INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2020); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:2(4), February:2021
Online Copy Available: www.ijmer.in

PERFORMANCE INVESTIGATION OF MILLING PROCESS UNDER OPTIMUM LUBRICANT USE BY TAGUCHI METHOD

[1]Shilpa B. Sahare, [2]Dr. Sachin P. Untawale , [3]P.D. Kamble and [4]Dr. S.S. Chaudhari
[2]Director and [1,3&4]Department of Mechnical Engineering
[2]Raisoni Group of Institutionand [1,3&4]Yeshwantrao Chavan College of Engineering, Nagpur
MS, India

Abstract Performance of the machining and the efficiency of milling operation depend on several process variables among which hardness of work material is of great significant. In this study, experimentation was carried out to investigate the effect of work hardness on end milling process. Workpiece material hardness is used as a noise factor. Input parameters used are spindle speed, feed; depth of cut and tool diameter. The experiments performed under wet and minimum Quantity lubrication and results of both compared. further for getting optimal lubricant conditions the experiments performed for various levels of flow rates of minimum quantity lubrication to get the best optimal setting. Output parameters are surface roughness, material removal rate, cutting force and tool wear. Design of Experiment (DOE) with Taguchi L27 Orthogonal Array (OA) has been explored to produce 27 specimens on Al2024 aluminium by end milling operation at three different levels of hardness of material. The experiments performed under wet and minimum quantity lubrication condition and results compared. Further For optimal lubricant condition the experiments performed at various flow rate of Minimum Quantity Lubrication and “best” optimal setting is identified.

Keywords: Al2024-T4 Workpiece Material, GRA, Taguchi Method, ANOVA, S/N Ratio.

1.INTRODUCTION

Due to the development of new engineering materials and high-speed cutting, cutting fluid plays an important role in machining. Commonly, the cutting fluid can decrease cutting temperature, reduce the friction between tool and work piece, extend tool life, and improve machining efficiency and surface quality. These effects of cutting fluid were mainly obtained from its basic functions including cooling, lubrication, corrosion protection, and cleaning. If cutting fluids, correctly selected and applied, it reduces the problems associated with the high temperature and high stresses. Unfortunately, waste cutting fluids create process-generated pollution. Conventional cutting fluid leads to environmental pollution and also health problems.

Therefore, the use of cutting fluids is an important part of a machining process system. Without cutting fluid, tools have only a short life, which makes the machining process costly. Solid tools need regrinding so that they can be reused and insert-type cutting tools require the cutting edges to be rotated so that a new cutting edge is ready to cut. These processes add extra costs.
An end mill can cut a work piece either vertically, like a drill, or horizontally using the side of the end mill to do the cutting. This horizontal cutting operation imposes heavy lateral forces on the tool and the mill, so both must be rigidly constructed. By making a series of horizontal cuts across the surface of a work piece, the end mill removes layers of metal at a depth that can be accurately controlled to about one thousand of an inch (.001”).

Today many techniques for improving lubricating in machining process are used. In dry machining process the cutting operation done without any lubricant. In wet marching process which is done in most of the industry the lubricant used in continuous basis on large quantity and hence go waste. Hence it will also increase the production time and cost.

2. EXPERIMENTATION

2.1 Definition of the problem: Before conducting the experiment, the knowledge of the product/process under investigation is of prime importance. Objectives of the quality characteristics should be identified first.

2.2 Identification of Noise Factors: Identification of noise factor is very important because it may deviate the performance of quality characteristics. The desired values of responses can be achieved by neglecting effect of noise factor.

2.3 Selection of Response Variables: In any process, the response variables need to be chosen so that they provide useful information about the performance of the process under study.

2.4 **Selection of Control Parameters and Their Levels:** After listing the control and the noise factors, decisions on the factors that significantly affect the performance will have to be ascertained and only those factors must be taken in to consideration in constructing the matrix for experimentation. Levels of control factors should be selected such that, there is the noticeable effect on performance of the quality characteristics.

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2020); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:2(4), February:2021
Online Copy Available: www.ijmer.in

2.5Identification of control factor interactions: Each OA has a particular set of linear graphs and a triangular table associated with it. The linear graphs indicate various columns to which parameters may be assigned and the columns subsequently evaluate the interaction of these parameters. The triangular tables contain all the possible interactions between parameters (columns). Using the linear graphs and/or the triangular table of the selected OA, the parameters and interactions are assigned to the columns of the OA.

2.6 Selection of Orthogonal Array (OA): In selecting an appropriate OA, the pre-requisites are] as given below.

- Selection of process parameters is to be evaluated.
- Selection of number of levels for the selected parameters.

2.7 Conducting the Matrix Experiments: The experiment is conducted against each of the trial condition of the inner array. Each experiment at a trial condition is repeated, simply without using any outer array, or according to the outer array used. Randomization strategies [72] should be considered during the experimentation.

According to the Design of Experiment (DOE), the cutting parameters are adjusted in the CNC Milling machine. Total 162 experiments were performed. The end mill operation is performed over a length of 75 mm. By setting different parameters and changing the different tool diameter and tool type under wet and MQL lubrication at three different levels work material hardness in terms of hardness (43- 48 HRB, 49- 53 HRB and 54-58 HRB).

3. ANALYSIS

Single Optimization by Taguchi Method

Taguchi method is used for single objective optimization. The S/N (signal-to-noise) ratio is used by Taguchi approach to analyse experimental data because the S/N ratio represents both the average (mean) and variation (scatter) of the experimental results. In single objective optimization, Taguchi method provides the individual optimal setting for each output parameters. The data analysis and optimization of surface roughness, material removal rate, cutting force and tool wear are performed as follows:

Table 1 Response Table for S/ N Ratios (Smaller the better) of Surface Roughness

Level	Spindle Speed	Feed	Depth of cut	Tool Diameter	Tool Type
1	-8.632	-7.7879	-0.546	-6.207	-6.64
2	-6.252	-5.4787	-6.786	-6.073	-6.007
3	-3.065	-4.6825	-10.62	-5.67	-5.302
Delta	5.567	3.1054	**10.07**	0.537	1.339
Rank	2	3	**1**	5	4

Table 2 ANOVA for signal to noise ratio of Surface Roughness

Process parameters	Degree of freedom	Sum of square	Mean sum of square	F	P	% Contribution
Spindle Speed (A)	2	140.419	70.2095	344.48	0	21.11
Feed (B)	2	46.831	23.4155	114.89	0	7.04
Depth of cut (C)	2	465.208	232.604	1141.3	0	**69.94**
Tool diameter (D)	2	1.406	0.703	3.4492	0.048	0.21
Tool type (E)	2	8.072	4.036	19.803	0	1.21
Residual Error	16	3.261	0.2038			0.49
Total	26	665.197				100

From the ANOVA table of S/N ratio, for 95 % confidence level, the P-value for spindle speed, feed, depth of cut, tool diameter and tool type is less than 0.05 i.e. (< 0.05), hence all the input parameters are significant to surface roughness. Also, depth of cut has the highest percentage contribution (69.94 %) to surface roughness.

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2020); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:2(4), February:2021
Online Copy Available: www.ijmer.in

Figure 1 Main effect plot for S/N ratio (Smaller the better)

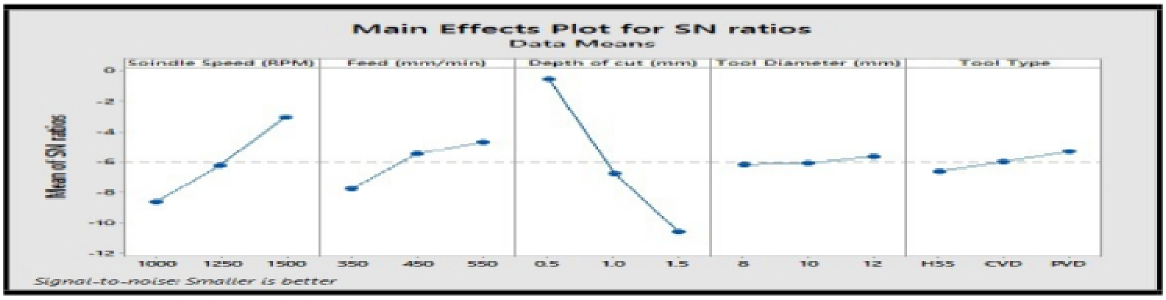
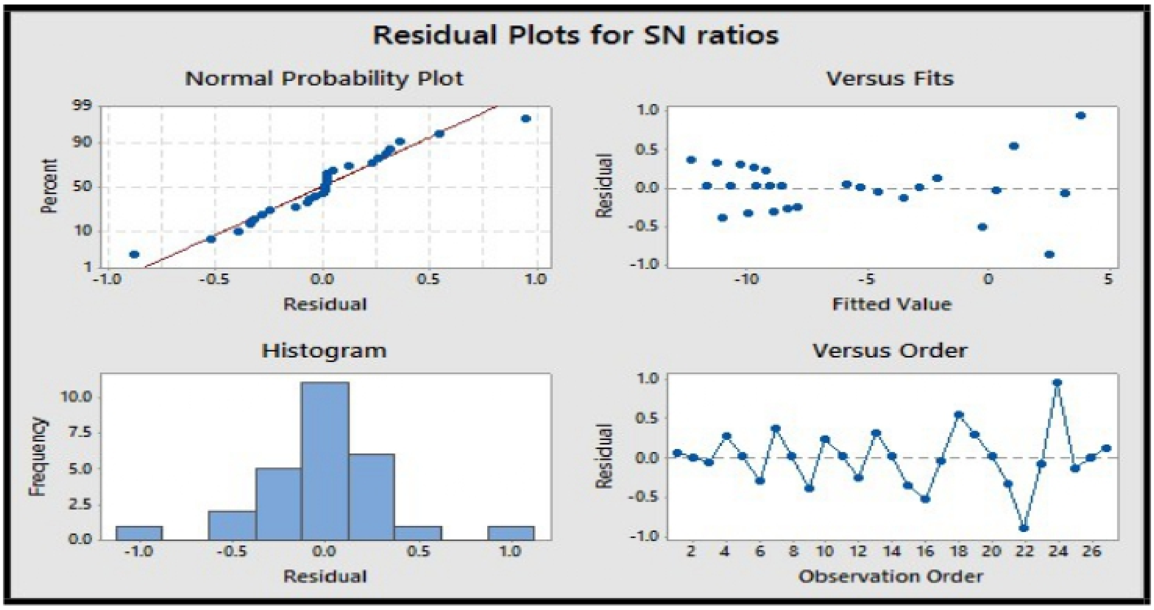


Figure 2 Residual plot for SN ratio



The results of ANOVA for Surface roughness indicate that depth of cut is the most significant machining parameters in affecting the Surface roughness followed by spindle speed, feed, tool type and tool diameter. Based on the above discussion and the main effect plot of S/N ratio, the optimal machining parameters are the spindle speed at level 3 (A**3** = 1500rpm), feed at level 3 (B**3**= 550mm/min), depth of cut at level 1 (C**3**=0.5), tool diameter at level 3 (D**3** = 12 mm), and tool type at level 3 (E**3**= PVD coated) or **A3 B3 C1 D3 and E3** in short.

Table 4. Values of Process Parameters at Optimum Level

Process Parameters	Code	level1	level2	level3
Spindle Speed (RPM)	A	1000	1250	1500
Feed (mm/min)	B	350	450	550
Depth of cut (mm)	C	0.5	1	1.5
tool diameter (mm)	D	8	10	12
Tool type	E	HSS	CVD	PVD

Predicted Value of Surface Roughness

Output parameter at optimal setting can be predicted by additive model

$$\mu_{pred} = \bar{Y} + \sum (\bar{Y}_i - \bar{Y}) \qquad \textit{(6.35)}$$

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2020); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:2(4), February:2021
Online Copy Available: www.ijmer.in

By using additive model, predicted value of surface roughness at optimal setting **A3B3C3D2E1** is calculated as follows:

$$\mu_{SR} = Y_{SR} + (A_3 - Y_{SR}) + (B_3 - Y_{SR}) + (C_1 - Y_{SR}) + (D_3 - Y_{SR}) + (E_3 - Y_{SR})$$

= 2.29 + (1.70-2.29)+ (2.06-2.29)+)+ (1.16-2.29))+ (2.40-2.29))+ (2.16-2.29)

= 0.321 um

Conformity Test

Conformity test is used to check whether the experimental value of output parameter at optimal setting is within the range given by confidence interval or not.

Confidence Interval (CI)

For the 95 % confidence level, CI is calculated as below:

$$CI = \sqrt{\frac{F_\alpha(1, f_e)\,V_e}{n_{eff}}}$$

Where $F_\alpha(1, f_e)$ = The F ratio at the confidence level of (1-α) against '1' and error of freedom f_e.

$$n_{eff} = \frac{N}{1 + [DOF\ associated\ in\ the\ estimate\ of\ mean\ response]}$$

=81/ (1+10) =7.3636,

N= Total number of results = 27 x 3=81

f_e =error DOF=4

$F_{0.05}(1,4)$ = 7.71 (Tabulated F value (Ross, 1996))

The 95% confidence level of the population is: [μ − CI] < μ < [μ + CI]

Where, μ is the predicted mean of response characteristic.

Error variance Ve =0.0706 (from Table 6.2)

Therefore,

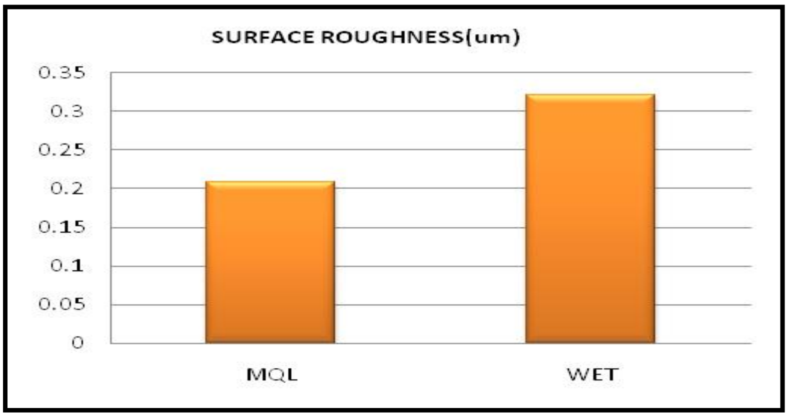
CI=+- 0.2718

The 95% confidence interval of the population is: [μSR − CI] < μSR < [μSR + CI]

Minimum Surface Roughness (0.321 um) is achieved when spindle speed is 1500 rpm, feed 550mm/min, depth of cut 0.5 mm and CVD Coated tool of diameter of 12 mm.

Under MQL Minimum Surface Roughness (0.107 um) is achieved when spindle speed is 1500 rpm, feed 550mm/min, depth of cut 0.5 mm and CVD Coated tool of diameter of 12 mm.

Figure 3 Residual plot for SN ratio



In order to compare different flow rates of MQL for optimal lubricant use, the experiments performed at optimal setting obtained from grey relational analysis, the results compared and is found that the best results obtained at 80ml/hr.

4. CONCLUSION

For wet lubrication

a) Depth of cut (**69.94 %** contribution) is the most significant machining parameter in affecting the Surface roughness. It is followed by spindle speed, feed, tool type and tool diameter.

For Minimum Quantity lubrication

a) Depth of cut (**68.84 %** contribution) is the most significant machining parameter in affecting the Surface roughness. It is followed by spindle speed, feed, tool type and tool diameter.

The values of responses at various flow rates are discussed in chapter 8. Hence, best results for multi-response optimization of the S/N responses and using the optimized process setting obtained through the application of this method (**A3B3C3D2E3**) would enable the machine operator to realize highly robust process performance. By comparing the results at all flow rates of MQL such as 70,80,90,110,120,130ml/hr respectively, it is found that the responses in terms of surface roughness, material removal rate, cutting force and tool wear are best at the flow rate of **80ml/hr.**

5. Possible Contribution to the Society

This research study may contribute to the society in following way

- The present study can be used for implementing the Minimum Quantity Lubrication Technique in place of conventional Wet Lubrication.
- This MQL techniques will definitely help to reduce the health hazards of workers working on machine and also reduces the environmental pollution.
- This work can signify the importance of Material hardness. The optimal setting obtained can be applicable for all the hardness of material Al2024.

6. REFERENCES

1. A. Prashant D Kamble, B. Atul C Waghmare, C. Ramesh D Askhedkar, Materials Today: Proceedings Elsevier Publication, (2015) 3318-3326.

2. A. E. Daniel Kirby, B. Zhe Zhang,C. Joseph C. Chen, The International Journal of Advanced Manufacturing Technology Volume 30, Issue 11–12 (October 2006), , pp 1021–1029

3.Yeh-Liang Hsu, 2005," One-Pass milling machining parameter optimization to achieve mirror surface roughness", Journal of Engineering Manufacture.

4.J. Caldeirani Filho, A.E.Diniz, 2002,"Influence of cutting conditions on tool life, tool wear and surface finish in the face milling process", Journal of the Brazilian Society of Mechanical Sciences.

5.Dr. A.Gopala Krishna, 2007,"A global optimization approach to select optimal machining parameters of multipass face milling".

6.K. Choudhuri, D.K.Pratihar, D.K.Pal, 2002,"Multi- Objective optimization in turning – using a Genetic Algorithm".

7.Z.G. Wang, Y.S.Wong, M.Rahman, 2003,"Optimization of multi-pass milling using genetic algorithm and genetic simulated annealing", Journal of Advanced Manufacturing Technology

8.Dalgobind Mahto And Anjani Kumar, 2008," Optimization of process parameters in vertical CNC mill machines using Taguchi's Design of Experiments", Journal of Industrial Technology.

9.C.C. Tsao, 2007," Grey-Taguchi method to optimize the milling parameters of aluminium alloy", Journal of Advanced Manufacturing Technology

10.Lohithaksha M Maiyar, Dr.R.Ramanujam K.Venkatesan , Dr.J.Jerald (2013), Optimizationof Machining Parameters for End Milling of Inconel 718 Super Alloy Using Taguchi Based Grey Relational Analysis, Procedia Engingg 64 (2013) 1276 – 1282.