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A Review on Experimental Investigation on Abrasive Jet Machining

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***Abstract* - Un-conventional Machining process is a group of process that remove excess material from work piece by various techniques involving mechanical, thermal, electrical, and chemical energy or combination of these energies but do not use a sharp cutting tools as it needs to be used for traditional machining process. Abrasive jet machining is a non-traditional machining process that means there is no direct contact between tool and work piece. This paper focus on the process parameters of the abrasive jet machining. Generally, the process parameters are Abrasive mass flow rate, Nozzle tip distance, Gas Pressure, Velocity of abrasive particles, Mixing ratio, Abrasive grain size. The present study represents the effect of process parameters on Material removal rate (MRR) and surface roughness (SR) while machining.**

Keywords: Abrasive Jet Machining, Material Removal Rate, Process Parameters.

I. INTRODUCTION

Abrasive jet machining (AJM) is one of the advanced machining processes (mechanical energy based) where a high velocity jet of abrasives is utilized to remove material from work surface due to the erosion. The abrasive jet is obtained by accelerating fine abrasive particles in highly pressurized gas (carrier gas). A nozzle is used to convert this pressure energy into kinetic energy and also to direct the jet towards work surface at a particular angle. AJM is suitable for hard and brittle materials. Different types of abrasives are used like alumina, silicon carbide, glass beads, sodium bicarbonate, etc. In sand blasting only silica sand (SiO_2) are used as abrasives. Several studies have been conducted by researchers to recycle Ceramic Sanitary Ware (CSW) waste. They showed that the main compound contributions to CSW waste were 30% to 40% AL_2O_3 and 50% to 60% SiO_2. AJM is used for so many applications like cutting, cleaning, polishing, deburring, drilling and finishing operations.

II. LITERATURE SURVEY

Bhaskar Chandra et al (2011) documented the results of a Study of Effect of Process Parameters of Abrasive Jet Machining. This paper presents various results of experiments have been conducted by changing pressure, nozzle tip distance on different thickness of glass plates. The effect of their process parameters on the material removal rate (MRR), top surface diameter and bottom surface diameter of hole obtained were measured and plotted.

Sebin Babu et al (2018) performed experimentation on AJM using silicon carbide granules as abrasives they conducted machining with the help of soda lime glass. This Experiment was carried out according to Taguchi L9 experimental array with abrasive particle size, jet pressure and standoff distance as process parameters at three levels. MRR increases to a maximum at an optimized value of abrasive particle size of 37 μm, jet pressure of 4.5 kg/cm^2 and SOD of 4 mm. From the experimental results jet pressure has found to have more influence on MRR than other process parameters.

Subhash. R (2019) Conducted experiment on process parameters of abrasive jet machining they were three types of abrasive particles are used in AJM are aluminum dioxide(Al203) and silicon carbide(sic). They conclude that Carrier gas acts as a transfer medium for abrasive mixture and also direction of flow. Nozzle material has to be chosen accordingly to avoid wear of nozzle due to high velocities of abrasive mixture. MRR increases directly with SOD.

Ivan Sunit (2014) conducted study on Effect of Pressure on Material Removal Rate on Glass Using Abrasive Jet Machining. They conclude that the drilling of glass sheets with different thickness and varying pressure have been carried out through abrasive jet machining in order to determine its machinability. Experimental results and graphs shows that gas pressure has a direct impact on material removal rate. Hence, when the pressure increases, material removal rate also increases.

Pradipkumar. S (2020) the current research focused on testing performance parameters such as Material Removal Rate (MRR) and Surface Roughness (SR) with different controlling parameters. Controlling parameters for measuring their effects on AJM performance parameters include air pressure, abrasive particle, temperature, and mixing chamber speed. They were Conclude that The average MRR increases as pressure and temperature rise, but drops slightly from 100

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RMP to 150 RPM, then rises from 150 RPM to 200 RPM. This is due to the high pressure jet of abrasives, which weakens the particle bond of the work piece material at high temperatures, and turbulent abrasive flow may affect the cutting action.

Pradipkumar S (2020) conducted experiment on Effect of Controlling Parameters on Performance of Abrasive Jet machine. The present study focused on experimental investigation for performance parameters like Material Removal Rate MRR and Surface Roughness SR with variation in controlling parameters. They conclude that The average MRR increases with increase in the pressure, temperature and speed of mixing chamber RPM

Sidharth M Nambiar (2019) a detailed report is researched on process parameters of material removal rate in abrasive jet machining. It can be concluded that a tremendous amount of research, experiments and analysis has been conducted in this field to improve the MRR. It is to be observed that majority of the research have focused on the effects of nozzle diameter, abrasive particle size and stand of distance (SOD). Some research has also focused on the pressure, velocity and carrier gas selection for optimum performance.

P.Arunkumar (2021) investigated the effect of process parameters in abrasive Jet Machining process using full factorial design the factorial design is obtained with the help of three process parameters Stand of distance, pressure and particle size. And the design was fabricated to perform the drilling operation. This experiment is evaluated Material Removal Rate (MRR) and Hole Diameter (HD) during drilling process of glass work piece. Further, the effect of each process parameters on MRR and HD is validated.

A.K. Chaitanya (2019) experimental study is done on surface roughness by using abrasive jet machine In this paper it was measured the surface roughness on ductile materials like mild steel and also studying how aluminum oxide, silicon carbide abrasive particles effected on work piece and surface roughness is obtained with the help of graphs of different materials.

Dhyanesh Lakshman T K (2020) investigated the Effect of Process Parameters on Abrasive Jet Machining using aluminium oxide as abrasive particles. 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.

III. COMPONENTS OF AJM

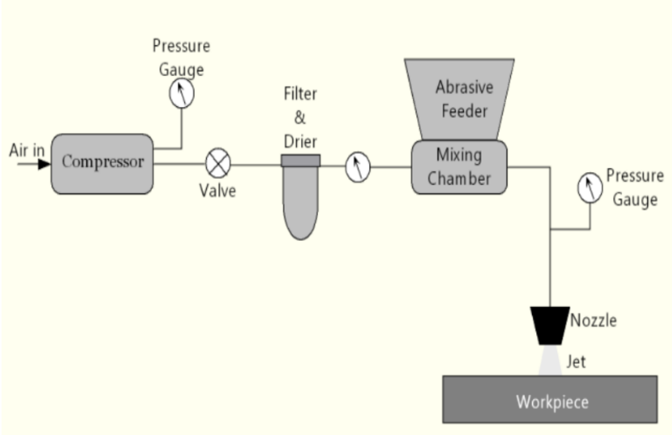

Figure 1: Layout of Abrasive Jet Machining

Abrasive jet Machining consists of

1. Gas propulsion system
2. Abrasive feeder
3. Mixing chamber
4. AJM nozzle
5. Abrasives

1. Gas propulsion system

The primary purpose of gas propulsion systems is to provide clean, dry air or gas for machining at high speed. Air, carbon dioxide, nitrogen, etc. are mainly used as gases in gas driven systems. This system consists of a compressor, air filter and dryer. Gases used in this system must be readily available. First, compress the gas with a compressor. This compressed gas is sent to a filler and dryer where dust and unwanted particles are removed along with moisture. This clean air is sent to the mixing chamber.

2. Abrasive feeder

The abrasive feeder is used to feed abrasive particles into the mixing chamber. It is passed through a sieve that vibrates at 50-60 Hz and the mixing ratio is controlled by the sieve vibration and its amplitude.

3. Mixing chamber

This is a completely enclosed gas-tight chamber that controls the concentration of abrasive particles around the work piece. This is equipped with a vacuum dust collector which collect used abrasive particle and removed material from mixing chamber.

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4. AJM Nozzle

AJM nozzles are typically made of tungsten carbide or sapphire (typical life - 300 hours for sapphire, 20-30 hours for WC). Nozzles are circular or rectangular in cross-section and either straight or rectangular in head. Constructed to minimize pressure loss due to bending, friction, etc. with increase in wear of a nozzle, the divergence of jet stream increases resulting in more stray cutting and high inaccuracy.

5. Abrasives

These are the main particles that participate in the machining process. These particles must have high metal removal rates and accuracy. The most commonly used abrasive particles are aluminum oxide, silicon carbide, boron carbide, etc. The selection of abrasive particle is depends upon material of work piece, speed of machining, and machining environment.

IV. PROCESS PARAMETERS

Process Parameters of Abrasive Jet machining (AJM) are factors that influence its Metal Removal Rate (MRR). In a machining process, Metal Removal Rate (MRR) is the volume of metal removed from a given work piece in unit time.

Generally the process parameters are

1. Abrasive mass flow rate
2. Nozzle tip distance
3. Gas pressure
4. Velocity abrasive particles
5. Mixing ratio
6. Abrasive grain size

1. Abrasive mass flow rate

Abrasive mass flow rate is the most important factor in ajm to control the MRR, when the abrasive mass flow rate increases, MRR value first reaches its peak position and then gradually decreased. Flow rate of abrasive can influence machining performance.

2. Nozzle tip distance

NTD is defined as the distance between the nozzles to the Work piece. When NDT increases, the cavity diameter on work surface increases. Low stand of distance gives high accuracy decreases the kerf width the taper in the machining of groove. Normally in AJM SOD IS 0.75 to 1 mm to achieve the maximum MRR

3. Gas pressure

When internal gas pressure increases the abrasive mass flow rate increases and the MRR increases. Kinetic energy of the abrasive particles is responsible for the removal of material by erosion process

4. Velocity of abrasive particles

As the velocity of abrasive particles increases the particle which leaving the nozzle increases the particles strikes the surface of the work piece is increases with the help of high velocity of abrasive particles. Therefore MRR will be increased.

5. Mixing ratio

It is defined as the ratio of volume flow rate of abrasive to the volume flow rate of carrier gas.MRR increases with the increases of mixing ratio up to certain limit after that it decreases because of decreasing energy available for erosion.

6. Abrasive grain size

Generally, in AJM, abrasive grains of about 50 microns collide with the work material at a speed of 200 m/s from a nozzle with an inner diameter of 0.5 mm and a distance of about 2 mm.

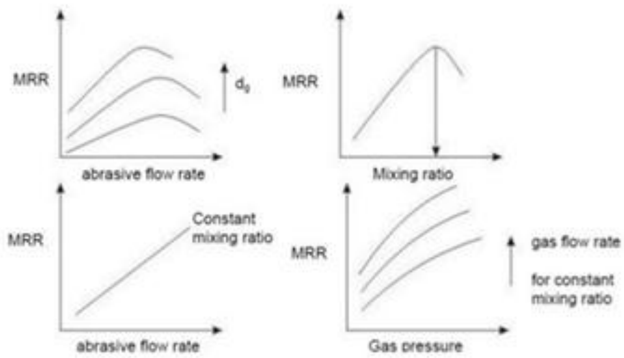

Figure 2: Effect of process parameters of AJM

Table 1: Abrasive grain size and its applications

Abrasives	Grain sizes	application
Aluminum oxide (Al_2O_3)	12, 20, 50 microns	Good for cleaning, cutting and deburring
Silicon carbide (SIC)	25,40 microns	Used for similar application but for hard material
Glass	0.635 to 1.27mm	Gives matte finish
Dolomite	200 mesh	Etching and polishing
Sodium bi carbonate	27 microns	Cleaning, deburring and cutting of soft material Light finishing below 500C

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V. MACHINING CHARACTERISTIC OF AJM

Table 2: Characteristics of AJM

Mechanics of metal removal	Brittle fracture by impinging abrasive grains at high speed
Work Material	Hard And Brittle Materials Like Glass, Quartz, Ceramics Etc.
Abrasive	Aluminium Oxide (Al_2O_3), Silicon Carbide (SIC), Glass Powder, Dolomite.
Size of Abrasive	Around 25 µm
Flow Rate	2-20 G/Min
Medium	N2, Or CO_2 or Air
Velocity	125-300 M/S
Pressure	2-8 Kg/Cm^2
Nozzle Material	Tungsten Carbide (WC) Or Synthetic Sapphire.
Life of Nozzle	Tungsten Carbide 12-20 hours Sapphire – 300hours
Nozzle Tip Distance	0.25-15mm
Tolerance	+- 0.05
Machining Operation	Drilling, Cutting, Debirring, Cleaning etc.

VI. CONCLUSION

By observing the above all journals we conclude that From the amount of research and effort put into this section of non-traditional machining, it is to be understood that the relationship between the process parameters and the process output, several factors have to be taken into consideration and these factors must be optimized to a higher level to obtain the better MRR & accuracy, tolerance and surface finish.

1. Investigation has reveals that material removal rate increased with increase in the kinetic energy of the abrasive particles.
2. It was found that applied pressure is the most significant parameter influencing MRR.
3. Nozzle diameter greatly affects MRR. For nozzles with too small or too large diameter for the particle size, the MRR decreased.
4. The MRR increased with the increase in standoff distance up to a certain limit and then the MRR decreased with the further increase of standoff distance.
5. MRR increased with increase in abrasive grain size.

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