A Review on Abrasive Jet Machining

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Abstract— AJM is a process of removal of materials by impact erosion through the action of concentrated, high velocity stream of the grit abrasives entrained in a high-velocity gas or air stream. Abrasive jet machining can be used to cut hard and brittle material (e.g. germanium, silica, mica, glass, ceramics) in a large variety of cutting and debarring and the process is smooth and free from vibration.Input process parameters that are taken into consideration are Air Pressure, Abrasive particle, Stand of distance, Nozzle diameter. Output parameters are Material removal rate (MRR), Diameter of cut (DOC), Depth of cut, Surface Roughness (SR). The effect of input parameters on performance parameters such as material removal rate, Diameter of cut, Depth of cut, surface Roughness, Kerf width is experimentally measured.

Key words: Abrasive Jet Machining, Abrasive Powder, MRR, KERF WIDTH, Surface Roughness

I. INTRODUCTION

Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process.

Machining is a part of the manufacture of many metal products, but it can also be used on materials such as wood, plastic, ceramic and composites.

This is a process of removal of material by impact erosion through the action of concentrated high velocity stream of grit abrasives entrained in high velocity gas stream. AJM is different from shot or sand blasting, as in AJM, finer abrasive grits are used and parameters can be controlled more effectively providing better control over product quality.

There are so many Advantages of abrasive jet Machining:

- In most of the cases, no secondary finishing required
- Capital cost is low and it is easy to operate and maintain AJM
- Smaller kerf size reduces material wastages
- Abrasive particle reused.
- No heat affected zone
- No cutter induced distortion
- Low cutting forces on work pieces
- Limited tooling requirements
- Little to no cutting burr
- Typical finish 125-250 microns

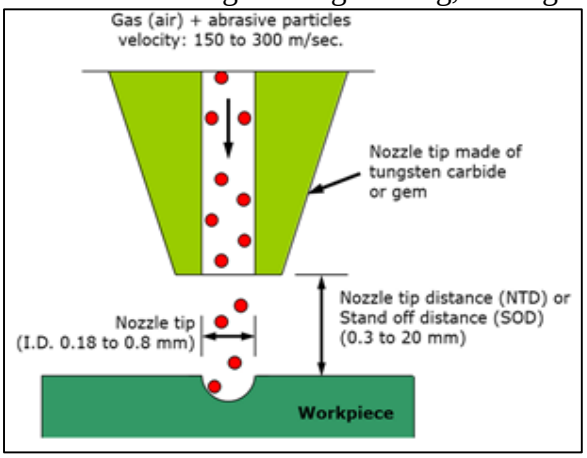

Fig. 1: Abrasive Jet Machining:

II. LITERATURE SURVEY

N. S. Pawar et al. [1] represents variation of cutting performance with Pressure, SOD, and Nozzle Diameter which were experimentally investigated in Abrasive Jet Machining process. Sea sand with 100 to 150 µm grain size used in AJM process. Work piece material likes a glass with 4 mm thickness were used. Pressure increased also material removal rate (MRR) increased.The compressed air with pressure variable from 5 kg/cm2 to 12 kg/cm2 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. Nozzle diameter 1.5 mm used for cutting of glass material. Powder flow rate 1.40-1.85 gm/sec.in this research paper find out the out-put parameter is MRR. The life of silicon nozzle is more than MS nozzle. The erosion rate of material depends on grain size of erodent abrasive.

Mr. Sachin Kumar et al. [2] In this paper we use Abrasive jet machine at different parameters to study the metal removal rate of Soda lime glass. Various parameters such as pressure, angle, abrasive size, nozzle tip distance, time, initial weight and final weight are taken in consideration to achieve the desired objective. Then, by using L9 values we have find out the MMR. In this paper drilling process worked. Abrasive particle like a Al2o3 with grain size 100-150 µm used. Work piece used glass with thickness 4 mm. mild steel nozzle and it's diameters 2.5 mm used. Although the MMR on Soda lime glass is calculated by using aluminium oxides on AJM with the application of Taguchi's method, still there is a scope for further investigation.

N. S. Pawar, R.R. Lakhe, R. L. Shrivastava[3] The present work gives performance of sand having grain size 100-150 micron in the tungsten carbide nozzle.The parameter like pressure, standoff distance of nozzle from work piece keeping constant and variable. It give the result of material removal rate, powder flow rate, similar to actually abrasive used like aluminium oxide, silicon oxide

etc. It is also notice that width of cut slightly increase with increase of feed rate .The taper cut slot was found to be a higher at greater stand of distance and work feed rate. Tungsten carbide is very hard. It maintains high cutting ability as abrasive strike on work piece. Nozzle material used stainless steel. Find out the output parameter is material removal rate (MRR). If the SOD is constant there is no more effect on MRR.

Rajeev Kumar et al. [4] This paper presents the effects of parameters of micro AJM on material removal rate (MRR, gm/sec) and overcut (mm) during micro machining of Silicon glass. A micro AJM setup has been fabricated for this purpose. A tungsten carbide nozzle having diameter 1.3mm, 1.5mm, 2.3mm is considered. For this experiment SiC abrasive with grit size 70µm is selected. Another parameter ranges are Pressure 50psi, 55psi, 60psi, Nozzle Tip Distance 8mm, 10mm, 12mm is considered. It is observed that MRR of glass, machining by AJM, is increased by increasing Pressure. MRR also increased by decreasing Nozzle Diameter. Further in the Over cut, it is observed that over cut decreased by increasing Pressure. It is observed that the optimum parameters for higher MRR are 60 psi pressure, 8mm nozzle tip distance and 1.5mm nozzle diameter. Minimum over cut is measured 0.45mm at two different ranks, at 60 psi pressure, 10mm nozzle tip distance and 1.2 mm nozzle diameter and again when 55 psi pressure, 12mm nozzle tip distance, and 1.2 mm nozzle diameter. It is observed that the optimum parameters for lower over cut are 50 psi pressure, 8mm nozzle tip distance and 1.2mm nozzle diameter

F. Anand Raju et al. [5] An attempt is made on cutting of fibre glass to provide the information on the related parameters such as stand –off distance and MRR by using Mat lab. Silicon carbide abrasive with grain size 120-220 µm used. Pressure 9.5-11.5 kg/cm², SOD 0.5-15 mm, Nozzle diameter 0.2-0.8 mm used. Fibre glass work piece material used. Output Parameter like material removal rate (MRR) is 0.006-0.081 gm/sec measured.. 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. From the regression for MRR vs. Stand off distance it is observed that as the stand-off distance increases material removal rate decreases. From the regression of MRR vs. Pressure it is observed that as pressure is increased the amount of material removed also increases.

D.V. Srikanth et al. [6] Drilling of glass with different SOD, Pressures and different Nozzle Diameters have been carried out by Abrasive Jet Drilling process (AJD) in order to determine its Mach inability under different controlling parameters of the AJM process. Micro abrasive particles are propelled by an inert gas of velocity. In this paper optimization of process parameters of Abrasive Jet Machining of glass by Taguchi methodology is presented. The Values obtained in Taguchi Analysis was compared with the Analysis of Variance (ANOVA).Various levels of Experiments are conducted using L9 Orthogonal Array for both MRR and KERF. Abrasive particle like Sic, Al2O3 with grain size 20-50 µm used. Process parameter likes Pressure range 2 to 8 kg/cm2, SOD 0.25 to 15 mm, Nozzle diameter 0.07 - 0.40 mm used. Glass work piece and Nozzle made by WC, Sapphire. As per the Table (4) the ranking of parameters are Nozzle diameter, Pressure and SOD. Where it was also observed from ANOVA F-test that the same parameters of Taguchi are repeated in same order. Optimal levels of Performance Found at Smaller is Better KERF was identified as Air Pressure (6 kg/cm2) SOD (9 mm) Nozzle diameter (3 mm).As per the Table (5)the ranking of parameters are Nozzle diameter, Pressure and SOD. Where it was also observed from ANOVA F-test that the same parameters of Taguchi are repeated in same order. Therefore the results obtained by TAGUCHI are nearly matching with ANOVA results.

Punit Grover et al. [7] The jet of abrasive particles is carried by carrier gas or air. The high velocity stream of abrasive is generated by energy. The high velocity abrasive particles remove the material by micro-cutting action as well as brittle fracture of the work material. This project deals with the fabrication of the Abrasive Jet Machine and machining on tempered glass, the different problem faced while machining on tempered glass are also discussed.Taguchi method and ANOVA is used for analysis of material removal rate .In this cutting process used abrasive Particle aluminium oxide with grain size 320 µm used. Process parameter likes Pressure 4-8 kg/cm2 used.workpiece material used tempered glass. The maximum metal removal rate is calculated as 0.00158 g/sec. by Taguchi's optimization method. Metal removal rate increases with increase in pressure and abrasive size (microns) in abrasive jet machining of tempered glass. Metal removal rate increases with the decrease in angle and abrasive mesh size in abrasive jet machining of tempered glass.

Parteek et al. [8] This project deals with the fabrication of the Abrasive Jet Machine and machining on tempered glass calculating the material removal varying various performance parameters like pressure, angle & abrasive grit size so on. Taguchi method and ANOVA is used for analysis of metal removal rate. In this paper cutting process works out. Input parameter likes a Pressure 4-10 kg/cm2, SOD 6-18 mm used. Silicon carbide abrasive particle with grain size 250-800 µm used. And Find output parameter material removal rate (MMR) is 0.0034-0.0148 gm/sec. Metal removal rate increases with decreasing the value of angle in abrasive jet machining of tempered glass. The optimum cutting parameters which are pressure=10 kgf/cm2, angle= 50, SOD=6 mm and abrasive = 600 mesh. The maximum metal removal rate is calculated as 0.0099 g/sec. by Taguchi's optimization method.

N. S. Pawar et al. [9] Invention was made to create the needs. Abrasive jet machining is also known as abrasive micro-blasting and it is traditional process. The work carried out with traditional nozzle like tungsten carbide, silicon carbide which available in market and new proposed mild steel nozzle. Powder flow rate is controlled by the amplitude of mixing chamber. The performance of sea sand in vibrating chamber show by using polynomial where R-square values very near to 1 i.e. 0.9687 using variable parameter. In drilling Process abrasive particle used sea sand And aluminium oxide with grain size 100-150 µm. Process parameter likes Pressure 5-7 kg/cm2, SOD range between 5-9 mm, Nozzle diameter 2.0 mm used. Nozzle made by Mild steel.workpiece glass with thickness 2 mm used. Abrasive flow rate 1.06-1.51 gm/sec.output parameter likes material

removal rate 0.042-0.060 gm/sec and depth of cut (DOC) 4.5-6.10 mm. The abrasive particles from the nozzle follow a parallel path only if pressure is increasing. The powder flow rate is increasing as pressure increases because of proper mixing. Life of mild steel nozzle is lesser than traditional nozzle as it is less hardness.

Jukti Prasad Padhy et al. [10] In this paper drilling experiment was done on glass as the work piece and aluminium oxide (Al2O3) as abrasive powder on AJM. The air pressure and stand-off-distance (SOD) are considering control parameter. The effect of Overcut (OC) and Material Removal Rate (MRR) of glass material was finding by using L9 Orthogonal Array (OA) based on Taguchi design. And the influence of these controlling parameters is analysed. Individual main effect of air pressure and SOD are plotted and optimized. Analysis of variance (ANOVA) results were performed implementing Taguchi technique. Grain size of abrasive particle is 50 µm. In this paper process parameter pressure 2-6 bar, SOD 0.6-1.0 mm, Nozzle diameter 2 mm used. Nozzle made by stainless steel. Output parameter material removal rate (MRR) is 1.667-10.417 mm3/min and diameter of cut (DOC) is 0.1325-0.5075 mm. The effect of observed value of MRR and OC was analysed by Taguchi design. From analysis it was concluded that the pressure and SOD both are significant for MRR and only pressure is significant for OC.

Pradeep Kumar Sharma et al. [11] This paper presents the effects of parameters of AJM machining on material removal rate (MRR, gm/min) overcut (mm) and taper cut (mm) during machining of glass fibre reinforced plastic. An AJM setup has been fabricated for this purpose. Tungsten carbide nozzle is used for experimentation. Another parameter is Air Pressure, 65psi and Nozzle Tip Distance (NTD) is considered. Sic abrasive with grit size70µm is selected for this experiment. It is observed that MRR, of glass reinforced plastic during machining by AJM is increased by increasing pressure and nozzle diameter and by decreasing Nozzle tip distance. The optimum value of MRR is obtained at Pressure 65psi, Nozzle Tip Distance 8mm, and Nozzle Diameter 2.3 mm. Further in the Over cut and Taper cut, it is observed that over cut and taper cut decreased by increasing pressure and nozzle diameter and decreasing nozzle tip distance. The optimum value for overcut and taper cut is obtained at Pressure 65psi, Nozzle Tip Distance 8mm and Nozzle Diameter 2.3mm.It was concluded that the minimum overcut observed is 1.72mm which is at air pressure 65 psi, nozzle dia. 2.3 mm and nozzle tip distance NTD 8 mm. It was also concluded that the minimum taper cut observed is 0.66 mm which is at air pressure 60 psi, nozzle dia. 1.5 mm and nozzle tip distance NTD 8 mm. It was also further concluded that optimum parameters for minimum taper cut were air pressure 65 psi, nozzle tip distance 8 mm and nozzle diameter 2.3 mm.

U. D. Gulhane et al. [12] Design of experiments is performed to analyse the effect of air pressure, nozzle diameter and Stand off distance on the Material Removal Rate (MRR) and Kerf width of hard and brittle materials like Ceramics. The results of the machining experiments were used to characterise the main factors affecting MRR and Kerf width by the Analysis of Variance (ANOVA) method. The maximum MRR obtained during experimentation is 0.09476 gm/sec & minimum Kerf width is 5.7325 mm. The nozzle diameter was found to be the most significant parameter influencing the MRR in cutting process. Abrasive particle used emery. Input process parameter likes a Pressure, Nozzle diameter used. Output Parameter measured material removal rate (MRR). Results obtained from Taguchi method closely matches with ANOVA. Best parameters found for Larger MRR are: Nozzle Dia.3 mm, Air Pressure 6 kg/cm2, SOD 40 mm. Best parameters found for Smaller Kerf width are: Nozzle Dia.3 mm, Air Pressure Kg/cm2, SOD 20 mm.

MEET R. VADGAMA et al. [13] The present experimental study is about drilling of glass at different thickness, pressure as well as stand of distance as input parameters. Process parameter likes a Pressure 50-90 bar, SOD 11-15 mm used. Work piece thickness 3-6 mm used. In this paper Taguchi technique applied. Output Parameter measured MRR. The MRR increases with increasing in pressure and decreasing in glass thickness and SOD. MRR is proportional to the pressure. The MRR increase with the SOD increases for certain limit, beyond the limit with increase in SOD there is decrease of MRR. With the decrease in SOD the work piece and nozzle jet and abrasive mesh size the MRR increase because the abrasive mixture impinge on the work piece more directly without deflecting, with a large force, thus results in greater removal rate.

III. CONCLUSIONS

In the literature review it is found that the researchers have investigated influence of a limited number of process parameters (combination of two-three parameters) on the performance measures of AJM.

Some of researchers have carried out work on investigation of effect of single abrasive particles on work piece. But there is a scope to investigate the effect of composite abrasive materials (two or more than two type of abrasive particles) on work pieces.

From literature review it is very clear that there is a scope to work on to investigate the effect of use of composite abrasives and effect of rotary in mixing chamber, on performance parameters of the AJM process.

From the literature review compare to above all mentioned parameter Pressure is most effective parameter for MRR. Abrasive flow rate is also an important parameter for increasing MRR. But beyond some limit with increase in abrasive flow rate the surface roughness decreases. So it is required to find optimum condition for process parameter to give better quality of cutting surface.

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