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Experimental Investigation of CNC Turning Process for Machining EN-31

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Abstract - *This paper investigates CNC turning process for machining EN-31. In this research work, the effects of three parameters, namely, speed, feed and DOC were studied upon MRR and Surface roughness. The objective was to study the effect of input parameter individually on the final outcome. Response surface methodology was used to design the experiments and the performance characteristics in CNC turning operation were studied. The experimental result indicate that speed is the most significant factor. At high values of speed, MRR and surface roughness were found high.*

Key Words: CNC Turning, EN-31, Optimization

1. INTRODUCTION

In the metal cutting industry, one of the major concerns is the health hazard associated with cutting fluids. It is estimated that over 380 million litters of metalworking fluids are used annually in the United States alone and National Institute for Occupational Safety and Health (NIOSH) estimates that 1.2 million employees, for example simply in US, are exposed to cutting fluids each year. This has made machining and manufacturing industries look seriously for various environmentally friendly approaches for material removal. Dry machining is one of the prominent option in terms of the environmental hazards over the wet process. EN-31 find frequent application in the automobile and aerospace industries .This alloy steel is very much popular due to its good mechanical and chemical properties. However, with its all qualities, there are some difficulties related to machinability that seriously affect the surface roughness of machined part. This can be minimized by selecting and optimizing the machining parameters.

Researchers worked in area of CNC turning to investigate effect of process parameters. **Rudra Patel et al. (2021)** optimized material removal process parameters using CNC turning operation to get the desired value of the surface roughness. With an orthogonal array of L27, the Taguchi approach is used where three levels of each parameter are taken into account, which are cutting speed, feed and nose radius. The experiments were done on EN8D carbon steel and a carbide insert was used for a total run of 27 experiments. It was found that with raising the nose radius and speed of cutting, the surface roughness (Ra) lowers [1]. **A. Johnson Santhosh et al. (2021)** in this study experimental investigation was carried out for surface roughness (Ra) of AISI 4340 alloy steel components for the effect of three different process parameter's such as Feed Rate (mm/rev), Speed (rpm), Depth of Cut (mm) in a typical CNC turning machine using Face-Centred Central Composite Design (CCD) approach in RSM and Genetic Algorithm through Artificial Neural network (ANN). The present work effectively minimizes the surface roughness of AISI 4340 alloy steel by implementing the optimal CNC turning process parameters with the help of RSM and ANN-Genetic Algorithm in the real time manufacturing environment. ANOVA reveals that the feed rate is the most essential factor [2]. **Dr. Vijay Kumar M et al. (2018)** The CNC turning investigation on material removal rate surface roughness has been carried out for EN 19 steel, in this research work the effect of lubrication, feed rate, depth of cut and rotational speed on response have been studied under L18 Taguchi's orthogonal array and significance of process parameters are analysed via ANOVA. It was observed that the material removal rate increases with increases in feed rate, MRR, depth of cut and spindle speed is high at dry machining condition compare to coolant. [3]. **G.Harinath Gowd et al. (2014)** used geared lathe for doing experiments, employing a variable continuously spindle speed up to a maximum of 1200rpm and maximum spindle power of 5kW. The feed rates is set to a maximum of 0.3 mm/rev. Experiments are done as per DOE. Depth of cut, Cutting speed and Feed is taken as process parameters and the output responses are Fx and Temperature. For different network configurations, as per the value of performance error obtained, best model is identified and selected. The models are evaluated by calculating the percentage deviation using predicted values and actual values [4].

2. EXPERIMENTAL SET-UP

During this study, series of experiments on the EN-31 were conducted to examine the effect of input machining parameters, such as speed, feed and DOC on MRR and surface roughness. All the experiments were performed on CNC Turning Centre Model Sprint 16TC Machining set up is shown in figure 1.

Fig -1: CNC Turning Set-Up

Machining parameters and their level chosen for this study are presented in Table 1.

Table 1: Machining parameters and their levels

Parameters	Units	Levels		
		-1	0	1
Speed	RPM	1000	1150	1200
Feed	mm/rev	0.07	0.1	0.13
DOC	mm	0.1	0.2	0.3

3. RESULT AND DISCUSSION

In this study the machining parameter such as speed, feed and DOC were studied to evaluate MRR and surface roughness. Total 23 experiments were conducted out of which 20 are as per DOE and 1 for confirmation purpose. Work piece after the machining are shown in figure 2.

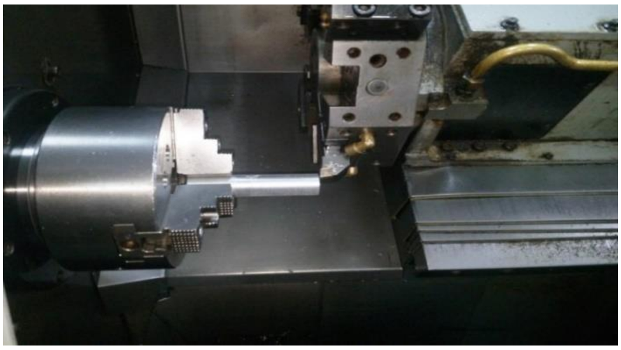

Fig -1: workpiece while machining

A. Analysis of MRR

Weight was measured using high precision weighing machine. Model-diligent, Max wt: 30 kg; Min wt: 100 gm.

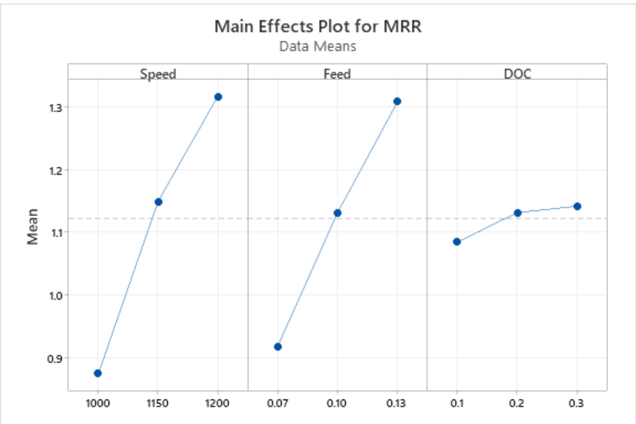

Fig. 3. Main effect plot for MRR

Figure 3 reveals the effect of speed, feed and DOC on the value of MRR. The speed and feed are directly proportional to MRR whereas DOC found less significant as compared to speed and feed in case of MRR.

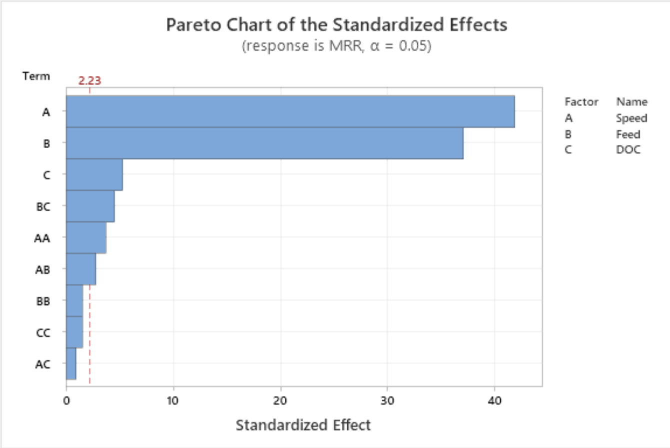

Fig.4. Pareto Chart for MRR

Figure 4 reveals the significant factor while CNC turning. Speed is most significant factor followed by feed and DOC. Regression equation for MRR is as follow:

$$\begin{aligned} MRR = {} & 4.07 - 0.00873\ Speed + 7.22\ Feed - 1.824\ DOC \\ & + 0.000005\ Speed*Speed + 17.2\ Feed*Feed \\ & + 1.55\ DOC*DOC - 0.00534\ Speed*Feed \\ & + 0.000540\ Speed*DOC + 8.92\ Feed*DOC \end{aligned}$$

…………………. (1)

B. Analysis of surface roughness

Surface roughness was measured using Model: Surf test SJ201 P (Mitutoyo) Cut-off Values (lc): 0.8mm; Evaluation Length (es):12.5mm;

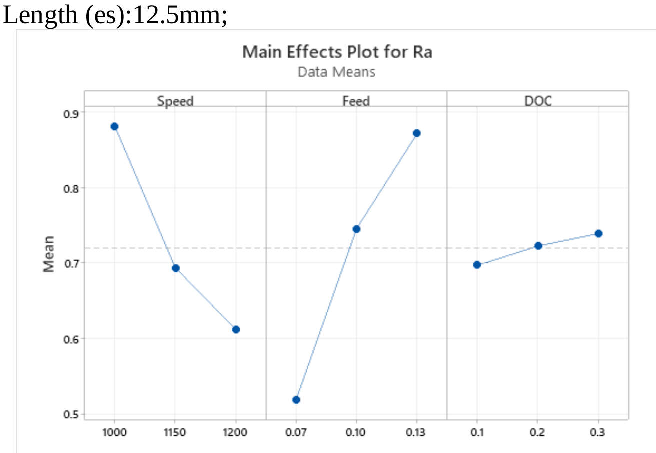

Fig. 5. Main effect plot for Ra

Figure 5 reveals the effect of speed, feed and DOC on the value of Ra. It shows when speed is increased; the Ra tends to decrease appreciably. Higher feed results in increase in the Ra value. Whereas DOC has comparatively less effect.

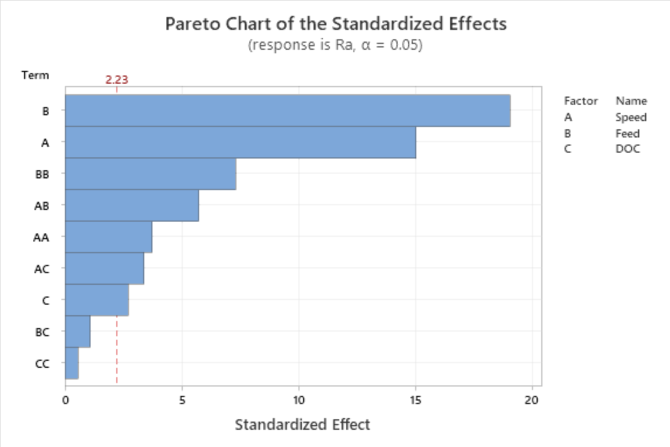

Fig. 6. Pareto Chart for Ra

Figure 6 reveals the significant factor while CNC turning. Feed is most significant factor followed by speed and DOC. Regression equation for Ra is as follow:

$$Ra = 12.25 - 0.02191\ Speed + 12.17\ Feed + 3.90\ DOC + 0.000009\ Speed*Speed - 138.4\ Feed*Feed - 0.96\ DOC*DOC + 0.01863\ Speed*Feed - 0.003312\ Speed*DOC + 3.66\ Feed*DOC \quad \ldots.. (2)$$

4. CONCLUSIONS

The CNC turning experiment were conducted on EN-31. The MRR and surface roughness was evaluated. It is observed from the experimental result that MRR increases drastically with increase in speed and feed. It was found that speed is most significant factor followed by feed and DOC.

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