Optimization of Material Removal Rate of Al2014 T651 Alloy By Using Taguchi Method

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Abstract- Present work include understanding in End Milling machining on the material removal rate 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 material removal rate. 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 maximize the material removal rate during machining of AL2014 T651 ALLOY material. The maximum material removal rate is helping to increase the productivity 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 material removal rate. The result indicated that depth of cut with contribution of 58.79% is most important parameter for material removal rate. The optimal parameter for material removal rate is obtained as cutting speed 1000 rpm, feed rate 1250 mm/min and depth of cut 0.75 mm.

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

1. 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 maximizing surface roughness and to increase the productivity. The major parameter that are considered for maximizing material removal rate 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 material removal rate considered response. End milling machine with carbide tool of 20 mm diameter. Material removal rate has been calculated by using three set of parameters.

2. 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.

3. EXPERIMENTAL DETAILS

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

Table 2 Process Parameter 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 material removal rate 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. The optimum result were verified with the help of analysis of variation (ANOVA).

Table 3 Orthogonal Arrya 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 3 represent the level of each parameter.

1. Speed (rpm)
2. Feed (mm/min)
3. Depth of cut (mm)

Table 4 Design of Experiment

Piece	**Speed (rpm)**	**Feed (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

4. EXPERIMENTAL RESULT AND DISCUSSION

The experiment were carried out using Taguchi Method, the design of experiment has to be implemented to select cutting speed, feed and depth of cut and that could result to increase productivity. The main aim of this research is to determine the process parameter which achieve to maximizing the material removal rate. Larger is better for to increase productivity is used for material removal rate as large value represent material removal rate improved or better productivity. Taguchi method and optimum parameter are selected. The aim of this research to determine the process parameter which maximizing the metal removal rate. During cutting operation adopt by measuring the time taken for each experimental sun by using stop watch and material removal rate are calculated by using given formula:

$$\frac{Wi - Wf}{\rho \, X \, t}$$

Where $w_i$is the initial weight, $w_f$is the final weight, ρ is the density of the material ($2.81x10^{-3}mm^3/sec$) and t is the time taken.

Table 5 show the response obtained from experimental runs, design by Taguchi method the corresponding value of S/N ratio is mentioned in table for each run.

Table 5 S/N Ratio for MRR

Piece	Speed (rpm)	Feed (mm/min)	Depth of Cut (mm)	MRR	SNR
1	500	750	0.75	228.36	47.1724
2	500	1000	0.50	195.31	45.8145
3	500	1250	0.25	165.90	44.3969
4	750	750	0.50	194.38	45.7730
5	750	1000	0.25	181.92	45.1976
6	750	1250	0.75	330.82	50.3918
7	1000	750	0.25	168.77	44.5459
8	1000	1000	0.50	235.86	47.4531
9	1000	1250	0.75	351.45	50.9173

The material removal rate as a productive characteristics with the concept of 'Larger is better'. Table 6 and 7 shows the response for signal to noise ratio for larger is better of MRR for each level of parameter.

Table 6 Larger is Better

Level	SPEED	FEED	DOC
1	45.79	45.83	44.71
2	47.12	46.16	46.35
3	47.64	48.57	49.49
Delta	1.84	2.74	4.78
Rank	3	2	1

Table 6 give the rank parameter for MRR. For material removal rate depth of cut and feed rate is the most significant parameters where speed is the least significant parameter.

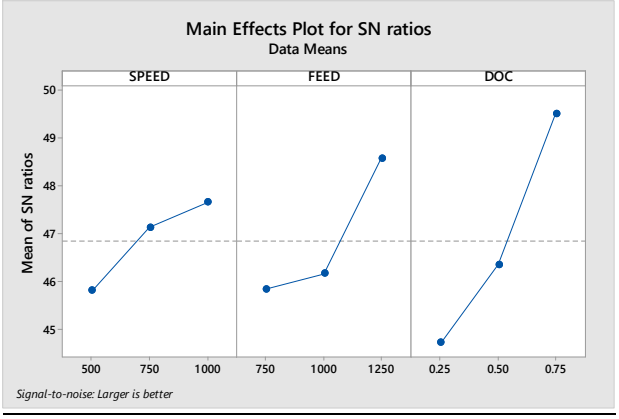
Analysis of variance (ANOVA)

Table 7 show the analysis of variance for MRR. The main purpose of analysis of variation is to investigates the design parameter on MRR. In our experiment work we have generated result for S/N ratio for MRR. The representation are as shown in below table.

Table 7 Anova for S/N Ratio for MRR

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Speed	2	5.4280	11.84%	5.4280	2.7140	163.35	0.006
Feed	2	13.4288	29.29%	4.9595	2.4798	149.25	0.007
depth of cut	2	26.9538	58.79%	26.9538	13.4769	811.15	0.001
Error	2	0.0332	0.07%	0.0332	0.0166		
Total	8	45.8439	100.00%				

From the table 7 observe the depth of cut (P=0.001) is most significant parameter having 58.79% effect on MRR. This analysis of variation were carried out at highest confidence level. The main purpose of that analysis to investigates the design parameter on MRR by indicating which parameter which are effected the quality characteristics. In our experimental work we have generated result for S/N ration for MRR. From table we found that the depth of cut is significantly effect on MRR with contribution 58.79% , feed rate contribution 29..29% and speed 11.84% with 0.07% error.



The main effect of MRR of each parameter of various level condition is shown in above graph. MRR increase with three major parameter speed, feed and depth of cut. MRR is maximum at when the spindle speed 1000rpm, feed rate 1250mm/min and depth of cut 0.75mm and optimal parameter found that S3F3D1 with 0.07% error.

Table 8 Predicted Value of MRR at Optimized Level

Speed (rpm)	Feed (mm/min)	Depth of Cut (mm)	MRR
1000	1250	0.75	351.045

5. CONSLUSION

In end milling of AL2014 T651 ALLOY, the conclusion are made drawn using experimental observation-The response parameter material removal rate (MRR) mostly affected by depth of cut.

1. Higher the depth of cut , higher the metal removal rate.
2. The experimental results show the average metal removal rate is higher at higher depth of cut.
3. The optimal contribution parameter for ALUMINIUM 2014 T651 ALLOY in case of MRR is depth of cut1-feed3-speed3.

The absolute error is 0.07%.

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