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Machining Character Analysis of Coated and Uncoated End Mill on Heat Treated C45 Steel

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Abstract: Machining operations are used to produce shapes or surface characteristics for a product. Some common conventional machining operations are turning, boring, drilling, reaming, milling, and tapping. Conditions for machining operations were chosen based on geometry and surface finish requirements rather than profit when costs were comparatively low on labor, resource, machines, and tools. However, nowadays, many researchers proposed optimizing machining parameters to maximize profit when using expensive modern machine tools. The purpose of machining operations is to make specific shapes or surface characteristics for a product. Conditions for machining operations were traditionally selected based on geometry and surface finish requirements. This study was investigated the parameter optimization of end milling operation various parameter and coated tools and ordinary tool with heat treated C45 steel with single objective function criteria based on the Taguchi orthogonal array with the Taguchi design. Comparison of coated and uncoated end mill process of heat-treated C-45 steel fine Ra is obtained with coated tool. Kerf width almost equal of both tools it did not show any major difference Optimum level and ANOVA were calculated for both tools.
Keywords: Ra, PVD coated, Heat treatment, End mill

I. INTRODUCTION

A. Milling

Milling is the process of removing metal by feeding the work past a rotating multipoint cutter. In milling operation, the rate of metal removal is rapid as the cutter rotates at a high speed and has many cutting edges. Thus, the jobs are machined at a faster rate than with single point tools and the surface finish is also better due to multipoint cutting edges.

The action of the milling cutter is vastly different from that of a drill or lathe tool. In milling operation, the cutting edge of the cutter is kept continuously in contact with the material being cut. The cuts pick gradually. The cycle of operation to remove the chip produced by each tooth is first a sliding action at the beginning, the cutter meets the metal and then crushing action takes place just after it is leading finally to the cutting actions. The versatility and accuracy of the milling process causes it to be widely used in modern manufacturing.

B. End Milling

The End Milling may be considering as the combination of peripheral and face milling operations. The cutter has teeth both on the end face and on the periphery. The cutting characteristics may be of peripheral or face milling type according to the particular cutter surface used. When the end cutting edges are only used to remove the metal the direction of rotation and the direction of the helix of the cutter should be same. When the peripheral cutting edges are used to remove the metal, the direction of rotation and the direction of helix should be opposite to each other. The end milling is the operation of producing a flat surface which may be vertical, horizontal or at an angle in reference to the table surface.

II. CNC MILLING OVERVIEW & INPUT PARAMETER

Fig: 1vertical Milling Machine

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A. Experimental Setup

The experiments were conducted based on L9 orthogonal array with Taguchi design. BATLIBOI CHETAK-75MC model was used to perform the coated and uncoated end milling operation.

B. Machine Specifications

TABLE I
MACHINE SPECIFICATIONS

Main Specifications	Batliboi Chetak 75 Mc
Table Size (L x B)	950 x 520 mm
X-Axis Traverse	762 mm
Y-Axis Traverse	510 mm
Z-Axis Traverse	510 mm
Spindle Nose Taper	BT-40

C. Tool and Insert

The tool diameter is a key factor while calculating the material removal rate. The diameter of tool is coated and uncoated (TISA FLEX) 8- mm for this experimental purpose.

D. Coated End Mill TISA FLEX

TISAFLEX from Oerlikon Balzers provides outstanding oxidation resistance, high thermal stability, and excellent wear resistance. The new high-end coating solution is thus the perfect solution for machining these demanding materials.

1) Superior oxidation resistance and thermal stability.
2) Perfect coating solution for machining difficult-to-cut materials like titanium, nickel-based alloys, stainless steel, and hardened steel
3) Coating material: AlTiN

E. Work Material Details

Work material – C45 Steel

Work material size–100X 100 mm rectangular plate 6 mm thickness. Heat treated with oil hardening method and hardness was found 40 HRC.

III.MACHINING PARAMETER

A. Design of Experiment

TABLE III
PROCESS PARAMETERS AND THEIR LEVELS

Levels	Process Parameters		
	Spindle Speed (*N*) (RPM)	Feed (Mm/Rev)	DOC mm
1	800	0.04	0.2
2	1000	0.06	0.4
3	1200	0.08	0.6

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B. Experimental Data Analysis and Optimization- Tisa Flex Coated End Mill

TABLE IIIII
EXPERIMENTAL DATA ANALYSIS-TISA FLEX

Sl. No	Speed (*N*) (RPM)	Feed (mm/Rev)	DOC	MT sec	Ra micron	Kerf Width mm
1	800	0.04	0.2	135	0.827	9.735
2	800	0.06	0.4	63	0.572	9.752
3	800	0.08	0.6	48	0.753	9.885
4	1000	0.04	0.4	73	0.781	9.725
5	1000	0.06	0.6	91	0.742	9.744
6	1000	0.08	0.2	79	0.89	9.895
7	1200	0.04	0.6	63	1.158	9.709
8	1200	0.06	0.2	43	0.937	9.744
9	1200	0.08	0.4	71	1.041	9.945

C. Experimental Data Analysis and Optimization- Uncoated End Mill

TABLE IVV
EXPERIMENTAL DATA ANALYSIS- UNCOATED

Sl. No	Speed (*N*) (RPM)	Feed (mm/Rev)	DOC	MT sec	Ra micron	Kerf Width mm
1	800	0.04	0.2	135	1.052	9.881
2	800	0.06	0.4	63	1.989	9.851
3	800	0.08	0.6	48	1.226	9.866
4	1000	0.04	0.4	73	0.387	9.875
5	1000	0.06	0.6	91	0.726	9.855
6	1000	0.08	0.2	79	0.754	9.896
7	1200	0.04	0.6	63	0.716	9.920
8	1200	0.06	0.2	43	1.164	10.034
9	1200	0.08	0.4	71	2.161	9.947

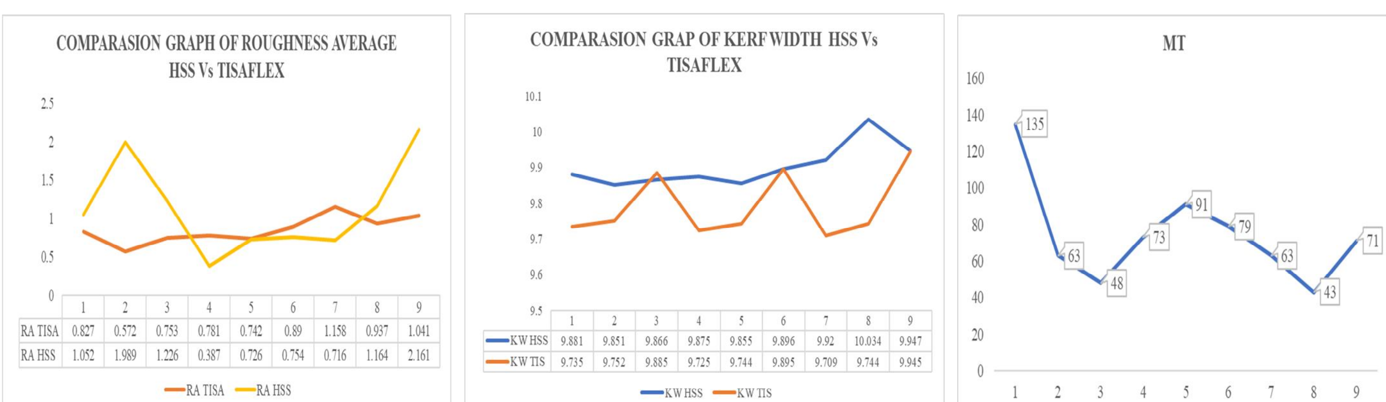

Fig: 2 Compraression graph of HSS Vs TISAFLEX (Ra, Kerf Width) & Graph of MT-Machining Time

D. Conclusion

Comparison of coated and uncoated end mill process of heat-treated C-45 steel minimum Ra is obtained with coated tool. Kerf width almost equal of both tools it did not show any major difference.

E. S/N Ratios Values for the Experiments- Tisa Flex Coated End Mill

Table V
S/N Ratios Values for the Experiments

Sl. No	Speed (*N*) (RPM)	Feed (mm/Rev)	DOC	MT SN-Ratio	Ra SN-Ratio	Kerf Width mm
1	800	0.04	0.2	-42.6067	1.64989	19.7667
2	800	0.06	0.4	-35.9868	4.85208	19.7819
3	800	0.08	0.6	-33.6248	2.46410	19.8995
4	1000	0.04	0.4	-37.2665	2.14698	19.7578
5	1000	0.06	0.6	-39.1808	2.59192	19.7747
6	1000	0.08	0.2	-37.9525	1.01220	19.9083
7	1200	0.04	0.6	-35.9868	-1.27417	19.7435
8	1200	0.06	0.2	-32.6694	0.56521	19.7747
9	1200	0.08	0.4	-37.0252	-0.34901	19.9521

F. Machining Time- Tisa Flex Coated & Uncoated End Mill (Analysis of Variance)

Table VI
Response Table for Signal to Noise Ratios-Smaller is better

Level	Speed	Feed	DOC
1	-37.41	-38.62	-37.74
2	-38.13	-35.95	-36.76
3	-35.23	-36.20	-36.26
Delta	2.91	2.67	1.48
Rank	1	2	3

Table VII
Analysis of Variance for MT, using Adjusted SS for Tests

Source	Df	Seq Ss	Adj Ms	F	P	% of Contribution
Speed	2	1014.0	507.0	0.33	0.753	1
Feed	2	1200.7	600.3	0.39	0.720	96
Doc	2	616.7	308.3	0.20	0.834	2
Error	2	3092.7	1546.3			1
Total	8	5924.0				100

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G. Surface Roughness- Tisa Flex Coated End Mill (Analysis of Variance)

TABLE VIII
Response Table for Signal to Noise Ratios-Smaller is better

Level	Speed	Feed	DOC
1	2.9887	0.8409	1.0758
2	1.9170	2.6697	2.2167
3	-0.3527	1.0424	1.2606
Delta	3.3413	1.8288	1.1409
Rank	1	2	3

TABLE IX
Analysis of Variance for Ra, using Adjusted SS for Tests

Source	Df	Seq Ss	Adj Ms	F	P	% of Contribution
Speed	2	0.1390	0.06948	0.70	0.589	15
Feed	2	0.1368	0.06842	0.69	0.592	15
Doc	2	0.4454	0.22272	2.24	0.309	48
Error	2	0.1990	0.09948			22
Total	8	0.9202				100

H. Kerf Width- Tisa Flex Coated End Mill (Analysis of Variance)

TABLE X
Response Table for Signal to Noise Ratios-Smaller is better

Level	Speed	Feed	DOC
1	19.82	19.76	19.82
2	19.81	19.78	19.8
3	19.82	19.92	19.81
Delta	0.01	0.16	0.02
Rank	3	1	2

TABLE XI
Analysis of Variance for Kw, using Adjusted SS for Tests

Source	Df	Seq Ss	Adj Ms	F	P	% of Contribution
Speed	2	0.000211	0.000105	0.20	0.834	1
Feed	2	0.061045	0.030522	57.66	0.017	96
Doc	2	0.001184	0.000592	1.12	0.472	2
Error	2	0.001059	0.000529			1
Total	8	0.063498				100

IV. RESULT & CONCLUISON

In this study, the Taguchi technique and ANOVA were used to obtain optimal end milling parameters of heat-treated C-45 steel with coated and uncoated end mill under wet conditions. The experimental results were evaluated using Taguchi technique. From the experimental study finally, we have concluded coated and uncoated end mill process of heat-treated C-45 steel fine Ra is obtained with coated tool. Kerf width almost equal of both tools.it did not show any major difference.

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A. Result Optimal Control Factor- Tisa Flex Coated End Mill

1) Surface roughness- A_1 (Speed-800) B_2 (Feed-0.06 mm/rev) C3 (DOC-0.6)
2) Kerf Width- A_3 (Speed-1200) B_1 (Feed-0.04 mm/rev) C_2 (DOC-0.4)
3) Machining timing- A_1 (Speed-800) B_2 (Feed-0.06 mm/rev) C3 (DOC-0.6)

B. Percentage Of Contribution for Tisa Flex End Mill Annova

1) Surface roughness- Speed- 71%
2) Kerf width - Feed-96%
3) Machining tining-20%

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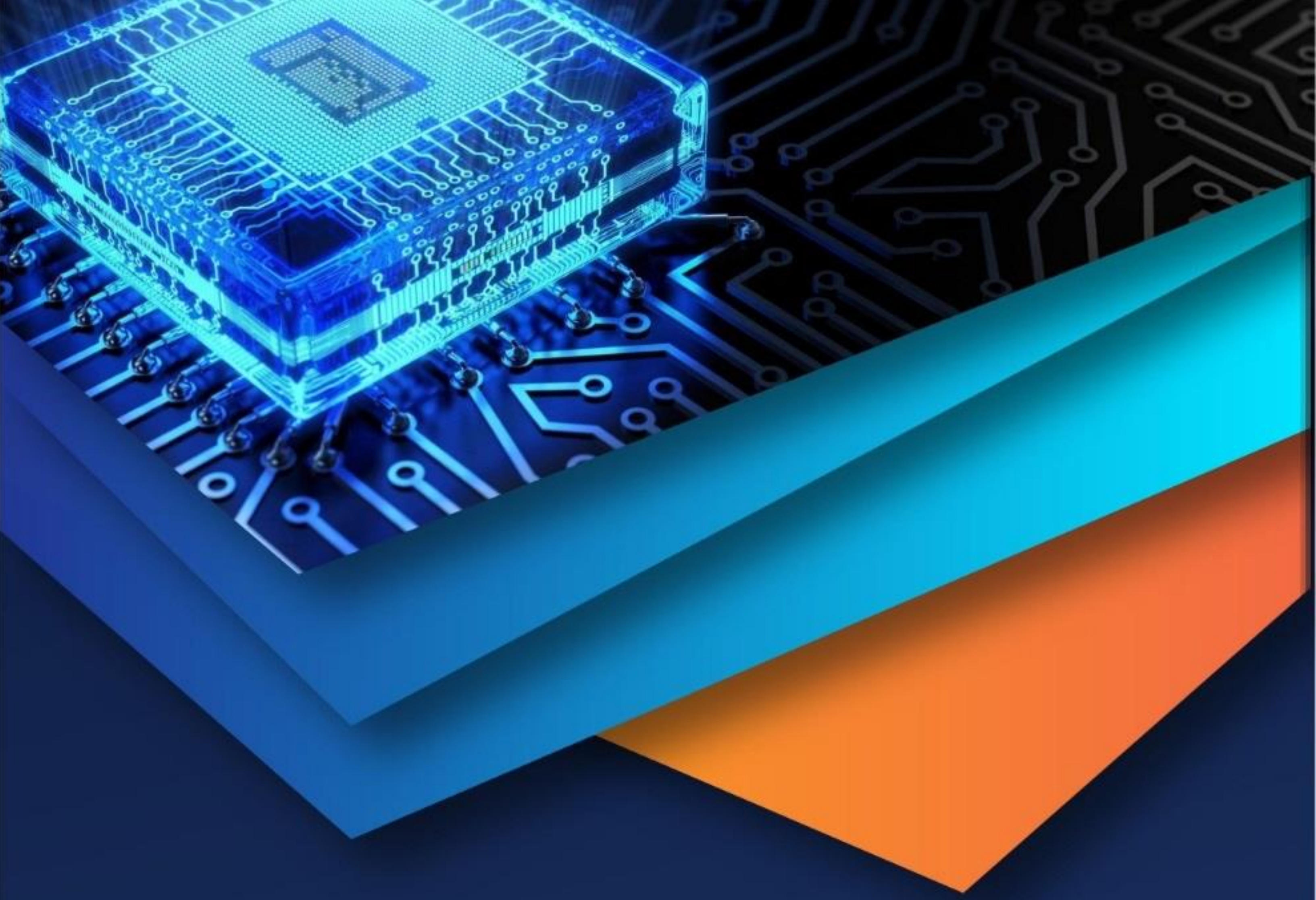

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