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Process Parameters Optimization of CNC Turning Process for machining EN-31

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ABSTRACT: This paper presents an investigation and optimization of process parameters of CNC turning process on EN-31. In the present study, attempt is made to find the optimal machining conditions with Material Removal Rate (MRR) and Surface Roughness (Ra) as objective. It was observed that with increase in speed, MRR and surface roughness increases. Response surface methodologies D optimality test was used to determine the optimal machining parameters, among which the speed and feed were found to be the most significant. It was observed that higher speed and low feed is suitable for better MRR and surface roughness.

KEYWORDS: CNC, MRR, surface roughness, RSM

I. INTRODUCTION

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the workpiece, usually to a specified dimension and to produce a smooth finish on the metal. Often the workpiece are turned so that adjacent sections have different diameters. Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface with the workpiece rotating and a single-point cutting tool feeding parallel to the axis of the workpiece that removes the outer surface of the work. Hard turning is mostly performed without coolants while some of the researches favour the coolant to be used in hard turning to minimize the white layer thickness. The elevated cutting zone temperature in hard turning causes the instant boiling of coolant decreasing the tool life and deteriorating surface finish by making thermal distortions. Hence in most of the hard turning operations the coolant is not used at all. However, the absence of Researchers worked in area of CNC turning to investigate effect of process parameters.

II. RELATED WORK

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. Also the surface roughness decreases with increasing the depth of cut and spindle speed, by lowering the feed rate the Ra can reduce and at coolant condition

the surface roughness can minimize [3]. G.HarinathGowd 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. In Matlab software, ANN module is available which is used to predict the relationships of input process parameters and the output variables. The models were developed to predict the MRR and Tool wear resistance through ANN. 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]. C.E.H. Ventura et al. (2013) done investigation of cutting edge preparation of PCBN inserts by grinding and the verification of their applicability in hard turning. Variable micro-geometry of cutting edge has shown its importance in both tool life and surface roughness but it's really a challenging to produce it. Results showed that the used method to prepare edge micro geometries is adequate and asymmetric rounding's can increase tool life and compressive residual stresses [5].

III. METHODOLOGY

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 Machine

The experiments were designed using response Surface Methodology. The experiments has been conducted with three controllable factors namely speed, feed and DOC. On the basis of preliminary experiments conducted by using one variable at a time approach the range of input parameters was selected. Machining parameters and their level chosen for this study are shown in Table 1.

Table. 1 Machining Parameters and 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

IV. EXPERIMENTAL RESULTS

The analysis was made using the popular software specifically used for design of experiment applications known as MINITAB. In present study, it is desirable to maximize MRR and to minimize surface roughness.

Analysis of MRR

The main effect plot for MRR is shown in Fig 2. It shows that the MRR is directly proportional to the speed and feed. Whereas DOC found less significant as compared to speed and feed in case of MRR. Regression equation for MRR is as follow:

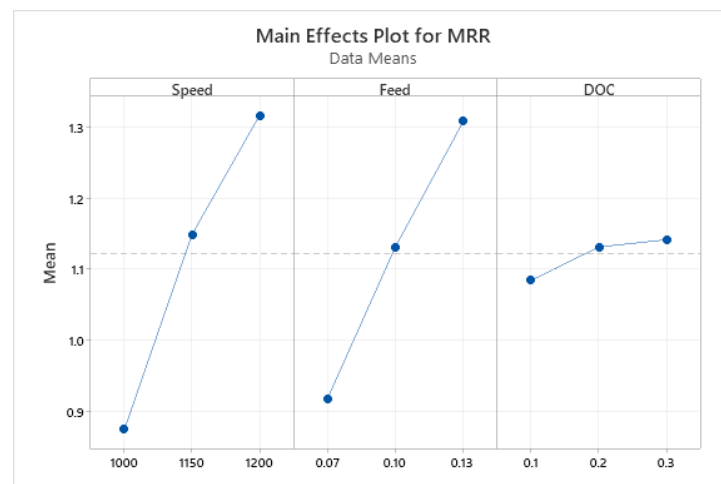


Fig. 2 Main Effect Plot for MRR

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

Analysis of surface roughness

The main effect plot for surface roughness is shown in Fig 3. It shows that the surface roughness is directly proportional to the feed and inversely proportional to speed. Whereas DOC found less significant as compared to speed and feed in case of Ra. Regression equation for Ra is as follow:

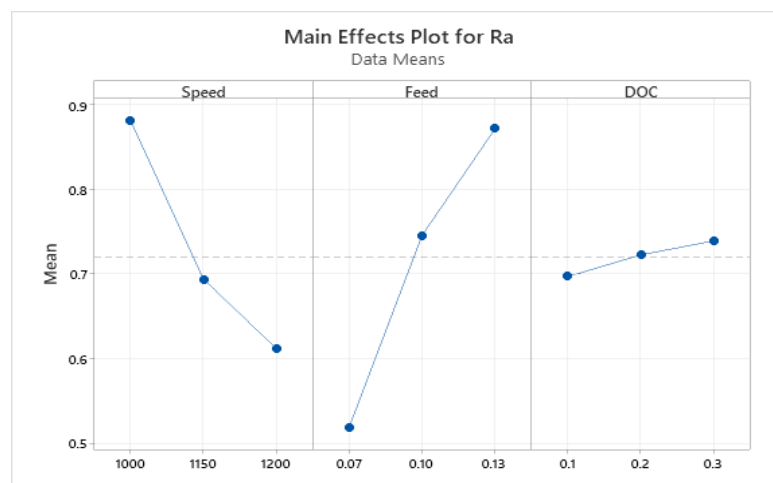


Fig. 3 Main Effect Plot for Surface Roughness

$$Ra = 12.25 - 0.02191 \text{ Speed} + 12.17 \text{ Feed} + 3.90 \text{ DOC} + 0.000009 \text{ Speed*Speed} - 138.4 \text{ Feed*Feed} - 0.96 \text{ DOC*DOC} + 0.01863 \text{ Speed*Feed} - 0.003312 \text{ Speed*DOC} + 3.66 \text{ Feed*DOC}$$

Response Optimizer helps to identify the factor settings that optimize a single response or a set of responses. For multiple responses, the requirements for all the responses in the set must be satisfied. Response optimization is often useful in product development when you need to determine operating conditions that will result in a product with desirable properties. In this work to find the optimum parameter setting RSMs response optimizer is used.

Table 2. Response Optimization for MRR and Ra

Parameters

Response	Goal	Lower	Target	Upper	Weight	Importance
Ra	Minimum		0.35200	1.05667	1	1
MRR	Maximum	0.665111	1.57333		1	1

Solution

Solution	Speed	Feed	DOC	Ra Fit	MRR Fit	Composite Desirability
1	1200	0.0706061	0.3	0.348506	1.15229	0.732402

From the plot it is observed that the composite desirability is obtained as 1.0000 reflecting the setting of input variables marked by red color will provide optimum responses value.

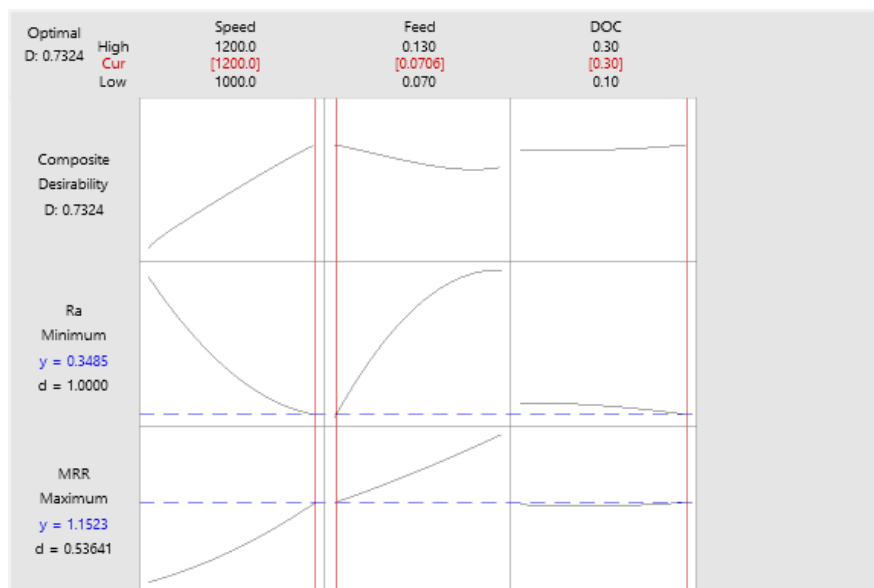


Fig. 4. Optimization Plot for MRR and surface roughness

V. CONCLUSION

The CNC turning of EN-31 was successfully performed. The MRR and surface roughness were evaluated. It is observed that increase in speed and feed drastically reduces the machining time to machine the workpiece at the same time surface roughness is high for higher values of feed. The optimal parameters for performance are speed = 1200 rpm, feed = 0.07 mm/rev and DOC = 0.3 mm. It was observed that speed is most significant among all parameters followed by feed and DOC.



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