Fibre Glass Cutting By Using Abrasive Jet Machining and Analysis of Process Parameters

F. Anand Raju[#1] V. Gnana Prakash[*2] Dr. M.L.S Deva Kumar[$3]

[#]*Associate professor,, Department of Mechanical Engineering, Siddhartha Institute of Engineering and Technology, Puttur - 517583 mob: 93969327777,*

[*]*PG Student, CAD/CAM, Siddhartha Institute of Engineering and Technology, Puttur - 517583 mob: 9542383868,*

[$]*Professor, Department of Mechanical Engineering, JNTUA College of Engineering, Anantapur, mob: 9440285609*

***Abstract*-- -Cutting of brittle materials like glass and ceramics by conventional machining is difficult than un conventional machining process .In this, an Abrasive jet machining is one of the best method to cut such materials. An abrasive jet machining is a jet of air which contains abrasive material. in AJM ,a high speed jet of air exits through a nozzle and the abrasive material is injected in the steam of jet. The purpose of the abrasive jet maching to perform machining or finishing operation such as cutting, deburring etc the cutting proceses is based on the principle of erosion of the material by impact of small abrasive particals with high stream of jet**

An attempt is made on cutting of, fiber glass to provide the information on the related parameters such as stand –off-distance and MRR by using Mat lab.

I. INTRODUCTION

Manufacturing processes can be broadly divided into two groups and they are primary manufacturing processes and secondary manufacturing processes. The former ones provide basic shape and size to the material as per designer's requirement. Casting, forming, powder metallurgy are such processes to name a few. Secondary manufacturing processes provide the final shape and size with tighter control on dimension, surface characteristics etc. Material removal processes are mainly the secondary manufacturing processes.

A. Principle of Working

Abrasive jet machining (AJM), also called abrasive micro blasting, is 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 removal occurs due to the erosive action of the particles striking the work piece surface. AJM has limited material removal capability and is typically used as a finishing process AJM is advantageous in two aspects. First, it has a high degree of flexibility. The abrasive media can be carried by a flexible hose to reach internal, difficult-to-reach regions. Second, AJM has localized force and less heat generation than traditional machining processes.

Abrasive jet machining (AJM) is considered to be one of the most attractive techniques that can engrave precise dimples on the surface of hard and brittle materials some practical applications of AJM have already demonstrated its high potential as a micro-machining method, such as decoration and texturing of window glass. In general, AJM is categorized as blast finishing. The machining technique is distinguished from traditional shot blasting in that it features a precision jet nozzle of less than 1 mm in diameter, through which a controlled mass of fine, hard abrasive particles is continuously directed at the work piece surface. As a consequence, AJM can meet the requirement for patterning of highly controlled micro-dimples onto the surface of difficult-to-machine materials. From another point of view, AJM is a machining method that utilizes the usually deleterious behavior of erosion, where fine, hard particles attack the work piece incessantly, in a positive manner.

Material removal in the AJM process is accomplished by the use of a continuous jet, which is produced by mixing abrasive particles with a high velocity air jet, which latter imparts momentum to the abrasive particles, accelerating them prior to their impingement on the work piece. The abrasive particles serve primarily as the abrasive medium, providing a diverse group of micro-machining mechanisms assisting in material removal. Highly localized machining forces and a low magnitude of generated heat are two Additional advantages of AJM. Basically it can be defined as the material removal process where the material is removed or machined by the impact erosion of the high velocity stream of air or gas and abrasive mixture, which is focused on to the work piece. In Abrasive Jet Machining (AJM), abrasive particles are made to impinge on the work material at a high velocity. The jet of abrasive particles is carried by carrier gas or air. The high velocity stream of abrasive is generated by converting the pressure energy of the carrier gas or air to its kinetic energy and hence high velocity jet. The nozzle directs the abrasive jet in a controlled manner onto the work material, so that the distance between the nozzle and the work piece and the impingement angle can be set desirably. The high velocity abrasive particles remove the material by micro-cutting action as well as brittle fracture of the work material. Fig. 1 below schematically shows the material removal process.

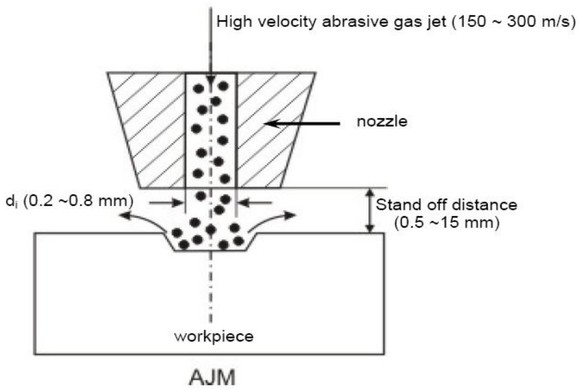


Fig. 1 AJM Basic set up

II. ANALYSIS OF DATA

TABLE NO. 1
VALUES OF VARIABLES (PARAMETERS) FOR DIFFERENT LEVELS

Level	Low	Medium	High
Coding	-1	0	1
Pressure (kg/cm²)	9.5	10.5	11.5
Abrasive size	120	150	220
Standoff distance(cm.)	1	1.5	2

TABLE NO. 2
VALUES OF MATERIAL REMOVED FOR DIFFERENT SET OF PARAMETERS

Pressure (kg/cm²)	Abrasive size	Stand off distance (cm.)	Material removed (gm.)	Coding		
				X_1	X_2	X_3
9.5	120	1	0.022	-1	-1	-1
11.5	120	1	0.081	1	-1	-1
9.5	220	1	0.008	-1	1	-1
11.5	220	1	0.049	1	1	-1
9.5	120	2	0.019	-1	-1	1
11.5	120	2	0.062	1	-1	1
9.5	220	2	0.006	-1	1	1
11.5	220	2	0.032	1	1	1
10.5	150	1.5	0.047	0	0	0
10.5	150	1.5	0.048	0	0	0
10.5	150	1.5	0.047	0	0	0
10.5	150	1.5	0.047	0	0	0
9.5	150	1.5	0.026	-1	0	0
11.5	150	1.5	0.055	1	0	0
10.5	120	1.5	0.076	0	-1	0
10.5	220	1.5	0.043	0	1	0
10.5	150	1	0.052	0	0	-1
10.5	150	2	0.035	0	0	1
9.5	150	1.5	0.026	-1	0	0
11.5	150	1.5	0.055	1	0	0
10.5	120	1.5	0.076	0	-1	0
10.5	220	1.5	0.043	0	1	0
10.5	150	1	0.052	0	0	-1
10.5	150	2	0.035	0	0	1

TABLE NO. 3
LOG VALUES OF MRR, ABRASIVE SIZE(S), PRESSURE (P) & STAND OFF DISTANCE (D)

Log P	Log S	Log D	Log MRR
0.977724	2.079181	0	-1.65758
1.060698	2.079181	0	-1.09151
0.977724	2.342423	0	-1.3098
1.060698	2.342423	0	-1.72125
0.977724	2.079181	0.30103	-1.72125
1.060698	2.079181	0.30103	-1.20761
0.977724	2.342423	0.30103	-2.22185
1.060698	2.342423	0.30103	-1.49485
1.021189	2.176091	0.176091	-1.3279
1.021189	2.176091	0.176091	-1.31876
1.021189	2.176091	0.176091	-1.3279
1.021189	2.176091	0.176091	-1.3279
0.977724	2.176091	0.176091	-1.58503
1.060698	2.176091	0.176091	-1.25964
1.021189	2.079181	0.176091	-1.11919
1.021189	2.342423	0.176091	-1.36653
1.021189	2.176091	0	-1.284
1.021189	2.176091	0.30103	-1.45593
0.977724	2.176091	0.176091	-1.58503
1.060698	2.176091	0.176091	-1.25964
1.021189	2.079181	0.176091	-1.11919
1.021189	2.342423	0.176091	-1.36653
1.021189	2.176091	0	-1.284
1.021189	2.176091	0.30103	-1.45593

The regression equation is

$$LogMRR = -5.31 + 6.63 \log P - 1.29 \log S - 0.358 \log D \quad \text{----- (1)}$$

TABLE NO.4

VALUES OF REGRESSION COEFFICIENTS

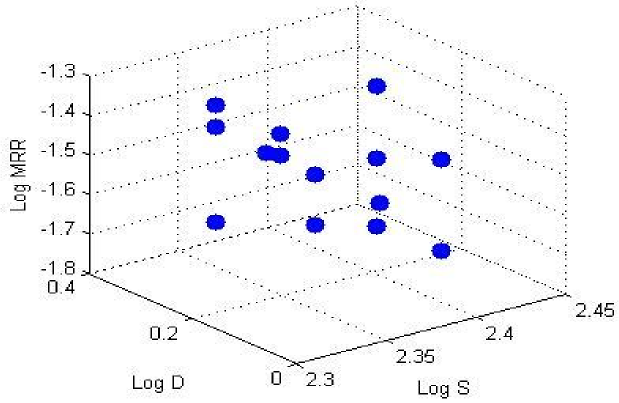
Predictor	Coef.	SE Coef.	T	P
Constant	-5.305	1.326	-4.00	0.001
log P	6.634	1.079	6.15	0.000
log S	-1.2908	0.3347	-3.86	0.001
log D	-0.3582	0.2956	-1.21	0.240

S = 0.1552 R-Sq = 73.0% R-Sq (adj.) = 69.0%

Now the above regression equation (1) can be written as

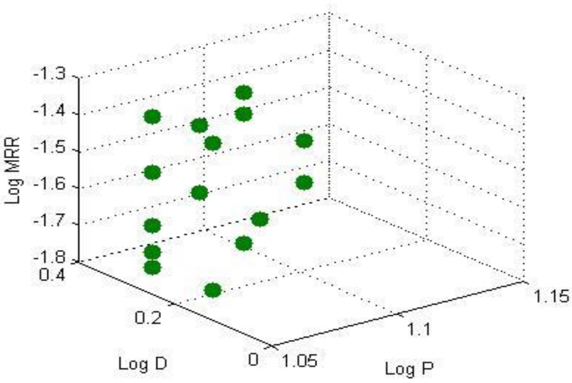
$$MRR = \left(4.897^{-6}\right)\left(P^{6.63}\right)\left(S^{-1.29}\right)\left(D^{0.358}\right) \text{---- (2)}$$

Equation No. (2) Is the equation obtained from the non linear regression of the data obtained and can be used to predict the values of the MRR for varying the other three variables in the equation.



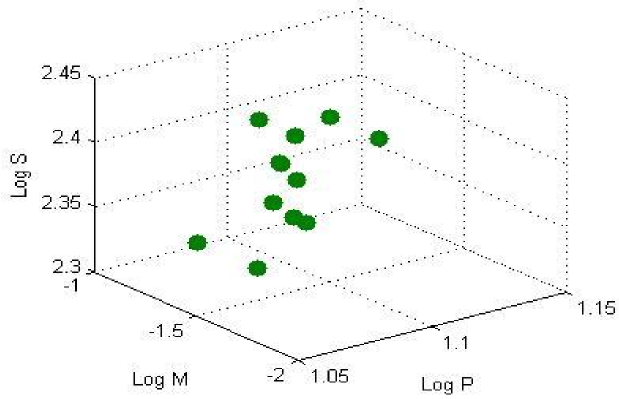
GraphNo1

Scatter plot for the log values of MRR versus Abrasive Size and Pressure



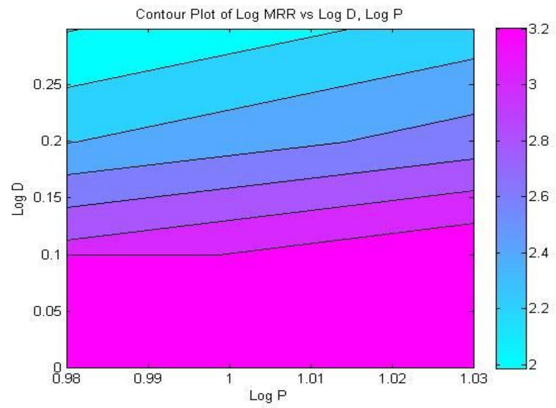
Graph No. 2

Scatter plot for the log values of MRR versus Stand off distance and Pressure

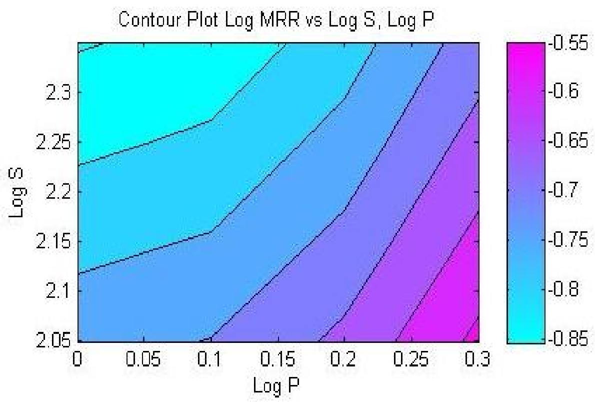


Graph No. 3

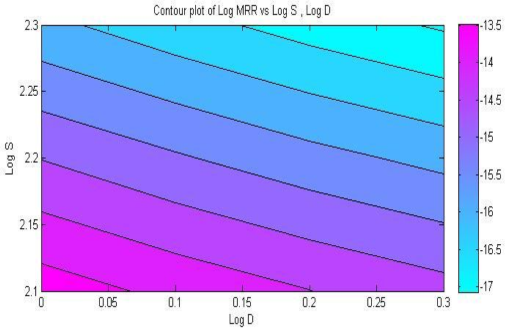
Scatter plot for the log values of MRR versus Stand off distance and Abrasive Size



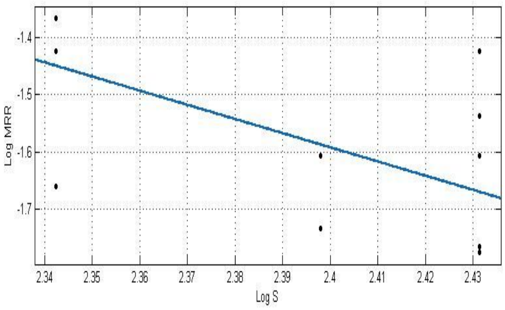
Graph No. 4



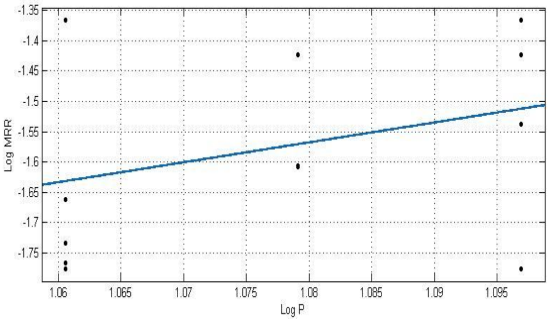
Graph No. 5



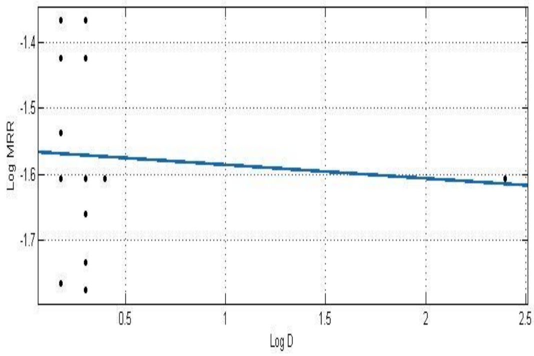
Graph No. 6



Fitted line plot Log MRR Vs Log S
Graph No. 7



Fitted line plot Log MRR Vs Log P
Graph No. 8



Fitted line plot Log MRR Vs Log D
Graph No. 9

III. CONCLUSIONS

The effect of the process parameters viz. Pressure, Abrasive size & Stand off distance on the work material (fiber glass) are investigated for their effect on MRR a non linear equation is being obtained and is presented graphically and from the equation and the graphs obtained some conclusions are drawn which are as follows:

From the regression for MRR vs. Abrasive Size it can be observed that as abrasive size is increased that is the grit no. is increased the MRR decreases i.e. the finer the abrasive less is the material removed. But if the pressure is increased keeping Stand off distance to optimum the MRR can be increased to some extent. It can be observed from the contour plot also that if coarser abrasive is used for machining then MRR is high to a wide range of stand off distance.

From the regression for MRR vs. Stand off distance it is observed that as the stand off distance increases material removal decreases. But polynomial regression and contour plot suggests that at optimum value of stand off distance the material removal rate is maximum which decreases if the stand off distance is varied on either side of the optimum value.

From the regression of MRR vs. Pressure it is observed that as pressure is increased the amount of material removed also increases. It is suggested by the contour plot that a coarser abrasive and high pressure are responsible for high material removal if stand off distance is kept to optimum level or slightly below the optimum.

It can also be concluded that abrasive jet machining with silicon carbide abrasive is suitable for hard and brittle materials like glass and fiber glass. It can also be concluded that in processes where material removal is of prime importance there stand off distance should be kept optimum, abrasive of coarser size should be used and high pressure should be employed. While in cases where surface finish is of prime importance low stand off distance high pressure and finer abrasive should be used.

From the non linear regression the equation obtained can be used to predict the MRR on account of variation in any or all of the three variables of the equation which are Pressure, Stand off distance & Abrasive Size.

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