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Analysis of quality characteristics on turning of Nickel based super alloy-Monel400

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Abstract: **In this era of mass manufacturing MRR (material removal rate) is of prime concern even in manufacturing using CNC machines. The main objective of today's modern manufacturing industries is to produce low cost and high quality product in short time. In order to improve the quality and to reduce the cost material removal rate should be optimum. In machining accurate dimensions is desired but with good product quality. The experimental study aims to investigate MRR and surface roughness as quality targets by taking feed, depth of cut & speed into consideration for turning of MONEL 400 employing Taguchi method. An optimal parameter combination of the turning operation was obtained via Taguchi method. The result of this analysis identifies the optimal values of process parameters for effective and efficient machining. The result indicates that the determined optimal combination of machining parameters improved the performance of the machining process. The predicted results are found to be closer to experimental results.**

Keywords: **Nickel Alloy, Monel-400, MRR, Surface roughness, Optimization.**

I. INTRODUCTION

Today CNC has become an integral part of industry. The accuracy (dimensional) surface finish, precision which is achieved through CNC cannot be done or achieved through Conventional process. The MRR is a factor which rate affects the machining hour's rate and machining cost, feed rates, spindle speed, depth of cut are the parameters which are taken in consideration. Turning is one of the machining processes which involve removal of extra/unwanted material from the surface of a rotating work piece [1]. In this research paper, L18 orthogonal array based Taguchi optimization technique is used to optimize the effect of various cutting parameter for surface roughness and Material Removal Rate (MRR) of EN 36 work material in turning operation. The orthogonal array, the signal to noise ratio and analysis of variance are employed to study the performance characteristics in both dry and wet machining conditions of cylindrical work pieces using Tin coated tungsten carbide cutting tool on CNC lathe [2]. Five machining parameter such as spindle speed, feed rate, depth of cut, nose radius and the cutting environment (wet & dry) are optimized with consideration of surface roughness. Results of this study indicate for optimal cutting parameter, minimum surface roughness (Ra) and maximum material removal rate were obtained and developed model can be used to increase the machine utilization at low production cost in manufacturing environment [3]. A thorough study of literature suggests that the machining of EN-36 Steel Alloy is very difficult, compared to other alloy materials. Very few works have been done in the Optimization of process parameters in turning process of EN-36 steel alloy with different controlled parameters such as cutting speed, feed rate and depth of cut and type of tool. The study demonstrates detailed methodology of the proposed optimization technique i.e. Taguchi method is used; and validates its effectiveness through material removal rate, characteristics of a Turning product. Hence the literature survey helped in proper selection of speed, feed rate, depth of cut and other related parameters [4].Optimized of Process Parameters for Surface Roughness and Material Removal Rate for SS 410 Material. All experiment conduct on CNC turning and the output parameters are MRR & SR is predicted by ANOVA [5].Investigated the optimum value of tangential force, feed force, and surface roughness for EN19 steel using confirmation test. They have used L27 orthogonal array. For Surface Roughness ANOVA result shows that, Feed is the most dominant factor [6]. In this study, Analysis found that varying parameters are affected in different way for different response. The ANOVA analysis was used to obtain optimum cutting parameters [7].Performed the machining process for optimized the parameters for SR in face milling. Test samples made of carbon steel St 52-3 with dimensions

230x100x100 mm were used in experiments. The parameters cutting speed, depth of cut and feed on machined surface roughness in face milling process have been examined [8]. The results of the performed research show that both feed and cutting speed influence on surface roughness but the feed is the most influential factor [9]. The turning tests were carried out to determine the material removal rate under various turning parameters. GC1035 coated carbide tool were used for experimental investigations. The single response optimization problems i.e. optimization of MRR is solved by using Taguchi method [10].

In the present study the nickel based Monel 400 alloy was used. The quality characteristics like surface roughness and MRR were analyzed using both experimental and software oriented. Finally the results depicts that the closeness of values between the experimental and predicted values.

II. EXPERIMENTAL DETAILS

In this paper, the cutting speed, feed rate and depth of cut have been considered as independent variables. The surface roughness (Ra) and material removal rate (MRR) were considered as responses. The nickel based super alloy Monel-400 (length 70 mm and diameter 25 mm) has been used as work material. The chemical composition of the Monel-400 has been summarized in Table I. The machining tests were carried out in a CNC machine using carbide inserts. The response values were collected corresponding to the experimental runs, for three times, and the mean was recorded for the analysis of work. The surface roughness was measured, after each machining run, using a Talysurf roughness tester. The material removal rate was measured using the difference between the initial weight and final weight of the machined material along with density of material and machining time, will comprises the material removal rate (MRR). The schematic representation of Monel-400 presented in figure 1.

Fig.1 Monel-400

TABLE I: CHEMICAL COMPOSITION OF MONEL 400

Elements	**% of composition**
Nickel	63 min
Carbon	0.3 max
Manganese	2.0 max
Iron	2.5 max
Sulphur	0.024 max
Silicon	0.5 max
Copper	28.0 – 34.0

In this work, Taguchi-based design of experiment (DOE) is adopted and 9 numbers of parameter designs (8 degrees of freedom) were created by L_9 orthogonal array (OA) which has the potentiality to evaluate multiple factors with the least trials. The parameters and their levels are tabulated in Table II.

TABLE II: PARAMETERS & LEVELS

Parameters	Level 1	Level 2	Level 3	Units
Cutting Speed	900	1400	1900	rpm
Feed	0.1	0.2	0.3	mm/rev
Depth of Cut	0.50	1.00	1.5	mm

In this study, the parameters are taken as factors, and there are three levels for every factor, as shown in Table II. The factors and levels are arranged by some order, namely, orthogonal arrays, as shown in Table III. MRR denote the material removal rate and R_a is average roughness value.

TABLE III: EXPERIMENTAL VALUES

Trial	Cutting speed (rpm)	Feed (mm/rev)	Depth of cut (mm)	MRR (mm^3/min)	Ra (microns)
1	900	0.1	0.50	0.000002424	3.4
2	900	0.2	1.0	0.000009556	2.9
3	900	0.3	1.50	0.000021184	3.0
4	1400	0.1	1.0	0.000007433	3.2
5	1400	0.2	1.50	0.000021969	2.8
6	1400	0.3	0.5	0.000011314	2.6
7	1900	0.1	1.50	0.000014907	2.7
8	1900	0.2	0.50	0.000010236	2.5
9	1900	0.3	1.0	0.000030262	2.8

III. RESULTS & DISCISSION

The Taguchi method, which represents the quality characteristic namely surface roughness and material removal rate. The set of nine experiments were conducted, with different parameter levels and the results reveals the good agreement with the current scenario. The material removal rate shows the optimal setting of parameters as 1900rpm, feed of 0.3 mm/rev and depth of 1.5mm and the reporting graphical plot is shown in Fig 4, where as the surface roughness follows 1900rpm, feed of 0.1 mm/rev and depth of 0.5mm, the representation was shown in Fig.2. The analysis reports that for material removal rate the feed is the predominant factor affects the quality, next to speed and depth, for the surface roughness the same feed is the most influencing factor, next to speed and depth. The interaction plot shown in Fig 3 and Fig 5 for surface roughness and MRR shows the relationship between one categorical factor and a continuous response depends on the value of the other factors.

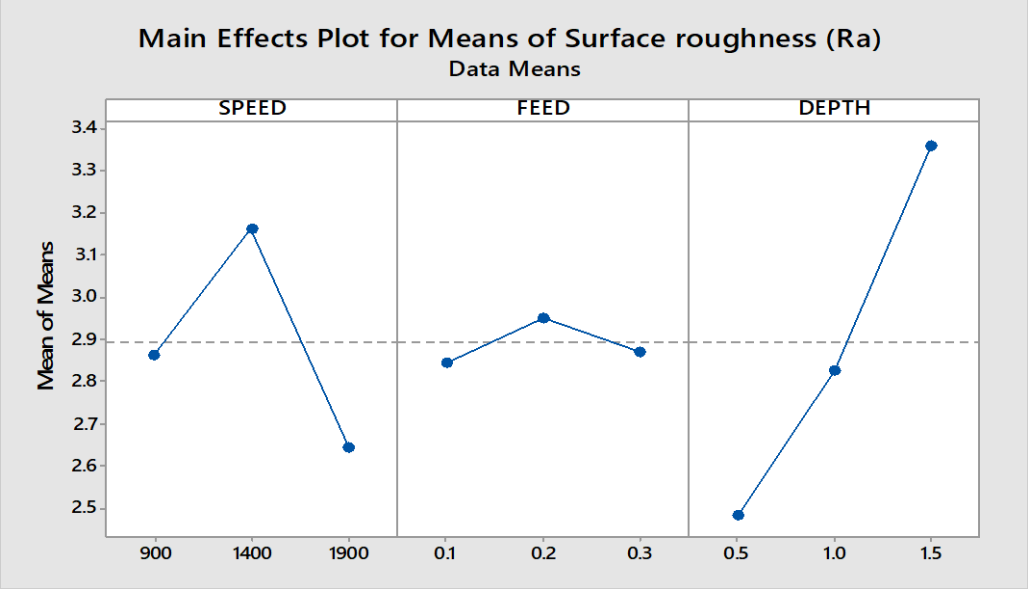

Fig.2 Mean plot for surface roughness

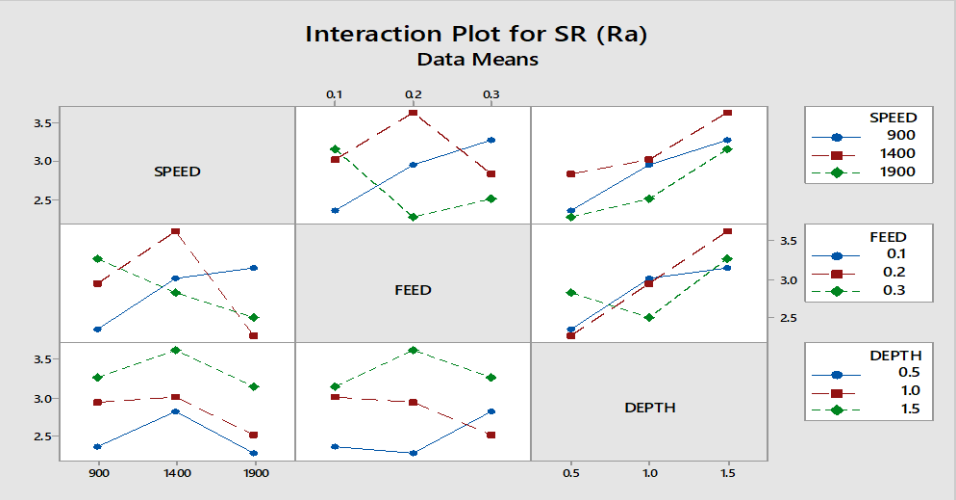

Fig. 3 Interaction plot for surface roughness

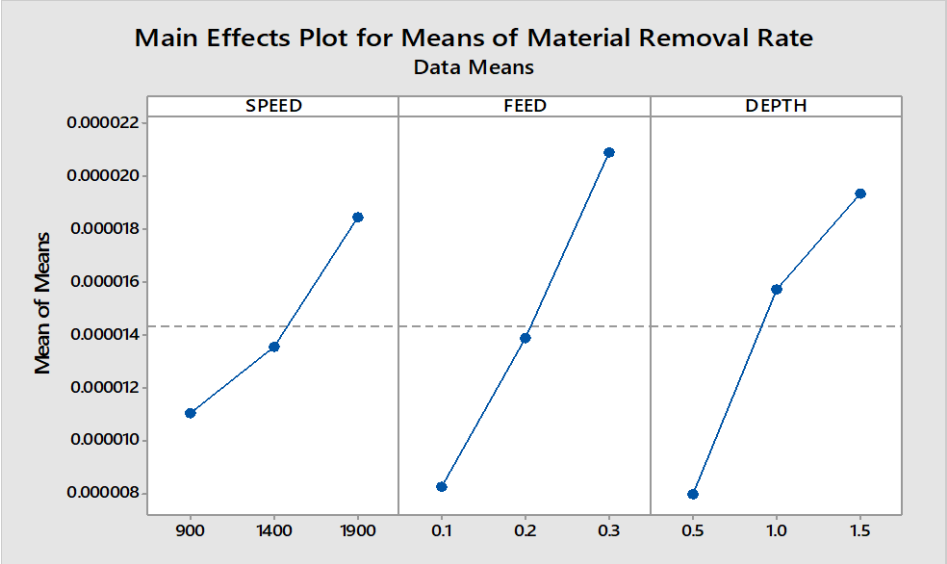

Fig. 4 Mean plot for material removal rate

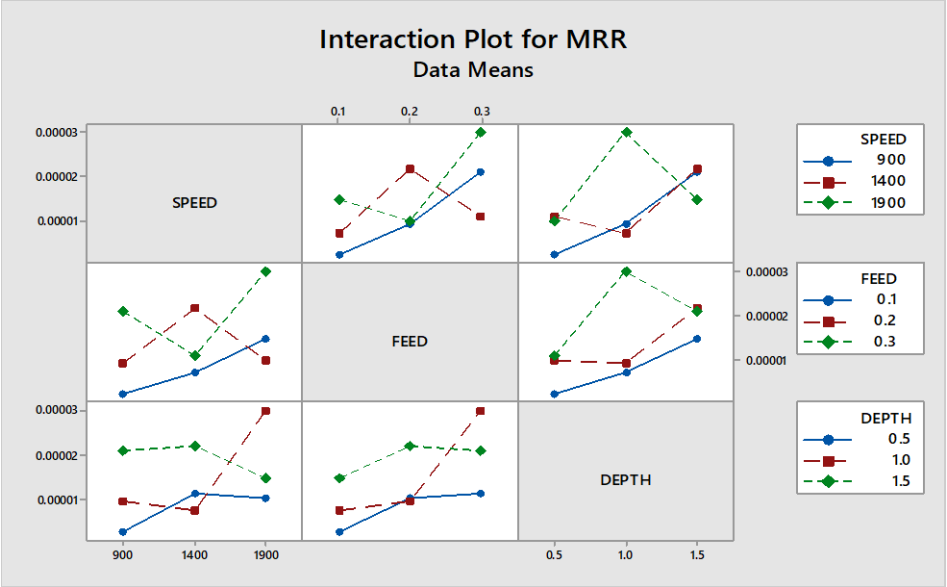

Fig. 5 Interaction plot for material removal rate

IV. CONCLUSION

Turning tests was performed on MONEL 400 work-piece using three different parameters and three levels. The influences of cutting speed, feed rate, and depth of cut were investigated on the machined surfaces in order to determine the surface roughness and material removal rate. Based on the results obtained, the following conclusions have drawn,

- The multiple performance characteristics such as material removal rate and surface roughness can be simultaneously considered and improved through this optimisation technique.
- The experimental observations highlights that MRR in CNC turning process is greatly influenced by depth of cut followed by cutting speed.
- The feed is most predominant parameter affects the surface roughness (R_a). Surface roughness was found to be increasing with the increase of feed. But it is reverse with the cutting speed. That is surface roughness decreased with the increase of cutting speed.
- The effectiveness of the model is only within the range and factors studies. The model adequacy can be improved further by considering more variables and ranges of parameters.

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