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Prediction of Surface Finish by end Milling using Factorial Technique

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ABSTRACT

Now a days research over improvement of surface finish on mechanical elements has become quite significant in the operational and aesthetical point of view. As a consequence, to enhance accuracy and precision, manufacturing firms are adopting, the automated systems in order to achieve manufacturing excellence.In the present work the effect of various process parameters like speed, feed and depth of cut on the surface finish in end milling process is investigated by using standard statistical tool i.e., Factorial Technique.The coefficients are calculated by using regression analysis and the model is constructed.Further,it is tested for its adequacy by using fisher's test.By using the mathematical model the main and interaction effect of various process parameters on surface finish is studied.The developed model helps in selection of proper mathematical tool and machining parameters for a specific material and also helps in achieving the desired surface finish.

Key words: End Milling, Surface Finish, Factorial Technique.

1.0 INTRODUCTION

Poor surface finish will lead to the rupture of oil films on the peaks of the micro irregularities, which lead to dry friction.It results too much wear on rubbing surface. Therefore finishing processes are developed to obtain a micro surface finish.

There are various techniques available from the statistical theory of experimental design, suitable for engineering applications. One such important technique is a Factorial technique for studying the effects of parameters in present investigation.

Patel K P [1] has done significant research over Experimental analysis on surface roughness by CNC end milling process using taguchi design method**.** Lou, B.M.S, J.C. Chen and C.M. Li [2] have carried research on Surface Roughness Prediction Technique by CNC

End-Milling. Evelio [3] has studied the Analysis of surface roughness on end milling operations. The method of coefficients was calculated by using regression analysis and the construction of model was given by, Samprit Chatterjee [4] and Ghani, J.A [5] have used Taguchi method to optimise the end milling parameters.

Factorial technique is a combination of Mathematical and statistical techniques. It is useful for the modeling and analysis of problems in which a response of interest is influenced by several variables and the objective is to optimise the response. For example, a person wishes to find levels of temperature (x_1) and pressure (x_2) that maximize the yield (Y) of a process. Equation (1) yields a function with the levels of temperature and pressure.

$$Y = f(x_1, x_2) + K \tag{1}$$

Where K represents the error or noise observed in the response Y.

In most of the problems, the relationship between the response and the independent variable is unknown. The first step in factorial technique is to find suitable approximation for the true function of relationship between Y and the set of independent variables. Usually, a low-order polynomial in some region of the independent variables is employed. If the response is well modeled by a linear function of the independent variables then the approximating function is the first order model, and it is given by equation (2).

$$\Upsilon = \beta + \beta_1 x_1 + \beta x_2 + \ldots\_ \beta_x x_x + \in \tag{2}$$

If there is curvature in the system then a polynomial of higher degree must be used, such as the second order model, and it is given by equation (3).

$$Y = \beta\alpha + \in \sum\beta_1 x_1 + \sum\beta\alpha x_1^2 + \sum\sum\beta x_i x + \in \tag{3}$$

2.0 MATHEMATICAL MODELLING

2.1 Identification of important process control variables

Identification of correct factors is very important to get a good and accurate model. Among them the parameters that influence the surface finish are speed, feed, depth of cut and nose radius.

2.2 Finding the limits of the process variables

a) Trial experiments are carried out to find out the value of surface finish by changing one parameter and other are kept constant.

b) By varying the parameters, extreme limits are found out.

c) For the convenience of recording and processing the experimental data is observed.

d) The upper and lower limits are coded as +1, -1 respectively or simply (+) and (-) for the case of recording

2.3 Development of Optimal Working Zones

Experiments are conducted separately for each combination to find the operating region. The upper and lower limits are denoted as +1 and –1 respectively. Trial runs are conducted by changing one of the factors and keeping the remaining factors constant. The maximum and minimum limits of the factors are fixed.

2.4 Conducting the Experiments as per the Design Matrix

The experiments are conducted according to the design matrix by using universal milling machine. The number of passes required to achieve the desired dimensional accuracy and surface finish is equal to 2^k.Where k is the number of input parameters.

Hence unnecessary expenditure due to the loss of cutting time and operational cost may be saved using this relation. Factorial designs constitute the main parameters of major interests and are compounded (mixed up) with effects of higher order interactions, since these interaction effects are assumed to be small and negligible. The resulting estimates are essentially the main effects of primary interest shown in Table 1.

Table 1 Typical Design Matrix

	N	F	d	NF	Nd	Fd	NFd
1	-	-	-	+	+	+	-
2	+	-	-	-	-	+	+
3	-	+	-	-	+	-	+
4	-	-	+	+	-	-	+
5	+	+	-	+	-	-	+
6	+	-	+	-	+	-	-
7	-	+	+	-	-	+	-
8	+	+	+	+	+	+	+

2.5 Selection of Design and Mathematical Model

Finding the effect of the machining parameters on the surface finish being the major part of investigation. It was considered best to design the experiments for the phase of study. This included the effect of maximum number of parameters could be used for all other phases.

2.6 Estimated of Regression Coefficients

The regression coefficients of the model are computed using the following formula based on the method of least squares.

Bj = xjiyi
N
Where:

j = 0, 1, 2…k
N = Number of experimental trails
X = Number of columns of the designed matrix
Xi= value of a factor or interaction in coded form.
Yi=Average

A matrix designed to apply the above formula for the calculation of regression coefficients of the model is given in table 1.Because of the orthogonal property of the design, the estimated coefficients do not correlate with one another. Since the method of least squares has been used to estimate the property of minimum variance. All the regression coefficients of the model are expressed by the above expression. The response parameters are estimated.

2.7 Checking the Adequacies of the Models

All the above estimated coefficients are used to construct the models for the response parameters and these models are tested by applying analysis of variance (ANOVA) technique. F-ratio is calculated and compared, with the standard values of 95% confidence level. If the calculated value is less than the F-table value then the model is considered as adequate.

3.0 EXPERIMENTAL PROCEDURE

Experimental work was conducted on Universal Milling Machine. Aluminum and Brass are chosen as work piece materials, High Speed Steel End Milling cutter is chosen as cutting tool material. Machining has been done as per the Design Matrix. In the present study influencing parameters on surface finish are speed, feed and depth of cut are taken apart from various parameters. Hence experimentation is performed by performing minimum and maximum values. Table 2 shows the minimum and maximum values of speed, feed and depth of cut.

Table 2 Maximum and minimum values of speed, feed and depth of cut on milling machine.

Limiting value	Speed N (r.p.m)	Feed F (mm/sec)	Depth Of Cut d (mm)
Maximum value	520	1.86	5
Minimum value	63	0.43	1

4.0 EXPERIMENTAL RESULTS

After conducting experiments as per design matrix shown in Table 1, the surface roughness values are measured using Talysurf instrument and the values are presented in Table 3.

Table 3 Measured Output Responses

Speed (rpm)	Feed (mm/s)	Depth of cut (mm)	Speed (rpm)	Feed (mm/s)	Depth of cut (mm)	ALUMINIUM Surface finish (Microns)	BRASS Surface finish (Microns)
-	-	-	63	0.43	1	1.33	0.90
+	-	-	520	0.43	1	1.85	1.43
-	+	-	63	1.86	1	1.50	0.67
-	-	+	63	0.43	5	2.97	2.38
+	+	-	520	1.86	1	2.65	1.18
+	-	+	520	0.43	5	1.49	0.99
-	+	+	63	1.86	5	2.15	1.36
+	+	+	520	1.86	5	1.35	0.82

From the Table 2, regression coefficients are derived. Equations (4) and (5) are for Aluminum and Brass respectively.

Regression Equation obtained for the above values

ALUMINIUM

$$Y_1= 1.90-0.40X_1+0.16X_2-0.08X_3-0.08X_1X_2+0.16X_2X_3-0.003X_1X_3 - 0.33X_1X_2X_3 \quad (4)$$

BRASS

$$Y_2=1.21-0.26X_1+0.30X_2+0.01X_3-0.09X_1X_2 +0.10X_2X_3-0.18X_1X_3-0.19X_1X_2X_3 \quad (5)$$

Where X_1, X_2, and X3 are the coded values of Speed, Feed, Depth of Cut and Y represents the Surface Roughness value.

5.0 COMPARISON OF SURFACE ROUGHNESS VALUES (Microns)

The values obtained by substituting coded values of speed, feed and depth of cut in the Equations (4) & (5) are presented in Tables 4 & 5 respectively.

Table 4 Comparison for Aluminum

ALUMINIUM		
Exp	Linear	Non-Linear
1.33	1.74	1.71
1.85	1.82	1.80
1.50	1.58	1.60
2.97	2.14	2.20
2.65	2.06	2.12
1.49	1.98	1.87
2.15	2.22	2.24
1.35	1.66	1.67

Table 5 Comparison for Brass

BRASS		
Exp	Linear	Non-Linear
0.90	1.23	1.16
1.43	1.22	1.24
0.67	0.93	0.91
2.38	1.49	1.61
1.18	1.18	1.66
0.9	1.19	1.16
1.36	1.48	1.41
0.82	0.92	0.99

The effect of each individual parameter on surface roughness values for Aluminum and Brass are presented in fig.1, fig.2 and fig.3 respectively.

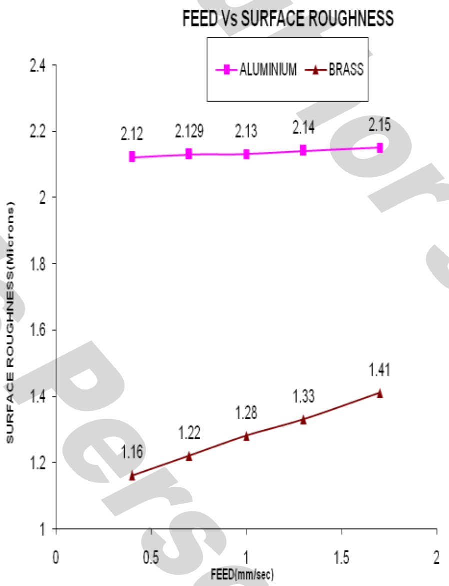

Fig.1 Effect of Feed

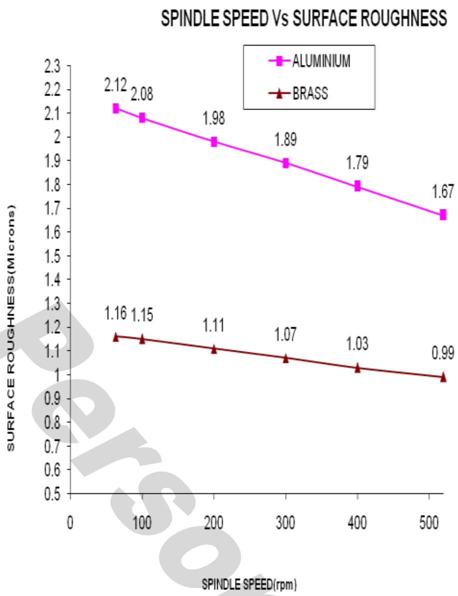

Fig.2 Effect of Spindle speed

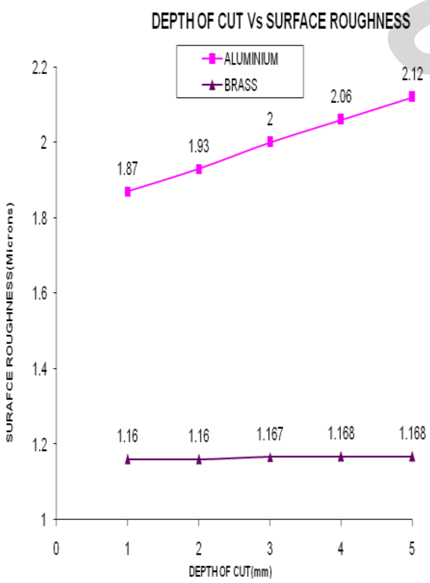

Fig.3 Effect of depth of cut

6.0 RESULTS AND DISCUSSION

1. The experimental values and evaluated values of surface roughness are well within the limits.
2. The surface roughness values are higher for aluminum than the brass.

3. From the fig.1, it is observed that as feed increases, the value of surface roughness also increases keeping the speed and depth of cut are constant.
4. From the fig.2, it is observed that as speed increases, the value of surface roughness also decreases keeping the feed and depth of cut are constant.
5. Also it is observed in fig.3 as depth of cut increases, the value of surface roughness increases keeping the speed and feed are constant.

7.0 CONCLUSIONS

1. Factorial Technique is convenient to predict the main effects and the interaction effects of different influential combination of end milling parameters with in the range of investigations on surface finish.

2. The developed model can be used to predict the surface finish in terms of machining process parameters within the range of variables studied. Alternately it is also helpful to choose the influential process parameters. So that the desired value of surface finsih can be obtained.

3. Factorial Technique is easy and accurate method for developing mathematical models for predicting the surface finish with in the working region of the process variables. The developed model can also be used in automatic and semi-automatic milling machine in the form of a program for obtaining the desired quality of surface finish.

4. It is evident from the graph; with the effect of feed on surface finish is decreasing while with the speed the surface finish is increasing.

8.0 REFERENCES

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