^L |y|\,dx = \frac{1}{L}\left(\sum S_{ui} + \sum S_{lj}\right) = \frac{S}{L} \quad (2)$$

Therefore,

$$R_a = R_t(S_u + S_l) \quad (3)$$

DOI : 10.31695/IJERAT.2018.3347

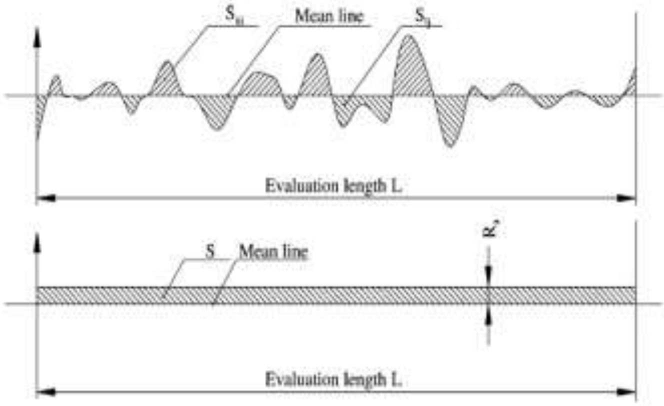

Figure 2. Scheme of surface roughness [18]

The surface roughness data of the specimens are taken from three different parts of the Al 7075-T6 workpiece material. Surface roughness tests were carried out using a surface profilometer.

3. RESULTS AND DISCUSSION

3.1. Experimental results

Table 4 shows the surface roughness values obtained after turning Al 7075-T6 workpiece. Furthermore, the measured Ra values are the average value of the three valid measurements and the standard deviation values are also indicated. S / N ratios were calculated according to these measured Ra values.

Table 4. Experimental layout and results of the responses using L_{18} Taguchi design

Experiments	Parameters			Results		
	Medium	Cutting speed	Feed rate	Ra (µm)	Standard Deviation	S/N Ra
1	Dry	400	0.1	0.336	0.0445	9.4732
2	Dry	400	0.2	0.501	0.0163	6.0032
3	Dry	400	0.4	1.162	0.0990	-1.3041
4	Dry	800	0.1	0.464	0.0184	6.6696
5	Dry	800	0.2	0.679	0.0042	3.3626
6	Dry	800	0.4	1.426	0.0531	-3.0824
7	Dry	1600	0.1	0.453	0.0771	6.8780
8	Dry	1600	0.2	0.699	0.0467	3.1105
9	Dry	1600	0.4	1.977	0.0361	-5.9201
10	Boron oil	400	0.1	0.248	0.0560	12.1110
11	Boron oil	400	0.2	0.391	0.0010	8.1565
12	Boron oil	400	0.4	1.043	0.0800	-0.3657
13	Boron oil	800	0.1	0.439	0.0158	7.1507
14	Boron oil	800	0.2	0.607	0.0002	4.3362
15	Boron oil	800	0.4	1.351	0.0821	-2.6131
16	Boron oil	1600	0.1	0.360	0.0084	8.8739
17	Boron oil	1600	0.2	0.605	0.0074	4.3649
18	Boron oil	1600	0.4	1.435	0.0159	-3.1370

DOI : 10.31695/IJERAT.2018.3347

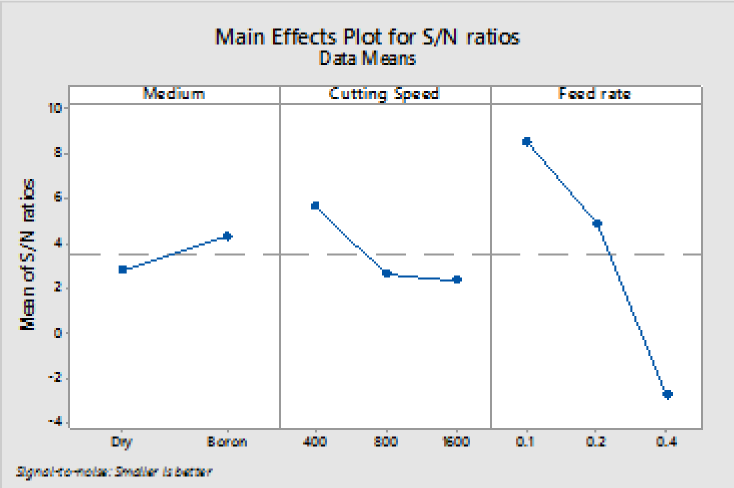

Figure 3. Change of Ra results to calculated S/N ratios

When the Figure 3. of average S / N ratios were examined according to the parameters, it was observed that the surface quality of the Al 7075-T6 workpiece obtained in boron oil was better than the dry medium. The surface roughness value of the lower cutting speeds is lower and the surface roughness value increases as the speeds increase. A significant increase in surface roughness value from 400 m/min to 800 m/min was observed, but a slight change from 800 m/min to 1600 m/min was observed. Again, it was observed that the surface quality was better in the experiments performed at low feed rates. It can be concluded that when the feed rate is increased from 0.1 mm/rev to 0.4 mm/rev, the quality of the surface deteriorates significantly. The S/N ratios and main effects plot were calculated using MINITAB 18 statistical software program. Figure 4 (a) and (b) show the effect of cutting speed and feed rate on surface roughness during turning process in different mediums.

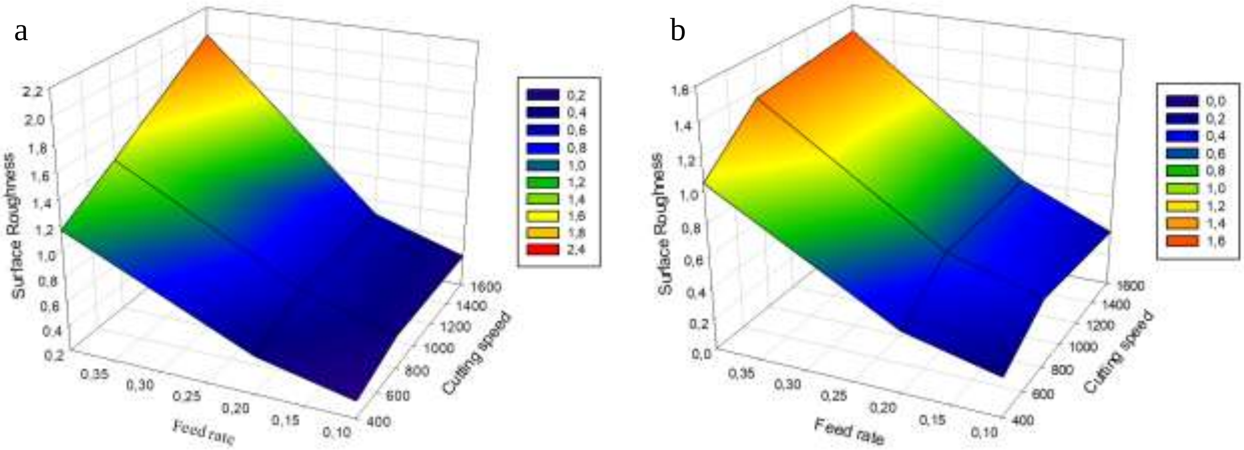

Figure 4. (a) Effect of feed rate and cutting speed on surface roughness in dry medium, (b) Effect of feed rate and cutting speed on surface roughness in boron oil medium

3.2. Analysis of Variance (ANOVA)

The ANOVA helps in order to obtain data such as degrees of freedom (DF), F-value, P-value, mean squares (MS), the sum of squares (SS) and percent contribution, and helps to determine how much "variation" and "which" factor by using these values. ANOVA is used to investigate process parameters and identify which process parameters are significantly affecting the turning process. ANOVA calculated and presented the Table 5. From the ANOVA table, the most significant parameter is feed rate it influences 84.8% followed by 7.3% of cutting speed and 2.0% of medium. Both Taguchi and ANOVA analysis identify feed rate most significant factor than the others. Contribution percentage of the face-turning parameters are shown in Figure 5. The F-test was used to find out which turning parameters have a significant effect on the performance characteristic. Generally, the variation of the turning parameters has an important relationship between the numerical value of F and performance features. The larger the F-value, the greater the effect of parameters on the result obtained. Considering the data in Table 5, it is seen that the feed rate parameter is the most dominant factor affecting the surface roughness. In ANOVA modeling the R^2 is found as 94.09 %. The high score of the high R^2 makes reliable the equation for this modeling.

DOI : 10.31695/IJERAT.2018.3347

Table 5. ANOVA results for surface roughness

Parameters	DF	SS	MS	F-Value	P-Value	% Contribution
Mediums	1	0.08242	0.08242	4.08	0.0660	2.0
Cutting speed (m/min)	2	0.29907	0.14954	7.39	0.0080	7.3
Feed rate (mm/rev)	2	3.48121	1.74060	86.07	0.0001	84.8
Error	12	0.24266	0.02022			5.9
Total	17	4.10536				

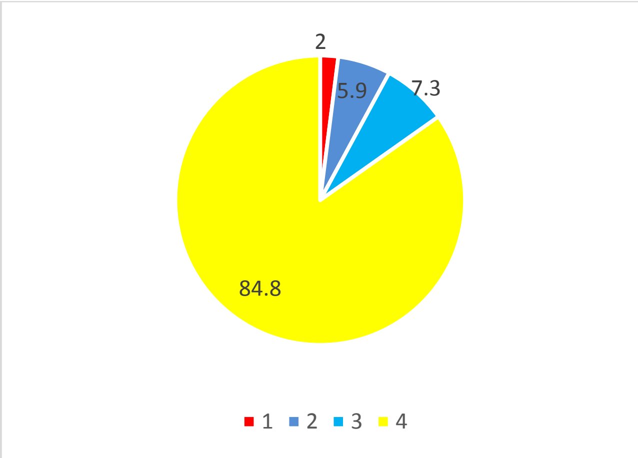

Figure 5. Contribution percentage of the turning parameters

4. CONCLUSIONS

The effect of different parameters (Mediums, cutting speeds and feed rates) on the surface roughness of the Al 7075-T6 workpiece during turning was investigated in this study. Design of experiment as the L_{18} Taguchi design was used. This method is very important to reduce the cost in manufacturing and it is vital to use this method because the Taguchi method is a high quality experimental design tool and reduces the number of experiments. The results obtained from the experiment are presented below:

- The optimum parameter combination for the best surface roughness value was obtained using an analysis of the S/N ratio. The parameters for the best surface roughness value and their levels are obtained as the Mediums: Boron oil medium, cutting speed: 400 m/min and feed rate: 0.1 mm/rev.
- When the analysis of variance results is examined, the feed rate is the most vital parameter on the surface roughness values of the Al 7075-T6 workpiece, with a contribution ratio of 84.8%. It was observed that the cutting speed and the mediums were 7.3% and 2.0%, respectively.
- Generally, the surface roughness of the Al 7075-T6 workpiece is improved by the reduction of the feed rate. The increment of the cutting speed by a certain amount decreases the surface roughness, it is seen that the surface quality deteriorates after a certain value. It seems that the boron oil medium used in the experiments do not have a very notable effect on the surface quality.

5. REFERENCES

[1] S.P. Thangamani, K. Ramasamy, M.S. Dennison, “The effect of cutting fluid on surface roughness of LM6 aluminium alloy during turning operation,” *International Research Journal of Engineering and Technology* (IRJET), 5, 1198-200, 2018.
[2] H. Ijaz, W. Saleem, M. Asad, T. Mabrouki, “Modified Johnson-Cook plasticity model with damage evolution: application to turning simulation of 2xxx aluminium alloy,” *Journal of Mechanics*, 33, 777-88, 2017.
[3] M. Mia, M. Al Bashir, M.A. Khan, N.R. Dhar, “Optimization of MQL flow rate for minimum cutting force and surface roughness in end milling of hardened steel (HRC 40),” *The International Journal of Advanced Manufacturing Technology*, 89, 675-90, 2017.
[4] M.K. Gupta, M. Mia, et.al., “Hybrid cooling-lubrication strategies to improve surface topography and tool wear in sustainable turning of Al 7075-T6 alloy,” *The International Journal of Advanced Manufacturing Technology*, 1-15, 2018.

DOI : 10.31695/IJERAT.2018.3347

[5] R.B.D. Pereira, R.R. Leite, A.C. Alvim, A.P. de Paiva, P.P. Balestrassi, J.R. Ferreira, et al. "Multivariate robust modeling and optimization of cutting forces of the helical milling process of the aluminum alloy Al 7075," *The International Journal of Advanced Manufacturing Technology*, 95, 2691-715, 2018.
[6] E. Ezugwu, "Key improvements in the machining of difficult-to-cut aerospace superalloys," *International Journal of Machine Tools and Manufacture*, 45, 1353-67, 2005.
[7] A. Eltaggaz, P. Zawada, H. Hegab, I. Deiab, H. Kishawy, "Coolant strategy influence on tool life and surface roughness when machining ADI," *The International Journal of Advanced Manufacturing Technology*, 94, 3875-87, 2018.
[8] H. Hegab, B. Darras, H. Kishawy, "Sustainability assessment of machining with nano-cutting fluids," *Procedia Manufacturing*, 26, 245-54, 2018.
[9] D. Vakondios, P. Kyratsis, S. Yaldiz, A. Antoniadis, "Influence of milling strategy on the surface roughness in ball end milling of the aluminum alloy Al7075-T6," *Measurement*, 45, 1480-8, 2012.
[10] M.P. Groover, "Fundamentals of modern manufacturing: materials processes, and systems," *John Wiley & Sons*, 2007.
[11] R. Jerez-Mesa, Y. Landon, et. al., "Topological surface integrity modification of AISI 1038 alloy after vibration-assisted ball burnishing," *Surface and Coatings Technology*, 349, 364-77, 2018.
[12] B.B. Buldum, S.C. Cagan, "Study of ball burnishing process on the surface roughness and microhardness of AZ91D alloy," *Experimental Technique*s, 1-9, 2017.
[13] H. Hegab, U. Umer, I. Deiab, H. Kishawy, "Performance evaluation of Ti–6Al–4V machining using nano-cutting fluids under minimum quantity lubrication," *The International Journal of Advanced Manufacturing Technology*, 95, 4229-41, 2018.
[14] B.B. Buldum, A. Şık, A. Akdağlı, M.B. Biçer, K. Aldaş, İ. Özkul, "ANN surface roughness prediction of AZ91D magnesium alloys in the turning process," *Materials Testing*, 59, 916-20 2017.
[15] B.B. Buldum, S.C. Cagan, "The optimization of surface roughness of AZ91D magnesium alloy using ANOVA in ball burnishing process," *Turkish Journal of Engineering*, 1, 25, 2017.
[16] D.P. Selvaraj, "Optimization of surface roughness of duplex stainless steel in dry turning operation using Taguchi technique," *Materials Physics and Mechanics*, 40, 63-70, 2018.
[17] C. He, W. Zong, J. Zhang, "Influencing factors and theoretical modeling methods of surface roughness in turning process: State-of-the-art," *International Journal of Machine Tools and Manufacture*, 2018.
[18] K. Aldas, I. Ozkul, A. Akkurt, Modelling surface roughness in WEDM process using ANFIS method. *Journal of the Balkan Tribological Association*, 20, 548-58, 2014.

DOI : 10.31695/IJERAT.2018.3347