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AN EXPERIMENTAL INVESTIGATION AND OPTIMIZATION OF CNC DRILLING PARAMETERS OF HCHCR STEEL WITH DIFFERENT COATED DRILL BITS

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ABSTRACT

The metal cutting is very essential for high metal removing rate and to produce the best product quality. The major problem of achieving high productivity and best quality is short life span of a tool. The Modified Taguchi optimization methodology of simultaneous is based on minimization and maximization of Surface Roughness (Ra), Material Removal Rate, Machining Time of HCHCR Alloy Steel will be aesthetical aspect of the final product. Due to this it is essential to select the best combination parameter value of CNC drilling process with minimum and maximum response. The experiments were conducted through CNC lathe, using physical vapor deposition coated (TiAlN, CrAlN &CrN) drilling tool bits for the machining of HCHCR steel. The experiments were carried out as per L27 orthogonal arrays of each experiment performed under different conditions of such as speed, type of drilling tool, and feed rate. The optimization (Taguchi) method and analysis of variance (ANOVA) was employed by using MINITAB-16 software to identify the level of importance of the machining parameters on Surface roughness (Ra), Machining time and Material Removal Rate (MRR). The Taguchi technique and ANOVA was used to obtain optimal drilling parameters in the drilling of HCHCR under wet conditions. Optimum value of the surface roughness obtained when the speed 600 RPM, Feed is 0.03 in the TiAlN coated drill bit. Optimum value of the Machining timing and MRR obtained when the speed 400 RPM, Feed is 0.09 in the TiAlN coated drill bit.

KEYWORDS: Surface Roughness, Physical Vapor Deposition, Taguchi Method, ANOVA

Basically the machining process of making holes will be drilling process and it is necessary for manufacturing industry like aerospace industry, medical industry, automobile industry, assembly industries and mechanical fasteners. It is reported that around 55,000 holes are drilled as a complete single unit production of the AIR BUS A350 aircraft Drilling of metals is increasing requirements for producing small products and more highly functional. With increasing demand for precise component production, the important of drilling processes is increasing rapidly. It is required for drilling process technologies to achieve higher accuracy and higher productivity. There are several convectional and non-conventional manufacturing process by which drilling can be possible. Drilling using laser beam, electron’s beam and electric discharge methods and also electrolytic polishing, electro chemical machining has been frequently used by industries and for experimental researches. In most of the general application conventional drilling process like to be higher economic benefits, higher productivity value, When compared to other non-convectional drilling processes. Physical vapour deposition (PVD) describes a variety of vacuum deposition methods used to deposit thin films by the condensation of a vaporized form of the desired film material onto various work piece surfaces . The coating method involves purely physical processes such as high-temperature vacuum evaporation with subsequent condensation, or plasma sputter bombardment rather than involving a chemical reaction at the surface to be coated as in chemical vapour deposition. HCHCR is an important material with desirable properties, including high resisting in nature against wear and can be used for components which are subjected to severe abrasion, wear, high surface loading. Hence, HCHCR promises fruitful development for applications in the automobile sector due to its high strength.

COATING DEPOSITION TECHNIQUES

There are many coating deposition techniques are available. These techniques are divided into two common groups like metallic and non-metallic.

Physical Vapour Deposition (PVD)

Physical vapor deposition (PVD) describes a variety of vacuum deposition methods used to deposit thin films by the condensation of a vaporized form of the desired film material onto various work piece surfaces. The pure

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physical process required for coatings like high-temperature vacuum evaporation, subsequent condensation, or plasma sputter bombardment for not involving chemical reaction as chemical vapor deposition done.

Work Material Details

Work material –HCHCRsteel

Work material size–32mm dia 20 mmthickness

Chemical Properties

Table 1: Chemical properties

C	Mn	Si	S	P	Cr
1.94	0.30	0.52	0.050	0.024	11.35
1.20	0.75	0.35	-		1.60

Physical Properties

Table 2: Physical properties

No	Properties	Value
1	Ultimate Tensile Strength (Mpa)	224.07
2	Yield Stress (Mpa)	2033.95
3	Elongation (%)	5
4.	Density(Kg/M^3)	7833.413
5.	Hardness(Hrc)	62

DESIGN OF EXPERIMENT

Table 3: Process parameters and their levels

Levels	Process parameters		Type of drill tool
	Spindle Speed (N) (rpm)	Feed (f) (mm/rev)	
1	400	0.03	CrN
2	600	0.06	TiAlN
3	800	0.09	CrAlN

Drill Bit Image of CrAlN, TiAlN & CrN

Experimental Data for HCHCR Steel

Table 4: Experimental data for HCHCR STEEL

S. No.	Designation	(A) Speed (N) (RPM)	(B) Feed (F) (MM/REV)	(C) Type of tool	Machining Time	RA	MRR
1	A1B1C1	400	0.03	CrN	1.58	0.659	134.3165
2	A1B1C2	400	0.03	TIALN	0.53	0.560	409.8491
3	A1B1C3	400	0.03	CrALN	0.55	0.863	396.4364
4	A1B2C1	400	0.06	CrN	1.60	0.323	136.65
5	A1B2C2	400	0.06	TIALN	0.54	0.347	401.7037
6	A1B2C3	400	0.06	CrALN	0.54	0.903	405.4259
7	A1B3C1	400	0.09	CrN	1.58	0.990	133.4177
8	A1B3C2	400	0.09	TIALN	0.54	0.482	396.1111
9	A1B3C3	400	0.09	CrALN	0.54	1.412	393.2963
10	A1B1C1	600	0.03	CrN	1.10	0.392	201.4545
11	A2B1C2	600	0.03	TIALN	0.38	0.302	578.0789
12	A2B1C3	600	0.03	CrALN	0.37	0.491	596.7297
13	A2B2C1	600	0.06	CrN	1.15	0.495	189.1043
14	A2B2C2	600	0.06	TIALN	0.38	1.548	574.3421
15	A2B2C3	600	0.06	CrALN	0.37	0.438	590.4595
16	A2B3C1	600	0.09	CrN	1.12	0.375	193.75
17	A2B3C2	600	0.09	TIALN	0.38	1.548	572.9211
18	A2B3C3	600	0.09	CrALN	0.37	0.905	581.6757
19	A3B1C1	800	0.03	CrN	0.23	0.939	973.1739
20	A3B1C2	800	0.03	TIALN	0.30	0.924	726.4667
21	A3B1C3	800	0.03	CrALN	0.30	0.260	731.5333
22	A3B2C1	800	0.06	CrN	0.25	0.761	890.56
23	A3B2C2	800	0.06	TIALN	0.30	0.382	723.9
24	A3B2C3	800	0.06	CrALN	0.30	0.984	743.8
25	A3B3C1	800	0.09	CrN	0.24	0.907	900.25
26	A3B3C2	800	0.09	TIALN	0.31	0.822	704.9677
27	A3B3C3	800	0.09	CrALN	0.30	1.280	741.1333

Surface Roughnesses (Analysis of Result)

Table 5: Surface roughness and S/N ratios values for the experiments of HCHCR steel

S. No	Designation	(A) Speed (N) (Rpm)	(B) Feed (F) (Mm/Rev)	(C) Type Of Tool	Surface Roughness Ra (µm)	S/N Response Valve (Db) For Roughness (Ra)
1	A1B1C1	400	0.03	CrN	0.69	3.6223
2	A1B1C2	400	0.03	TIALN	0.44	5.0362
3	A1B1C3	400	0.03	CrALN	0.91	1.2798
4	A1B2C1	400	0.06	CrN	0.41	9.8159
5	A1B2C2	400	0.06	TIALN	0.48	9.1934
6	A1B2C3	400	0.06	CrALN	0.55	0.8862
7	A1B3C1	400	0.09	CrN	0.95	0.0873

8	A1B3C2	400	0.09	TIALN	0.67	6.3391
9	A1B3C3	400	0.09	CrALN	1.07	-2.9967
10	A1B1C1	600	0.03	CrN	0.51	8.1343
11	A2B1C2	600	0.03	TIALN	0.34	10.3999
12	A2B1C3	600	0.03	CrALN	0.51	6.1784
13	A2B2C1	600	0.06	CrN	0.38	6.1079
14	A2B2C2	600	0.06	TIALN	0.73	-3.7954
15	A2B2C3	600	0.06	CrALN	1.21	7.1705
16	A2B3C1	600	0.09	CrN	0.74	8.5194
17	A2B3C2	600	0.09	TIALN	0.75	-3.7954
18	A2B3C3	600	0.09	CrALN	0.90	0.8670
19	A3B1C1	800	0.03	CrN	0.89	0.5467
20	A3B1C2	800	0.03	TIALN	0.92	0.6866
21	A3B1C3	800	0.03	CrALN	1.09	11.7005
22	A3B2C1	800	0.06	CrN	0.59	2.3723
23	A3B2C2	800	0.06	TIALN	0.45	8.3587
24	A3B2C3	800	0.06	CrALN	0.94	0.1401
25	A3B3C1	800	0.09	CrN	0.51	0.8479
26	A3B3C2	800	0.09	TIALN	0.93	1.7026
27	A3B3C3	800	0.09	CrALN	1.29	-2.1442

Table 6: Response Table for Signal to Noise Ratios Smaller is better

LEVELS	SPEED	FEED	TYPE OF TOOL
1	3.696	5.287	4.450
2	4.421	4.472	3.792
3	2.690	1.047	2.565
Delta	1.731	4.240	1.886
Rank	3	1	2

ANALYSIS OF VARIANCE (ANOVA)

Table 7: (ANOVA) Results for the Roughness of HCHCR Steel

Source	DOF	SS	MS	F	P	% CON
Speed	2	1.67161	0.83580	12.69	0.000	30.46
Feed	2	0.00045	0.00023	0.00	0.997	0.009
TOT	2	2.00299	1.00149	15.20	0.000	40.13
Error	20	1.31736	0.06587			29.41
Total	26	4.99241				

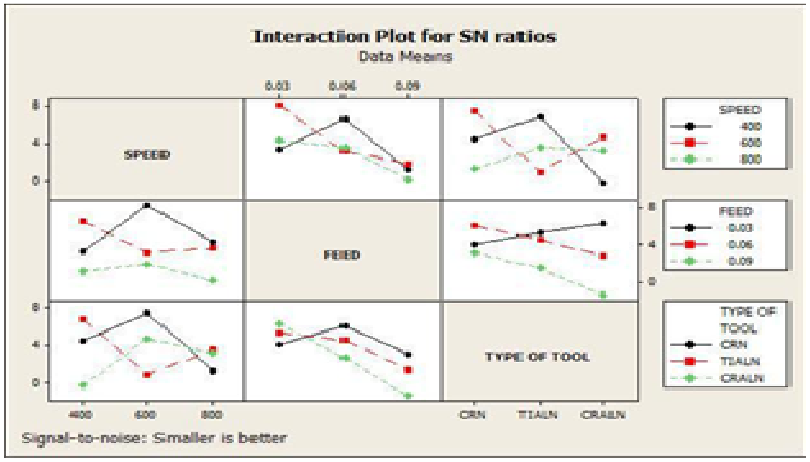

Figure 1: Interaction plot for SN ratio for roughness

Machining Time (Analysis if Result)

Table 8: Machining time and S/N ratios values for the experiments of HCHCR STEEL

S. No	Designation	(A) Speed (N) (Rpm)	(B) Feed (F) (Mm/Rev)	(C) Type Of Tool	MT	S/N Response
1	A1B1C1	400	0.03	CrN	1.58	-3.9731
2	A1B1C2	400	0.03	TIALN	0.53	5.5145
3	A1B1C3	400	0.03	CrALN	0.55	5.1927
4	A1B2C1	400	0.06	CrN	1.60	-4.0824
5	A1B2C2	400	0.06	TIALN	0.54	5.3521
6	A1B2C3	400	0.06	CrALN	0.54	5.3521
7	A1B3C1	400	0.09	CrN	1.58	-3.9731
8	A1B3C2	400	0.09	TIALN	0.54	5.3521
9	A1B3C3	400	0.09	CrALN	0.54	5.3521
10	A2B1C1	600	0.03	CrN	1.10	-0.8279
11	A2B1C2	600	0.03	TIALN	0.38	8.4043
12	A2B1C3	600	0.03	CrALN	0.37	8.6360
13	A2B2C1	600	0.06	CrN	1.15	-1.2140
14	A2B2C2	600	0.06	TIALN	0.38	8.4043
15	A2B2C3	600	0.06	CrALN	0.37	8.6360
16	A2B3C1	600	0.09	CrN	1.12	-0.9844
17	A2B3C2	600	0.09	TIALN	0.38	8.4043
18	A2B3C3	600	0.09	CrALN	0.37	8.6360
19	A3B1C1	800	0.03	CrN	0.23	12.7654
20	A3B1C2	800	0.03	TIALN	0.30	10.4576
21	A3B1C3	800	0.03	CrALN	0.30	10.4576
22	A3B2C1	800	0.06	CrN	0.25	12.0412
23	A3B2C2	800	0.06	TIALN	0.30	10.4576
24	A3B2C3	800	0.06	CrALN	0.30	10.4576
25	A3B3C1	800	0.09	CrN	0.24	12.3958
26	A3B3C2	800	0.09	TIALN	0.31	10.1728
27	A3B3C3	800	0.09	CrALN	0.30	10.4576

Table 9: Response Table for Signal to Noise Ratios Smaller is better

Levels	Speed	Feed	Type Of Tool
1	2.232	6.292	2.461
2	5.344	6.156	8.058
3	11.074	6.201	8.131
Delta	8.842	0.136	5.670
Rank	1	3	2

Analysis of Variance (ANOVA)

Table 10: Analysis of Variance (ANOVA) results for the Machining time of HCHCR STEEL

Source	DOF	SS	MS	F	P	% CON
Speed	2	0.0410	0.0205	0.14	0.870	1.080
Feed	2	0.6731	0.3365	2.31	0.126	17.73
TOT	2	0.1634	0.0817	0.56	0.580	4.304
Error	20	2.9192	0.1460			76.90
Total	26	3.7966				100

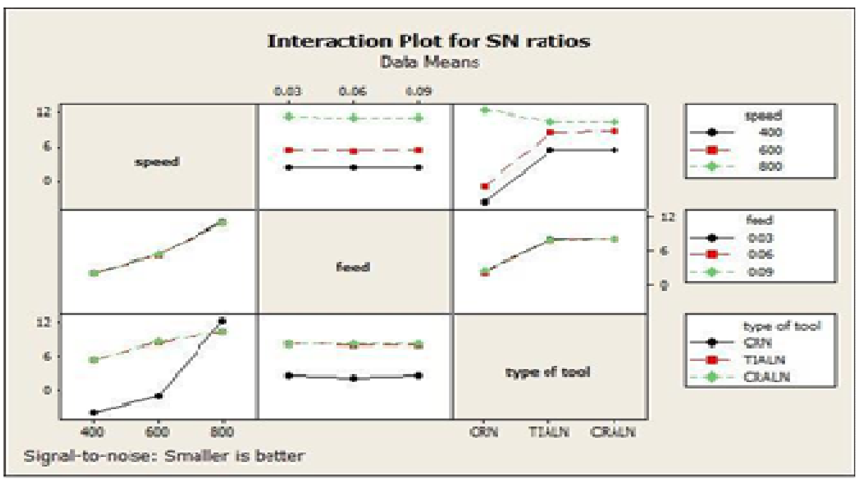

Figure 2: Interaction plot for SN ratio for machining time

Metal Removal Rate (Analysis of Result)

Table 11: Metal removal rate and S/N ratios values for the experiments of HCHCR STEEL

S. No	Designation	(A)Speed(N) (Rpm)	(B)Feed (F) (mm/rev)	(C)Type Of Tool	MRR	S/N Response
1	A1B1C1	400	0.03	CrN	134.3165	42.5626
2	A1B1C2	400	0.03	TIALN	409.8491	52.2525
3	A1B1C3	400	0.03	CrALN	396.4364	51.9635
4	A1B2C1	400	0.06	CrN	136.65	42.7122
5	A1B2C2	400	0.06	TIALN	401.7037	52.0781
6	A1B2C3	400	0.06	CrALN	405.4259	52.1582
7	A1B3C1	400	0.09	CrN	133.4177	42.5043
8	A1B3C2	400	0.09	TIALN	396.1111	51.9563
9	A1B3C3	400	0.09	CrALN	393.2963	51.8944
10	A2B1C1	600	0.03	CrN	201.4545	46.0835

11	A2B1C2	600	0.03	TIALN	578.0789	55.2397
12	A2B1C2	600	0.03	TIALN	578.0789	55.2397
13	A2B2C1	600	0.06	CrN	189.1043	45.534
14	A2B2C2	600	0.06	TIALN	574.3421	55.1834
15	A2B2C3	600	0.06	CrALN	590.4595	55.4238
16	A2B3C1	600	0.09	CrN	193.75	45.7448
17	A2B3C2	600	0.09	TIALN	572.9211	55.1619
18	A2B3C3	600	0.09	CrALN	581.6757	55.2936
19	A3B1C1	800	0.03	CrN	973.1739	59.7638
20	A3B1C2	800	0.03	TIALN	726.4667	57.2243
21	A3B1C3	800	0.03	CrALN	731.5333	57.2847
22	A3B2C1	800	0.06	CrN	890.56	58.9933
23	A3B2C2	800	0.06	TIALN	723.9	57.1936
24	A3B2C3	800	0.06	CrALN	743.8	57.4291
25	A3B3C1	800	0.09	CrN	900.25	59.0873
26	A3B3C2	800	0.09	TIALN	704.9677	56.9634
27	A3B3C3	800	0.09	CrALN	741.1333	57.3979

Table 12: Response Table -Ratios Larger is better

Levels	Speed	Feed	Type of tool
1	48.9	53.1	49.22
2	52.13	52.97	54.81
3	57.93	52.89	54.93
DELTA	9.03	0.21	5.71
Rank	1	3	2

Analysis of Variance (ANOVA)

Table 13: MRR of HCHCR steel

Source	DOF	SS	MS	F	P	% CON
Speed	2	1099989	549995	29.04	0	67.86
Feed	2	1000	500	0.03	0.974	0.06
TOT	2	141894	70947	3.75	0.042	8.75
Error	20	378790	18939			23.36
Total	26	1621673				100

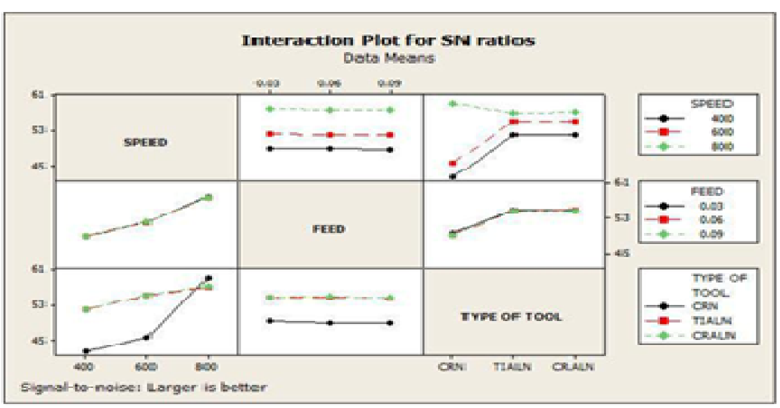

Figure 3: Interaction plot for SN ratio for MRR

CONCLUSION

In this study, the Taguchi technique and ANOVA were used to obtain optimal drilling parameters in the drilling of HCHCR under wet conditions. The experimental results were evaluated using TAGUCHI&ANOVA. The following conclusion can be drawn.

Optimal Control Factor

1.Surface Roughness-A3(Speed -600)B1(Feed -

0.03)C2(Type of Tool-TiAlN)

2.Machining Timing-A1(Speed-400)B3(Feed

0.09)C2(Type of Tool-TiAlN)

3.Material Removal Rate- A1(Speed-400)B3(Feed

0.09)C2(Type of Tool-TiAlN)

Percentage of Contribution of Process Parameter

1.TiAlN Tool contribution- 40.13%

2.Machining Timing- Feed 17.73%

3.Material Removal Rate- speed-67%

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