An Experimental Analysis of End Mill Cutter for AISI 316 using Regression

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Abstract— Quality and productivity play important role in today's manufacturing market. Now a day's due to very stiff and cut throat competitive market condition in manufacturing industries. The main objective of industries reveal with producing better quality product at minimum cost and increase productivity. CNC end milling is most vital and common operation use for produce machine part with desire surface quality and higher productivity with less time and cost constrain. To obtain main objective of company regards quality and productivity. In the present research project an attempt is made to understand the effect of machining parameters such as cutting speed (m/min), feed rate (mm/min),depth of cut (mm), four no. of cutting flute that are influences on responsive output parameters such as Surface Roughness by using optimization philosophy. The effort to investigate optimal machining parameters (Speed, Feed and Depth of cut) and their contribution on producing better Surface quality and higher Productivity.

Key words: CNC End milling, Surface roughness, AISI 316, Minitab

I. Introduction

Milling is the process of machining flat, curved, or irregular surfaces by feeding the work piece against a rotating cutter containing a number of cutting edges. The milling machine consists basically of a motor driven spindle, which mounts and revolves the milling cutter, and a reciprocating adjustable worktable, which mounts and feeds the work piece. Among several CNC industrial machining processes, milling is a fundamental machining operation. End milling and face

Milling is the most common metal removal operation encountered. It is broadly used in a variety of manufacturing industries including the aerospace, automotive sectors, where quality is vital factor in the production of slots, pockets, precision moulds and dies [1].

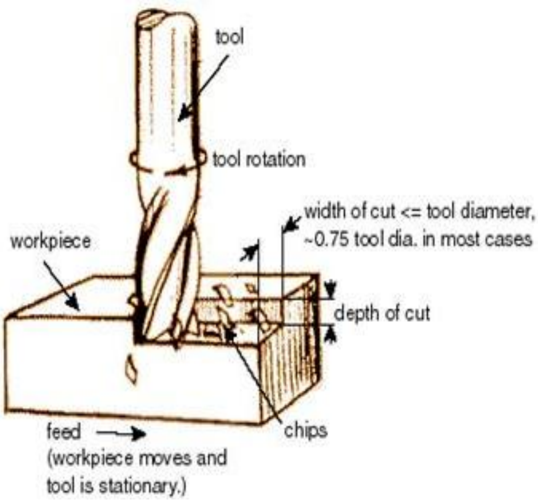

Fig. 1.1: Milling Operation

II. Objective of Topic

- To study the effect of Solid carbide tool on end milling of AISI 316 in dry machining.
- To compare the outcomes resulting from Solid carbide tools while milling of AISI 316.
- To decide the range of machining parameter (feed, speed, depth of cut) by which one can optimize the performance of AISI 316.
- To evaluate the effect of cutting conditions on surface roughness of solid carbide tools in end milling of AISI 316.
- To measure the Surface Roughness surface roughness tester.
- Compare the Experimental and predicted values of surface roughness.

III. Scope of Topic

The scope of this research is focused on milling of AISI 316 using solid carbide tools. The processes will be conducted under various independent variables which include cutting speed, feed rate, and depth of cut. At the end of the study the performance of each cutting tool will be compared by observed data while milling process on CNC. Finally measurement of Surface roughness will be carried out using surface roughness tester.

IV. Surface Roughness

Roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. Surface roughness is an important parameter of quality of work piece surface and has so much effect on final function and production cost of pieces, and also on mechanical properties such as fatigue life, corrosion resistance, and creep resistance and on the other features of the piece like as friction, lubrication, electrical conductivity and so on. Hence it is necessary to carried out on 2 odelling surface roughness and optimizing and controlling the parameters in order to find ideal surface roughness through choosing correctly the machining parameters. If these deviations are large, the surface is rough; if they are small the surface is smooth.

V. Literature Survey

S.kalidass, at el.[2] were carried out "Prediction of tool wear using regression and artificial neural network models in end milling of AISI 304 Austenitic Stainless Steel" They describe use and steps of four factors at five level design of experiments to find a specific range and combinations of machining parameters like spindle speed, feed rate and depth of cut to achieve optimal values of response variables like Roughness parameters (Ra) in machining of material AISI 304.Six Sigma software was used for finding the coefficients to develop the regression model. Artificial neural network is used to predict the tool wear, Predicted values of response by both models, i.e. regression and ANN are compared with the experimental values. The predictive neural network model was found to be capable of better predictions of tool flank wear within the trained range.

JigneshG. Parmar&Prof.AlpeshMakwana, [3] were carried out"Prediction of surface roughness for end milling process using Artificial Neural Network". They describe to prediction surface roughness for end milling process by using artificial neural network analysis. The neural network model can be effectively find the best cutting parameters value for a specific cutting condition in milling operation and achieve minimum surface roughness. In this experimental investigation of the end milling of M.S material up to 30 HRC with carbide tool by varying feed, speed and depth of cut and the surface roughness was measured using Mitutoyo Surface Roughness Tester. The neural network design and development was done using MATLAB. Neural Network Fitting Tool Graphical User Interface is used to establish the relationship between the surface roughness and the cutting input parameters (spindle speed, feed and depth of cut). The result from this research is useful to be implemented in industry to reduce time and cost in surface roughness prediction.

VI. EXPERIMENTAL SETUP

Machining experiments have been carried out in a Pinnacle LV117 vertical machining centre as per the design matrix on AISI 316 Austenitic Stainless Steel work piece using an uncoated solid carbide end mill cutter with a diameter of 10 mm and having 4 flutes. The dimensions of the work piece specimen were 50 mm X 10 mm in cross section and 115 mm in length

AISI 316	Carbon	0.026 %
	Manganese	1.010 %
	Phosphorus	0.028 %
	Sulphur	0.011 %
	Silicon	0.380 %
	Chromium	16.490 %
	Nickel	10.130 %
	Molybdenum	2.060 %

Table 1.1: Chemical Composition of AISI 316

Sectional dimension, width & thickness	38.00 & 9.81 mm
Gauge length	50 mm
Final gauge length	77.2 mm
Yield load	117.78KN
Ultimate yield load	214.05 KN
Yield stress	315.79 MPa[205 Mpa min.]
Ultimate tensile stress	574.19 Mpa [515 Mpa min.]
Hardness in HRB	84/84/85[95 max.]
% Elongation	54.4 [40 min.]

Table 1.2: Mechanical Composition of AISI 316

The machining is carried out by selecting proper spindle speed and feed rate during each experimentation. Experiment was carried out by varying the depth of cut.

Cutting parameter	Unit	Level	Factors of level				
			I	II	III	IV	V
Cutting Speed (v)	rpm	5	2500	3000	3500	4000	4500
Feed rate (f)	mm/min	5	200	400	600	800	1000
Depth of cut (d)	mm	5	0.1	0.2	0.3	0.4	0.5

Table 1.3: Cutting process variables and their levels

Surface roughness values of work pieces were measured by Mitutoyo Surface Roughness Tester by a proper procedure while measuring instrument.

VII. RESULT AND DISCUSSION

The experimental investigation on machinability characteristics of AISI 316 steel with end milling

Sr. No.	Speed (rpm)	Feed (mm/min)	Depth of cut (mm)	Experimental Surface roughness Value Ra (µm)
1	2500	200	0.1	0.237
2	2500	400	0.2	0.359
3	2500	600	0.3	0.584
4	2500	800	0.4	0.824
5	2500	1000	0.5	1.410
6	3000	200	0.2	0.894
7	3000	400	0.3	1.164
8	3000	600	0.4	0.699
9	3000	800	0.5	1.338
10	3000	1000	0.1	1.210
11	3500	200	0.3	0.952
12	3500	400	0.4	0.286
13	3500	600	0.5	0.389
14	3500	800	0.1	0.633
15	3500	1000	0.2	1.043
16	4000	200	0.4	0.220
17	4000	400	0.5	0.346
18	4000	600	0.1	0.381
19	4000	800	0.2	0.694
20	4000	1000	0.3	0.279
21	4500	200	0.5	0.191
22	4500	400	0.1	0.177
23	4500	600	0.2	0.434
24	4500	800	0.3	0.344
25	4500	1000	0.4	1.640

Table 1.4: L25 Orthogonal Array for Solid Carbide Tool

Cutter during milling process was optimized the milling parameters and predict low surface roughness based on taguchi prediction that the bigger different in values of S/N ratio shows more effect on surface roughness (Tables 4 and 5). It can be calculated and concluded by spindle speed is more significant factor and give most contribution on surface roughness of AISI 316 steel plates.

Level	Cutting Speed	Feed	Depth of Cut
1	4.9544	8.2873	7.6487
2	-0.2840	8.5421	3.9857
3	4.6214	6.3230	4.8273
4	9.0025	3.1132	4.9039

5	8.3284	0.3571	5.2571
Delta	9.2865	8.1851	3.6629
Rank	1	2	3

Table 1.5 Response Table for S/N. (Smaller is better)

Figure 1.2-1.3 shows the Minitab window which shows the creation of design and S/N ratioand Meandata.

sources	DF	Seq SS	Adj SS	Adj MS	F	P
Cuttig speed	4	1.2382	1.2382	0.3096	2.42	0.106
Feed rate	4	1.5458	1.5458	0.3864	3.02	0.061
Depth of cut	4	0.1440	0.1440	0.0360	0.28	0.864
Error	12	1.5341	0.5341	0.1278		
Total	24	4.4620				

Table 1.6: Analysis of Variance for Surface Roughness of AISI 316

The result of S/N ratio values of milling parameters were analysed by analysis of variance method which consists of DOF (Degree of Freedom), S (sum of square), V (Variance) F (variance ratio) and P(significant factor) (Table6). in most significant values were selected by 5% (α= 0.05) from this main effect interaction plot values of milling parameters predict the low value of surface roughness as indicate at spindle speed of 4000 rpm, feed rate 400 mm/min and depth of cut 0.1mm were the best combinations of this experimental work (Figures 1.4). [4].

VIII. Regression Equation

Ra = 0.71922 (Constant) + (- 0.00018564)(SPEED) + 0.0007677 (FEED) + 0.4634 (DOC)

Term	Coef	SE Coef	T	P
Constant	0.719220	0.424731	1.69335	0.105
Speed	-0.000186	0.000102	-1.81532	0.084
Feed	0.000768	0.000256	3.00284	0.007
Depth of cut	0.463400	0.511316	0.90629	0.375

Table 1.7: Regression Equation

A. *Main Effects Plot for SN Ratios:*

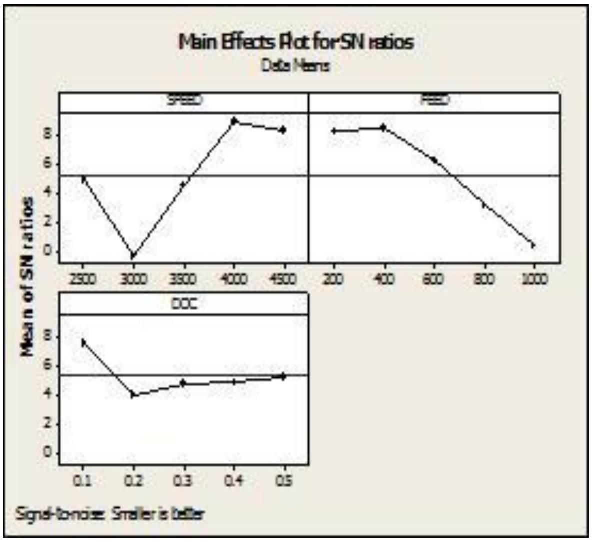

Fig. 1.2: S/N Ratio for Milling Parameter

B. *Analysis of Main Effects Plot for Means:*

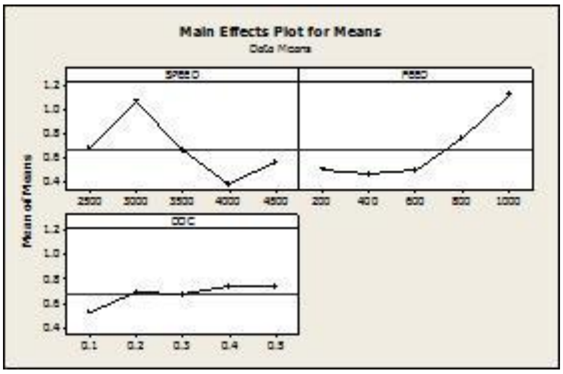

Fig. 1.3: Mean Plot for Milling Parameter

C. *Residual Plot for Ra:*

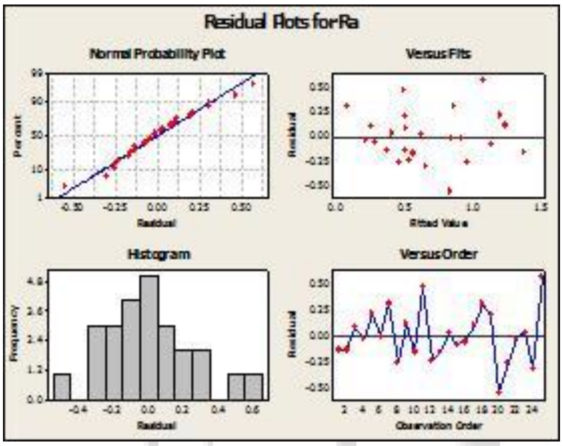

Fig. 4: Residual Plot for Ra

IX. Conclusion

The following conclusions can be drawn based on the results of experimental study on machining AISI 316 steel during milling process using end milling cutter.

– Cutting speed is statistically significant factors influencing the surface roughness in milling process.
– The low surface roughness is obtained at cutting speed of 4000 rpm, feed rate 400 mm/min and depth of cut 0.1 mm. This may be ideal machining parameters of AISI 316 steel plates.
– Milling process is best suitable marching process of AISI 316 steel other than conventional machining process such as turning, planning and shaping process.
– End milling cutter is suitable for machining AISI 316 steel which produce good surface finish with required accuracy.
– These models can be used to prediction of surface roughness in end milling process

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