Study Of Cutting Parameters On Drilling EN24 Using Taguchi Method

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Abstract

Tool cost for the machining operation will affect the production cost. The selection of cutting tool and cutting parameters for corresponding work material is very important during the machining operation. In this paper, the cutting parameters for drilling EN24 material with the high speed steel drill are analyzed using Taguchi method. By using suitable cutting parameters like feed rate, speed and lip angle, the experiment is conducted and that the optimized cutting parameters are found with reference to the surface roughness of the part, metal removal rate and machining time for the operation.

Keywords: *cutting parameters, surface finish, feed, speed, lip angle and MRR.*

1. Introduction

All manuscripts must be in English. Drilling is easily the most common machining process. One estimate is that 75% of all metal-cutting material removed comes from drilling operations. Drilling involves the creation of holes that are right circular cylinders. This is accomplished most typically by using a twist drill, a cross section of a hole being cut by a common twist drill The chips must exit through the flutes to the outside of the tool. Due to the improper selection of cutting parameters and cutting tool leads to reduce the cutting tool life period, wokpiece surface finish and dimensional accuracy of the work piece. This problem, increase the total product cost. In this research work, the optimal cutting parameters speed, feed rate and lip angle of the drill bit for drilling operation is identified to minimize the tool wear and to improve the accuracy of the work.

In the view of above machining problems, the main objective of the present work is to investigate the influence of different cutting parameters on surface finish, machining time and material removal rate(MRR) criterion. The Taguchi L9 orthogonal array is utilized for experimental planning for drilling of EN24 with HSS drill in CNC turning centre. The results are analyzed to achieve optimal surface roughness, machining time and material removal rate (MRR).

2. Literature Survey

Matthew Bono and Jun Ni [1] analyzed the temperature profile along the cutting edges of a drill and describe how the temperature on the chisel edge can exceed the temperature on the primary cutting edge. Rahamathullah and M. Shanmugam[2] investigated the carbide drill breakage during the micro milling of glass fibre – reinforced plastics (GFRP). Rui Li and Albert J. Shih [3] were compares that the temperature distributions in the spiral point drill of Kennametal K285A03906, with an S-shaped chisel edge. Compared to a conventional twist drill. S. S. Panda,[4] has investigated the reason for acquiring the drill wear state information is to enhance the predictive capability to allow the machine operator to schedule tool change or regrind just in time to avoid underused or overuse of tools. On the other hand, drill wear affects the ability of the hole cutting system to satisfy specified performance characteristics, such as hole roundness, centering, burr formation at drill exit, and surface finish. Matthew Bono [5] analyzed the temperature profile along the cutting edges of a drill and describes how the temperature on the chisel edge can exceed the temperature on the primary cutting edges.

3. Experimental Procedure and Measurements

For the experiment investigation, the drilling operation is performed on the EN24 material and HSS drill is used. CNC turning centre Lynex 220L is used. The experiment parameters are designed in orthogonal array and Taguchi method is used for the analyzing.

CNC turning centre, resolution is in mutually perpendicular directions, X, Y, and Z. A high-speed spindle with a speed range of 50-4000 revolutions / min. The spindle speed is controlled through the frequency converter, which allows infinitely variable speed within the range. There is a provision in the spindle itself for air cooling. Figures 1, 2, and 3 are shows the schematic arrangement of the drilling experimental set-up and images of the drilling operation. The HSS drill of 16 mm diameter is used to perform the drilling operation. The drilling time and lip angle variation were observed for the HSS drill. The cutting parameters are selected for the operation based on the three level three factors orthogonal array and experimental design as shown in table.2.

Fig.1 CNC Turning Centre

3.1 Workpiece

EN24 is usually supplied with a tensile strength of 850/1000 N/mm2. EN24 is a popular grade of through-hardening alloy steel due to its excellent machinability. EN24 is used in components such as gears, shafts, studs and bolts. EN24 can be further surface-hardened to create components with enhanced wear resistance by induction or nitrating processing.

Fig.2 EN24 work pieces

Table.1 Chemical Composition of EN24

Element	C	Si	Mn	Ni	Cr	Mo
% composition	0.40	0.30	0.60	1.50	1.20	0.25

3.2 Machining calculations

Metal removal rate (MRR) = [πd2/4]fN, mm3/min,
Where,
d- Diameter of drill mm
f- Feed in mm per rev
N - Spindle speed in rpm.

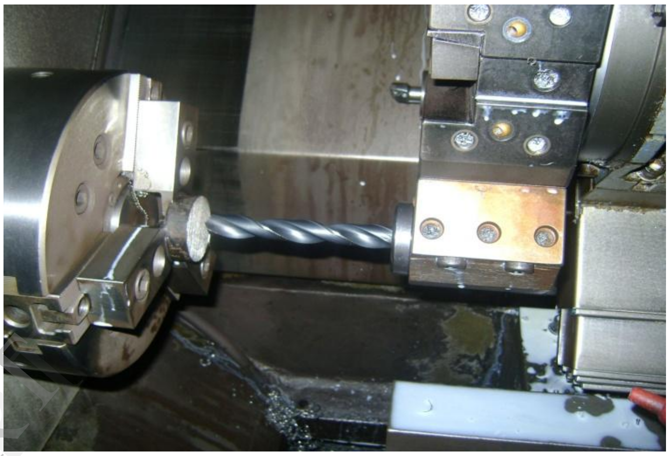

Fig.3 Drilling Operation

3.3. Taguchi Technique

Taguchi technique is a powerful tool for the design of high quality systems. It provides a simple, efficient and systematic approach to optimize design for performance, quality and cost. The methodology is valuable when design parameters are qualitative and discrete.

Table.2 Orthogonal Array

Exp No	Feed (f) (mm/rev)	RPM	Lip Angle (φ)
1	0.06	800	12
2	0.06	1000	13.5
3	0.06	1200	15
4	0.12	800	15
5	0.12	1000	12
6	0.12	1200	13.5
7	0.19	800	13.5
8	0.19	1000	15
9	0.19	1200	12

Taguchi parameter design can optimize the performance characteristics through the setting of design parameters and reduce the sensitivity of the system performance to the source of variation. This technique is multi step process, which follow a certain sequence for the experiments to yield an improved understanding of product or process performance. This design of experiments process made up of three main phases: the planning phase, the conducting phase and analysis interpretation phase. The planning phase is the most important phase; one must give a maximum importance to this phase. The data collected from all the experiments in the set are analyzed to determine the effect of various design parameters. This approach is to use a fractional factorial approach and this may be accomplished with the aid of orthogonal arrays.

Based on the orthogonal array assigned, the experiment is conducted and that the results were tabulated in the table.3

3.4. Data analysis to determine the optimum levels for control factors:

After the experiments have been conducted, the optimal test parameter configuration within the experiment design must be determined. To analyse the results, the Taguchi method uses a statistical measure of performance called signal to noise (S/N) ratio borrowed from electrical control theory.

3.5. Signal to Noise (S/N) ratio

The S/N ratio developed by Dr. Taguchi is a performance measure to choose control levels that best cope with noise. The S/N ratio takes both the mean and the variability into account. In its simplest form, the S/N ratio is the ratio of the mean (signal) to the standard deviation (noise). The S/N equation depends on the criterion for the quality characteristic to be optimized. While there are many different possible S/N ratios, three of them are considered standard and are generally applicable in the situations below;

Biggest-is-best quality characteristic (strength, yield),

Smallest-is-best quality characteristic (Surface Roughness),

Nominal-is-best quality characteristic (dimension).

In this work smaller the better quality characteristic and biggest is best quality were chosen.

Table.3 Experimental results

Ex. no	Feed mm/ rev	Speed rpm	Surface Roughness µm	Drilling time sec	MRR mm^3/ min
1	0.06	800	3.286	65	651
2	0.06	1000	2.751	56	2064
3	0.06	1200	2.283	46	4476
4	0.12	800	3.125	34	9302
5	0.12	1000	2.842	28	24127
6	0.12	1200	2.413	23	8953
7	0.19	800	3.156	22	561
8	0.19	1000	2.456	21	8202
9	0.19	1200	2.413	20	5842

3.6. Main Effect Plots

Main effect plots are graphical representations of change in performance characteristics with the variation in machining parameter level. Figure 4, 5, and 6 shows the response graph for three factors and tree levels. From the graphical representation the peak points are chosen as the optimum levels of machining parameters, such as feed rate, spindle speed and lip clearance angle.

Fig 3 shows the main effect on surface roughness of the work material Fig. 4 shows the main effect on metal removal rate during drilling operation.

Fig. 5 shows the main effect on machining time of the drilling operation.

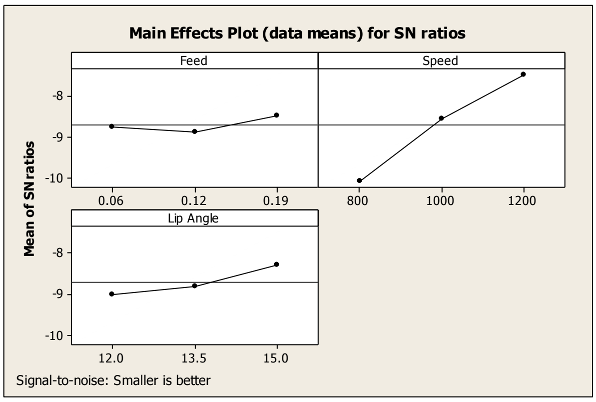

Fig.3 Main effect plots for surface roughness

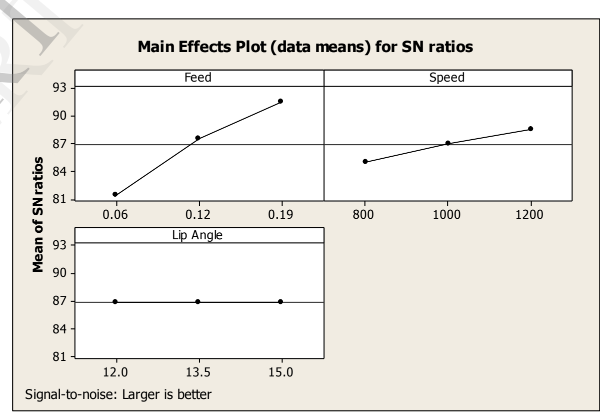

Fig.4.Main effect plots for metal removal rate

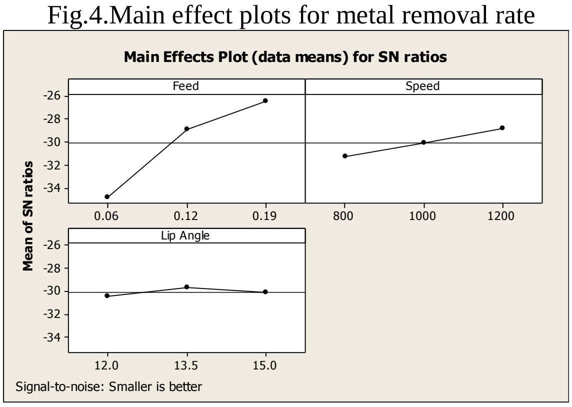

Fig.5.Main effect plots for machining time

From the computation results the optimum set of machining parameters was found as shown in the table.4.

Table.4 Optimum machining parameters for HSS drill

Response	Feed rate (f), mm/rev	Spindle speed (N), rpm	Lip Angle, (φ) Deg
Surface roughness	0.19	1200	15
Metal removal rate	0.19	1200	13.5
Machining time	0.19	1200	13.5

4. Conclusion

The influences of feed rate, spindle speed and lip angle of the drill on machined surface roughness, machining time and metal removal rate in drilling operation was examined. The experiments were performed on EN24 and obtained data has been analyzed using Taguchi techniques.
It was observed that, Taguchi's orthogonal array provides a large amount of information in a small amount of experimentation. All the three parameters are predominantly contributing to the response and all have been considered.
Optimum machining parameter combination was found through Taguchi technique. Results of Taguchi techniques were compared and optimum machining parameter combination setup was suggested for minimum surface roughness, maximum metal removal rate and minimum machining time.

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