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Design and Fabrication of Abrasive Jet Machine

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Abstract : *The Abrasive jet machining 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 tin 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 machining, Nozzle tip distance, Material removal rate (MRR), Flexibility, Abrasive mass flow rate.*

I. INTRODUCTION

The Abrasive jet machining (AJM) is a processing non- traditional 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. 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 as diverse as: Titanium, Brass, Aluminum, Stone, Any Steel, Glass, Composites etc.

II. PROBLEM IDENTIFIED

Designing and fabrication of a semi-automated machine to carry out the process in which a material is removed from the brittle material due to the impingement of fine grained abrasive by high velocity gas stream.

III. METHODOLOGY

Abrasive jet machining is the process in which a material is removed from the work piece due to the impingement of fine grained abrasive by high velocity gas stream. The stream of abrasive mixed gas is directed to the work piece by suitably designed nozzles. The process differs from conventional sand blasting. In that abrasive particles used are finer and the process parameters and cutting actions is carefully controlled. Abrasive jet machining is applied to cut brittle material such as mica, germanium, glass, ceramics etc. The process is free from vibrations problems. As no current is passes from the tool and the work piece, there is no restriction to material to be machined. Thus it cuts conductive as well as nonconductive materials. The word non-conventional is used in the sense that the metals are such that they cannot be machined by conventional methods, and require some special techniques.

AJM is included in these methods carried by high pressure as at high velocity, which is made to impinge on the work interface. This eliminates tool to metal contact, which are the main criteria of non-conventional machining method used in AJM. Following are the parameters, which affect the material removal are of the work piece.

- Stand- off distance.
- Abrasive particle size and type.
- Abrasive jet velocity.
- Carrier gas pressure.
- Mass flows rate of abrasive.

IV. 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 are discussed. The parameters like SOD, carrier gas, air pressure, type of abrasive, size, mixing ratio etc. are focused.

1. Dr. Pushpendra Kumar Sharma 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 standoff distance increases the entry side diameter and the entry side edge radius increases, Increase in standoff 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.

2. C.S. Kalra has presented an experimental study to understand the effect of process parameters (like nozzle diameter, air pressure, abrasive mass flow rate) on the cutting performance measures (like groove depth and width) in abrasive jet micro-grooving of quartz crystals. Groove depth increase by increasing the abrasive mass flow rate which leads 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.

3. Dr. A. K. Paul &P. K. Roy (1987) Carried out the effect of the carrier fluid (air) pressure on the MRR, AFR, and the material removal factor (MRF) have been investigated experimentally on an indigenous AJM set-up developed in the laboratory. Conducted Experimentation on the cutting of Porcelain with Sic abrasive particles at various Air pressures. Observed that MRR has increased with increase in grain size and increase in nozzle diameter. The dependence of MRR on standoff distance reveals that MRR increases with increase in SOD at a particular pressure.

4. Sarkar & Pandey (l980) suggested a model to calculate MRR (Q) during AJM. Q = x Zd3v3/2 (8/ l2Hw)3/4, Where Z is no of particles impacting per unit time, D is the mean diameter of Abrasive grain, K is the density, V is the velocity of abrasive particles, how is hardness of work material, X is a constant.

5. Ghobeity et al. 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.

6. Dr. M. Sreenevasa Rao, D. V. Shrekanth. 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.

V. CONSTRUCTION OF ABRASIVE JET MACHINE

The operating principle of the process is very simple. High pressure air from the compressor passes through filters and control valves into a mixing chamber. The abrasive particles and carrier gas are thoroughly mixed in the mixing chamber and a stream of abrasive mixed gas passes through a nozzle on the work piece. It cause indentation on the work piece.

The indentation ultimately results in rupture of particles from the work surface. The nozzle geometry and its inclination, size of grit, the abrasive used for cutting and the carrier gas pressure and the velocity are used as a criteria for evaluating XYZ AJM process. A high velocity jet containing abrasive particles is directed on to the work surface through the nozzle. Due to this the nozzle has to sustain maximum wear due to abrasion;

secondly, the accuracy of working and the metal removal rate depends upon the nozzle wear. The material used for nozzle should are therefore have high wear resistance. in practice the nozzle are made of tungsten carbide or sapphire having regular round or square hole. Nozzle made from tungsten carbide last for 12 to 30 hrs. When used with 27 micron abrasive in the present study the tungsten carbide nozzle 1mm and 2 mm diameters are used. The AC Synchronous motor is used to rotate the pinion gear so as to give linear motion to rack, thus X direction is given to the material.

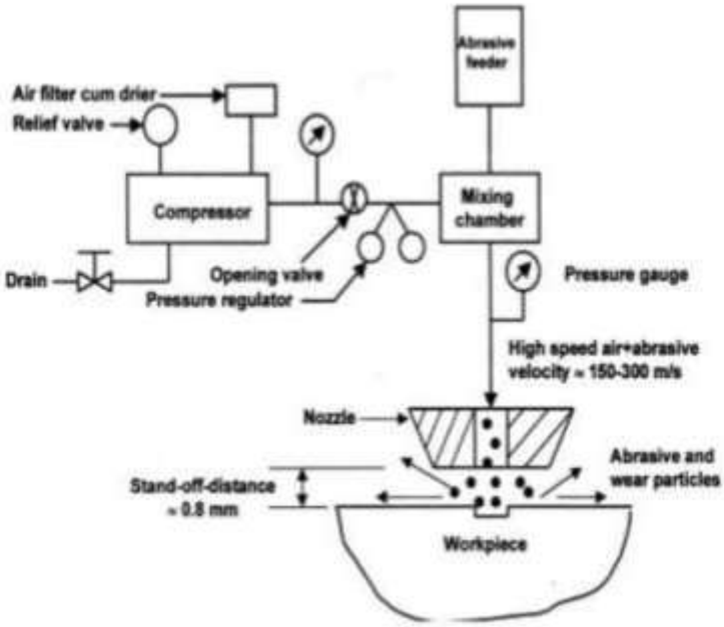

FIG.1 Construction of abrasive jet machine

VI. WORKING OF ABRASIVE JET MACHINE

The compressor builds up the required pressure of about 2 to 8 kN/cm2. By opening the compressor was the air allowed to flow into main mixing chamber and abrasive chamber through Tee. When the abrasive chamber cock is open, the abrasive powder enters the main mixing chamber. The abrasive powder is carried away by the high pressure air. Thus the mixture of air and abrasive comes out through the nozzle at a very high velocity. In the mixing chamber and the nozzle, pressure energy is converted in to the kinetic energy of the particles of abrasive. The abrasive particles comes out in the form of a line jet. This jet strikes on the work piece placed in front of nozzle at a particular stand of distance. Due to the impact of the high velocity abrasive on the work piece is cut. During machining: direction is given to the material by AC motor & y direction is given by rotating the screw.

Steps to be followed in starting the machine:-

1. In order to start the machine following steps are to be taken.
2. Load abrasive feeding chamber with required girt size of abrasive.
3. Ensure that all the pipe fitting are air tight and leak proof.
4. Start the compressor to build up the necessary pressure of about 2 of 8 kn/cm2.
5. Fix the nozzle of known diameter to the tapered rod and place the cap properly.
6. Place the glass piece to be machined in the fixture. Adjust the stand of distance
7. Close the dust collection box and cover properly

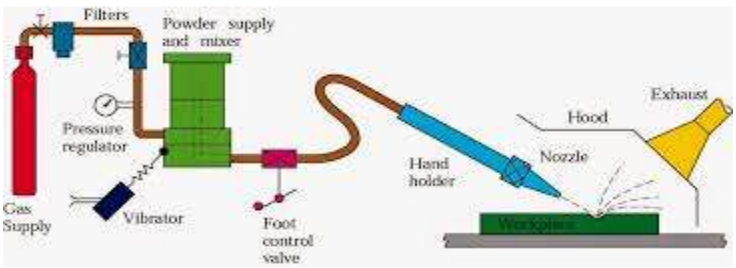

FIG.2 Working of abrasive jet machine

VII. Advantages

1. It is the ability to cut intricate holes in material of any hardness and brittleness.
2. It is possible to machine fragile, brittle and heat sensitive materials without damage.
3. Mechanical contact between the tool and work piece is avoided. This absence of tool work contact and metal removal at microscopic scale leads to very little or no heat generation, resulting, insignificant surface damage.
4. This sections if hard and brittle material like germanium, silicon, glass and ceramics can be machined without mechanical, thermal distortion.
5. The process can be utilized conventionally in drilling, cutting, deburring, etching, polishing and cleaning operations.
6. High surface finish can be achieved.
7. Depth of surface damage is low.
8. The process is characterized by low capital investment and low power consumption.
9. The initial cost of AJM is low.

VIII. Disadvantages

1. Limited capability owing to low material rate.
2. Embedding of the abrasive in the work piece surface may occur while machining softer material.
3. Tapering effect may be found because of the unavoidable flaring of the abrasive jet.
4. Nozzle wear is high.
5. There must be suitable dust collection system as the process tends to pollute the environment.

IX. Conclusion

We have studied the effect of performance characteristics (nozzle diameter air pressure, mass flow rate, stand of distance) stand of distance governs the MR ,1ncrease in stand of distance increase the center line velocity of jet thereby 1ncreasing MRR. Air pressure too has same direct relation with MRR. We have thereby successfully drilled, slotted glass work piece which-is free of vibration and does not require electric power . Due to low capital operative cost the AJ M is Compatible to other processes

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