OPTIMIZATION STUDIES ON FRICTION DRILLING

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ABSTRACT

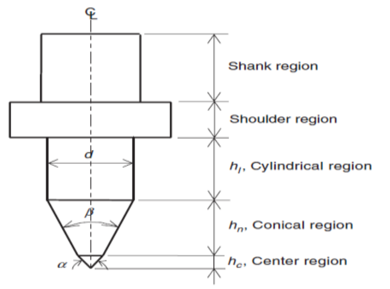
Friction drilling is Chipless drilling method which uses the frictional heat developed between a rotating conical tool and the workpiece to soften and penetrate the work-material and obtained a hole in a Aluminium hollow channel material and at the result a bush formation takes place. In this, Experimental trials effect the friction drilling input parameters viz. Spindle speed, feed and conical angle on the responses on w/p viz. dimensional error and surface roughness of the bush. Tool material as HSS and workpiece material as AA6063 Aluminium hallow channel which have 2mm thickness. The effects of Conical angles (CA), feed rate (FR), and spindle speed (SS) on the two quality characteristics, surface roughness (SR) and dimensional error (DE) were also measured and recorded. Conducting the experimental trials, the analysis procedure followed by DESIGN EXPERT V8 software. It was investigated that generated surface roughness, Dimensional error according to spindle speeds, feed rates and conical angles. Response Surface Method (RSM) has been used to develop an empirical model for the responses in terms of drilling parameters.

Key words: **Friction Drilling, speed, feed, conical angle, surface roughness, Dimensional error, Response Surface Method.**

I.*INTRODUCTION:*

Friction drilling is a chip less hole making method that uses the heat generated due to the friction between a rotating tool and the work piece to soften and penetrate the work-material and generate a hole in a Aluminium hollow channel. In machining and production methods these results often unwanted but they are unavoidable and important to affect the quality of friction drilled holes. Traditionally there is no chip formation, all elongated material form the bushing and it eliminates chip generation in friction drilling, therefore it can be called Chipless hole making process. According to the tool geometry there are four steps in friction drilling. In the First step, the tip of the tool touches and penetrates the work piece. In Second step, the generated heat that softens the work material due to the friction on the contact surface which is between tool and work piece. Third, it softened material is pushed sideward and tool moves forward to form the bushing using the cylindrical center of the tool. In Fourth step, the extruded material is pressed to the work piece surface by the shoulder of the tool and finally the tool retract and leaves a hole with a bushing. The tool tip and the frictional force on the contact area which is between the tool-workpiece interfaces, into the workpiece and support the drill in radial directions. The softened material pushed sideward by the tool which extruded and pierces through the workpiece. The tip of tool penetrates the workpiece and tool waves further forward to push the softened material and form the bushing with using the cylindrical part of the tool. The ratio of workpiece thickness (t), to tool diameter (d), is an important parameter in friction drilling. The bushing height, and surface roughness and dimentional error are made to judge the friction drilled hole quality. The ductility of work piece material, which is extruded onto both the front and back sides of the material drilled increases due to the frictional heat. The friction drilling tools geometry is important. The tool geometry denotes here in five parts, which are called centre region, conical region, and cylindrical region, shoulder, and shank regions. The centre region provides the support in the both radial and axial directions. Conical region is sharper than the centre region. This region rubs against workpiece in the contact area which is between and pushes the material sideward forms bushing. Shoulder region presses to the workpiece to round the entry edge of the hole. Shank region grippes the tool to holder of the machine.

II .*NOMENCLATURE:*



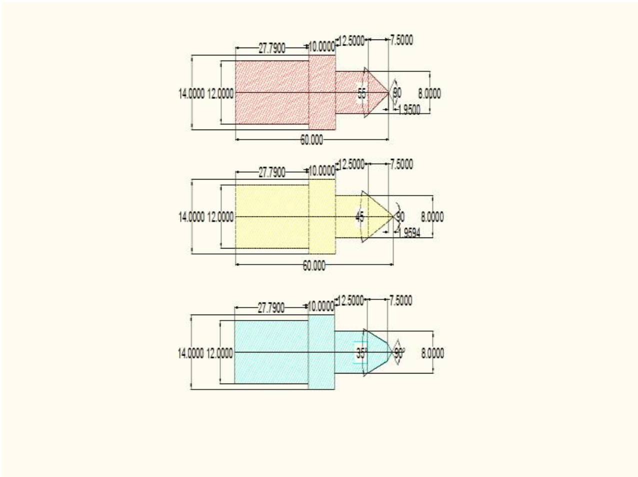


Fig 1. Key dimensions of the friction drilling tool

III. *EXPERIMENTAL SET UP AND PROCEDURE:*

The experiments are carried on 5 axes CNC vertical machining center named as VAYU BMV51 TC24 having speed range of 60-9000 RPM. The materials selected for this study is AA6063 Aluminium hallow channel as work piece material and HSS as tool material. Work piece materials as 3 pieces of Rectangular hallow channel of 50 x 25 x 2 mm thickness and 280 mm length has been selected to drill the holes. The material selected for w/p is AA6063 aluminium hollow channel which has chemical composition as Cu< 0.015%, Mg 0.493%, si 0.415%, Fe 0.143%, Mn 0.011%,Zn 0.003%,Ti 0.026%,Cr 0.012%. Three (3) Friction drilling tools diameter with 8mm made of HSS have been selected for experimental trails. The selected spindle speeds were 2000rpm, 2500rpm, 3000rpm, feed rates were 30mm/min, 45mm/min, 60mm/min. Tool material was HSS which has 35°,45°,55˚ conical angle and 12.50mm cylindrical region length. The work piece was held on the top of the fixture which is acts like the vise. The drill tool is hold in the standard cullet tool holder of the Vertical CNC machine. Then according to the Experimental parameters i.e. spindle speed and feed accordingly illustrated in table 2,listed below will helpful to perform the drilling operation. Three similar materials used for experiments in this friction drilling study of 2mm thick. After completion of friction drill on 3 similar w/p's calibration will be taken place on parameters like Bush length, Surface roughness, and Dimensional Error measurement, and at last starting temperature and end temperature are measured which are shown in table 2 are given below.

Fig 2. Shows the friction drilling setup on vertical CNC milling machine.

Fig 3.shows the Friction drills made up of HSS

III.I *DESIGN OF EXPERIMENT*

A). EXPERIMENTAL PARAMETE

Table 1: Input parameters and their respective levels

S.NO	PROCESS PARAMETERS	UNITS	LEVELS		
			1	2	3
1	Speed(N)	Rpm	2000	2500	3000
2	Feed(mm/min)	Mm/rev	30	45	60
3	Conical angle(β)	Angles in (°)	35°	45°	55°

B). EXPERIMENTAL RESULTS:

Table 2: Experimental values of input parameters and measured values

s.no	speed (rpm)	feed (mm/min)	Tool angles (β)	Surface roughness (μm)	Dimensional error of holes measured by (CMM)
1	3000	30	55	6.97	8.3590
2	2000	30	35	3.07	8.0560
3	2500	60	55	6.97	8.1376
4	3000	45	45	4.82	8.0213
5	2500	30	45	4.77	7.9884
6	3000	30	35	3.17	8.1476
7	2000	30	55	5.22	8.1684
8	2000	60	45	4.98	8.0453
9	2000	45	35	3.54	8.0509
10	2500	45	45	5.09	7.9837
11	2500	45	35	4.26	8.1369
12	2000	30	45	5.37	8.0271
13	2000	45	45	4.51	7.9983
14	3000	45	55	6.02	8.1862
15	3000	60	55	6.17	8.1381
16	3000	45	35	4.45	8.1652
17	2000	45	55	6.23	8.1096
18	3000	60	35	4.33	8.1492
19	2500	30	35	5.08	8.1313
20	2500	30	55	6.31	8.0914
21	2500	60	55	6.22	8.0796
22	2000	60	55	4.17	8.1546
23	2500	60	45	5.26	8.0374
24	2500	45	55	3.86	8.2020
25	3000	60	45	5.56	8.1242
26	2000	60	35	4.26	8.0671
27	3000	30	45	4.64	8.3006

III.II *Frictional drilled holes on work pieces after Experimental trails:*

Figure.4 Components after friction drilling

IV. *RESULT AND CONCLUSION:*

IV.I *DISCUSSION OF RESULTS BASED ON RSM:*

OPTIMIZATION STUDIES ON FRICTIONAL DRILLING experiment is conducted by using the parametric approach of the RSM. The effects of frictional drilling process parameters, on the selected quality characteristic such as surface roughness and Dimensional error have been discussed in this section. The main effects of process variables were plotted. The response curves (main effects) are used for examining the parametric effects on the response characteristic. The analysis of variance (ANOVA) of raw materials which are used and main effect of analysis is carried out by analyzing the response curves and the ANOVA tables.

A).Analysis of variance (ANOVA) for Surface roughness (SR):

Table3: shows ANOVA for Response Surface Quadratic Model Analysis of variance table

Source	**Sum of Squares**	**Df***	**Mean Square**	**F Value**	**p-value Prob > F**	
Model	18.00	9	2.00	3.11	0.0211	Significant
A-A	*1.26*	*1*	*1.26*	*1.96*	*0.1790*	
B-B	*0.24*	*1*	*0.24*	*0.38*	*0.5471*	
C-C	*12.20*	*1*	*12.20*	*18.95*	*0.0004*	
AB	*0.20*	*1*	*0.20*	*0.30*	*0.5891*	
AC	*0.50*	*1*	*0.50*	*0.78*	*0.3884*	
BC	*0.71*	*1*	*0.71*	*1.10*	*0.3080*	
A^2	*0.59*	*1*	*0.59*	*0.92*	*0.3509*	
B^2	*0.61*	*1*	*0.61*	*0.95*	*0.3427*	
C^2	*0.014*	*1*	*0.014*	*0.022*	*0.8847*	
Residual	10.94	17	0.64			
Lack of Fit	*10.65*	*16*	*0.67*	*2.30*	*0.4805*	not significant
Pure Error	*0.29*	*1*	*0.29*			
Cor Total	28.94	26				

According to the analysis report the Surface roughness is to be higher on feed and as the speed increases surface roughness decreases. Here Graphs shows the variances accordingly speed, Feed, and conical angles by the figures (4.1.1, 4.1.2, 4.1.3). And a contour Graph shows the variance of Surface roughness with speed and feed which is shown in the figure (4.1.4)

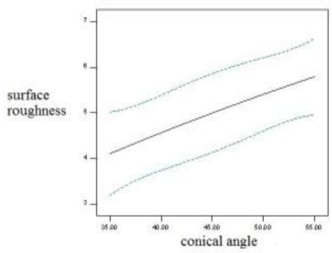


Figure 4.1.1: Variation of Surface roughness with conical angle

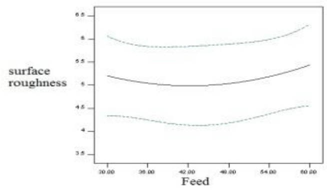


Figure 4.1.2: Variation of Surface roughness with Feed

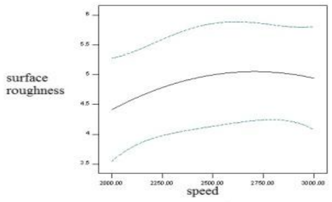


Figure 4.1.3: Variation of Surface roughness with Speed

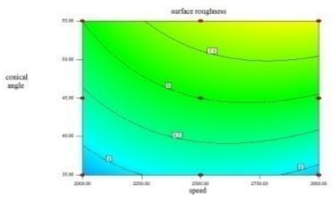


Figure 4.1.4: Contour plot showing variation of Surface roughness with conical angle and speed

B). Analysis of variance (ANOVA) for Dimensional Error (DE)

Table 4:ANOVA for Response Surface Quadratic Model Analysis of variance table

Source	Sum of Squares	df*	Mean Square	F Value	p-value Prob > F	
Model	1.388E+005	9	15427.15	4.05	0.0064	significant
A-A	*46421.04*	*1*	*46421.04*	*12.18*	*0.0028*	
B-B	*7081.73*	*1*	*7081.73*	*1.86*	*0.1906*	
C-C	*14417.54*	*1*	*14417.54*	*3.78*	*0.0685*	
AB	*14090.45*	*1*	*14090.45*	*3.70*	*0.0714*	
AC	*114.70*	*1*	*114.70*	*0.030*	*0.8643*	
BC	*2807.14*	*1*	*2807.14*	*0.74*	*0.4027*	
A^2	*9814.04*	*1*	*9814.04*	*2.58*	*0.1270*	
B^2	*4016.50*	*1*	*4016.50*	*1.05*	*0.3190*	
C^2	*38600.74*	*1*	*38600.74*	*10.13*	*0.0054*	
Residual	64789.71	17	3811.16			
Lack of Fit	*63107.71*	*16*	*3944.23*	*2.34*	*0.4770*	*not significant*
Pure Error	*1682.00*	*1*	*1682.00*			
Cor Total	2.036E+005	26				

According to the analysis report as the speed increases Dimensional Error decreases and if feed increases Dimensional Error increases. Here Graphs shows the variances accordingly speed, Feed, and conical angles by the figures (4.2.1, 4.2.2, 4.2.3). And a contour Graph shows the variance of Surface roughness with speed and feed which is shown in the figure (4.2.4).

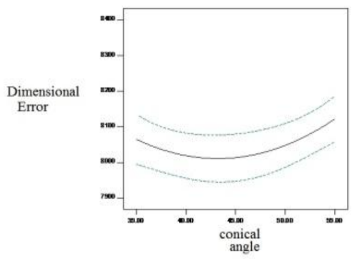


Figure 4.2.1: Variation of Dimensional Error with conical angle.

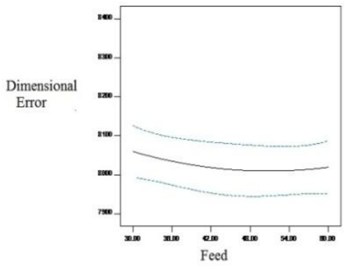


Figure 4.2.2: Variation of Dimensional error with feed.

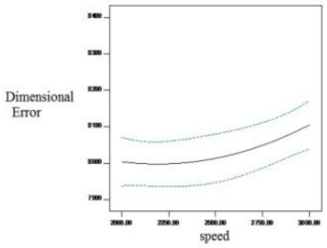


Figure4.2.3: Variation of Dimensional Error with speed.

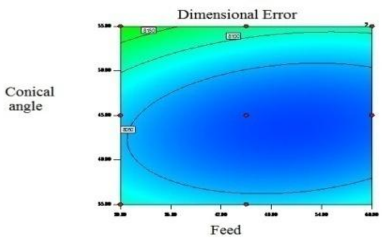


Figure 4.2.4: Contour plot showing variation of Dimensional Error with conical angle and speed.

V. *CONCLUSIONS:*

The experimental report involves and shows the 27 drilled holes in AA6063 Hallow Chanel with 2 mm thick using friction drilling. Input parameters and their interaction on the quality of the hole produced in frictional drilling process. The ANOVA tables are presented and the model adequancy is carried out by Design Expert V8 software. It is proved from the analysis that the speed has the less effect on dimensional error though it has considerable effect on surface roughness.

In the given table.2 after performing experimental trails the important property is to be measured is surface roughness test, which is going to be measured by SJ-201 surface roughness tester according to the bushes obtained. Stailous is the important unit in the tester. And obviously all drilled holes by friction drill will be measured by these apparatus. According to the analysis report the Surface roughness is to be higher on feed rates and as the speed increases surface roughness decreases. In this experiment top surface roughness is obtained as 6.97 µm at 3000Rpm, at 30mm/min as feed rate, same at 60mm/min,at 2500Rpm.The minimum surface roughness obtained as3.07µm at 2000Rpm at 30mm/min and again as 3.17µm at 3000Rpm at 30mm/min on AA6063 aluminium hollow channel.

In this experimental report Dimensional Error of the friction drilled holes are measured by the Coordinate measuring machine (3D CMM), which is illustrated in the table 2. The quality of drilled holes is widely inspected by Dimensional Error (DE) through CMM and all the efforts are required to produce the desired size holes. In this Experiment higher dimentional error (**DE**) recorded as 83590 mm by the conical angle of the tool 55°. And the least **DE** recorded as 79837mm by the conical angle 45°.

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