OPTIMIZATION OF MACHINING PARAMETERS IN A TURNING OPERATION OF FLYASH COMPOSITE TO MINIMIZE SURFACE ROUGHNESS

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Abstract - The primary objective of the ensuing study was to use the Taguchi Method in order to determine the effect of turning on Aluminium flyash composites. The objective was to find the optimum machining parameters so as to minimize the surface roughness for the selected work material in the chosen domain of the experiment. The experiment was conducted in an experiment matrix of 9 runs designed using a Orthogonal Taguchi Array Method. Surface Roughness was measured using a Talysurf. The data was compiled into MINITAB ⓡ 17 for analysis. The relationship between the machining parameters and the response variables (surface roughness) were modelled and analysed using the Taguchi Methodology. Analysis of Variance (ANOVA) was used to investigate the significance of these parameters on the response variable. Results showed that Depth of cut is the most significant factor affecting the surface roughness, closely followed by Speedand Work material.

***Key Words*: Anova, Minitab -17, Taguchi methodology.**

1. INTRODUCTION

The ensuing chapter covers published work of researchers pertaining to the turning process in order to optimize parameters. Specifically, theory and information relating to the experiment and the turning process is presented. The scope of the review also extends to various optimization techniques that are used to obtain optimal solution mainly focusing on the Taguchi Method.

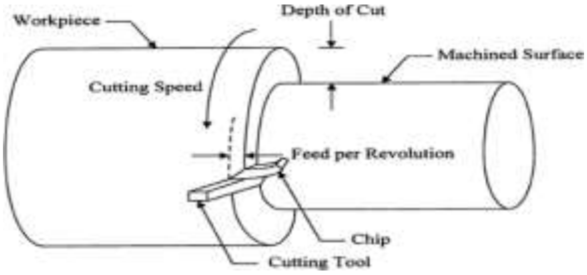
1.1 The Turning Operation

The turning operation is a basic metal machining operation that is used widely in industries dealing with metal cutting. In a turning operation, a high-precision single point cutting tool is rigidly held in a tool post and is fed past a rotating work piece in a direction parallel to the axis of rotation of the work piece, at a constant rate, and unwanted material is removed in the form of chips giving rise to a cylindrical or more complex profile.

1.2 MACHINING PARAMETERS

The turning operation is governed by geometry factors and machining factors. This study consists of the two primary adjustable machining parameters in a basic turning operation viz. speed and depth of cut,Geometry factors such as Work Material.Other input factors influencing the output parameters such as surface roughness and also exist, but the latter are the ones that can be easily modified by the operator during the course of the operation [15]

1. Spindle Speed
2. Feed
3. Depth of cut



CUTTING TOOL

A cutting tool can be defined as a part of a machine tool that is responsible for removing the excessive material from the work piece by direct mechanical abrasion and shear deformation [13,17]. According to Choudhury et. al [16] and Schenider [18], an efficient cutting tool should have the following characteristics

For the ensuing study, we used a Carbide Tip Single point cuttingtool as shown in Figure

Taylsurf instrument:

The Taylor-Hobson Talysurf.

The Talysurf an electronic instrument working on carrier modulating principle this instrument also gives the same information as the previous instrument, but much more rapidly and accurately. This instrument as also the previous one records the static displacement of the stylus and is dynamic instrument like profile meter.

Talysurf (Courtesy, CMRCET)

CUTTING CONDITION

Dry cutting environment was used for the experimentation process. Dry cutting process is one that uses no coolant during machining. By the use of dry cutting, costs of cutting fluid were alleviated. Cutting fluids have corrosive effects and non-environment-friendly. Dry cutting reduces machining cost and is environment friendly. Also, inserts perform better at higher cutting temperatures achieved during dry cutting.

OBJECTIVES OF PRESENT WORK

Surface finish is an inherent occurrence in any machining process. And this influence product quality. Therefore Surface finish is also an important aspect of a machined product.

To study the influence/effect of machining parameters viz. speed, feed, tool nose radius and depth of cut, on the surface roughness of machined material.To determine optimum machining parameter settings for the chosen tool/work combination so as to minimize the surface roughness using Taguchi Method.To develop an empirical model for the Surface Roughness for the chosen tool/work combination within the specified domain of parameters.

Design of Experiments

Design of experiments (DOE) is a structured method that is used to identify relationships between several input variables and output responses. With the help of DOE, the resources needed to carry out the experiment can be optimized [14]. Hence, it finds wide use in R & D studies. A few methods used as DOE are Taguchi Method,and Factorial Designs. We will be focusing on the ology during the ensuing study.

Taguchi Methodology

Taguchi method is a scientifically disciplined mechanism for evaluating and implementing improvements in products, processes, materials, equipment, and facilities. These improvements are aimed at improving the desired characteristics and simultaneously reducing the number of defects by studying the key variables controlling the process and optimizing the procedures or design to yield the best results. Taguchi proposed a standard procedure for applying his method for optimizing any process.

Taguchi Orthogonal Array Designs

EXP.No.	WORK MATERIAL	SPEED	DEPTH OF CUT
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	1
9.	3	3	2

Minitab 17:

Minitab is a statistics package developed at the Pennsylvania State University by researchers Barbara F. Ryan, Thomas A. Ryan, Jr., and Brian L. Joiner in 1972. It began as a light version of OMNITAB 80, a statistical analysis program by NIST. Statistical analysis software such as Minitab automates calculations and the creation of graphs, allowing the user to focus more on the analysis of data and the interpretation of results. It is compatible with other Minitab, Inc. software.

ANOVA ANALYSIS

Analysis of variance (ANOVA) is a collection of statistical models and their associated estimation procedures (such as the "variation" among and between groups) used to analyze the differences among group means in a sample. ANOVA was developed by statistician and evolutionary biologist Ronald Fisher. In the ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether the population meansof several groups are equal, and therefore generalizes the t-test to more than two groups. ANOVA is useful for comparing (testing) three or more group means for statistical significance. It is conceptually similar to multiple two-sample t-tests, but is more conservative, resulting in fewer type I errors,[1] and is therefore suited to a wide range of practical problems.

WORK MATERIAL

Metal matrix composites are the forerunners amongst different classes of composites. Over the past two decades metal matrix composites have been transformed from a topic of scientific and intellectual interest to a material of broad technological and commercial significance. MMCs offer a unique balance of physical and mechanical properties.

Equipment Used:

Mounting of Workpiece and CuttingTool

Various level of 3 factors

ool Material	Material compositions	Cutting Speed	Depth of Cut	Cutting Medium
arbide tip ool	Aluminium-Flyash composite (3% Flyash)	325RPM, 533RPM, 878RPM.	0.5mm, 1.0mm, 1.5mm.	DRY
	Aluminium-Flyash composite (6% Flyash)			
	Aluminium-Flyash composite (9% Flyash)			

Number of control factors = 3

Number of levels for each control factor = 3

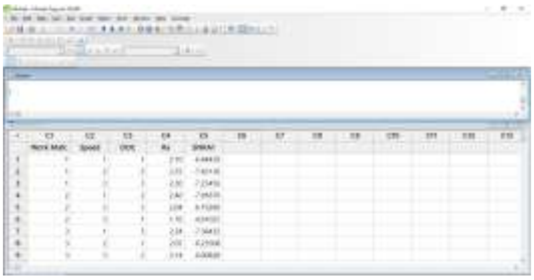
Number of Experiments to be conducted = 9

Machined Work Pieces

Machined Surface

EXPERIMENTAL RESULTS

The results obtained from the experimental work are summarized and shown in figure.



Column5 represents S-N ratios for each value of “Ra”.

Table specifications -

L9(3^3)

Factors: 3

Runs: 9

Columns of L9(3^4) Array

1 2 3

Results of Taguchi analysis:-

In the Taguchi method, the term ‘signal’ represents the desirable value (mean) for the output characteristic and the term ‘noise’ represents the undesirable value for the output characteristic. Taguchi uses the S/N ratio to measure the quality characteristic deviating from the desired value. Smaller is better S/N ratio was used in this study because less surface roughness was desirable.

Quality characteristic of the smaller is better is calculated in the following equation

$$S / N = -10 \log_{10} \left(\frac{\sum y^2}{n} \right).$$

Experiments are conducted in the order given by Taguchi method and surface roughness values are measured and tabulated.

Surface roughness parameter, Roughness average Ra values, S/N values for machining the Aluminium-Flyash Composites work piece.

S.No	Work Material	Speed (RPM)	Depth of Cut	Ra	SNRA1
1	1	328	0.5	2.1	-6.44439
2	1	533	1.0	2.35	-7.42136
3	1	878	1.5	2.3	-7.23456
4	2	328	1.5	2.46	-7.81870
5	2	533	0.5	2.04	-6.19260
6	2	878	1.0	1.76	-4.91025
7	3	328	1.0	2.34	-7.38432
8	3	533	1.5	2.06	-6.27800
9	3	878	0.5	2.14	-6.60828

After calculating S/N Ratios, the effect of control parameters on S/N ratio is shown Below

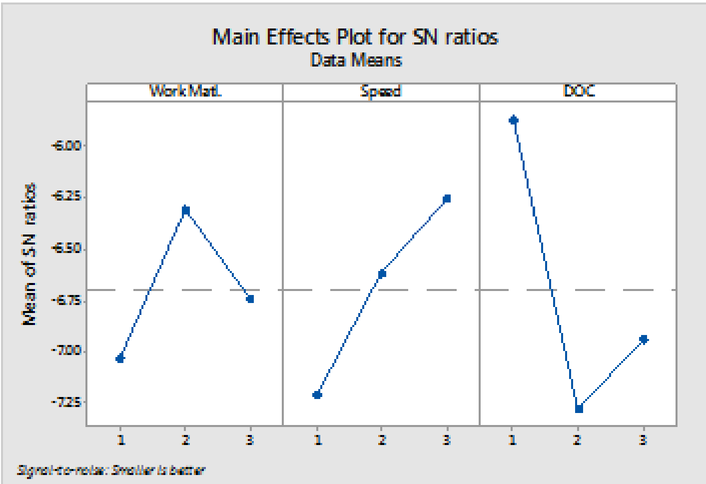


Fig.29 Main Effects Plot for SN ratios

Taguchi Analysis: Ra versus Work Matl., Speed, DOC

Table.11 Response Table for Signal to Noise Ratios Smaller is better

Level	Work Material	Speed	Depth of cut
1	-7.033	-7.216	-5.863
2	-6.307	-6.616	-7.283
3	-6.743	-6.251	-6.937
Delta	0.726	0.965	1.420
Rank	3	2	1

Table.12 Factor levels for predictions for Aluminium-Flyash Composites

Work material	Speed	Depth of cut
B	878RPM	0.5mm

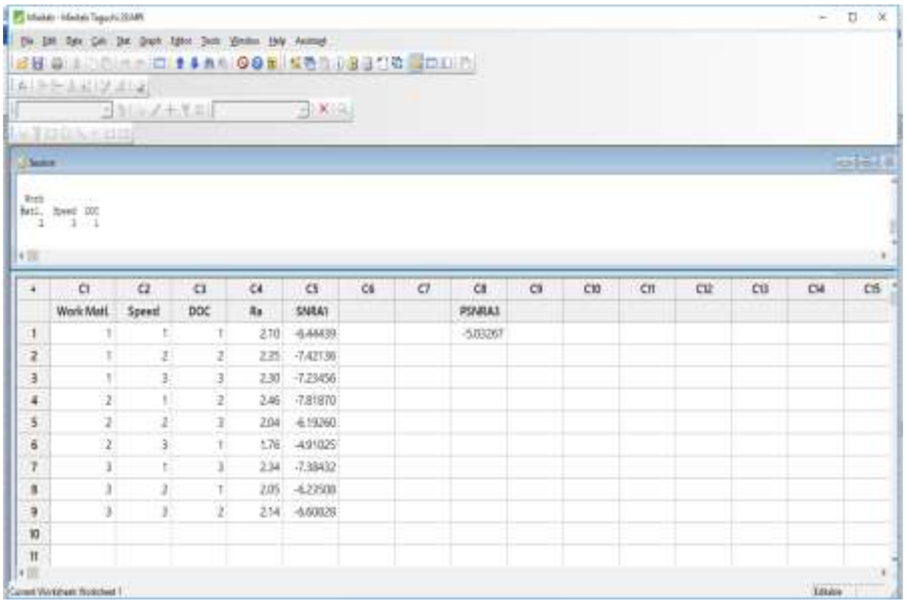
B= Aluminium-Flyash Composites with 6%flyash

Predicted S/N Ratio = -5.03267

$$S / N = -10 \log_{10}\left(\frac{\sum y^2}{n}\right).$$

Predicted Surface roughness value Corresponding to S/N = -5.03267 is 1.784µm

Experimental surface roughness value = 1.76 µm



ANOVA:

The analysis of variance (ANOVA) was used to study the significance and effect of the cutting parameters on the response variables i.e. Ra.

Estimated Model Coefficients for SN ratios

Term	Coefficient	SE Cofficient	T	P
Constant	-6.69439	0.2059	-32.512	0.001
WORK MAT 1	-0.33904	0.2912	-1.164	0.364
WORK MAT 2	0.38721	0.2912	1.330	0.315
SPEED 328	-0.52141	0.2912	-1.791	0.215
SPEED 533	0.07805	0.912	0.268	0.814
DOC 0.5	0.83115	0.2912	2.845	0.104
DOC 1.0	-0.58839	0.2912	-2.021	0.181

S = 0.6177 R-Sq = 87.8% R-Sq(adj) = 51.4%

Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
WORK MATERIAL	2	0.8016	0.8016	0.4008	1.05	0.488
SPEED	2	1.4236	1.4236	0.7118	1.87	0.349
DOC	2	3.2878	3.2878	1.6439	4.31	0.188
Residual Error	2	0.7631	0.7631	0.3816		
Total	8	6.2762				

Response Table for Signal to Noise Ratios

Smaller is better

Main Effects Plot for SN ratios

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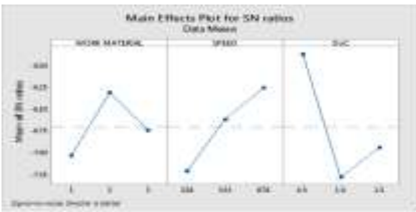

Taguchi Analysis: Ra versus WORK MATERIAL, SPEED, DoC

Predicted values

S/N Ratio -5.03267

Factor levels for predictions

WORK MATERIAL	SPEED	DoC
2	878	0.5

Optimum Settings

The best optimal settings are shown in Table 12 below. The best setting is found to be WorkMatl. =Aluminium-Flyash composite with 6% flyash, Speed = 878RPM and DOC = 0.5mm

Work material	Speed	Depth of cut
B	878RPM	0.5mm

Percentage Significance of Each Input factor in Ra :

From Analysis of variance for S-N ratios

Work Material = 0.8016/6.2762*100 = 12.77%

Speed = 1.4236/6.2762*100 = 22.68%

Depth of Cut = 3.2878/6.2762*100 = 52.38%

From above percentages it is clear that Depth of cut has a significant effect on surface roughness, closely followed by Speed and Work Material.

CONCLUSION

Taguchi Method was successfully applied in optimizing the surface roughness for the chosen tool-work combination and for the selected domain of the input machining parameters. ANOVA analysis was carried out and it is observed that Depth of Cut is the most significant factor affecting the surface roughness, closely followed by Speed and Work Material. The optimum running condition was found to be at Work Material (Aluminium-Flyash Composite with 6%flyash), Speed(878RPM) and DOC (0.5 mm).

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