MACHINING OF GLASS AND CERAMIC WITH ALUMINA AND SILICON CARBIDE IN ABRASIVE JET MACHINING
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ABSTRACT
As the world is advancing forth technically in the field of space research, missile and nuclear industry; very complicated and precise components having some special requirements are demanded by these industries. The conventional methods, in spite of recent advancements are inadequate to machine such materials from stand point of accuracy, precision and economic production. The metal like hastalloy, Nitra alloy, nimonic and many harder to machine material are such that they can’t be machined by conventional methods but require some special techniques. Abrasive jet machine (AJM) removes material through the action of focused beam of abrasive laden gas. Micro – abrasive particles are propelled by an inert gas of velocity. When directed at a work piece, the resulting erosion can be used for cutting, etching, drilling, polishing and cleaning. In this paper testing and analyze various process parameters of abrasive jet machining is presented

KEYWORDS Abrasive jet machining, Erosion rate, Glass

1. INTRODUCTION AND PREVIOUS WORK
Abrasive machining is a machining process where material is removed from a work piece using a multitude of small abrasive particles. Common examples include grinding, honing, and polishing. Abrasive processes are usually expensive, but capable of tighter tolerances and better surface finish than other machining processes chances, delectability, costs and safety aspect etc.) The literature study of Abrasive Jet Machining [1-7] reveals that the Machining process was started a few decades ago. Till date there has been a through and detailed experiment and theoretical study on the process. Most of the studies argue over the hydrodynamic characteristics of abrasive jets, hence ascertaining the influence of all operational variables on the process effectiveness including abrasive type, size and concentration, impact speed and angle of impingement. Other papers found new problems concerning carrier gas topologies, nozzle shape, size and wear, jet velocity and pressure, stand off distance (SOD) or nozzle tip distance (NTD). These papers express the overall process performance in terms of material removal rate, geometrical tolerances and surface finishing of work pieces, as well as in terms of nozzle wear rate. Finally, there are several significant and important papers which focus on either leading process mechanisms in machining of both ductile and brittle materials, or on the development of systematic experimental statistical approaches and artificial neural networks to predict the relationship between the settings of operational variables and the machining rate and accuracy in surface finishing. In recent years abrasive jet machining has been gaining increasing acceptability for deburring applications. AJM deburring has the advantage over manual deburring method that generates edge radius automatically. This increases the quality of the deburred components. The process of removal of burr and the generation of a convex edge were found to vary as a function of the parameters jet height and impingement angle, with a fixed SOD. The influence of other parameters, viz. nozzle pressure, mixing ratio and abrasive size are insignificant. The SOD was found to be the most influential factor on the size of the radius generated at the edges. The size of the edge radius generated was found to be limited to the burr root thickness. Abrasive jet finishing combined with grinding gives rise to a precision finishing process called the integration manufacturing technology, in which slurry of abrasive and liquid solvent is injected to grinding zone between grinding wheel and work surface under no radial feed condition. The abrasive particles are driven and energized by the rotating grinding wheel and liquid hydrodynamic pressure and increased slurry speed between grinding wheel and work surface achieves micro removal finishing Abrasive water jet machines are becoming more widely used in mechanical machining. These machines offer great advantages in machining complex geometrical parts in almost any material. This ability to machine hard to machine materials, combined with advancements in both the hardware and software used in water jet machining has caused the technology to spread and become more widely used in industry. New developments in high pressure pumps provide more hydraulic power at the cutting head, significantly increasing the cutting performance of the machine. Analysis of the economic and technical has been done by researchers. Those technology advancements in applying higher power machining and intelligent software control have proven to significantly improve the overall performance of the abrasive water jet machining operation, thus widening the scope of possible applications of this innovative and promising technology. Quality of the surface produced during abrasive water jet machining of aluminum has been investigated in recent years. The type of abrasive used was garnet of mesh size 80. The cutting variables were stand off distance of the nozzle from
the work surface; work feed rate and jet pressure. The evaluating criteria of the surface produced were width of cut, taper of the cut slot and work surface roughness. It was found that in order to minimize the width of cut; the nozzle should be placed close to the work surface. Increase in jet pressure results in widening of the cut slot both at the top and at exit of the jet from the work. However, the width of cut at the bottom (exit) was always found to be larger than that at the top. It was found that the taper of cut gradually reduces with increase in standoff distance and was close to zero at the stand off distance of 4 mm. The jet pressure does not show significant influence on the taper angle within the range of work feed and the stand off distance considered. Both stand off distance and the work feed rate show strong influence on the roughness of the machined surface. Increase in jet pressure shows positive effect in terms of smoothness of the machined surface. With increase in jet pressure, the surface roughness decreases. This is due to fragmentation of the abrasive particles into smaller sizes at a higher pressure and due to the fact that smaller particles produce smoother surface. So within the jet pressure considered, the work surface is smoother near the top surface and gradually it becomes rougher at higher depths.

2. Experimental Work on AJM

Experiments were conducted to confirm the validity of my results as well as the theoretical results. The experimental work was carried on a test rig which was manufactured in the workshops of ITM University, Gurgaon, and Haryana, India. The abrasive grits like aluminum oxide, silicon carbide were mixed with air stream ahead of nozzle and the abrasive flow rate was kept constant throughout the machining process. The jet nozzle was made of tool steel to carry high wear resistance. Drilling of glass sheets was conducted by setting the test rig on the parameters listed in Table 2 Glass and ceramic tiles were used as a work piece material because of its homogeneous properties. The test specimens were cut into square and rectangular shape for machining on AJM unit. In machine the initial weights of glass plates and ceramic tiles were measured with the help of digital balance. After machining the final weights were measured with the help of digital balance to calculate the material removal rate. In our machine the movement to specimens in x-y directions is provided with the help of cross slide and in z direction with help of worm and worm wheel drive. First the abrasive that was alumina in powder form was fed in the hopper carefully. After that compressor connections were checked. The glass specimen was properly clamped on cross slide with the help of various clamps. As the compressor was switched on, the hopper gate valve was opened so that abrasive grains were mixed with air jet coming from the compressor and focused on the specimen with help of nozzle. Same experiments were with silicon carbide as abrasive in AJM process. Different readings were taken using different process parameters on the glass plates and ceramic tiles of different thickness and all results were tabulated. All results were compared with the theoretical results also to check the validity of our results.

Fig 1: Layout of AJM

<table>
<thead>
<tr>
<th>Table 1: Abrasive jet machine characteristics</th>
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<tbody>
<tr>
<td>Mechanics of metal removal: Brittle fracture by impinging abrasive grains at high speed.</td>
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<tr>
<td>Carrier gas: Air, carbon-dioxide</td>
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<tr>
<td>Abrasives: Alumina, SiC</td>
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<tr>
<td>Pressure: 2-10 atm</td>
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<tr>
<td>Nozzle: WC, sapphire</td>
</tr>
<tr>
<td>Critical parameters: Abrasive flow rate and velocity, nozzle tip distance abrasive grain size</td>
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<tr>
<td>Material application: Hard and brittle metals, alloys, and non metallic</td>
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</tbody>
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Table 2 Various Process Parameters of AJM

<table>
<thead>
<tr>
<th>S. No</th>
<th>Process Parameter</th>
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<tbody>
<tr>
<td>1</td>
<td>Carrier gas</td>
</tr>
<tr>
<td>2</td>
<td>Nozzle tip distance</td>
</tr>
<tr>
<td>3</td>
<td>Type of abrasive</td>
</tr>
<tr>
<td>4</td>
<td>Size of abrasive grains</td>
</tr>
<tr>
<td>5</td>
<td>Velocity of abrasive jet</td>
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<tr>
<td>6</td>
<td>Mixing ratio</td>
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<tr>
<td>7</td>
<td>Work material</td>
</tr>
<tr>
<td>8</td>
<td>Nozzle design</td>
</tr>
<tr>
<td>9</td>
<td>Shape of cut</td>
</tr>
</tbody>
</table>

Fig. 2 schematic layout of abrasive jet machine test rig

3. RESULTS
A. Experimental Results

GRAPH 1: B.W MRR AND NTD BY USING SILICA AS ABRASIVE AND GLASS AS WORKPIECE

GRAPH 2: B.W MRR AND NTD BY USING SILICON CARBIDE AS ABRASIVE AND CERAMIC AS WORKPIECE
GRAPH 3: B.W MRR AND STAND OFF DISTANCE BY USING SILICON CARBIDE AS ABRASIVE AND GLASS AS WORKPIECE

GRAPH 4: B.W MRR AND PRESSURE BY USING SILICON CARBIDE AS ABRASIVE AND GLASS AS WORKPIECE

GRAPH 5: B.W MRR AND NTD BY USING 60 MESH SIZE ABRASIVE

GRAPH 6: B.W MRR AND PRESSURE BY TAKING 60 MESH SIZE ABRASIVE
GRAPH 7 B.W MATERIAL REMOVAL RATE AND PRESSURE BY TAKING ALUMINA AS ABRASIVE

PRESSURE

B. VALIDATION AND DISCUSSION OF RESULTS

a. EFFECT OF PRESSURE ON METAL REMOVAL RATE as shown in graph 8 below

When we compared this graph with the theoretical graph then we find out that the inc. rate of MRR with pressure in case of actual graph is more than the theoretical graph.

b. GRAPH 9 BETWEEN NOZZLE TIP DISTANCE AND THE MATERIAL REMOVAL RATE:

STAND OFF DISTANCE

So from this graph we can say that initially the material removal rate varies linearly with the stand off distance but after a limit it starts diminishing. From both the graphs we can say the inc. rate is same in both case but the diminishes rate after some time is much in case of theoretical than the actual graph.

c. GRAPH 10 B.W ABRASIVE PARTICLE SIZE AND MATERIAL REMOVAL RATE:
ABRASIVE PARTICLE SIZE

From this graph 10 we can also say that material removal rate varies with the abrasive particle size as the abrasive particle size increases material removal rate also increases and the same case will happen in case of theoretical graphs we can say that in case of MRR with abrasive size both the theoretical and the actual graphs are same. Samples of work pieces machined on AJM are shown in figures 3 and 4.

4. CONCLUSION

This paper presents various results of experiments have been conducted by changing pressure, nozzle tip distance on different thickness of glass plates and ceramic plates. The effect of process parameters of AJM on the material removal rate (MRR) was measured and graphs were plotted. These were compared with the theoretical results. It was observed that as nozzle tip distance increases, material removal rate (MRR) increases as it is in the general observation in the abrasive jet machining process. As the pressure increases material removal rate (MRR) is also increased as we found in AJM process. Similarly as abrasive particle size increases MRR increases.

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