OPTIMIZATION OF TURNING PARAMETERS TO IMPROVE SURFACE ROUGHNESS OF 2024-T3 ALUMINIUM

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ABSTRACT

This paper deals with the effect of controllable factors mainly spindle speed (800, 900, 1000), feed rate (80, 100, 120), depth of Cut (0.5, 0.8, 1.0) on Surface Roughness in CNC turning operation. The experiments were performed on 2024-T3 Aluminium material using Taguchi method. A three level, three Factor design of experiment prepared according to Taguchi orthogonal array L_9 using Minitab 16 software. The Analysis of Variance (ANOVA) and Signal to Noise (S/N) Ratio was carried to find out the most significant factor and percentage contribution of individual factor for Surface Roughness. The all experiments were performed at dry condition. From result it is found that optimum level for Surface Roughness is obtained as 800 m/min of Spindle speed, 80 mm/min of feed and 0.8mm of depth of cut.

Keyword: - *CNC Turning[1], Taguchi method[2], Surface roughness[3], ANOVA[4], Minitab 16[5].*

1. INTRODUCTION

Now a day's customer demands better quality product with minimum cost in the manufacturing field. The Surface finish is the important parameter at the point of view quality of the product and better surface finish can be achieved that using optimization technique. Material removal rate decides the productivity of the manufacturing component. So the Surface roughness and Material removal rate plays an important role in manufacturing industry.

In turning, surface roughness and material removal rate are two important aspects, which require attention both from industry as well as research & development point of view. In modern industry, one of the trends is to manufacture low cost, high quality products in short time. Automated and flexible manufacturing systems are employed for that purpose. On the other hand, material removal rate is another important factor that greatly influences production rate and cost. So, there is a need for a tool that allows the evaluation of the surface roughness and material removal rate before the machining of the part and which, at the same time, can easily be used in the production-floor environment contributing to the minimization of required time and cost and the production of desired surface quality. [1]

In present time the technology of CNC turning machine has been advanced significantly, in order to meet the advance requirements in various manufacturing fields, especially in the precision turning metal cutting industry. Among the several CNC industrial machining processes. It is widely used in a variety of products/components manufacturing in the industries. The material removal rate (MRR) and Surface roughness (Ra) are an important controlling factor of machining operation. MRR and Ra are measurement of productivity and quality of the machining component. In order to improve the machining characteristics, effort to minimize the value of Ra and maximize the value of MRR by selecting optimal machining process parameters like cutting speed, feed rate, depth of cut and insert nose radius are required to be study in details. [5]

Metal cutting is one of the vital processes and widely used manufacturing processes in engineering industries highly competitive market requires high quality products at minimum cost. Products are manufactured by the transformation of raw materials. Industries in which the cost of raw material is a big percentage of the cost of finished goods, higher productivity can be achieved through proper selection and use of the materials. To improve productivity with good quality of the machined parts is the main challenges of metal industry; there has been more concern about monitoring all aspects of the machining process. Surface finish is an important parameter in manufacturing engineering and it can influence the performance of mechanical parts and the production costs. [6]

From literature it is observed that very less work has been carried out on optimization of CNC Turning process parameters on 2024-T3 Aluminium material. The aim of this research is to find out the effect of CNC Turning process parameters on turned work pieces at the point of view surface roughness by employing Taguchi's orthogonal array design and analysis of variance (ANOVA). In this experiment L_9 orthogonal array is used with three controllable factors like Spindle speed (rpm), Feed rate (mm/min) and depth of cut (mm) with three levels of each to find out optimum level of process parameters for CNC Turning operation. The ANOVA results used to find out significant factor and percentage contribution of individual factor.

2. EXPERIMENTAL METHODOLOGY

2.1 Experimental Design

In this work CNC Turning operation was performed on 2024-T3 Aluminium material. The parameters identified for investigation are Spindle speed, Feed rate and depth of cut. The selected process parameter and their levels are shown in Table 1. The Work pieces for machining are as shown in Fig. 1.

Fig -1: Work pieces for machining

Table -1: Control factors and their levels

Control Factors	Units	Level I	Level II	Level III
Spindle Speed	rpm	800	900	1000
Feed rate	mm/min	80	100	120
Depth of Cut	mm	0.5	0.8	1.0

2.2 Taguchi Method

Orthogonal array is one of the Taguchi tool, which takes out the quantity of test required, decreases the cost, and reduce the time of trials.(5) The Orthogonal array L_9 is shown in Table 2. Taguchi gives three types of quality characteristics Smaller the better, Nominal the better and Larger the better.

Table -2: Taguchi L_9 Orthogonal array

Run	Factor 1 Spindle Speed (rpm)	Factor 2 Feed rate (mm/min)	Factor 3 Depth of Cut
1	800	80	0.5
2	800	100	0.8
3	800	120	1.0
4	900	80	0.8
5	900	100	1.0
6	900	120	0.5
7	1000	80	1.0
8	1000	100	0.5
9	1000	120	0.8

2.3 ANOVA Analysis

Analysis of variance (ANOVA) of the overall grade is done to show the significant parameters. If the P value for a factor becomes less than 0.05 then that factor is considered as significant factor at 95% confidence level. Statistical software with an analytical tool of ANOVA is used to determine which parameter significantly affects the performance characteristics.

2.4 S/N ratio

The signal-to-noise (S/N) ratio measures how the response varies relative to the nominal or target value under different noise conditions. You can choose from different S/N ratios, depending on the goal of your experiment. Taguchi introduced three types of quality characteristics Smaller is better, Nominal is better and Larger is better

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the smaller-is-better S/N ratio using base 10 log is:

$$\text{S/N Ratio} = -10\log\left[\frac{1}{n}\sum_{i=1}^{n}(Y_i^2)\right] \quad \text{---------- (1)}$$

Where Y = responses for the given factor level combination and n = number of responses in the factor level combination.

3. EXPERIMENTAL PROCEDURE

The Experiments were performed on CNC Turning machine make by sine wave engineering Pvt. Ltd. The actual photograph of Machine is as shown in Fig. 2.

Fig -2: Photograph of experimental set up

The work pieces after machining are as shown in Figure 3. After Machining the Surface Roughness of machined component is measured using a contact type surface roughness tester. The Table 3 shows the results for Surface Roughness.

Fig -3: Work pieces after machining

Table -3: Experimental result for Surface Roughness

Run	Factor 1 Spindle Speed (rpm)	Factor 2 Feed rate (mm/min)	Factor 3 Depth of Cut	Surface Roughness (µm)
1	800	80	0.5	1.874
2	800	100	0.8	1.61
3	800	120	1.0	1.853
4	900	80	0.8	1.479
5	900	100	1.0	2.512
6	900	120	0.5	2.755
7	1000	80	1.0	2.502
8	1000	100	0.5	2.822
9	1000	120	0.8	2.973

3. RESULT & DISCUSSION

The Signal to Noise (S/N) Ratio for Surface Roughness is calculated by using Smaller the better characteristic. The S/N Ratio result for Surface Roughness is as shown in Table 4.

Smaller the Better,

S/N Ratio = -10log [$\frac{1}{n}\sum_{i=1}^{n}(Y_i^2)$] ---------- (1)

Table -4: Calculated S/N ratio for Surface Roughness

Run	Factor 1 Spindle Speed (rpm)	Factor 2 Feed rate (mm/min)	Factor 3 Depth of Cut (mm)	Surface Roughness (µm)
1	800	80	0.5	-5.45
2	800	100	0.8	-4.14
3	800	120	1.0	-5.36
4	900	80	0.8	-3.40
5	900	100	1.0	-8.0
6	900	120	0.5	-8.80
7	1000	80	1.0	-7.8
8	1000	100	0.5	-9.01
9	1000	120	0.8	-9.46

3.1 Analysis of Tensile strength

The Analysis of variance result for Surface Roughness as shown in Table 5. From the result of ANOVA for Surface Roughness the Spindle speed shows more contribution of 53.39 %, Feed rate shows 19.13 % contribution and Depth of cut has lowest contribution of 16.61 %. Here the residual error was found as 10.87 %.

Table -5: ANOVA for Surface Roughness

Source	DF	Seq SS	Adj MS	F	P	% Contribution
Spindle Speed	2	22.063	11.031	4.91	0.169	53.39
Feed rate	2	7.905	3.952	1.76	0.362	19.13
Depth of Cut	2	6.865	3.432	1.53	0.396	16.61
Residual error	2	4.493	2.247			10.87
Total	8	41.325				100

From response Table 6 it is observed that Spindle speed has the greatest influence on the Surface roughness also feed rate has the next greatest influence followed by Depth of cut.

Table -6: Response of S/N ratio for Surface Roughness

Level	Spindle speed	Feed rate	Depth of cut
1	-4.983	-5.607	-7.756
2	-6.734	-7.049	-5.667
3	-8.814	-7.875	-7.108
Delta	3.830	2.268	2.090
Rank	1	2	3

Figure 4 shows the main effect for S/N Ratio of Surface Roughness. From figure 5 the optimum level of CNC Turning process parameters are obtained at Spindle speed of 800 rpm, Feed rate of 80 mm/rev and depth of cut of 0.8.

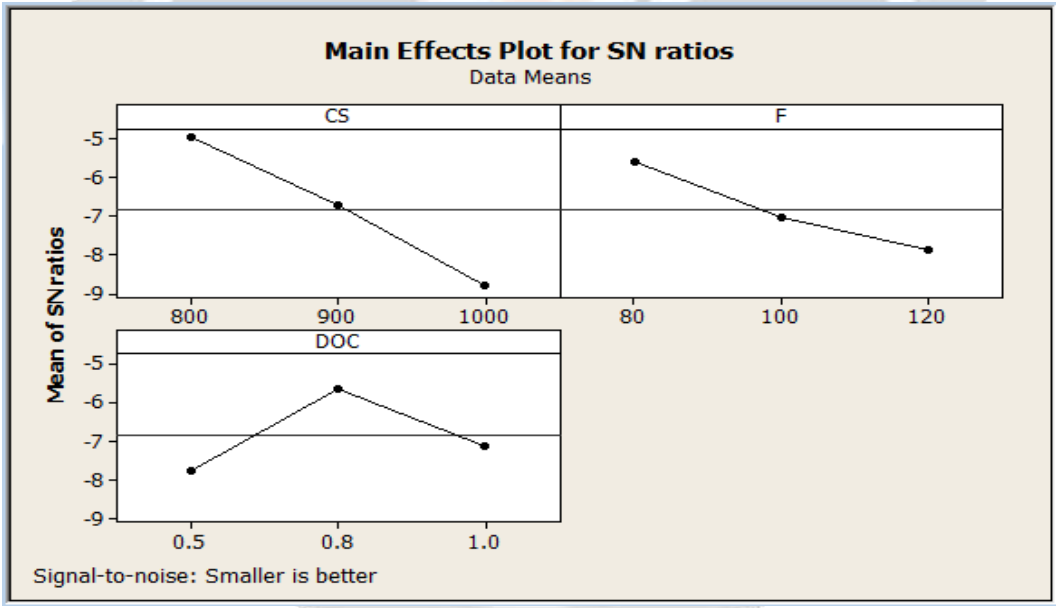

Fig -4: Main effect plot for S/N ratio of Surface roughness

4. CONCLUSIONS

In this study, the Taguchi method was used to obtain optimal condition for CNC Turning of 2024-T3 Aluminium. Experimental results were evaluated using ANOVA and following conclusions are drawn:

1. Taguchi's design of experimental technique was used to find the optimum levels of process parameters in CNC Turning operation. The optimum levels of the Spindle speed, feed rate and depth of cut are 800 rpm, 80 mm/min and 0.8mm respectively.
2. In this investigation Spindle speed plays a vital role and contributes 53.39 % to the overall contribution.
3. Feed rate has the second greatest influence on Surface roughness of CNC Turned 2024-T3 Aluminium materials.

4. Depth of cut has negligible influence on Surface roughness of CNC Turned 2024-T3 Aluminium materials.
5. Optimum level of parameters is obtained at spindle speed (800 rpm), feed rate (80mm/min) and depth of cut of 0.8 mm
6. Taguchi method successfully optimized CNC Turning process parameters.

5. REFERENCES

[1] Meenu Gupta, Surinder Kumar (2015), Investigation of surface roughness and MRR for turning of UD-GFRP using PCA and Taguchi method, Engineering Science and Technology, an International Journal, 18, (2015) 70-81.

[2] Prashant D. Kamble, Atul C. Waghmare, Ramesh D. (2017), Multi objective optimization of turning parameters considering spindle vibration by Hybrid Taguchi Principal component analysis (HTPCA), Materials Today: Proceedings, 4, 2077–2084.

[3] B.Singarvel, T.Selvaraj , R.Jeyapaul (2014), Multi Objective Optimization in Turning of EN25 Steel Using Taguchi Based Utility Concept Coupled With Principal Component Analysis, Procedia Engineering, 97, 158 – 165.

[4] Arshad Noor Siddiquee, Zahid A. Khan, Pankul Goel, Mukesh Kumar, Gaurav Agarwal, Noor Zaman Khan (2014), Optimization of Deep Drilling Process Parameters of AISI 321 Steel using Taguchi Method, Procedia Materials Science, 6, 1217 – 1225.

[5] Krupal Pawar and R. D. Palhade (2015), Multi-objective Optimization of CNC Turning Process Parameters for High Speed Steel (M2) Using Taguchi and ANOVA Method, International Journal of Hybrid Information Technology, 8, 67-80.

[6] Harsh Y Valera, Sanket N Bhavsar (2014), Experimental Investigation of Surface Roughness and Power Consumption in Turning Operation of EN 31 Alloy Steel, *Procedia Technology*, 14, 528 – 534.

[7] Sujit Kumar Jha (2016), Parametric Optimization Of Turning Process Using Taguchi Method And Anova Analysis, International Journal of Advances in Engineering & Technology, 9, 289-301.

[8] Shivam Goyal, Varanpal Singh Kandra, Prakhar Yadav (2016), Experimental Study Of Turning Operation And Optimization Of Mrr And Surface Roughness Using Taguchi Method, *International Journal of Innovative Research in Advanced Engineering*, 3, 44-50.

[9] Arshad Qureshi, Prof Madhukar Sorte, Prof S.N. Teli (2015), A literature review on optimization of cutting parameters for surface roughness in turning process, International Journal of Engineering Research and Development, 11, 66-69.