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PERFORMANCE ANALYSIS IN END MILLING OPERATION

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ABSTRACT

This project deals with the effect of three selective parameters viz. cutting speed, feed rate and depth of cut on end milling operation. The main objective of this work is to investigate the influence of the above mentioned parameters on surface roughness, milling force, temperature, slot width and material removal rate to obtain optimum performance by using Response Surface Methodology. The values of above mentioned three parameters taken for the study are: spindle speed range 90.4-231.2 rpm, feed range 0.3-0.8 mm/rev and depth of cut range 0.3 to 0.9 mm, are given as input for the experiments. As a result of 18 number of design of experiments with various combinations of the three parameters under consideration have been generated. Experimental data are collected by using Vernier calliper, Force Dynamometer, Infrared thermometer and Stopwatch. Consequently this work is to analyses the differences in machining parameters on surface roughness, milling force, temperature, slot width and material removal rate by using design of experiments software for speed, thrust, and material removal rate. Finally prepare the ANOVA (Analysis of variance) table for all the responses. In addition to an empirical relation between cutting parameters, surface roughness is also derived by regression model.

Key Words: End Milling Process, Regression Model, ANOVA Table, Cutting Parameters, Response Surface Methodology

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1. INTRODUCTION

Materials are manufactured from casting, forging etc. are required close tolerance to assemble the components in machine tool design. For the reason machining processes were introduced in manufacturing firms. In that lots of machining processes are available for obtain the close tolerance value such as turning, milling, grinding, drilling etc. in regard milling operation is one of the important process, which is used to remove the excess work piece materials from the cylindrical stock in the form of chips with the aid of cutting tools.

Alamdeep Cheema *et al* [1] proposed taguchi and analysis of variance method ANOVA method. Modelling is done ANN on D2 steel. It is best network model which gives minimum error between network output and real output. ANN method is used for prediction. It shows that for any value of input data we can easily predict the output with minimum error. Chockalingam *et al* [6] proposed for different coolant condition on milling of AISI304 stainless steel. Cooling method used in investigation were flooding of synthetic oil, water based emulsion and compressed cold air. Arockiadass *et al* [4] discussed about the study and analysis of surface quality improvement in end milling operation of Al/Sic_p metal matrix composition. These materials are selected as they are most widely used in automobile and aerospace industry. Ali Riza Motorcu [2] proposed the surface roughness in the milling of AISI8660 harden alloy steel by ceramic based cutting tool was investigated with main cutting parameters such as cutting speed, feed, depth of cut in addition to tool nose radius, using a statistical approach.

Budak [5] explained structural deformations and tolerance integrity to obtain high performance for end milling process. If milling conditions are not selected properly, the process may result in violation machine limitations, part quality and reduce productivity. Antoniadis *et al* [3] discussed about milling software needle program (MSN).This determines surface topomorphy and prediction of surface roughness, dynamic cutting behaviour. Ball end mill tool used for machining 3D surfaces for dies, moulds for aerospace components. Dinesh *et al* [7,8] studied about the machining of AISI 4340 steel and attempted to optimize the input parameters using GRA, RSM and Taguchi methods. A.M.Rameshbabu *et al* [9] has analysis nanocrystalline equiatomic AlMgNiCrTi high entropy alloy has been successfully synthesized by mechanical alloying and consolidated by spark plasma sintering at 800°C with 50 Mpa pressure. B. Radha Krishnan *et al* [10] the paper, classification algorithms ANFIS and random forest are used to classify the test data samples for determining the error rate by comparing its classification response with its corresponding actual response.

2. METHODOLOGY

The runs (experiments) carried out in the machining process are based on deign of experiments (D.O.E). The factors, Spindle Speed (N), Feed Rate (f) and Depth of Cut (d) of distinct values at various levels are used as the input parameters, which in turn has its effect on the response. The range on input parameters have be tabulated in table 1. In total, 18 experiments were conducted based on design on experiment concept having wok piece dimensions with square plate of50mm and 10mm thickness.

Table 1 Experimental Range Values

S.No	Spindle Speed (r.p.m)	Feed Rate (m/sec)	Depth of Cut (mm)
1	90.4	0.3,0.8	0.3,0.6,0.9
2	134.2	0.3,0.8	0.3,0.6,0.9
3	231.2	0.3,0.8	0.3,0.6,0.9

2.1. Work Piece and Tool Material

EN8 material is one of the medium carbon steel is used as a work piece having dimensions 50mm*50mm square plate and 10mm thickness. High speed steel is used as a tool having diameter 10mm are used for purpose of machining. The work piece and tool used for end milling operation are shown in figure 1 & 2. The composition of EN8 material is shown above in table 2.

Figure 1 Work Piece **Figure 2** Tool

Table 2 Composition of EN8 material

Material	C (%)	Mn (%)	Si (%)	P (%)	S (%)
EN8	0.415	0.876	0.318	0.020	0.019

3. RESULTS AND DISCUSSION

3.1. Introduction

The collected experimental data were analysed with statistical analysis for investigation of the parameters for considered response (surface roughness, material removal rate, width of grooving etc.) DESIGN EXPERT software has been used for statistical analysis. The ANOVA analysis is used for identification of parameter influences interaction effects. The regression analysis is carried out for building empirical model. Based on the analysis, following and discussion were made.

3.2. Effect of Spindle Speed and Feed Rate on Material Removal Rate

The characteristics of spindle speed, feed rate on material removal rate is shown in figure 3. The graph shows that when feed rate and spindle speed increases the surface roughness also increases. It can be noted that at spindle speed of 231.2 rpm and feed rate 0.80 mm/sec gives the highest material rate of 0.16 gm/sec.

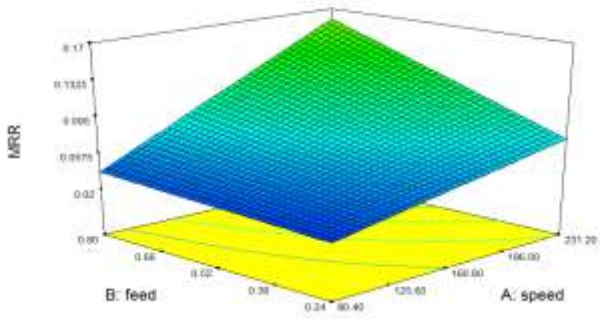

Figure 3 Spindle speed Vs feed on MRR

3.3. Effect of Spindle Speed and Depth of Cut on Material Removal Rate

The descriptions of spindle speed, depth of cut on Material removal rate is shown in figure 4. The graph shows that when depth of cut and spindle speed increases the material removal rate also increases. It can be noted that at spindle speed of 231.2 rpm and depth of cut 0.90 mm gives maximum material removal rate 0.18 gm/sec.

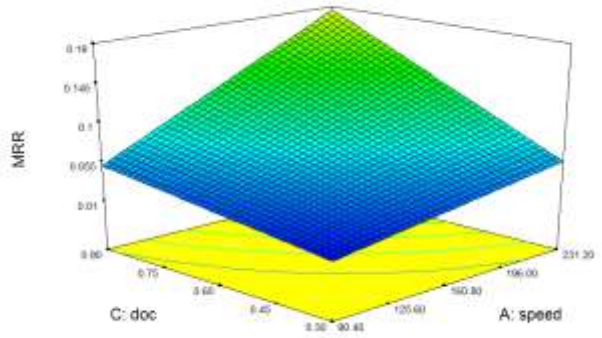

Figure 4 Spindle speed Vs Depth of cut on MRR

3.4. Effect of Feed Rate and Depth of Cut on Material Removal Rate

The impact of feed rate, depth of cut on Material removal rate is shown in figure 5. The graph shows that when depth of cut and spindle speed increases the surface roughness also increases. It can be noted that at feed rate of 0.80 mm/sec and depth of cut 0.90 mm gives high material removal rate of 0.15 gm/sec.

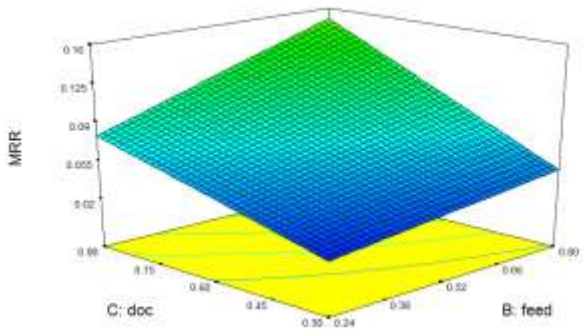

Figure 5 Feed rate Vs Depth of cut

3.5. Effect of Spindle Speed and Feed Rate on Feed Force (F_X)

Figure 6 demonstrates the effect of spindle speed, feed rate over feed force. The graph shows that at the low level combination of spindle speed 90.4 rpm and low feed rate of 0.24 mm/sec gives the lowest force of 23 kgf. At the combination of feed rate 0.80 mm/sec and spindle speed 231.2 rpm high feed force of 24 kgf is obtained.

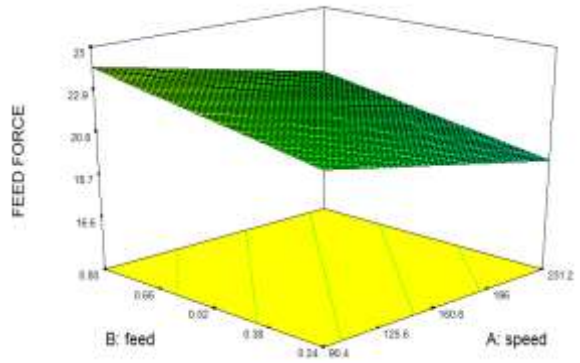

Figure 6 Spindle speed Vs Feed rate on Feed Force

3.6. Effect of Spindle Speed and Depth of Cut on Feed Force (F_X)

The routine of spindle speed, feed rate over feed force is depicted in figure 7. The graph shows that at the low level combination of spindle speed 231.2 rpm and depth of cut 0.30 mm gives the lowest force of 17 kgf. Feed force 27kgf is maximum when spindle speed 90.4 rpm and depth of cut 0.90 mm.

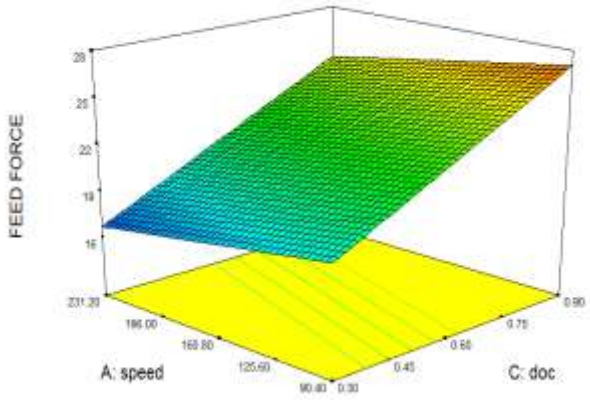

Figure 7 Spindle Speed Vs Depth of Cut on Feed Force

3.7. Effect of Feed Rate and Depth of Cuton Feed Force (F_X)

The impact of spindle speed, feed rate over feed force is depicted in figure 8. The graph shows that the low depth of cut 0.30 mm and low feed rate of 0.24 mm/sec gives the lowest force of 15 kgf. At the combination of feed rate 0.90 mm/sec and depth of cut 0.90 mm high feed force of 26.8 kgf is obtained.

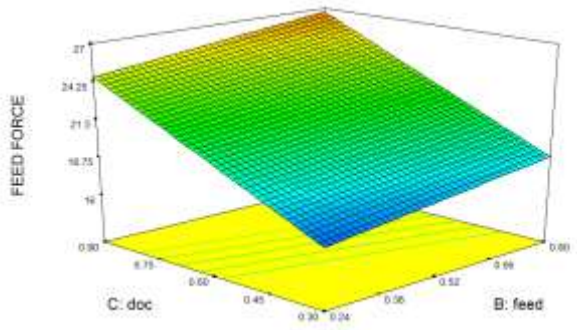

Figure 8 Depth of cut Vs Feed Rate on Feed Force

3.8. Effect of Spindle Speed and Feed Rate on Thrust Force (F_Y)

The figure 9 reveals the variation between feed rate and spindle speed on thrust force. When spindle speed of 90.4 rpm and feed rate of 0.24 mm/sec gives the minimum thrust force of 46.5 kgf. When Spindle speed of 231.2 rpm and feed rate of 0.80 mm/sec gives the maximum thrust force of 50 kgf.

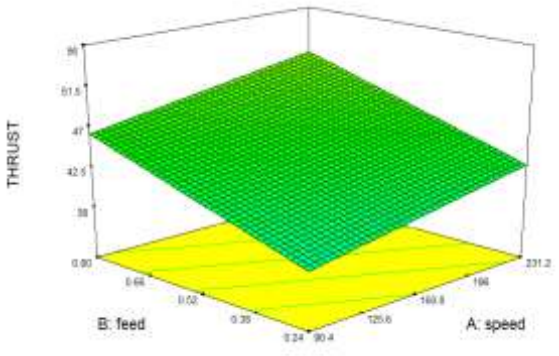

Figure 9 Feed Rate Vs Spindle Speed on Thrust Force

3.9. Effect of Spindle Speed and Depth of Cut on Thrust Force (F_Y)

The graph is drawn between spindle speed and depth of cut is shown in figure 10. At low level combination the spindle speed of 90.4 rpm and depth of cut of 0.30 mm gives the low thrust force of 25 kgf. And the combination of high spindle speed of 231.2 rpm and depth of cut of 0.90 mm gives the high thrust force of 64kgf.

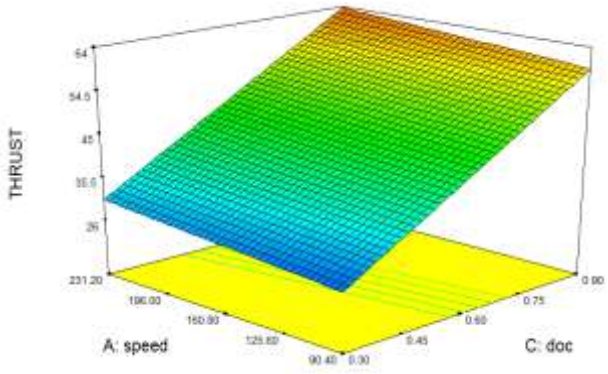

Figure 10 Spindle Speed Vs Depth of Cut on Thrust Force

3.10. Effect of Feed Rate and Depth of Cut on Thrust Force (F_Y)

The figure 11 shows the influence of thrust force on feed rate and depth of cut. The combination of levels, low depth of cut of 0.30 mm and feed rate of 0.24 mm/sec gives the minimum thrust force of 23 kgf. And the combination of high depth of cut of 0.90 mm and feed rate of 0.80 mm/sec gives the high thrust force of 65 kgf.

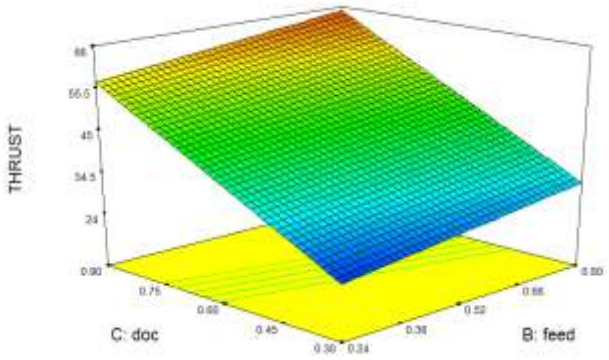

Figure 11 Depth of Cut Vs Feed Rate on Thrust Force.

3.11. Effect of Spindle Speed and Feed Rate on Cutting Force (F_Z)

The figure 12 shows the effect of feed rate and spindle speed over cutting force. The feed rate at the range of 0.24 mm/sec and spindle speed of 90.4 rpm gives the cutting force as 27 kgf. And the combination of high levels of feed rate 0.80 mm/sec and spindle speed 231.2 rpm gives high cutting force of 48 kgf as shown in figure 12.

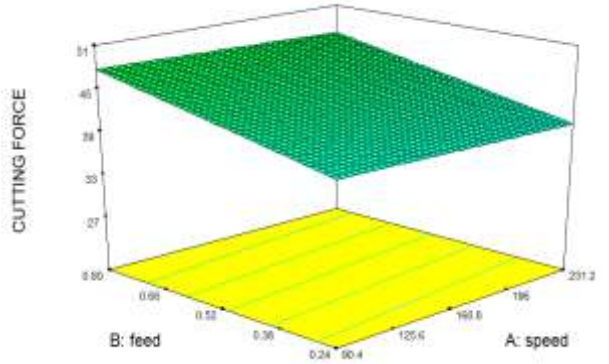

Figure 12 Feed Rate Vs Spindle Speed on Cutting Force

3.12. Effect of Spindle Speed and Depth of Cut on Cutting Force (F_Z)

The figure 13 shows the performance of feed rate and spindle speed over cutting force. The depth of cut of 0.30 mm and spindle speed of 90.4 rpm gives low cutting force as 30 kgf. And the combination of high levels of depth of cut of 0.80 mm and spindle speed 231.2 rpm gives high cutting force of 55 kgf as shown in figure.

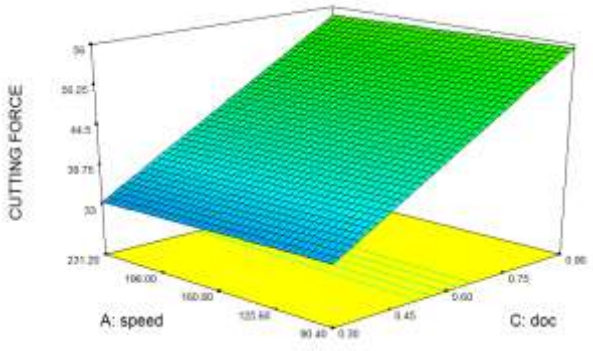

Figure 13 Spindle Speed Vs Depth of Cut on Cutting Force

3.13. Effect of Feed Rate and Depth of Cut on Cutting Force (F_Z)

The figure 14 shows the outcome of feed rate and spindle speed over cutting force. The feed rate at the range of 0.24 mm/sec and depth of cut of 0.30 mm gives the cutting force as 25 kgf. And the combination of high levels of feed rate 0.80 mm/sec and spindle speed 231.2 rpm gives high cutting force of 58 kgf as shown in figure.

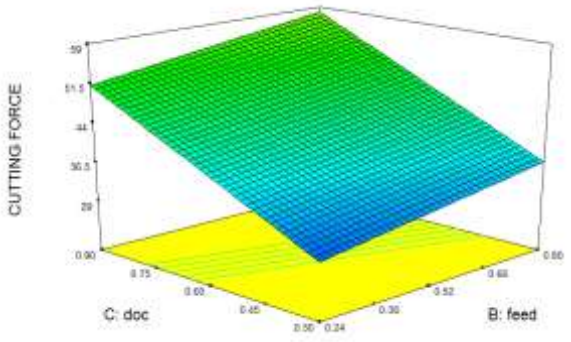

Figure 14 Depth of cut Vs Feed Rate on Cutting Force

4. CONCLUSIONS

The grooving of EN8 material for various levels of process parameters has lead to the following conclusions:

- Responses, surface roughness and material removal rate, Width depends on the machining parameters such as spindle speed, feed rate and depth of cut.
- During themachining, tool wear occurred at high speed (231.4rpm) with high depth of cut (0.9mm) and high speed with high feed rate (0.8mm/sec).
- At high spindle speed, chip formation is continuous whereas in medium speed, chip formation is discontinous.
- Material removal rate is high when spindle speed, depth of cut and feed rate are high.
- Feed force is maximum under the combination of high depth of cut and feed rate.

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