Analysis of Process Parameters to Optimize Axial Force in Radial Drilling using Taguchi

Mohit uppal
Department of Mechanical Engineering
MANAV INSTITUTE OF TECHNOLOGY AND MANAGEMENT
JEVRA (HISAR), HARYANA, INDIA

Bharat Bhushan
Department of Mechanical Engineering
MANAV INSTITUTE OF TECHNOLOGY AND MANAGEMENT
JEVRA (HISAR), HARYANA, INDIA

Abstract- In this work Taguchi's Parameter Design Approach is applied to optimize cutting parameters in drilling. Another analysis tool (ANOVA)is used to study the effect of process parameters on machining process. In this work Radial Drilling Machine is used and the process parameters are Cutting Speed and Feed Rate.In this procedure there is no need of repeated experiments, so it saves time and conserves the material as opposed by the conventional procedure. A series of experiments are conducted on Radial Drilling Machine fitted with dynamometer to relate the cutting parameters and cutting thrust. In the experiment an orthogonal array is used for conductance, raw data and signal-to-noise ratio (S/N ratio) are employed to analyze the influence of these parameters on axial force during drilling operation. The methodology could be useful in predicting thrust and torque parameters as a function of cutting parameters and specimen parameters. The main objective of this work is to find the important factors and combination of factors which influence the machining process in drilling to achieve low axial force.

Keywords –Radial Drilling Machine, Process Parameters, Axial Force, Taguchi Analysis.

I. INTRODUCTION

The present work deals with the analysis of process parameters of a Radial Drilling Machine to optimize its axial force. Taguchi technique is used for the analysis of process parameters which are Cutting Speed and Feed Rate. Twist drill is used to make a hole and this is the most common hole making operation usually performed. Unlike shaping and turning, this involves two principal cutting edges. If the total advancement of the drill per revolution (the feed rate) is *f*, then the share of each cutting edge is *f*/2 because each lip is getting the uncut layer the top surface of which has been finished by the other lip 180^0 ahead (during 180^0 rotation, the vertical displacement of the drill is *f*/2). The uncut thickness t1 and the width of cut *w* are given as t_1= (f/2) $\sin_\beta$ and w= (D/2) $\sin_\beta$.Where $_\beta$ is the half point angle. It is the largest and most versatile of the drilling machines and is very well suited for drilling large number of holes. It is a single spindle intended for handling large and heavy work or work which is beyond the capacity of the small drilling machines. It consists of vertical column with a radial arm that can be driven for vertical movement, is an independently driven drilling head equipped with a power feed. The Taguchi Technique for quality engineering is intended as a guide and reference source for industrial practitioners (managers, engineers & scientists) involved in product or process experimentation and development. ANOVA is the statistical method used to interpret experimental data and make the necessary decisions. It is a statistically based decision tool for detecting any differences in average performance of groups of item tested.

II.PROPOSED WORK

A scientific approach to planning and conducting of experiments was incorporated in order to perform the experiments most effectively. Taguchi Technique was taken as the basis for planning the experiments so that the appropriate data can be collected which may be analyzed to obtain valid and objective conclusions. Planning of experiments was employed in order to fulfill the following requirement:

- To get the data uniformly distributed over the whole range of controllable factors to be investigated.

- To reduce the total number of experiments.
- To establish a relationship between different input variables.

The following are basic steps, which are followed during the experiment.

1) Selection of variables: The variables selected are feed rate and cutting speed.
2) Selection of the levels: The levels selected are 3 for both the variables.
3) Selection of the Orthogonal Array: As variables having three levels are being taken, so the degree of freedom associated with one variable is 2 (No. of levels -1). The DOF associated with the two variables is 4. The interaction study between the variables required and additional DOF since the DOF of two factors interaction is equal to the product of DOF of the factors. Thus total DOF required becomes 8. An orthogonal array having at least 8 DOF is to be selected. In the present work, the OA selected is L_9.

During experimentation all the trials were repeated three times, so the total number of experiments performed is 27.

Then the raw data analysis and S/N data analysis are done.

The material selected for tool bit is HSS and the work piece material is mild steel.

The mild steel work pieces having 60 mm diameter and 43.5 mm length were drilled of the radial drilling machine.

Designing, Conducting and Analyzing the Experiment: **-**

The major initial steps are

1) Selection of factors and/or interactions to be evaluated
2) Selection of number of levels for the factors
3) Selection of the appropriate Orthogonal Array
4) Assignment of factors and/or interactions to columns
5) Conduct tests
6) Analyze results
7) Confirmation experiment

Table1: Drill angles used for various materials.

Material(s)	Helix angle (degree)	Point angle 2 (degree)	Lip relief angle (degree)	Chisel angle (degree)
Brittle and hard	22-33 (lower value for smaller size)	80	6-8	55
Steel & cost irons	22-33 (lower value for smaller size)	118	6-8	51
Soft	22-33 (lower value for smaller size)	140	6-8	51

III. Experiment and Result

The ranges of the selected process variables were decided by the conducting experiments using one variable at-a-time approach. The process parameters, there designation and three levels selected are given in Table2.

Table2: Process Parameter and their Ranges for Cutting Force

Process Parameter	Parameter Designation	Levels		
		L1	L2	L3
Cutting Speed (m/min)	A	20	24	28
Feed (mm/rev.)	B	0.10	0.16	0.28

Results of the Axial Force:

Table3 shows experimental results of axial force obtained using the above discussed procedure in previous section. The experiments were repeated thrice and R1, R2, R3 denote the repetitions. The S/N data of the axial force are also given in Table3.

Table3: L9 OA with responses (Raw Data & S/N Ratios)

Column	1	2	3	4	Response (Raw Data)			S/N Ratio
Trial No.	A	B	AxB	AxB	R_1(N)	R_2(N)	R_3(N)	S/N=-10log1/r $\sum_{i=1}^{r} y_i^2$
1	1	1	1	1	690	672	682	-56.67
2	1	2	2	2	970	980	975	-59.76
3	1	3	3	3	1345	1301	1320	-62.43
4	2	1	2	3	980	970	976	-59.78
5	2	2	3	1	1300	1245	1275	-62.1
6	2	3	1	2	1925	1934	1930	-65.71
7	3	1	3	2	979	985	976	-59.83
8	3	2	1	3	1560	1585	1540	-63.87
9	3	3	2	1	2460	2472	2450	-67.82

IV.CONCLUSION

After analyzing S/N response graphs and the average plots for the raw data the optimal cutting conditions for the selected quality Characteristic, axial force, are:

Cutting Speed (A, Level 1) : 20 m/min
Feed (B, Level 1) : 0.1 mm/rev

The following are the percentage contributions of the parameters to the variations of axial force in drilling of Mild Steel part using HSS drill.

For raw data:

Cutting Speed : 27.74%
Feed : 64.6%
Interaction between cuttings : 7.61%

For S/N data:

Cutting Speed : 28.64%
Feed : 68.1%

The percentage contribution of the parameters reveal that the influence of the feed rate in controlling both mean and variation of axial force is significantly larger than that of cutting speed.

The interaction between cutting speed end feed rate (A x B) is significant at 95% confidence level in ANOVA for raw data. Thus it affects the mean values.

The predicted optimal range of axial force is: $667.7 < AF(N) < 694.96$

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