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Experimental Investigation during CNC Milling of Hastelloy C-276 in Dry Condition

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Abstract*: In this Study, RSM method is implemented to study the imapct of input variables i.e cutting speed, feed rate and depth of cut on the output responses i.e surface roughness, material removal rate and tool wear during the milling of Hastelloy C-276. Experiment was performed on CNC milling (Hurco VM10) with physical vapour deposition (PVD) coated inserts under dry condition. Analysis of variance (ANOVA) was implemented to figure out the utmost dominant factor affecting the output responses studied. Optimization of result is carried out with the help of Desirability approach. The optimum combination for dry machining was identified to be cutting speed 40 m/min, feed rate 0.08 mm/ and depth of cut 1mm for achieving the surface roughness 0.676µm, material removal rate 1.445cc/min and tool wear 141µm.

***Keywords*: RSM, ANOVA,PVD Coating, Desirability approach, Dry machining.**

***Nomenclature*: Cutting Speed (m/min)-V, Feed Rate (mm/tooth)-F, Depth of Cut (mm)-DOC, Degree of Freedom –DOF, Surface Roughness (µm)-SR, Material Removal Rate (cc/min)-MRR, Tool Wear (µm)-TW.**

I. INTRODUCTION

Hastelloy C-276 (Nickel base alloy) is very popular in industrial application because of its high corrosion resistance, retain their mechanical and chemical properties at high temperature and heat resist. Nickel based alloy found versatile applications in marine industries, turbines, in petrochemical industries and rocket engines. Hastelloy C-276 hard to machine because of high rate of work hardening, adhesiveness ,tough ,gummy, low thermal properties leading to high cutting temperature and tendency to weld. Basim [1] experimentally examine the consequences of input variables such as V, F, nose radius and tool material during the machining of Hastelloy C-276.The RSM is used to generate the prediction model to reveal the optimal values of input variables From the experimental results it was concluded that V and DOC had largest influence on output responses. Kaitao et al. [2] experimentally studied the high machining of Hastelloy C-276 with a newly developed Ti (C7N3)-based cermet insert. Taguchi method was used to establish the prediction model for tool life, SR and MRR. The optimal conditions for output responses was found to be V= 833.33mm/sec, DOC= 0.4mm and F =0.15mm/rad. At the optimal conditions the tool life is 32 min and MRR are 3000 mm3/min. J.S. et al. [3] experimentally studied the consequences of input variables on output responses such as SR and cutting forces during the dry milling of hollysite nano tube with the help of aluminum reinforced epoxy hybrid composite material. The Taguchi method is used for generation of prediction model. The optimized value at which SR was minimum found to be DOC=0.4 mm, V=1500 rpm and F=60mmpm and for minimum cutting forces the optimized values found to be DOC=0.6 mm, V=1000 rpm and F=40mmpm H.H et al. [4] experimentally studied the effect of input parameters during the machining of Hyanes 242 with CBN under dry condition. The RSM technique was used to find the optimal values. The result of experiments showed that SR= 0.052-0.008 µm. The SR getting finer with increase in V from 70-300mm/min. On the other hand, the SR getting rougher with increase in F (0.1-0.3 mm/tooth) and DOC from (0.025-0.075mm).

II. EXPERIMENTAL PROCEDURE AND SELECTION OF PROCESS PARAMETERS

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

A. *Selection of Work Material*

Hastelloy C-276 in plate form of size 30x30x25mm^3 has been used to perform the experimental tests. Hastelloy C-276 is shown for the experimentation because it possess excellent wear resistant because of presence Cr and Mo, high hardness, resistance to thermal shocks and so on. The physical and chemical properties of Hastelloy C-276 are shown in Table 1 and 2 respectively [5].

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TABLE I Physical properties of Hastelloy C-276

Hardness, HRB	90
Melting point ◦c	1323.8-1371.11
Density g/cm^3	0.0089
Ultimate Tensile Strength MPa	682
Yield Strength MPa	263

TABLE III CHEMICAL COMPOSITION OF HASTELLOY C-276

Sr. No	Chemical Compound	Percentage
1	Ni	57Balance
2	Co	2.5
3	Mo	16
4	Cr	16
5	Fe	5
6	W	4
7	Mg	1
8	V	0.35
9	Si	0.08
10	C	0.01
11	Cu	0.5

B. Selection of Tool for Experimentation

The machining test was performed by PVD coated inserts, milling of Hastelloy C-276 was carried on CNC milling machine (Hurco VM10) as shown in Fig 1.

Fig 1 Schematic diagram of CNC vertical milling machine (Hurco VM10)

C. Experimental Design

Design of experiment is statistical method developed by the Sir R.A Fisher in 1920 in England. Design of experiment is organized and structured method that is used to determine the relation between input parameters and output responses. The result of experiments conducted was analyzed to find the optimal value, also the factor which influences the results dominantly.

1) *Response Surface Methodology*: Response Surface Methodology is the sequential process and also collections of statistical and mathematical technique used to develop improve optimized process. In the response surface methodology, response surface function is expressed in terms of

Y= f(X1, X2, X3 …….) + E

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Where, Y= output response (dependent),
Xi= input variables (independent) (i=1, 2, 3 …)
E = Experimental Error

2) *Central Composite Design:* A second-order model can be constructed efficiently with central composite designs (CCD) (Montgomery, 1997). CCD is first-order designs augmented by additional centre and axial points to allow estimation of the tuning parameters of a second-order model. After prior examination, the suitable levels of parameters were used to infer the design parameters. The following are input parameters elected for current experimental work such as V (m/min), F (mm/tooth) and DOC (mm). Table 3 shows the selected input variables. Experimentation was performed according to Table 4.

TABLE IIIII
DIFFERENT LEVELS OF PARAMETERS

Parameters	Levels		
	Low	Medium	High
	-1	0	1
V (m/min)	20	30	40
F(mm/tooth)	0.06	0.07	0.08
DOC (mm)	.8	.9	1

TABLE IVV
Experimental Run Order

RunOrder	PtType	Blocks	V (m/min)	F (mm/ tooth)	DOC (mm)
1	-1	1	30	0.06	1.1
2	0	1	30	0.06	0.9
3	-1	1	47	0.06	0.9
4	-1	1	30	0.08	0.9
5	0	1	30	0.06	0.9
6	1	1	20	0.07	0.8
7	-1	1	30	0.04	0.9
8	1	1	40	0.07	1.0
9	1	1	40	0.07	0.8
10	0	1	30	0.06	0.9
11	0	1	30	0.06	0.9
12	1	1	20	0.05	1.0
13	-1	1	13	0.06	0.9
14	0	1	30	0.06	0.9
15	1	1	20	0.05	0.8
16	0	1	30	0.06	0.9
17	-1	1	30	0.06	0.7
18	1	1	40	0.05	0.8
19	1	1	20	0.07	1.0
20	1	1	40	0.05	1.0

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III.RESULT AND DISCUSSION

After each experiment the SR, MRR and TW has measured. The SR is measured with the help of Mitutoyo Surftest SJ-301.The MRR is measured by weight. TW measured with Machine Vision and SEM.

In this paper the data analysis based on Central Composite Design technique of RSM by using Design of Expert 10 software, to know the main effect of parameters ANOVA is used. The results are optimized with the help of Desirability approach. The output responses after experimentation testing are shown in Table 5.

TABLE V
Output Responses

RunOrder	PtType	Blocks	V (m/min)	F (mm/ tooth)	DOC (mm)	SR (µm)	MRR (cc/min)	TW (µm)
1	-1	1	30	0.06	1.1	1.59	0.92	151
2	0	1	30	0.06	0.9	1.61	0.77	159
3	-1	1	47	0.06	0.9	0.39	1.21	135
4	-1	1	30	0.08	0.9	1.35	0.99	161
5	0	1	30	0.06	0.9	1.58	0.77	149
6	1	1	20	0.07	0.8	1.85	0.54	178
7	-1	1	30	0.04	0.9	1.78	0.56	154
8	1	1	40	0.07	1.0	0.45	1.34	142
9	1	1	40	0.07	0.8	0.53	0.68	138
10	0	1	30	0.06	0.9	1.24	0.77	158
11	0	1	30	0.06	0.9	1.32	0.77	162
12	1	1	20	0.05	1.0	1.62	0.48	189
13	-1	1	13	0.06	0.9	1.75	0.34	212
14	0	1	30	0.06	0.9	1.5	0.77	157
15	1	1	20	0.05	0.8	1.35	0.38	178
16	0	1	30	0.06	0.9	1.69	0.77	154
17	-1	1	30	0.06	0.7	1.65	0.63	153
18	1	1	40	0.05	0.8	0.38	0.76	145
19	1	1	20	0.07	1.0	1.08	0.67	198
20	1	1	40	0.05	1.0	0.42	0.96	148

A. Static Analysis

1) For SR

A Analysis of Variance of SR, MRR and TW was made with the objective of analyzing the effect of V(m/min), F(mm/tooth) and DOC(mm) on the results. Table VI,VII and VIII shows the ANOVA results for SR,MRR and TW. This analysis shows the 95% confidence level of output responses.

TABLE VI
ANOVA for Response Surface Linear model

Source	Sum of Squares	DOF	Mean Square	F Value	p-value Prob > F	Remarks
Model	3.06	3	1.02	7.66	0.0021	Significant
A-V	3.00	1	3.00	22.52	0.0002	
B-F	0.032	1	0.032	0.24	0.6287	
C-DOC	0.027	1	0.027	0.20	0.6574	
Residual	2.13	16				
Lack of Fit	1.98	11	0.18	5.84	0.0320	Not Significant
Pure Error	0.15	5	0.031			
Cor Total	5.19	19				

From the Table VI,it is clear that the model is significant for SR having p-value 0.0021 which is less than 0.05.V is least effect on SR while DOC is significant effect followed by F. Interaction between V,F and DOC also affect the SR.

2) MRR

TABLE VI
ANOVA

Source	Sum of Squares	DOF	Mean Square	F Value	p-value Prob > F	Remarks
Model	1.12	6	0.19	40.37	< 0.0001	Significant
A-V	0.25	1	0.25	54.25	< 0.0001	
B-F	0.14	1	0.14	30.92	< 0.0001	
C-DOC	0.15	1	0.15	31.74	< 0.0001	
AB	3.125E-004	1	3.125E-004	0.068	0.7987	
AC	0.050	1	0.050	10.76	0.0060	
BC	0.030	1	0.030	6.51	0.0241	
Residual	0.060	13	4.609E-003			
Lack of Fit	0.060	8	7.490E-003			
Pure Error	0.000	5	0.000			
Cor Total	1.18	19				

From the Table VII, it is clear that the model is significant for MRR having p-value less than .0001 which is less than 0.05.V ,F and DOC has same effect on MRR. Interaction between V, F and DOC also affect the MRR.

3) FOR TW

TABLE VIII
ANOVA

Source	Sum of Squares	DOF	Mean Square	F Value	p-value Prob > F	Remarks
Model	7476.76	9	830.75	29.44	< 0.0001	Significant
A-V	3059.55	1	3059.55	108.42	< 0.0001	
B-F	13.43	1	13.43	0.48	0.5059	
C-DOC	60.75	1	60.75	2.15	0.1730	
AB	60.50	1	60.50	2.14	0.1738	

AC	72.00	1	72.00	2.55	0.1413	
BC	12.50	1	12.50	0.44	0.5207	
Residual	606.15	1	606.15	21.48	0.0009	
Lack of Fit	7.59	1	7.59	2.27	0.06152	Not Significant
Pure Error	17.54	1	17.54	0.62	0.4488	
Cor Total	282.19	10	28.22			

From the Table VIII,it is clear that the model is significant for TW having p-value less than .0001 which is less than 0.05.V has least effect on TW while F has most significant effect followed by DOC has same effect on TW. Interaction between V, F and DOC also affect the TW.

B. Multi Response Optimization Using Desirability

1) *Desirability approach:* The desirability approach most commonly used in industrial application for multi response optimization. This method was proposed by Derringer and Suich (1980).

2) *Desirability approach steps:* Perform the experimental tests for each response;Specify desirability function to each response separately;Maximize the overall desirability with respect to governable factors[6].

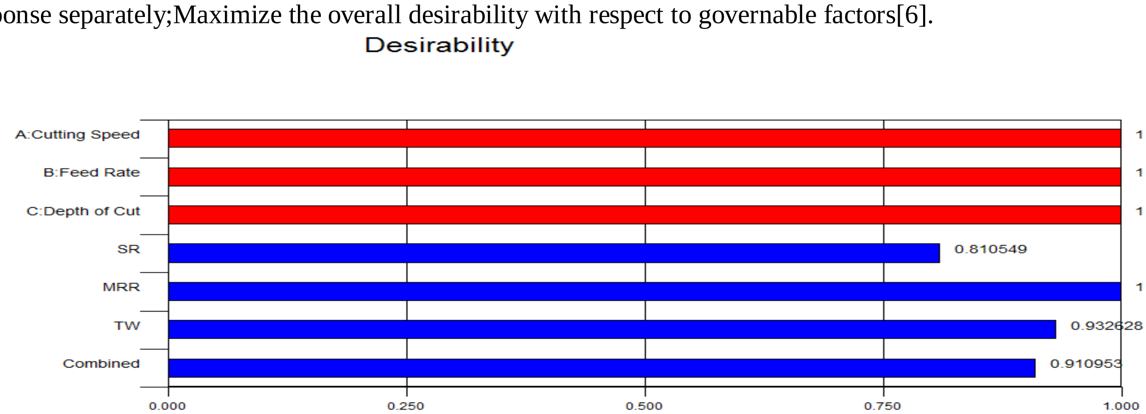

Fig 2 Desirability plot

Figure 2 shows the desirability plot. From the plot it was evident that desirability for input variables i.e V, F and DOC is 1 and output parameter i.e SR is 0.81, MRR is 1 and TW is 0 .932 and combined desirability for both input and output parameters is 0.91.

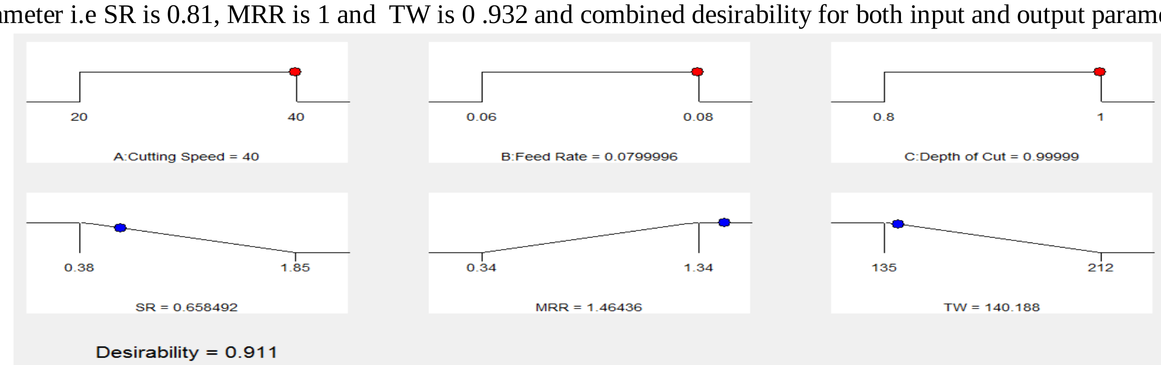

Fig 3 Predicted results by ramp order

TABLE V
Optimized parameters for validation of dry machining

	Input Parameters			Output Parameters		
	V (m/min)	F (mm/tooth)	DOC (mm)	SR (µm)	MRR (cc/min)	TW (µm)
Experimental Values(A1)	40	0.080	1.000	0.676	1.495	141
Multi optimized Values (Desirability approach)A2	40	0.080	1.000	0.658	1.464	140.188
% Error= A1A2/A1*100	N.A			2.662	2.07	0.578

IV. CONCLUSIONS

A. Response Surface Methodology is suitable method for analysis of metal cutting problems as described in current work.

B. The optimum combination for dry machining was determined to be V= 40 m/min, F= 0.08 mm/tooth and DOC= 1 mm for achieving the SR= 0.676µm, MRR= 1.445cc/min and TW= 141µm.

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REFERENCES

[1] Basim A. Khidhir and Bashir Mohamed, "Analyzing the Effect of Cutting Parameters on Surface Roughness and Tool Wear when Machining Nickel Based Hastelloy–C276", IOP Conference Series Materials Science and Engineering, Research Gate, Vol. 17, 2011, pp. 1-10.

[2] Kaitao Xu, Bin Zo, Chuanzhen Huang,Yang Yao, Huijun Zhou and Zhanqiang Liu, " Machinability of Hastelloy C-276 using Hot-pressed sintered Ti(C_7N_3)-based cermet cutting tools", Chinese Journal of Mechanical Engineering, Springer,Vol.28, 2012, pp. 599-606.

[3] J.S. Pang , M.N.M. Ansari, Omar S. Zaroog , Moaz H. Ali and S.M. Sapuan, "Taguchi design optimization of machining parameters on the CNC end milling process of halloysite nanotube with aluminium reinforced epoxy matrix (HNT/Al/Ep) hybrid composite" HBRC Journal, Elsevier, Vol. 10, 2014,pp. 138-144 .

[4] H.H Habbeb, K.Kadirgama, M Noor, M.M Rahman, B.Mohammad, R.A Bakar, and K.A. Abou-El-Hossein, "Tool Life and Wear Mechanism when Machining Hastelloy C22 HS", Journal of Applied Science, Vol. 10, 2010 , pp. 2322-2327.

[5] http://haynesintl.com/docs/default-source/pdfs/new-alloy-brochures/corrosion-resistant-alloys/c-276.pdf?sfvrsn(date of access 14-11-2016).

[6] http://www.itl.nist.gov/div898/handbook/pri/section5/pri5322.htm=4