OPTIMIZATION OF MACHINING PARAMETERS AFFECTING METAL REMOVAL RATE OF ALUMINIUM ALLOY 6082 IN DRY END MILLING OPERATION ON VMC

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***Abstract** - Every manufacturing industry wants to reduce the manufacturing cost and increase the production rate of a product. The aim of this project work is to optimize the selected control factors in order to increase the metal removal rate in dry end milling operation. The machining parameters are spindle speed, feed rate and depth of cut. These parameters are investigated at three different levels and 27 experiments were performed on the basis of L_{27} orthogonal array of Taguchi method. The machining operation performed on vertical machining centre in dry condition. These experimental data were analyzed using Minitab software to identify the most significant factor. The material used in this project is Al6082 Aluminium alloy.*

***Keywords:** Surface Roughness, Taguchi, ANOVA, Minitab, End mill.*

1. INTRODUCTION

In current age due to lot of competition every industry wants to produce a good quality of product at higher production rate. In machining process production rate is mainly affected by metal removal rate. The metal removal rate is depending upon machining parameter. The metal removal rate is selected such that they not affect too much the other properties like surface roughness, power consumption and strength etc.

1.1 Metal Removal Rate (MRR)

Metal removal rate is defined as the volume of metal remove in unit time during machining operation. The formula for calculating MRR in end milling is -

$$MRR = \frac{(f*w*d)}{60} \ (mm^3/sec)$$

Where f = feed rate (mm per min)
W = width (mm)
d = depth of cut (mm)

2. LITERATURE REVIEW

The many researchers have research on material Al6082, but very few researchers has research work on End milling operation on Al6082. In this present work we are selected the material Al6082.

The objective of present work is to optimize the cutting parameter of Al6082 in dry end milling operation.

Kurt et al. [1] (2008) were performed an experiment on the role of different coating, point angle, cutting speed and feed rate on the hole quality (hole size, surface roughness, roundness and radial deviation of produced hole) in drilling of Al 2024 alloy. They conclude that, for low cutting speed and feed rate and the best hole quality obtained from near the bottom of the produced hole.

Ali Riza Motorcu et al. [2] (2010) is conducted an experiment to find the optimum machining parameter by Taguchi method. The material AISI 8660 hardened alloy steel is used in this experiment. The cutting speed, feed, depth of cut and nose radius are the machining parameter for optimization surface roughness. The ceramic based cutting tool is used in this experiment. The result shows that the feed rate is the most dominant factor for surface roughness followed by depth of cut and nose radius.

B Fnide et al. [3] (2011) were conducted an experiment by the application of response surface methodology for evaluating the cutting forces in hard turning of AISI H11 hot work tool steel. Machining was done under dry conditions by a mixed ceramic tool (insert CC650 of chemical composition 70%Al2O3+30%TiC. They found that the depth of cut was the dominant factor affecting cutting force components. The tangential cutting force was more affected rather than radial and axial forces. The radial force was more affected by cutting speed rather than tangential and axial forces.

Ilhan Asilturk ET al. [4] (2011) were conducted the experiment for optimization of cutting parameters for minimum surface roughness (Ra & Rz). Nine experiments had been carried out using L9 orthogonal array in CNC turning. Dry turning tests were carried out on hardened AISI 4140 with coated carbide tools and result observed that feed rate were the most dominated parameter for surface roughness.

M. Kaladhar et al. [5] (2011) were conducted an experiment on AISI 304 for surface finish and metal removal rate and investigate the effects of process parameters on it. For this experiment they used ANOVA software for analysis. They found that the feed and nose radius were the most significant parameters for surface roughness and for metal removal rate, depth of cut and feed are the significant factors.

Aruna et al. [6] (2012) were conducted an experiment for optimizing cutting parameters with respect to the data obtained from high speed lathe machining of INCONEL 718 material, a nickel based super alloy by Taguchi and RSM optimisation method. The cutting speed was the most dominated affected parameter for surface roughness and tool wear.

Mahesh Babu et al. [7] (2012) were studied the various characteristics of the surface quality on machining of hybrid (Al–SiC–B4C) composites. They found that the feed rate was the most dominant parameter followed by cutting speed, which affected the surface roughness.

V. S. Thanhgarasu et al. [8] (2012) were conducted an experiment to find the optimum cutting parameters for high speed CNC milling, in which they used Taguchi, based Box-Behnken RSM (Response Surface Methodology) to develop prediction formula and Multi Objective Genetic Algorithm (MOGA). The Result was found that, the Ra was more affected by the upward variation of the depth of cut and feed rate than that of the spindle speed but had a significant influence over the responses.

P. Raveendran et al. [9] (2016) were conducted an experiment to find the optimum cutting parameters for Glass fiber reinforced polymers (GFRP) material for good surface finish by using Response Surface Methodology (RSM). The result shows that depth of cut was the main influencing factor on the surface roughness, followed by the feed rate and cutting speed.

H R Ghan et al. [10] (2017) were provides literature review on machining parameters, such as cutting speed (Vc), feed (f) and depth of cut (t), of different material. They found that parameters play a very vital role for the machining and utilized in the industries.

Mayur N. Trimbakwade et al. [11] (2017) were conducted an experiment to find the optimum cutting parameters for CNC face milling for surface roughness and metal removal rate for Inconel 718 by Using Taguchi Method. Inconel 718 was mostly used nickel based super alloy. The result was analysed in ANOVA and they found the set of optimum value for minimum surface roughness.

3. EXPERIMENTAL DESIGN

3.1 Taguchi Method

The Taguchi Methods was developed by was Genichi Taguchi. He was a Japanese engineer who began working for the telecommunications company, Electrical Communications Lab, a part of NT&T, in 1950's. Taguchi method is used evaluating and implementing improvements in the products, optimization of the objectives function. Optimization means determination of best levels of control factors that maximize the signal-to – noise ratio.

3.2 Signal- to- Noise Ratio

Signal-to-noise ratio is very important and useful parameter in taking into account of goal and variation in comparing two sets of samples. Signal–to- noise ratio is the log functions of a given output. It is used for optimization of objectives function. It is also help in data analysis and prediction of results. Signal to noise ratio formula are as follow-

- Smaller the better

$$SNs = -10\log\left(1/n\sum_{i=1}^{n} Yi^2\right)$$

- Nominal the best

$$SNt = 10\log\left(\bar{y}_i^2/S^2\right)$$

- Larger the better

$$SN_l = -10\log\left(1/n\sum_{i=1}^{n} 1/Yi^2\right)$$

4. EXPERIMENTAL WORK

4.1 Workpiece Material

The workpiece material used in this experiment is Aluminium Alloy 6082. It is a medium strength alloy. It is mostly used in high stress application, trusses, bridges, cranes and transport application etc. The material properties are given below.

Table -1: Material Properties

Density	2.71 g/cm^3
Young modulus	71 GPa
UTS	140 to 330 MPa

Yield strength	90 to 280 MPa
Hardness Brinell	91 HB
Material composition	Al- 95.2 to 98.3% Cr- 0.25% max Cu- 0.1% max Fe- 0.5% max Mg- 0.6 to 1.2% Mn- 0.4 to 1% Si- 0.7 to 1.3% max Ti- 0.1% max Zn- 0.2% max

Fig -1: Workpiece

4.2 CNC Vertical machining Centre

CNC Vertical Machining Centre is an automatic machine tool. It is controlled by computer executes pre-programmed commands. The machine table is moved along x and y axis and machine spindle move along z axis.

The G and M codes are based on the three dimensional Cartesian coordinate system and controlled the machine. In CNC vertical machining centre the cutting tool is hold on a vertical spindle and feed is provided by the machine table.

Fig -2: Vertical Machining Centre

Table -2: VMC Specification

Machine Specification	
M/C model no.	TURBO-450-R40
Serial no.	6225/1215/66844
Capacity	450 W/hr
Spindle speed	6000 rpm
Temperature range	10^0 to 45^0 C
Frequency	50 HZ
Coolant System	
Tank capacity	450 litter
Type of coolant	Servo Cut-S
Coolant/water ratio	1:20
Coolant around spindle	50 lpm @ 1.8 bar
Coolant wash	60 lpm @ 4 bar
Lubrication System	
Tank capacity	3 litter
Type of oil	Servo way- H68
Max. working pressure	15 bar

4.3 Cutting Tool or End Mill

In this operation multipoint end milling cutter is used for machining. The material of cutting tool is carbide. The diameter of the cutting tool is 10 mm.

Fig -3: End Mill

4.5 Machining Parameter and Levels of Experiment

Table -3: Levels of Experiment

Parameter / Levels	speed(N) in rpm	Feed(f) in mm/ min.	Depth of Cut(d) in mm
Level 1	800	100	0.5
Level 2	1200	150	1.0
Level 3	1600	200	1.5

In this experiment spindle speed, depth of cut and feed rate are taken as the machining parameters. Also we select the three levels of experiment for optimize these parameters..

4.6 Experimental Data

Now with the help of Minitab software orthogonal array is prepared and with the help of this array conduct the experiment. Then this experimental data are analysed in Minitab software and we get S/N ratios. The following experimental data are given below.

Table -4: Experimental Data

Exp. no.	Speed (N)	Feed (f)	Depth of cut (d)	Cutter dia. (D)	Cutting Speed (V)	MRR	S/N
	rpm	mm/ min.	mm	mm	m/min.	mm^3 / sec	Db
1	800	100	0.5	10	25.132	8.33	18.413
2	800	100	1	10	25.132	16.7	24.433
3	800	100	1.5	10	25.132	25	27.959
4	800	150	0.5	10	25.132	12.5	21.938
5	800	150	1	10	25.132	25	27.959
6	800	150	1.5	10	25.132	37.5	31.481
7	800	200	0.5	10	25.132	16.7	24.439
8	800	200	1	10	25.132	33.3	30.457
9	800	200	1.5	10	25.132	50	33.979
10	1200	100	0.5	10	37.698	8.33	18.413
11	1200	100	1	10	37.698	16.7	24.439
12	1200	100	1.5	10	37.698	25	27.959
13	1200	150	0.5	10	37.698	12.5	21.938
14	1200	150	1	10	37.698	25	27.959
15	1200	150	1.5	10	37.698	37.5	31.481
16	1200	200	0.5	10	37.698	16.7	24.439
17	1200	200	1	10	37.698	33.3	30.457
18	1200	200	1.5	10	37.698	50	33.979
19	1600	100	0.5	10	50.264	8.33	18.413
20	1600	100	1	10	50.264	16.7	24.439
21	1600	100	1.5	10	50.264	25	27.959
22	1600	150	0.5	10	50.264	12.5	21.938
23	1600	150	1	10	50.264	25	27.959
24	1600	150	1.5	10	50.264	37.5	31.481
25	1600	200	0.5	10	50.264	16.7	24.439
26	1600	200	1	10	50.264	33.3	30.457
27	1600	200	1.5	10	50.264	50	33.979

5. RESULT ANALYSIS

The experimental data are analysed in Minitab software we get the following result.

Table -5: Response Table for Signal to Noise Ratios

Level	N	F	D
1	26.78418	23.60289	21.5966
2	26.78418	27.12588	27.61749
3	26.78418	29.62494	31.13961
Delta	0	6.02205	9.54301
Rank	3	2	1

Table -6: Response Table for Average MRR

Level	N	F	D
1	25	16.66556	12.5
2	25	25	24.9989
3	25	33.3333	37.5
Delta	0	16.66774	25
Rank	3	2	1

It is clear that from both the table, the rank of depth of cut and feed are 1 and 2 respectively. It means that the MRR is maximum affected by depth of cut follow by feed. Also there is no any effect of speed on MRR.

5.1 Effect of Machining Parameters on MRR and S/N Ratio

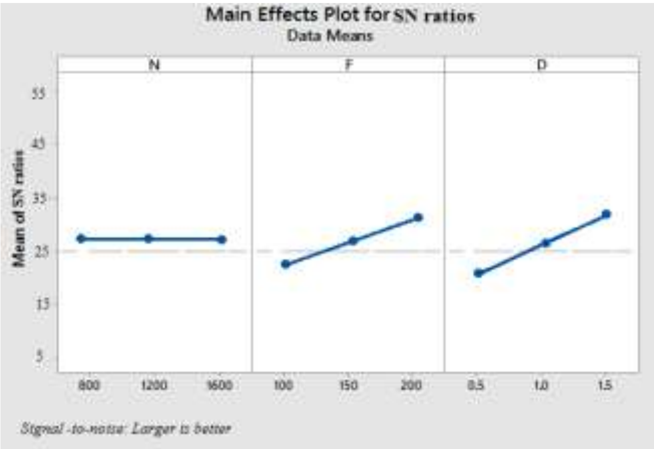

Fig -4: Effects of machining parameter on MRR

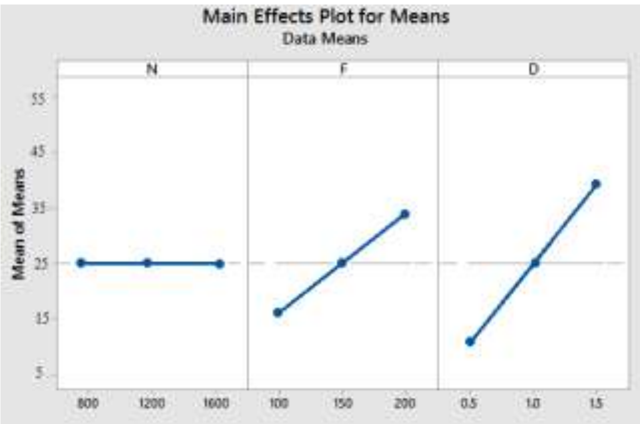

Fig -5: Effects of machining parameter on S/N Ratio

It is clear from figure -4 MRR increases with increasing feed and depth of cut. Also there is no effect of spindle speed on MRR. Also from figure-5 it is clear that S/N ratio increases with increasing feed and depth of cut. Also there is no effect of spindle speed on S/N ratio.

6. CONCLUSIONS

In this research work we are selected the material Aluminium alloy 6082 for optimization of machining parameters spindle speed, feed and depth of cut for metal removal rate in dry end milling operation. Taguchi method is used to optimize these parameters. According to L_{27} orthogonal array 27 experiments are performed. The experimental data is analysed in Minitab software and we get the following result.

Factor	Rank
Depth of cut	1
feed	2
Spindle speed	3

- Depth of cut, feed and spindle speed have rank 1, 2 and 3 respectively. It means that the MRR is maximum affected by depth of cut followed by feed. Also there is no effect of spindle speed on MRR

- The MRR is increases with increasing depth of cut and feed rate.

- The optimum values of machining parameter for maximum MRR in dry end milling operation are feed 200 mm per min. and depth of cut 1.5 mm.

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