[Abbas* *et al.*, 5(7): July, 2016] ISSN: 2277-9655
IC™ Value: 3.00 Impact Factor: 4.116

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

OPTIMIZATION OF CUTTING PARAMETERS TO IMPROVE SURFACE ROUGHNESS OF AL 1070 IN TURNING OPERATION USING TAGUCHI METHOD

Mohd Abbas*, Sravan Kumar, Atishey Mittal
* Assistant Professor, Department of Mechanical Engineering, AFSET, Faridabad
P.G Student, Department of Mechanical Engineering, AFSET, Faridabad
Assistant Professor, Department of Mechanical Engineering, SRM University, Modinagar

DOI: 10.5281/zenodo.58657

ABSTRACT
This experimental study presents an effective approach for the optimization of turning parameter using MINITAB 17 and Taguchi Technique in varying condition. The information about machining of difficult cutting materials is inadequate and complicated. Therefore an experimental study has to be conducted to come out with an optimum outcome. In this study, the machining parameters namely Depth of Cut, Cutting Speed, Feed Rate and Tool Nose angle are optimized with multiple performance characteristics, such as maximum material removal rate and maximum surface finish. Moreover we have to demonstrate a systematic procedure of using Taguchi Parameter Design in process control of individual Lathe machine and to identify the optimum Material Removal Rate and Surface Roughness performance with particular combination of cutting parameters in a turning process. At first the design of experiment has to be implemented to select manufacturing process parameters that could result in a better quality product. The response table and response graph for each level of machining parameters are obtained from the Taguchi Method and the optimum levels of machining parameters are being selected. For the statistical representation MINITAB 17 was used. Analysis of variance (ANOVA) is used to find out variables affecting the material removal rate and surface roughness. Assumptions of ANOVA are discussed and carefully examined using analysis of residuals. Results from the ANOVA, show that Cutting Speed and Feed Rate are the significant factors for the material removal rate and Depth of Cut and Feed Rate are the significant factors for surface roughness.

Keywords: - ANOVA, surface roughness, cutting tool, feed rate

INTRODUCTION
In order to built-up bridge between quality and productivity the present experimental study highlight CNC lathe machine process parameters to provide good surface finish as well as high material removal rate. Surface finish and material removal rate has been identified as quality attributes and are assumed to be directly related to productivity.
This experimental study presents an effective approach for the optimization of lathe machine using MINITAB 17 and Taguchi Technique in varying condition. The information about machining of difficult cutting materials is inadequate and complicated. Therefore an experimental study has to be conducted to come out with an optimum outcome. In this study, the machining parameters namely Depth of Cut, Cutting Speed, Feed Rate and Tool Nose Angle are optimized with multiple performance characteristics, such as maximum material removal rate and maximum surface finish. Moreover we have to demonstrate a systematic procedure of using Taguchi Parameter Design in process control of individual lathe machine and to identify the optimum Material Removal Rate and Surface Roughness performance with particular combination of cutting parameters in a turning process. At first the design of experiment has to be implemented to select manufacturing process parameters that could result in a better quality product. The response table and response graph for each level of machining parameters are obtained from the Taguchi method and the optimum levels of machining parameters are being selected. For the statistical representation MINITB 17 was used. Analysis of variance (ANOVA) is used to find out variables affecting the material removal rate and surface roughness. Assumptions of ANOVA are discussed and carefully examined using analysis of residuals. Results from the ANOVA, show that Cutting Speed and Feed Rate are the significant factors for the material removal rate and Depth of Cut and

Feed Rate are the significant factors for surface roughness. Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences between group means and their associated procedures (such as "variation" among and between groups), developed by R.A. Fisher. In the ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are equal, and therefore generalizes the *t*-test to more than two groups. As doing multiple two-sample t-tests would result in an increased chance of committing a statistical type I error, ANOVAs are useful in comparing (testing) three or more means (groups or variables) for statistical significance. ANOVA is a particular form of statistical hypothesis testing heavily used in the analysis of experimental data. A statistical hypothesis test is a method of making decisions using data. A test result (calculated from the null hypothesis and the sample) is called statistically significant if it is deemed unlikely to have occurred by chance, assuming the truth of the null hypothesis. A statistically significant result, when a probability (p -value) is less than a threshold (significance level), justifies the rejection of the null hypothesis, but only if the a priori probability of the null hypothesis is not high.

LITERATURE REVIEW

P. Sam Paul,et.al., (2015) say that in his research paper that the cutting fluid is the hazardous issue in the disposal of the cutting fluid. Recently the concept of hard turning has gained much attention in the metal cutting industry. In hard turning, multiple operations can be performed in single step, thereby it replaces the traditional process cycle. But it involves very large quantities of cutting fluid. Procurement, storage and disposal of cutting fluid involve expenses and environmental problem. Pure dry turning is a solution to this problem as it does not require any cutting fluid at all. But pure dry turning requires ultra hard cutting tools and extremely rigid machine tools, and also it is difficult to implement in the existing shop floor as the machine tool may not be rigid enough to support hard turning. In this context, turning with minimal fluid application is a viable alternative wherein, extremely small quantities of cutting fluid are introduced at critical contact zones as high velocity pulsing slugs, so that for all practical purposes it resembles pure dry turning and at the same time free from all the problems related to large scale use of cutting fluid as in conventional wet turning. In this study, fluid application parameters that characterize the minimal fluid application scheme were optimized and its effect on cutting performance and tool vibration was studied. From the results, it was observed that minimal fluid application in the optimized mode brought forth low vibration levels and better cutting performance. [1].

R. Robinson Gnanadurai in his research paper that hard turning with minimum fluid application is a recently developed technique to alleviate the problem associated with cutting fluid. During this process, very small quantity of cutting fluid is applied as a narrow high velocity pulsing jet at the cutting zone. As the quantity of cutting fluid is very small, some auxiliary cooling of tool using heat pipe was attempted in the present work to enhance heat dissipation and thus improving cutting performance. Heat pipe was installed in vertical position in contact with the tool for extracting more heat from the tool. The influence of heat pipe cooling of tool on the cutting performance was analyzed by Taguchi's design of experiments. It was observed that the use of heat pipe in minimal fluid application reduced cutting temperature and tool wear to a maximum of 22% and 15%, respectively, in comparison with conventional hard turning with minimal fluid application without the aid of heat pipe. It appears that heat pipe can be successively employed as a mean of cooling the tool during hard turning with minimal fluid application. [5].

METHODOLOGY

The objective of this experimental study is to determine the influence of cutting parameters on Aluminium Alloy while carrying out turning operation. In this project presents a new methodology for the optimization of the machining parameters for turning of Aluminium. Taguchi's L_{18} orthogonal array is used for experimental design. The machining process parameters such as tool nose radius, tool rake angle, feed rate, cutting speed, cutting environment (dry, wet, cooled) and depth of cut are optimized with multiple performance considerations namely surface roughness and material removal rate. Principal Component Analysis (PCA) is used to solve such correlated multi-attribute optimization of turning operation. The quality index (principal component) having highest accountability proportion is treated as equivalent single objective function. ANOVA is used to find the significant parameters.

Work material

In the present study, the work material is aluminium alloys. Aluminium / aluminium are the second most widely used metal in the world today. It is a versatile metal that can be cast into any form. This lightweight metal can be welded, riveted, brazed, or resin bonded according to the requirement.
Aluminium / aluminium 1070 alloy is a wrought alloy type with good corrosion resistance. It is an excellent brazing alloy.

	Tool nose radius (A)	Tool rake angle (B)	Feed rate (C)	Cutting speed (D)	Cutting environment (E)	Depth of cut (F)
Level 1	1.849	1.841	1.560	1.726	1.753	1.747
Level 2	1.776	1.793	1.557	1.672	1.767	1.706
Level 3	-	1.802	2.319	2.038	1.917	1.984
Differences (Δ)	0.073	0.048	0.762	0.366	0.163	0.278
Rank	5	6	1	2	4	3

Table 3.1: - Response table for surface roughness

	Tool nose radius (A)	Tool rake angle (B)	Feed rate (C)	Cutting speed (D)	Cutting environment (E)	Depth of cut (F)
Level 1	134.36	132.86	78.77	97.21	141.54	46.31
Level 2	139.39	144.90	133.35	147.95	122.98	152.55
Level 3	-	132.87	198.50	165.46	146.11	211.77
Differences (Δ)	5.03	12.04	119.73	68.25	23.14	165.46
Rank	6	5	2	3	4	1

Table 3.2: - Response table for material removal rate

RESULT AND DISCUSSION
The mean response refers to the average value of the performance characteristic for each parameter at different levels. The average value of surface roughness for each parameter at levels 1, 2 and 3 are calculated. The main effects of the various process parameters when they change from the lower to higher levels can be visualized from the Fig. 4.1 that shows the response graphs of surface roughness for the tool nose radius, tool rake angle, feed rate, cutting speed, cutting environment and depth of cut. It is clear from the Fig. 4.1 (a) (e) (f) that the surface roughness is lowest at A2, B2, C2, D2, E1 and F2. The results indicated that the increase of tool nose radius reduce the surface roughness up to 0.8 mm as shown in Fig. 4.1 (a). The surface roughness increased with increase in tool rake angle as shown in Fig. 4.1 (b). The figure indicates that the surface roughness increased at high feed rate and cutting speed as shown in Fig.

4.1 (c) & (d). The reason being, the increase in the feed rate increases the heat generation and hence, tool wear, which resulted in the higher surface roughness. The results indicated that the surface roughness increases with cooled cutting environment and increase in depth of cut as shown in Fig. 4.1(e) & (f).

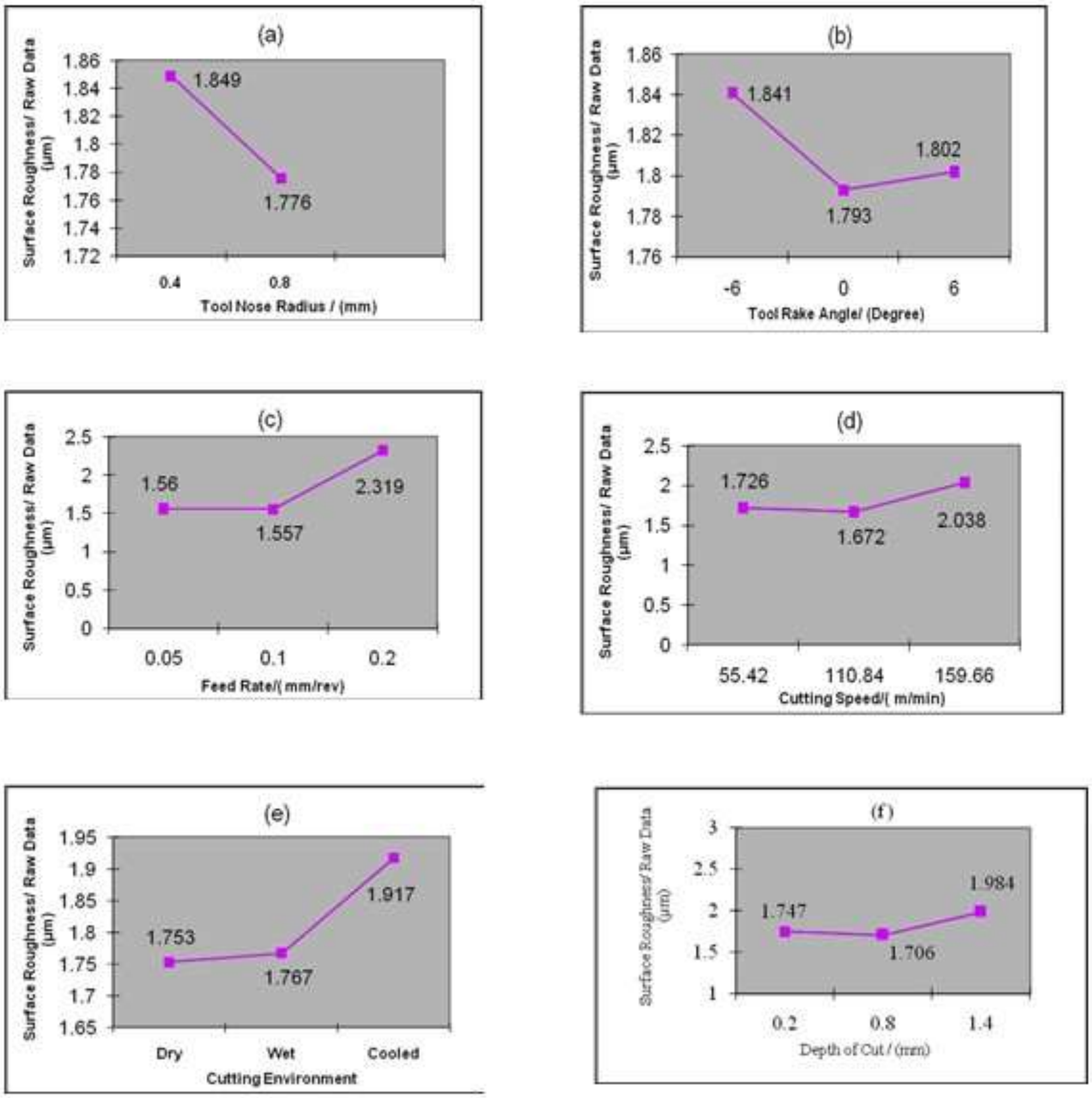

Fig 4.1 :- Response graph of surface roughness (a) effect of tool nose radius (b) effect of tool rake angle (c) effect of feed rate (d) effect of cutting speed (e) effect of cutting environment (dry, wet, cooled) (f) effect of depth of cut.

The increase in the feed rate increases the heat generation and hence, tool wear, which resulted in the higher surface roughness. The increase in the feed rate also increases the chatter and it produces incomplete machining at faster traverse, which leads to higher surface roughness. At low cutting speeds there is a large quantity aluminium alloys that are cut that causes the large surface roughness. It can be observed that the surface roughness gradually decreases with increase in the cutting speed up to 110.84 m/min and thereafter it increases. This is because matrix material deforms to a lesser extent. The figure shows that the best surface roughness could be arrived only at medium speed. Higher cutting speed produces more damage on the machined surface. This is attributed to higher cutting temperature, which results in local softening of work material. So moderate cutting speeds are preferred nose radius is a major factor that affects surface finish of the machined surface. A larger nose radius produces a smoother surface. There is a direct relationship between the size of the insert's nose radius and the surface finish produced. While it's true that a smaller nose radius decreases the pressure on a tool, it also limits the feed rate that can be used. An insert is capable of feeding only at one-half of the nose radius. Once this is exceeded, the surface produced is similar to a thread. Therefore, use the largest radius possible to produce the best finish and not create chatter. Positive rake make the tool more sharp and pointed. As the rake angle is increased in the positive direction, the normal force between the chip and the tool is reduced and the formation of built-up edge also reduced. So the increase of positive rake angle decreases the surface roughness. Greater negative rake give higher compressive stresses. So,0° rake angle is preferred. Depth of cut shows minimum effect on the surface roughness compared to other parameters. However, at low depth of cut, the removal of alloy from the matrix is partial and leads to high surface roughness, whereas at intermediate depth of cut, complete removal of alloys can be possible and leads to good surface finish. Surface roughness further decreases with increase in depth of cut. The use of cutting fluid is one of the machining techniques that are applied for a number of reasons, such as to reduce the cutting temperature, to lengthen the tool life, to produce a better surface finish, and to facilitate chip disposal. However, the application of cutting fluid creates a number of problems. If it is not disposed of properly it may affect the environment adversely and carry economic consequences. With dry and wet conditions, near about same surface roughness is obtained but surface roughness increased with cooled atmosphere. So, dry cutting condition is preferred.

CONCLUSION

Conventional machining was selected in this study. Sustainability issues related to economic and environmental aspect in the form of surface roughness, material removal rate and power consumption were studied. Experiments were conducted with varying conditions for speed feed, depth of cut, machining environment and cutting tool type. Taguchi analysis was performed to understand the ranking of factors affecting the response. ANOVA results were obtained to understand the significance of the model developed.

Experiments were conducted using CNC Lathe machine on AL1070 specimens with carbide tool material. From the experimental results, it is evident that the surface roughness and material removal rate increases as feed rate increases. Feed rate is the factor, which has great influences on surface roughness, followed by cutting speed. The study proposes Principal Component Analysis for the optimization of multiple performance characteristics. Application of PCA is recommended to eliminate response correlation by converting correlated responses into uncorrelated quality indices called principal components which have been treated as response variables for optimization.

Study has revealed that surface roughness by large is influenced by cutting environment and the kind of tool. It was also found that material removal rate is influenced by tool type, cutting velocity, feed and depth of cut while power required for machining depends on cutting environment, tool type cutting velocity and depth of cut. The experimental and the results obtained from model are closely related.

The results were optimized from sustainability point of view providing importance to surface roughness and material removal rate to keep it to minimum. The outcome of the model facilitate for setting machining parameters to accomplish the objective.

REFERENCE

[1] P. Sam Paul , A.S. Varadarajan , R. Robinson Gnanadurai , Study on the influence of fluid application parameters on tool vibration and cutting performance during turning of hardened steel, International Journal of Engineering Science and Technology, 19 (2016) 241–253.
[2] Sayak Mukherjee, Anurag Kamal, Kaushik Kumar, Optimization of Material Removal Rate During Turning of SAE 1020 Material in CNC Lathe using Taguchi Technique, Journal of Procedia Engineering , 97 (2014) 29 – 35.
[3] Fisher, Ronald Studies in Crop Variation. I, "An examination of the yield of dressed grain from Broadbalk", Journal of Agricultural Science, (1918), 11:107135. doi:10.1017/S0021859600003750.
[4] https://www.ee.iitb.ac.in/~apte/CV_PRA_TAGUCHI_INTRO.htm.

[5] R. Robinson Gnanadurai, A.S. Varadarajan, Investigation on the effect of cooling of the tool using heat pipe during hard turning with minimal fluid application, Engineering Science and Technology, an International Journal (2016), doi: 10.1016/j.jestch.2016.01.012.
[6] Puneet Bansal, Lokesh Upadhyay, Experimental Investigations To Study Tool Wear During Turning Of Alumina Reinforced Aluminium Composite, Journal of Procedia Engineering 51 (2013) 818 – 827
[7] B. de Agustina, C. Bernal, A.M. Camacho, E.M. Rubio, Experimental Analysis of the Cutting Forces Obtained in Dry Turning Processes of UNS A97075 Aluminium Alloys, International Journal of Procedia Engineering 63 (2013) 694 – 699.
[8] Rusdi Nur, D. Kurniawan, M.Y. Noordin,S. Izman, Optimizing power consumption for sustainable dry turning of treated aluminium alloy, International Journal of Procedia Manufacturing 2 (2015) 558 – 562.
[9] Meenu Gupta, Surinder Kumar, Investigation of surface roughness and MRR for turning of UD-GFRP using PCA and Taguchi method, International Journal of Engineering Science and Technology, an International Journal 18 (2015) 70-81.
[10] M.P. Jenarthanan, R. Jeyapaul, Evaluation of machinability index on milling of GFRP composites with different fibre orientations using solid carbide end mill with modified helix angles, Int. J. Eng. Sci. Technol. 6 (4) (2014)1e10.
[11] F. Kolahan, M. Abachizadeh, Optimizing turning parameters for cylindrical parts using simulated annealing method, World Acad. Sci. Eng. Technol. 46 (2008) 436e439.
[12] W. Konig, Ch. Wulf, P. Grab, H. Willerscheid, Machining of fibre reinforced plastics, CIRP Ann. 34 (1985) 537e548.
[13] S. Kumar, Meenu, P.S. Satsangi, H.K. Sardana, Modeling and analysis for -surface roughness and material removal rate in machining of UD-GFRP using PCD tool, Int. J. Eng. Sci. Technol. 3 (8) (2011) 248e270.
[14] S. Kumar, Meenu, P.S. Satsangi, H.K. Sardana, Multiple regression model for cutting force in turning UD-GFRP using polycrystalline diamond cutting tool, Int. J. Adv. Eng. Technol. 3 (1) (2012) 108e112.
[15] S. Kumar, Meenu, P.S. Satsangi, H.K. Sardana, Optimization of surface rough- ness in turning unidirectional glass fiber reinforced plastics (UD-GFRP) composites using polycrystalline diamond (PCD) cutting tool, Indian J. Eng. Mater. Sci. 19 (2012) 163e174.
[16] S. Kumar, Meenu, P.S. Satsangi, Multiple-response optimization of turning machining by the Taguchi method and the utility concept using uni-directional glass fiber reinforced plastic composite and carbide (K10) cut- ting tool, J. Mech. Sci. Technol. 27 (9) (2013) 2829e2837.
[17] E.S. Lee, Precision machining of glass fibre reinforced plastics with respect to tool characteristics, Int. J. Adv. Manuf. Technol. 17 (2001) 791e798.
[18] J. Paulo Davim, Machining Composite Materials, Wiley-ISTE, 2009.
[19] J. Paulo Davim, P. Reis, Multiple regression analysis (MRA) in modeling milling of glass fibre reinforced plastics (GFRP), Int. J. Manuf. Technol. Manage. 6 (1/2) (2004) 85e197.
[20] J. Paulo Davim, F. Mata, New machinability study of glass fibre reinforced plastics using polycrystalline diamond and cemented carbide (K15) tools, Mater. Des. 28 (2007) 1050e1054.
[21] M.S. Phadke, Quality Engineering Using Robust Design, Prentice-Hall, Engle- wood Cliffs, NJ, 1989.
[22] T. Rajasekaran, K. Palanikumar, B.K. Vinayagam, Application of fuzzy logic for modeling surface roughness in turning CFRP composites using CBN tool, Prod. Eng. Res. Dev. 5 (2011) 191e199.
[23] P. Raj, A. Elaya Perumal, P. Ramu, Prediction of surface roughness and delamination in end milling of GFRP using mathematical model and ANN, Indian J. Eng. Mater. Sci. 19 (2012) 107e120.
[24] P.J. Ross, Taguchi Techniques for Quality Engineering, McGraw, Hill, New York1996.
[25] C.T. Su, L.I. Tong, Multi-response robust design by principal component analysis, Total Qual. Manage. 8 (6) (1997) 409e416.
[26] R. Teti, Machining of composite materials, CIRP Ann. Manuf. Technol. 51 (2) (2002) 611e634.
[27] A.M. Zain, H. Haron, S. Sharif, Integrated ANN-GA for estimating the minimum