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Effect of Speed and Feed on Surface Roughness During Drilling of Glass Fibre Reinforced Polymer

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Abstarct : *The present work focuses on study of machinability of glass fibre reinforced polymer laminated composites. The objective of this research paper is to find out optimal values of drilling parameters in order to achieve minimum value of surface roughness is obtained. The combination of optimal process parameters for the work piece under consideration with regards to minimum surface roughness has been obtained at speed 440 rpm, drill diameter 10 mm and feed rate 0.20 mm/rev. In this study TAGUCHI analysis has revealed that feed is dominant parameter followed by speed and drill diameter.*

Keywords : *Drilling, Taguchi, Optimization, speed, feed, surface roughness, glass fibre reinforced polymer*

I. INTRODUCTION

The development of composite materials and their related design and manufacturing technologies is one of the most important advances in the history of engineering materials. Composite materials due to their exclusive mechanical and physical properties are being used in variety of applications. Composite materials having a range of advantages over other conventional materials such as tensile strength, impact strength, flexural strengths, stiffness and fatigue characteristics Because of their numerous advantages they are widely used in the aerospace industry, commercial mechanical engineering applications, like machine components, automobiles, combustion engines, mechanical components like drive shafts, tanks, brakes, pressure vessels and flywheels, thermal control and electronic packaging, railway coaches and aircraft structures etc. (1,2,3,4)

Composite materials are manufactured by reinforcing high tensile strength fibres / particles in polymer, metal and ceramic matrices. However polymer matrix composites gained importance due to its advantages such as low density, good thermal and electrical insulator, ease of fabrication, and low cost (6,7). Drilling of composite materials can be considered as a critical operation owing to their tendency to delaminate when subjected to mechanical stresses. The principle drawbacks of drilling operation in composite materials are surface delamination, fiber / resin pullout and inadequate surface smoothness of the wall of the hole. Among these defects caused by drilling, delamination appears to be the most critical

Surface roughness is mainly a result of process parameters such as tool geometry (i.e. nose radius, edge geometry, rake angle, etc) and cutting conditions (feed rate, cutting speed, depth of cut, etc). Controllable process parameters include feed, cutting speed, tool geometry, and tool setup. Other factors, such as tool, work piece and machine vibration, tool wear and degradation, and work piece and tool material variability cannot be controlled as easily. The important cutting parameters discussed in the present article are cutting speed, feed and drill diameter. It is found in most of the cases surface roughness decreases with increase in cutting speed and decrease in feed and depth of cut (22). The Taguchi method is statistical tool, adopted experimentally to investigate influence of surface roughness by cutting parameters. Researchers optimized the cutting parameters to get minimum surface roughness by turning process by developing many mathematical models. Proper selection of cutting parameters and tool can produce longer tool life and lower surface roughness. Hence, design of experiments by Taguchi method on cutting parameters was adopted to study the surface roughness (21, 22).

The present work focuses on machinability study of glass fibre reinforced polymer laminated composites. The objective of this research paper is to find optimal values of drilling parameters so that minimum value of surface roughness is obtained.

II. EXPERIMENTAL

Materials and Method

The work-piece of Glass fibre reinforced polyepoxide of dimension 12”x12”x1.6” was used (Procured from local market). The composite material specimen used for experimental work were manufactured using the hand layup method. Glass fibres with random orientation were used for the reinforcement. Methyl Ethyl Ketone Peroxide (MEKP) and cobalt were used to harden the material.

Figure1: (a) Material before drilling

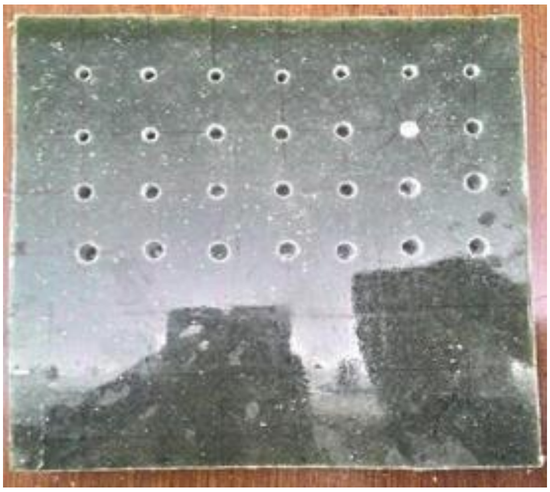

Fig 1. (b) Material after drilling

Nomenclature of holes was done by the twin axis system in which x- axis was numbered from a - g and the y- axis was numbered from one to seven. Consequently, any hole lying at the intersection of the respective alphabet and number was named accordingly. For example hole at the intersection of A & 7 was names 7A.

Note: During the experiment, hole number 6F was damaged due to an error in the machining operation.

In our experimental work, radial drilling machine was used to drill holes in the glass fibre reinforced polymer material. Drill bits made of HSS were used to machine the GFRP material. Three drill bits of sizes 8mm, 10mm and 12mm were used. The basic composition of HSS is 18% W, 4% Cr, 1% V, 0.7% C and rest Fe. Surface finish was measured using surtronic 3+, manufactured by taylor hobson ltd., which has a diamond tip probe for measuring surface roughness. A profile measurement device is usually based on a tactile measurement principle. The surface is measured by moving a stylus across the surface. As the stylus moves up and down along the surface, a transducer converts these movements into a signal which is then transformed into a roughness number and usually a visually displayed profile.

III. RESULTS AND DISCUSSIONS

First, Drilling was done using radial drill machine in the glass fibre reinforced polymer material. 27 holes were made by varying 3 parameters (Feed, Speed, Diameter of drill bit). The following table depicts the coding of the holes along with their specific parameters.

Table 1: Experimental Data

Hole no.	Diameter	Speed	Feed	Surface roughness(Ra)	Surface roughness (Rz)
7A	8	150	0.12	1.75	15.4
7B	8	150	0.20	2.08	14.8
7C	8	150	0.30	2.6	29.2
7D	8	300	0.12	2.56	25.3
7E	8	300	0.20	3.45	30.4
7F	8	300	0.30	2.84	33.1
7G	8	440	0.12	4.22	38.6
6A	8	440	0.20	5.6	40.8
6B	8	440	0.30	3.37	39.2
6C	10	150	0.12	2.44	18.6
6D	10	150	0.20	3.87	38.1
6E	10	150	0.30	3.98	49.3
6G	10	300	0.12	5.58	48.1
5A	10	300	0.20	5.16	38.1
5B	10	300	0.30	5.83	43.1
5C	10	440	0.12	5.64	47.5
5D	10	440	0.20	7.79	58
5E	10	440	0.30	5.12	38
5F	12	150	0.12	4.24	35.8
5G	12	150	0.20	4.9	45.5
4A	12	150	0.30	4.45	35.1
4B	12	300	0.12	4.7	40.3
4C	12	300	0.20	5.4	39.8
4D	12	300	0.30	6.3	49.6
4E	12	440	0.12	5.16	59.7
4F	12	440	0.20	5.23	39.7
4G	12	440	0.30	4.26	35.7

In the taguchi method, the term signal represents the desirable value (mean) for the output characteristic and the term noise represents the undesirable value (deviation, SD) for the output characteristic. Therefore the S/N ratio is the ratio of the mean to the SD. Taguchi uses the S/N ratio to measure the quality characteristic deviating form the desired value. There are several S/N ratios available, depending on the type of the characteristic; lower the better, nominal is best and higher the better. The lower the better characteristic (Eq.1) is used for surface roughness, tool wear and hole diameter error and higher the better (Eq.2) is used for Metal removal rate and both the characteristics are formulated as shown below:

Smaller is better : S/N = -10 *log(Σ(Y^2)/n)).….1

Larger is better : S/N = -10 *log(Σ(1/Y^2)/n)…..2

Using the above-presented data with the selected above formula for calculating S/N, the Taguchi experiment results are summarized in Fig. 3,4,5, which were obtained by means of MINITAB 17 statistical software

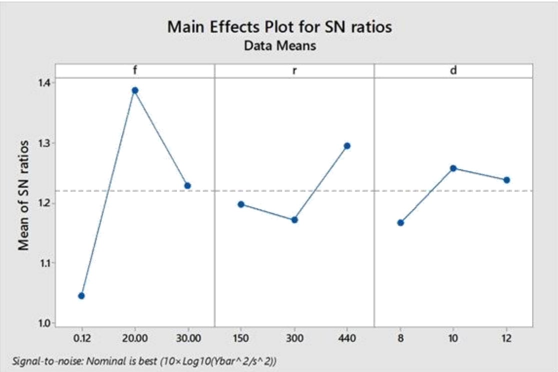

Figure 3: Main Effect Plots for S/N Ratios

Figure 4: Main Effect Plots for Means

Taguchi Orthogonal Array Design
L27(3^3), Factors: 3, Runs: 27
Taguchi Analysis: Ra, Rz versus f, r, d
Response Table for Signal to Noise Ratios
Nominal is best (10×Log10(Ybar^2/s^2))

Table2: Levels

Level	Feed	Speed	Drill Diameter
1	1.046	1.197	1.167
2	1.389	1.172	1.258
3	1.229	1.295	1.239
Rank	1	2	3

Table 3 :Response table For Means

Level	Feed	Speed	Drill Diameter
1	22.61	16.45	16.58
2	22.26	22.47	23.13
3	19.77	25.73	24.94
Rank	3	1	2

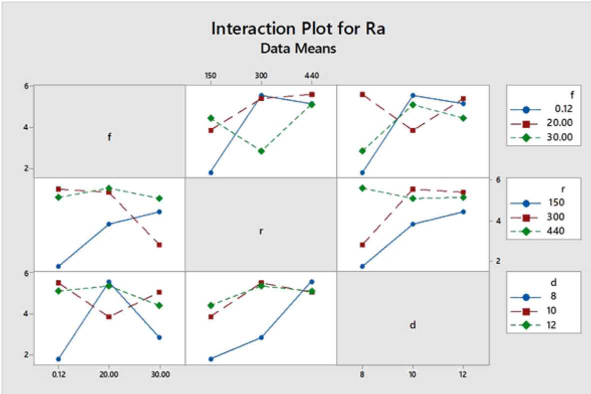

Figure 5: Interaction Plots for Ra

IV. CONCLUSIONS

This work presented an experimentation approach to study the impact of machining parameters on surface roughness. A Systematic approach was provided to design and analyze the experiments, and to utilize the data obtained to the maximum extent. The following are conclusions drawn based on the experimental investigation conducted at three levels by employing Taguchi technique to determine the optimal level of process parameters.

- Increase in speed increases the surface roughness
- Increase in drill diameter increases the surface roughness upto a certain extent
- Increase in feed rate adversely affects the surface finish slightly, but a large increase deteriorates surface finish to a large extent.
- TAGUCHI analysis reveals that feed is dominant parameter followed by speed and drill diameter.
- The optimal combination process parameters for the work piece under consideration with regards to minimum surface roughness or maximum surface finish is obtained at speed 440 rpm, drill diameter 10 mm and feed rate 0.20 mm/rev.

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