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Optimization of Process Parameters in Drilling of Mild Steel for Exit Burr

Mr. Dhanke V. D.(1) , Prof. Phafat N.G.(2), Prof. Gangane V.S.(3)
[1,2]Student, M.E. Manufacturing, [2]Assistant Professor
Mechanical Engineering Department, J.N.E.C. Aurangabad, Maharashtra, India

Abstract

This paper presents the statistical analysis of process parameters for burr height in drilling of Mild steel. In the present investigation work, the influence of process parameters like speed, feed and depth of cut in dry drilling, are studied as burr height as the output response variable. The experimental work was completed on Radial Drilling Machine under varying speed, feed and depth of cut. Taguchi orthogonal array method was used for design of experiment. Using L9 orthogonal array nine readings were taken for measurement of exit burr. The experimental results were analyzed statistically to study the influence of process parameters on burr height.

Keywords

Drilling, burr height, orthogonal array, SN ratio.

Introduction

Drilling is one of the important manufacturing operations that can be carried out on number of parts for assembly work. Drilling operation is essential for manufacturing industries like automobile industry, aerospace industry, medical and electrical related industries etc.

Formation of exit burr after drilling operation is one of the important problems that have to be minimized or control in order to avoid its adverse effect during manufacturing stage or assembly work. Burr is defined as the projection of material at the end of the hole due to plastic deformation of the material. Burr has two types' viz. entrance burr and exit burr. The exit burr is important because these are larger in size than entrance burr. Exit burr creates several problems like decreasing quality of the products, improper seating between mating parts during assembly, jamming and misalignment of parts etc. Burrs are injurious to workers during machining operations.[2,3] Especially in precision industries, burrs are quiet undesirable. Due to all these problems deburring operation should be carried out on the work piece to remove the burr formed during drilling operation. This will result in waste of time and money. Almost 30% of the total manufacturing cost [3] will be spending on deburring and edge finishing of components.

Therefore a special attention should be given to minimize or control the exit drilling burr. To minimize the burr formation, it is necessary to understand the burr formation mechanism and factors affecting the burr size during machining. This will be done by preparing the accurate mathematical model that describe the relation of the burr size with the process parameters and gives the correct value of burr height. This paper only concentrates on the analysis of experimental readings for finding the best possible input parameters within the given range.

Burr formation Mechanism

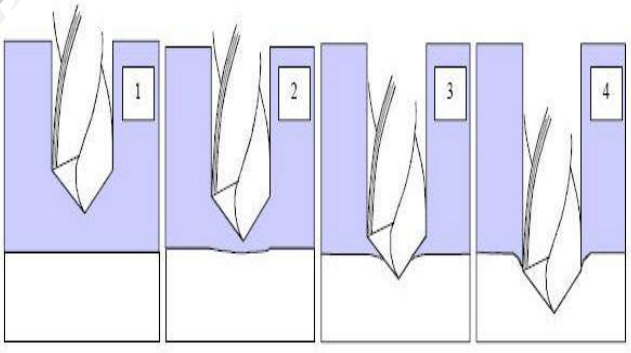

FIG. 1 EXIT BURR FORMATION

Figure 1 describes the formation of an exit burr in drilling.[6] As the drill approaches the exit, the work piece deflects and then plastically deforms due to the thrust force created by the drill (frame 2). Once this deformation is initiated, it increases as the drill (frame 3) cuts more of the work piece material. When the drill exits the work piece, the remaining material deflects creating an exit burr (frame 4).

The material mild steel has lot of applications in manufacturing industries such as nails, screws, nuts, bolts, car bodies, sheep plates, boiler plates, fan blades etc.

TABLE 1 FACTOR AND LEVELS

Factors	Level 1	Level 2	Level 3
Speed (N) r.p.m	400	520	675
Feed (f) mm/rev.	0.01	0.02	0.03
Depth of cut (D) mm	5	8	9

Design of Experiment

In the given work three levels are defined for each factor hence L9 orthogonal array was selected. Nine experiments were conducted on mild steel to plates measure burr height (B_h).

TABLE 2 L9 ORTHOGONAL ARRAY

Run	N r.p.m	f mm/rev.	D mm
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Experimental Work

Experimental studies were performed on CNC Machining centre HASS VF2SS with following specifications,
The max. table travel along X-axis, X = 762 mm
The max. table travel along Y-axis, Y = 406 mm
The max. table travel along Z-axis, Z = 508 mm
Maximum speed = 12000 mm, HAAS Control

The material used for this work is Mild steel plates of 100 x 50 x 10 mm having chemical composition and mechanical properties as bellow:

TABLE 3 CHEMICAL COMPOSITION OF AISI 1015

Element	C	Mn	P	S
Weight %	0.17	0.60	0.040	0.050

TABLE 4 MECHANICAL PROPERTIES OF AISI 1015

Density (kg/m^3)	7845
Tensile Strength (Mpa)	518.8
Yield Strength (Mpa)	353.4
Hardness (HB)	149
Elongation (%)	30.2

Work pieces having dimensions 100 X 50 X 10 mm were used for this study. HSS twist drill bit was used for drilling operation. The burr height was measured using profile projector made by Batty. Burr was measured at four equally spaced areas around the circumference of hole and average reading of burr height was taken as a response.

TABLE 5 EXPERIMENTAL DATA

Expt. No.	N (r.p.m)	f (mm/rev.)	D (mm)	B_h (mm)
1	400	0.01	5	0.28
2	400	0.02	8	0.42
3	400	0.03	9	0.675
4	520	0.01	8	0.302
5	520	0.02	9	0.75
6	520	0.03	5	0.22
7	675	0.01	9	0.77
8	675	0.02	5	0.13
9	675	0.03	8	0.445

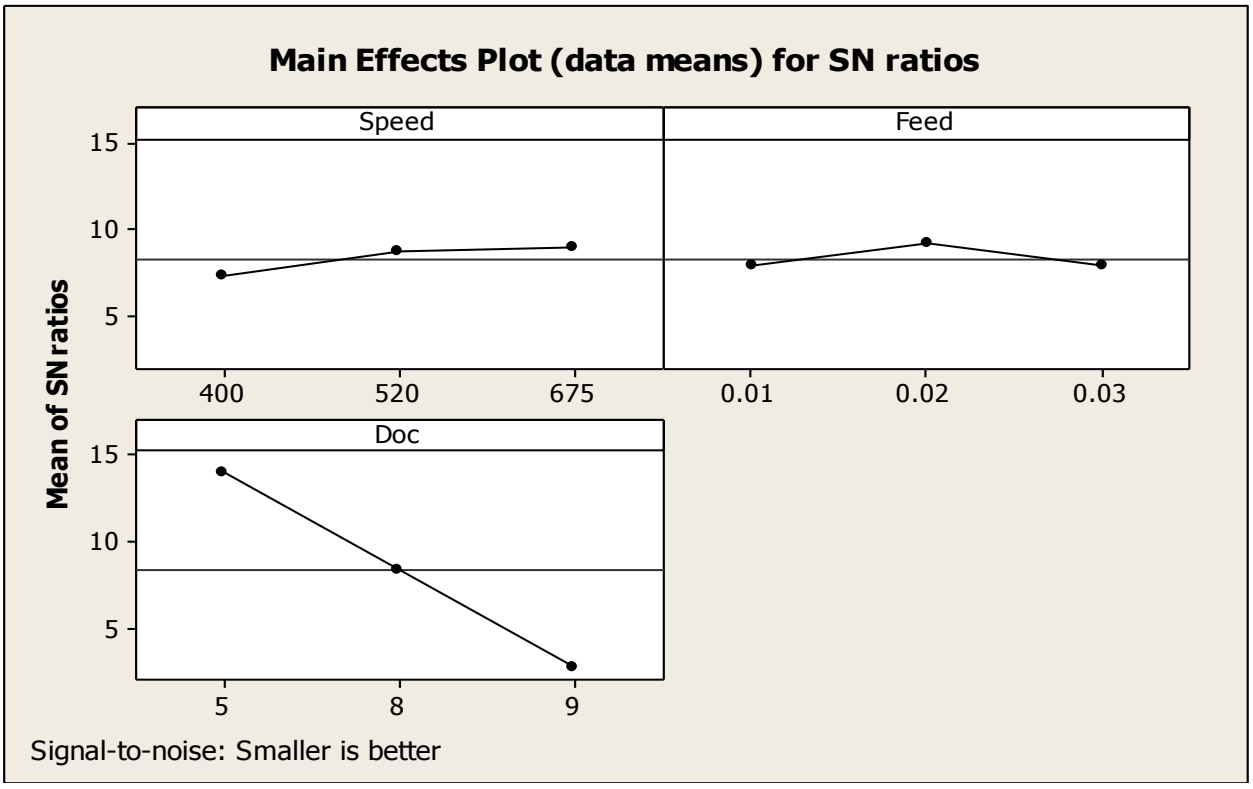

FIG 2 MAIN EFFECTS PLOT FOR SN RATIO

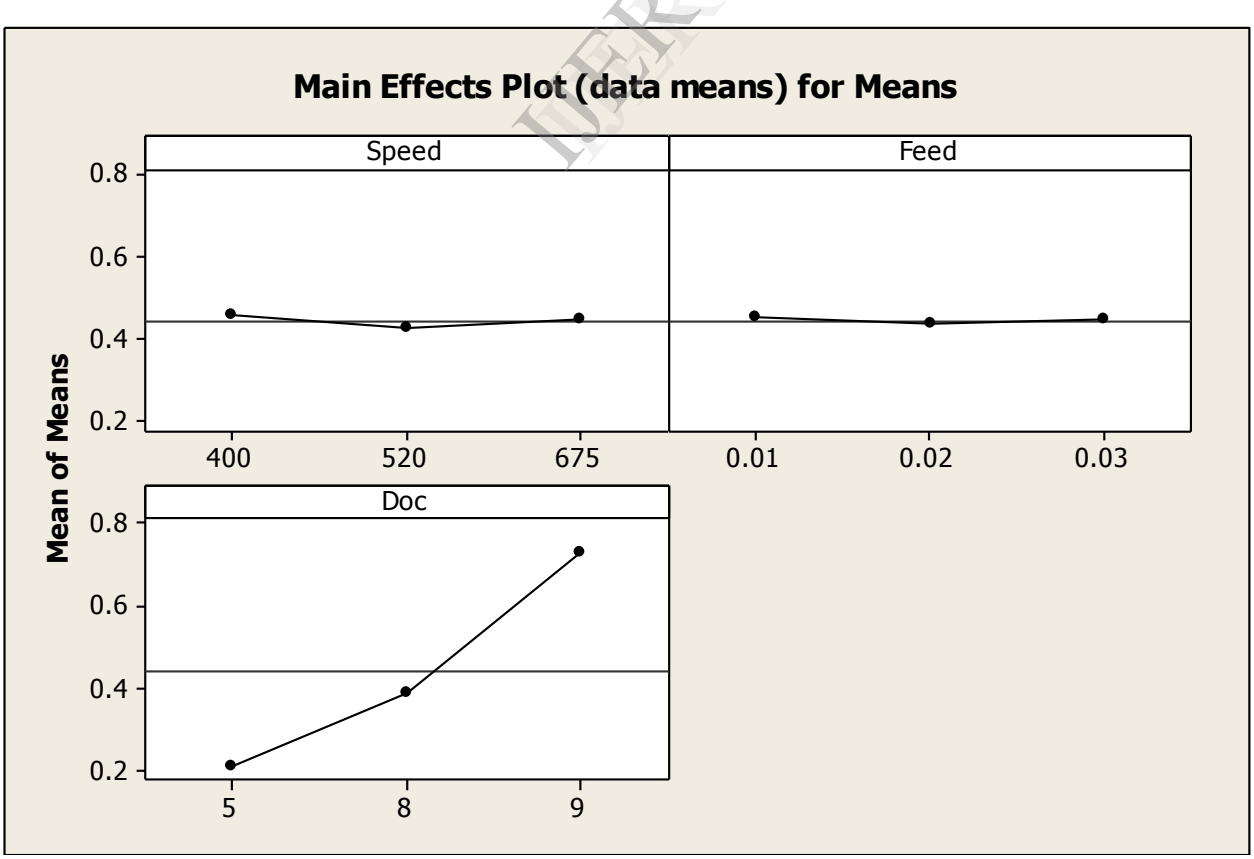

FIG. 3 MAIN EFFECTS PLOT FOR MEANS

Analysis of Results

The results were analyzed statistically for signal to noise ratio and the response table for S/N ratio and data means is shown in table 6 and 7, respectively. Taguchi method is used for the analysis of given data to find the influencing parameter on the production of burr.

TABLE 6 RESPONSE TABLE FOR SIGNAL TO NOISE RATIO

Level	Speed	Feed	Depth of cut
1	7.335	7.909	13.977
2	8.683	9.252	8.323
3	9.008	7.866	2.728
Delta	1.673	1.386	11.249
Rank	2	3	1

TABLE 7 RESPONSE TABLE FOR MEANS

Level	Speed	Feed	Depth of cut
1	0.4583	0.4507	0.2100
2	0.4240	0.4333	0.3890
3	0.4483	0.4467	0.7317
Delta	0.0343	0.0173	0.5217
Rank	2	3	1

The results was again analyzed to investigate the interaction among process parameters and main effect plots for S/N noise ratio and means were generated as shown in figure 1 and2, respectively.

Delta values of depth of cut is the maximum for signal to noise ratio as well as for means as shown in table 7 and table 8 respectively. The ranks to the parameters are given considering from maximum to minimum delta values which indicates the severity of effect of each of these parameters on burr height.

Use the response tables to select the best level for each factor. Usually, our objective is to maximize the S/N ratio, and meet the optimum values of input parameters. Use the delta and rank values to identify the factors that have the greatest effect on each response characteristic

Conclusions

In this paper, the experimental investigation of process parameters is carried out in drilling of mild steel to understand the influence of process parameters on burr height and optimal drilling parameters from given set of experimental values were determine for the burr height in the drilling process by using the signal to noise ratio and related plots.

The experimentation was carried out on radial drilling machine and burr height was measured using digital height gauge at four equal spaced areas around the drilled hole. The average of four readings was taken as a response. The results were then analyzed statistically for which SN ratio and means table and related graphs were used.

Following conclusions are drawn from the given study:

1. Burr height (B_h) values are increasing with increase in depth of cut (DOC). Hence we can say that for smaller diameter holes burr height will small for larger diameters it will be large for given speed and feed values.
2. Speed and feed are not much influencing parameters on burr height. Therefore any optimum value from a given range for speed and feed can be used as they have minimal effect on burr height.
3. From response table for SN ratio the optimum parameters for minimum burr height are speed-675 r.p.m, feed-0.02 mm/rev and Depth of cut-5 mm

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