International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 03 Issue: 01 | Jan-2016 www.irjet.net p-ISSN: 2395-0072

OPTIMIZATION OF MACHINING PARAMETERS FOR TURNING OF ALUMINIUM ALLOY 7075 USING TAGUCHI METHOD

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Abstract - ***Every manufacturing industry aims at producing a large number of products within relatively lesser time. This study applies Taguchi design of experiment methodology for optimization of process parameters in turning of Aluminium Alloy 7075 using tungsten coated carbide tool. Experiment have been carried out based on L_{27} standard orthogonal array design with three process parameters namely Cutting Speed, Feed, Depth of Cut for Material removal rate and Machining time. The signal to noise ratio and analysis of variance were employed to study the performance characteristics in turning operation. ANOVA has shown that the speed has significant role to play in producing higher material removal rate and lesser machine time. Thus, it is possible to increase machine utilization and decrease production cost in an automated manufacturing environment.***

Key Words: AA-7075, Material Removal Rate, Machining Time, Taguchi's Technique, ANOVA.

1. INTRODUCTION

Productivity play significant role in today's manufacturing market. The manufacturing industries are continuously challenged for achieving higher productivity within lesser time. Turning process is one of the most fundamental and most applied material removal operations in a real manufacturing environment. The process of turning is influenced by many factors such as Cutting speed, Feed rate and Depth of cut. The challenge that the engineers face is to find out the optimal parameters for the preferred output and to maximize the output by using the available resources. Higher material removal rate is desired by the industry to cope up with mass production without sacrificing product quality in short time. Higher material removal rate is achieved through increasing the process parameters like Cutting speed, Feed and Depth of cut. Aluminium Alloy 7075 are the most widely used non-ferrous materials in engineering applications owing to their attractive properties such as high strength to weight ratio, good ductility, excellent corrosion, availability and low cost. It is used for aircraft fittings, gears and shafts, fuse parts, meter shafts and gears, missile parts, regulating valve parts, worm gears, keys, aircraft, aerospace and defense applications; bike frames, all terrain vehicle (ATV) sprockets. Aluminium Alloys are soft and high strength material.

M.Naga Phani Sastry, K.Devaki Devi [1] This paper explains an optimal setting of turning parameters (Cutting speed, Feed and Depth of Cut) which results in an optimal value of Surface Roughness and maximum Metal Removal Rate while machining Aluminium bar with HSS tool. A mathematical technique has been used to generate model with Response Surface Methodology. P.Warhade, Sonam K.Bhilare, Shirlev R.Gaikwad [2] paper investigated the effect of cutting parameters namely, cutting speed, depth of cut and feed rate on minimize required machining time and maximizing metal removal rate during machining of Aluminium Alloy 6063 using VBM0.2 tool. Experiments were conducted based on the established Taguchi's technique L27 orthogonal array and minitab-16 statistical software is used to generate the array. H.K.Dave, L.S.Patel, H.K.Raval [3] In this study, the optimization of two response parameters (Surface roughness and Material Removal Rate) by three machining parameters (cutting speed, feed rate and depth of cut) is investigated in high speed turning of EN materials using TiN Coated cutting tools in dry conditions. Taguchi's L'18 orthogonal array and analysis of variance (ANOVA) are used for individual optimization. Kamal Hassan, Anish Kumar, M.P.Gang [4] This paper have been investigation of the machining characteristic of C34000 (medium brass alloy) material in CNC turning process using GC1035 Coated carbide tool. In this research paper focused on the analysis of optimum cutting conditions to get the maximum material removal rate in CNC turning of different grades of medium brass alloy material by Taguchi method. It has been found that ANOVA shown that the depth of cut has significant role to play in producing higher MRR.

Taguchi method was developed by Dr. Genichi Taguchi. This method involves three stages: system design, parameter design, and tolerance design. The Taguchi method is a statistical method used to improve the product quality. It is commonly used in improving industrial product quality due to the proven success. With the Taguchi method it is possible to significantly reduce the number of experiments. The Taguchi method is not only an experimental design technique, but also a beneficial technique for high quality system design. The Taguchi process helps select or determine the optimum cutting conditions for turning process. Many researchers developed many mathematical models to optimize the cutting parameters to get the maximum material removal rate and minimum machining time by turning process. The variation in the material hardness, alloying elements present in the work piece material and other factors affecting material removal rate and machining time.

2. MATERIALS AND METHOD

2.1. Work Piece Material

The work piece material used for present work was Aluminium Alloy 7075. Table 1 and Table 2 show the chemical composition and mechanical properties of AA7075.

Table - 1: Chemical Composition of AA7075

Elements	Composition %
Aluminium	89.58
Silicon	0.4
Copper	0.098
Manganese	1.41
Magnesium	0.055
Chromium	2.33
Zinc	5.95

Table - 2: Properties of AA7075

Property	Value
Tensile Strength	572 Mpa
Density	2.81 kg/m^3
Elongation	11 %
Machinability	70 %

2.2. Cutting Inserts

The cutting tool used for experimentation with the standard specification is TNMG115100 tungsten carbide insert. Coated carbide tools have shown better performance when compared to the uncoated carbide tools.

Fig -1: Tungsten Carbide Insert

2.3. Selection of Control Factors

In this study, cutting experiments are planned using statistical three-level full factorial experimental design. Cutting experiments are conducted considering three cutting parameters: Cutting Speed (m/min), Feed rate (mm/rev), Depth of Cut (mm) and Overall 27 experiments were carried out. Table 3 shows the values of various parameters used for experiments:

Table - 3: Machining Parameters and Levels

Sr. No	Process Parameter	Levels		
		1	2	3
1	Speed (m/min)	500	1000	1500
2	Feed (mm/rev)	0.10	0.15	0.20
3	Depth of Cut (mm)	0.3	0.5	0.8

2.4. Experimental Procedure

Turning is a popularly used machining process. The CNC machines play a major role in modern machining industry to enhance increase productivity within lesser time. The CNC machine used for Jobber X_L.

Fig - 2: CNC Lathe Jobber X_L

Each work piece is cut in size of 25mm diameter and 115mm length and after turning (20mm diameter and 65mm length) is performed on CNC turning centre. Turning program is prepared and feed in the CNC machine.

The instruments used for measuring initial and final weight of the work piece are noted. Machining time was noted by stopwatch. Material removal rate is calculated by using relation.

$$MRR = (W_i - W_f) / \rho \times T \text{ mm}^3/\text{sec}$$

Where,

Wi – is initial weight of the work piece (gm)

Wf – is final weight of the work piece (gm)

T – Machining time (sec)

ρ – Density of material (kg/m³)

2.5. METHODOLOGY

2.5.1. Taguchi Approach

Taguchi method uses a loss function to determine the quality characteristics. Loss function values are also converted to a signal-to-noise (S/N) ratio η. The term "signal" represents the desirable value (mean) for output characteristic and the term "noise" represents the undesirable value for the output characteristic. Usually there are three categories of the performance characteristic in the analysis of the S/N ratio, that is, the lower-the-better, nominal-the-better and the higher-the-better. The S/N ratio for each level of process parameters is computed based on the S/N analysis. The optimal level of the process parameters is the level having highest S/N ratio. Furthermore, ANOVA is performed to see which process parameters are statistically significant.

Signal to Noise Ratio: Smaller is better

$$\text{S/N Ratio} = -10 \log \sum_{i=1}^{n} y^2 \quad \text{.........(1)}$$

Signal to Noise Ratio: Larger is better

$$\text{S/N Ratio} = -10 \log \frac{1}{n} \sum_{i=1}^{n} \frac{1}{y^2} \quad \text{.........(2)}$$

Where, y- is the observed data at i^{th} trial and n -is the number of trials. The factor levels that have maximum S/N ratio are considered as optimal. The aim of this study was to produce maximum material removal rate and minimum machining time in turning operation. Larger-the- better quality characteristic is used for material removal rate as larger MRR values represent better. Smaller-the-better quality characteristic is used for machining time as smaller machining time values represent better or improved productivity.

Table- 4: Experimental Result for MRR & Machining Time

S. No.	*Speed m/min*	*Feed mm/rev*	*DOC mm*	*MRR mm³/s*	*MT (sec)*
1	500	0.10	0.3	76.082	145
2	500	0.15	0.3	88.180	113
3	500	0.20	0.3	96.085	100
4	500	0.10	0.5	60.630	135
5	500	0.15	0.5	79.082	108
6	500	0.20	0.5	104.88	95
7	500	0.10	0.8	84.213	131
8	500	0.15	0.8	78.291	100
9	500	0.20	0.8	76.258	98
10	1000	0.10	0.3	88.967	116
11	1000	0.15	0.3	124.55	80
12	1000	0.20	0.3	146.53	68
13	1000	0.10	0.5	87.460	118
14	1000	0.15	0.5	112.83	82
15	1000	0.20	0.5	145.58	66
16	1000	0.10	0.8	88.207	117
17	1000	0.15	0.8	123.01	81
18	1000	0.20	0.8	150.13	64
19	1500	0.10	0.3	144.98	81
20	1500	0.15	0.3	156.82	59
21	1500	0.20	0.3	193.40	46
22	1500	0.10	0.5	108.49	82
23	1500	0.15	0.5	159.52	58
24	1500	0.20	0.5	239.03	46
25	1500	0.10	0.8	141.43	78
26	1500	0.15	0.8	184.07	58
27	1500	0.20	0.8	248.28	43

3. RESULTS AND ANALYSIS

Minitab statistical software has been used for the analysis of the experimental work. The Minitab software studies the experimental data and then provides the calculated results of signal-to-noise ratio. The objective of the present work is to minimize machining time and maximize the MRR in turning process optimization. The effect of different process parameters on material removal rate and machining time are calculated and plotted as the process parameters changes from one level to another. The average value of S/N ratios has been calculated to find out the effects of different parameters and as well as their levels. The use of both ANOVA technique and S/N ratio approach makes it easy to analyze the results and hence, make it fast to reach on the conclusion. Table 4 shows the experimental results for material removal rate and machining time and corresponding S/N ratios.

3.1. Analysis of Signal-to-Noise Ratio

Larger-the-better performance characteristic is selected to obtain material removal rate. Smaller-the better performance characteristic is selected to obtain machining time.

Table - 5: Response Table for MRR

Level	***Speed***	***Feed***	***DOC***
1	38.25	39.50	41.47
2	41.29	41.42	41.06
3	44.60	43.22	41.61
Delta	6.35	3.73	0.55
Rank	1	2	3

Table - 6: Response Table for Machining Time

Level	***Speed***	***Feed***	***DOC***
1	-41.03	-40.73	-38.57
2	-38.64	-38.02	-38.41
3	-38.49	-36.41	-38.18
Delta	5.54	4.31	0.39
Rank	1	2	3

From the response Table 5 and Fig.3 it is clear that cutting speed is the most influencing factor followed by feed rate and depth of cut for MRR. The optimum for MRR is cutting speed of 1500 m/min, feed rate of 0.20 mm/rev and depth of cut of 0.8mm.

From the response Table 6 and Fig.4 it is clear that cutting speed is the most influencing factor followed by feed rate and depth of cut for machining time. The optimum for machining time is cutting speed of 1500 m/min, feed rate of 0.20 mm/rev and depth of cut of 0.8mm.

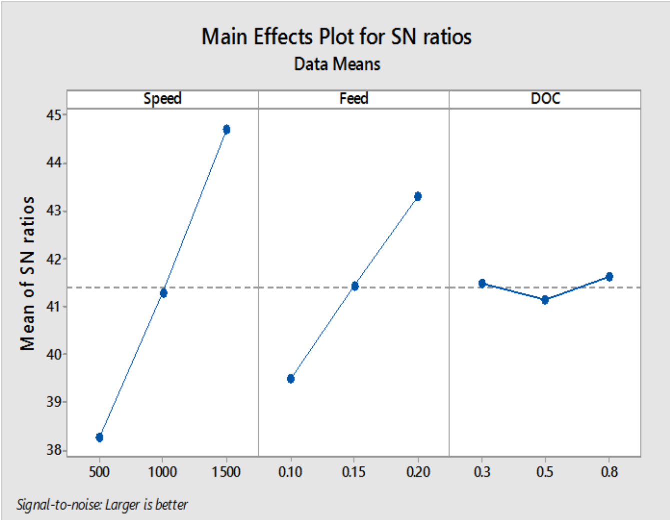

Fig - 3: Main Effect Plot for MRR

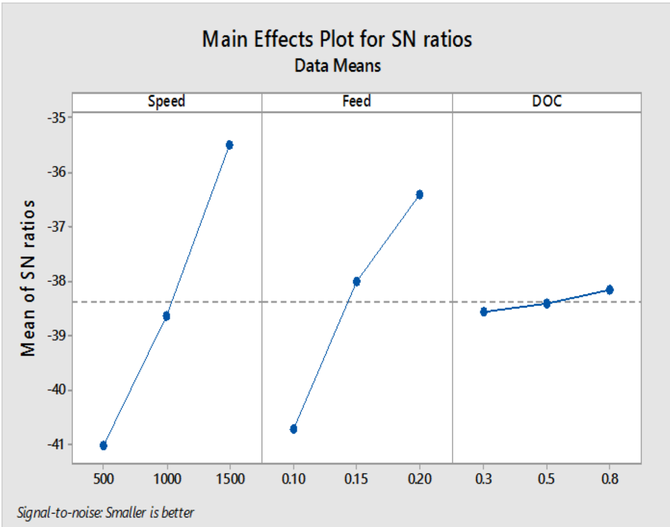

Figure - 4: Main Effect Plot for Machining Time

3.2. Analysis of Variance (ANOVA)

Taguchi method cannot judge and determine effect of individual parameters on entire process while percentage contribution of individual parameters can be well determined using ANOVA. Using Minitab 17 software

ANOVA module can be employed to investigate effect of parameters.

Table - 7: ANOVA Results for MRR

Source	*DOF*	*SS*	*MS*	*F*	*% CON*
Speed	2	41548.3	20774.2	40.13	60.46
Feed	2	16580.1	8290.2	16.01	24.13
Doc	2	228.8	114.4	0.22	0.332
Error	20	10353.6	517.7	-	15.06
Total	26	68710.8	-	-	
S = 22.7526		**R-Sq = 84.93%**		**R-Sq(adj) = 80.41%**	

Table 8: ANOVA Results for Machining Time

Source	*DF*	*SS*	*MS*	*F*	*% CON*
Speed	2	12483.2	6241.6	313.76	58.66
Feed	2	8318.3	4159.1	209.08	39.09
Doc	2	80.3	40.1	2.02	0.377
Error	20	397.9	19.9	-	1.86
Total	26	21279.6	-	-	
S = 4.46011		**R-Sq = 98.13%**		**R-Sq(adj) = 97.57%**	

Table 7 & 8 shows the analysis of variance for material removal rate and machining time. It is observed that the speed (60.46%) is most significantly influences the material removal rate followed by feed rate (24.13%) and least significant of depth of cut (0.332%). In case of machining time, speed (58.66%) is the most significant parameter followed by feed rate (39.09%) and least significant of depth of cut (1.86%). In both the cases, error contribution (15.06%) and (1.86%) reveals that the interaction effect of the process parameters is negligible.

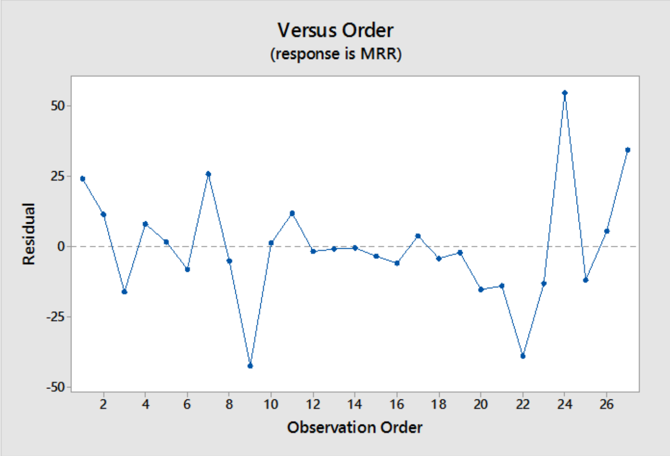

Fig - 5: Residual Plot for MRR

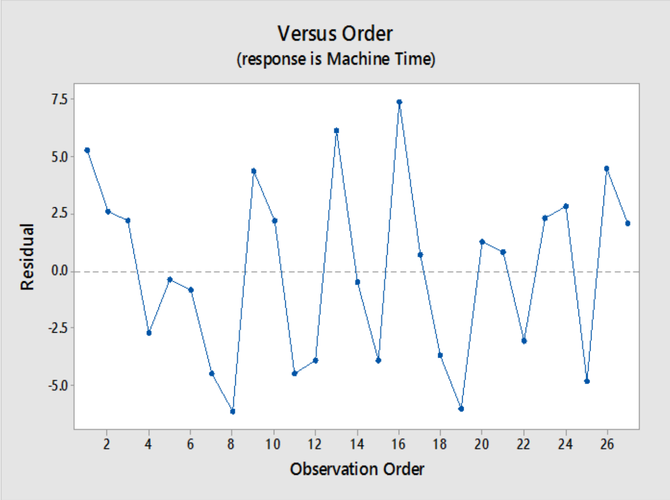

Fig - 6: Residual Plot for Machine Time

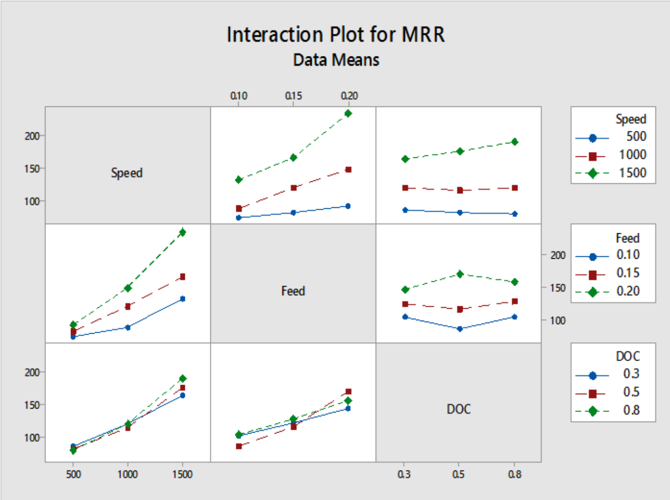

Fig - 7: Interaction Plot for MRR

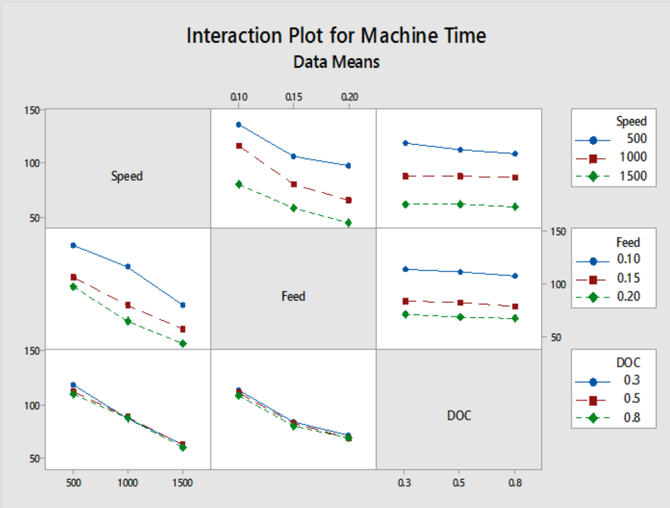

Fig - 8: Interaction Plot for Machining Time

4. CONCLUSIONS

The optimum conditions obtained from Taguchi method for optimizing Material Removal Rate during turning of Aluminium Alloy 7075 under dry condition are cutting speed of 1500 m/min, Feed rate of 0.20 mm/rev and depth of cut of 0.8 mm.

From response table for S/N ratio of MRR it is clear that cutting speed is the most significant factor influencing MRR followed by Feed rate and Depth of Cut is the least significant factor.

Analysis of Variances (ANOVA) for S/N ratio for MRR clearly indicates that the cutting speed is majorly contributing of about 60.46% in obtaining optimal MRR followed by feed rate 24.13% and depth of cut 0.332%.

Optimum conditions for optimizing Machining Time are cutting speed of 1500 m/min, Feed rate of 0.20 mm/rev and depth of cut of 0.8 mm.

From response table for S/N ratio of surface roughness it is clear that cutting speed is the most significant factor influencing MRR followed by Feed rate and depth of cut is the least significant factor.

Analysis of Variances (ANOVA) for S/N ratio for machining time clearly indicates that the cutting speed is majorly contributing of about 58.66% in obtaining optimal surface roughness followed by feed rate of 39.09% and depth of cut of 0.377 %.

The combination of parameters of specimen 27 given higher material removal rate with lesser time. Desired values of parameters are Speed 1500 m/min, Feed 0.20 m/rev and Depth of Cut 0.8 mm.

5. REFERENCES

[1]. Ashok Kumar Sahoo, Achyuta Nanda Baral. *"Multi-objective Optimization and Predictive Modelling of Surface roughness and Material removal rate in Turning using Grey relational and Regression Analysis."* Elsevier Procedia Engineering 38(2012)1606-1627.

[2]. M.Naga Phani Sastry, K.Devaki Devi. *"Optimizing of Performance Measures in CNC Turning using Design of Experiments (RSM)."* Science Insights: An International journal, 2011;1(1):1-5.

[3]. U.D.Gulhane, S.P.Ayare, V.S.Chandorkar. *"Investigation of Turning Process To Improve Productivity (MRR) For Better Surface Finish Of AL7075-T6 Using DOE."* International journal of design and manufacturing technology. Vol.4, Issue.1, Jan.-Apr.2013 pp-59-67.

[4]. P.Warhade, Sonam K.Bhilare, Shirley R.Gaikwad. *"Modeling and Analysis of Machining Process using Response surface methodology"*. International Journal of Engineering and Development Volume 2, December- 2013 .ISSN 2249-6149.

[5]. C.Ramudu, Dr.M.Naga Phani Sastry.*"Analysis and Optimization of Turning Process Parameters Using Design of Experiments"*. International Journal of Engineering Research and Application, Vol.2, Issue6, Nov-Dec2012, pp.20-27.

[6]. H.K.Dave, L.S.Patel, H.K.Raval.*"Effect of machining conditions on MRR and surface roughness during CNC Turning of different Materials Using TiN Coated Cutting Tools-A Taguchi Approach"*International Journal of Industrial Engineering Computations3 (2012)925-930.

[7]. M.Kaladhar, K.V.Subbaiah, Ch.Srinivasa Rao. *"Application of Taguchi approach and Utility Concept in solving the Multi-objective Problem when turning AISI 202 Austenitic Stainless Steel"*. Journal of Engineering Science and Technology Review4 (1) (2011)55-61.

[8]. U.D.Gulhane, B.D. Sawant, P.M.Pawar. *"Analysis of Influence of Shaping Process Parameters on MRR and Surface roughness of Al6061 using Taguchi method."* International Journal of Applied Research and Studies.ISSN:2278-9480 Volume 2, Issue 4(April-2013).

[9]. Ilhan Asilturk, suleyman neseli. "Multi response optimization of CNC turning parameters via

Taguchi method based response surface analysis." Measurement 45(2012) 785-794.

[10]. H.M.Somashekara, Dr.N.Lakshmanaswamy. *"Optimizing surface roughness in turning operation using Taguchi technique and Anova."* International journal of engineering science and technology, ISSN 0975-5462. VOL-4 No.05 May 2012.

[11].Poornima, sukumar. *"Optimization of machining parameters in CNC turning of martensitic stainless steel using RSM and GA."* International journal of modern engineering research. Vol.2, Issue.2, Mar.-Apr.2012 pp-539-542. ISSN: 2249-6645.

[12]. B. Sidda Reddy, J. Suresh Kumar, K. Vijaya Kumar Reddy. *"Prediction of Surface Roughness in Turning Using Adaptive Neuro-Fuzzy Inference System".* Jordan Journal of Mechanical and Industrial Engineering Volume 3, Number 4, December- 2009 .ISSN 1995-6665.

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