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ANOVA PREDICTION OF MICRO DRILLING PARAMETER ON ALUMINUM ALLOY

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ABSTRACT

Predicting the optimal parameter has become increasingly important given the rise in expenses involved in drilling a well. This has meant that oil companies engage in a perpetual struggle to predict the optimum mechanical property parameters. Predicting optimal mechanical property parameters, specifically speed, feed and lubricating oil with water percentage added, has become increasingly important given the rise in expenses involved in drilling a well. Several models and methods have been published for predicting, and therefore potentially optimizing. The system uses a knowledge base of various drilling parameters, to produce a "correlation" description of the responses. These responses are predicted by ANOVA method.

KEYWORDS: ANOVA Prediction, Micro Drilling, Aluminum Alloy

1. INTRODUCTION

Traditional mechanics of cutting approach and empirical approaches have been used for drilling performance prediction, in the past. While these predictions are comparable with conventional models, 'simultaneous' estimation of more than one performance feature is quite often necessary for 'on-line' control of a machining process. The conventional mechanics of cutting models are efficient to the extent of predicting individual performance but cannot estimate different performance features 'simultaneously'. A brief description of unified mechanics of cutting and empirical approaches to drilling performance prediction are carried out in this work before the capabilities of neural network models are presented. The basic principle of this method is that by drilling a small hole in a sample the removal of material will permit stress relaxation around the hole. Measuring these lateral strains with a specially designed triple strain gauge permits an estimation of the in-plane stresses that were present in the drilled material from the measured strain relaxations. The strengths of this technique are its simplicity, common usage, and ability to be used in the field with standard equipment. Hole drilling is also somewhat depth limited - it is a common rule of thumb that the diameter of the hole is equal to the maximum depth over which reliable results may be attained.

The smallest micro drills are of the spade type. The drills do not have helical flutes as do conventional drills and this makes chip removal from the hole more difficult. Drills smaller than this are exclusively of the spade type because of the difficulty in fabricating a twist drill of this size. [2] Drilling may affect the mechanical properties of the work piece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the work piece to become more susceptible to corrosion at the stressed surface. Micro drilling small diameter presents greater problems since coolant fed drills cannot be used and high spindle speeds are required.

2. BACKGROUND WORK

M.A. Amrana. et.al. [1] investigates the effects of drilling parameters such as spindle speed, feed rate and drill diameter on the surface roughness and surface texture of drilled hole by applying RSM. Murthy B.R.N. et.al. [2] stated the effect of process parameters i.e. spindle speed, feed, drill diameter, point angle & material thickness on thrust force and torque generated during drilling of Glass Fiber Reinforced Polymer (GFRP) composite material through integration of Taguchi method and Response Surface Methodology. S. Madhavan. et.al. [3] reports the effect of drilling parameters - Speed, Feed rate, drill type on thrust force during drilling of holes in Carbon Fiber Reinforced Plastic composite laminate using HSS, Solid Carbide (K20) and Poly Crystalline Diamond insert drills. Yogendra Tyagi. et.al. [4] states the impact process parameters- Spindle speed, Feed rate and Depth of cut on Surface Roughness and Material Removal Rate for CNC drilling machine operation by using high speed steel Tool and by applying Taguchi methodology. Erol Kilickap. et.al. [7] focuses study on the influence of machining parameters- cutting speed, feed rate, and cutting environment on the surface roughness obtained in drilling of AISI 1045.

3. OBJECTIVE OF WORK

The proposed work shows that we are supposed to determine the region of critical process control factors such as drill diameter, material thickness and the drill point angle leading to desired output or responses with acceptable variations that will ensure a low cost of manufacturing through prediction. Thus, it contributes to manufacturers to face the challenge of higher productivity and quality of the product. The aim of the present study is, thus, to develop a statistical model for using the main cutting parameters such as cutting speed, feed rate and depth of cut on Alloy Al 5052. Machining tests were carried out under different conditions with tipped Tungsten carbide cutting tool.

1. To study the influence/effect of drilling parameters viz. feed, cutting speed and coolant mixture on micro milling.
2. To develop an empirical model for the hole diameter error and MRR for the chosen combination within the specified domain of parameters.
3. The influence of drilling parameters (feed, cutting speed and coolant mixture) on hole diameter error MRR has been analysed. Under the both responses conditions ANOVA analysis is applied to obtain the significant parameter.

4. MATERIAL AND METHOD

Before starting with the investigation, we purchased commercial aluminum alloy Al 5052 plates from the open market in cold rolled condition with plate thickness 10 mm respectively for drilling tests to be conducted. During the experiment, the thrust force was measured with the help of dynamometer connected to multi-channel charged amplifier. The three feeds were selected as 0.2, 0.3, 0.4 mm/sec, spindle speeds used in the experiment were 100, 120, 150 rpm and the type of coolant has taken with water mixture of their percentage, for this experiment the coolant lubricant is taken 200 ml with their different level of water percentage have been added is 25%, 30% & 35% respectively. In this experiment, three machining parameters having 3 levels each was taken as input parameter as shown in Table 1.

Table 1 Factors and Level

S. No.	Feed mm/sec	Cutting Speed Rpm	Coolant Mixture %
1	.2	100	25
2	.3	120	30
3	.4	150	35

Orthogonal arrays are special standard experimental design that requires only a small number of experimental trials to find the main factors effects on output. On the basis of factors and their level L9 orthogonal array has to be design in Minitab software. The material removal rate (MRR) in drilling is the volume of material removed by the drill per unit time. For a drill with a diameter D, the cross-sectional area of the drilled hole is required

ANOVA is a fundamental step in the DOE, which is a dominant statistical tool aimed at statistically quantifying interactions between independent variables through their methodical modifications to determine their impact on the predicted variables. The ANOVA pre-requires the following assumptions:

• The treatment data must be normally distributed,

• The variance must be the same for all treatments,

• All samples are randomly selected

Each of the sources of variation is measured using its 'sum of squares'. The sum total of all the 'sums of squares' equals the total sum of squares for all the variation.

5. RESULT

The drilling speed experiments are performed for three different speeds of 100, 120 and 150 RPM, while the feed rate is kept at 0.2, 0.3 and 0.4 mm/sec, with three different level of water and coolant mixture, hole is being drilled for 10 mm in depth and drill diameter is 1.5 mm. Increasing the drilling speed as expected significantly increases responses.

This reduction in temperature is due to the fact that coolant allows faster dissipation of heat generated during micro drilling process, experimental setup and specimen after drilled are shown in Fig 1.

Fig 1 Micro drilling

On the base of DOE parameter, the micro drilling on aluminum plate is applied as per the sequence of experiment with their input parameter control operation, MRR and Hole diameter error is taken by Rehinshaw graph as shown in fig 2. The response of hole diameter error and MRR as shown in table 2

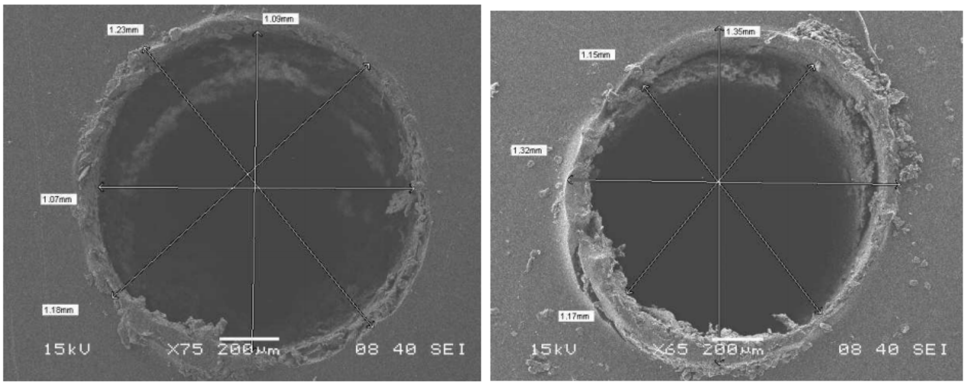

Fig 2 Graph of Drillng parameter

Table 2 Responses of parameter

S. No.	F	S	M	Hole Diameter Error (µm)	MRR mm^3/min
1	0.2	100	25	51.62	0.58875
2	0.2	120	30	58.72	0.7065
3	0.2	150	35	64.10	0.883125
4	0.3	100	30	76.70	0.883125
5	0.3	120	35	70.66	1.05975
6	0.3	150	25	89.30	1.324688
7	0.4	100	35	61.48	1.1775
8	0.4	120	25	78.58	1.413
9	0.4	150	30	82.68	1.76625

For ANOVA test of the responses are tabulated in table 3 and it shows that the lowest P value is 0.049 of Feed, so it means that the feed is the significant parameter against the responses of hole diameter Error. The S/N graph shows the parameter which gives the better result of accuracy the level is lowered in the graph as shown in Fig 3.

Table 3 Analysis of Variance for Hole Diameter Error

Source	DF	Seq SS	Adj SS	Adj MS	F	P
F	2	710.89	710.89	355.44	19.62	0.049
S	2	362.48	362.48	181.24	10.00	0.091
M	2	113.43	113.43	56.71	3.13	0.242
Residual Error	2	36.24	36.24	18.12		
Total	8	1223.04				

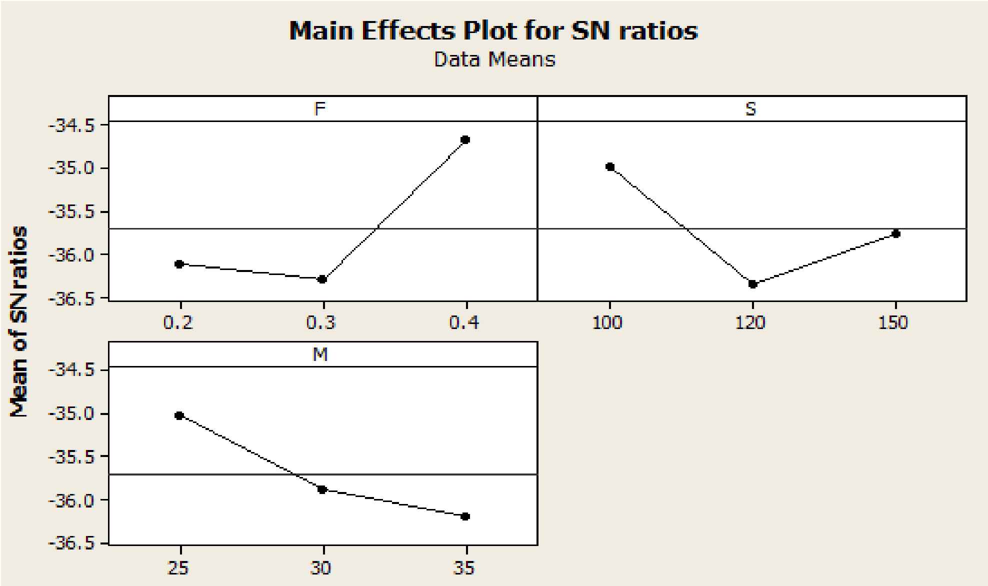

Fig 3 Prediction graph of Hole Diameter Error

For ANOVA test the S/N ratio of the responses are tabulated in table 4 and it shows that the lowest P value is 0.014 of Feed, so it also proves that the feed is the significant parameter against the responses of MRR. The S/N graph shows the parameter which gives the better result of accuracy the level is higher the better in the graph as shown in Fig 4.

Table 4 Analysis of Variance for MRR

Source	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F**	**P**
F	2	0.79089	0.79089	0.395443	72.05	0.014
S	2	0.29637	0.29637	0.148183	27.00	0.036
M	2	0.01098	0.01098	0.005488	1.00	0.500
Residual Error	2	0.01098	0.01098	0.005488		
Total	8	1.10921				

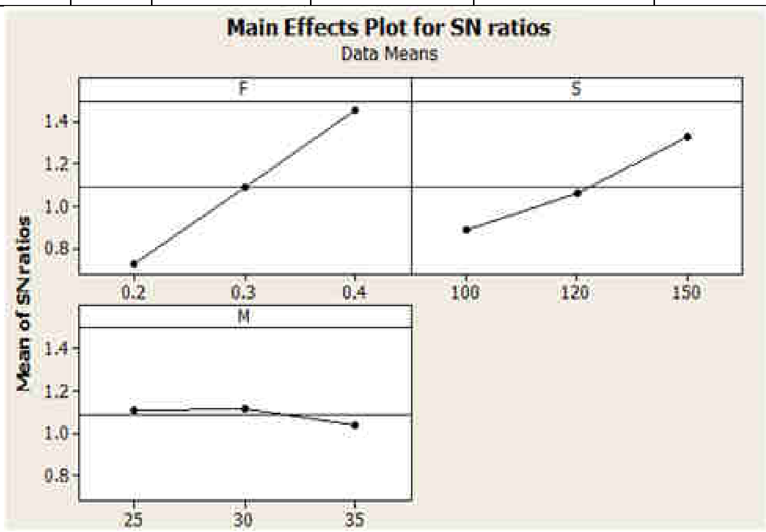

Fig 4 Prediction graph of MRR

6. CONCLUSIONS

ANOVA Analysis was successfully applied in predicting the process parameter of drilling based on the responses hole diameter error and Material removal rate for the selected domain of the input drilling parameters as shown in table 5. The predicted drilling parameter setting were found to be setting feed 0.4 mm/sec, cutting speed 150 rpm, and coolant mixture is 30% of water added in coolant. Mist application of cutting fluid could be applied in the future to the same tool-work combination for the same domain of cutting parameters as chosen in the present study and its effects on the surface roughness and tool wear could be studied and analyzed. Another improvement that can be made to the present study is that cutting forces could be added as an output response in addition to surface roughness and tool wear.

Table 5 Prediction Input Parameter

1) **Feed f (mm/sec)**	2) **Speed S rpm**	3) **Coolant mixture M (%)**
0.4	150	30

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