ADVANCED MANUFACTURING PROCESS EDMS

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Non-traditional Machining Processes

Manufacturing processes can be broadly divided into two groups:

a) primary manufacturing processes : Provide basic shape and size

b) secondary manufacturing processes : Provide final shape and size with tighter control on dimension, surface characteristics

Material removal processes once again can be divided into two groups

1. Conventional Machining Processes
2. Non-Traditional Manufacturing Processes or non-conventional Manufacturing processes

Conventional Machining Processes mostly remove material in the form of chips by applying forces on the work material with a wedge shaped cutting tool that is harder than the work material under machining condition.

Non-traditional Machining Processes

The major characteristics of conventional machining are:

- Generally macroscopic chip formation by shear deformation
- Material removal takes place due to application of cutting forces – energy domain can be classified as mechanical
- Cutting tool is harder than work piece at room temperature as well as under machining conditions

Non-conventional manufacturing processes is defined as a group of processes that remove excess material by various techniques involving mechanical, thermal, electrical or chemical energy or combinations of these energies but do not use a sharp cutting tools as it needs to be used for traditional manufacturing processes.

The major characteristics of Non-conventional machining are:

1. Material removal may occur with chip formation or even no chip formation may take place. For example in AJM, chips are of microscopic size and in case of Electrochemical machining material removal occurs due to electrochemical dissolution at atomic level.

Non-traditional Machining Processes

The major characteristics of Non-conventional machining:

2. In NTM, there may not be a physical tool present. For example in laser jet machining, machining is carried out by laser beam. However in Electrochemical Machining there is a physical tool that is very much required for machining
3. In NTM, the tool need not be harder than the work piece material. For example, in EDM, copper is used as the tool material to machine hardened steels.
4. Mostly NTM processes do not necessarily use mechanical energy to provide material removal. They use different energy domains to provide machining. For example, in USM, AJM, WJM mechanical energy is used to machine material, whereas in ECM electrochemical dissolution constitutes material removal.

Classification of NTM processes

classification of NTM processes is carried out depending on the nature of energy used for material removal.

1. Mechanical Processes

- Abrasive Jet Machining (AJM)
- Ultrasonic Machining (USM)
- Water Jet Machining (WJM)
- Abrasive Water Jet Machining (AWJM)

2. Electrochemical Processes

- Electrochemical Machining (ECM)
- Electro Chemical Grinding (ECG)
- Electro Jet Drilling (EJD)

3. Electro-Thermal Processes

- Electro-discharge machining (EDM)
- Laser Jet Machining (LJM)
- Electron Beam Machining (EBM)

4. Chemical Processes

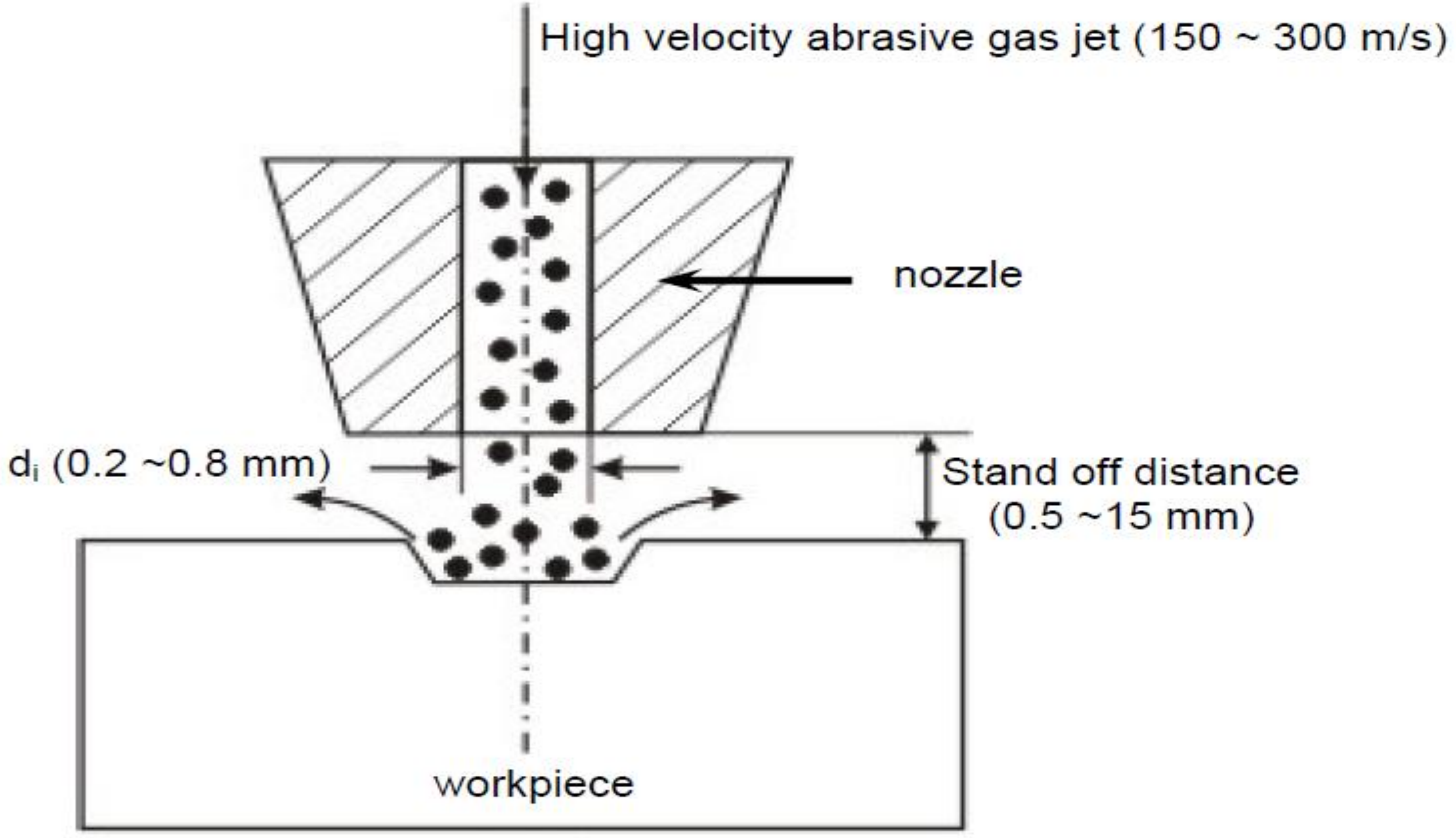
- Chemical Milling (CHM)
- Photochemical Milling (PCM)

Needs for Non Traditional Machining

- Extremely hard and brittle materials or Difficult to machine materials are difficult to machine by traditional machining processes.
- When the workpiece is too flexible or slender to support the cutting or grinding forces.
- When the shape of the part is too complex.
- Intricate shaped blind hole – e.g. square hole of 15 mmx15 mm with a depth of 30 mm
- Deep hole with small hole diameter – e.g. φ 1.5 mm hole with l/d = 20
- Machining of composites.

Abrasive Jet Machining

In Abrasive Jet Machining (AJM), abrasive particles are made to impinge on the work material at a high velocity. The high velocity abrasive particles remove the material by micro-cutting action as well as brittle fracture of the work material.

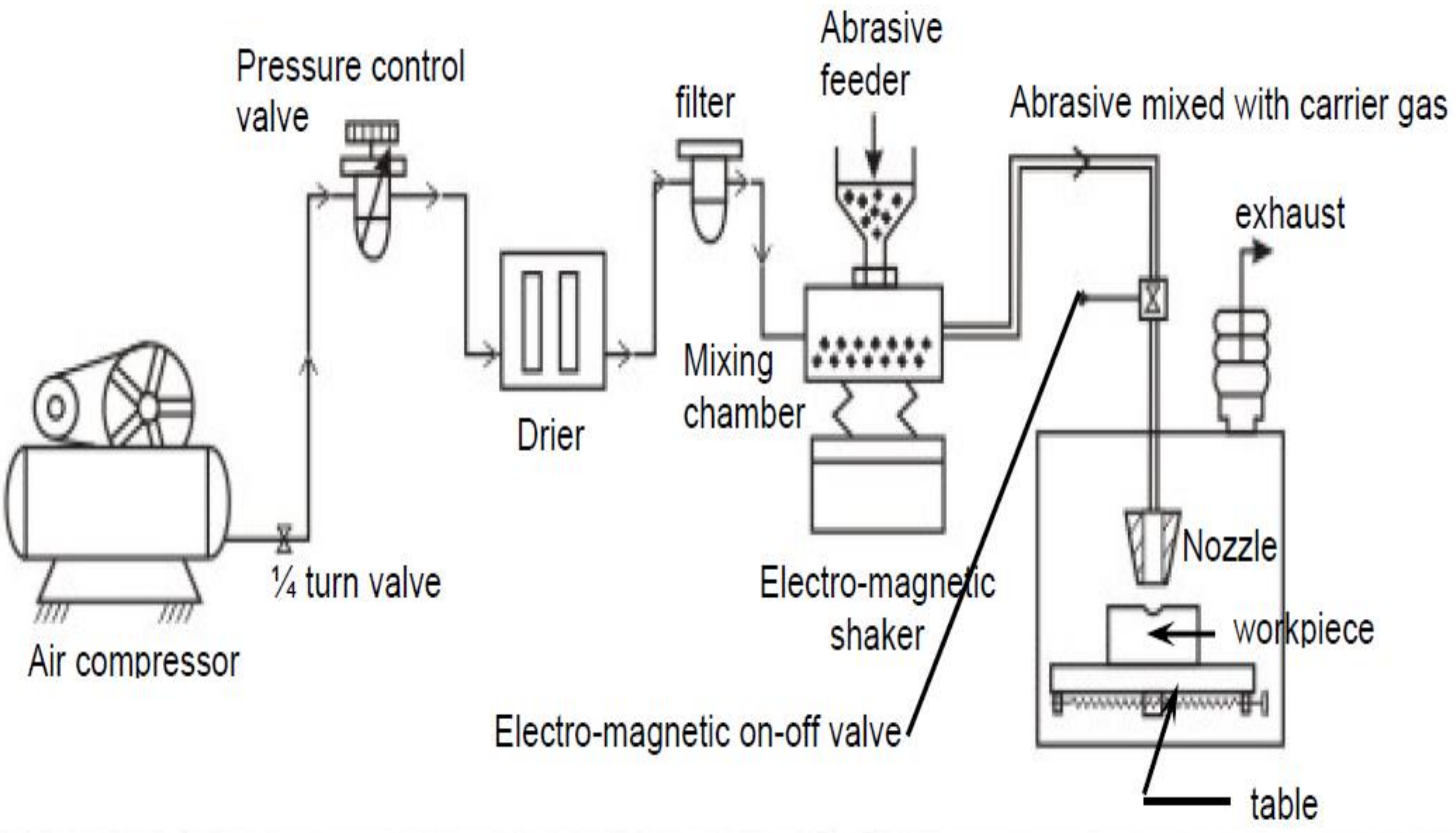


AJM

Abrasive Jet Machining

In AJM, generally, the abrasive particles of around 50 μm grit size would impinge on the work material at velocity of 200 m/s from a nozzle of I.D. of 0.5 mm with a stand off distance of around 2 mm. The kinetic energy of the abrasive particles would be sufficient to provide material removal due to brittle fracture of the work piece or even micro cutting by the abrasives.

Abrasive Jet Machining



AJM set-up

Abrasive Jet Machining

Process Parameters and Machining Characteristics

Abrasive : Material – Al_2O_3 / SiC

Shape – irregular / spherical

Size – 10 ~ 50 μm

Mass flow rate – 2 ~ 20 gm/min

Carrier gas : Composition – Air, CO_2, N_2

Density – Air ~ 1.3 kg/m3

Velocity – 500 ~ 700 m/s

Pressure – 2 ~ 10 bar

Flow rate – 5 ~ 30 lpm

Abrasive Jet : Velocity – 100 ~ 300 m/s

Mixing ratio – mass flow ratio of abrasive to gas

Stand-off distance – 0.5 ~ 5 mm

Impingement Angle – 60^0 ~ 90^0

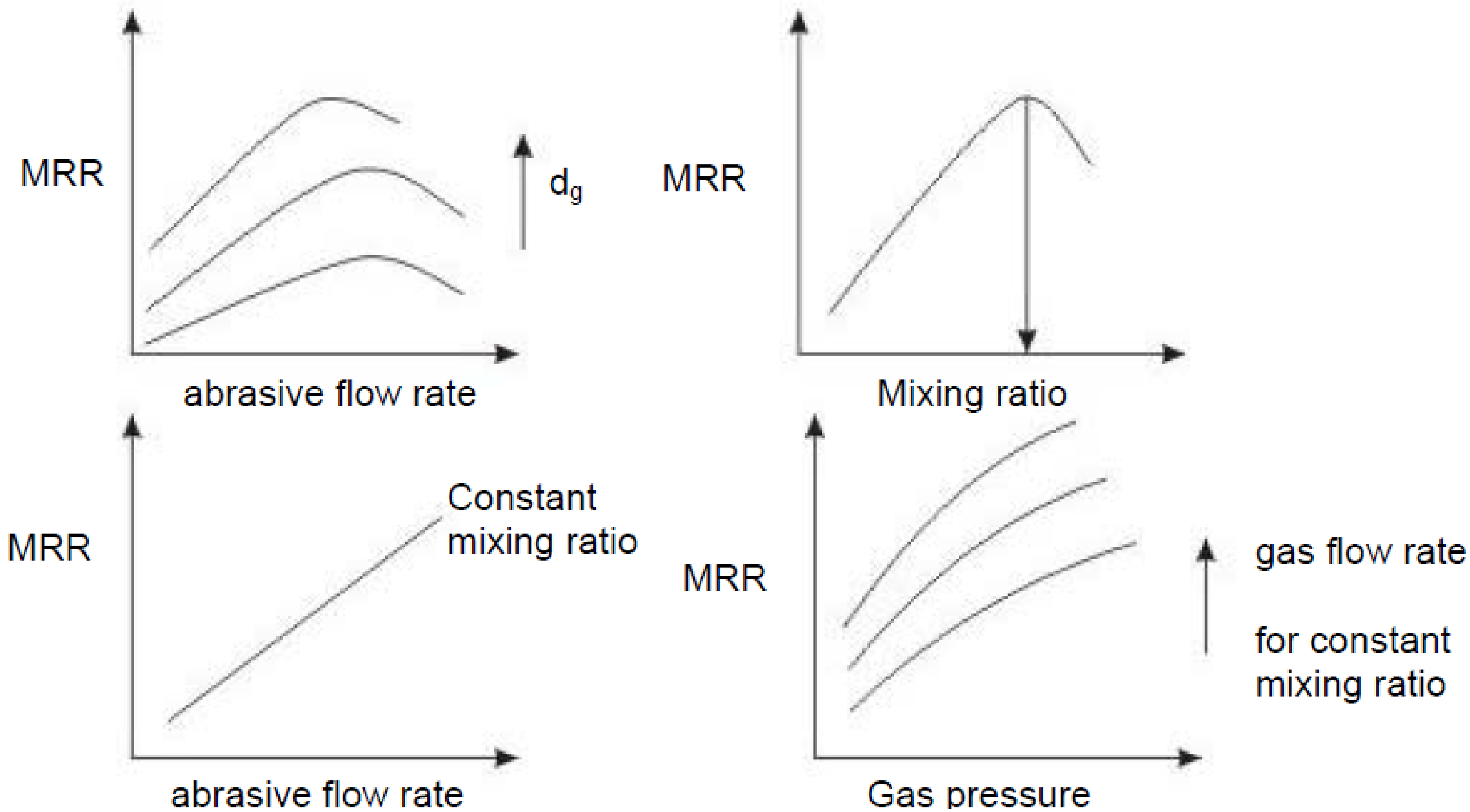
Nozzle : Material – WC

Diameter – (Internal) 0.2 ~ 0.8 mm

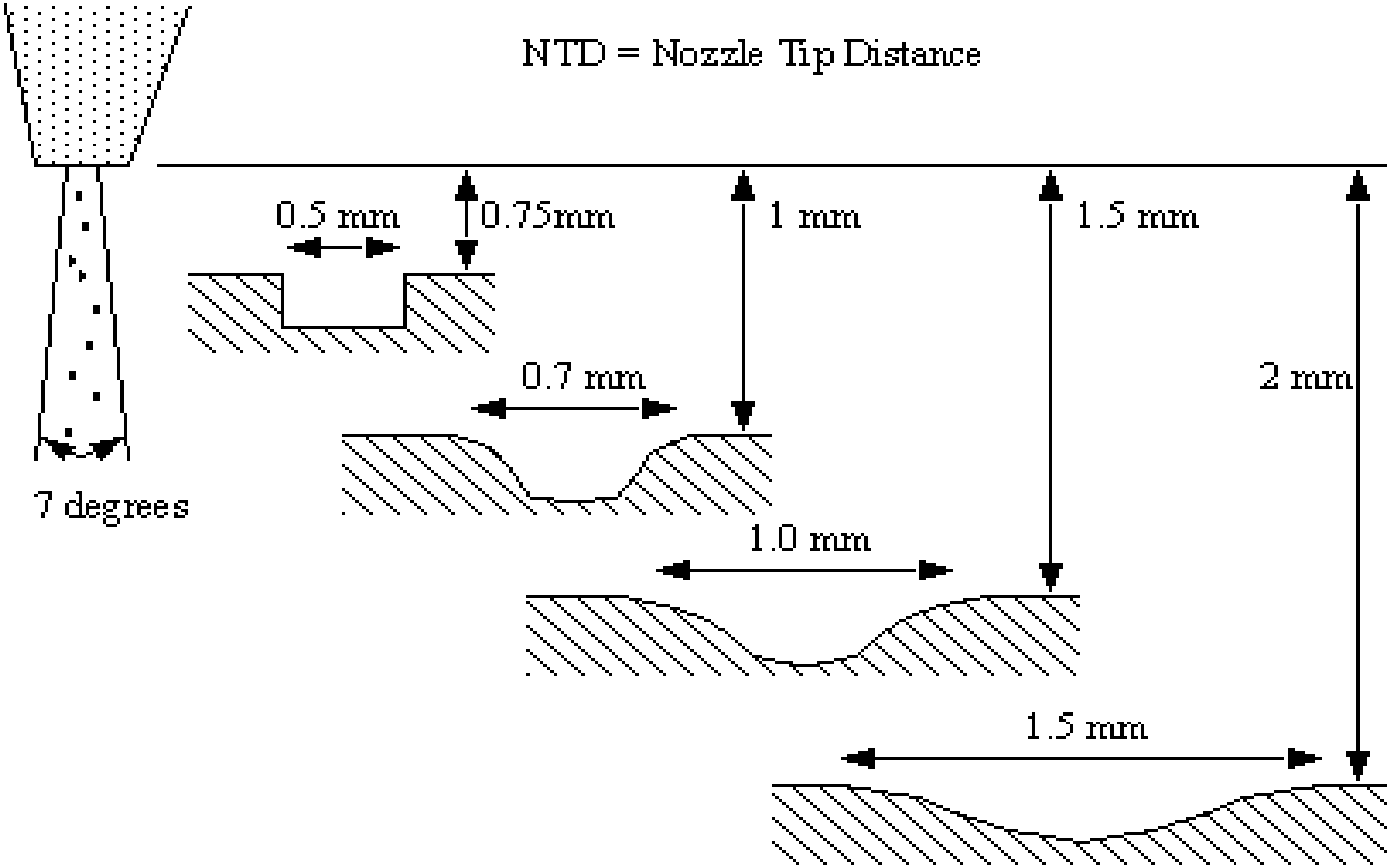
Life – 10 ~ 300 hours

Abrasive Jet Machining

Effect of process parameters on material removal rate (MRR)



Abrasive Jet Machining



Abrasive Jet Machining

Modelling of material removal

Material removal in AJM takes place due to brittle fracture of the work material due to impact of high velocity abrasive particles.

Modelling has been done with the following assumptions:

(i) Abrasives are spherical in shape and rigid. The particles are characterised by the mean grit diameter

(ii) The kinetic energy of the abrasives are fully utilised in removing material

(iii) Brittle materials are considered to fail due to brittle fracture and the fracture volume is considered to be hemispherical with diameter equal to chordal length of the indentation

(iv) For ductile material, removal volume is assumed to be equal to the indentation volume due to particulate impact.