Surface Roughness on End Milling Process parameter Special Steel (20MNCR5)

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Abstract— In machining to improve machinability, productivity and to extend tool life coolants and lubricants where used. Increasing industry the use of cutting fluids subsequently increasing this leads in reduce of living conditions nearby future all the governments recommend the manufacturers to reduce the usage of toxicity cutting fluids. Still research for dry machining challenge is exiting for the industries, particularly in aerospace engineering. In this study Taguchi method is applied to evaluate the machinability of 20Mncr5 by carbide insert with coolant and compressed air of 1 bar as coolant medium. The experiment carried by orthogonal array, S/N ratio, ANOVAs for optimum machining.

Key words: Dry Machining, Air Coolant Medium, Milling, Optimization

I. Introduction

Taguchi's parameter design has a systematic approach to optimize the parameters in response to quality, cost and performance [1-4]. With P10 carbide insert the hardened steel AISI H13 machined by face milling operation in high speed circumstance the optimised cutting parameters evaluated by Taguchi methodology [5]. In extent design optimization for quality [6] was executed and S/N ratio and ANOVA utilised for experimental result to verify the effectiveness. For AISI 1030 steel bar with Tin-coated tool optimised cutting parameters for turning operation to predict the smaller surface roughness the evergreen Taguchi method is used [7]. Machining hardened steel AISI 4140(63HRC) with AL_2O_3 + TiCN ceramic tool was employed for turning process using Taguchi techniques [8]. Davim et al [9] investigated the machining possibilities on cold work steel where the cutting speed influences in tool wear by evaluating S/N ratio and ANOVA test. To study dry sliding wear on matrix composite material also used [10]. Oktem et al [11] studied to reduce warpage problem by optimizing the plastic injection moulding parameters.

Tool life and surface roughness tested on AISI D2 steel 58 HRC by ball nose end mills with cermet and solid carbide tools. In the Studies on wear pattern the tool wear mechanism on chipping had experimented [12]. Dutta et al [13] investigated progressive flank wear with silver + alumina inserts. Milling of hardened steel under high speed environment the process parameters tool life and surface roughness evaluated [14-20]. PCBN (polycrystalline cubic boron carbide)inserts are ineffective at feed rate (0.08-0.20 mm/rev) and cutting speed (70-90 m/min) which fails by raising flank wear while machining AISI D2 steel [14]. The martentistic stainless steel machined by ceramic cutting tool, the flank wear influences on tool life at speed lesser than 200m/min On turning process the tool life has increased while applying lubricant on flank face was studied by Attanasio et al [16].

AISI D3 cold worked tool steel having 35 HRC is investigated on high speed condition for milling process [17]. The study explains CBN tool has optimum performance over TiCN + AI_2O_3 ceramic insert on comparing with carbide, cermet. For medium alloy steel continuous and interrupted turning process performance investigated by cemented carbide insert [18]. The material AISI 1045 steel machined by coated insert (chromium carbide Cr 10%C) had optimum result on wear resistance in turning process. Simultaneously the insert (Cr50%C) worked on two types of materials that copper and printed board circuit and evaluated both optimums for machining [19]. Milling of hardened steel under maximum speed to evaluate the machinability

In this experiment, the involvement of machining parameters on surface roughness in milling of 20Mncr5 alloy steel with cutting tool ROMU 1605MOER-GH were investigated. Taguchi L18 orthogonal array is employed to conduct experiment. The results of optimum machining obtained from 18 experiments by various process parameters(cutting speed, feed rate, coolant, compressed air). ANOVA has been performed and compared with Taguchi method

II. Methods

A. *Milling*

In wet and dry condition CNC milling machine VM 20 model 3 axis has maximum spindle speed 10000 rpm and a 14.9-KW motor is used. Set-up is made for Face milling to test the material 20Mncr5 having size 200x100x14mm blank and chemical composition of it is table 1. The process for three various cutting speed (380,430,530 m/min) and three various feed rates (0.38,0.43 and 0.53 mm/rev) while the depth of cut made constant at 0.75 mm.

B. *Coolant and cutting tool*

With coolant and without coolant the experimented by using MRX face milling cutter shank type with round insert of 16mm the figure 1 shows. The coolant Neat Cut 25 water soluble is used and for dry machining compressed air of 1 bar is used. The cutting tool ROMU 1605MOER-GH is used.

C. *Surface roughness*

Surface roughness of machined area was tested by portable surface tester of Mitutoyo SJ 210. The roughness tested from various points parallel to machined path and its average is taken for the experiment.

III. DESIGN AND OPTIMIZATION (EXPERIMENT)

A. Design of Experiment Taguchi Method

The Taguchi method is used for effective design and analysis. The factors which cannot be controlled in the effects on process can be minimised and the number of experiments reduces by using orthogonal array. Taguchi method provides simple and systematic work to find and evaluate the optimum parameters in the selected process. The taguchi method uses to find S/N ratio converting the loss function which calculates the deviation between the experimental and desired values. In Taguchi method we have three types of characters on behalf of quality to evaluate S/N ratio the following are nominal the best, higher the better and smaller the better. This study was to minimise the value of surface roughness, taking in account every step of the process the S/N ratio is derived for smaller the better quality as in the equation 1

B. Signal to Noise Ratio: Smaller is better

Formula: $-10\times Log10(sum_{i-n}(Y_i^2)/n)$ (1)

Where y – observed data, i - i_{th} experiment, n- number of observations.

Coolant Neat cut 25 oil is used and the compressed air is used for dry machining, various cutting speed and feed used as factors as shown in table .2

1) Orthogonal array and analysis of S/N ratio

Design Table Taguchi Orthogonal Array Design L18 (2^1x3^2)

Factors: 3 Runs: 18

Run	A	B	C
1	1	1	1
2	1	1	2
3	1	1	3
4	1	2	1
5	1	2	2
6	1	2	3
7	1	3	1
8	1	3	2
9	1	3	3
10	2	1	1
11	2	1	2
12	2	1	3
13	2	2	1
14	2	2	2
15	2	2	3
16	2	3	1
17	2	3	2
18	2	3	3

Table 3: Factorial Design Columns of L18 (21x 32) Array 1 2 3

Run – Experiment, A- Coolant factor, B- C/S factor, C-Feed factor

For quality improvement on the product and reducing cost on production is aim, hence the smaller the better equation is used to evaluate S/N ratio. Through the S/N ratio the optimised control factor which has smaller effect is evaluated the table. 4 show the S/N ratio. The average value of S/N ratio was calculated as 0.54µm similarly the average value of S/N ratio 5.345 db correspondingly. Signal and noise ratio response for surface roughness over the factors was conducted the table 5 shows the details. The graph is executed to find the optimum levels for surface roughness. The optimised machining parameters in minimizing the surface roughness can be found easily through the graph. According to the graph fig : 2 and the table : 5 of S/N ratio the optimised Ra value produced from as follows factor A (level 1, S/N = 5.583), factor B (level 3, S/N= 5.797), factor C (level 1 ,S/N= 6.724) , the optimum Ra value obtained from pressured air coolant medium(A1) comparing to the coolant neat cut 25 oil at cutting speed 530m/min(B3) and feed rate 0.38mm/rev (C1).

IV. ANOVA ANALYSIS

To define interactions for control factors in this experiment ANOVA tool is effectively utilised to analyse the impact of coolant, cutting speed and feed with surface roughness. The experiment carried for 5% significant level and 95% confidence level. By comparing the F data's with all factors the significance of control is evaluated. The P value indicates the influence on performance. The p value from table refers the factors A B C on influence of surface roughness respectively 0.013, 0.001, 0.000. The factor C has 0.000 which affects the surface roughness. Since the error has no "P" value the error is negligible.

V. TABLE & FIGURE

C	Si	Mn	S	P	V	Pb	Cr	Mo	N
0.37	0.40	1.50	0.07	0.015	0.011	0.18	0.12	0.035	0.020

Table 1: Chemical composition of 20Mncr5 (wt%)

Fig. 1: MRX cutter for face milling with round carbide insert.

Factor(symbol)	Level1	Level2	Level3
Coolant(A)	Air	Coolant Neat cut 25	
Cutting speed (B) m/min	380	430	530
Feed rate (C) mm/rev	0.38	0.43	0.53

Table 2 Milling parameters and levels

A	B	C	Ra	SNRA1
1	380	0.38	0.48	6.37518
1	380	0.43	0.56	5.03624
1	380	0.53	0.69	3.22302
1	430	0.38	0.44	7.13095
1	430	0.43	0.50	6.02060
1	430	0.53	0.64	3.87640
1	530	0.38	0.43	7.33063
1	530	0.43	0.48	6.37518
1	530	0.53	0.57	4.88250
2	380	0.38	0.49	6.19608
2	380	0.43	0.55	5.19275
2	380	0.53	0.74	2.61537

2	430	0.38	0.48	6.37518
2	430	0.43	0.53	5.51448
2	430	0.53	0.64	3.87640
2	530	0.38	0.45	6.93575
2	530	0.43	0.53	5.51448
2	530	0.53	0.65	3.74173

Table 4 S/N ratio values.

A-coolant factor, B-c/s factor m/min, C-feed mm/rev, Ra-surface roughness, SNRAI-signal noise ratio

LEVEL	A	B	C
1	5.583	4.773	6.724
2	5.107	5.466	5.609
3		5.797	6.724
DELTA	0.476	1.024	3.021
RANK	3	2	1

Table 5 Response Table for Signal to Noise Ratios Smaller is better

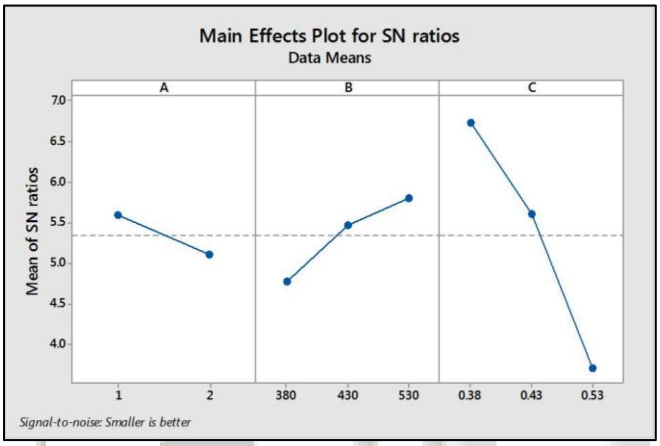

Figure 2

Analysis of Variance for surface roughness.

Source	DF	SS	MS	F-VALUE	P-VALUE
A	1	0.004050	0.004050	8.54	0.013
B	2	0.014044	0.007022	14.81	0.001
C	2	0.116578	0.058289	122.95	0.000
Error	12	0.005689	0.000474		
Total	17	0.140361			

DF-degree of freedom, SS-sum of square, MS-mean square

VI. CONCLUSION

In this experiment taguchi method is used to determine the optimal machining parameter on milling of 20Mncr5 with coolant and air medium by carbide insert. The following result evaluated using ANOVA. The optimum possibility to minimize the surface roughness were observed from S/N ratio is $A_1B_3C_1$ that is air medium (A_1), 530m/min (B_3), 0.38mm/rev (C_1) and $A_1B_3C_1$ similarly air medium (A_1), 430m/min (B_2) and 0.38 mm/rev (C_1) respectively. So by this experiment we can study that air medium has better performance regarding surface roughness could be recommended as coolant for machining in milling process. The result gives us that the feed rate plays major role on surface roughness. The Taguchi methodology reduces machining time and control cost against manufacturing, in future the experiment can be carried out on other operating process like turning and drilling.

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