

Experimental Investigation of Effect of Process Parameters on Abrasive Jet Machining

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ABSTRACT: Abrasive Jet Machining (AJM) is the process of material removal from a workpiece by the application of a high-speed stream of abrasive particles carried in a gas or air medium from a nozzle. The material removal process is mainly by erosion phenomena. The AJM will chiefly be used to cut shapes in hard and brittle materials like glass, ceramics, etc. Where in the machine comprised of Compressor, Vibrator, Pressure Regulator, Dust filter, Nozzle and Pressure gauge, etc. In the present work, a model of the Abrasive Jet Machine is designed using available hardware taking into consideration of commercially available components. Care has been taken to use more fabricated components rather than directly procuring them, this helped us gain hands-on experience in the fabrication process. Experimental results are tabulated for machining a glass plate using aluminium oxide as abrasive particles.

KEYWORDS: Nozzle tip distance, Aluminium oxide, Metal removal rate, carrier gas pressure.

I. INTRODUCTION

Abrasive machining is a machining process where the material is removed from a workpiece using a multitude of small abrasive particles. Common examples include grinding, honing, and polishing. Abrasive processes are usually expensive, but capable of tighter tolerances and better surface finish than other machining processes (chances, delectability, costs, and safety aspects, etc.) The literature study of Abrasive Jet Machining reveals that the Machining process was started a few decades ago. Till date, there has been a thorough and detailed experiment and theoretical study on the process. Most of the studies argue over the hydrodynamic characteristics of abrasive jets, hence ascertaining the influence of all operational variables on the process effectiveness including abrasive type, size and concentration, impact speed, and angle of impingement. Other papers found new problems concerning carrier gas typologies, nozzle shape, size and wear, jet velocity and pressure, standoff distance (SOD) or nozzle tip distance (NTD).

These papers express the overall process performance in terms of material removal rate, geometrical tolerances and surface finishing of workpieces, as well as in terms of nozzle wear rate. Finally, there are several significant and important papers which focus on either leading process mechanisms in the machining of both ductile and brittle materials, or on the development of systematic experimental statistical approaches and artificial neural networks to predict the relationship between the settings of operational variables and the machining rate and accuracy in surface finishing. The abrasive jet machining (AJM) is considered as an attractive and effective machining method for hard and brittle materials. Machining mechanisms and characteristics of abrasive jet machining are major topics of many research work in the recent years. In recent years' abrasive jet machining has been gaining increasing acceptability for deburring applications. AJM deburring has the advantage over a manual deburring method that generates an edge radius automatically. This increases the quality of the deburred components. The influence of other parameters such as nozzle pressure, mixing ratio, and abrasive size are insignificant.

II. EXPERIMENTAL SETUP AND PROCEDURE

A schematic layout of AJM is shown in below Figure 1. The filtered gas, supplied under pressure to the mixing chamber containing the abrasive powder and vibrating, entrains the abrasive particle and is passed into a connecting hose. This abrasive and gas mixture emerges from a small nozzle at high velocity. The abrasive powder feed rate is controlled by the amplitude of the vibration of the mixing chamber. A pressure regulator controls the gas flow and pressure. The nozzle is mounted on a fixture. Either the workpiece or the nozzle is moved by cams pantograph or other

suitable mechanisms to control the size and shape of the cut. Hand operation is sometimes adequate to remove surface contaminations or in cutting where accuracy is not very critical.

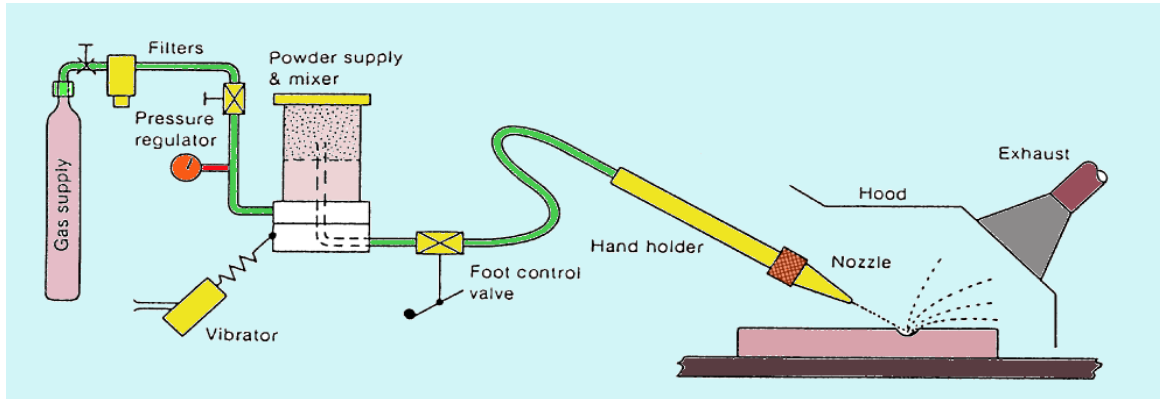


Fig.1: Components of AJM.

The major field of application of AJM process is in the machining of essentially brittle materials and heat-sensitive materials like glass, quartz, sapphire, semiconductor materials, mica, and ceramics. It is also used in cutting slots, thin sections, countering, drilling, deburring, for producing integrate shapes in hard and brittle materials.

III. FABRICATED AJM MODEL



Figure 2: Assembled front view of the abrasive jet machining equipment

Experiments were conducted on a test rig, as shown in above figure 2. The abrasive grits (alumina) were mixed with airstream ahead of the nozzle and the abrasive flow rate was kept constant throughout the machining process. The jet nozzle was made of tool steel to carry high wear resistance. Drilling of glass sheets was conducted by setting the test rig as shown in Figure and the parameters listed in Table 1



Glass was used as a workpiece material because of its homogeneous properties. The test specimens were cut into square and rectangular shape for machining on the AJM unit having thickness 3mm, 4mm, 5mm. In the machine, the initial weights of glass specimens were measured with the help of digital balance. After machining the final weights were measured with the help of digital balance to calculate the material removal rate. In our machine the movement to specimens in x-y directions are provided with the help of a cross slide and in the z-direction with the help of a worm and worm wheel drive. First, the abrasive that was alumina in powder form was fed in the hopper carefully. After that compressor connections were checked. The glass specimen was properly clamped on the cross slide with the help of various clamps. As the compressor was switched on, the hopper gate valve was opened so that abrasive grains were mixed with air-jet coming from the compressor and focused on the specimen with help of nozzle. Different readings were taken using different process parameters on the glass specimens of different thickness and all results were tabulated.

Table 1: AJM Machining Parameters

Mechanics of metal removal	Brittle fracture by impinging abrasive grains at high speed.
Carrier gas	Air, carbon –dioxide
Abrasives	Alumina, SiC
Pressure	2-10 atm
Nozzle	WC, sapphire,
Critical parameters	Abrasive flow rate and velocity, nozzle tip distance abrasive grain size
Material application	Hard and brittle metals, alloys, and non-metallic

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The results of experiments were tabulated here. In our experiments first, we changed the nozzle tip distance (NTD) and observed the effect of NTD on the diameter of holes of workpieces. Secondly, we changed the pressure of gas and observed its effect on material removal rate (MRR) of the workpieces. We had taken readings at different nozzle tip distance (NTD) and different pressures. After taking readings we plotted our results in the form of graphs here. The following graphs show the effect of nozzle tip distance (NTD) on the diameter of holes of work pieces and the effect of pressure on material removal rate(MRR).

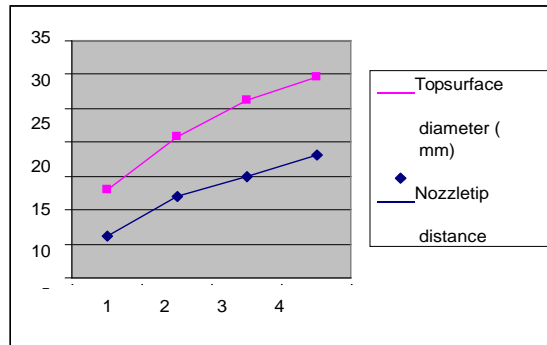


Fig.3 Graph shows the relationship between nozzle tip distance and top surface diameter of the hole at a set pressure of 5.5 kg/ cm ²

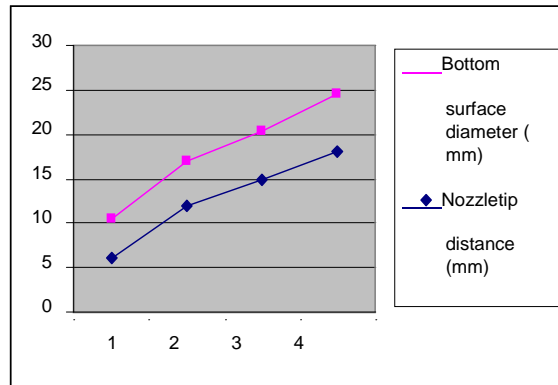


Fig.4 Graph shows the relationship between nozzle tip distance and bottom surface diameter of the hole at a set pressure of 5.5 kg/ cm ²

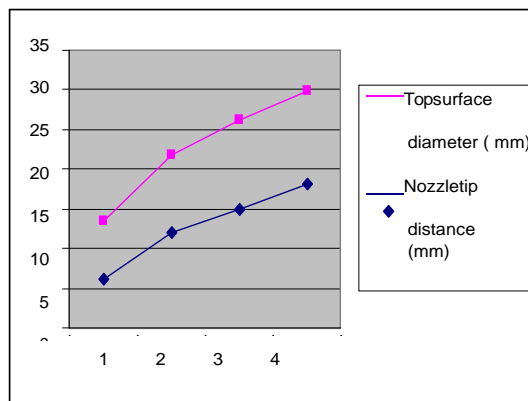


Fig.5 Graph shows the relationship between nozzle tip distance and top surface diameter of the hole at a set pressure 6.5 kg/ cm ²

V. CONCLUSION

By the experiments conducted by changing pressure, nozzle tip distance on different thicknesses of glass plates. The effect of their process parameters on the material removal rate (MRR), top surface diameter, and bottom surface diameter of the hole obtained was measured and plotted. 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 the pressure increases material removal rate (MRR) was also increased.

REFERENCES

- [1] Neelesh K. Jain, V.K. Jain, K. Deb, "Optimization of process parameters of mechanical type advanced machining processes using genetic algorithm", International Journal of Machine Tools and Manufacturer (2006).
- [2] Sarkar, P.K., Pandey, P.C., "Some investigations on abrasive jet machining", Journal of Inst. Eng. (56), 1976.
- [3] Neema, M.L., Pandey, P.C., "Erosion of glass when acted upon by abrasive jet machining", Int. Conference on wear of materials, 1977.
- [4] Venkatesh V.C., "Parametric studies on abrasive jet machining", CIRP Ann 1984; 33(1): 109-120.
- [5] Ramachandran N, Ramakrishnan N., "A review on abrasive jet machining", J Mater Proc Tech 1993; 39: 21-31.
- [6] M.A. Azmir, A.K. Ahsan, "A study of abrasive water jet machining process on glass/epoxy composite laminate", Journal of Materials Processing Technology 209(2009) 6168-6173.
- [7] J.M. Fan, C.Y. Wang, J. Wang, "Modelling the erosion rate in micro abrasive air jet machining", Wear 266(2009) 968-974.
- [8] M. Kantha Babu, O.V. Krishnaiah Chetty, "A study on recycling of abrasives in abrasive water jet machining", Wear 254(2003) 763-773.
- [9] R. Balasubramaniam, J. Krishnan, and N. Ramakrishnan, "An experimental study on the abrasive jet deburring of cross drilled holes", Publication: Journal of Materials Processing Technology, Volume 91, Issues 1-3, 30 June 1999, Pages 178-182
- [10] R. Balasubramaniam, J. Krishnan and N. Ramakrishnan "A study on the shape of the surface generated by abrasive jet machining", Publication: Journal of Materials Processing Technology, Volume 121, Issue 1, 14 February 2002, Pages 102-106
- [11] F.C. Tsai, B.H. Yan, Kuan, Huang "A Taguchi and experimental investigation into the optimal processing conditions for the abrasive jet polishing of SKD61 mold steel", International Journal of Machine Tools and Manufacturer, 48, 2008, Pages 932-945.
- [12] A. P. Verma and G. K. Lal Publication "An experimental study of abrasive jet machining", International Journal of Machine Tool Design and Research, Volume 24, Issue 1, 1984, Pages 19-2