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Comparative Performance Analysis of Cryogenic Treated Carbide Tools

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Abstract – Surface roughness became important issue for industries for sustainable manufacturing. Surface finish became improve by using method such as optimal cutting condition, cutting fluid, coatings and heating process. Another method tool life became improvement such as cryogenic treatment .Metal cutting operation it became necessary to reduce surface roughness and improve the product quality. A comparative investigation of the R_a (surface roughness) behaviour of with cryogenically tungsten carbide inserts and without cryogenically tungsten carbide inserts in dry machining. The tungsten carbide inserts square-shaped and cryogenic has done at −196 °C. Experimental has designed by Taguchi's L9 orthogonal array. ANOVA analysis machining parameters has affected on the Ra . The analyzed result was using ANOVA and signal-to-noise ratios (S/N) and with cryogenic tungsten carbide inserts better result compared to that without uncryogenic tungsten carbide inserts in machining conditions .In cryogenic depth of cut has maximum affected on R_a.

Index Terms – Analysis, with Cryogenic and without cryogenic treatment carbide tools, Surface roughness.

1. INTRODUCTION

Cryogenic treatment has used to observed that the tool life improve up to 39% for EN24 and 90% for soft material AISI 1040[1]. It has observed that best parameter has used for machining then improve the tool life and improve surface quality[2].It has observed that optimal cutting parameter at obtained maximizing MRR and minimum R_a and tool wear [3]. It has observed that online monitoring system used improve surface finish and reduce tool wear. [4].It has observed that cutting speed and feed rate effected on R_a[5]. It has observed that depth of cut most affected factor on cutting fouce(Fc) and feed rate most affected factor on surface roughness.[6]. It has observed that increase cutting speed and decrease in feed rate minimum surface roughness [7]. It has observed that minimum quantity lubrication used to increase the overall effectiveness [8].Cryogenic process has used to improve hardness of material [9]. Deep cryogenic temperature has used from -125 °C to -196 °C temperature and improve the hardness of material [10,11]. Cryogenic treatment are used for improve of properties of tool. Cryogenic temperature are used for made of hard tool and temperature limit highest has used -196 ˚C. [12]. finally has analyzed that depth of cut most affected on R_a (surface roughness) [13]. It has observed that increase speed and decrease in feed rate obtained minimum R_a (surface roughness) [14]. Cryogenic treatment are used for improve of properties of tool. Cryogenic temperature are used for made of hard tool and temperature limit highest has used -196 ˚C [15]. It has observed that cryogenic tool life increase 14% to 218% and better result has obtained as minimum tool wear, minimum R_a and maximum MRR [16]. It has observed that cryogenic result has best compare to conventional coolant tool and in the cryogenic cutting parameter has evaluated best as maximum MRR, minimum tool wear, and minimum Ra (surface roughness)[17]. It has observed that reduce the tool wear then cryogenic tungsten carbide inserts by applying coolant [18]. It has investigation of the turning of C45steel; WC inserts after cryogenic treatment at196 ˚C for 38h after improve the tool life 20%to 36%. [19]. It has observed that optimal cutting parameter has obtained by design of experiment method. This cutting parameter has useful for cutting of the work piece material [20].

1.1 Experimental Conditions and Procedures

Investigation of the R_a and material with respect to machining time for without cryogenic tungsten carbide and with cryogenic WC (tungsten carbide) inserts in machining of AISI 316 stainless steel (36 ± 2 HRC) in dry condition. The surface roughness has been measured by the MITUTOYO surface tester. In this study, parameter range (v = 70, 90,120 mm/min, f = 0.1, 0.24, 0.48 mm/rev and d = 0.4, 0.8, 1.2 mm) were taken to measure its performance in machining. The details of instrumentations and measurements and the procedure used for the investigation are discussed.

1.2. Test Specimen

AISI 316 stainless steel has used for test of composition and length 100 mm and 30 mm diameter cut of material 50mm. The work piece chemical composition has measured by Scanning electron microscopy (SEM). Work piece material hardness has found to be 36 ± 2 HRC after measurement by hardness tester. Work piece Specification Shown in Table 1.

Table 1 Work piece Specification

Specification of Work Piece Material	Chemical Composition in %	
AISI 316	Fe	0.67
	Cr	17.92
	Ni	11.07
	Si	0.86
	Mn	1.04
	P	0.07
	S	0.53
	Mo	1.47
Diameter	30 mm	
Length	100 mm	

1.3. Cutting Inserts

In tests, available uncryogenic tungsten carbide inserts and cryogenic tungsten carbide inserts (manufactured by TAEGU TEC) of ISO designation CNMG 120408 FA grade - TT5100 (squared shaped insert) have been used for experimentation. Deep cryogenic treatment has cooled to cryogenic temperature -196 °C, these temperatures has held generally for 72h and then gradually heated to room temperature.

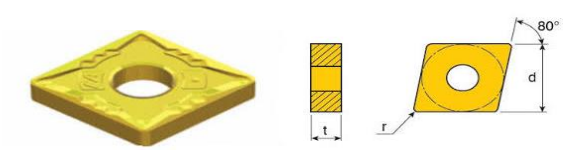

Fig.-1: Photograph of cutting inserts

1.4. Surface Roughness Measurements

Surface roughness is the main objective for every machine component. For every product surface quality is main important.Surface roughness of the finished components are also measured. For every cutting process the R_a are measured thrice for a component and the average of the process is taken as the output surface roughness for that run. Surf test SJ-301 model of Mitutoyo is used for measuring the surface roughness.

2. RESULTS AND DISCUSSION

Surface roughness experimental results has show of at different cutting speed (A) (mm/min) and depth of cut(C) (mm), feed rate (B) (mm/rev) during machining for both with cryogenic tungsten carbide inserts and without cryogenic tungsten carbide inserts are show in Table 3. S/N ratios has used to obtained optimal parameter. ANOVA analyzed has affected factor on R_a.

The summary of experimental designed by Taguchi L9 is presented below:

Table -2:

Sr. No.	A	B	C
1	70	.1	.4
2	70	.24	.8
3	70	.48	1.2
4	90	.1	.8
5	90	.24	1.2
6	90	.48	.4
7	120	.1	1.2
8	120	.24	.4
9	120	.48	.8

Table -3:

Test Run	Cryogenic Experimental value	uncryogenic Experimental value
	R_a (μm)	R_a (μm)
1	0.95	0.96
2	2.15	2.17
3	4.12	4.15
4	0.84	0.83
5	1.95	1.97
6	3.76	3.79

7	0.59	0.63
8	1.62	1.65
9	3.54	3.58

3. SIGNAL TO NOISE RATIOS

It was used to analyze best parameter for the cutting process. Cutting parameter that corresponds to highest value of 'signal to noise is the best level of combination. The best parameter setting is found in cryogenic to be level 2 cutting speed and 1 feed rate and level 3doc, for minimum surface roughness. The best parameter setting is found in uncryogenic inserts to be level 1 feed rate and level 2 cutting speed, level 3 doc for minimum R_a.

Table- 4: with cryogenic inserts Surface roughness response table based on S/N ratios.

Level	A	B	C
1	-6.167	2.181	-5.083
2	-5.263	-5.547	-5.371
3	-3.529	-11.594	-4.505
Delta	2.638	13.775	0.866
Rank	2	1	3

Table- 5: without cryogenic inserts Surface roughness response table based on S/N ratios.

Level	A	B	C
1	-6.245	1.995	-5.189
2	-5.281	-5.656	-5.396
3	-3.805	-11.670	-4.746
Delta	2.440	13.666	0.650
Rank	2	1	3

4. MAIN EFFECT PLOT ANALYSIS

MINITAB-16 software package has used for analyzed cutting parameter. The plot of main effect is shown in fig.2and 3 . Three output parameter such as cutting speed (A) and DOC(depth of cut) (C), feed rate (B). Signifies value in the plot x-axis of each process parameter and signifies value in the plot y-axis value of the response value. Horizontal line has indicated mean of the response. From with cryogenic inserts main effect plot has analyzed the optimal parameter to get minimum R_a (surface roughness). Main effect plot has indicated best parameter for minimum R_a (surface roughness) are cutting speed at level 2(120 mm/min), feed rate at level 1 (0.10 mm/rev), DOC at level 3 (1.2 mm).From without cryogenic inserts main effect plot has analyzed the optimal parameter conditions to R_a (surface roughness). Main effect plot has indicated best parameter for minimum surface roughness are cutting speed at level 2(120 mm/min), feed rate at level 1 (0.10 mm/rev), DOC at level 3 (1.2 mm).

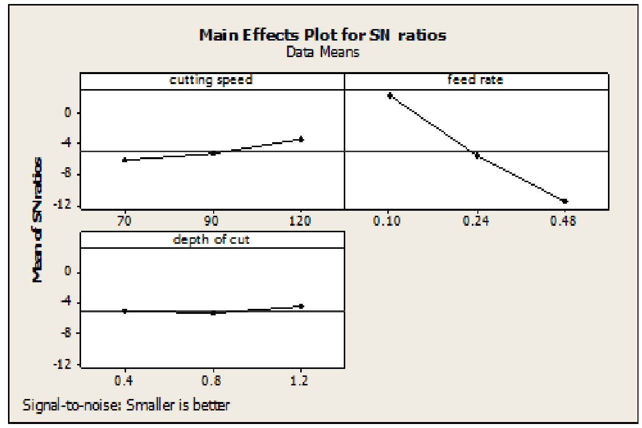

Fig-2: with cryogenic inserts effect of turning parameter on surface roughness

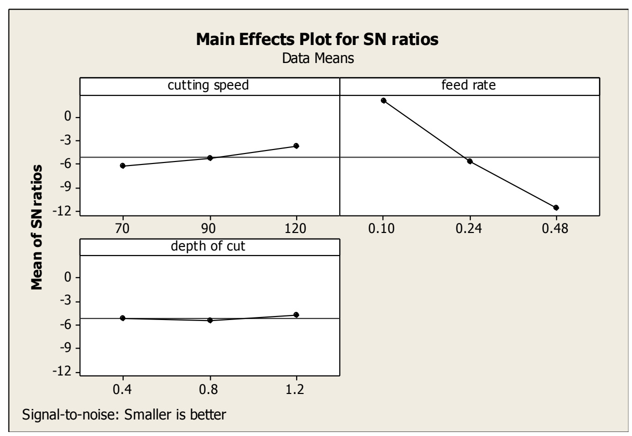

Fig-3: From without cryogenic inserts effect of turning parameter on surface roughness

5. ANOVA AND THE EFFECTS OF FACTOR

The general linear model procedure has used to conduct an ANOVA test which requires a response or measurement taken and the factor on which the response varies. In order to find out affected factor such as cutting speed (A), Feed rate (B), and DOC (C), analysis of variance (ANOVA) is performed on experimental data. Table 6 and 7 ANOVA result for the R_a. The P-column of the Table 6 and 7 indicated the percentage contribution of the control factor and their interaction on the performance output. With cryogenic insert table 6 it can be observed that for R_a among the three value of factor the contribution percentage of Feed rate is 0.000, depth of cut has .151 and Cutting speed has .009, thus DOC has the maximum influence on Surface R_a.

Table -6: From with cryogenic inserts for ANOVA for R_a.

Level	DF	Seq.SS	Adj.SS	Adj.MS	F	P
A	2	0.3611	0.3611	0.1805	109.79	0.009
B	2	13.9297	13.9297	6.9648	4235.38	0.000
C	2	0.0184	0.0184	0.0092	5.60	0.151
Error	2	0.0033	0.0033	0.0016		
Total	8	14.3125				

Table -7: From without cryogenic inserts for ANOVA for R_a..

Level	DF	Seq.SS	Adj.SS	Adj.MS	F	P
A	2	0.3362	0.3362	0.1681	135.06	0.007
B	2	14.1111	14.1111	7.0555	5669.63	0.000
C	2	0.0204	0.0204	0.0102	8.21	0.109
Error	2	0.0025	0.0025	0.0012		
Total	8	14.4702				

without cryogenic inserts table 7 it can be observed that for R_a among the three value of factor the percentage contribution of Feed rate is 0.007, DOC has 0.000 and Cutting speed has .109, thus Cutting speed has the maximum influence on R_a.

In Table 6 and 7: Df: Degree of Freedom; Seq.SS: Sequential Sum of Squares; Adj.SS: Extra Sum Of Squares; Adj.MS Extra Mean Square; F: Factor; P: Level Of Significance.

6. COMPARISONS

Comparisons between with cryogenic tungsten carbide insert and without cryogenic tungsten carbide insert behavior of R_a in dry machining. The result of the Taguchi analysis after the optimal parameter has obtained in the with cryogenic. The minimum R_a characteristics obtained was at feed rate 0.10mm/rev and DOC 1.2 mm, cutting speed 120 mm/min.

7. CONCLUSIONS

The conclusions can be obtained from this investigation on turning of hardened AISI 316 stainless steel using non cryogenic and cryogenic tungsten carbide inserts at different cutting parameters: The following conclusion can be drawn based on the analyses of the turning operations:

1. S/N ratio graph has analyzed the optimal setting of the influencing parameter for R_a in with cryogenic are: cutting speed 120 mm/min and feed rate 0.10mm/rev and DOC 1.2.mm
2. From ANOVA in with cryogenic it is found that in turning, DOC has the most affected on the surface roughness respectively.

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