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Optimization of Drilling Parameters in Cu-Ni-Tib_2 Material Using Taguchi Methodology

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Abstract: The drilling process is most important in manufacturing industries. In this case various drilling process parameters have been performed to cut the material. This paper mainly focusing on material removal rate and better surface roughness. The various drill holes to produce in Cu-Ni-Tib_2 material based on given input parameters of speed, feed and selected drill tool. The optimized input parameters have been finding out in Taguchi L_9 orthogonal array. The Cu-Ni-Tib_2 material basically High hardness and high corrosion resistivity material using in various industrial applications. The various drilling input control factor precious in Cu-Ni-Tib_2 material surface. The output parametric optimization has been performed in thrust force, torque, material removal rate and surface finish based on the results confirmations using in minitab-17 Tool.

Keywords: ANOVA, Drilling, Material Removal Rate (MRR), Surface roughness.

I. Introduction

Nowadays the various applications of alloys and composite materials are widely used in manufacturing field to concentrate for higher material removal rate and good surface roughness. Prasanna *et al*. [1] introduced the advancement of process parameters of little gap dry drilling in Ti– 6Al– 4V utilizing taguchi and grey relational process examination the result of the exploration was finished by uncovered that spindle rotational speed and output of air pressure have the most critical effect on the dimensional exactness of the drilling hole, spindle speed and feed rate controls the manufacturing process. Laurentiu *et al*. [2] investigated in robust engineering of profound drill hole procedure by surface state streamlining to advance the better surface structure also considered by optical measurements. Takashi Matsumura *et al*. [3] was done the experimental work the orthogonal cutting data of Carbon Fiber Reinforced Plastics (CFRP) also of titanium composite materials are connected to manufactured in different models of tool cutting geometry according to the change in difference materials. The cutting force model is well known in approximation between the executions and deliberate in cutting armed forces. Ahmet Taskesen *et al*. [4] studied the multi-target examination on drill hole of boron carbide reinforced metal network composites utilizing grey relation investigation T_iAlN coated carbide drills demonstrated the better output concerning the surface finish and also ANOVA demonstrated that the most successful factor on grey relational review was observed to be weight division and took after by drilling in a given material. Mayuet *et al*. [5] indicated that the harmed region based investigation of the break-in and out imperfections in the dry drill hole of CFRP territory is ascertained from picture examination of the area in a drill holes. For that the reason dry drill holes test was conducted by uncoated WC-Co drills have been directly measured. Taskesen *et al*. [6] [7] studied the optimization of drilling parameters in wear of the tool and drill hole precision in B_4C Reinforced aluminium alloy and the outcomes uncovered that ideal blend of the drilling process could be utilized to get both least device wear and delamination errors. Redouane zitoune *et al*. [8] [9] was studied in Drilling of composite material and Aluminium alloys they did wear, amid initial 30 different holes thrust force in CFRP experiences a more important of increment (90%) than compared of aluminium (6%). This experimental work was done by the higher cutting accuracy in dry cutting environment. The tool was having various types of speeds various types of cutting diameters then constant feed rate then using the L_9 orthogonal array can used to drilling Cu-Ni-Tib_2 materials the work peace sizing for 50 x 50 x 20 mm. The material can used to drilling three average holes after finishing the project and also using the drill tool dynamometer having the result of thrust force and then torque measured. So the project must be tested on the surface roughness for using telesurf surface tester and then applied the values then get to taguchi method analysis. The resistance, toughness, hardness and S/N ratio in addition due to analyzed from MiniTab 17 Software.

Experimental Methods

In this investigation was performed in Cu-Ni-Tib$_2$ stir casted material. The measurements of the work piece are 50 × 50 × 20 mm and the drill tool was used in 6 mm, 8 mm and 10 mm as shown in Fig. 4. The drilling test was conducted by Sidhapura radial drilling machine as shown in Fig. 2 with a most extreme shaft speed of 2500 rpm and the cutting velocities 500, 850 and 1300 rpm feed rate is 0.012 mm/rev while gap profundity was kept consistent at 20 mm. All experiments were conducted by dry cutting environment. The Cu-Ni-Tib$_2$ material properties as shown in Table I and II.

II. Material Properties

Table I: Cu-Ni-Tib$_2$ Material Properties

Hardness	Tensile Strength	Density
125 BHN	510 MPa	8.37 g/cm3

Chemical Composition of Cu-Ni-Tib$_2$

Table II: Chemical Properties of Cu-Ni-Tib$_2$

Cu	Ni	Ti	B_2	O
71.41	19.59	3.92	0.52	4.56

Cu-Ni-Tib$_2$ material has been prepared by stir cast metal matrix composite material as shown in Fig. 1. This analysis for scanning electron microscope and atomic force microscope to analysis for particle size transformation. We find a smooth curvature result has been obtained and uniform particle size have been achieved.

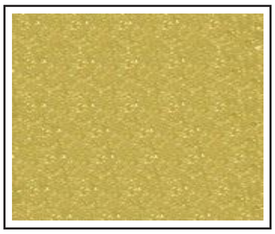

Fig. 1: Cu-Ni-Tib$_2$ Material

III. Machine and Dynamometer

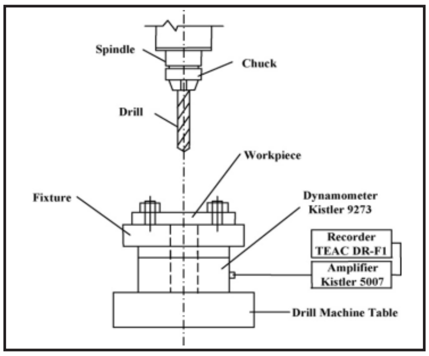

Fig. 2: 2D Radial Drilling Machine

A. Drill Tool Dynamometer

A drill tool dynamometer is a device for measuring force, torque in a various drill hole. It is a standard testing output has been measure from United States Environmental Protection Agency (US EPA) as shown in Fig. 3.

Fig. 3: Drill Tool Dynamometer

B. Drill Tool

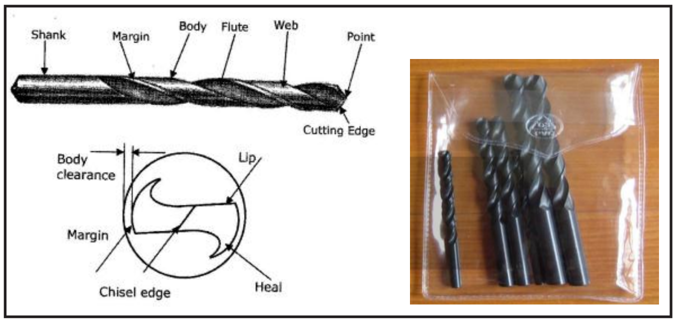

Fig. 4: Selection of Drilling Tool

C. Measurement of Thrust Force

The drilling thrust force measurement was measured in a Kistler piezoelectric dynamometer. The signals of dynamo meter using a Kistler 5070 - intensifier and afterward recorded on a PC. In the trial arrangement using in components of the cutting force happened amid drilling procedure to be specific fundamental cutting force, thrust force and radial drilling forces are estimated. The forces are following up on both cutting edge is considered to offset each other as shown in Fig. 5 and 6. As fundamental cutting power esteems got in the drilling tests are essentially small amount of thrust force was investigated in three cutting power esteems were estimated but output of thrust force values only evaluated.

Fig. 5: Work and Tools

Fig. 6: Drilling Process

D. Formula Used for Metal Removal Rate (MRR)

MRR = Area of drill × Feed rate × Cutting speed

Design of Experiments

Genichi Taguchi built up a structure for a mathematics modelling outline experimental tests adjusted to the specific prerequisites of engineering level. Taguchi recommended that the outline procedure comprises of three stages:

- Systematic design
- Parametric design
- Tolerance level of design

In the framework configuration stage the fundamental idea is chosen utilizing theoretical learning and experience to measure in the essential parameter esteems to give the execution required.

Taguchi said that the two types of variables, the name is called the control factors and noise factors. Control factors variables are basically economically controlled. Noise factors variables are expensive to control in exercise although can be controlled in experimental procedures.

IV. Level of Experiments

Table III: Design of Experiments

Trail no L_9	A	B	C
1	1	1	1
2	1	1	2
3	1	1	3
4	2	1	1
5	2	1	2
6	2	1	3
7	3	1	1
8	3	1	2
9	3	1	3

The Signal to noise ratio proportion changes a few repetitions into one esteem which mirrors the measure of variety exhibit and the mean reaction or response. The various characteristic of signal to noise ratio is nominal is better, smaller is better and larger is the better. The finally calculation of output response for no loss values can accepted in nominal is better. The settled level of accomplishment wanted is known as the objective and better nominal values.

The formula for signal to noise ratio in nominal is best characteristics is defined as:

$$L(Y) = K(Y\text{-}M)2$$

Formula for nominal is the best vale is:

$$SN = 10 \log(Y2/S2) = 20 \log(Y/S)$$

A. Cutting Parameters and Their Levels

Table IV: Drill Tool Cutting Parameters

S. No	Parameters	Input Parameter Levels		
1	Cutting tools (Ct)	6 mm	8 mm	10 mm
2	Cutting Speed (V-m/min)	500	850	1300
3	Feed rate (f-mm/rev)	0.012	0.012	0.012

Number of level factors to be considered for improvement the quantity of collaborations to be analyzed the quantity of levels required for each factor the target of the test, and obviously the accessibility of exploratory spending plan and sources as shown in Table IV.

B. Orthogonal Array of Taguchi L_9

In this investigation the surface finish and thrust force were estimated by means of the test plan for every blend of the control factors. Assurance of the quality attributes of the deliberate control factors are given by Signal to noise ratio proportions attributes through a lowest number of tests. The choice of which orthogonal array to utilize transcendently relies upon the accompanying things arranged by need the quantity of variables. The experimenter may run a larger test which will have a higher Resolution potential however will likewise be more costly to finish. The cutting tool speed, feed were chosen as control factors for the surface finish and values are decided. The cutting parameters utilized for the chose orthogonal array are allocated to every section sixteen blends or combinations are (3 × 3 × 1 = 9) cutting parameters were produced in Taguchi technique based on number of trails as shown in Table III. Taguchi proposes the utilization of orthogonal array for arranging the outline or process optimizing test.

V. Experimental Results and Discussions

The Taguchi techniques utilize the Signal to noise proportion to quantify the various trial outlines. The condition of smaller than the better was chosen for the estimation of Signal to noise ratio. Since the most reduced estimation of the surface finish and thrust force has been coveted in better results as shown in Table V. Signal to noise ratio of surface finish has utilizing to appeared in drill hole input parameters are isolated by allowing for diverse levels and conceivable impacts as indicated by the chose orthogonal array. From the after effects in different testing experiments the normal estimation of surface finish has been computed.

A. Experimental Calculation

TABLE V: EXPERIMENTAL INPUT AND OUTPUT

S. No	Cutting Speed (rpm)	Feed Rate (mm/rev)	Drill Dia (mm)	Thrust Force (kgf)	Torque (kgm)	Surface Finish (μm)	MRR (m3/min)
1	500	0.012	6	40.00	0.25	0.7566	169.460
2	500	0.012	8	43.33	0.966	1.86	402.123
3	500	0.012	10	57.00	0.533	1.61	785.398
4	850	0.012	6	52.667	1.60	1.63	170.421
5	850	0.012	8	45.00	0.40	1.25	326.230
6	850	0.012	10	34.00	0.666	1.84	800.235
7	1300	0.012	6	30.00	0.266	1.44	155.236
8	1300	0.012	8	35.66	0.333	1.65	311.124
9	1300	0.012	10	21.33	0.20	0.90	902.101

Rap = Tra + (A3-Tra) + (B4-Tra) + (C5-Tra)

The elements output parameters and their levels were utilized as a part of the estimation of the better ideal thrust force by thinking about their individual impacts. The condition determined for the anticipated ideal push drive is mentioned below:

Ffp = TFf + (A1 - TFf) + (B2 – TFf) + (C1 – TFf)

The A1 is the mean trail results are in primary level factor. B3 is the mean 813.2.3N of test trials at the 3 level of orbit factor B. C1 is represented the mean 775.6N of experiment results in various level of factor C. As indicated by these values, the ideal thrust force was generated as 725N.

B. Effect of Control Factors in Surface Roughness

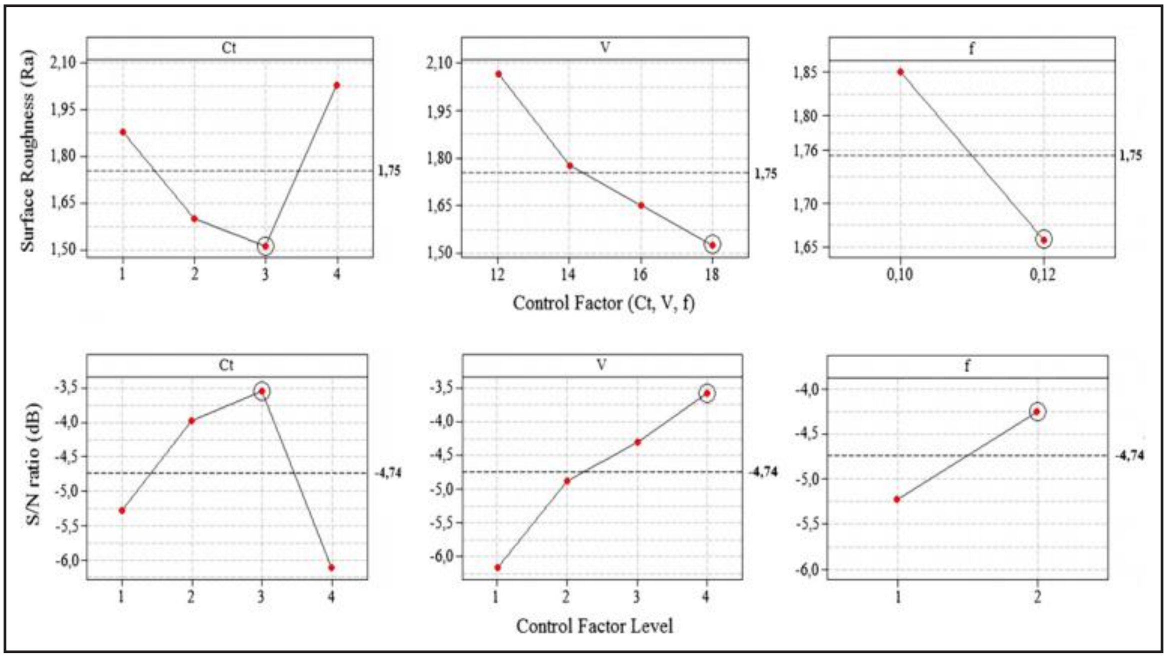

Fig. 7: S/N Ratio of Surface Roughness

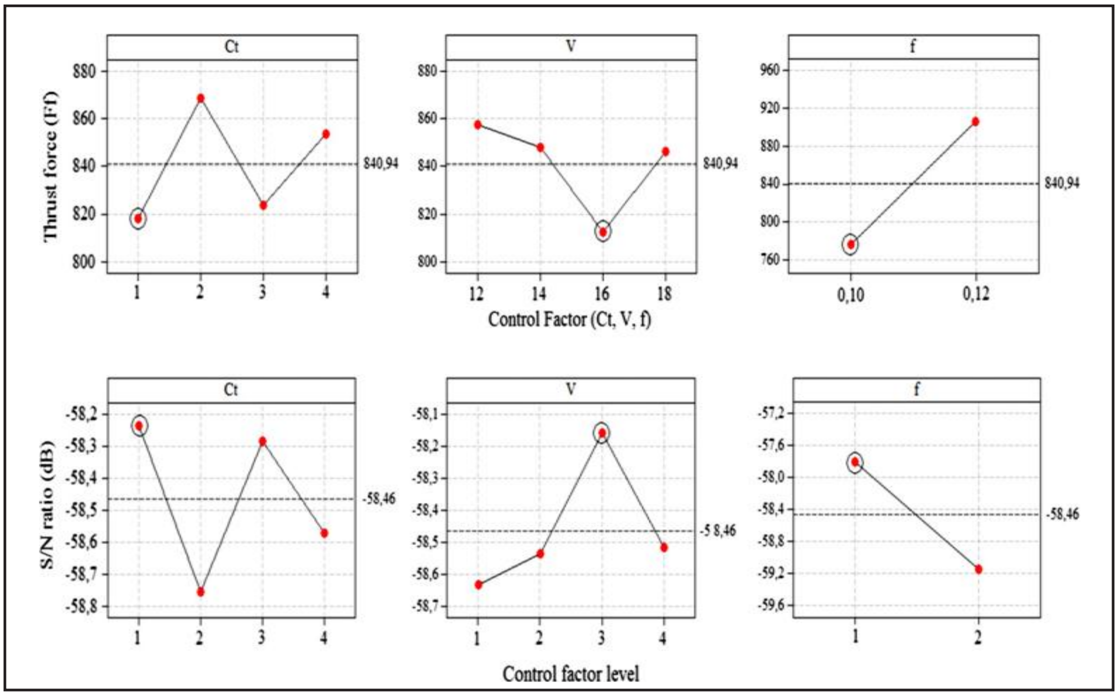

Fig. 8: S/N Ratio of Thrust force

The Fig. 7 and Fig. 8 represents better optimal results in a mean values of signal to noise response in surface roughness and thrust force is given control factor have been performed. The ANOVA results expose that feed rate and speed are the maximum significant influencing on the thrust force and torque of a surface finish.

VI. Conclusion

In this paper has been analyzed the values of the different input parameters to ensure that the specified confines for MRR, Surface Roughness are best performance of given work piece and tools. A dynamometer based on a set up experiments the deterioration model was developed as a frontward model in the first part of this paper where the well-known ANOVA analyses were used to study the degree of consequence of the different parameters the different set of calculation. The optimum process parameters in the drilling of Cu-Ni-Tib_2 material given input Speed of 500 rpm, feed rate at 0.012 mm/rev using drill dia 6 mm whereas for parameters of torque, better speed is 500 rpm, selected feed rate is 0.012 mm/rev, drilling diameter 8 mm are found to be optimum. Speed at 800 rpm, feed rate of 0.012 mm/rev, and drill dia is 10 mm for best surface roughness and for Material Removal Rate (MRR) it is the optimum value compared with speed 800 rpm, feed rate 0.012 mm/rev and drilling tool size is 8 mm. While conducting hard material surface roughness and Material Removal Rate (MRR) analysis using signal to noise ratio S/N analysis the speed of 800 rpm and torque value is 34 kgf surface finish is 1.84 µm is the best optimum value to be concluded.

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