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Optimization of Surface Roughness of Al2014 T651 Alloy by using Taguchi Method

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Abstract – Present work include understanding in End Milling machining on the surface roughness of finished product effects of various parameters such as spindle speed, feed rate and depth of cut on the surface roughness of AL2014 T651 ALLOY by using Taguchi method. The experimental plan was based on the Taguchi's Technique including L9 orthogonal array with three factor and studying the contribution of each factor on surface roughness. The experimental were conducted on AL2014 T651 ALLOY material on CNC milling machine using carbide tool inserted. An approach which determine the best cutting parameter, which are leading the minimum surface roughness during machining of AL2014 T651 ALLOY material. The roughness is helping to increase the quality of product which helps to satisfy the need of customer. The analysis of signal to noise ratio and analysis of variation technique is employed to significance of each machining parameters on the surface roughness. The result indicated that speed with contribution of 64.64% is most important parameter for surface roughness. The optimal parameter for surface roughness is obtained as cutting speed 1000 rpm, feed rate 750 mm/min and depth of cut 0.25 mm.

Keywords : Carbide inserts, CNC milling machine, L9 Orthogonal Array, Taguchi Method.

I. INTRODUCTION

For success of manufacturing organization finding the optimum balancebetween higher production rate and improved quality in most important objective. The metal cutting industry continue to improve the quality control of metal cutting during machining. Productivity can be interpreted in term of material removal rate in machining process and quality represent represents the product characteristics as desired by the customer which will give competitive edge over the competitors. In end milling, surface finish and material removal rate are two significant parameters, which are focus for manufacturing as well as in Research & Development, because two factors extremely effect the machining efficiency. In case of End milling operation, material are removed from the work piece by using multi point cutting tool. End milling machining is the most important machining for metal removing. To increase the efficiency of the machine is important to find out the best cutting parameter before machining of work piece for obtaining minimum surface roughness and to increase the quality of product. The major parameter that are considered for minimizing surface roughness i.e. cutting speed, feed rate and depth of cut. The effect of other influencing parameter such as operator skill, type of coolant, type of tool, condition of machining are not to be considered. Only surface roughness considered response. End milling machine with carbide tool of 20 mm diameter. Surface roughness has been calculated by using three set of parameters.

II. MATERIAL AND METHOD

Following material are used for experimentation a carbide insert tool and 20 mm diameter was used and the work piece material used AL2014 T651 ALLOY of 112x106 mm flat piece. The composition of material in percentage as shown in below table.

Table 1: Chemical Composition of Aluminium 2014 T651 Alloy

Silicon	0.7
Iron	0.3
Copper	4.2
Manganese	0.6
Chromium	0.02
Zinc	0.14
Titanium	0.06
Magnesium	0.5

Taguchi Method is involved via Dr. Genichi Taguchi, a Japanese first-class management representative. This method based on ORHOGONAL ARRAY which give must reduced 'variance' for the

experiment with optimum setting of control parameters. The Design of Experiment with optimization of control parameter to obtained best result is achieved in Taguchi Method. (Smaller is better)

$$SNR = -10\log 1/n\sum y^2$$

This is usually chosen S/N ratio for all undesirable characteristics like defect etc. for which idea value is zero.

III. EXPERIMENTAL DETAILS

Present work involves the optimization of surface roughness in the milling process which are depends on factor such as cutting speed, feed rate and depth of cut.

Table 2: For Process Pararmeter and Level

Factors	Levels	Factors Level value
Speed (rpm)	3	500 750 1000
Depth of Cut (mm)	3	0.75 0.50 0.25
Feed (mm/min)	3	750 1000 1250

The parameters which influence the surface roughness of machined surface called control parameters such as speed, feed rate and depth of cut. L9 Orthogonal array was used for milling the wok piece with carbide inserts.

Table 3: Orthogonal Array L9

Sample No.	Spindle Speed (rpm)	Feed Rate (mm/min)	Depth of Cut (mm)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	2
9	3	3	1

The design of experiment chosen for End Milling operation of AL2014 T651 ALLOY material was adopted Taguchi Method L9 orthogonal array, by carrying out of total no. 9 experiment.

Table 4: Design of Experiment

Pieces	Speed (rpm)	Feed Rate (mm/min)	Depth of Cut (mm)
1	500	750	0.75
2	500	1000	0.50
3	500	1250	0.25
4	750	750	0.50
5	750	1000	0.25
6	750	1250	0.75
7	1000	750	0.25
8	1000	1000	0.50
9	1000	1250	0.75

IV. EXPERIMENT RESULT AND DISCUSSION

By performing nine experiment the value of surface roughness for each experiment is measured by using surface roughness tester. The experimental data of surface roughness is analyzed by using Taguchi design in Minitab software and signal to noise ratio value are determined based on obtained S/N ratios. The signal to noise ratio for each experimental run are calculated by using the following equation

$$SNR = -10\log 1/n\sum y^2$$

Table 5: Response Obtained from Experimental Run

Pieces	Speed (rpm)	Feed Rate (mm/min)	Depth of Cut (mm)	Ra	SNR1
1	500	750	0.75	0.81	1.83030
2	500	1000	0.50	0.83	1.61844
3	500	1250	0.25	0.73	2.73354

4	750	750	0.50	0.63	4.01319
5	750	1000	0.25	0.57	4.88250
6	750	1250	0.75	0.69	3.22302
7	1000	750	0.25	0.46	6.74484
8	1000	1000	0.50	0.63	4.01319
9	1000	1250	0.75	0.63	4.01319

Table 6: Smaller Is Better

Level	SPEED	FEED	DOC
1	2.061	4.196	4.787
2	4.040	3.505	3.215
3	4.924	3.323	3.022
Delta	2.863	0.873	1.765
Rank	1	3	2

Table 6 give the rank parameter for surface roughness speed and depth of cut is the most significant parameters where as the feed is the least parameters.

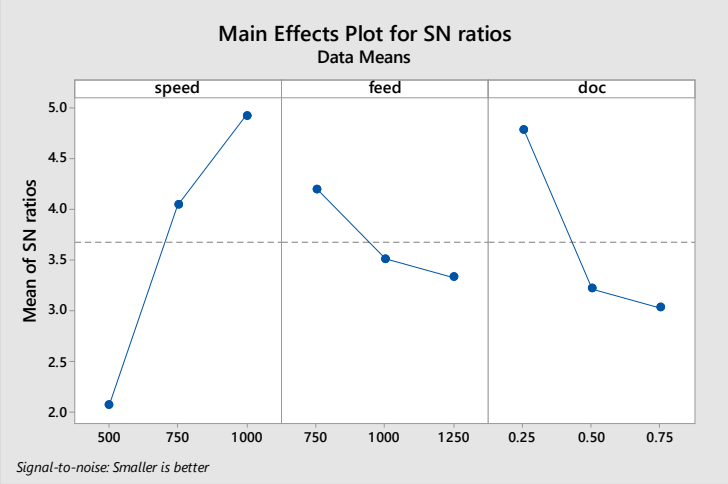
Analysis of Variance (ANNOVA)

The main purpose of analysis of variation is to investigates the influence of the design parameter on surface roughness by indicating that parameter is direct significantly affected the quality characteristics.

Table 7: Anova for S/N Ratio

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Speed	2	12.8941	64.64%	12.8941	6.4471	64.45	0.015
Feed	2	1.2728	6.38%	1.2310	0.6155	6.15	0.140
Doc	2	5.5811	27.98%	5.5811	2.7905	27.90	0.035
Error	2	0.2001	1.00%	0.2001	0.1000		
Total	8	19.9481	100.00%				

From table 7 speed (p=0.015) is most significant parameter having 64.64% contribution on surface roughness. The various contribution of the process parameter on above response analysis of variation table. From table we found that the speed is significantly effect on Surface Roughness with contribution 64.64% , depth of cut contribution 27.98% and feed 6.38% with 1.0% error. The above table give the result of analysis of variation (ANNOVA) for surface roughness.. In our experimental work, we have generated result for S/N ratio of surface roughness.



The experimental result show the average surface roughness low at higher speed and lower depth of cut. ANNOVA show the speed is the most influence parameters for surface roughness. Optimum parameters setting for surface roughness is

Table 8: For Optimum Parameters of Surface Roughness

Speed (rpm)	Feed (mm/min)	Depth of Cut (mm)	Ra (um)
1000	750	0.25	0.46

V. CONCLUSION

In end milling of AL2014 T651 ALLOY, the conclusion are made drawn using experimental observation- The response parameter surface roughness mostly affected by speed.

1. Cutting speed effect the surface roughness. During machining experimental results show cutting speed is high and minimize the surface roughness of work piece.
2. Depth of cut effect the surface roughness. During machining The experimental results show the average surface roughness low at lower depth of cut.
3. For achieving good surface finish on the ALUMINIUM 2014 T651 ALLOY work piece, higher cutting speed, lower feed and lower depth of cut are preferred. The optimal parameter combination for ALUMINIUM 2014 T651 ALLOY is S3F1D1.
4. ANOVA shows that the cutting speed is the most influence parameter for surface roughness.

   Mean absolute error pressure is calculated 1.0% in case of surface roughness.

VI. FUTURE SCOPE

The work can be extended to study the effect of input parameter on surface roughness . The effect of input parameters can also be extended to determine the vibration, noise. Measured values vibration and noise can be used as a input parameter to increase the accuracy of prediction. The present study is based on dry machining in end milling process AL 2014 T651 Alloy materials. This work has scope of extension in end milling process using coolants with tool and the effect of coolant properties in prediction of output cutting parameters such as tool wear and surface roughness.

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