Optimization Of Drilling Parameters To Minimize The Cutting Force In Machining Of Titanium Grade 2

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Abstract— **This research outlines the Taguchi methodology for optimizing the cutting parameters in Titanium Grade 2 drilling. Cutting speed, Drill bit diameter and feed rate are the drilling parameters evaluated. In order to relate the cutting parameters to thrust force and torque, no of experiments are conducted. A series of drilling operations were conducted on radial drilling machine by using L9 orthogonal array. The operations were conducted by using HSS twist drills on Titanium Grade 2. A signal-to-noise ratio of L9 orthogonal array is used to examine the outcome of these parameters during drilling on thrust force, torque. The study displays that Taguchi method is appropriate with the minimum trials to solve stated problem. The main goal is to find the important factors and combinations of these factors that affects the process of machining to achieve low thrust and torque. The drill diameter was found to be the most noticeable factor for cutting force after 9 experimental tests. The Taguchi method analysis shows that feed rate is most important factor influencing the thrust force, whereas the cutting speed contributes most to torque**.

Keywords—Drilling,Taguchi Method,L9OA,Thrust Force,S/N Ratio

I. INTRODUCTION

Metal cutting operations are widely used in manufacturing to p roduce a variety of mechanical components, such as drilling, turning, and milling. The most widely used process in manufa cturing is hole drilling.Conventional twist drilling is the most cost - effective and efficient machining processes in the aerospace and automotive industries for hole production, as well as for riveting and fastening structural assemblies at the beginning of unproductivity, critical thrust force and torque plays the major role, and these are correlated with the process parameters

Tsao &Hocheng [1] developed a device to solve difficulty of relative motion ,chip removal in drilling in between inner & outer drills to analyze their action.

During the drilling process, cutting variables & tool geometries have a major effect on cutting force and torque ,therefore on the quality of the machined holes. In some cases, low feeds enhance the roughness of the surface due to reduced thrust force. In other cases, drilling at lower feeds and high speed results in higher temperature generation [2,3]. On the other hand, the effect of drilling and material variables on cutting force and torque was studied by Khashaba et al. [4]. The results show that availability of sand filler in continuous - winding composite not only raised the cutting forces & push - out delamination values, but also raised their values with more cutting speed.

M.A.Elhamid et al.[5]studied effect of the drilling parameters, speed, feed on the required thrust forces, torque & delamination which occur in drilling composites with different fiber volume fractions at entrance and exit. No clear influence of drilling speed was observed on this size of the delamination, while this size of the delamination reduces as feed reduces.

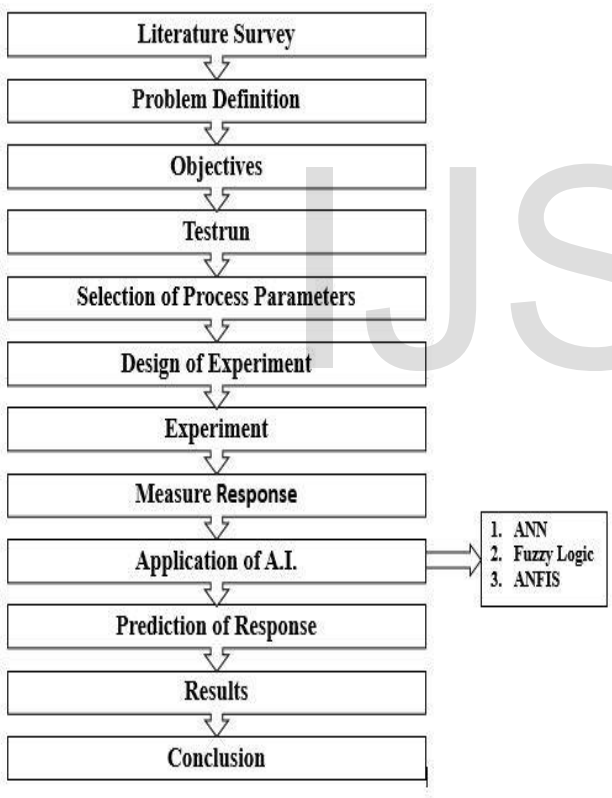
The aim of this paper is to minimize the thrust force in drilling of Titanium grade 2 by changing the process parameters. we have taken the process parameter like speed of rotating drill, feed rate, drill bit diameter, by doing the experimentation we have found that the all the process parameter is influencing the

thrust force acting on Titanium grade 2. Also, we have found that thrust force gets most significantly affected by the drill diameter.

II. Experimental Details and Measurement

The Drilling tests were done on Radial Drilling Machine, the radial drill fitted with a rotating, cutting tools which is known as drill bit. It has big gear head moving along with the arm and radiating from the drilling machine's column. Radial arm swings away and moves away the drill head to place the piece of work on base of radial drilling machine. This swinging motion also allows the work piece to drill holes on different points without moving work piece.
We have used three HSS drill bit's diameter the basic composition of HSS is 18% W, 4% Cr, 1% V, 0.7% C and rest Fe. The work piece used is Titanium Grade 2 for drilling.

The drilling experiments were performed on a drilling machine. The thrust force and torque were measured using a drill tool dynamometer connected to the Drill Tool Dynamometer measuring both the thrust and torque. .



Procedure: Use the slot provided on dynamometer to fix drill tool dynamometer on work platform post. Ensure that the drilled object is mounted at top center of the dynamometer of drill tool Connect the input cable to the thrust and the torque axis to output socket of dynamometer that connect to the other end to sensor socket on front panel of instrument. Place the switch READ-CAL at READ. Switch the POWER-ON switch to the ON position of the instrument. modify the ZERO potentiometer so that in both displays the display reads Zero.

Table no 2.1 L9 orthogonal array and measurement

Trial no.	Speed (rpm)	Feed Rate	Drill Diameter	Thrust (kg)
1	80	0.1	3.17	75
2	80	0.125	4.76	78
3	80	0.15	6.36	115
4	160	0.1	4.76	66
5	160	0.125	6.36	105
6	160	0.15	3.17	69
7	250	0.1	6.36	95
8	250	0.125	3.17	65
9	250	0.15	4.76	63

In this calculation of Thrust force value by using three parameters i.e speed, drill diameter & feed rate as shown in above table. The Table no 2.1. shows an L9 orthogonal array. There are a total of 9 experiments were performed and each experiments were based on the level values combination is shown in the table. For example, by keeping independent design variable 1 at the level 1, variable 2 at the level 3 and variable 3 at the level 3, the third experiment was conducted.

Table no.2.2 S/N ratio

Trial no.	Speed (rpm)	Feed Rate	Drill Diameter	Thrust (kg)	S/N Ratio
1	80	0.1	3.17	75	-37.5012
2	80	0.125	4.76	78	-37.8418
3	80	0.15	6.36	115	-41.2139
4	160	0.1	4.76	66	-36.3908
5	160	0.125	6.36	105	-40.4237
6	160	0.15	3.17	69	-36.7769
7	250	0.1	6.36	95	-39.5544
8	250	0.125	3.17	65	-36.2582
9	250	0.15	4.76	63	-35.9868

Table no.2.2 shows the calculated s/n ratio for the thrust force value obtained from different set of experimentations. The S / N ratio is estimated as the performance parameter of the calculation for the smaller the better criteria with thrust force. Use the equation to calculate the S / N ratio.

$$S/N = -10\log_{10}\left(\frac{\sum y_i^2}{n}\right)$$

From the calculated values of S/N ratio optimal values of variables are obtained from average table.

Table no 2.3 Average table

Level	Speed (rpm)	Feed Rate	Drill diameter
1	**-39.0523**	**-37.8154**	**-36.8454**
2	**-37.8638**	**-38.1745**	**-36.7398**
3	**-37.2664**	**-37.9925**	**-40.3973**
Delta	**1.7859**	**0.3591**	**3.6575**
Rank	**2**	**3**	**1**

Table number 2.3 shows the calculation of average values of S/N ratio divided into three levels where all the three variables are categorized in these three levels. For the 9 sets of experiment Shown above the three levels are designed with process parameters in each level. Therefore, the average taken is shown above.

III. TAGUCHI METHOD

Taguchi method is mechanism for evaluating and executing improvements in processes, product, equipment, materials, and facilities that is scientifically disciplined. While, traditional experimental design methods are sometimes too complex and time consuming, Taguchi methodology is a relatively simple method. Taguchi method uses extremely fractionated factorial designs and another types of fractional designs acquired from OA to investigate the entire experimental region of curiosity for experimenter with minimum number of experiments. The method applies across large range of engineering fields, including processes that produce raw materials, sub-systems, professional and consumer products. The method can actually be applied to any process, be it manufacturing engineering, computer-aided design, banking and service sectors, etc.

IV. RESULTS AND CONCLUSIONS

This experimental result output showed that Taguchi method selected the optimal parameters as Speed (250), Drill bit diameter (4.76), feed rate (0.1). The thrust force aquired by this combination. The thrust force obtained is best at this level and when we increase the drill diameter and Speed while drilling on radial drill machine then we get more thrust force

The L9 OA is used to conducted experiment and for measurement of minimum thrust force. Drill Tool dynamometer device is used to calculated minimum and maximum value of thrust force. The optimization is done by TAGUCHI method. Experimental result displayed that Taguchi parameter design is an significant way of finding out the optimal drilling parameters for achieving best minimum thrust force. By this experimentation we get the optimized set of Speed and drillbit diameter for minimum thrust force

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