CHAPTER 4

EXPERIMENTAL SET-UP

4.1 INTRODUCTION

The experiments were conducted in order to study the effect of pressurized circulation of slurry and liquid media (along with some chemicals) on material removal rate, surface finish and accuracy of the machined components.

An experimental set-up has been developed in order to study the effect of abrasive water jet on machining of glass plates of different thickness. The main parameters studied are material removal rate and quality aspects like accuracy and surface finish produced.

4.2 GENERAL DESCRIPTION OF AWJM

The experimental set-up of Abrasive Water Jet Machining consists of a main cylindrical tank with a semispherical bottom, a storage tank, an air compressor, abrasive water jet cutting head and work holding arrangements.

The working tank has provision for slurry inlet and outlet and also for high-pressure air inlet. The cutting head with a nozzle is mounted on a stationary worktable. The stand-off-distance is adjusted by the vertical movement of the cutting head and is measured by the graduated scale fitted to the cutting head. The cutting head has a provision to accommodate nozzles of different orifice diameters.
4.2.1 The Working Tank

The working tank is a cylindrical tank made up of mild steel. The bottom end of the tank is made semi-spherical so that abrasive particles that tend to settle down are lifted up by the pressure of the compressed air coming out of small holes drilled on the periphery of a small pipe, which is fitted at the bottom. A circular lid made up of mild steel is fastened to the top end of the working tank using bolts and nuts.

A pressure gauge is fitted to the working tank so that pressure inside the tank can be recorded. A pressure relief valve is fitted at the center of the lid to release excess pressure.

It also consists of two control valves to control the inflow of air and outflow of slurry. A slurry inlet is made near the top of the tank.

4.2.2 Air Compressor Unit

The air compressor used has a maximum rated capacity of delivering air at a pressure of 10 kgf/cm². The compressed air from the air compressor flows into the slurry tank through a pneumatic pressure hose.

4.2.3 Abrasive Water Jet Cutting Head

It consists of a convergent nozzle fitted to a galvanized iron pipe. Since nozzles are subjected to a great degree of abrasion wear, they are made up of hard materials such as tungsten carbide, synthetic sapphire (ceramics) to reduce the wear rate. Nozzles made up of tungsten carbide have an average life of 10 to 20 hours, while nozzles of sapphire lost about 300 hours of operation when used with 27µm abrasive powder.
The nozzle materials that are used in the present experimentation work are EN 31. The AWJ nozzle inside diameter varies from 1 to 3mm. Dimensional details of nozzle are shown in Figure 4.1.

4.2.4 Work Holding and Cutting Head Holding Arrangement

![Figure 4.1 Cutting Head Holding Arrangement](image)

It consists of base, column, table, clamping arrangement for holding the cutting head and a transparent hood as shown in Figure 4.1.

The work piece is held on table with the help of C-clamp. The table can be moved up and down with the help of a pair of rack & pinion. And also the table can be swung about the column. The abrasive water jet cutting head can be moved vertically up and down with the help of another pair of rack & pinion, which facilitates the adjustment of stand-off-distance.

A transparent hood is placed at the machining zone as shown in Figure 4.2. This is provided to avoid the spilling of slurry around the machining zone during the machining operation.

A collector is placed at the bottom of the table to collect the abrasive slurry during machining operation.
4.2.5 Pressure Hose

A flexible high pressure hose made up of fiber reinforced rubber having capacity to withstand pressure up to 15kgf/cm² is made use to transfer abrasive slurry from abrasive tank to cutting head.

4.2.6. Storage Tank

It is used to store the slurry before passing into the working tank. It is made up of mild steel cylinder, sealed at bottom and with a slurry outlet.

Figure 4.2 Schematic diagram of Abrasive Water Jet Machining.
4.3 PREPARATION OF ABRASIVE SLURRY

Silicon carbide abrasive of 180 mesh (grit) is taken and mixed with different liquid media as stated below.

- Tap Water
- Pure Water
- Pure Water + Acetone (5% by Volume)
- Pure Water + Phosphoric acid (5% by Volume)
- Pure Water + Polymer (5% by Volume)

The abrasive is mixed with the above stated liquid media in five different concentrations of 1:6, 1:8, 1:10, 1:12 & 1:14 (by volume: One volume of abrasive particles is mixed with 6 volumes of liquid) respectively (the percentage of acetone and phosphoric acid has been taken arbitrarily).

4.4 EXPERIMENTAL PROCEDURE

The abrasive is mixed with water in a suitable proportion in the slurry tank and stirring should be done continuously till all the slurry from the slurry tank is passed to the working tank. After passing the slurry mixture into the working tank, compressed air is also being passed into the working tank. This compressed air pressurizes the slurry mixture and avoids the settlement of abrasive particles in the slurry. The pressurized slurry is supplied to the cutting head through a pressure hose and the nozzle and then is made to impinge on the work surface. The impact of high-pressure abrasive particles on the work surface lead to erosion of the work material and thereby the material removal takes place.

Abrasive water jet machining with pressurized slurry is essentially an erosion process which involves two distinct mechanisms depending upon whether the eroded material is brittle or ductile in nature.
Ductile erosion is defined as a process in which the abrasive particles progressively cut the eroded materials, eventually causing volumetric material removal.

Brittle erosion is described as a cracking process in which the material is removed by the propagation and intersection of cracks.

To begin with the experiments, initial experimentation was done to choose optimum nozzle diameter, stand-off-distance, slurry concentration, and abrasive grit size.

Initially nozzle diameters of 1mm, 1.5mm, 2mm, 2.5mm & 3mm were tried to identify the optimum nozzle diameter with varied parameters. Nozzle diameter of 2mm was identified to be the appropriate nozzle diameter and hence in the present investigation nozzle diameter of 2mm only has been used.

The stand-off-distance of 1mm, 2mm, 3mm, 4mm & 5mm were tried to identify the optimum value with varied parameters. It was observed that 3mm is appropriate and hence for further experimentation 3mm stand-off-distance has been used.

The slurry concentration of 1:6, 1:8, 1:10, 1:12, & 1:14 were tried to identify the optimum slurry concentration with varied parameters. It was observed that 1:8 slurry concentrations is the appropriate slurry concentration and hence in the present investigation slurry concentration of 1:8 only has been used.

The abrasive grit sizes of 180, 220, 280, 320, & 400 were tried to identify the influence of these abrasive grits on material removal. Amongst these, 180 abrasive grit sizes had shown highest material removal in comparison with the other grit sizes. As the other grit sizes were small in dimension & assumed to be having less sharp edges, to make effective impact on work material showed less
material removal and hence the abrasive grit size of 180 was being used as the optimum grit size in the present investigation.

The experiments were conducted by mixing pure water with acetone, pure water with phosphoric acid, pure water with polymer.