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EXPERIMENTAL ANALYSIS AND GEOMETRICAL EFFECT ON MILD STEEL WITH UNCOATED AND COATED HSS DRILL BITS USING TAGUCHI TECHNIQUE

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Abstract - *The main aim of this project work is to utilize Taguchi technique, to analyze the impact of drilling process parameters such as speed, feed rate and depth of cut on the mild steel with uncoated and coated HSS drill bits and obtain the optimal values for the process parameters. In this work, a HSS uncoated drill bit and a Tungsten Carbide powder coated drill bits are used for the purpose of machining the mild steel work pieces in dry conditions. The reasons to coat drill bit in a production situation is to increase tool life, to improve the surface quality of the product, and to increase the production rate. The advantages of tungsten carbide coating include high hardness, excellent lubrication and tough resistance to wear, corrosion and temperature. The experimental work is carried out on the CNC milling machine. The results of surface roughness, hole diameter and material removal rate values for both uncoated drilling and coated drilling are collected after the machining processes. Finally, the values are analyzed using MINITAB-17 software.*

***Key Words*: Taguchi technique, uncoated drill bit, coated drill bit, optimal values, process parameters.**

1. INTRODUCTION

The vital goal within the trendy industries is to manufacture the products with lower price and with prime quality in brief span of time. There are two main sensible issues that engineers face in a manufacturing process. The primary is to work out the values of process parameters that may yield the required product quality (meet technical specifications) and therefore the second is to maximize manufacturing system performance by using the available market resources. Drilling operation is widely utilized in the aerospace, aircraft and automotive industries, though trendy metal cutting methods have improved within the manufacturing industries, however typical drilling still remains one amongst the foremost common machining. The experiment was carried out on the idea of Taguchi's L9 orthogonal array of experiments. The vital input drilling parameters were chosen as spindle speed, depth of cut and feed rate specifically. So as to attenuate the values of all the above mentioned performance characteristics, an optimum combination of input drilling parameters is needed. Taguchi optimization technique is employed for optimization of drilling parameters and Analysis of Variance is employed to search out the extremely powerful drilling parameter(s) that contributes to a prime quality product.

1.1 Drilling process

Making of hole is among the foremost vital operations in any manufacturing industry. Drilling could be a major and customary of hole making method. Drilling is the cutting method of employing a drill bit to cut or enlarge holes in solid materials like wood and metal. Totally different tools and strategies or methods are used for drilling depending on the sort of material, the scale of the hole, the number of holes, and therefore the time to finish the operation. It is often performed in material removal and is employed as a preliminary step for several operations, like reaming, tapping and boring. The cutting method with which a hole is originated or enlarged with the help of a multipoint, fluted, end cutting tool because the drill is rotated and advanced into the work piece, then material is removed in the form of chips that move on the fluted shank of the drill. Figure 1 shows the drilling operation on to the work piece.

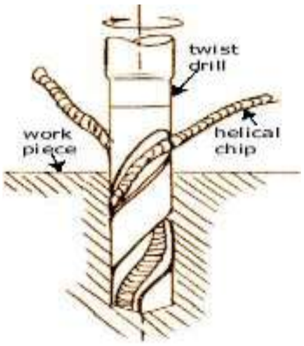

Fig-1: drilling operation on the work piece

Although long spiral chips typically result from drilling, adjustment of the feed rate may end up in chips with a variety of total different shapes and sizes. Material of the work piece can also vary the chip shapes and sizes. Usually, the diameter of the holes that are made by the drilling operation is slightly larger than the drill diameter (oversize). The number of drilled holes diameter depends on the standard of the drill and additionally the equipment used by the machinist.

1.2 Drill Geometric Attributes

Drill bits are unit cutting tools accustomed to produce cylindrical holes. Bits are held in a tool referred to as a drill tool that rotates them and provides force and axial force to form the hole completely. Different purpose angle drills, different diameter drills and various lengths of drills are often used in line with the application of work. Drills with no purpose point angle are employed in things wherever a blind, flat-bottomed hole is needed. These drills are terribly sensitive to changes in lip angles associated in nursing even a small modification may end up in a not suitably quick cutting drilling bit which will suffer premature wear. Usually, twist drill bit diameters ranges from 0.15 to 75mm. Body, point, and shank are 3 basic elements of drill bit. Twist drill bit has 2 spiral or helical grooves referred to as flutes separated by Lands. Angle of spiral flute is termed because the angle around is 30°. Flutes helps for extraction of material from the hole. Web is the thickness of the drill bit between the flutes and it supports the drill support over its length. The spiral, or rate of twist within the drill, controls the speed of chip removal in every drill. A quick spiral drill is used in high feed rate applications under low spindle speeds.

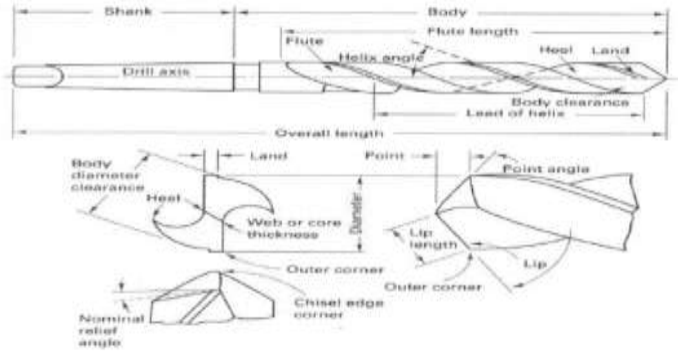

Fig-2: Nomenclatures and Geometry of Twist Drills

2. LITERATURE REVIEW

Ulaş Çaydaş [1], performed on HSS, K20 solid carbide, and TiN-coated HSS tools in dry drilling of AISI 304 austenitic stainless steel. The roles of spindle speed, feed rate, drill point angle, and number of holes on the surface roughness, tool flank wear, exit burr height, and enlargement of the hole size were experimentally investigated. The structure of this analysis has been determined by means of the technique called the design of experiments (DOE), which allows us to perform a relatively small number of experiments. An L9 orthogonal array was used to collect the experimental data. The experimental results demonstrated that the above mentioned drilling performances showed a tendency to increase in response to the cutting parameters. TiN coated HSS drill showed the highest performance with longer tool life and higher hole quality, as well as lower surface roughness, followed by the K20 carbide and the HSS tools.

V Balakumaran [2], investigated through the method and methodology of the Modified Taguchi optimization method for simultaneous minimization and maximization of Surface roughness (Ra), machining time and material removal rate of EN31 Alloy steel affect the aesthetical aspect of the final product and hence it is essential to select the best combination values of the CNC drilling process parameters to minimize as well as maximize the responses. The experiments were carried out by a CNC lathe, using physical vapor deposition coated Chromium nitride drilling tool bit for the machining of EN19. The experiments were carried out as per L9 orthogonal array with each experiment performed under different conditions of such as speed, type of drilling tool, and feed rate. The Taguchi method and analysis of variance (ANOVA) was employed by using MINITAB-15 software to identify the level of importance of the machining parameters on Surface roughness (Ra), Machining time and Material Removal Rate (MRR).

3. EXPERIMENTAL WORK

Drilling is a versatile machining process which creates holes with the utilization of multi-edged cutting edges by removing material from the surface of a work piece. Drilling could be a difficult method and lots of factors have an impact on the standard of the machined surface. During this study, drilling is performed on mild steel. The drilling is conducted on a CNC milling machine that produces a hole at a rate of spindle speed, feed and hole-depth in the absence of cutting fluid. Cutting fluid is employed to lubricate the machined surface and to decrease heat from the tool and the work piece. Therefore, three cutting parameters, i.e., speed, feed, and depth of cut are considered for drilling operation. As, the purpose of drilling operation is to provide minimum surface roughness of machined surface and minimum geometrical error, the optimization of the process parameters will be required.

3.1 Work material details

Work material – Mild steel

Work material size – 100*100*10 mm

3.1.1 Chemical properties

C	Fe	Mn	p	S
0.14-0.20%	98.81-99.26%	0.60 - 0.90 %	≤ 0.040 %	≤ 0.050 %

Table-1: Chemical properties of mild steel

4. EXPERIMENTAL PLAN

The proposed work approach and methodology has been elaborately shown in the flow chart below.

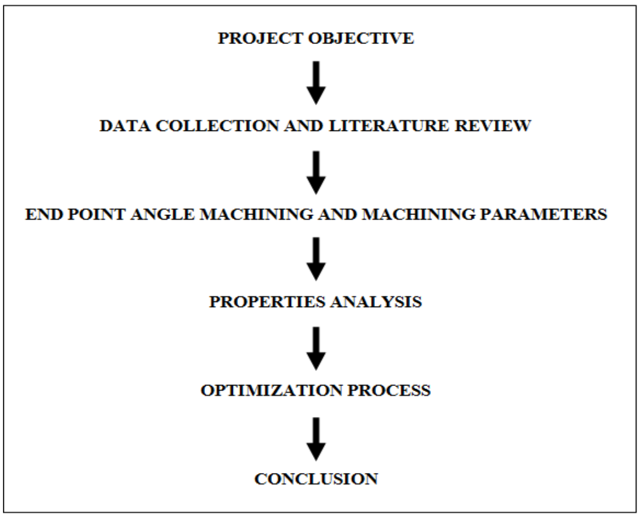

Fig-3: Experimental Plan

5. TAGUCHI APPROACH

Basically, experimental design methods were developed by Ronald Fisher. But these experimental design methods are too complicated and not easy to use. Furthermore, a range of experiments need to be carried out once the amount of the process parameters increases. To unravel this downside, the Taguchi methodology uses a special design of orthogonal arrays to study the whole parameter area with a little range of experiments solely. The experimental results are then changed into a signal– to – noise (S/N) ratio to live the standard characteristics deviating from the specified values. The S/N ratio for each level of process parameter is compared based on the S/N analysis. In spite of the class of the standard characteristic, a larger S/N ratio corresponds to raised quality characteristics. Therefore, the best level of the process parameters are that the level with the best S/N ratio. Furthermore, a statistically important S/N and ANOVA analyses are the best combination to expect the optimal values of the process parameters. There are three signal/noise ratios of common interest for optimization of Static issues. The formulae for signal to noise ratio are designed so that an experimenter will perpetually choose the most important issue level setting to optimize the standard characteristic of an experiment. So a method of calculating the ratio is chosen for quality characteristic.

They are:

1. Smaller- The- Better
2. Larger- The- Better
3. Nominal- The- Best

5.1 Design of experiment

Table-2: Process parameters and their levels

LEVELS	PROCESS PARAMETERS		
	SPEED (RPM)	FEED (mm/rev)	DOC (mm)
1	400	0.1	0.15
2	400	0.2	0.25
3	400	0.3	0.35
4	500	0.1	0.25
5	500	0.2	0.35
6	500	0.3	0.15
7	600	0.1	0.35
8	600	0.2	0.15
9	600	0.3	0.25

5.1.1 An orthogonal array L_9 formation (interaction)

Table-3: An orthogonal array L_9 formation (interaction)

TRIAL NO.	(A)SPEED (*N*), (rpm)	(B)FEED (*f*), (mm/rev)	(C)DEPTH OF CUT (DOC), (mm)
1	400	0.1	0.15
2	400	0.2	0.25
3	400	0.3	0.35
4	500	0.1	0.25
5	500	0.2	0.35
6	500	0.3	0.15
7	600	0.1	0.35
8	600	0.2	0.15
9	600	0.3	0.25

6. EXPERIMENTAL DATA

6.1 Surface roughness values

Table-4: Data of surface roughness

TRIAL NO.	SURFACE ROUGHNESS, microns	
	UNCOATED	COATED
1	3.911	3.396
2	6.760	6.753
3	5.154	5.074
4	6.307	5.017
5	4.781	3.192
6	6.759	5.584
7	5.209	2.639
8	4.948	2.521
9	5.992	3.212

6.1.1 Surface roughness graph

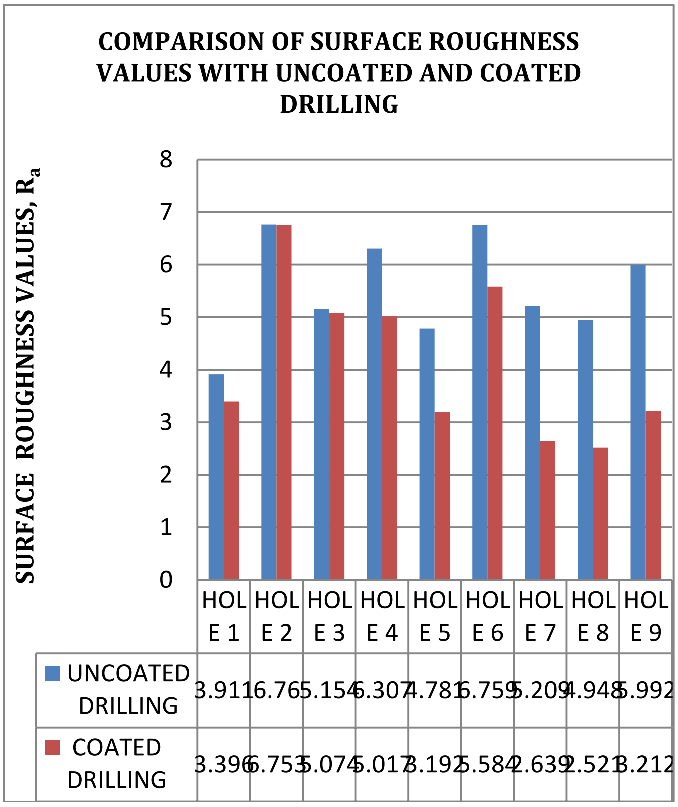

Chart-1: Comparison of surface roughness values

6.2 Hole diameter values

Table-5: Data of hole diameter

TRIAL NO.	HOLE DIAMETER, mm	
	UNCOATED	COATED
1	9.1334	8.6667
2	9.8000	9.7667
3	9.5667	9.1667
4	9.6334	9.2667
5	9.8000	9.3334
6	9.6667	9.5667
7	9.8000	9.5334
8	9.7667	9.6000
9	9.6334	9.5334

6.2.1 Hole diameter Graph

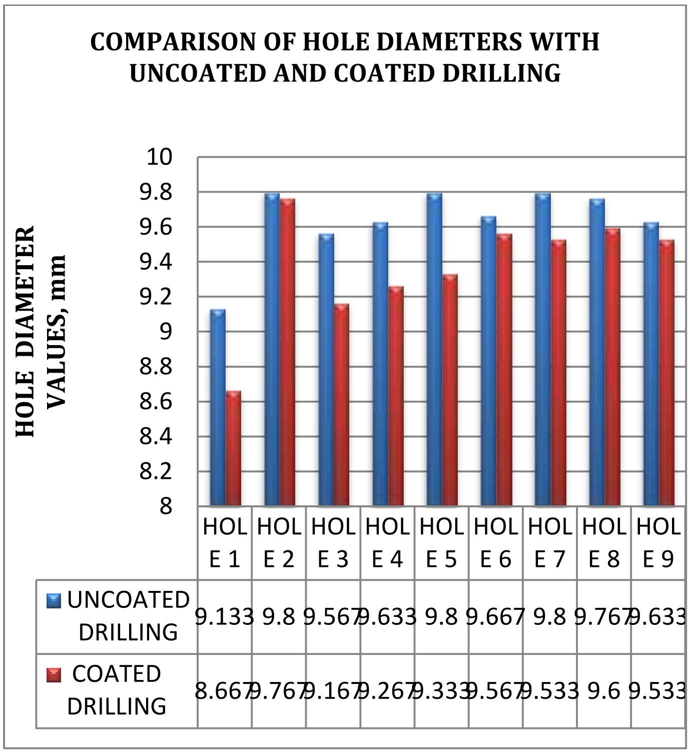

Chart-2: Comparison of hole diameter values

6.3 Material removal rate values

Table-6: Data of Material removal rate

TRIAL NO.	MRR, (mm³/rev)	
	UNCOATED	**COATED**
1	2010.6193	2138.2465
2	4021.2386	4276.4929
3	6031.8579	6414.7395
4	2513.2742	2672.8082
5	5026.5483	5345.6163
6	7539.8224	8018.4244
7	3015.9289	3207.3698
8	6031.8579	6414.7395
9	9047.7869	9622.1093

6.3.1 Material removal rate graph

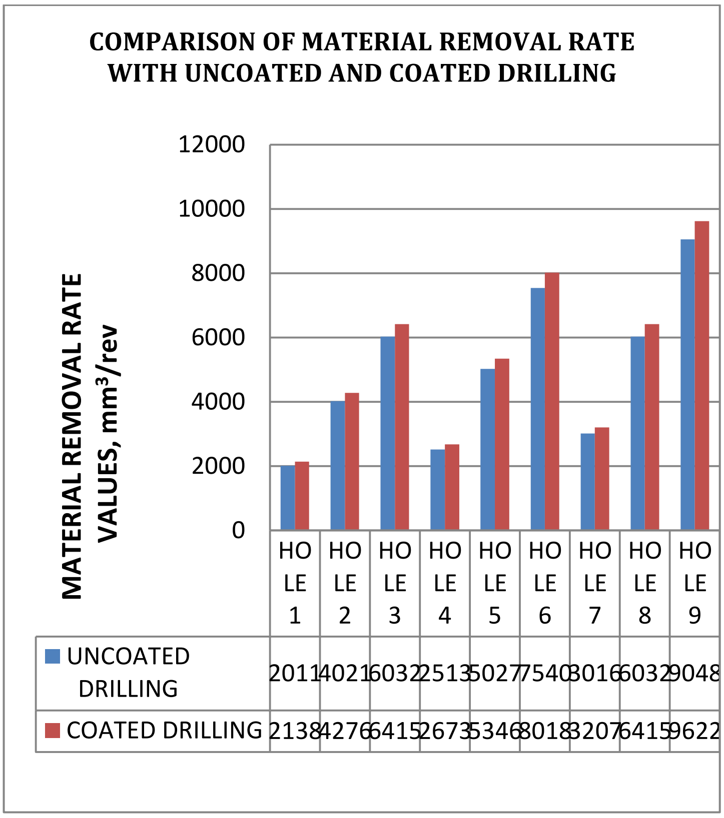

Chart-3: Comparison of MRR values

7. EXPERIMENTAL ANALYSIS

7.1 Analysis of results for surface roughness of uncoated drilling

Table-7: Surface Roughness and S/N Ratios Values for the Experiments

S.NO	SPEED	FEED	DOC	RA UNCOATED	SNRATIO
1	400	0.1	0.15	3.911	-11.8458
2	400	0.2	0.25	6.760	-16.5989
3	400	0.3	0.35	5.154	-14.2429
4	500	0.1	0.25	6.307	-15.9965
5	500	0.2	0.35	4.781	-13.5904
6	500	0.3	0.15	6.759	-16.5976
7	600	0.1	0.35	5.209	-14.3351
8	600	0.2	0.15	4.948	-13.8886
9	600	0.3	0.25	5.992	-15.5514

7.1.1 Taguchi Analysis: UNCOATED Ra versus SPEED, FEED, DOC

Table-8: ROUGHNESS RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER

Level	SPEED	FEED	DOC
1	-14.23	-14.06	-14.11
2	-15.39	-14.69	-16.05
3	-14.59	-15.46	-14.06
Delta	1.17	1.40	1.99
Rank	3	2	1

7.1.2 Main Effects Plot for SN ratios for Ra uncoated drilling

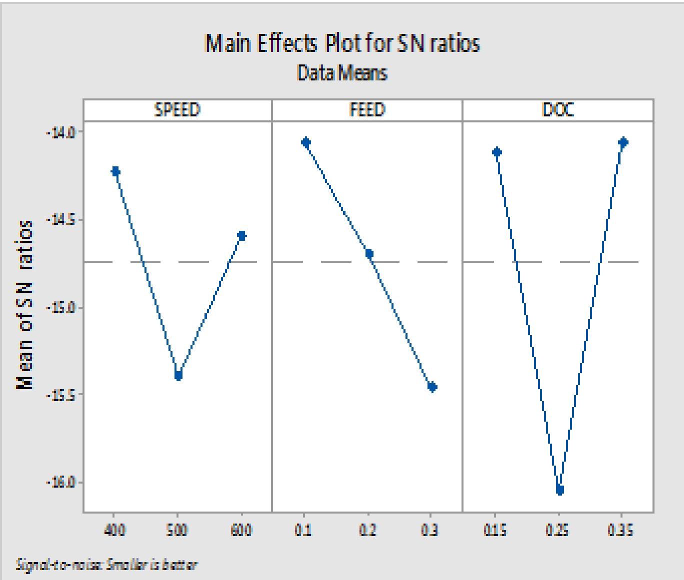

Chart-4: Main effects plot for SN ratios for Ra of uncoated drilling

7.1.3 General Linear Model: UNCOATED RA versus TON, TOFF, CURR

Table-9: Factor Information

FACTOR	TYPE	LEVELS	VALUES
Speed	FIXED	3	400,500,600
Feed	FIXED	3	0.1,0.2,0.3
Doc	FIXED	3	0.15,0.25,0.35

7.1.4 Analysis of Variance for Ra of uncoated drilling

Table-10: ANOVA for Ra of uncoated drilling

SOURCE	DF	ADJ SS	F VALUE	P VALUE	% of contribution
Speed	2	0.7863	0.29	0.777	10.34
Feed	2	1.0304	0.38	0.727	13.55
Doc	2	3.0436	1.11	0.474	40.02
ERROR	2	2.7453			36.10
TOTAL	8				100.00

7.1.5 Residual plots for Ra of uncoated drilling

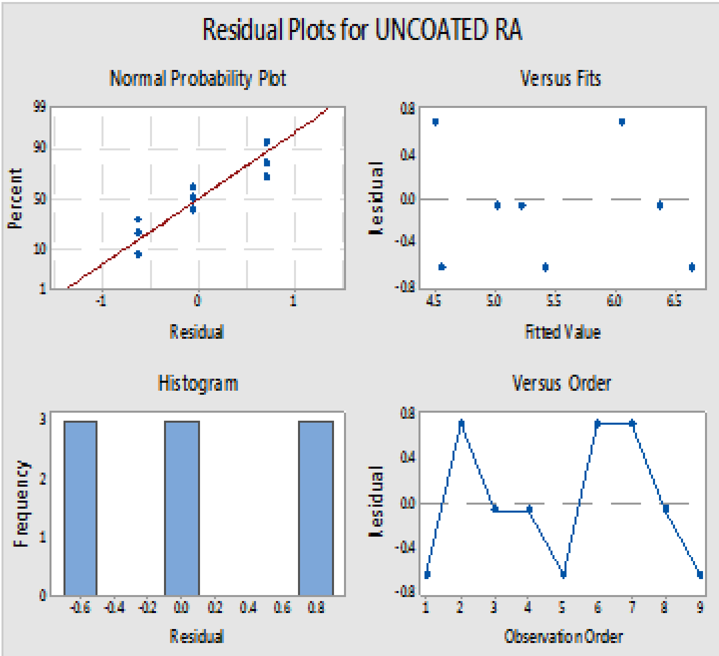

Chart-5: Residual plots for surface roughness of uncoated drilling

7.2 Analysis of results for Ra of coated drilling

Table-11: Surface Roughness and S/N Ratios Values for the Experiments

S.NO	SPEED	FEED	DOC	RA COATED	SNRATIO
1	400	0.1	0.15	3.396	-10.6194
2	400	0.2	0.25	6.753	-16.5899
3	400	0.3	0.35	5.074	-14.1070
4	500	0.1	0.25	5.017	-14.0089
5	500	0.2	0.35	3.192	-10.0813

6	500	0.3	0.15	5.584	-14.9389
7	600	0.1	0.35	2.639	-8.4288
8	600	0.2	0.15	2.521	-8.0315
9	600	0.3	0.25	3.212	-10.1355

7.2.1 Taguchi Analysis: COATED Ra versus SPEED, FEED, DOC

Table-12: ROUGHNESS RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER

Level	SPEED	FEED	DOC
1	-13.772	-11.019	-11.197
2	-13.010	-11.568	-13.578
3	-8.865	-13.060	-10.872
Delta	4.907	2.041	2.706
Rank	1	3	2

7.2.2 Main Effects Plot for SN ratios for Ra coated drilling:

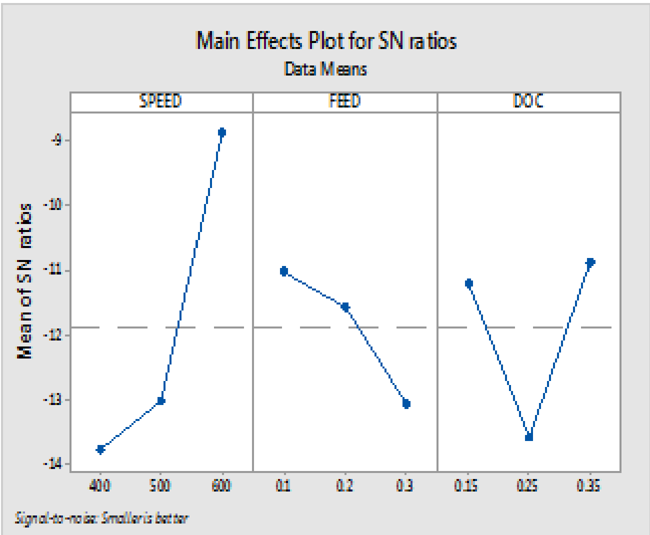

Chart-6: Main effects plot for SN ratios for Ra of coated drilling

7.2.3 General Linear Model: Coated RA versus TON, TOFF, CURR

Table-13: Factor Information

FACTOR	TYPE	LEVELS	VALUES
Speed	FIXED	3	400,500,600
Feed	FIXED	3	0.1,0.2,0.3
Doc	FIXED	3	0.15,0.25,0.35

7.2.4 Analysis of variance for RA of coated drilling

Table-14: ANOVA for Ra of coated drilling

SOURCE	DF	ADJ SS	F VALUE	P VALUE	% of contribution
Speed	2	8.708	1.95	0.340	49.08
Feed	2	1.324	0.30	0.772	7.46
Doc	2	3.233	0.72	0.581	18.22
ERROR	2	4.476			25.23
TOTAL	8				100.00

7.2.5 Residual plots for Ra of coated drilling

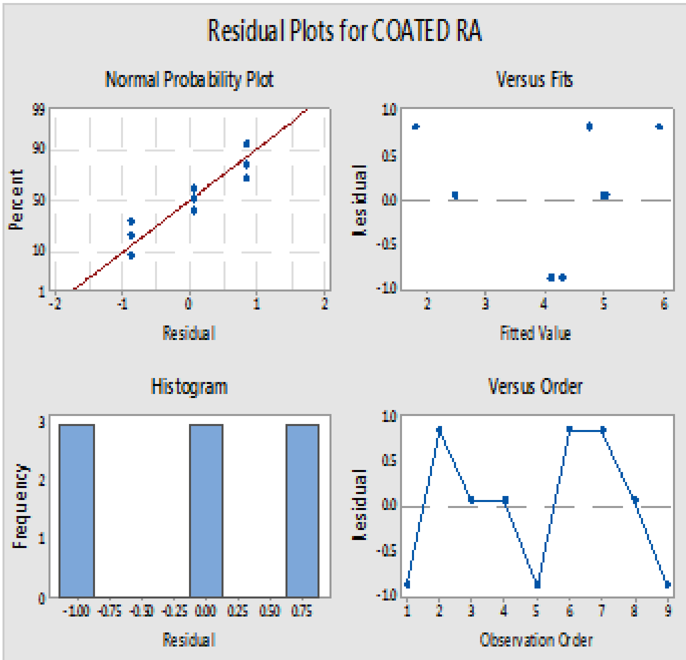

Chart-7: Residual plots for Ra of coated drilling

7.3 Analysis of results for hole diameter of uncoated drilling

Table-15: Hole diameter and S/N Ratios Values for the Experiments

S.NO	SPEED	FEED	DOC	UNCOATED HOLE DIA	SNRATIO
1	400	0.1	0.15	9.1334	-19.2126
2	400	0.2	0.25	9.8000	-19.8245
3	400	0.3	0.35	9.5667	-19.6152
4	500	0.1	0.25	9.6334	-19.6756
5	500	0.2	0.35	9.8000	-19.8245
6	500	0.3	0.15	9.6667	-19.7056
7	600	0.1	0.35	9.8000	-19.8245

8	600	0.2	0.15	9.7667	-19.7950
9	600	0.3	0.25	9.6334	-19.6756

7.3.1 Taguchi Analysis: uncoated hole dia versus SPEED, FEED, DOC

Table-16: UNCOATED HOLE DIAMETER RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER

Level	SPEED	FEED	DOC
1	-19.55	-19.57	-19.57
2	-19.74	-19.81	-19.73
3	-19.77	-19.67	-19.75
Delta	0.21	0.24	0.18
Rank	2	1	3

7.3.2 Main Effects Plot for SN ratios for hole diameter of uncoated drilling:

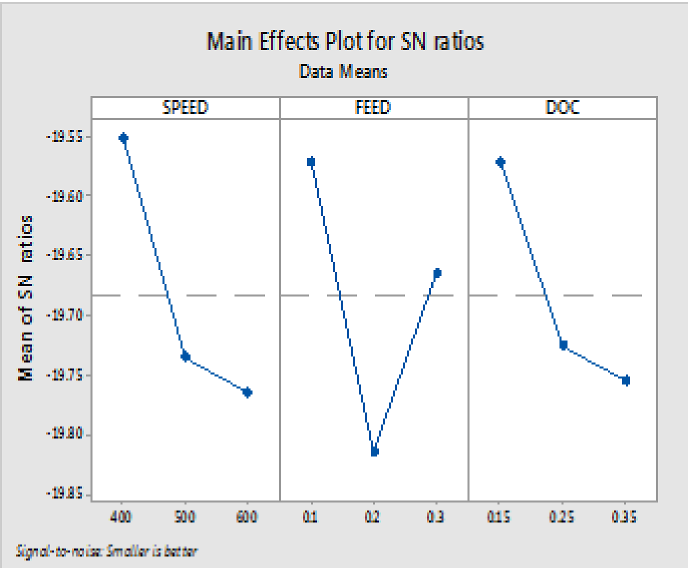

Chart-8: Main effects plot for SN ratios for hole diameter of uncoated drilling

7.3.3 General Linear Model: uncoated hole dia versus SPEED, FEED, DOC

Table-17: Factor Information

FACTOR	TYPE	LEVELS	VALUES
Speed	FIXED	3	400,500,600
Feed	FIXED	3	0.1,0.2,0.3
Doc	FIXED	3	0.15,0.25,0.35

7.3.4 Analysis of Variance for HOLE DIA of uncoated drilling:

Table-18: ANOVA for hole diameter of uncoated drilling

SOURCE	DF	ADJ SS	F VALUE	P VALUE	% of contribution
Speed	2	0.09556	1.16	0.462	26.88
Feed	2	0.10886	1.32	0.430	30.62
Doc	2	0.06887	0.84	0.544	19.37
ERROR	2	0.08220			23.12
TOTAL	8				100.00

7.3.5 Residual plots for hole diameter of uncoated drilling

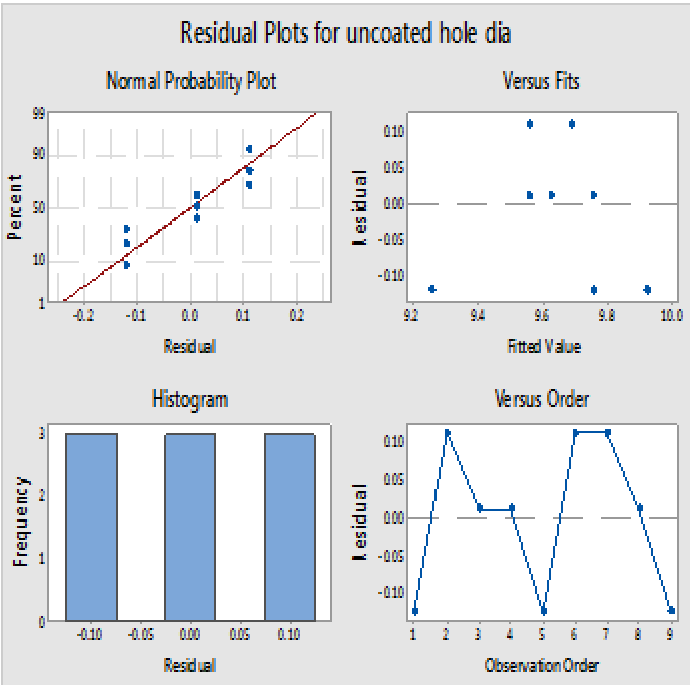

Chart-9: Residual plots for hole diameter of uncoated drilling

7.4 Analysis of results for hole diameter of coated drilling

Table-19: Hole diameter and S/N Ratios Values for the Experiments

S.NO	SPEED	FEED	DOC	COATED HOLE DIA	SNRATIO
1	400	0.1	0.15	8.6667	-18.7571
2	400	0.2	0.25	9.7667	-19.7950

3	400	0.3	0.35	9.1667	-19.2443
4	500	0.1	0.25	9.2667	-19.3385
5	500	0.2	0.35	9.3334	-19.4008
6	500	0.3	0.15	9.5667	-19.6152
7	600	0.1	0.35	9.5334	-19.5850
8	600	0.2	0.15	9.6	-19.6454
9	600	0.3	0.25	9.5334	-19.5850

7.4.1 Taguchi Analysis: coated hole dia versus SPEED, FEED, DOC

Table-20: COATED HOLE DIAMETER RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER

Level	SPEED	FEED	DOC
1	-19.27	-19.23	-19.34
2	-19.45	-19.61	-19.57
3	-19.61	-19.48	-19.41
Delta	0.34	0.39	0.23
Rank	2	1	3

7.4.2 Main Effects Plot for SN ratios for hole diameter of coated drilling:

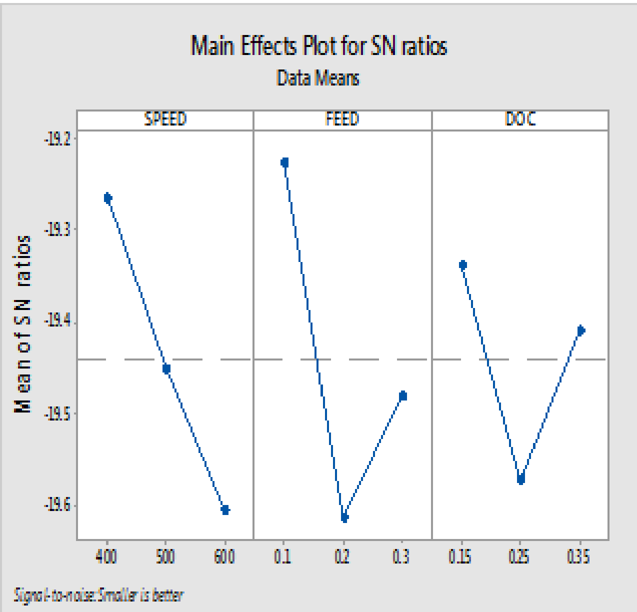

Chart-10: Main effects plot for SN ratios for hole diameter of coated drilling

7.4.3 General Linear Model: coated hole diameter versus SPEED, FEED, DOC

Table-21: Factor Information

FACTOR	TYPE	LEVELS	VALUES
Speed	FIXED	3	400,500,600
Feed	FIXED	3	0.1,0.2,0.3
Doc	FIXED	3	0.15,0.25,0.35

7.4.4 Analysis of Variance for hole diameter of coated drilling

Table-22: ANOVA for hole diameter of coated drilling

SOURCE	DF	ADJ SS	F VALUE	P VALUE	% of contribution
Speed	2	0.18989	0.63	0.614	22.36
Feed	2	0.26098	0.86	0.537	30.73
Doc	2	0.09581	0.32	0.759	11.28
ERROR	2	0.30246			35.62
TOTAL	8				100.00

7.4.5 Residual plots for hole diameter of coated drilling

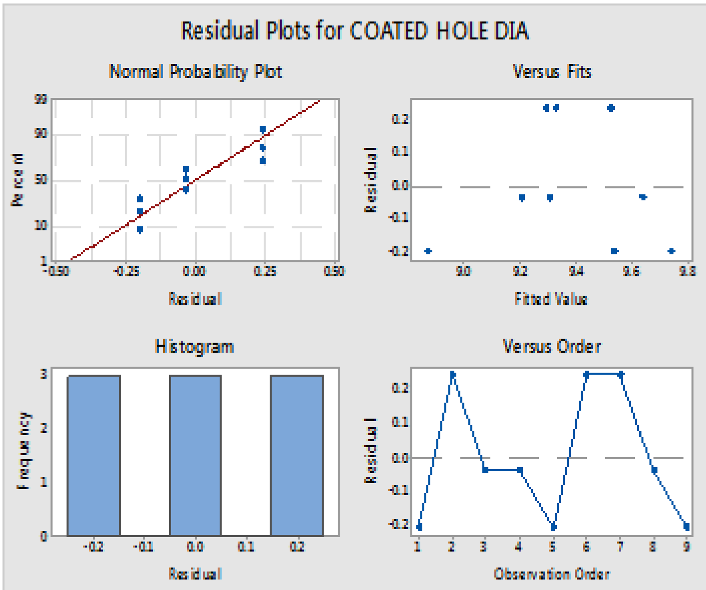

Chart-11: Residual plots for hole diameter of coated drilling

7.5 Analysis of results for MRR of uncoated drilling

Table-23: UNCOATED MRR and S/N Ratios Values for the Experiments

S.NO	SPEED	FEED	DOC	UNCOATED MRR	SNRATIO
1	400	0.1	0.15	2010.6193	66.0666
2	400	0.2	0.25	4021.2386	72.0872
3	400	0.3	0.35	6031.8579	75.6090
4	500	0.1	0.25	2513.2742	68.0048
5	500	0.2	0.35	5026.5483	74.0254
6	500	0.3	0.15	7539.8224	77.5472
7	600	0.1	0.35	3015.9289	69.5884
8	600	0.2	0.15	6031.8579	75.6090
9	600	0.3	0.25	9047.7869	79.1308

7.5.1 Taguchi Analysis: UNCOATED MRR versus SPEED, FEED, DOC

Table-24: UNCOATED MRR RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER

Level	SPEED	FEED	DOC
1	71.25	67.89	73.07
2	73.19	73.91	73.07
3	74.78	77.43	73.07
Delta	3.52	9.54	0.00
Rank	2	1	3

7.5.2 Main Effects Plot for SN ratios for MRR of uncoated drilling:

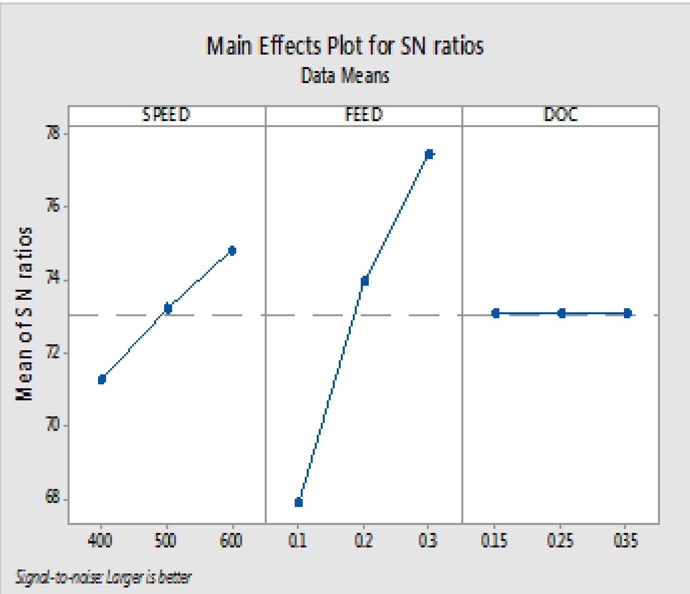

Chart-12: Main effects plot for SN ratios for MRR of uncoated drilling

7.5.3 General Linear Model: uncoated MRR versus SPEED, FEED, DOC

Table-25: Factor Information

FACTOR	TYPE	LEVELS	VALUES
Speed	FIXED	3	400,500,600
Feed	FIXED	3	0.1,0.2,0.3
Doc	FIXED	3	0.15,0.25,0.35

7.5.4 Analysis of Variance for MRR of uncoated drilling

Table-26: ANOVA for MRR of uncoated drilling

SOURCE	DF	ADJ SS	F VALUE	P VALUE	% of contribution
Speed	2	6063885	12.00	0.077	13.48
Feed	2	37899281	75.00	0.013	84.27
Doc	2	505324	1.00	0.500	1.12
ERROR	2	505324			1.12
TOTAL	8				100.00

7.5.5 Residual plots for MRR of uncoated drilling

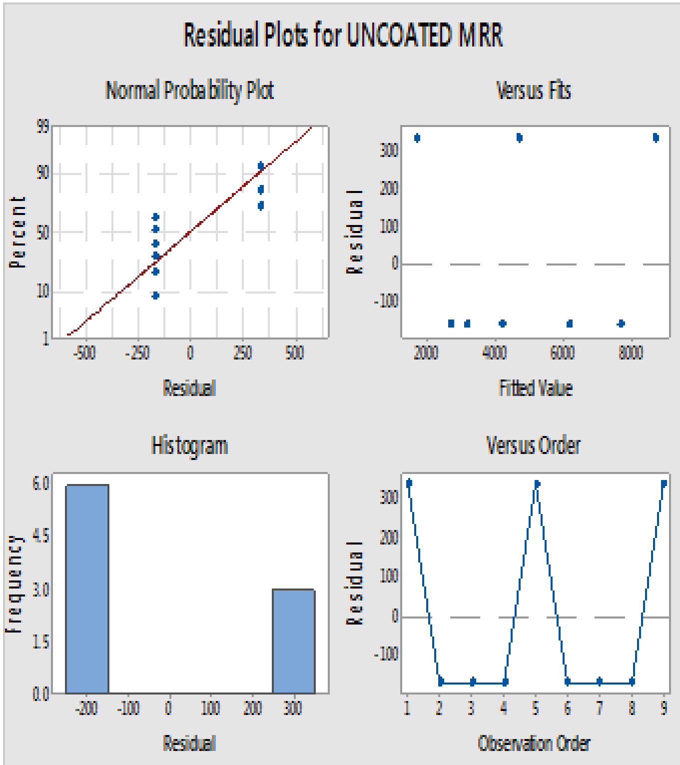

Chart-13: Residual plots for MRR of uncoated drilling

7.6 Analysis of results for MRR of coated drilling

Table-27: MRR and S/N Ratios Values for the Experiments

S.NO	SPEED	FEED	DOC	COATED MRR	SNRATIO
1	400	0.1	0.15	2138.2465	66.6012
2	400	0.2	0.25	4276.4929	72.6218
3	400	0.3	0.35	6414.7395	76.1436
4	500	0.1	0.25	2672.8082	68.5394
5	500	0.2	0.35	5345.6163	74.5600
6	500	0.3	0.15	8018.4244	78.0818
7	600	0.1	0.35	3207.3698	70.1230
8	600	0.2	0.15	6414.7395	76.1436
9	600	0.3	0.25	9622.1093	79.6654

7.6.1 Taguchi Analysis: coated MRR versus SPEED, FEED, DOC

Table-28: COATED MRR RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER

Level	SPEED	FEED	DOC
1	71.79	68.42	73.61
2	73.73	74.44	73.61
3	75.31	77.96	73.61
Delta	3.52	9.54	0.00
Rank	2	1	3

7.6.2 Main Effects Plot for SN ratios for MRR of coated drilling

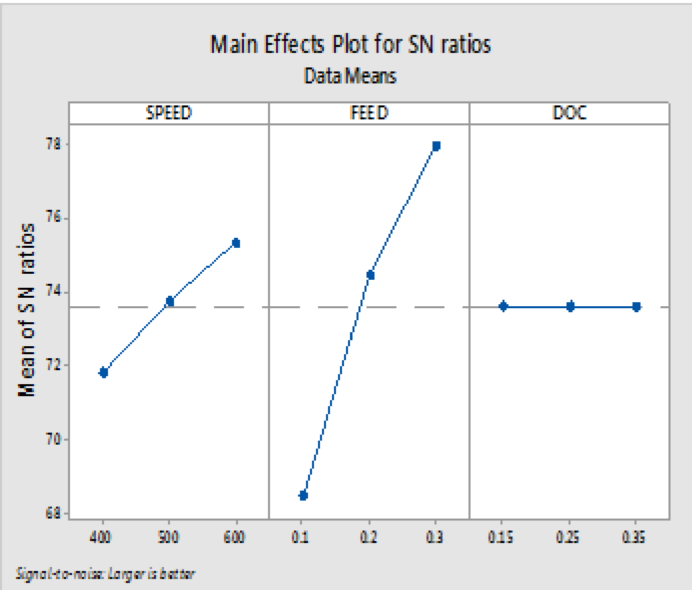

Chart-14: Main effects plot for SN ratios for MRR of coated drilling

7.6.3 General Linear Model: coated MRR versus SPEED, FEED, DOC

Table-29: Factor Information

FACTOR	TYPE	LEVELS	VALUES
Speed	FIXED	3	400,500,600
Feed	FIXED	3	0.1,0.2,0.3
Doc	FIXED	3	0.15,0.25,0.35

7.6.4 Analysis of Variance for MRR of coated drilling

Table-30: ANOVA for MRR of coated drilling

SOURCE	DF	ADJ SS	F VALUE	P VALUE	% of contribution
Speed	2	6858148	12.00	0.077	13.48
Feed	2	42863419	75.00	0.013	84.27
Doc	2	571512	1.00	0.500	1.12
ERROR	2	571512			1.12
TOTAL	8				100.00

7.6.5 Residual plots for MRR of coated drilling

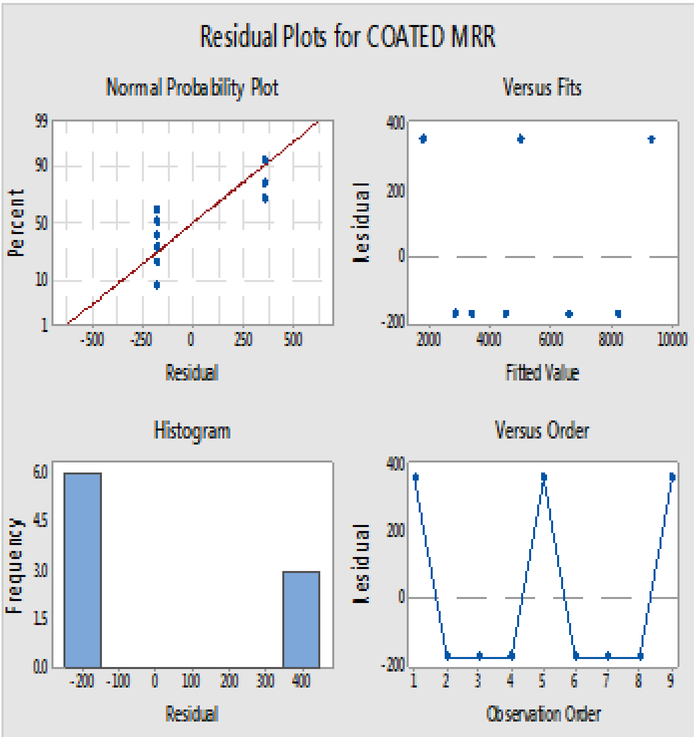

Chart-15: Residual plots for MRR of coated drilling

8. RESULT AND CONCLUSIONS

In this study, the Taguchi technique and ANOVA were used to obtain optimal drilling parameters in the drilling of various process parameters under dry conditions with coated and uncoated drill bits. The experimental results were evaluated using ANOVA. The following conclusions can be drawn.

1. In coated drilling, the surface roughness is minimum at speed=600RPM, feed=0.2mm/rev, depth of cut=0.15mm and hole diameter is minimum at speed=400RPM, feed=0.1mm/rev and depth of cut=0.15mm
2. In the same way, in coated drilling, the material removal rate is maximum at speed=600RPM, feed=0.3mm/rev and depth of cut=0.25mm.
3. As a result of the Taguchi experimental trials, it was found that in the uncoated drilling, the minimum surface roughness mainly depends upon the parameter of depth of cut followed by feed and speed. The percentage contribution of depth of cut is 40% respectively.
4. Similarly, in the coated drilling, the minimum surface roughness mainly depends upon the parameter of speed followed by depth of cut and feed. The percentage contribution of speed is 49% respectively.
5. It was found that in both uncoated and coated drilling, the minimum hole diameter depends upon the parameter of feed followed by speed and depth of cut. The percentage contribution of feed is 30% respectively.
6. It was also found that in both uncoated and coated drilling, the maximum material removal rate depends upon the parameter of feed followed by speed and depth of cut. The percentage contribution of feed is 84% respectively.

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