DESIGN AND FABRICATIONS OF ABRASIVE JET MACHINE

Presented By:

Group no:06

Patel Vivek R. (110780119009)

Patel Vishal K. (110780119035)

Patel Milin D. (110780119056)

Patel Kiran A. (110780119062)

Guided By:

Prof. S.S.PATEL

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Smt. S. R. PATEL ENGINEERING COLLEGE

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1) INTRODUCTION

- Abrasive jet machine:

  Abrasive jet machine is device which specially made for the purpose of it Utilization to remove the material from the w/p which is very brittle & Make a hole or any design on it. And at very high accuracy.

- Concept :

  The material removal is done due to **EROSION.**

  High velocity Flow of abrasive material & compressed air through nozzle strike the w/p And remove the material from it.

  The rate of material (MRR) is very slow but the accuracy is very higher.

  The material of nozzle is very tough &Strengthens is very high. So tungsten carbide , high speed steel are used.

AJM AS UNCONVENTIONAL MACHINE

- The world unconventional is use 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 Velocity, which is made to impinge on the work interface This eliminated tool to metal, which care the main criteria of unconventional machining method use In AJM.

➢ Following are the Parameters, which affect the material removal rate of the work piece.

1. Carrier gas
2. Types of abrasive
3. Size of abrasive grain
4. Velocity of abrasive jet
5. Flow rate of abrasive
6. Work material
7. Geometry, composition and material of nozzle
8. Nozzle work distance (stand off distance)
9. Shape of cut and operation type

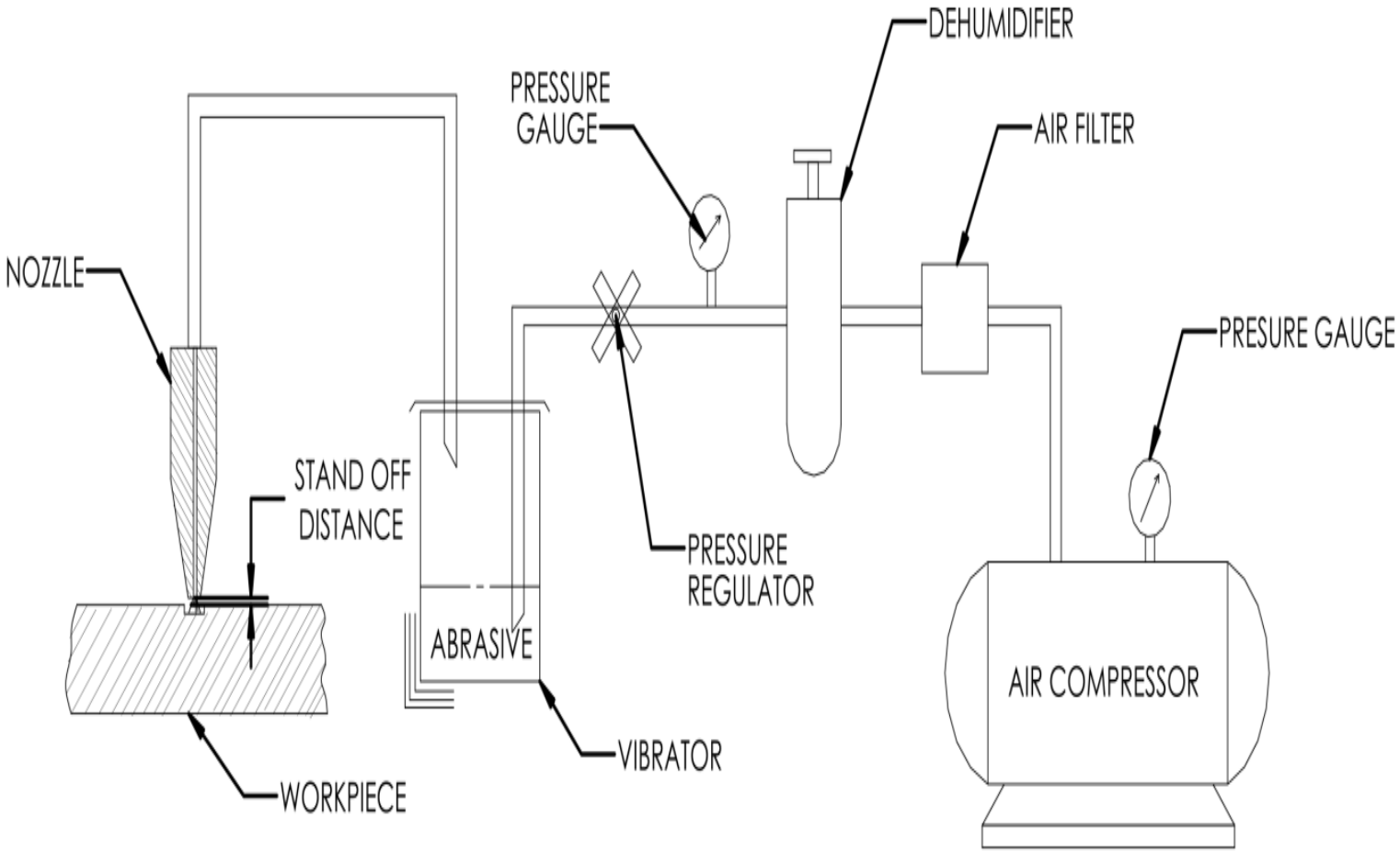


FIG-1: SCHEMATIC LAYOUT OF ABRASIVE JET MACHINE

- **Major components :-**

1. Air compressor.
2. Air filter.
3. Dehumidifier.
4. Pressure Gauge.
5. Pressure Regulator.
6. Vibrator or Mixer.
7. Nozzle.
8. Horizontal and Vertical motion module (for xyz motion).
9. Arrangement to hold the work piece.

WORKING PRINCIPLE

The operating principle of process is very simple. High pressure air from the compressor passes through filters and control valves into 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 causes indentation on the work piece. The indentation ultimately results in Capture of particles from the work surface.

2)BRIEF LITERATURE REVIEW

SR NO.	PUBLISH YEAR	TITLE	NAME OF AUTHORS
1	2007	ABRASIVE JET MACHINING FOR EDGE GENERATION	Dr. C. K. BISWAS
2	2009	DESIGN AND FABRICATION OF ABRASIVE JET MACHINE	K.B. Sehgal
3	2009	Drilling of Glass Sheets by Abrasive Jet Machining	A. El-Domiaty, H. M. Abd El-Hafez, and M. A. Shaker
4	2011	Study and Optimization of Process Parameters in Abrasive Jet Machining	Matthew W. Chastagner and Albert J. Shih
5	2012	Modified nozzle for jet engraving	Alina oancea

3) OBJECTIVE AND AIM OF WORK

- Abrasive Jet Machining (AJM) is the process of material removal from a work piece by the application of a high speed stream of abrasive particles carried in a gas medium from a nozzle.
- The major field of application of AJM process is in the machining of essentially brittle materials and heat sensitive materials like glass, quartz, sapphire, semiconductor materials, mica and ceramics. It is also used in cutting slot, thin sections, countering, drilling, deburring, for producing integrate shapes in hard and brittle materials.

1) Ability to cut intricate holes shape in materials of any hardness and brittleness.
2) Ability to cut fragile and heat sensitive material without damage.
3) No change in microstructure as no heat is generated in the process.
4) Low capital cost.

4) PROCESS PARAMETRS OF AJM

- **NOZZLE :**

The abrasive particles are directed into work surface at high velocity Through nozzle. Therefore the material of nozzle is subjected to a great Degree of abrasion wear and hence these are made of hard such as tungsten carbide or synthetic sapphire. Tungsten carbide nozzle is used for circular c/s in the range of 1 to 3mm dia.

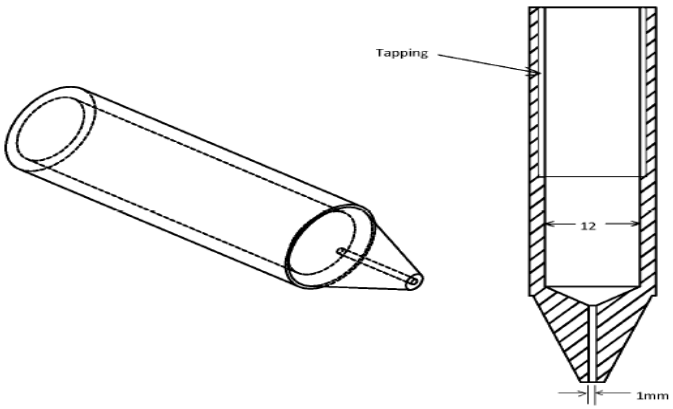
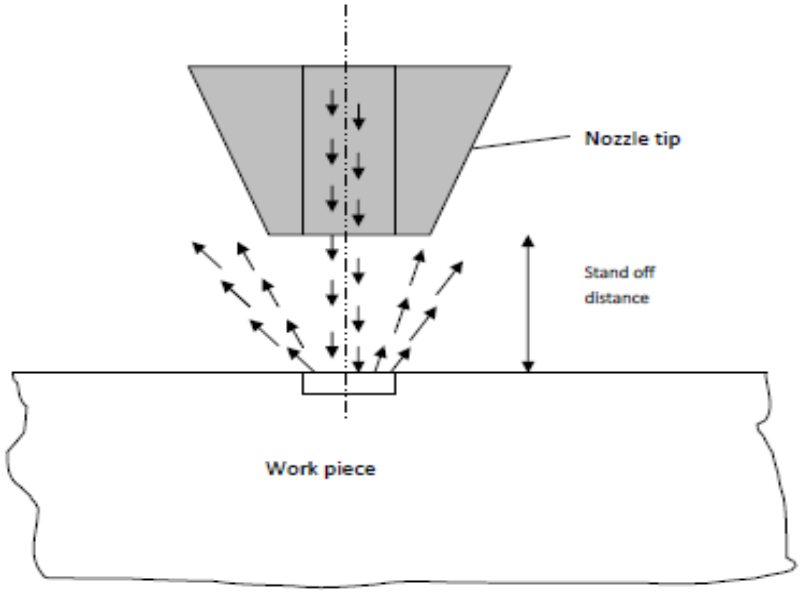


FIG- 27: Nozzle

STAND OFF DISTANCE (SOD)

- Stand off distance off nozzle tip distance (NTD) is define as the Distance between the face of the nozzle and the working surface of the work Piece .
- SOD has been found to have considerable effect on the MRR as well as Accuracy.



- **CARRIER GAS**

Carrier gas to be used in AJM must not flare excessively when Discharged from the nozzle into the atmosphere. Further he gas should be nontoxic, cheap, easily available and capable and being dried and cleaned without difficulty. Air, nitrogen and carbon dioxide is generally used as carrier gas. Commercially filled cylinder gases can also be us satisfactorily. Air is widely owing availability and little cost.

- **SIZE OF ABRASIVE GRAIN :**

The rate of metal removal depends upon the size of the abrasive grain. Fine grain are less irregular in shape in hence posses lesser cutting ability. More over finer grains tends to stick . together and check the nozzle . the most Favorable grain size from 10 to 5o microns, coarse grains recommended for Cutting whereas their grains are useful in polishing , debarring etc.

- **VELOCITY OF THE ABRASIVE JET :**

The kinetic energy of the abrasive jet is utilized for metal removal by Erosion. FANNIE & SHELDON (ref. ASME code book) have shown that for Erosion to occurs. The jet must impinge the work surface with a certain Minimum velocity for the erosion of glass by silicon carbide (grain size 25Micron) the minimum jet velocity has been found to be 150 m/sec The jet velocity is the functions of nozzle pressure , nozzle design ,abrasive grain size and that mean no. of abrasive nit volume of the carrier gas.

- **WORK MATERIAL:**

AJM is recommended for the progressing of the brittle material such as Glass, ceramic ,refractory, semiconductors, cement carbide etc. most of the Ductile material are practically un machin able by AJM . the rate of metal removal Has been found to depend upon the mohr's hardness of material to be machined.

- **SHAPE OF CUT:**

The accuracy of machining is also dependent upon the shape of cut. It May not be possible to machine component with sharp corners because of stry cutting.

5) MATERIALS USED

Abrasive material	Application
Aluminum oxide	Most widely use , cutting most hard material
Silicon carbide	Fast cutting on ceramics and other extra hard materials
Glass beads	Fine debarring ,externally light cleaning and polishing
Sodium bicarbonate	Extra fine cleaning of precision parts
Calcium/magnesium	Light cleaning and etching

- **Abrasive material information**:

Listed are the grit size for different types of abrasive materials and orifice diameters. grit diameter size range from 10 micron to as large as 0.05 in. orifice diameter range from 0.005 to 0.05in

Abrasive material	Grit size	Orifice diameter
Aluminum oxide	10 to 50µ	0.005 to 0.018
Sodium bicarbonate	25 to 50 µ	0.008 to 0.018
dolomite	2500 µ	0.026 to 0.05
Glass beads	0.025 to 0.05 in.	0.026 to 0.05

6) DESIGN OF PARTS

1) NOZZLE

$$\frac{V1^2}{2G} + Y1 + H1 + Q = \frac{V2^2}{2G} + Y2 + H2 + W$$

For adiabatic expansion the above relationship changes to,

As

Y1 = Y2 (Nozzle length is very small, hence we neglect the elevation)

Q = 0 (No heat transfer into atmosfear)

W = 0 (Adiabatic expansion)

$$V2 = \sqrt{2g(H1 - H2)}$$

We know

H = Cp x T

i.e (H1 – H2) = Cp (T1- T2)

$$\frac{T2}{T1} = \frac{'}{} \frac{P2}{P1}^{\frac{n-1}{n}}$$

$$V2 = \sqrt{2gcpT1\{1 - \left[\frac{P2}{P1}\right]^{n-1/n}\}}$$

We know that for supersonic velocity Mach No is greater than 1
MACH NO = V /c

We,know that for nozzle

P1/P2=A1/A2

2) CHAMBER

As per our requirement as well as the compactness and lightness os the model, also for the better mixing of power and air the chamber should be as small as possible.

Thickness of cylinder (t) = Pd / 2F

Whaere

F = hoop stress

P = Pressure

D = internal diameter

3) PIPE LINE DESIGN

To be on safer will select as 4 mm thik. but in actual practice. The rigid pipe will not be c onvenient to handle. To overcome this pipe has to be of Flexible material such as rubber or P.V.C. or high
-pressure pipe etc.
The hosepipe available has greater stress value and wears resistance than M.S Also they are cheaper than
steel. The P.V.C hosepipes are flexible as per our requirements.
So, diameter of pipe = 0.8 cm = 8 mm
Thickness of pipe (t) = 4 mm.

7) MODEL OF AJM

STEPS TO BE FOLLOWES IN STARTING THE MACHINE

1) Load abrasive feeding chamber with required grit size of abrasive (about 250 gms).
2) Ensure that all the pipe fitting are air tight and leak proof.
3) Start the compressor to build up the necessart pressure of about 2 to 8 kg/cm^2.
4) Fix the nozzle of known diameter to the tapered rod and place the cap properly.
5) Place the glass piece to be machined in the fixture. Adjust the stand of distance.
6) Close the dust collection box and cover properly.

8) APPLICATION , MERITS & DEMERITS OF AJM

APPLICATIONS

1) CLEANING
2) MICROMODULE FBRICATION
3) SEMICONDUCTORS
4) CRYSTALLINE MATERIAL
5) STEEL MOULDS
6) DEBURRING
7) MISCELLANEOUS MATELWORKINGAPPLICATON
8) TESTING ABRASION RESISTANT OF VARIOUS MATERIALS
9) MISCELLANEOUS LABORATORY APPLICATION

MERITS OF AJM

1) It has ability to cut intricate holes in material of any hardness and brittleness.
2) It is possible to machine fragile, brittle and heat sensitive material without damage.
3) The process can be utilized conventionally in drilling, cutting, deburring etching, polishing and cleaning operations.
4) High surface finish can be achieved.
5) Depth of surface damage is low.
6) The process is characterized by low capital investment and low power consumption.
7) The initial cost of AJM is low.

DEMERITS OF AJM

1) Limited capacity owing to low material rate
2) Nozzle wear rate is high.
3) There must be suitable dust collecting system, as the process ends to pollute the environment.

9) RESULT DISCUSSION

EFFECT OF PARAMETERS

1) Stand of distance.

2) Abrasive flow rate.

3) Abrasive grit size.

4) Nozzle distance.

DISCUSSION

1) Effect of -S.O.D on MRR

2) Effect of flow rate on MRR

3) Effect of size of partical on MRR

10) CONCLUSION

- In our country even today abrasive machine is relative unknown process. So much so, people often consider it similar with grinding, which is traditionally branched as finishing operations usually, proceeded by planning, milling, turning. But in many cases it has been proved that the abrasive machining process as primary as well as final process replace non abrasive process and compare favorably productivity and economy wise. In great majority of cases well fine abrasive machining is useful to cut down cots.
- Due to low capital and operative cost the ajm is compatible to other processes. In future with slight modifications, ajm will become a important machine tool on shop floor.

There is some scope for future works

- Study of nozzle wear
- Dimensional analysis for calculating theoretical metal removal rate.
- Study of characteristic of abrasive particles and types of abrasive particles.

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