Journal of Advances and Scholarly Researches in Allied Education
Vol. 16, Issue No. 3, (Special Issue) March-2019, ISSN 2230-7540

Cutting Parameters Optimization in CNC Turning Operation for Controlled Surface Roughness and Higher Material Removal Rate using Design of Experiment Approach

Prateek Vaishnav[1]* Dheeraj Soni[2]

[1] Department of Mechanical Engineering, SS College of Engineering, India

[2] Department of Mechanical Engineering, SS College of Engineering, India

Abstract – Obtaining controlled surface roughness and maximum Material Removal Rates (MRR) is an essential prerequisite for any unmanned computer numeric controlled (CNC) machinery. In the present work, it is observed that, using design of experiment (DOE) approach, the quality of surface finish and MRR can be achieved within a reasonable degree of accuracy by taking highly affecting independent parameters into account.

In the present paper, an attempt has been made to optimize the cutting conditions to get desired surface roughness and higher MRR in turning of 8011 Aluminium Alloy. The experiments were designed using Taguchi design of experiment approach in which (3^3) 27 experimental runs were conducted for all the combinations of cutting parameters. The orthogonal array, signal to noise ratio and analysis of variance (ANOVA) was employed to study the performance characteristics at different conditions. Three parameters were chosen i.e. spindle speeds, depth of cut and feed rates.

Keywords: CNC; Surface Roughness; Taguchi Method; Orthogonal Array; Anova.

- X -

I. INTRODUCTION

Under the Make in India initiative, the Government of India aims to increase the share of the manufacturing sector in terms of the gross domestic product (GDP) to 25 per cent by 2022, from 16 per cent recently. It is also expected to create 100 million new jobs by 2022 showing the positive response on Make in India Initiative **[1].**

The engineering sector, being closely associated with the manufacturing and infrastructure sectors of the economy, is of strategic importance to India's economy. According to the top economists, mechanical industries and manufacturing play a crucial role in GDP of any country either economically developed or developing country **[2].**

Throughout the world, all the industrial sectors are facing a new challenge of customized demand. To fulfill the customer need in due time is a great challenge for all kind of industries today. To accomplish these needs industries are trying to evolve new techniques and flexibility in manufacturing system. Companies throughout the world have embraced 'Mass Customization' in an attempt to provide unique value to their customers in an efficient manner. Thus, with 'Mass Customization', the manufacturing enterprises are forced to make use of the modern machineries with programmable operation and high rate of output. Thus, present work is focused on use of CNC Cell. Manufacturing has conventionally played a major role in the economic growth of developing countries. Kaldor (1967) **[3]** characterized the manufacturing sector as "The main engine of fast growth."

Meng Q. et al. (2000) **[4]** studied for calculating the optimum cutting conditions in turning for minimizing the cost or maximizing the production rate. In their work, modified form of Taylor tool life equation was used for predicting response values and optimizing its value.

Robust design for the engineering is a better methodology for obtaining best set of results which are minimally sensitive to the numerous causes of variation to produce best quality products at least cost. Taguchi and ANOVA parameters are important tool for such kind of robust design which offers simple and systematic approach to optimize the design data[5-10]. These techniques can be employed for optimizing the desired results by controlling the design parameters in several experimental runs. Taguchi design can optimize the results through setting of design parameters as per requirement[11]. On the other hand, ANOVA is employed to recognize the most significant variables and their interaction effects along with their percentage contribution.

Various factors have been considered by numerous researchers and scientists to study their effect on surface roughness. Sunderam & Lambert[12-13] considered six controlled factors which may affect the surface roughness i.e. speed, depth of cut, feed, time of cut, nose radius and type of tool. But finally it is found that the three factors i.e. spindle speed, feed rate and depth of cut can affect the surface roughness[14-18].

Mukharjee et al., (2006) **[19]** worked for optimization of Material removal rate using SAE 1020 material in CNC turning process. In his study three cutting parameters were used namely feed rate, depth of and spindle speed which are the highly contributing parameters in machining process.

The present research work describes about how to select the controlled factors (spindle speed, depth of cut and feed rate) that can minimize the effect of noise factor on the response (surface roughness and MRR).

II. MATERIALS AND METHODS

Material & its specifications

The work piece material for this experiment was 8011-AA i.e. Aluminium Alloy. This material is chosen specially due to some of its special properties as low weight, corrosion resistive, easy maintenance of final product and good strength property. The present experimentations are performed using the material in the form of bar. The dimensions of bar are taken as length=100 mm and diameter=32 mm.

Experimental Design and Setup

This experiment involves a basic full factorial design of experiment approach. The experiment involves three controlled factors and two response variables. The controlled factors are spindle speed, depth of cut and feed rate while the response variables are surface roughness and MRR. The experiment was performed using CNC Lathe DX-200 Series slant bed using a new diamond shaped carbide tool insert.

After final finish cut, the surface roughness was measured for each work piece along the circumference using Mitutoyo Surface roughness measuring tester SJ-210. Measurements were obtained with the help of movement of stylus with diamond tip over the surface along the z axis. For this experiment, Arithmetic mean of roughness (Ra) was calculated for each work piece.

Experimental Procedure

The schedule of runs was created at various combinations according to full factorial design of experiments specified in Minitab Statistical software. The work pieces from the bar were turned with specified cutting conditions. After completion of all the runs, the surface roughness of all the work pieces was measured. Data processing and its analysis were performed through MINITAB-18 statistical software.

Analysis of S/N Ratios & Analysis of Variance (ANOVA)

For Taguchi analysis, experimental results of surface roughness and MRR are transformed into Signal to Noise (S/N) ratio. For this experimental analysis, the smaller is better was employed to calculate S/N ratio of surface roughness and larger is better was employed for MRR. Furthermore, variance analysis was performed for collected data to analyze the results for Ra and MRR.

III. CONCLUSIONS

Finally, it can be concluded that, it is impossible to achieve surface roughness in controlled manner or higher MRR by ‘Trial and Error’ method. It needs an in-depth analysis of the parameters affecting it. As identified from the results, it is concluded that Surface roughness is highly affected by Feed rate followed by depth of cut and spindle speed and Coefficient of determination is also significant i.e. 87.41 % which shows a best set of parameters.

In similar manner conclusions are drawn for MRR which shows that MRR is highly affected by Feed rate followed by depth of cut and spindle speed and Coefficient of determination using ANOVA table for MRR is found to be 90.59% showing high level of significance.

REFERENCES

1. http://www.makeinindia.com/article/-/v/make-in-india-reason-vision-for-the-initiative. Jan, 2017.

2. http://www.entrepreneurscouncil.in/Manufacturing.php/March, 2017.

3. Kaldor N. (1967). Strategic Factors in Economic Development. Ithaca, NY: Cornell University.

4. Meng, Q., Arsecularatne, J.A. and Mathew, P. (2000). “Calculation of Optimum Cutting Conditions for Turning Operations Using a Machining Theory”, *Int. J. of Machine Tools*

and Manufacture, Vol. 40(12), pp. 1709–1733.

5. Park S.H. (1996). Robust design and analysis for quality engineering, Chapman & Hall, London.

6. Ghani J.A., Choudhury I.A., Hassan H.H. (2004). "Application of Taguchi method in the optimization of end milling parameter", *J. of Mate. Processing Technol.*, 145, pp. 84–92.

7. Kopac J., Krajnik P. (2007). "Robust design of flank milling parameters based on grey-Taguchi method", *J. of Mate. Processing Technol.*, 191, pp. 400–403.

8. Bendell T. (1988). Taguchi methods, in: Proceedings of the European Conference on Taguchi Method, *Elsevier, Amsterdam.*

9. Julie Z. Zhang, Chen J.C., Kirby E.D. (2007). "Surface roughness optimization in an end-milling operation using the Taguchi design method", *J. of Mate. Processing Technol.,* 184, pp. 233–239.

10. Kuram E., Simsek B.T., Ozcelik B., Demirbas E., and Askin S. (2010). "Optimization of the cutting fluids and parameters using Taguchi and ANOVA in milling" *World Congress on Engineering*, 2, pp. 978-988

11. Berger P.D. and Maurer R.E. (2001). Experimental design with applications in management, engineering and the sciences. 1st Edn., Duxbury Press, USA, ISBN: 10: 0534358225, pp. 496.

12. Sundaram R.M., Lambert B.K. (1981). Mathematical model to predict surface finish in fine turning of steel, Part-I. *Int. J. of Prod. Research* **19**. pp. 547-556.

13. Sundaram R.M., Lambert B.K. (1981). Mathematical model to predict surface finish in fine turning of steel, Part-I. *Int. J. of Prod. Research* **19**. pp. 547-556.

14. Lascoe O.D., Nelson C.A., & Porter H.W. (1973). Machine shop operations and setups. Alsip, *IL: American Technical Publishers.*

15. Cirstoiu C.A. (2005). Influence of feed rate on surface roughness in turning processes with different tool inserts. *UPB Scientific Bulletin, Series D: Mechanical Engineering*, **67**(2), pp. 63-70.

16. Feng C.X. & Wang X.F. (2003). Surface roughness predictive modeling: neural networks versus regression. *IIE Transactions* **35**(1), pp. 11–27.

17. Özel T., Hsu T.K., & Zeren E. (2005). Effects of cutting edge geometry, work piece hardness, feed rate and cutting speed on surface roughness and forces in finish turning of hardened AISI H13 steel. *J. of Adv. Manuf. Technol.* **25**(3-4), pp. 262- 269.

18. Vernon A. & Özel T. (2003). Factors affecting surface roughness in finish hard turning. Paper presented at the 17th International Conference on Production Research, Blacksburg, Virginia.

19. Mukherjee I. and Ray P. K. (2006). A Review of Optimization Techniques in Metal Cutting Processes. J. of Comput and Ind. Eng. 50(1–2): pp. 15–34.

Corresponding Author

Prateek Vaishnav*

Department of Mechanical Engineering, SS College of Engineering, India