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EFFECT OF INPUT PARAMETER ON GFRP WITH SiC AS ABRASIVE USING (AJM) ABRASIVE JET MACHINING-DRILLING OPERATION

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Abstract: *Abrasive jet machining is the non-traditional material removal process. It is an effective machining process for processing a variety of hard, brittle and composites material. In this study variety of fundamental research on Abrasive jet machining (AJM) process parameters on different materials is studied and reviewed. This work aims at studying the effect of input parameter on GFRP. The effect of process parameters (Material thickness, air pressure and stand- off distance) is studied on response parameters (material removal rate, taper) by designing and performing the detailed experiments using full factorial methodology. Process performance data for various parameters is analyzed using ANOVA.*

Keywords: *Abrasive jet machining, GFRP, Process Parameters, MRR, DOE, ANOVA.*

I. INTRODUCTION

Abrasive jet machining (AJM), is also called abrasive micro blasting, a manufacturing process that utilizes a high-pressure air stream carrying small particles to impinge the work piece surface for material removal and shape generation. The material removal occurs due to the erosive action of the particles striking the work piece surface. Abrasive jet machining has limited material removal capability and is typically used as a finishing process. Abrasive Jet Machining has high degree of flexibility, and hence it is typically used for machining of glass, ceramic and composite material.

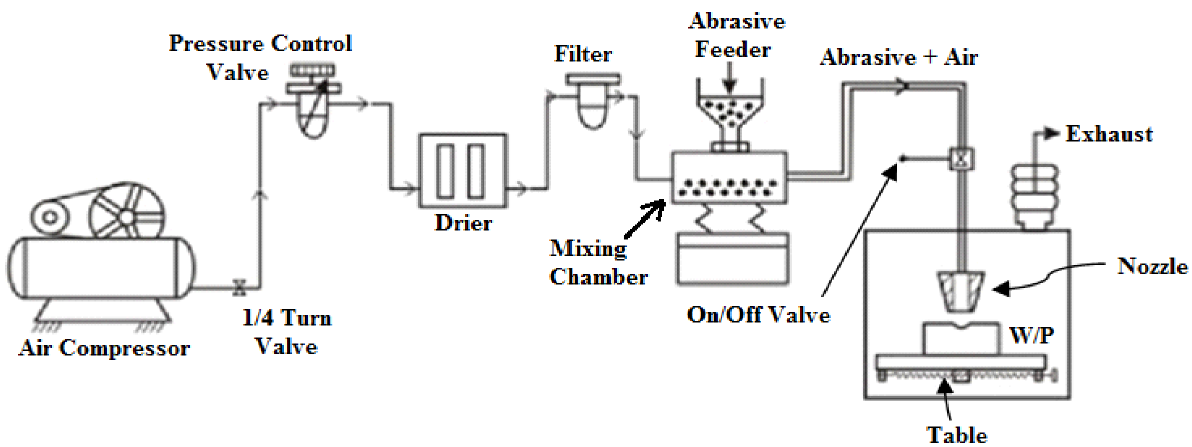

Fig. 1 Abrasive Jet Machine schematic diagram

In Abrasive jet machining abrasive particles are made to impinge on work material at high velocity. Jet of abrasive particles is carried by carrier gas or air. As pressurized gas nitrogen and CO_2 cab be taken. In this experiment as nozzle diameter is taken 1.0 mm. The high velocity stream of abrasives is generated by converting pressure energy of carrier gas or air to its Kinetic energy and hence high velocity jet. Nozzle directs abrasive jet in a controlled manner onto work material. The high velocity abrasive particles remove the material from the work material.

II. LITERATURE REVIEW rom

Barun halder and et.al[1] Experiment using process parameters to influence effect on material removal rate and analyzed experimental reading through ANOVA. By using efficient dust collection system, the environment loading problem can be eliminated and the abrasive jet system can be used smoothly. Abrasive particles can be reused during experiment this is one of the big advantage.

Swapnil Wagh and et.al [2] In Abrasive jet machining abrasive particles are made to impinge on the work material at high velocity. A jet of abrasive particles is carried by carrier gas or air. The high velocity stream of abrasives is generated pressure energy of carrier gas or air and converting to its Kinetic energy. The high velocity abrasive particles remove the material by micro-cutting action. For this experiment full factorial methodology is used. Three factors with their three levels are taken. 27 experiments runs taken during this experiment.

Dirk Biermanna and et.al [3] L9 orthogonal array In abrasive jet machining device, the Pressurized abrasive particles gets accelerated through the jet nozzle. AJM is depend on some parameter likes abrasive pressure, abrasive grit size and SOD. The results reveal that pressure is most significant parameter for abrasive jet machining. As pressure increased material removal rate is also increased.

Tarun Batra and et.al [4] As different condition by changing parameters many operation can be done by AJM like drilling, cutting, cleaning, polishing, surface finishing etc. AJM process is receiving more and more attention in the machining areas, particularly for the processing of difficult-to-cut materials. Its unique advantages is abrasive particles which are used during experiment can be reused.

Meet R. Vadgama and et.al [5] Experiment had been done by Taguchi L9 method and get value of MRR. The MRR increases with increasing in pressure and decreasing in glass thickness and SOD. With the increase in pressure the kinetic energy of the abrasive particle is responsible for material removal. Pressure is most significant parameter during experiment.

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N. S. Pawar and et al. [6] By using sea sand as abrasive particle experiment had been done with tungsten carbide nozzle. The microscopic structure can observed by sedimentation and decontation, sedimentation balance, illustration method. For 1.5 to 2 mm diameter of nozzle 50-150 micron grain size is preferably used. As the pressure increases the MRR is also changing. If the SOD is constant there is no more effect on MRR.

Gaurav Mahajan and et.al [7] Parameters are affected in AJM operation like abrasive material, velocity, mixing ratio, abrasive grit size, gas, shape of cut, carried SOD, jet pressure etc. By using silicon carbide as abrasives material provide good [MRR] material removal rate. These were compared with the Standard results and with it was observed that as nozzle tip distance increases, the top surface diameter and bottom surface diameter of hole increases as it is in the general observation in the abrasive jet machining process. As SOD increased hole on work material is also bigger. As the pressure increases material removal rate (MRR) was also increased.

Jiuan Hung and et.al [8] In flexible magnetic abrasive jet machining (FMAJM), a magnet is settled onto the equipment. L9 orthogonal array helps in experiment. The magnetic abrasive was often made by iron grits without elasticity. And it is help to achieve better surface roughness & high MRR. The flexible magnetic abrasive is adopted in abrasive jet machining not only restrains the abrasive jet direction to enhance more uniform main processing area and material removal rate but also have slip-scratch effect to obtain better surface roughness than traditional machining.

Mr. Bhaskar Chandra and et.al [9] Studied the variation in input parameter according to change in gas pressure and hole diameter according to change in nozzle tip diameter (NTD). Various experiments were conducted on work piece material- glass using abrasive material. For this experiment L27 methodology is used.

R. Balasubramaniam and et.al [10] It had been conducted with increase in abrasive particle size MRR increased. But increase in material removal rate nearer to the periphery is very less. As the SOD increased the entry side diameter and the entry side edge radius is also increased because of high pressurized air. Due to high pressure of gas abrasive particles cannot focused on fixed place. As the pressure increased the MRR is also increased. Parameters like pressure, SOD, work piece material thickness are affected during the experiment. By controlling this parameters operation on AJM becomes easier and more flexible.

III. EXPERIMENTATION

Various controllable parameters such as current, standoff distance, pressure, cutting speed have been considered for analysis during the experiment. However, many other parameters which may have an effect on the output have not been studied. Some of these may be beyond our control (such as environmental conditions: room temperature and humidity). During the experiments it is essential to keep such parameters at some pre-set values so that data obtained from different runs are comparable. To ensure this minimum standard has been maintained and necessary precaution has been taken throughout all the experiments.

For the drilling of GFRP using abrasive jet machining, the input parameters selected are stand-off distance, pressure and material thickness. The responses selected are: Material Removal Rate (MRR), Taper.

Full factorial methodology is selected for this experiment. The levels of factors selected for the final experiment runs by full factorial methodology as shown in table 3 and final experiments are conducted and the results are shown in table 4.

Table 3: Levels of Thickness, SOD and Pressure

Level	Thickness	SOD	Pressure
	mm	mm	Bar
1	1.0	3	3
2	1.5	4	4
3	2.0	5	5

Table 4: Experiment runs

Run order	Thickness	Pressure	SOD	MRR (mg/sec)	Taper (mm)
1	1	3	3	0.000586	1.5389
2	1	3	4	0.000850	1.1712
3	1	3	5	0.000537	1.0884
4	1	4	3	0.001057	2.1468
5	1	4	4	0.000903	1.7771
6	1	4	5	0.000590	1.5456
7	1	5	3	0.001641	2.3085
8	1	5	4	0.001429	1.2586
9	1	5	5	0.000645	1.5358
10	1.5	3	3	0.001096	1.2647
11	1.5	3	4	0.001006	1.5379
12	1.5	3	5	0.000782	1.2991
13	1.5	4	3	0.000860	2.4721
14	1.5	4	4	0.001670	1.6675
15	1.5	4	5	0.001143	1.0879

16	1.5	5	3	0.002823	1.9997
17	1.5	5	4	0.001872	1.6026
18	1.5	5	5	0.001187	1.2991
19	2	3	3	0.000998	2.1875
20	2	3	4	0.001387	1.0826
21	2	3	5	0.000936	0.9215
22	2	4	3	0.001776	2.9591
23	2	4	4	0.001921	1.8448
24	2	4	5	0.001031	1.2488
25	2	5	3	0.002383	2.1445
26	2	5	4	0.002321	1.5845
27	2	5	5	0.002151	0.7092

IV. MAIN EFFECTS PLOTS

1. Main Effects plot for MRR

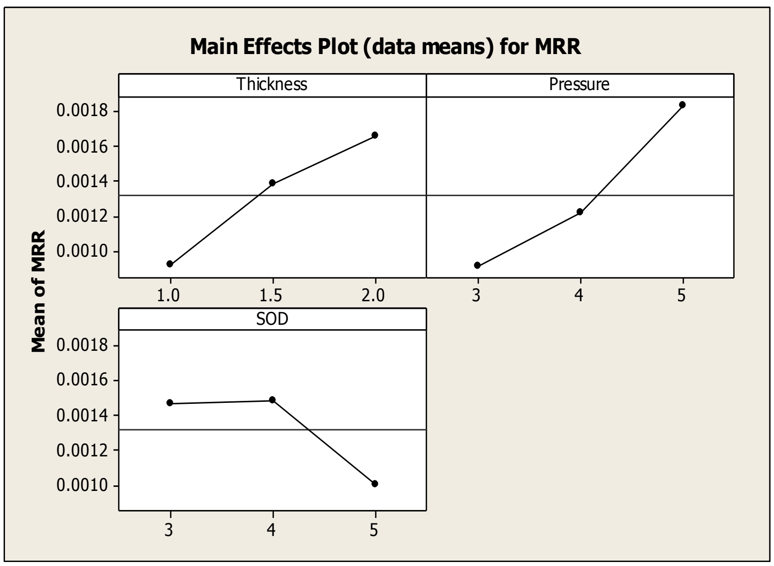

Figure 3: Main effects plot for MRR

From the figure 3 it is observed that thickness of the workpiece is the most significantly affecting parameter for MRR. The material removal rate increase linearly at increasing rate with increase in workpiece thickness. The rate of increase is rapid from lower thickness level to intermediate thickness level but then the rate of increase from intermediate thickness to highest thickness. The increase in MRR is due to the increasing collision of impinging particles in the working zone.

The air pressure is the second significant parameter affecting MRR. With increase in air pressure, the MRR is observed to increase at increasing rate. The rate of increase is slower from lower pressure to intermediate pressure and then increases. The nozzle converts pressure energy into kinetic energy. The increase in pressure leads to increased velocity at the exit of the nozzle causing the particles to impinge on the work surface with larger momentum.

From the main effects plot in Fig. 3 it is observed that there is slight increase in the MRR with increase in SOD from lower value to intermediate value. The abrasive carrying jet tends to expand as it travels and impinges on larger area due to expansion causing slight increase in MRR with increase in SOD. Further increase in SOD takes the work surface away from nozzle exit and the internal friction and air resistance causes reduction in jet energy before striking the work surface. This causes reduction in the MRR with increase in SOD from intermediate level to highest level.

2. Main effect plot for taper

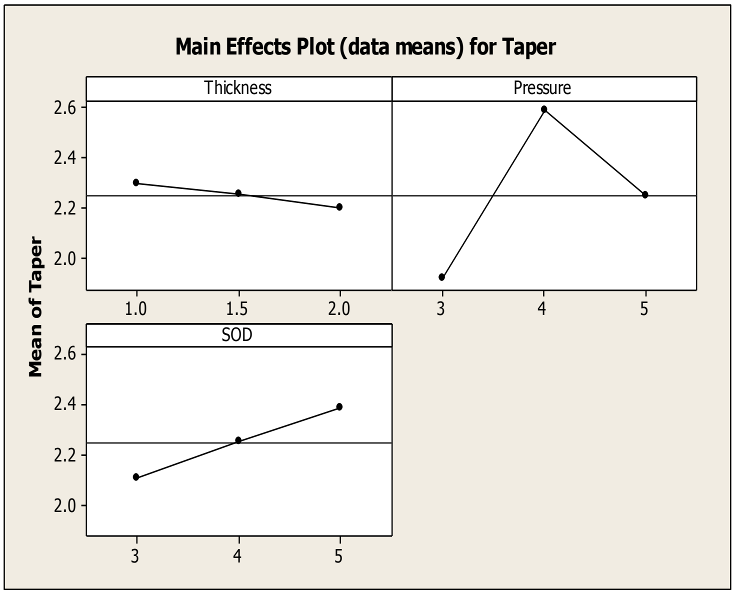

Figure 4: Main effects plot for Taper

From the figure 4 it is observed that reduction rate in taper with increase in thickness from lowest value to intermediate value is higher and this rate of reduction decreases from intermediate value to the highest value of thickness. With increase in thickness the effect of side cutting leading to increasing the diameter at bottom is large.
From the main effects plot in Fig. 4 it is observed that there is increase in the taper with increase in SOD with the increase being almost linear. The increase in taper with increasing SOD is due to the expansion of the abrasive carrying jet and increased side cutting towards the bottom due to reflected particles and debris causing the impinging particles to move sideways and increase side cutting as the cutting progresses towards the bottom end. This leads to production of larger diameter hole at the bottom as compared to the top causing increase in taper with increase in SOD.

From the figure 4 it is observed that there is increase in taper with increasing in pressure linearly at intermediate point and that decreased non-linearly from intermediate point to end point.

V. ANALYSIS OF VARIANCE

1. Analysis of Variance for MRR

Table 5: ANOVA Table for MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% Contribution
Thickness	2	0.0000025	0.0000025	0.0000013	12.57	0.000	25.510
Pressure	2	0.0000039	0.0000039	0.0000020	19.64	0.000	39.795
SOD	2	0.0000014	0.0000014	0.0000007	6.79	0.006	14.285
Error	20	0.0000020	0.0000020	0.0000001			20.408
Total	26	0.0000098					100.00

S = 0.000316723	R – Sq =79.59%	R – Sq (adj) = 73.47%

From table 5 it is observed that pressure is the most significant effect on MRR and thickness is also having significant effect on MRR as its p value is less than 0.05. SOD has no significant effect on MRR as their p values are greater than 0.05. The % contribution of pressure and thickness are 39.79% and 25.51% respectively.

2. Analysis of Variance for Taper

Table 6: ANOVA Table for Taper

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% Contribution
Thickness	2	0.01329	0.01329	0.00664	0.07	0.934	0.187
Pressure	2	1.22101	1.22101	0.61051	6.26	0.008	17.186
SOD	2	3.91943	3.91943	1.95972	20.09	0.000	55.167
Error	20	1.95084	1.95084	0.09754			27.458
Total	26	7.10458					100.00

S = 0.312317	R – Sq = 72.54%	R – Sq (adj) = 64.30%

From table 6 it is observed that SOD is the most significant effect on taper as its p value is less than 0.05. thickness and pressure has no significant effect on taper as their p values are greater than 0.05. The % contribution of SOD is 55.16% which is highest.

VI. CONCLUSION

1. Based on the experiments, the effect of selected input parameters on the output responses like MRR and Taper are studied.
2. From ANOVA analysis it is observed that thickness and pressure are most significant parameter for MRR. And SOD is most significant parameter for Taper.
3. With increasing thickness of material and pressure MRR is also increased, and other side with increasing in SOD Taper is also increased. By increasing SOD MRR is decreased and by increasing thickness and pressure taper is decreased.
4. It has been observed that by this experiment pressure is most significant parameter for this process, after that SOD is most significant parameter for abrasive jet machining.

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