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Optimization of Quality Characterstics of CNC Milling Machine Using the Taguchi Method on Hot Die Steel H-13

KEYWORDS: Hot Die Steel H-13, Vertical CNC Milling Machine, Taguchi Method ,MRR, Surface Roughness, Minitab

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ABSTRACT *This paper outlines the Taguchi optimization methodology, which is applied to optimize the cutting parameters in vertical CNC milling machine while machining Hot Die steel H-13 with Solid carbide tool under semi-finishing and finishing condition. The inputs of model consist of spindle speed, depth of cut & feed rate while the output of the model is material removal rate & surface roughness.. An orthogonal array L9, S/N ratio are employed to analyze the effect of these milling parameters. The study shows that the Taguchi method is suitable to solve the stated problem with minimum number of trials as compared with other DOE methods.*

The results shows that DOC has more effect than SS, and SS has more effect than FR in controlling the MRR & the FR has more effect than SS, and SS has more effect than DOC in controlling the Ra.

INTODUCTION :

In the proposed research work, material removal rate (MRR) and surface roughness (Ra) of the product prepared by CNC end milling operation are to be studied experimentally and the results, thereof, obtained are to be interpreted analytically. During milling, cutting parameters have great influence on performance characteristics arer spindle speed, DOC & FR. The performance characteristics are taken as MRR & Ra . Both the surface roughness and material removal rate greatly vary with the change of cutting process parameters. That is why proper selection of process parameters is also essential along with the prediction of the surface finish and material removal rate in CNC end milling process. Taguchi method of optimization was developed by Genichi Taguchi 1940. Taguchi defines controllable variables as signal factors and uncontrollable variables as noise factors. The ratio, usually signal-to-noise (S/N) ratio, decides our requirement to the experiment design, i.e.,, whether we require smaller the better , nominal the best, or higher the better .Taguchi designs experiments using specially constructed tables known as ' Orthogonal Array'(OA). It utilizes the Orthogonal Array from experimental design theory to study a large number of variables with a small number experiments. This technique helps to study the many factors (variables) on the desired quality characteristic most economically. By studying the effect of individual factors on the results, the best factor combination can be determined. The standardized Taguchi-based experimental design used in this study is an L9.

MATERIAL DESCRIPTION :

Material : Hot Die steel H13 .

Size of the material (mm^3) : 140X100X25

Weight of the material (Kg) : 3.3

Main Constituent of Hot Die Steel H13: Iron

Tool Material : Solid Carbide.

Chemical Composition	C	Si	Mn	Cr	Mo	V
Percentage (%)	0.35	1.00	0.30	5.00	1.50	0.90

EXPERIMENTAL WORK :

Taguchi method of optimization using L_9 array is selected . Spped, feed and depth of cut are taken as input variables. The MRR and Ra are considered as response factors. S/N ratio Larger the better is taken for MRR and Smallest the better for Ra. The experiment is designed using statistical software MINITAB 16.

$S/N = -10 \log (\sum(1/ Y^2)/n)$..... For Larger is better

$S/N = -10 \log (\sum Y^2/n)$ ..... For Smaller is better

Where Y is the value of Response variable and n is the number of trials.

MRR = Volume of cutting slot / machining time

= (L×W×H)/machining time

Here L=length of slot , W=width of slot H=depth of slot (all in mm)

DATA ANALYSIS :

	Cutting Slot Variables at 3 levels		
Variables	1	2	3
Spinlde Speed (rpm)	1500	2500	3500
DOC (mm)	0.2	0.4	0.6
Feed Rate (mm/rev.)	0.20	0.28	0.36

VALUES OF MRR & Ra IN L9 ORTHOGONAL ARRAY :

SLOT NO.	SPINDLE SPEED(rpm)	DEPTH OF CUT(mm)	FEED RATE (mm/rev)	MRR in mm^3/sec	Roughness (µm)(mean)	S/N for MRR	S/N for Roughness
1	1500	0.2	0.20	12.00	2.38	21.5836	-7.53154
2	1500	0.4	0.28	28.23	2.44	29.0142	-7.74780
3	1500	0.6	0.36	48.00	2.44	33.6248	-7.74780
4	2500	0.2	0.28	20.00	2.42	26.0206	-7.67631
5	2500	0.4	0.36	53.33	2.47	34.5394	-7.85394
6	2500	0.6	0.20	48.00	2.22	33.6248	-6.92706
7	3500	0.2	0.36	30.00	2.49	29.5424	-7.92399
8	3500	0.4	0.20	43.63	2.28	32.7957	-7.15780
9	3500	0.6	0.28	80.00	2.48	38.0618	-7.88903

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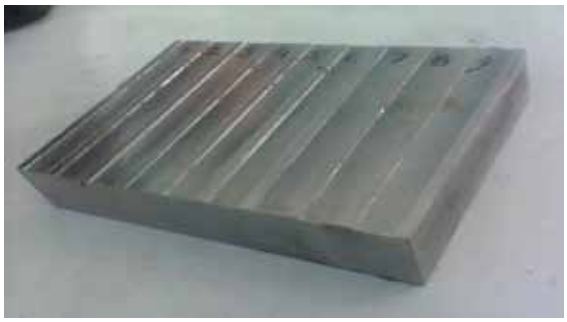


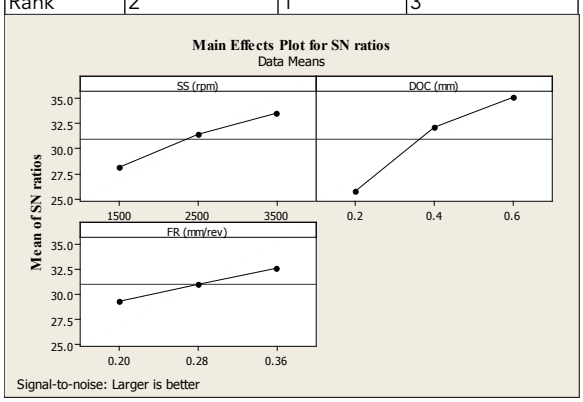
Work Piece Photo (Finished)

RESULT & DISCUSSION :

Selection of Optimum level for MRR :

The below table shows the average of each response characteristics for each level of each factor, including ranks based on delta statistics, which compare the relative magnitude of effects. The delta statistics is the highest minus lowest average for each factor. Minitab assigns the ranks based on delta value, rank 1 to the highest delta value, rank 2 to second highest value and so on. The rank indicate the relative importance of each factor to the response. The rank and delta values for various parameters shows that DOC has greatest effect on MRR followed by SS and feed in that order.

	Response Table for S/N ratio for MRR		
Level	Spindle Speed	Doc	Feed Rate
1	28.07	25.72	29.33
2	31.39	32.12	31.03
3	33.47	35.10	32.57
Delta	5.39	9.39	3.23
Rank	2	1	3



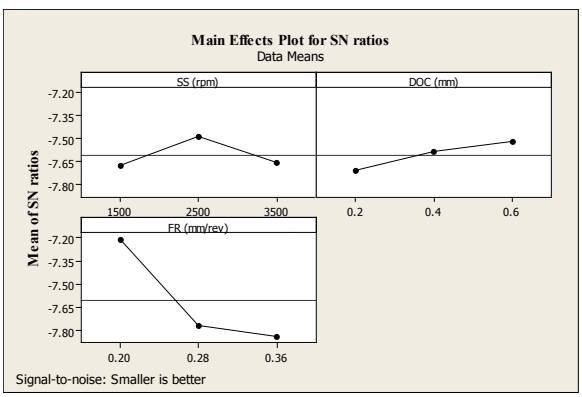
Effect of Process Parameter on MRR :

The above graph shows that the relation between input parameters and the MRR, the larger is the better, and is increase with the increase in DOC, SS and FR. The graph is plotted between S/N ration of MRR versus SS, DOC & FR at 3 levels.

Selection of Optimum level for Ra :

The below table shows the average of each response characteristics for each level of each factor, including ranks based on delta statistics, which compare the relative magnitude of effects.. The rank indicate the relative importance of each factor to the response. The rank and delta values for various parameters shows that FR has greatest effect on Ra followed by DOC and SS in that order.

	Response Table for S/N ratio for Roughness (mean)		
Level	Spindle Speed	Doc	Feed Rate
1	-7.676	-7.711	-7.206
2	-7.486	-7.587	-7.771
3	-7.657	-7.521	-7.842
Delta	0.190	0.189	0.636
Rank	2	3	1



Effect of Process Parameter on Ra :

The above graph shows that the relation between input parameters and the Ra, the Smaller is the better, and is increase with the increase in DOC, and is decreased as increase in FR and SS. The graph is plotted between S/N ration of Ra versus SS, DOC & FR at 3 levels.

CONCLUSION :

Based on study following conclusion are drawn :

From the Response Table for S/N ratio for MRR it is understand that the DOC has more effect than SS, and SS has more effect than FR in controlling the MRR & From the figure it is cleared that optimal cutting conditions for MRR are SS, DOC & FR at level 3.

From the Response Table for S/N ratio for Ra it is understand that the FR has more effect than SS, and SS has more effect than FR in controlling the Ra & From the figure it is cleared that optimal cutting conditions for Ra are SS at level 1, DOC at level 1 & FR at level 3.

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