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DESIGN AND FABRICATION OF ABRASIVE JET MACHINE

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ABSTRACT:

Abrasive Jet Machining (AJM) is the process of material removal from a work piece by the application of a highspeed stream of abrasive particles suspended in a gas medium from a nozzle. The material removal process is mainly caused by brittle fracture by impingement and then by erosion. The Abrasive Jet Machining will chiefly be used to cut shapes, drill holes and de-burr in hard and brittle materials like glass, ceramics etc. Care was taken to efficiently use the available material and space. The machine was fabricated in the institute workshop with convectional machine tools like arc welding machine, hand drill, grinding machine using commonly available materials like mild steel sheet and rod, aluminum sheet, glue, polythene sheet, glass fiber which are commonly available in the local market. Care has been taken to use less fabricated components, because, the lack of accuracy in fabricated components would lead to a reduced performance of the machine. The different functional components of AJM are the machining chamber, work holding device, abrasive drainage system, compressor, air filter and regulator, abrasive nozzle, and mixing chamber with cam motor arrangement. The different components are selected after appropriate design calculations.

Keywords: AJM, Aluminum sheet, welding machine, hand drill.

I INTRODUCTION

Abrasive Jet Machining (AJM) is the removal of material from a work piece by the application of a high-speed stream of abrasive particles carried in gas medium from a nozzle. The AJM process is different from conventional sand blasting by the way that the abrasive is much finer and the process parameters and cutting action are both carefully regulated. The process is used chiefly to cut intricate shapes in hard and brittle materials which are sensitive

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to heat and have a tendency to chip easily. The process is also used for drilling, de-burring and cleaning operations. AJM is fundamentally free from chatter and vibration problems due to absence of physical tool. The cutting action is cool because the carrier gas itself serves as a coolant and takes away the heat. 2. Equipment A schematic layout of AJM is shown in Figure. The main components being the compressor, air filter regulator, mixing chamber, nozzle and its holder, work holding devices and X-Y table. Air from the atmosphere is compressed by the compressor and is delivered to the mixing chamber vie the filter and regulator. The mixing chamber contains the abrasive powders and is made to vibrate by an electric motor and cam arrangement. Then the abrasive particles are passed into a connecting hose leading to the nozzle. This abrasive and gas mixture emerges from the orifice of nozzle at high velocity. The feed rate of abrasive air is controlled by the amplitude of vibration of the mixing chamber. A pressure regulator installed in the system controls the gas flow and pressure.

WORKING PRINCIPLE OF AJM

Dry air or gas is filtered and compressed by passing it through the filter and compressor. A pressure gauge and a flow regulator are used to control the pressure and regulate the flow rate of the compressed air. The valve is open when the speed of compressed air is at 8bar pressure Compressed air is then passed into the mixing chamber. In the mixing chamber, abrasive powder is fed. A vibrator is used to control the feed of the abrasive powder. The abrasive powder and the compressed air are thoroughly mixed in the chamber. The pressure of this mixture is regulated and sent to nozzle. The nozzle increases the velocity of the mixture at the expense of its pressure. A fine abrasive jet is rendered by the nozzle. This jet is used to remove unwanted material from the work piece. A compressor of Lt.24 is used for the follow of the compressed air into the valve of mixing chamber.

Fig.1. Model diagram.

II LITERATURE SURVEY

Dr. Pushpendra Kumar Sharma (2002) 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.

C.S. Kalra (1990) 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.

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.

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.

Ghobeity et al (2005) 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.

III METHODOLOGY

Abrasive Jet Machining (AJM) is one of the mechanical energy based modern machining processes where material is removed by controlled micro-cutting action caused by the impact of a concentrated high-velocity (100 – 300m/s) jet of abrasive grits accelerated by dehumidified pressurized gas (10 – 15bar). A nozzle directs the abrasive jet in a controlled way onto the work surface. Air is directly taken from atmosphere then, it is filtered and compressed to a high pressure with the help of a high-pressure compressor. Loose abrasive particles having predefined sizes are mixed with this pressurized gas in a certain proportion (mixing ratio) and this mixture is then allowed to strike the surface of the workpiece in the form of jet at a desired incident angle, incident at a very high velocity. A nozzle converts the pressure energy of the mixture into kinetic energy. A nozzle is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe. A nozzle is often a pipe or tube of varying cross sectional area, and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them. In nozzle velocity of fluid increases on the expense of its pressure energy. The main aim of the nozzle model here is to with stand the pressure load acting on the inner wall of the nozzle i.e.80 bar. The main areas of interest of the above analysis are to observe the deflections on the structure and stresses developed in the body because of applied load.

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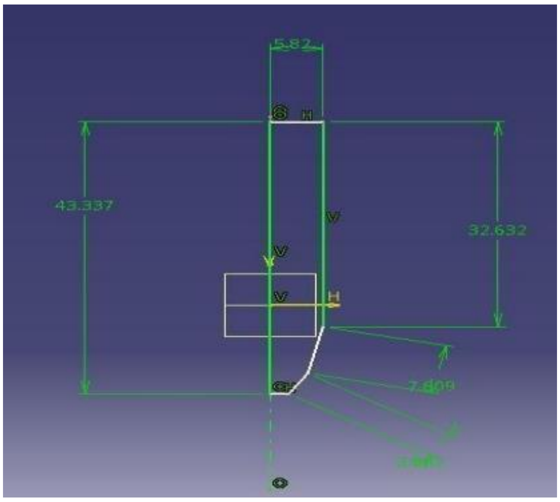

Fig.2. 2D model.

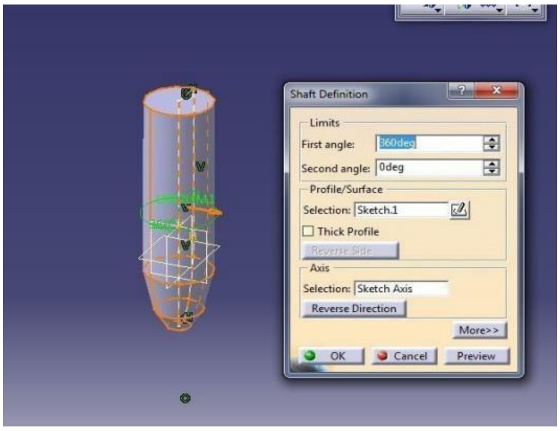

Fig.3. Circular Nozzle.

A bonded abrasive is composed of an abrasive material contained within a matrix, although very fine aluminum oxide abrasive may comprise sintered material. This matrix is called a binder and is often a clay, a resin, a glass or a rubber. This mixture of binder and abrasive is typically shaped into blocks, sticks, or wheels. The most usual abrasive used is aluminum oxide. Also common are silicon carbide, tungsten carbide and garnet. Artificial sharpening stones are often a bonded abrasive and are readily available as a two sided block, each side being a different grade of grit. Grinding wheels are cylinders that are rotated at high speed. While once worked with a foot pedal or hand crank, the introduction of electric motors has made it necessary to construct the wheel to withstand greater radial stress to prevent the wheel flying apart as it spins. Similar issues arise with cutting wheels which are often structurally reinforced with impregnated fibres. High relative speed between abrasive and workpiece often makes necessary the use of a lubricant of some kind. Traditionally they were called coolants as they were used to prevent frictional heat buildup which could damage the work piece (such as ruining the temper of a blade). Some research suggests that the heat transport property of a lubricant is less important when dealing with metals as the metal will quickly conduct heat from the work surface. More important are their effects upon lessening tensile stresses while increasing some compressive stresses and reducing "thermal and mechanical stresses during chip formation".[2]

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Various shapes are also used as heads on rotary tools used in precision work, such as scale modelling.

IV RESULTS EXPLANATION

It was shown that AJM process is receiving more and more attention in the machining areas, particularly for the processing of difficult-to-cut materials. Its unique advantages over other conventional and un- conventional methods make it a new choice in the machining industry. It is concluded that wide experimental investigations are required to fully understand the relationship between important AJM parameters, namely Air pressure, nozzle size and shape, abrasive mass flow rates and process output in greater detail for aluminum, brass, cast iron, ceramics, copper, composites, granite, mild steel, stainless steel and titanium as the right choice of process parameters is very important for good cutting performance. There is much scope of research in the AJM which can be performed by changing the nozzle design, pressure, angle, SOD, etc. and Comparing the effect of various parameters on MRR on different metals like super alloys, composites, glass, and ceramics, by improving the cylindricity of the hole. And also Integration of AJM with CNC, model comparison, etc. is to be held in further stages.

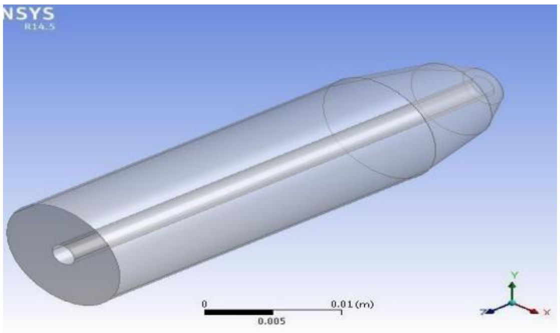

Fig.4. 3d model with dimensions.

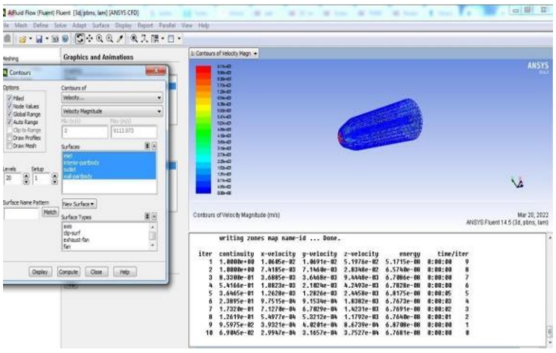

Fig.5. Contours of velocity magnitude (m/s) min 2.11. To 9113.973, Circular Nozzle file

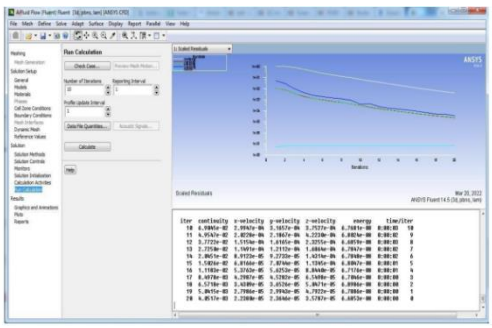

Fig.6. Circular Nozzle file scaled residuals run calculation.

Model1:

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s. no	Names	Min	Max
1	density (kg.m3)	1.225	1.225
2	pressure (pascal)	900	5.291394e+07
3	velocity magnitude (m/s)	2.11.	9113.973,
4	static temperature (k)	799.9995	800.0007,

Model2:

s.no	Names	Min	Max
1	density (kg.m3)	1.225	1.225
2	pressure (pascal)	900	3.798066e+07
3	velocity magnitude (m/s)	1.3	7355.729
4	static temperature (k)	799.9997	800.0003

Model3:

s.no	Names	Min	Max
1	density (kg.m3)	1.225	1.225
2	pressure (pascal)	900	3.798066e+07
3	velocity magnitude (m/s)	1.3	7355.729
4	static temperature (k)	799.9997	800.0003

ASSEMBLY OF EXPIREMENT

Complete Assembly After fabricating different components of abrasive jet machining, a frame like structure was designed and fabricated which supports all the major components of abrasive jet machining. The figure shows the assembly design of abrasive jet machining. All the above components, including dehumidifier, carrier gas supply line and pressure gauge were mounted on the frame, which gives the overall experimental setup. The material used for manufacturing the above frame is mild steel. The carrier gas supply pipe is made up of pneumatic material which has high strength. The purpose of using pneumatic material instead of general pipe was to prevent the pipe from being eroded due to the flow of abrasive grit under high pressure.

Fig.7. Frame cutting pipes

Fig.8. Single pipes

CONCLUSION

The portable abrasive jet machine was developed and fabricated with the help of drawings and CAD model. This machine has successfully produced holes on glass material which is brittle and hard in nature. The precise holes were produced on glass material efficiently. This machine can be useful for machining of conducting as well as non-conducting materials. The low cost abrasive jet machine can be useful for industrial applications. The material removal rate increases with increase in abrasive flow rate. The Sic abrasives give more material removal rate and perfectly round holes on glass surface. In future with slight modifications, AJM will become important machine tool on shop floor. There is scope for future work are study of nozzle wear, study of characteristic of abrasive particles, dimensional analysis for calculating theoretical metal removal rate. 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 occurs due to 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 work piece 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.

SCOPE FOR FUTURE

In future the efficiency of the ABRASIVE JET MACHINE systems can be improved by incorporating newer materials and parts. First of all we should have a clear cut idea of our systems, and then depending on the type of work material used we should select the design parameters. Use of masks or stencils to control over spray or to produce holes of larger diameter and high degree of details without moving the nozzle and tracing the shape is also possible. In the selection of nozzle material, to withstand the abrasion at the exit of nozzle, the material selected has to be one with hardness values significantly higher than the abrasive mix being used. In most of the precision works mentioned in the application part of our project, brass has played the vital role in the nozzle. So using a harder material such as tungsten carbide may give higher stability of cut without stray cut and taper hole.

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