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Literature Review on Abrasive Jet Machining

Tejas Pawar, Swapnil Wagh, Rohit Shinde

Department of Mechanical Engineering

Walchand College of Engineering, Sangli,

E-mail- tejaspawar120@gmail.com,Contact-8308258706

Abstract- Abrasive jet machining is the non-traditional material removal process. It is an effective machining process for processing a variety of Hard and Brittle Material. And has various distinct advantages over the other non-traditional cutting technologies, such as, high machining versatility, minimum stresses on the work piece, high flexibility no thermal distortion, and small cutting forces. This paper presents an extensive review of the current state of research and development in the abrasive jet machining process. Further challenges and scope of future development in abrasive jet machining are also projected. This review paper will help researchers, manufacturers and policy makers widely.

Keywords- Abrasive jet machine (AJM), Material removal rate (MRR), Stand-off distance (SOD), Abrasive mass flow rate, Glass, versatility, flexibility, non-traditional

INTRODUCTION:

Abrasive jet machining (AJM) is a processing nontraditional machine which operates materials without producing shock and heat. AJM is applied for many purposes like drilling, cutting, cleaning, and etching operation. In Abrasive jet machining abrasive particles are made to impinge on the work material at high velocity. A jet of abrasive particles is carried by carrier gas or air. The high velocity stream of abrasives is generated by converting the pressure energy of carrier gas or air to its Kinetic energy and hence the high velocity jet. Nozzles direct abrasive jet in a controlled manner onto work material. The high velocity abrasive particles remove the material by micro-cutting action as well as brittle fracture of the work material. Machining, Drilling, Surface Finishing are the Major Processes that can be performed efficiently.

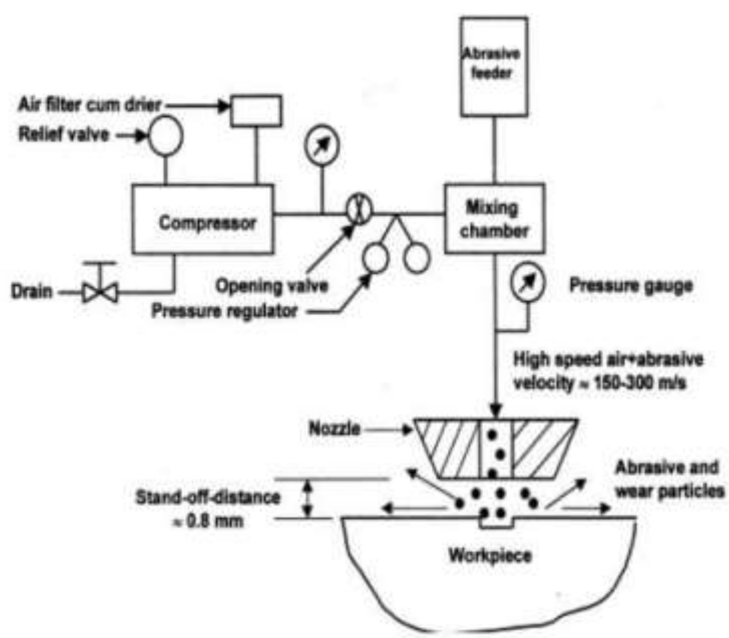

Fig.1 Schematic Diagram of AJM

The process parameters are used like variables which effect metal removal. They are carrier gas, abrasive, and velocity of abrasive, work material, and nozzle tip distance (NTD). Abrasive jet cutting is used in the cutting of materials like: Titanium, Brass, Aluminum, Stone, Any Steel, Glass, Composites etc.

Background

This novel technology was first initiated by Franz to cut laminated paper tubes in 1968 and was first introduced as a commercial system in 1983. In the 1980s garnet abrasive was added to the water stream and the abrasive jet was born. In the early 1990s, water jet pioneer Dr. John Olsen began to explore the concept of abrasive jet cutting as a practical alternative for traditional machine shops. His end goal was to develop a system that could eliminate the noise, dust and expertise demanded by abrasive jets at that time. In the last two decades, an extensive deal of research and development in AJM is conducted.

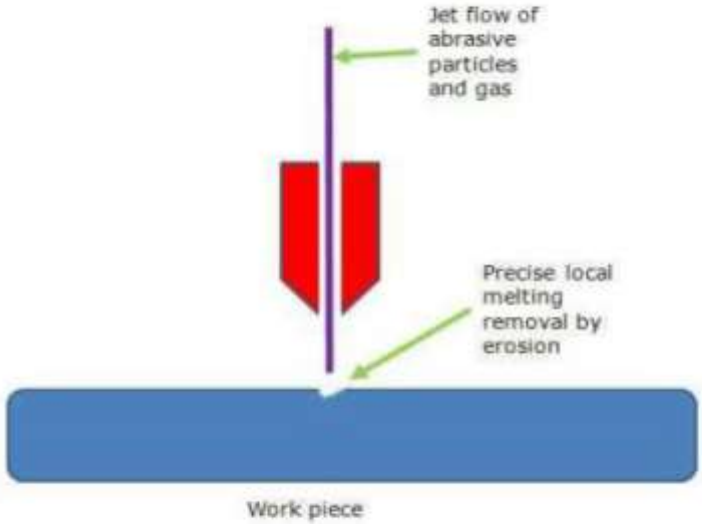

Fig.2 Material Removal by Erosion

Literature Review:

In this section the experimental analysis of Abrasive jet machining is discussed. The experimentations conducted by various researchers by influencing the abrasive jet machining (AJM) process parameters on material removal rate, Surface integrity, kerf are discussed. The parameters like SOD, Carrier gas, Air Pressure, Type of Abrasive, Size, Mixing Ratio etc. are focused.

Dr. A. K. Paul et al.[1] carried out the effect of the carrier fluid (air) pressure on the MRR and the material removal factor (MRF) have been investigated experimentally on an indigenous AJM set-up developed in the laboratory. Experiments are conducted on Porcelain with silicon carbide as abrasive particles at various air pressures. It was observed that MRR has increased with increase in grain size and increase in nozzle diameter. The dependence of MRR on stand-off distance reveals that MRR increases with increase in SOD at a particular pressure.

Dr. M. Sreenevasa Rao [2] reviewed that Ingulli C. N. (1967) was the first to explain the effect of abrasive flow rate on material removal rate in AJM. Along with Sarkar and Pandey (1976) concluded that the standoff distance increases the MRR and penetration rate increase and on reaching an optimum value it start decreasing. J. Wolak (1977) and K. N. Murthy (1987) investigated that after a threshold pressure, the MRR and penetration rate increase with nozzle pressure. The maximum MRR for brittle and ductile materials are obtained at different impingement angles. For ductile material impingement angle of 15-20 results in maximum MRR and for brittle material normal to surface results maximum MRR.

X. P. Li et al. [3] stated that during cutting of work piece, reinforcement particles made impact on surface of the work which causes wear of work specimen. These particles get dislodged in material surface. It is reported that pressured air approach minimizes the t ool wear and also prevent of particles from being embedded in work piece .Experimental tests for cutting of SiC-Al has been carried out with tungsten carbide tool with or without the aid of the pressured air jet are conducted. It shows that pressured air jet method significantly minimize the wear of work piece.

Manabu Wakuda et al. [4] reported that the material response to the abrasive impacts indicates a ductile behavior, which may be due to the elevated temperature during machining. Chipping at the peripheral region of the dimples was found for coarse-grained alumina samples. The use of synthetic diamond abrasive is a possible choice if high machining efficiency is desired. However, the machined surface reveals a relatively rough appearance as a result of large-scale intergranular cracking and subsequent crushing

A. Ghobeity et al. [5] have experimented on process repeatability in abrasive jet machining. They mentioned that many applications have several problems inherent with traditional abrasive jet equipment. Poor repeatability in pressure feed AJM system was traced to uncontrolled variation in abrasive particle mass flux caused by particle packing and local cavity formation in reservoir. Use of mixing chamber improved the process repeatability. For finding out process repeatability they measured depth of machined channel.

A. Ghobeity et al. [6] stated that particle distribution can greatly affect the shape and depth of profile. Analytical model has developed with by considering the particle size distribution. It results that if particle size distributed uniformly it helps to maintain uniform velocity of abrasive jet which causes improvement in MRR.

A. El-Domiaty et al. [7] did the drilling of glass with different thicknesses have been carried out by Abrasive jet Machining process (AJM) in order to determine its machinability under different controlling parameters of the AJM process. The large diameter of the nozzle lead to the more abrasive flow and which lead to more material removal rate and lower size of abrasive particle lead to the low material removal rete. They have introduced an experimental and theoretical analysis to calculate the material removal rate.

Alireza Moridi et al. [8] has presented an experimental study to understand the effect of process parameters (like nozzle diameter, air pressure, abrasive mass flow rate, jet impact angle and nozzle traverse speed) on the cutting performance measures (like groove depth and width, kerf taper angle and roughness of the groove bottom surface) in abrasive jet micro-grooving of quartz crystals. Groove depth increase by increasing the abrasive mass flow rate which lead to more particles impinging the target surface and gives more material removal. However, excessive abrasive flow-rate increases inter-particle collision which reduces the average removal rate per particle.

Mr. Bhaskar Chandra [9] Studied the variation in Material Removal Rate according to change in Gas pressure and Hole diameter according to change in NTD. Various experiments were conducted on work piece material- glass using abrasive material- alumina. The effect of gas pressure on the material removal rate is shown in fig 3

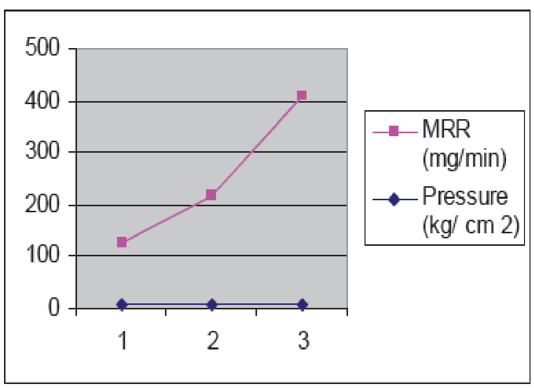

Fig.3 Graph shows the Relationship between pressure and material removal rate (MRR) at thickness 8 mm and NTD 12 mm

Jukti Prasadn Padhy [10] carried the drilling experiment on glass work piece using aluminum oxide as abrasive powder. Experimental work was done by considering stand-off distance (SOD) and pressure as machining parameter to study material removal rate (MRR) and overcut (OC). The effect of observed value of MRR and OC was analyzed 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. Individual optimal settings of parameters are carried out to minimize the OC and maximize the MRR.

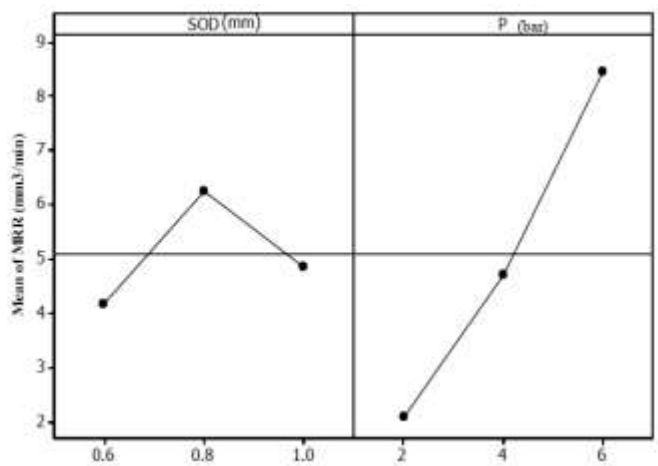

Fig.4 Main effect of Material Removal Rate

R. Balasubramaniam et al. [11] stated that as the particle size increases, the MRR at the central line of the jet drastically increases; but the increase in MRR nearer to the periphery is very less. As the stand-off distance increases the entry side diameter and the entry side edge radius increases, Increase in stand-off distance also increases MRR. As the central line velocity of jet increases, the MRR at the central line of the jet drastically increases. But there is no increase in MRR nearer to the periphery of the jet. The increase in entry side diameter and edge radius is not significant. As the peripheral velocity of the jet increases, the edge radius and entry side diameter increase. It also increases the MRR.

F. Anand Raju et al. [12] stated 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. If coarser abrasive is used for machining then MRR is high to a wide range of stand-off distance. Also it is stated that as the stand-off distance increases material removal decreases. 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 as pressure is increased the amount of material removed also increases. 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.

Conclusion

According to the various research papers available till date, lot of work has done on abrasive particles and its geometry, different process parameters, volume of material removal during machining. Very less research has been done on study of effect of abrasive flow rate on performance characteristics. Hence there is scope for improvement for the study of effect of abrasive flow rate on performance characteristics like material removal rate and taper angle. Improper mixing chamber construction causes various problems such as abrasive powder stratification, powder compaction, powder humidification etc. This affects the machining results undesirably.

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