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AN OVERVIEW ON ABRASIVE JET MACHINING (AJM) RESEARCH ARTICLE

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ABSTRACT

Abrasive jet machining is an efficient process for processing a variety of Hard and Brittle Material and has numerous distinct benefits over the other non-traditional cutting technologies, such as, high machining versatility, minimum stresses on the work piece, high flexibility no thermal distortion, and relatively small cutting forces. This paper presents an extensive review of the current state of research and development in the abrasive jet machining process. Further scope of future development in abrasive jet machining are also projected. This review paper can facilitate researchers, policy makers and manufacturers widely.

Keywords: *Abrasive jet machining (AJM), Material removal rate (MRR),Velocity, Compressor, Flexibilty*

I. INTRODUCTION

Abrasive jet machining (AJM) could be a nontraditional machine that operators on no physical contact between tool and a piece of work therefore there's no thermal stresses and shocks are going to be developed. AJM is applied for several applications like cutting, cleaning, polishing, debarring, etching, drilling and finishing operations. In Abrasive jet machining, abrasive particles are made to effect on work material at high velocity. A jet of abrasive particles is carried by carrier gas or air. This high-velocity stream of abrasives is generated by converting pressure energy of carrier gas or air to its Kinetic energy and hence high-velocity jet. Nozzles direct abrasive jet during a controlled manner onto work material. The high-velocity abrasive particles remove the material by micro-cutting action additionally as a brittle fracture of the work material.

The process parameters are used like variables which may effect metal removal. They are carrier gas, abrasive, and rate of abrasive, work material, and nozzle tip distance (NTD). Abrasive jet cutting is employed within the cutting of materials like Titanium, Brass, Aluminum, Stone, Any Steel, Glass, Composites, Plastics, Ceramics, Tungsten carbide, metal inorganic compound etc (Sutar *et al*., 2017).

II. THE PARAMETERS OF AJM PROCESS

The material removal rate (mrr) in the AJM process is considered to depend on the following important independent parameters.
(i) The mixing ratio (m_r): This is the mass flow rate of abrasive powder m,, per unit mass flow rate of the mixture.
(ii) The stand off distance (s_d) : The distance of the nozzle tip from the work surface
(iii) Nozzle diameter (d_n)
(iv) System pressure (p_s)

In addition to the above process parameters, the following material properties are also considered in the analysis. They are:
(i) the density of the abrasive,
(ii) mean diameter of the abrasive particles d,, obtained from their size distributions
(iii) elastic constants of the work medium. (Young's modulus E and Poisson's ratio v) and
(iv) the mean ultimate strength of the material (The critical strain energy density) (Vijayakumar, 2002).

III. CONCEPT OF AJM

A schematic layout of AJM is shown in figure (a). In AJM air is compressed in an air compressor at a pressure of 5 bar, which can be used as carrier gas. Gases, like CO2, N2, etc., which can be directly issued from a cylinder and also can be used as carrier gas. The carrier gas first passes through a pressure regulator to get the specified operating pressure. The gas is then passed through an air filter regulator to remove any residual water vapour. To remove any oil vapour or particulate contaminant the same is passed through a series of filters. After that carrier gas enters a closed chamber known as the mixing chamber. The abrasive particles enter the chamber from a hopper through a metallic sieve. The sieve is consistently vibrated by an electromagnetic force shaker. The mass flow rate of abrasive (16 gm/min) entering the chamber depends on the frequency and amplitude of vibration of the sieve. The abrasive particles are then carried by the carrier gas to the machining chamber via an electromagnetic on-off valve. The machining chamber is crucial to contain the machined particles and abrasives in a very safe and eco-friendly manner. The machining is carried out at high velocity (200- 300 m/s) abrasive particles are issued from the nozzle onto a piece of surface traversing beneath the jet.

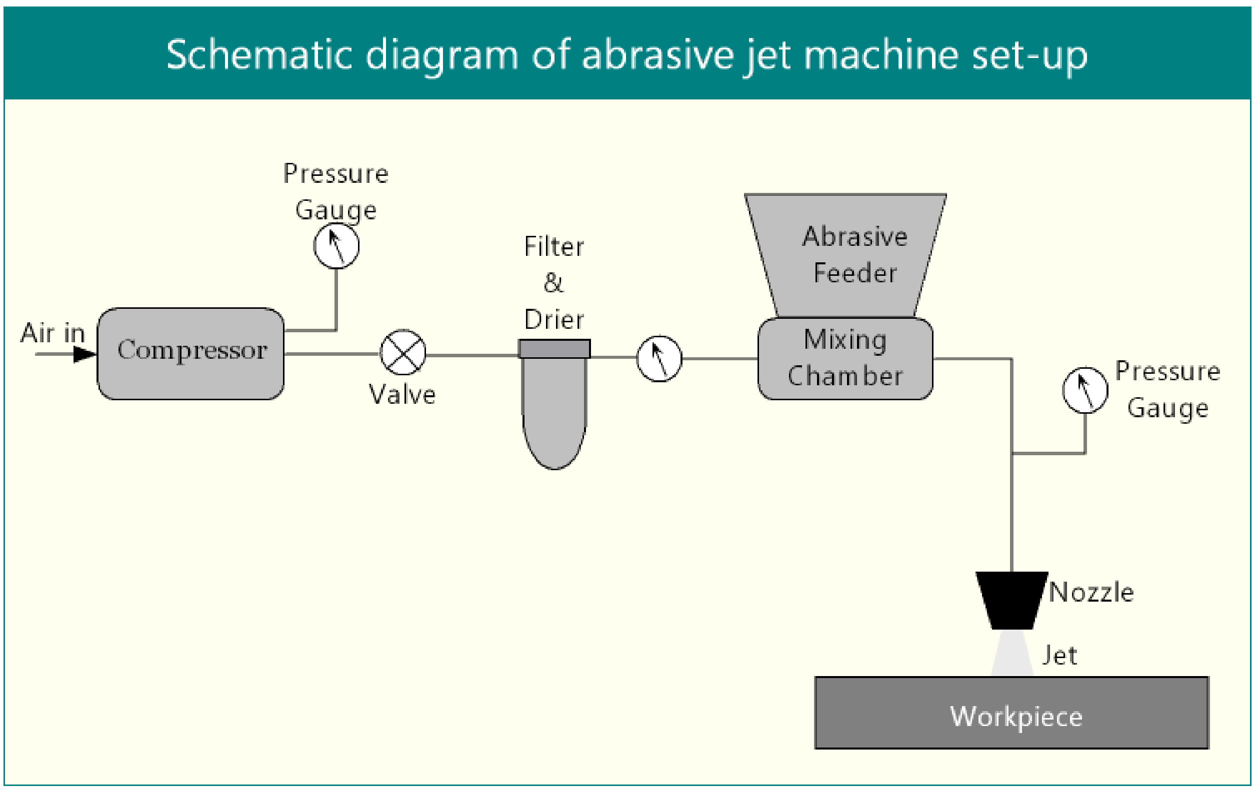

Figure a- Schematic diagram of Abrasive jet machine

IV. COMPONENTS OF AJM

1. Air compressor
2. Air filter
3. Dehumidifier
4. Pressure gauge
5. Mixing chamber
6. Pressure regulator
7. Nozzle
8. Machining chamber

9. Vibrator
10. Work holding device (Singh *et al.*, 2018).

Advantages

- High surface finish.
- It will machine heat sensitive material.
- It is free from vibration
- Initialization cost is low compare to other non-traditional processes.
- Thin section may be machined simply.

Disadvantages

- Low metal removal rate.
- Abrasive particle will embedded into work piece usually in soft metals.
- Nozzle life is limited so it needs frequent replacement of such nozzles.
- The abrasive particles cannot be reused in this process.
- It cannot be used for machine soft and ductile material.

Applications

- It is employed in drilling and cutting of hardened metals.
- It is employed for machining of brittle and heat sensitive material like glass**,** quartz,mica,etc.
- It is Use to manufacture electronic devices.
- It is employed in deburring small holes and some critical zones in machine components ("Abrasive Jet Machining: Principle, Working, Equipment's, Application, Advantages and Disadvantages", 2017)**.**

V. LITERATURE REVIEW

R. Balasubramaniam et al. investigated the abrasive jet deburring process parameters and also the edge quality of Abrasive Jet deburred elements. Experimental design based on Taguchi Orthogonal array was used as systematically to measure the influence of the key cutting parameters on abrasive jet deburred specimens. The experimental specimens used were 1.5mm thick, 25mm sq. grade AISI304 stainless-steel sheets. Burrs were generated by the face milling operations. ANOVA method was used for the checking of edge quality. It was found that the deburring process is significantly affected by 'height of the jet' and 'impingement angle'. It was concluded that Abrasive Jet deburring method has many advantages over the manual deburring process. The standard of deburred parts chiefly will increase the generation of edge radius (Balasubramaniam, 1998).

Y. Yamauchi et al. investigated the result of work piece properties on machinability in abrasive jet machining of ceramic materials. Three varities of common abrasives viz. Aluminium Oxide, Silicon Carbide, and synthetic diamond were used for conducting the experiment. The target materials used were four varities of ceramics viz. ZrO2, Si3N4, Al2O3, SiC. A laser scanning microscope was used to measure the volume that was removed by abrasive jet machining. The machinability of the AJM process was compared with the established models of solid particle erosion, in which the material removal is assumed to originate in the ideal crack formation system. It was also concluded that AJM process had high potential micromachining method as damage free for many materials because the radial cracks did not extend downwards by the impact of the particle during the machining process (Kanzaki *et al.*, 2012).

S. Ally et al. used surface evolved models to predict Abrasive jet machining of metallic substrates. The abrasive jet inclination angle of abrasion rate was measured. The material is Aluminum 6061-T6, Ti-6Al-4V Titanium alloy and 316L stainless steel. The jet inclination angle was measured using 50 micrometers Al2O3 abrasive powder launched at an average velocity of 110m/s. The peak erosion rate was found to occur 200 to 350 relative to the surface for all three systems. It was found that Aluminum has a high volumetric erosion rate than Titanium alloy which is higher than the stainless steel erosion rate on a volumetric basis, which in turn is significantly lower than a brittle material such as glass and polymers (Ally *et al.*, 2012).

N. S. Pawar et al. investigated abrasive material sea sand in vibratory chamber. The tungsten metal carbide nozzle was utilized in the abrasive jet small machining method. The sand of 100-150 metric linear unit was used for the experiment. The work piece used was a glass of thickness four millimetre. The evaluated performances were material removal rate and flow rate. It absolutely was found that the impact through nozzle caused severe erosion on the fabric of work piece. It absolutely was incontestable that the erosion of the fabric surface relied on velocity, direction and brittleness of the material. The experiment was performed by using the combination of two different parameters viz. Standoff distance and pressure. From the result, it absolutely was all over that material removal rate and flow were the same as the rellay abrasive used like aluminum oxide, silicon carbide, etc (Pawar *et al.*, 2013).

Rajkamal Shukla and Dinesh Singh et al. used Taguchi methodology for experimental investigation of abrasive water jet machining parameters. The material used is AA6351 aluminum alloy. Parameters like transverse speed, stand off distance and mass flow rate are considered to obtain the influence of those parameters on kerf prime dimensions and taper angle. Regression models have been developed to correlate the data generated using experimental results. The percentage contribution of standoff distance in kerf prime dimension and taper angle is found to be 77.642% and 81.774% respectively (Shukla *et al.*, 2017).

A. Ghobeity et al. predicted models of abrasive jet micro disguised for masked and unmasked borosilicate glass channels by the use of 25 micro meter aluminum oxide. A novel technique is used for the velocity distribution of the particles in the jet of an abrasive jet micro machining. It was found that the velocity decreased linearly from the centre line of the jet to the periphery, Weibull distribution followed by the probability of a particle arriving at the surface a given radial distance from the centre of the impacting jet. To predict the cross sectional profile of unmasked channels this Weibull distribution was used with an extension of the already existing model. Time-dependent particle mass flux and velocity distribution were used for modeling of the effect of the nozzle. Further, it was demonstrated that the distribution of net erosive power over the cross section passing through the round nozzle had the same form as the distribution along the diameter of the stationary nozzle. By measuring the particle velocity across the cross section of the jet, it was found that the velocity decreased linearly from the centre to the periphery. It was concluded that by reducing the incident particle energy flux caused by mask edge scattering the prediction of masked channel profiles is affected (Ghobeity *et al*., 2014).

Manabu Wakuda et al. investigated the material response of alumina ceramics to the abrasive particle impact in the AJM process. Three types of abrasive grains, viz. Aluminum Oxide, Silicon Carbide and Synthetic diamond were used for the impact on alumina ceramics. AJM equipment with Micro-Blaster (MB2-ML-001, Sintobrator, Japan) was used which is capable of shooting fine abrasives along with a pressurized nitrogen gas stream through a small jet nozzle. It was found that the softest abrasive aluminum Oxide leads to roughening of the alumina surface, but causes no mark, due to the lack of the hardness of the abrasive against that of the work piece. It was also found that by employing Silicon Carbide, a relatively smooth face could be produced as a result of ductile behaviour under the elevated temperature caused by the abrasive impacts (Wakuda *et al*., 2013).

Dong-Sam Park et al. improved micro-machining using the machining ceramics, semiconductors, electronic devices and LCD. For micro grooving of glass, he checked the performance of micro-AJM. Process parameters for micro AJM were pressure, velocity and time, stand-off distance, material properties number of nozzle scanning times. Microgrooving consisted of masking process, abrasive jet machining process and a mask removing and cleaning process. White Alundum was used for machining whose main ingredients were Al2O3. The results showed that when the heat amount was 160mJ at 1050°C, then the masking results were considerable and otherwise were poor (Park *et al*., 2004).

VI. RESULT AND CONCLUSION

In AJM, a focused jet or stream of abrasive particles carried by high-pressure gas (carrier) is made to impinge on the work surface through a nozzle. The metal cutting happens because of erosion caused by the abrasive particles impacting the work surface at high speed. As a result of the impact, small bits of materials get loosened and separated from the workpiece surface, exposing a fresh surface to the jet. This process is capable of cutting intricate holes and shapes in materials of any hardness and brittleness.

VII. FUTURE SCOPE

The use of manual nut assembly to vary the tip distance of the nozzle. This can be done automatically.
For shaking of the mixing chamber, we have used handle manually. This can be done automatically by using a motor.

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