Effect of HSS Cutting Tool on Cutting parameters while Drilling of EN19 Steel

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Abstract

The objective of this work is to optimize the cutting parameters in drilling of EN19 steel to achieve Minimum Cutting Forces and Minimum Tool Temperature using HSS as tool materials. Nowadays as HSS is most commonly used tools for manufacturing industries, therefore a comparative study is conducted to study the machining abilities on EN19 material. In the present work Full Factorial Design is considered with three process parameters: Speed, Feed, drill diameter and Depth of Cut. By using the mathematical model the main and interaction effect of various process parameters on Thrust Force and Tool Temperature are studied. The developed model helps in selection of proper machining parameters for the specific material and also helps in achieving the desired multiple responses.

Keywords: Thrust Force, Cutting Torque, Cutting Temperature, Response Surface Methodology.

1.Introduction

The general process of drilling involves in fixing a part while d rotating drill bit moves perpendicular to the workpiece surface. It is used to make holes on the work piece, usually to a specified dimension and to produce smooth surface finish on the hole of the metal. In drilling, the major output characteristics that generally considered are material removal rate, surface roughness, tool life, tool temperature and etc. These performance characteristics were influenced by many factors like material properties, tool geometry, cutting conditions and etc.

Panagiotis Kyratsis. studied Prediction of Cutting Torque and Thrust Force of EN19 work material by employing Taguchi techniques. Results were obtained that the diameter and feed rate were found to be factor of high significance, whie cutting speed did not affect on the force and Torque.

D. Vishnu Vardhan Reddy. investigated Optimization of Cutting parameters in drilling of EN19 applying Taguchi methods and Genetic Algorithm to improve the quality of manufactured goods, and engineering development of designs for studying variation. EN19 steel is used as the work piece material for carrying out the experimentation to optimize the Surface Finish material removal rate and Material Removal Rate. The MRR values measured from the experiments and their optimum value for maximum material removal rate.

Yassmin Seid Ahmed. studied prediction and optimization f drilling parameters in drilling of AISI 304 using Taguchi Optimization Method. The experiments were conducted by varying cutting speeds, feed rates, and depths of cut under. The effect of process parameters with the output variable were predicted which indicates that the highest cutting speed has significant role in producing least surface roughness followed by feed and depth of cut. The resut of this studyshows the workpiece has a shorter tool life, and higher specific cutting energy.

2. Experimentation Details

A medium carbon steel EN19 has been selected as the work piece. The chemical composition and mechanical properties of EN19 steel are given in tables 1 and 2. For the experimentation HSS used and shown in figures 1 and 2.

Table 1. Chemical Composition of EN19 Steel

C	Si	S	Mn	P	Mo	Cr	Ni
0.35-0.44	0.10-0.35	0.050	0.50-0.80	0.035	0.20-0.40	1.00-1.40	1.30-1.70

Table 2. Mechanical Properties of EN19 Steel

Parameters	**Values**
Maximum Stress	775-1075 N/mm^2
Yield Stress	555-755 N/mm^2
Hardness	241-285 BHN
Density	7.850 kg/cm^3

Figure 1. HSS Tools with different Diameters

3. Design of Experiments

Design of experiments is an experimental or analytical method that is commonly used to statistically signify the relationship between input parameters to output responses. DOE has wide applications especially in the field of science and engineering for the purpose of process optimization and development, process management and validation tests. DOE is essentially an experimental based modelling and is a designed experimental approach which is far superior to unplanned approach whereby a systematic way will be used to plan the experiment, collect and analyze the data. A mathematical model has been developed by Response Surface Methodology(RSM). Optimization and Desirability functions helps to optimize the quality characteristics considered in a DOE under a cost effective process. For the present work, three process parameters of spindle speed, feed and depth of cut at three different levels has been considered as given in table 3 and the suitable orthogonal array L27 given is used for the experimentation.

Table 3. Process Variables and their Limits

Values in coded form	Spindle speed(N) ‘rpm’	Feed(F) ‘mm/rev’	Drill Dia(D) ‘mm’
-1	112	0.13	8
0	180	0.21	10
1	280	0.33	12

4. Results and Discussions

a. Response Surface Methodology

Response Surface Methodology(RSM) explores the relationships between several explanatory variables and one or more response variables. The method was introduced by George E. P. Box and K. B. Wilson in 1951. The main idea of RSM is to use a sequence of designed experiments to obtain an optimal response. Box and Wilson suggest using a second-degree polynomial model to do this. They acknowledge that this model is only an approximation, but they use it because such a model is easy to estimate and apply, even when little is known about the process.Statistical approaches such as RSM can be employed to maximize the production of a special substance by optimization of operational factors.

b. Mathematical Model of Response Surface Methodology

A second-order polynomial is employed for developing the mathematical model for predicting weld pool geometry. If the response is well modelled by a linear function of the independent variables then the approximating function is the first order model as shown in Equation.

$$Y= \beta + \beta_1 x_1 + \beta_2 x_2 + ...\beta_x x_x + \epsilon$$

c. Mathematical Relationship between the Input Parameters and Tool Temperature by using HSS as a Tool

The mathematical relationship for correlating the Tool Temperature and the considered process variables has been obtained as follows:

Temp = -37 + 0.710 speed + 438 feed - 11.0 dia - 0.001074 speed*speed
- 892 feed*feed+ 0.47 dia*dia - 0.871 speed*feed + 0.0023 speed*dia
+ 21.8 feed*dia.

Table 4. Comparison of predicted and experimental values of Tool Temperature

S.No.	Temp (pred.)	Temp (exp.)	% error
1	24.45	36.40	11.95
2	25.51	52.0	26.49
3	30.33	54.0	23.67
4	41.33	39.40	-1.93
5	45.87	58.00	12.13
6	54.17	69.00	14.83
7	45.23	41.00	-4.23
8	55.00	60.00	5.00
9	68.51	76.00	7.49
10	44.95	47.00	2.05
11	46.33	59.00	12.67
12	51.46	69.00	17.54
13	57.09	48.00	-9.09
14	61.95	64.00	2.05
15	70.56	75.00	4.44
16	53.88	51.00	-2.88
17	63.97	55.00	-8.97
18	77.80	60.00	-17.80
19	53.50	53.50	-3.56
20	60.00	60.00	1.10
21	68.00	68.00	3.50

22	62.33	58.00	-4.23
23	67.56	60.00	-7.56
24	76.64	66.00	-10.64
25	4857	60.50	11.93
26	59.12	63.00	3.88
27	73.42	79.00	5.88

i. Various graphs for Temperature

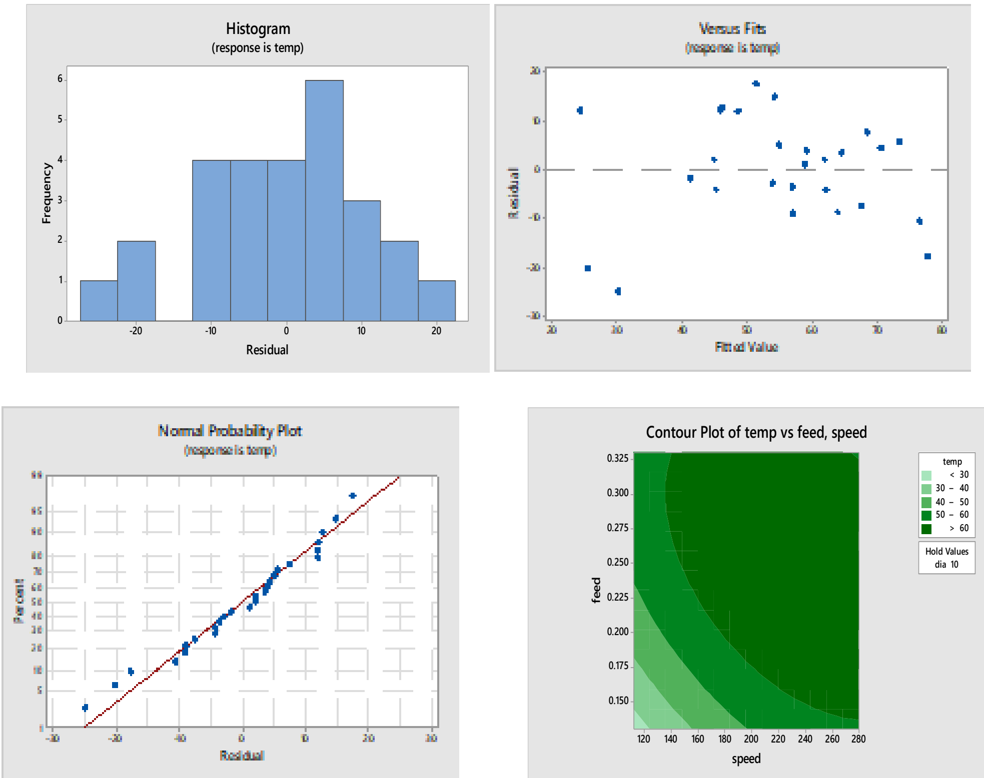

Figure 2. Various graphs for Temperature

d. Mathematical Relationship between the Input Parameters and Force in Thrust Force by using HSS as a Tool

The mathematical relationship for correlating the Thrust force and the considered process variables has been obtained as follows:

Thrust, F = 204.6 - 0.626 speed - 212 feed - 24.6 dia
+ 0.000337 speed*speed - 62 feed*feed+ 0.736 dia*dia - 0.023 speed*feed
+ 0.0477 speed*dia + 36.4 feed*dia

Table 5. Comparison of predicted and experimental values of F

S.No.	F (pred.)	F (exp.)	% error
1	40.32	38	-2.32
2	37.68	33	-4.68
3	40.93	51	10.07
4	44.74	42	-2.75
5	47.94	54	6.06
6	57.01	60	2.99
7	49.90	44	-5.90
8	61.83	66	4.17
9	79.64	72	-7.64
10	30.20	33	2.80
11	34.05	31	-3.05
12	43.29	40	-3.79
13	34.50	38	3.50
14	44.18	40	-4.18

15	59.75	48	-11.75
16	39.46	42	2.54
17	57.88	75	17.12
18	82.18	79	-3.18
19	20.98	22	1.02
20	34.38	38	3.62
21	53.67	50	-3.67
22	25.10	27	1.90
23	44.32	39	-5.32
24	69.44	79	9.56
25	29.78	29	-0.98
26	44.32	44	-13.74
27	69.44	99	7.41

4.41 Various graphs for Thrust Force

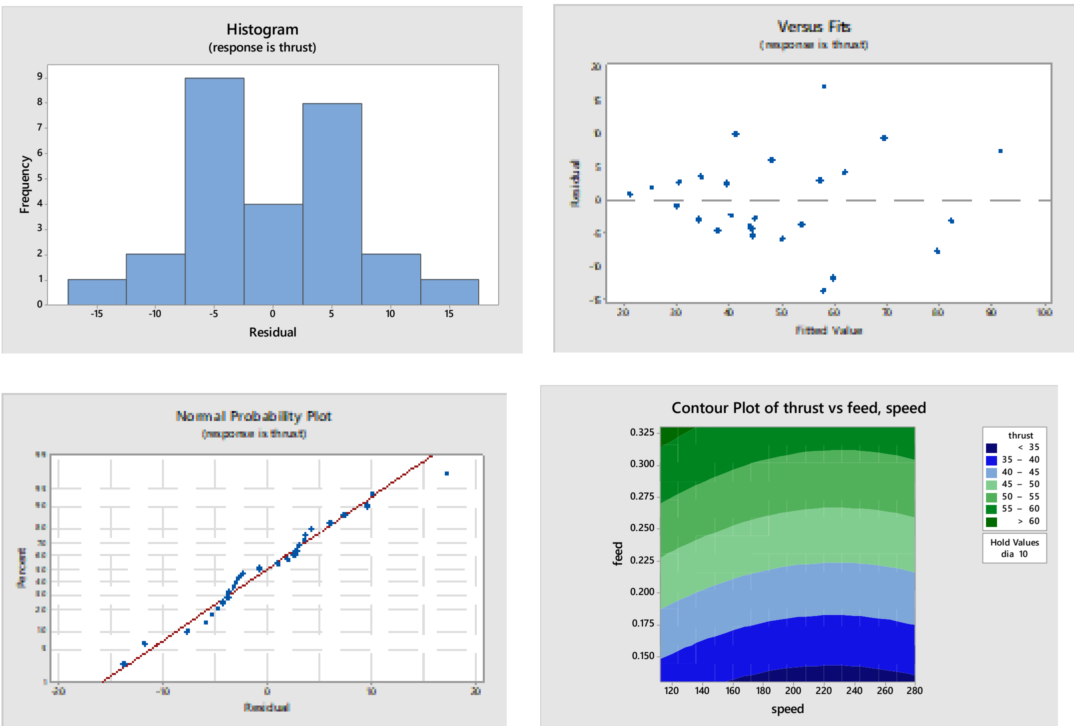

Figure 3. Various graphs for F

Conclusion

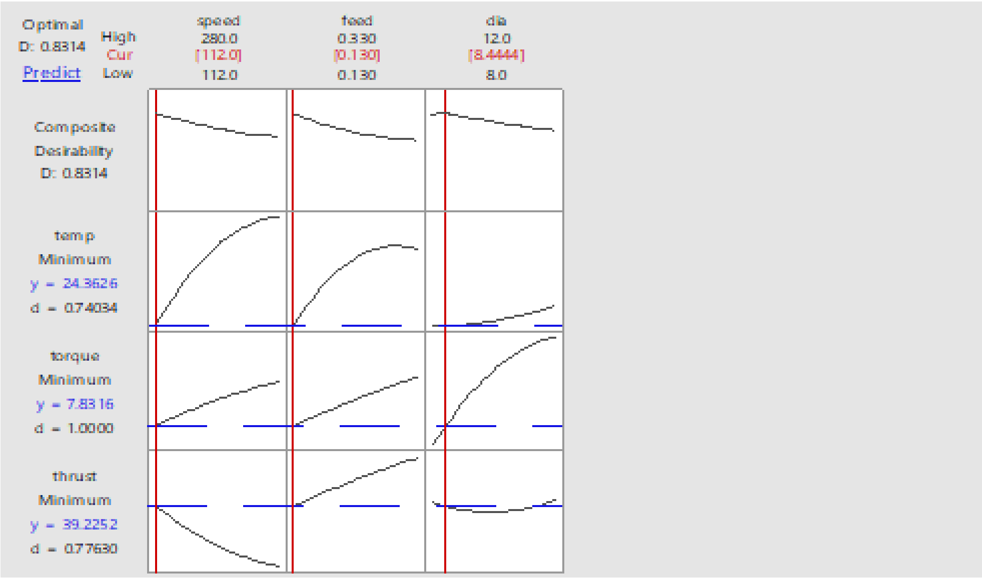

Figure 4. HSS Optimization Plot

- This paper produces a direct equation with the combination of controlled parameters which can be used in industries to know the values of Thrust Force and cutting tool temperature.
- The optimal solution for Thrust Force is 39.2252 N and temperature 24.3636°C will be obtained when the EN19 work piece is machined at speed 112rm, feed 0.13(mm/rev) and depth of drill diameter 8.44(mm) using **HSS** as a tool for drilling.

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