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Optimization and Process Parameters of CNC End Milling For Aluminum Alloy 6082

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ABSTRACT

The study aims at optimization of cutting parameters in CNC End milling of Aluminum Alloy 6082. CNC milling is a versatile and most widely used operation in present industry. Surface quality affects fatigue life of components and influences various mechanical properties and has received serious attention for many years. In this work, experiments are conducted to analyze the surface roughness using various machining parameters such as Spindle speed, feed rate and depth of cut . The data was used to develop surface roughness prediction models as a function of the machining parameters. In the present study, CNC machining centre with Cemented carbide end mill of 25mm diameter and 30° helix angle was used. A multiple regression analysis is used to correlate the relationship between the machining parameters and surface roughness. RS methodology was selected to optimize the surface roughness resulting minimum values of surface roughness and their respective optimal conditions.
Key words: CNC end milling, Aluminum alloy 6082, Taguchi, ANOVA

INTRODUCTION

Milling is the machining process of using rotary cutters to remove material from a work piece advancing in a direction at an angle with the axis of the tool. It covers a wide variety of different operations and machines, on scales from small individual parts to large, heavy-duty gang milling operations. It is one of the most commonly used processes in industry and machine shops today for machining parts to precise sizes and shapes.

Fig.1 CNC End Milling Work Plate

After the advent of computer numerical control milling machines evolved into machining centers (milling machines with automatic tool changers, tool magazines or carousels, CNC control, coolant systems, and enclosures), it is possible to create complex shapes with accurate dimensions. Generally CNC milling machines are classified as vertical machining centers and horizontal machining centers.

METHODOLOGY

In this work, Taguchi and ANOVA using MINITAB have been used for obtaining the relationship between responses and machining parameters.

Taguchi Technique:
Taguchi technique is a most effective tool, which is majorly adopted by industrial engineers to approach the high qualitative productivity at possible optimal cost and time. The factors which are affecting the response are arranged in the form of lattice square model; this model is called as orthogonal array. Forming and selection of the orthogonal array and the factors for conducting experiments are the main criteria in the Taguchi process. In Taguchi method, Signal to noise ratio is the statistical measuring process for predict the optimum factors to respected responses. The smaller the better, the higher the better, and the nominal the better (Ross, 1996) are three sorts for the S/N ratio for examine the Factor's enactment. In this present work we are adopted that the smaller the better sort for surface roughness and bigger the better sort for MRR response values in S/N Ratio process. Surface roughness (SR) and material removal rate (MRR) of machined objects are playing vital role in the industrial production rate and cost. The main object of the machining operations is to maximize the MRR and minimize the surface roughness to improve productivity and product quality by controlling the machining factors. Low surface roughness helps to improve the machined object life time and appearance. High MRR gives good industrial productivity in period time. But the ANOVA is gives the impact of the factors with respect to their responses normally.

Fig. 2.1 MITUTOYO surf tester

EXPERIMENTAL PROCEDURE

The experiments were conducted to study the effect of process parameters over the output response characteristics with the process parameters and interactions assigned to columns as given in Table 1. L27 experiments were conducted using Taguchi experimental design methodology. In the present study all the designs, plots and analysis have been carried out using Minitab statistical software.

Taguchi analysis:
Signal to Noise Ratio:

- Calculation of the S/N ratio depends on the experimental objective.
- The signal to noise ratio provides a measure of the impact of noise factors on performance. The larger the S/N, the more robust the product is against noise.

Fig 3.1 CNC End Milling Machine

S.No	Speed (rpm)	Feed (mm/rev)	DOC (mm)	Ra (µm)
1	900	337.5	0.3	0.113
2	900	337.5	0.6	0.209
3	900	337.5	0.9	0.483
4	900	450	0.3	0.152
5	900	450	0.6	0.193
6	900	450	0.9	0.154
7	900	562.5	0.3	0.113
8	900	562.5	0.6	0.226
9	900	562.5	0.9	0.132
10	1200	337.5	0.3	0.152
11	1200	337.5	0.6	0.137
12	1200	337.5	0.9	0.36
13	1200	450	0.3	0.15
14	1200	450	0.6	0.125
15	1200	450	0.9	0.262
16	1200	562.5	0.3	0.187
17	1200	562.5	0.6	0.148
18	1200	562.5	0.9	0.15
19	1500	337.5	0.3	0.163
20	1500	337.5	0.6	0.267
21	1500	337.5	0.9	0.39
22	1500	450	0.3	0.139
23	1500	450	0.6	0.149
24	1500	450	0.9	0.13
25	1500	562.5	0.3	0.129
26	1500	562.5	0.6	0.212
27	1500	562.5	0.9	0.201

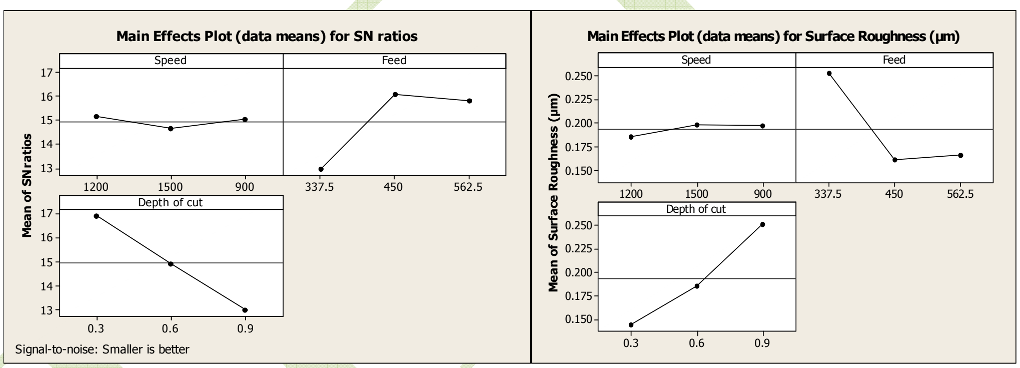
Table 1 Machining Parameters with measured response

RESULTS AND DISCUSSIONS

The experiments were conducted by using the parametric approach of the Taguchi's method. The effect of individual Milling process parameters, on the selected quality characteristics – material removal rate, has been discussed in this section. The average value and S/N ratio of the response characteristics for each variable at different levels were calculated from experimental data. The main effects of process variables both for raw data and S/N data were plotted. The response curves (main effects) are used for examining the parametric effects on the response characteristics. The analysis of variance (ANOVA) of raw data is carried out to identify the significant variables and to quantify their effects on the response characteristics. The most favourable values of process variables in terms of mean response characteristics are established by analyzing the response curves and the ANOVA tables.

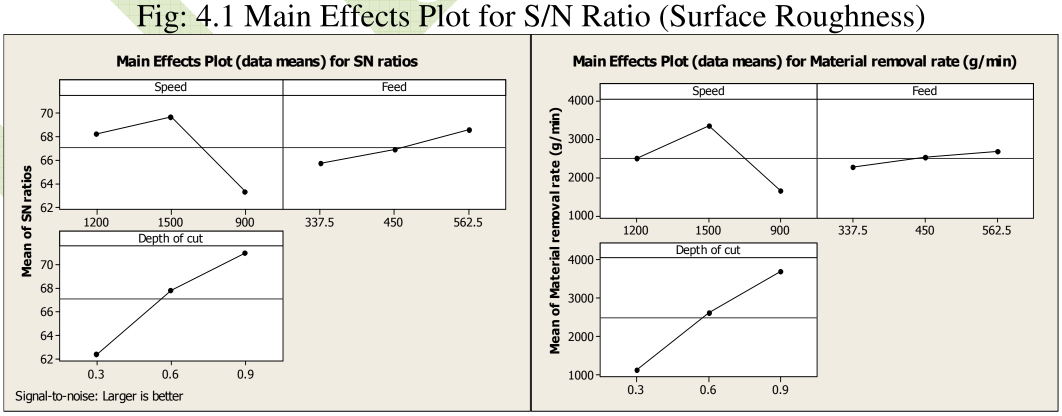
Effect on Surface roughness

In order to see the effect of process parameters on the surface roughness, experiments were conducted using L27 OA Table 1.The average values of material removal rate for each parameter at levels 1, 2 and 3 for raw data and S/N data are plotted in Figures 4.1(a) and 4.1(b) respectively. Figures 4.1(a) and 4.1(b) shows that the Ra increases with the increase of depth of cut, and decreases with increase in feed. It is seen from the Figures 4.2(a) and 4.2(b) that there is very weak interaction between the process parameters in affecting the surface roughness since the responses at different levels of process parameters for a given level of parameter value are almost parallel.



(a) (b)

Fig: 4.1 Main Effects Plot for S/N Ratio (Surface Roughness)

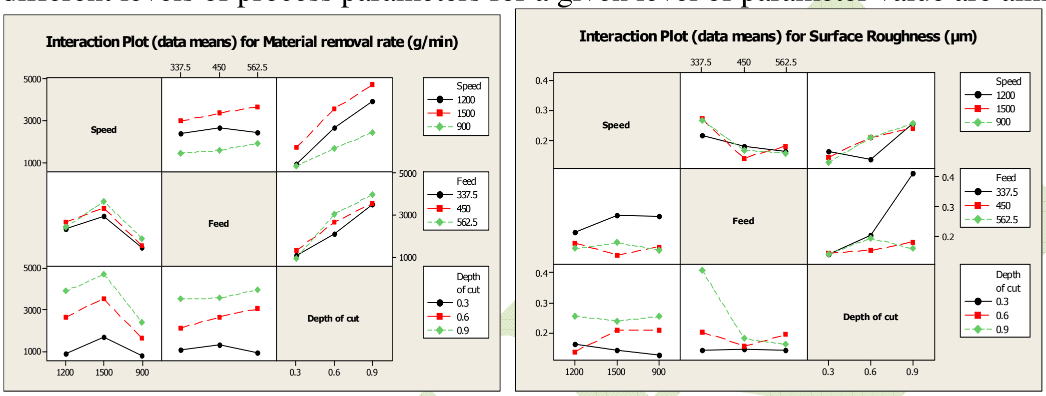


(a) (b)

Fig: 4.2 Main Effects Plot for SN Ratio (MRR)

Effect on Material removal rate

The experimental data is given in Tables 1.The average values of material removal rate for each parameter at levels 1, 2 and 3 for raw data and S/N data are plotted in Figures4.1(a) and respectively. Figures 4.1(b) shows that the MRR increases with the increase of feed, and decreases with increase in depth of cut. The effects of speed and depth of cut on material removal rate are not very significant. It is also evident that material removal rate is minimum at first level of speed and maximum at third level of speed and so on. It is seen from the Figure 4.2(a) and that there is very weak interaction between the process parameters in affecting the material removal rate since the responses at different levels of process parameters for a given level of parameter value are almost parallel.



(a) (b)

Fig :4.3 Interaction plot for Material removal rate (MRR), Interaction plot for Surface Roughness (Ra)

S = 0.9430   R-Sq = 98.8%   R-Sq(adj) = 96.2%

Analysis of Variance for SN ratios

Source	DF	Sqe.ss	MS	F	P
Speed	2	198.646	99.323	111.69	0.000
Feed	2	37.130	18.565	20.88	0.001
Depth of cut	2	345.965	172.983	194.51	0.000
Speed*Feed	4	3.041	0.760	0.85	0.529
Speed*Feed	4	3.041	0.760	0.85	0.529
Speed*Depth of cut	4	7.260	1.815	2.04	0.181
Feed*Depth of cut	4	9.142	2.285	2.57	0.119
Residual Error	8	7.114	0.889		
Total	30	608.299			

CONCLUSIONS

The development of aluminum alloys is constrained is aeronautical requirements, but aluminum is very useful for several applications in other sectors. The machining of aluminum alloys has become relatively than aluminum, as the cutting forces involved are low and the tool life is relatively high if there is no built-up edge or material adhesion problem. However, some problems may arise with the chip form and particle emissions. It is shown that long, continuous and spiral chips can indeed be prevented by selecting appropriate Machining feeds and speeds.
In the earlier chapters, the effects of process variables on response characteristics (Surface roughness &material removal rate) of the dry machining (CNC End Milling) process have been discussed. An optimal set of process variables that yields the optimum quality features to machined parts produced by turning process has also been obtained.
The important conclusions from the present work are summarized as follows.
1. The effects of the process parameters viz. Spindle speed, Feed and Depth of cut on response characteristics viz. Material removal rate were studied.
2. The optimal sets of process parameters were obtained for the performance measures using Taguchi's design of experiment methodology. The summary of results of predicted optimal values of the responses are given as under:

Performance Measures	Optimal Set of Parameters
Surface roughness	**A1-B2–C1**
Material removal rate	**A2-B3-C3**

Table 2: Optimum Machining Conditions

3. Analysis of reveals that the depth of cut is the influencing parameter followed by Speed and feed on Surface roughness, and the interaction of Speed x Feed is the influence parameter on MRR.
4. The Depth of cut is the influencing parameter followed by Speed and feed on Material removal rate and the interaction of Speed x depth of cut is the influence parameter on MRR.

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