# CHAPTER I

# INTRODUCTION

## 1.1 NON-TRADITIONAL MACHINING PROCESSES - AN OVERVIEW

Material scientists and metallurgists have developed new materials having higher strength, hardness, heat resistence and various other properties in order to cope with the needs of various new industries such as aerospace and nuclear. For shaping these materials, it is quite difficult to find suitable tool and die materials and the processes for producing them. Consequently, non-traditional or non-conventional machining processes have come into existence to deal effectively with the need of time. Though, non-traditional machining processes came up to tackle certain unique situations, but incourse of time, versatility has cost their uniqueness. In conventional metal cutting operation, it is the mechanical energy which causes material removal by shearing. On the other hand, non-traditional machining uses various forms of energy such as mechanical, electrical, thermal, chemical and electro-chemical in their direct or indirect forms. The different nontraditional machining processes which have earned their places in industry are Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Electro-chemical Machining (ECM), Chemical Machining (CHM), Electrical Discharge Machining (EDM), Electron Beam Machining (EBM), Laser Beam Machining (LBM), Plasma Arc Machining (PAM) etc.

Comparative statements of physical parameters, process capabilities, process economy and material applications as given in Tables 1.1, 1.2, 1.3 and 1.4 may help one to select a suitable non-traditional process for a particular situation.

Tables 1.1 to 1.4 indicate that PAM and ECM require high power for fast machining. The EBM and the LBM require high voltages and are useful in micro drilling and cutting. The USM and the EDM are suitable for cavity sinking and hole drilling. The AJM is useful for shallow pocketing. The ECM is useful for contour machining and it can machine faster with low thermal surface damage. The AJM has very low material removal rate combined with high tool wear.

## 1.2 ABRASIVE JET MACHINING (AJM)

The AJM works on the principle of impact erosion by multiple particles. As shown in the Fig.1.1, compressed air from a reservior or any other carrier gas from a storage cylinder is made to pass through a mixing chamber where the gas gets properly mixed up with the abrasive particles flowing from a container. This abrasive powder loaded gas after passing through a sufficiently long accelerator tube, is made to impinge on the work piece by holding the nozzle at 90 deg. to it (Fig.1.1). The process criteria are greatly influenced by the various operating parameters as mentioned now.

- Abrasives : composition, shape and size.

## TABLE 1.1

Physcial parameters of the Process

| Parameter | USM | AJM | ECM | CHM | EDM | EBM | LBM | PAM |
|---|---|---|---|---|---|---|---|---|
| | Processes | | | | | | | |
| Potential (volts) | 220 | 110 | 10 | - | 45 | 150000 | 4500 | 100 |
| Currents (Amps) | 12AC | 1.5 | 10000 DC | - | 60 pulsed DC | 0.001 pulsed DC | - | 500 DC |
| Power (watts) | 2400 | 250 | 100000 | - | 2700 | 150average 2000peak | 2average 2000peak | 50000 |
| Gaps (mm) | 0.25 | 0.76 | 0.20 | - | 0.03 | 102 | 152 | 7.62 |
| Medium | Abrasive in water | Abrasive in gas | Liquid electr-olyte | Liquid chemi-cal | Liquid diele-ctric | Vacuum -- | Air | Argon or Hydrogen |

**TABLE 1.2**

Process Economy

| | Processes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Conventi- onal | USM | AJM | ECM | CHM | EDM | EBM | LBM | PAM |
| Capital investment | B | B | A | E | C | C | D | C | A |
| Tooling and fixture | B | B | B | C | B | D | B | B | B |
| Power requirement | B | B | B | C | D | B | D | A | A |
| Efficiency | A | D | D | B | C | D | E | E | A |

Note: A = very low; B = low; C = medium; D = High; E = very high.

## TABLE 1.3

Process capability

| Processes | Conventional milling of steel | USM | AJM | ECM | CHM | EDM | EBM | LBM | PAM |
|---|---|---|---|---|---|---|---|---|---|
| Material removal rate ($cm^3$ /hr) | 4097 | 19.7 | 1.0 | 983 | 1.0 | 49-197 | 0.10 | 0.007 | 4916 |
| Dimensional control (mm) | 0.05 | 0.008 | 0.05 | 0.05 | 0.05 | 0.13 | 0.03 | 0.03 | 1.27 |
| Corner radii (mm) | 0.05 | 0.03 | 0.10 | 0.03 | 1.27 | 0.03 to 0.13 | 0.25 | 0.25 | - |
| Surface finish ( $\mu m$ rms) | 0.5 to 5.1 | 0.3 to 0.5 | 0.2 to 1.5 | 0.1 to 2.5 | 0.5 to 2.5 | 2.5 to 38.1 | 0.5 to 2.5 | 0.5 to 1.3 | rough |
| Depth of possible damage | 0.03 | 0.03 | 0.003 | 0.005 | 0.005 | 0.13 to 0.38 | 0.25 | 0.13 | 0.51 |

TABLE 1.4

Material Applications

| | USM | AJM | ECM | CHM | EDM | EBM | LBM | PAM |
|---|---|---|---|---|---|---|---|---|
| Aluminium | C | B | B | A | B | B | B | A |
| Steel | B | B | A | A | A | B | B | A |
| Super Alloys | C | A | A | B | A | B | B | A |
| Titanium | B | B | B | B | A | B | B | B |
| Refractories | A | A | B | C | A | A | C | C |
| Ceramic | A | A | D | C | D | A | A | D |
| Plastic | B | B | D | C | D | B | B | C |
| Glass | A | A | D | B | D | B | B | D |

Note : A = Good, B = Fair, C = Poor, D = Incapable.