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Modelling and Analysis of Machining Characteristics of $AlSiO_2$ composite on CNC Milling Machine

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Abstract:-- **The machining of aluminum silicon oxide produced using rice husk is used in high speed conditions in CNC in light of the fact that such composites have extensive applications in the aeronautics industry. The motivation behind this examination is to research the impacts of cutting parameters on surface finish in high precision CNC processing machine because industry requires top-notch results, the forecast of surface roughness, which relies upon process parameters like speed, feed, and depth of cut, and step over ratio. An observational relationship is set up amongst dependent and independent factors from nine trials directed by Taguchi L9 orthogonal exhibit as linear regression conditions in MINITAB 18 software. The machining of $AlSiO_2$ is done on rapid CNC processing machine utilizing face mill of diameter 50 mm and the outcomes are investigated.**

Key Words- CNC Milling, Aluminium silicon oxide, Face milling, Roughness, ANOVA Technique, Taguchi method

I. INTRODUCTION

Surface quality is one of the most important and essential requirements in manufacturing industries. High speed Computer Numerical Control (CNC) machines are used in place of conventional machining processes in order to achieve desired surface quality. Surface roughness is studied by number of researchers who found that it is mostly affected by cutting conditions such as, depth of cut, spindle speed, feed rate, etc,. In addition to these, process parameters such as, tool geometry (tool nose radius, rake angle, edge geometry, etc) and machine tool vibration have their influence on surface quality. In order to optimize the surface roughness in any milling operation, it is very important to understand the effects of cutting parameters that are mentioned above on surface roughness. The focus of study in this research paper is face milling operation which can be performed using a wide range of different tools. Tools with a 45º entering angle are most widely used, but square shoulder cutters, round insert cutters and face and side mills are also used for certain conditions.

Many researchers have worked in the area of machining of aluminium alloys and their composites. Anand et al. [1] applied Taguchi method to find the optimal surface flatness with AlSiO2 and applied HSS insert in end milling cutting operation. They have taken viz., four input variables, spindle speed, feed rate, depth of cut and step over ratio. They applied an orthogonal array L9 (34),and the analysis of variance (ANOVA) and figured out the important factors that are influencing to the surface roughness. Krishnakant et al. [2] successfully applied Taguchi method to enhance the quality of manufacturing goods for turning process. They have done their analysis part using MINITAB 16. The work material used is EN24 steel for conducting the experimentation and optimized the material removal rate. Vikas et al. [3] obtained surface roughness models after optimization using four meta-heuristic techniques and their work reveals that gravitation search algorithm (GSA) proved to be the best among the four unconventional optimization techniques in terms of optimum value of surface roughness and that teacher learner based optimization (TLBO) gave better result in terms of number of iterations. They concluded that non-linear regression equation, better explains the relationship between surface roughness and input parameters. Patel et al. [6] optimize the surface quality of an end-milled surface by using the Taguchi's nested experimental design. The author had worked on two work materials namely plain carbon steel and aluminum alloy. They observed the influence of various machining parameters on surface roughness. They concluded that depth of cut was the most indispensable factor that affects the surface roughness. Feed rate and spindle speed are the other two critical factors which affect surface roughness while machining aluminum alloy parts. Kusuma et al. [7] conducted experiment on milling machine based on design of experiment (DoE), machine tool vibration data acquisition using MEMS accelerometer, measurement of surface roughness, analysis using analysis of variance (ANOVA) and investigation on influence of cutting parameters on the vibration data and surface roughness values, prediction of surface roughness value, and optimization of cutting parameters required for adaptive control of cutting parameters using artificial neural network and genetic algorithm approach.

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Subbaiah et al. [9] have carried out work on CNC turning machine in order to observe the effect of high speed CNC turning parameters like feed rate, cutting speed and depth of cut on the roughness of AA6063-T6 aluminium alloy. The optimization techniques namely Taguchi method and genetic algorithm have been used to optimize the high speed CNC turning operation for attaining better surface quality on the turned components in their study. Saini et al. [10] designed the experiments according to the Box-Behnken approach of response surface methodology (RSM). Main experiment contains three factors each at three levels. Hence, total number of runs required is seventeen including five replications of centre point. The design expert software version 6 was used to develop the experimental plan for RSM. In their work, the surface roughness is mainly affected by feed rate and depth of cut. With the increase in feed rate & depth of cut the surface roughness increases, as the cutting speed increases there is slightly increase in surface roughness. In this research work, experiments are conducted on aluminium silicate where silicon is extracted from rice husk before alloying with aluminium using casting method. In addition to introduction, the second section explains the methodology and experimentation, third section covers results and discussion part. The conclusions drawn are listed out in the last section.

2. METHODOLOGY AND EXPERIMENTATION

In this research work, main experiment contains four factors each at three levels. So, total number of runs required is 81 but by Taguchi L9 we have conducted nine experiments. Hence, Taguchi L9 orthogonal array was applied to find the optimum number of machining parameters that result in 96% confidence level.

2.1 WORK MATERIAL

In present study, aluminium silicon oxide (200×50×30) is used as work piece. It is suitable for manufacturing of automotive & aeronautics industry components. The silica is extracted from rice husk by using chemical process involving acid and base. The advantage of this process is that the raw material is available free of cost and the resultant silica has desirable machining properties

2.2 Selection of Equipment & Tools

Selecting of tool is done based on five factors, such as, the machine being used, the material being used, the quantities of machining parts, the requirements of the customer, and the specifications of the tool to be used. Surface roughness tester (profilometer) is used for the roughness measurement having least count of 0.1 micron. A profilometer is a measuring instrument for studying surface's profile in order to find the roughness.

In this paper, a high speed CNC milling machine of computer aided manufacturing laboratory is used with selected process parameters for machining of $AlSiO_2$ (200mm x 50mm x 30mm) with face mill cutting tool. The CNC milling machine is having Siemen's code and 20 tool magazine supplied by MTAB MaxMill Plus. As aluminium silicon oxide alloy is soft material carbide tool is selected as tool material. Four tip carbide face milling tool 50mm diameter has been used for the machining of aluminium silicon oxide. The operating conditions and other details are given in Table-1.

2.3 Process Parameters and their Levels

The input process parameters and their levels are given in Table-2. The output parameter chosen in our case is surface roughness. It is measured by the deviations toward the typical vector of a genuine surface from its optimal frame. In the event that these deviations are huge, the surface is unpleasant, and in the event that they are little, the surface is smooth.

Table-1: Operating Conditions

CONDITIONS	DETAILS
Work Material	Aluminium Silicon Oxide
Geometry	Rectangular Work Piece 200*50*30
CNC Model	Mtab
Tool	Carbide Tip Face Mill
Measuring Instrument	Surface roughness meter
Cutting Condition	Fluid Coolant

Table-2: Input Process Parameters and their levels

Input Parameters	Level 1	Level 2	Level 3
Spindle Speed (rpm)	2000	3000	4000
Feed Rate (mm/min)	100	150	200
Depth of Cut(mm)	0.2	0.3	0.4
Step over Ratio (%)	50	60	70

2.4 Measurement of Roughness

The experiments have been conducted as per the plan as explained above according to Taguchi L9 array by using four tip carbide face mill. Roughness is measured by roughness tester and the results obtained are tabulated in Table-3.

Table-3: Experimental data of $AlSiO_2$ machining

Exp. No.	**N(rpm)**	**f (mm/ min)**	**d (mm)**	**sr (%)**	**Roughness**
1	2000	100	0.2	50	1.385
2	2000	150	0.3	60	1.539
3	2000	200	0.4	70	1.050
4	3000	100	0.3	70	1.043
5	3000	150	0.4	50	0.661
6	3000	200	0.2	60	1.649
7	4000	100	0.4	60	0.689
8	4000	150	0.2	70	0.842
9	4000	200	0.3	50	0.598

3. RESULTS AND ANALYSIS

The data from the above table is used to develop linear regression equation. Regression analysis is a process for developing the relationship among variables. The linear regression equation obtained using MINITAB 18 software, is as follows:

SR = 2.580 - 0.000208N - 0.002567f - 1.048d - 0.00683sr ……. (1)

From the above equation, it may be concluded that surface roughness is having strong correlation with the selected input variables.

4. CONCLUSION

The examinations of this investigation demonstrate that the parameters cutting speed, feed, depth of cut and step over ratio are the essential factors impacting the surface roughness of aluminium silicon oxide face mill processing. The approach exhibited in this paper gives linear regression model of experimental results obtained using the minitab18 software.

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