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Optimization of Process Parameters for Machining Of 6061 Aluminum Alloy Under Different Lubrication Conditions

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Abstract: The use of aluminum alloys in manufacturing industry has increased significantly in the recent years, due to its lightweight and they offer different interesting mechanical and thermal properties. In this context, knowledge of the characteristics on mach inability of aluminum alloys is essential to provide researchers and industry with information that allows them to make the right decisions when they come to machining of Al Alloys. In this present paper an attempt is made to identify the machining characteristics of Aluminium alloy 6061 considering different cutting conditions. On the other hand the effect lubrication condition under dry, flooded and MQL conditions is also studied. Taguchi Robust Design Methodology is used to understand the correlation between machining of Al alloy under different lubrication conditions. The MQL lubrication condition is suggested as best condition over flooded and dry conditions.

1. INTRODUCTION:

Aluminum (Al) is the third most abundant metal in the earth's crust and in its natural form is combined with oxygen and other elements. It is a face-centered cubic (FCC) structure, is relatively easy to machine and has high ductility at ambient temperature. Compared to other engineering metals, aluminum has a low melting temperature about 660 °C. Alloys can be formed through reaction with chemical elements such as copper, zinc, manganese, silicon, magnesium, iron, etc. to give primary aluminum new mechanical properties. Aluminum alloys have been employed in aircraft construction since 1930, mainly those of classes 2xxx, 7xxx, and 6xxx. These alloys are responsible for most of the machining activities in the aerospace and automotive industries, since they present a high strength-to-weight ratio and can advantageously substitute steel and cast iron in the fabrication of parts. Their low weight reduces the environmental impact caused by energy consumption [1]. Among the main applications of aluminum alloys are the fabrication of car wheels, panels, and structures using 6061 alloy [1-3], pistons, brake discs, brake drums, and piston sleeves using SiC (silicon carbide hard particle) or Al_2O_3 (aluminum oxide hard particle) reinforced 6061 aluminum alloy or aluminum-silicon alloys containing up to 20 % Si [4]. A thorough study of literature suggests that the machining of Aluminium Alloy 6061 is difficult and most application oriented compared to other Al alloy materials [5].

2. MATERIALS AND METHOD

The Literature survey helped in proper selection of the material and suitable method [6-17]. Taguchi Robust Design Methodology is used to determine the optimum conditions for the selected control parameters. Orthogonal Array, Signal to Noise Ratio and ANOVA are employed to study the performance characteristics for the selected process parameters. The turning operations (facing) are carried out on CNC machine at BRD Rock Drills, Cherlapaly, Hyderabad and the machine used is WASINO LJ-63m CNC Turning Machine shown in fig.no.1.

The work piece material used is Aluminium Alloy 6061 in the form of round bars of 50 mm diameter and length of 200 mm.

Fig. No. 1: CNC Lathe

The cutting insert used for machining are uncoated carbide tool of KORLEY Company.

Selection of cutting fluid is important in order to maintain better tool life, less cutting forces, lower power consumption, high machining accuracy and better surface integrity etc. Here Nano fluid is used as cutting fluid. In the present work alumina (Al_2O_3) Nano particles are mixed with distilled water, as the base fluid used is distilled water, to make Al_2O_3Nanofluid. Five grams of Al_2O_3 Nano particles and directly mix with 100 ml of water as a base fluid with a mixture of triethanol amine.

The four control factors type of lubricant (A), Speed (B), Feed (C)and Depth of cut (D) are selected with three levels and the corresponding orthogonal array L_9 (3^4) is chosen with respect to its degrees of freedom and are tabulated in Table No.1.

Table No. 1: Control Factors & Levels

Factors /Levels	**Type of lubrication (A)**	**Speed (B) (m/min)**	**Feed (C) (mm/min)**	**Depth Of Cut (D) (mm)**
1	Dry	200	0.05	0.2
2	Flooded	400	0.1	0.4
3	MQL	600	0.15	0.6

Table No. 2. Experimental Design Considering control factors for $L_9(3)^4$ OA

EXPERIMENT NO.	**Type of lubrication (A)**	**Speed (B) (m/min)**	**Feed (C) (mm/min)**	**Depth Of Cut (D) (mm)**
1	Dry	200	0.05	0.2
2	Dry	400	0.1	0.4
3	Dry	600	0.15	0.6
4	Flooded	200	0.1	0.6
5	Flooded	400	0.15	0.2
6	Flooded	600	0.05	0.4
7	MQL	200	0.15	0.4
8	MQL	400	0.05	0.6
9	MQL	600	0.1	0.2

Al Alloy bars of 50mm diaX200mm length are prepared for conducting the experiment. Using different levels of the process parameters as per the experimental design shown in table no.2, the specimens have been machined in CNC Lathe Machine accordingly, the surface roughness is measured precisely for all the experiments. Surface roughness measurement is measured using a portable surface roughness tester TR110. The measurement of surface texture is done by Pick up Type Piezoelectric method. The parameter evaluations are microprocessor based. The measurement results are displayed on an LCD screen. The Tester is placed on the surface of the specimen and switched on. When the pickup is driven by a driver is making a linear motion along the testing surface, the stylus which touches with the work surface moves up and down along the work surface perpendicularly. Its motion is converted into electric signal, which are amplified, filtered and transformed into digital signals through an Analogue to Digital. The signals are then processed by CPU and Ra values displayed on the screen shown in figure no. 2

Figure no. 2 surface roughness tester

3. RESULTS & DISCUSSION

The surface roughness is measured precisely with the help of a portable surface roughness tester TR110 and the results are tabulated in table no 3 for two trails. For each experiment the corresponding S/N values are also tabulated. Optimization of surface roughness is carried out using Taguchi method. Confirmatory test have also been conducted to validate optimal results.

Table No 3: Experimental Data Related To Surface Roughness (R_a)

EXP NO.	SURFACE ROUGHNESS(Ra)			S/N RATIO
	TRAIL1	TRAIL2	MEAN	
1	3.18	3.01	3.095	-9.81321
2	3.42	3.5	3.46	-10.7815
3	5.52	5.46	5.49	-14.7914
4	2.86	2.78	2.82	-9.00498
5	2.96	2.88	2.92	-9.30766
6	2.66	2.58	2.62	-8.36603
7	2.18	2.28	2.23	-6.9661
8	2.84	2.76	2.8	-8.94316
9	2.66	2.54	2.6	-8.29947

Table No 4: Summary of S/N Ratios

Factor	Level 1	Level 2	Level 3
Type of lubrication (A)	-11.79	-8.892	**-8.069**
Speed (B) (m/min)	**-8.59**	-9.67	-10.485
Feed (C) (mm/min)	**-9.04**	-9.361	-10.35

Depth Of Cut (D) (mm)	-9.140	**-8.70**	-10.91

The best condition for type of lubrication is level 3 (MQL Condition), for Speed is level 1 (200m/min), for feed is level 1 (0.05mm/min) and depth of cut is level 2 (0.4mm). Thus, the optimum conditions chosen were: **A3-B1-C1-D2**.

Table No 5: Optimum Set Of Control Factors

Factors/Levels	**Type of lubrication (A)**	**Speed (B) (m/min)**	**Feed (C) (mm/min)**	**Depth Of Cut (D) (mm)**
Optimum Value	**MQL**	**200**	**0.05**	**0.4**

From table no. 4 the following calculations are done, for all the cases the predicted value is calculated in the same procedure.

$$\eta_{predicted} = Y + (A3-Y) + (B1-Y) + (C1-Y) + (D2-Y)$$
$$= A2+B1+C1+D2-3Y$$
$$= [(-8.069) + (-8.59) + (-9.04) + (-8.70)] - [3X (-9.585)]$$
$$\eta_{predicted} = -5.644$$

Therefore, the predicted averagee for optimum condition of surface roughness is -5.644.

4. CONCLUSION

A confirmation test is performed with the obtained optimum cutting parameters type of lubrication is level 3 (MQL Condition), for Speed is level 1 (200m/min), for feed is level 1 (0.05mm/min) and depth of cut is level 2 (0.4mm). The surface roughness values are taken for two trials and the S/N ratio is calculated for this condition. The conformation test and the predicted values are tabulated in the table no 6 & 7.

Table No 6: Conformation Test Results

SURFACE ROUGHNESS(Ra) VALUES			S/N RATIO
1	2	Average	
1.98	2.01	1.995	-5.99886

Table No. 7: Comparison Of S/N Ratios

$\eta_{predicted}$	-5.644.
$\eta_{conformation}$	-5.99886

The objective of the present work is to find out the set of optimum parameters in order to reduce surface roughness, using Taguchi's techniques considering the Turning selected parameters for the Al Alloy 6061 material.

In the present experimentation the optimum results obtained using Tauguchi Robust Design Methodology is for Speed is 200m/min, for feed is 0.05mm/min, depth of cut is 0.4mm. The S/N and the best suitable type of lubrication condition is MQL Condition, the ratio of predicted value and verification test values are valid when compared with the optimum values. It is found that S/N ratio value of verification test is within the limits of the predicted value and the objective of the work is full filled

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