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REVIEW ON FABRICATION OF ABRASIVE JET MACHINE TO STUDY EFFECT OF SiC ABRASIVE PARTICLES ON VARIOUS MATERIALS

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Abstract - *Abrasive jet machining is nontraditional machining process in which fine abrasive particles are accelerated in carrier gas stream. This high velocity particles are directed towards focus of machining through convergent nozzle. As high speed particles impact surface it causes micro fracture. Erosion is conventionally considered as undesired phenomenon since it damages structures. But in case of abrasive jet machining erosion act as instrument for removing material from work piece. Abrasive jet machining is based on erosion localization and intensification. Since heat generation during abrasive jet machining is very low it is suitable machining heat sensitive materials like silicon, gallium. During abrasive jet machining work piece is subjected to minimum stresses.*

Key Words: Abrasive jet machining, material removal rate

1.INTRODUCTION

Abrasive jet machining involves sizeable amount of cutting edges having indefinite orientation and geometry. In abrasive jet machining failure of one cutting edge does not have effect on method. The main differences which can be perceived while analysing abrasive jet machining and cutting tool machining are the cutting edge geometry and comparative number of chips produced. Since exceedingly thin chips are produced during abrasive jet machining it is possible to focus the machining stress at very local points on the work piece. Due to this characteristics Abrasive jet machining is suitable for deburring of small precision parts that required a burr finish such as medical appliances, hydraulic valve, aircraft fuel systems, surgical needles, bio medical plastic components, and delicate beryllium-copper electronic springs. Abrasive jet machining is best method for deburring small milled slots in hard metallic components, small holes like in hypodermic needles and cavities inaccessible by other means. Due to small cutting forces abrasive jet machining is used for machining of thin, brittle, fragile materials. Abrasive jet machining is used for shallow machining applications such as resistor path in insulators, intricate patterns on silicon semiconductors. Abrasive jet machining is used for engraving permanent mark on materials such as registration numbers on motor car toughened glass windows. Abrasive jet machining is also applicable for cleaning purposes such as removal of oxides on metals, smears on ceramics, and other resistive coating on work material. Abrasive jet machining is useful for cutting of metallic foils, machining of super alloys and refractory materials. Abrasive jet machining is used in micro grit blasting, trimming, bevelling, and frosting of shiny material.

Abrasive jet machining system consist of gas propulsion system, mixing chamber, nozzle. To form high velocity abrasive laden air jet, a mixture of abrasive particles and pressurised air is expelled through fine nozzle. After gaining momentum from pressurised air high velocity abrasive particles become capable of eroding target material to generate required part feature by means of micro plastic deformation and/or brittle fracture.

2. Literature Review

Wakuda and Yamuchi reported that when softest abrasive such as aluminium oxide is selected, it leads to roughing of the alumina surface but causes no engraving, due to the absence of sufficient abrasive hardness which is required against that of the work piece. Abrasive jet machining with silicon carbide abrasive produce smooth faced dimples, although it exhibits relatively low material removal rates. It was observed that due to elevated temperature during machining, the material response to abrasive impacts indicates a ductile behaviour.

Balasubramaniam showed that during deburring of the external burrs by abrasive jet, different edge conditions such as concave radius, convex radius and taper edge were obtained depending on level of parameters jet height and impingement angle. With increase in particle size, the material removal rate at the centre line of jet drastically increases; but increase in material removal rate nearer to periphery is very less. Entry side diameter and entry side edge radius increase with increase in stand-off distance. Increasing stand-off distance also increases material removal rate.

Verma and Lal reported that after a threshold pressure the material removal rate and penetration rates increases with nozzle pressure. For brittle material normal impingement results maximum material removal rate and in case of ductile material maximum material removal rate can be obtained by keeping impingement angle 15-20 degrees.

Masaki et al. introduced a circular vane to slot nozzles in order to achieve a more uniform particle velocity distribution in order to machine large areas.

Haj Mohammad Jafar et al. experimentally investigated the effect of particle size velocity and angle of attack on rough micro-channels using abrasive jet machining. They found that post blasting with a particle of low kinetic energy is an effective method to reduce surface roughness of abrasive jet machining channels.

3. Abrasive Jet Machining Experimental Set Up

The abrasive jet machining experimental setup consist of following components:

1. Air Compressor: Air compressor supplies pressurised air which act as working fluid of the abrasive machining process.

2. Air Filter: Air filter ensures supply of dry and dust free air.

3. Pneumatic Control Valve: It will control the pressure of compressed air and will help to vary magnitude of pressure of carrier gas.

4. Abrasive feeder: Abrasive material is introduced in carrier gas through abrasive feeder.

5. Mixing Chamber: Mixing chamber ensures proper mixing of abrasive with carrier gas.

6. Nozzle: Nozzle directs high velocity abrasive jet on work piece.

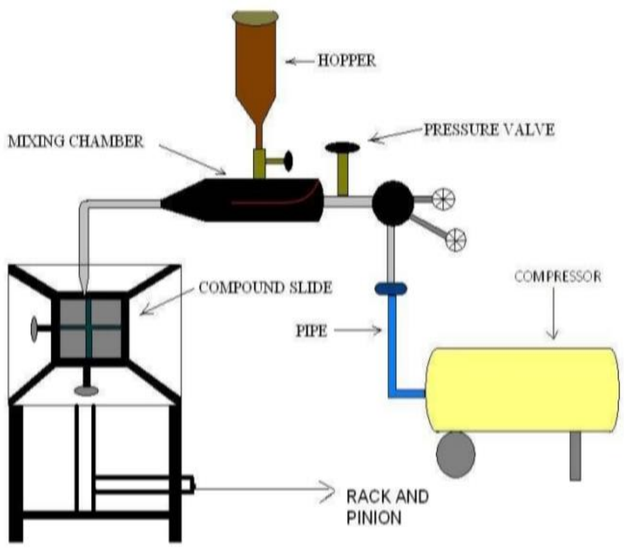

Figure-1: Schematic layout of abrasive jet machining (Publish in IJEST; ISSN: 0975-5462)

4. Influence of Process Parameters

4.1 Nozzle Pressure

Pressure directly affects kinetic energy of abrasive particles. Kinetic energy of abrasive particles act as the driving force for the removal of material by erosion process. As the internal gas pressure rises there will be surge in abrasive mass flow rate and it leads to increase in material removal rate.

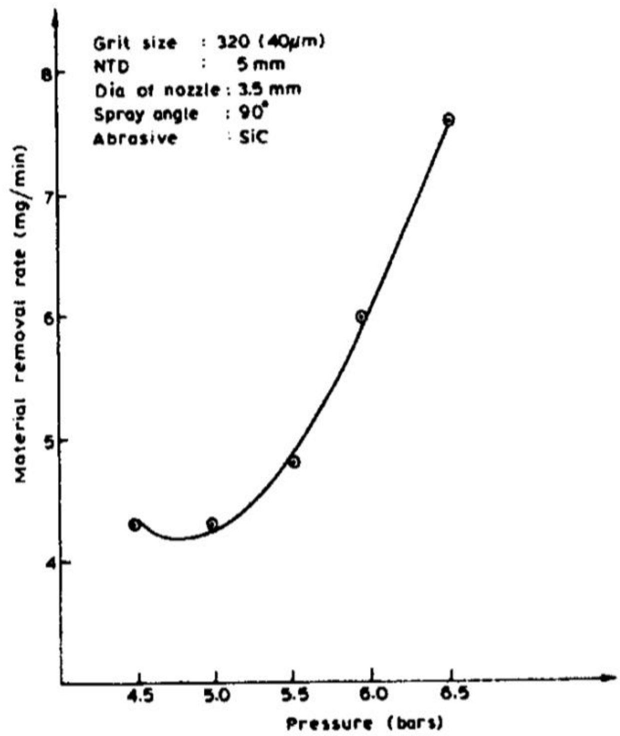

Figure-2: Effect of changing the nozzle pressure on the material removal rate (CIRP Annals- Manufacturing Technology 1984; 33: 109-112)

4.2 Stand-off Distance

Stand-off distance is defined as the distance measured between the nozzle face and the work surface of the work piece. It has been observed that stand-off distance have considerable effect on the work material and accuracy. A large stand-off distance results in flaring of jet that ends up in poor accuracy.

Material removal rate increases with increase in nozzle tip distance or stand-off distance up to certain distance and then decreases. Penetration rate also increases with stand-off distance and then decreases. Decrease in stand-off distance improves accuracy, reduces kerf width, and lessen taper in machined groove. However light operation like cleaning, frosting etc. are conducted with large stand-off distance. (Say 12.5 to 75 mm)

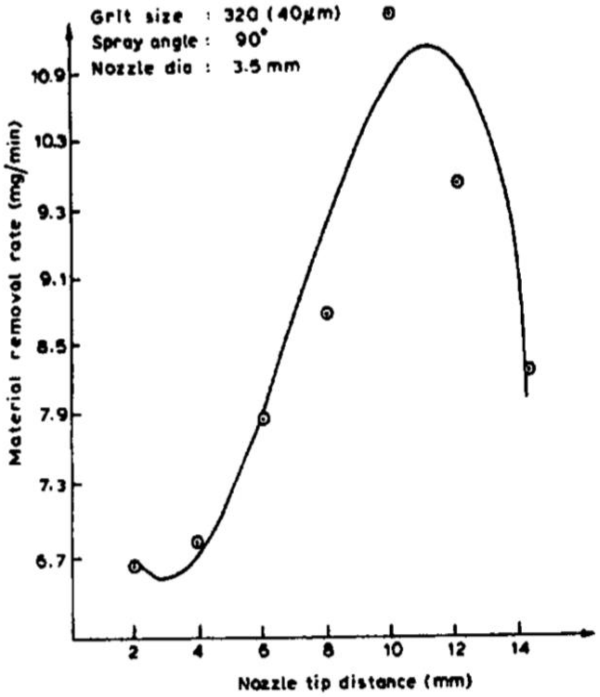

Figure-3: Effect of the stand-off distance on the material removal rate (CIRP Annals- Manufacturing Technology 1984; 33: 109-112)

4.3 Feed Rate

Material removal rate decreases with increase in feed rate.

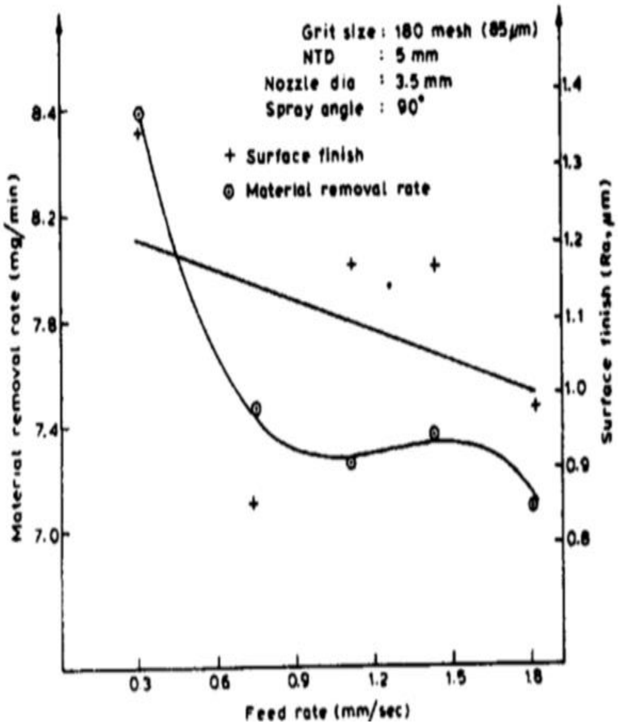

Figure-4: Effect of feed rate (CIRP Annals- Manufacturing Technology 1984; 33: 109-112)

4.4 Spray Angle

Spray angle is angle between nozzle axis and machined surface. Depending on target hardness different effects were observed for nozzle inclinations. Large angles (close to 90°) provide higher material removal rate in brittle material, particularly in ceramics, while the soft work piece is cut more efficiently with the angles at around 20° to 30°. The normal force component contributes to plastic deformation and to the propagation of intergranular micro cracks, resulting in grains detachment. The tangential component is mainly responsible for cutting.

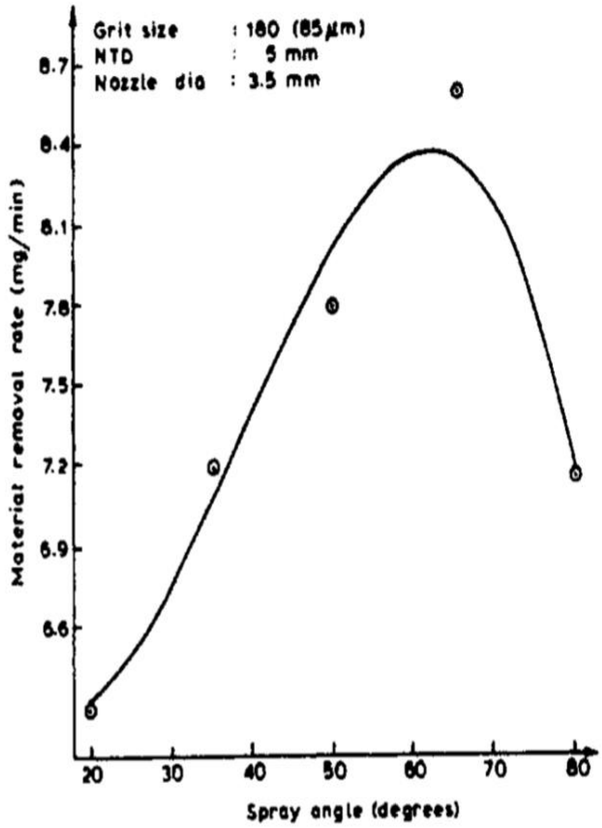

Figure-5: Effect of the spray angle on material removal rate (CIRP Annals- Manufacturing Technology 1984; 33: 109-112)

4.5 Abrasive Grit Size

Abrasive grit size was found out to be most influential factor in abrasive jet machining. When particle size increases, the single grain gain bigger mass and volume which directly affects kinetic energy of abrasive particle which in turn influence material removal rate. The increase in abrasive particle size leads to chips enlarging and surface roughening. Smaller abrasive particles possessing a higher square to volume ratio are very sensitive to humidity level in storage. Absorption of moisture intensifies interparticle adhesion which affects abrasive flow consistency.

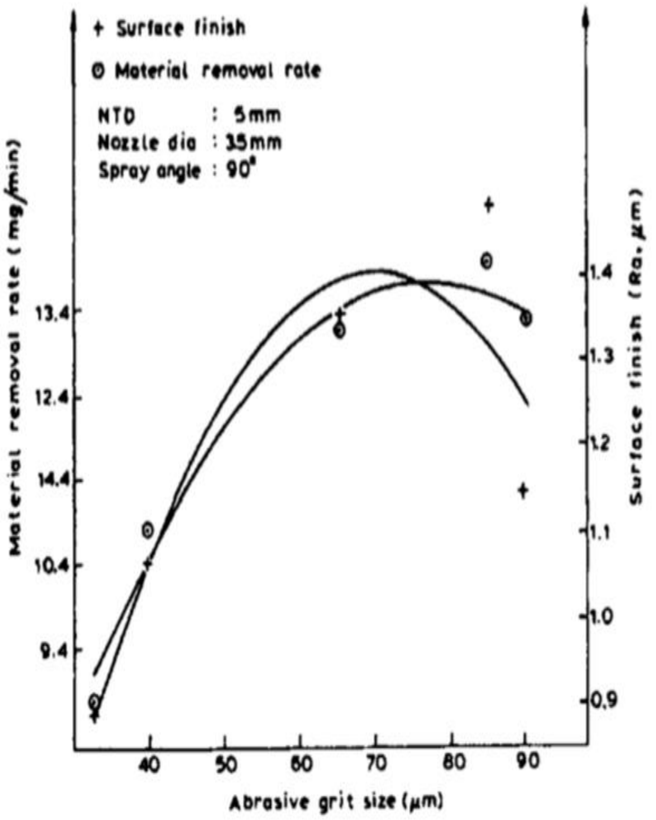

Figure-6: Effect of abrasive grit size (CIRP Annals-Manufacturing Technology 1984; 33: 109-112)

5. CONCLUSIONS

Abrasive jet machining is capable of fulfilling recent and oncoming industrial demands. Concerning the influence of process parameters, it should be noted that there is no universal algorithm for process parameter selection. The results of distinct independent factors may vary significantly or even change to the opposite. However, the dominant effects of key factors were established by various researches by conducting experimentations.

Abrasive jet machining provides process control flexibility. Machining spot, material removal rate, and surface roughness are easily changeable through numerous options of pneumatic, abrasive or machining process parameters.

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