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DEPARTMENT OF
MECHANICAL ENGINEERING

UNIT I

INTRODUCTION

UNCONVENTIONAL MACHINING PROCESS:

Unconventional 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. Extremely hard and brittle materials are difficult to machine by traditional machining processes such as turning, drilling, shaping and milling. Non-traditional machining processes, also called advanced manufacturing processes, are employed where traditional machining processes are not feasible, satisfactory or economical due to special reasons as outlined below.

- Very hard fragile materials difficult to clamp for traditional machining
- When the work piece is too flexible or slender
- When the shape of the part is too complex

Several types of non-traditional machining processes have been developed to meet extra required machining conditions. When these processes are employed properly, they offer many advantages over non-traditional machining processes. The common nontraditional machining processes are described in this section.

NEED :

- Extremely hard and brittle materials or Difficult to machine material 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.

CLASSIFICATION- BRIEF OVERVIEW :

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 Unconventional Machining 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.

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.

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.

CLASSIFICATION OF UCM PROCESSES :

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)

Electron Beam Machining :

Electron Beam Machining (EBM) and Laser Beam Machining (LBM) are thermal processes considering the mechanisms of material removal. However electrical energy is used to generate high-energy electrons in case of Electron Beam Machining (EBM) and high energy coherent photons in case of Laser Beam Machining (LBM). Thus these two processes are often classified as electro-optical-thermal processes.

Laser Beam Machining :

Laser Beam Machining or more broadly laser material processing deals with machining and material processing like heat treatment, alloying, cladding, sheet metal bending etc. Such processing is carried out utilizing the energy of coherent photons or laser beam, which is mostly converted into thermal energy upon interaction with most of the materials. Nowadays, laser is also finding application in regenerative machining or rapid prototyping as in processes like stereo-lithography, selective laser sintering etc. Laser

stands for light amplification by stimulated emission of radiation. The underline working principle of laser was first put forward by Albert Einstein in 1917 though the first industrial laser for experimentation was developed around 1960s.

Laser beam can very easily be focused using optical lenses as their wavelength ranges from half micron to around 70 microns. Focused laser beam as indicated earlier can have power density in excess of 1 MW/mm². As laser interacts with the material, the energy of the photon is absorbed by the work material leading to rapid substantial rise in local temperature. This in turn results in melting and vaporisation of the work material and finally material removal.

Electrochemical Machining :

Electrochemical Machining (ECM) is a non-traditional machining (NTM) process belonging to Electrochemical category. ECM is opposite of electrochemical or galvanic coating or deposition process. Thus ECM can be thought of a controlled anodic dissolution at atomic level of the work piece that is electrically conductive by a shaped tool due to flow of high current at relatively low potential difference through an electrolyte which is quite often water based neutral salt solution.

Water jet cutting :

Water jet cutting can reduce the costs and speed up the processes by eliminating or reducing expensive secondary machining process. Since no heat is applied on the materials, cut edges are clean with minimal burr. Problems such as cracked edge defects, crystallisation, hardening, reduced weldability and machinability are reduced in this process. Water jet technology uses the principle of pressurizing water to extremely high pressures, and allowing the water to escape through a very small opening called "orifice" or "jewel". Water jet cutting uses the beam of water exiting the orifice to cut soft materials. This method is not suitable for cutting hard materials.

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. 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 standoff 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.

Ultrasonic Machining :

USM is mechanical material removal process or an abrasive process used to erode holes or cavities on hard or brittle work piece by using shaped tools, high frequency mechanical motion and an abrasive slurry. USM offers a solution to the expanding need

for machining brittle materials such as single crystals, glasses and polycrystalline ceramics, and increasing complex operations to provide intricate shapes and work piece profiles. It is therefore used extensively in machining hard and brittle materials that are difficult to machine by traditional manufacturing processes. The hard particles in slurry are accelerated toward the surface of the work piece by a tool oscillating at a frequency up to 100 KHz - through repeated abrasions, the tool machines a cavity of a cross section identical to its own.

Electrical Discharge Machining :

Electrical discharge machining (EDM) is one of the most widely used nontraditional machining processes. The main attraction of EDM over traditional machining such as metal cutting using different tools and grinding is that this technique utilises thermoelectric process to erode undesired materials from the workpiece by a series of discrete electrical sparks between the workpiece and the electrode.

Chemical Machining :

Chemical machining (CM) is the controlled dissolution of work piece material (etching) by means of a strong chemical reagent (etchant). In CM material is removed from selected areas of work piece by immersing it in a chemical reagents or etchants; such as acids and alkaline solutions. Material is removed by microscopic electrochemical cell action, as occurs in corrosion or chemical dissolution of a metal. This controlled chemical dissolution will simultaneously etch all exposed surfaces even though the penetration rates of the material removal may be only 0.0025–0.1 mm/min.