A comparative Experimental Analysis of Sea sand as an abrasive material using Silicon carbide and mild steel Nozzle in vibrating chamber of Abrasive Jet machining process

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Abstract- A number of investigations carried out in an abrasive jet machining process having a traditional material with traditional nozzle. In some publication are focusing on water jet cutting machining and some are focusing on sand bond grinding , some work are wear behavior of nozzle and some are on performance of material in water jet machining.

The present research work give an analysis of performance of sea sand in silicon carbide nozzle and mild steel nozzle (newly used) and their estimate life of nozzle diameter. In this experiment glass used as work piece. The approximate service life of silicon carbide nozzle is 300-400 hrs as it depend on the abrasive material hardness. The performance of the sand in vibration chamber , silicon carbide nozzle is used with variable and constant parameter. It is also noticed that the width of cut is increased with increasing of feed rate. The taper cutting has found to be more at greater stand of distance and work feed rate. Silicon carbide is hard as compared to mild steel but gives its characteristic. The performance characteristic of MRR (material removal rate),SOD (stand off distance) are similar in nature as used by traditional material in this process.

Index Terms- vibrating chamber, nozzle, Abrasive jet machine, particle size, stand off distance ,material removal rate , glass

I. Introduction

Abrasive jet machining is also called as abrasive micro blasting, which is manufacturing process utilized a high pressure stream carrying micro particle of an abrasive to impinges on glass work piece (surface for material removal as well as shape generation). The removal occurring due to the erosion action of particle striking on the glass surface or work piece surface.

Matthew w. chantangner (10) has emphasis limited material removal rate, capability and typically emphasis on finishing process. Recent studies by Dang Sam park (1) have focus on line type microgrooving of glass by using micro abrasive water jet machining process. The vibration chamber has number of aspect i.e. it has high degree of flexibility, the abrasive material carried out by flexible hose with tight nozzle attached at other end. The specific cylindrical vibrating chamber in this set has localized cam and follower. The DC motor is used for variable speed to avoid sudden impact on vibration chamber. The compressed air with pressure variable from 5 kg/cm^2 to 12 kg/cm^2 for mixing of abrasive material in mixing chamber.

In this research work the vibration chamber has cylindrical shape for better mixing and non striking of material at corner. This chamber has provided inlet and outlet at lower and upper of outer surface for compressed air. In some studies displacement chamber has used instead of vibrating chamber but results are not upto the mark due to less pressure stream.

The main objectives of this study to performed essential experiments required to machine hole on glass workpiece. To achieve the goals optimum condition for workpiece is fixed and masking along with the process of abrasive machining.

II. Experimental procedure and material

2.1 : fabrication of cylindrical vibration chamber

The M.S. cylindrical sheet of thickness 4 mm with the height of 30 cm is used. The lower and upper end is used for outlet and inlet of abrasive material and compressed air. The cylindrical chamber has so design for non sticking of sand at corner and proper mixing with comp air. The fundamentals of vibration analysis can be understood by studying the simple mass–spring–damper model. The mathematics used to describe its behavior is identical to other simple harmonic oscillators such as the RLC circuit.

The dimension 160 x 110 x 4 (mm). The high compressed air inside the chamber which the cylinder walls and cover plate have to withstands. It was design and selected in a such way that the cover plate and cylinder wall should not bend due to the internal pressure and total leakages were avoided.

The equation used for thickness

$T = a \times b \times c_3 [p / \{\sigma 1 \; (a^2 + b^2) \}]^{½}$

Where,

p = uniform pressure

a = length of the plate in mm

b = breadth of plate in mm

c_3 = co-efficient = 0.49

$T = 0.49 \times 230 \times 160 [0.8 / \{ (2302 + 1602) \}]^{½}$

T = 4.85 mm

T = 4 mm

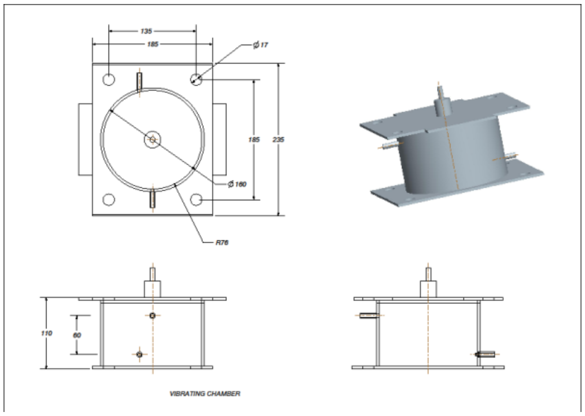

Fig no.1.cylidrical vibrating chamber

The difference in hardness between the two substances: a much harder abrasive will cut faster and deeper. Grain size (grit size): larger grains will cut faster as they also cut deeper. Adhesion between grains, between grains and backing, between grains and matrix: determines how quickly grains are lost from the abrasive and how soon fresh grains, if present, are exposed.

2.2: sea sand as abrasive material:

Usually traditionally abrasive are using after preparing grain size (100-150 microns)and testing hardness of the sand. The minerals are either crushed or are already of a sufficiently small size (anywhere from macroscopic grains as large as about 2 mm to microscopic grains about 0.001 mm in diameter) to permit their use as an abrasive. These grains, commonly called grit, have rough edges, often terminating in points which will decrease the surface area in contact and increase the localized contact pressure. The abrasive and the material to be worked are brought into contact while in relative motion to each other. Force applied through the grains causes fragments of the worked material to break away while simultaneously smoothing the abrasive grain and/or causing the grain to work loose from the rest of the abrasive. Heavy minerals (dark) in a quartz beach sand (Chennai, India). In terms of particle size as used by geologists, sand particles range in diameter from 0.0625 mm (or 1⁄16 mm) to 2 mm. An individual particle in this range size is termed a sand grain. Sand grains are between gravel (with particles ranging from 2 mm up to 64 mm) and silt (particles smaller than 0.0625 mm down to 0.004 mm). The size specification between sand and gravel has remained constant for more than a century, but particle diameters as small as 0.02 mm were considered sand under the Albert Atterberg standard in use during the early 20th century.

2.3 specification of sand
Physical specification - 20 mm - 2.5 mm
Uniform coefficient - 1.3 - 1.7
Specific gravity - 2.67
Mohs Hardness - 7
Density - 105 – 115 lbs / foot cubic

III. Parameters and Observations

The various parameter related to performance of sand as an abrasive in both cases

1) Operating Pressure (P) – 5 kg/cm. sq to12 kg/cm.sq
2) Carrier Gas - compressed air
3) Material Removal Rate(MRR) – gm/sec.sq
4) Standoff Distance (SOD) - mm (variable & constant)
5) Diameter of cut (DOC) – 4mm to 5 mm
6) Powder flow rate – gm per sec
7) Size of abrasive or Grain size - 100 to 150 micron

IV. Observation : Detail specification

1) Nozzle : a) Material = silicon carbide b) Diameter = 1.5 mm

2) Abrasive : a) Material = sand b) Grain Size = 100-150 µm

3) Workpiece: a) Material = Glass b) Thickness = 4 mm

Table no. 1: SOD & Pressure is variable

Sr. No	P Kg/cm²	SOD mm	MRR W/T = gm/sec)	PFR Wa/T = gm/sec	DOC Mm
1	5	5	0.04	1.40	4.5
2	5.5	6	0.042	1.45	4.7
3	6.5	7	0.058	1.47	5.0
4	7	8	0.066	1.527	5.1
5	7.5	9	0.072	1.56	4.4
6	8	9.5	0.081	1.62	5.2
7	8.5	10	0.097	1.70	5.4
8	9	11	0.102	1.81	5.6
9	9.5	12	0.102	1.82	5.4
10	10	12	0.1047	1.85	5.5

The polynomial Equation for third degree :
Performance of : MRR v/s PFR
F(x)=p1*x^3+p2*x^2+p3*x+p4

The value of coordinates p1 = -0.5277, p2 = 2.315, p3 = -3.179 and p4 = 1.39 the value R-square = 0.984 which is very closed to 1 for best fit of curve.

Fig No : 2 Curve fitting of MRR v/s Pressure

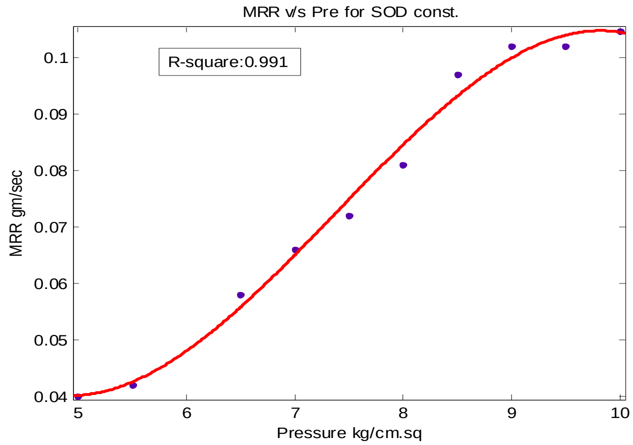

Fig No :3 Best curve fitting of MRR v/s PFR

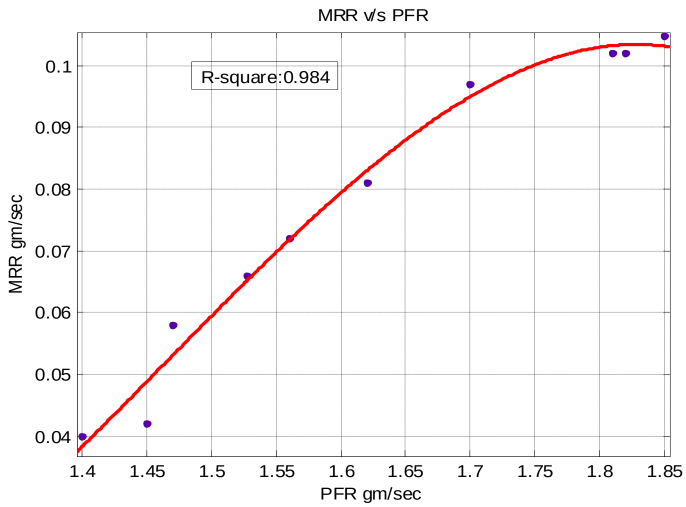

Table no.2 : SOD & pressure constant

Sr. No	P Kg/cm²	SOD mm	MRR W/T = gm/sec	PFR Wa/T = g/se	DOC mm
1	10	5	0.082	1.80	5.1
2	10	5	0.082	1.81	5.0
3	10	5	0.081	1.81	5.1
4	10	5	0.082	1.81	5.1
5	10	5	0.081	1.80	5.0

Observation :for M.S.Nozzle material
1) Nozzle : a) Material = **Mild steel** b) Dia = 2.5 mm
2) Abrasive: a) Material = **sand** b) Grain Size = 100-150 μm
3) Workpiece a) Material = Glass b) Thickness = 4 mm

Table No. 3 : SOD is constant for MS

Sr. No	P Kg/cm²	SOD mm	MRR W/T = gm/sec)/ 10^{-3}	PFR Wa/T = gm/sec	D mm
1	6.2	8	6.9	0.50	5.3
2	6.2	8	8.1	0.63	5.5
3	6.2	8	5.94	0.61	6.0
4	6.2	8	1.6	0.39	6.0
5	6.2	8	1.52	0.30	6.0

V. Result and Discussion

The material removal rate (MRR) is increasing with change in pressure and standoff distance is also variable. The operating hrs of nozzle is directly proportional to material of nozzle i.e. hardness of nozzle. The hardness of silicon material is more than mild steel nozzle and life is absolutely more than mild steel nozzle.

VI. Conclusion

In this experimental study silicon carbide nozzle and mild steel nozzle is used for sea sand abrasive material. 1) The hardness of material of nozzle play a key role with resp. to its erosion wear in the AJM process. The silicon nozzle being high hardness exhibited with lower erosion rate while the MS nozzle with relative low hardness having low erosion rate under same test condition and curve fitting for this is good fitting .2) the life of silicon nozzle is more than MS nozzle 3) A silicon nozzle exhibited a brittle facture induced removal process, while the MS nozzle showed mainly plowing type of removal rate.4) The erosion rate of material depend on grain size of erodent abrasive.

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