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Fabrication of abrasive Jet Machine with Parameters Investigation

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Abstract— Abrasive Jet Machining (AJM) or Micro Blast Machining is a non-traditional machining process, wherein material removal is affected by the erosive action of a high velocity jet of a gas, carrying fine-grained abrasive particles, impacting the work surface. The process is particularly suitable to cut intricate shapes in hard and brittle materials which are sensitive to heat and tend to chip easily. As Abrasive jet machining (AJM) is like sand blasting and effectively removes hard and brittle materials. AJM has been applied to rough working such as debarring and rough finishing. With the increase of needs for machining of ceramics, semiconductors, electronic devices and L.C.D., AJM has become a useful technique for micromachining.

Our project report deals with various experiments which were conducted to assess the influence of abrasive jet machining (AJM) process parameters on material removal rate and diameter of holes of glass plates using various types of abrasive particles.

The experimental results of the present work are used to discuss the validity of proposed model as well as the other models. With the increase in nozzle tip distance (NTD), the top surface diameter and bottom surface diameter of hole increases as it is in general observation of abrasive jet machining process. As the pressure increases, the material removal rate (MRR) is also increased. The present study has been introduced a mathematical model and the obtained results have been compared with that obtained from the theoretical.

1. Introduction

Abrasive Jet Machining (AJM) is the removal of material from a workpiece by the application of a high-speed stream of abrasive particles carried in gas medium from a nozzle. The AJM process differs from conventional sand blasting in that the abrasive is much finer and the process parameters and cutting action are carefully controlled.

The process is used chiefly to cut intricate shapes in hard and brittle materials which are sensitive to heat and tend to chip easily. The process is also used for deburring and cleaning operations. AJM is inherently free from chatter and vibration problems. The cutting action is cool because the carrier gas serves as a coolant.

Variables in Abrasive Jet Machine:
* Carrier gas
* Types of abrasive
* Size of abrasive grain
* Velocity of abrasive jet
* Flow rate of abrasive
*Work material
*Nozzle work distance (stand of distance)
*Shape of cut and operation type
*Geometry, composition and material of nozzle.

2. Experimental Set-up

The compressed air from the compressor enters the mixing chamber partly prefilled with fine grain abrasive particles. The vortex motion of the air created in the mixing chamber carries the abrasive particles to the nozzle through which it is directed on to the work-piece. The nozzle and the work-piece are enclosed in a working chamber with a Perspex sheet on one side for viewing the operation

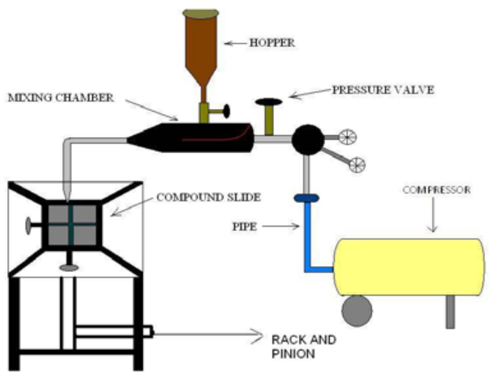


Fig 2.0: Schematic Diagram Of Experimental Set-Up

The abrasive particles used were Sic (grain size 60 microns and 120 microns). The nozzle material was stainless steel and the nozzles used were of diameters 1.83 mm and 1.63 mm. This type of set-up has the advantage of simplicity in design, fabrication and operation. The equipment cost is much less except the compressor. The mixture ratio is controlled by the inclination of the mixing chamber

The mixture ratio is defined as

$$\alpha \text{ (mixture ratio)} = \frac{\dot{m}_p}{\dot{m}_a + \dot{m}_p}$$

Where m_p is the mass flow rate of the abrasive particle sand m_a the mass flow rate of air.

A.Effect Of Nozzle Tip Distance (NTD) On Diameter Of Hole

The effect of SOD or NTD on material removal rate (MRR) is shown in fig as the NTD increases the diameter of hole increases which is general observation in abrasive jet machining.

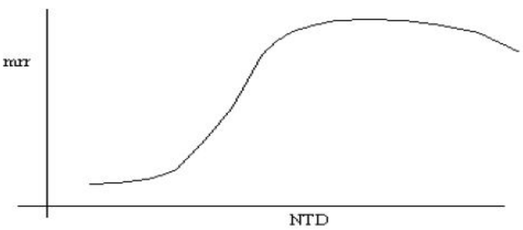


Fig 2(A): Effect Of Nozzle Tip Distance (NTD) On Diameter Of Hole

B.Effect Of Nozzle Tip Distance (NTD) On Material Removal Rate

The effect of abrasive flow rate (AMF) on material removal rate (MRR) is shown in Fig as the abrasive mass flow rate increases the material removal rate (MRR) increase which is also general observation in abrasive jet machining.

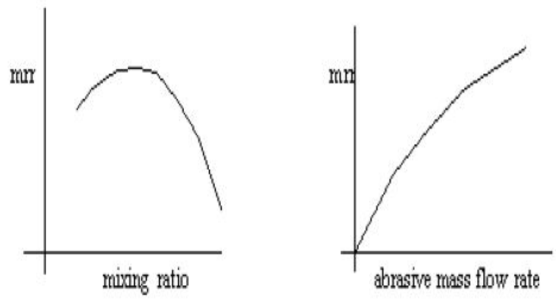


Fig 2(B): Effect Of Nozzle Tip Distance (NTD) On Material Removal Rate

C.Effect Of Abrasive Mass Flow Rate And Mixing Ratio On Material Removal Rate (MRR)

The effects of stand off distance on MRR and penetration rates have been reported by **Ingulli, Sarkar** and **Pandey**, **Verma** and **Lal**. These investigations indicate that after a threshold pressure, the MRR and penetration rates increase with nozzle pressure. For brittle materials, normal impingement results maximum MRR and for ductile materials, an impingement angle of 15-20 degrees results in maximum MRR. The effects of abrasive grit size and mixing ratio which is the ratio of the weight of the abrasive powder to the weight of the abrasive powder and the air have been thoroughly investigated by many investigators. As the abrasive grit size and mixing ratio increase, the MRR and penetration rate increase but the surfaces finish value which is measured in Ra decreases.

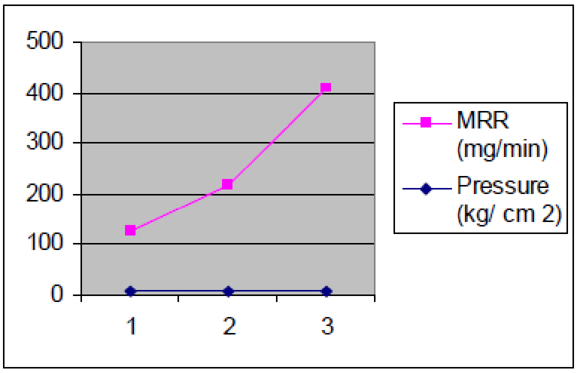
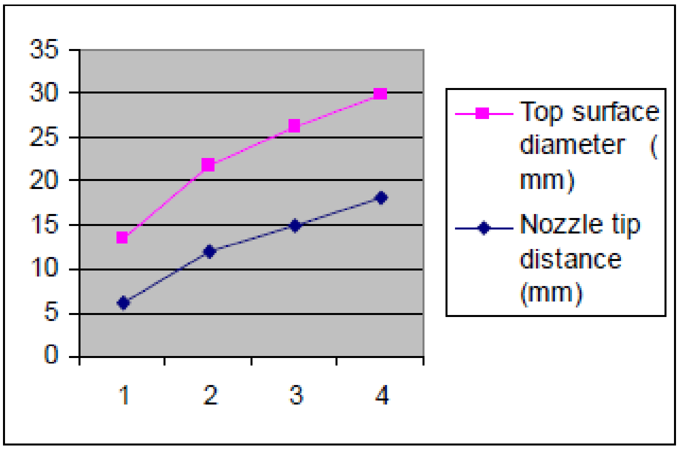
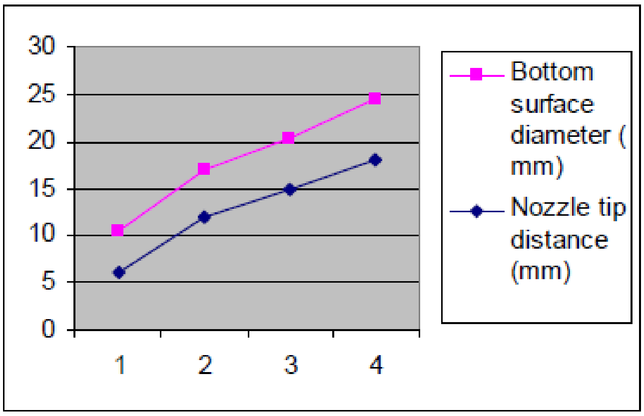


Fig 2 (C): Effect Of Abrasive Mass Flow Rate And Mixing Ratio On Material Removal Rate (MRR)

D. D. Graph Shows The Relationship Between Nozzle Tip Distance And Top Surface Diameter Of Hole At A Set Pressure Of 5.5 Kg/ cm^2



E. Graph Shows The Relationship Between Nozzle Tip Distance And Bottom Surface Diameter Of Hole At A Set Pressure Of 5.5 Kg/ cm^2



F. Typical Curves Showing the Variation Of Erosion With Impact Angle

$$Q = \frac{C f(\theta)\ M\ V^n}{\sigma}$$

Where *Q* is the volume of material removed by an impacting particle of mass *M* carried in a stream of air expanding in a nozzle of fixed geometry; C and *n*, the constants; *V*, the velocity of impacting particle; ø the impingement angle; and σ the minimum flow stress of the target material. Subsequently Sheldon found the value of the impingement angle for which the volumetric material removal rate is maximum. For brittle materials, the impingement angle is 90° for maximum erosion rate while it is 20°-30° for ductile materials

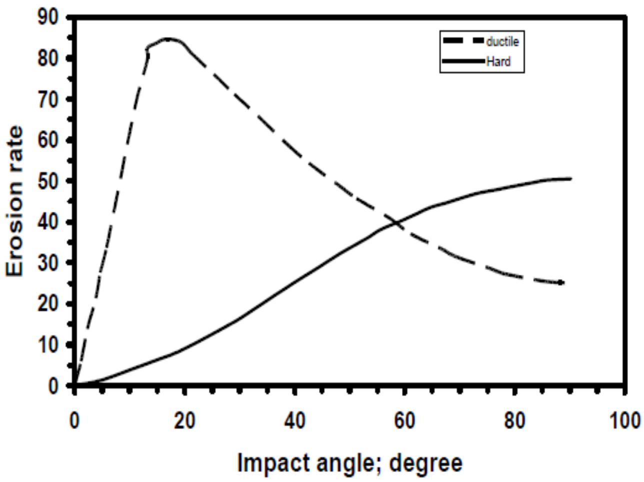


Fig 2 (F): Typical Curves Showing the Variation Of Erosion With Impact Angle

G. The Relationship Between NTD And Diameter Of Hole

Table 1 and Fig.2 (G) show the effect of nozzle tip distance (NTD) on diameter of hole. As the distance between the face of nozzle and the working surface of the work increases, the diameter of hole also increases because higher the nozzle tip distance allows the jet to expand before impingement which may increase vulnerability to external drag from the surrounding environment. It is desirable to have a lower nozzle tip distance which may produce a smoother surface due to increased kinetic energy.

S.No	Nozzle tip distance (mm)	Diameter of hole(mm)
1	0.79	0.46
2	5.00	0.64
3	10.01	1.50
4	14.99	2.01

Table 1: Effect of NTD on diameter of hole

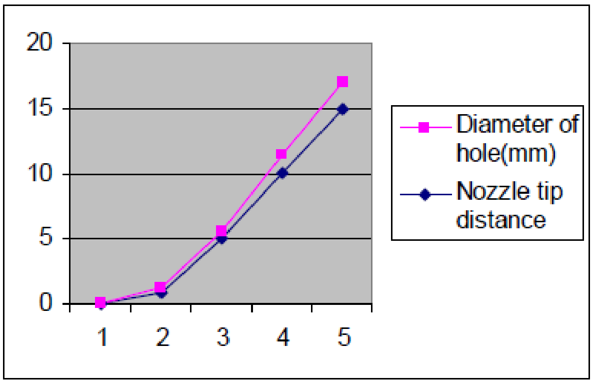


Fig 2(G): Graph Shows the Relationship Between NTD And Diameter Of Hole

3. FUTURE SCOPE

It is very clear that AJM is greater Non-conventional machining process which is used as a multipurpose system. It is also a most effective among various affordable systems. This system is eco-friendly. Even some of the companies in India like ABB, L & T and ESSAR are already using this system with CNC programming. This system is also use as Water Jet Machining (WJM) in which abrasives such as garnet, diamond or powders can be mixed into the water to make slurry with better cutting properties than straight water. Further development in WJM is called Hydrodynamic Jet Machining (HJM) which combines the principle of Water Jet Machining and Abrasive Jet Machining process. AJM is also used as Abrasive Flow Machining (AFM), Ultrasonic Machining (USM).

4. CONCLUSION

In this project a complete design of the Abrasive Jet Machine is given. The XYZ motion modules are designed taking in account of currently available components in the market. The designing and assembling of very large number of components was a tremendous task and was completed on time. However because of some parts couldn’t be purchased the whole assembly was limited to drilling operation.

The project can go beyond its current position and capabilities by employing automation into it. This can be done by using stepper motors or DC servo motors interfaced with standard PCI controllers or standalone controllers. 2-D profiles can be converted into standard G-codes and M-codes and that can be sent to the machine to perform automated machining.

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