Tishk International University
Mechatronics Engineering Department
Manufacturing Technology 8/1/2026

# Non traditional Manufacturing Process

Instructor: Sara Serwer Youns
Email:sara.sarwer@tiu.edu.iq

- Machining is a broad term to describe removal of material from a workpiece.
- Machining categories:
  - <u>Cutting</u> involves single-point or multipoint cutting tools, each with a clearly defined geometry.
  - <u>Abrasive</u> processes, such as grinding.
  - <u>Nontraditional</u> machining, utilizing electrical, chemical, and optical sources of energy.

# Nontraditional Machining

- Ultrasonic Machining (USM)
- Water-Jet Machining & Abrasive-Jet Machining
- Chemical Machining
- Electrochemical Machining (ECM)
- Electrical-Discharge Machining (EDM)
- High-Energy-Beam Machining
  - Laser-beam machining (LBM)
  - Electron-beam machining (EBM)

# Traditional vs. Nontraditional

- Primary source of energy
  - Traditional: mechanical.
  - Nontraditional: electrical, chemical, optical
- Primary method of material removal
  - Traditional: shearing
  - Nontraditional: does not use shearing (e.g., abrasive water jet cutting uses erosion)

Water jet machining

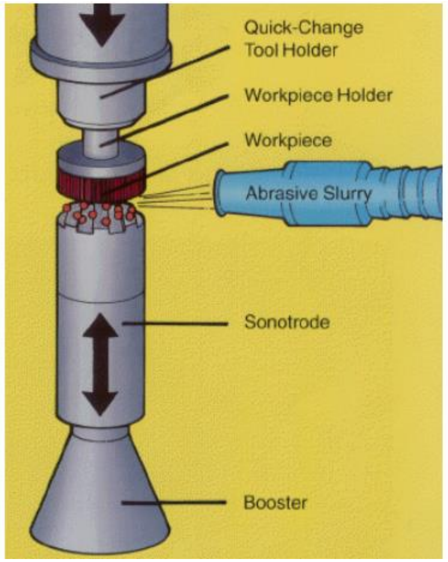
# Why Nontraditional Machining?

- Situations where traditional machining processes are unsatisfactory or uneconomical:
  - Workpiece material is too hard, strong, or tough.
  - Workpiece is too flexible to resist cutting forces or too difficult to clamp.
  - Part shape is very complex with internal or external profiles or small holes.
  - Requirements for surface finish and tolerances are very high.
  - Temperature rise or residual stresses are undesirable or unacceptable.

# Ultrasonic Machining (USM)

Ultrasonic Machining (USM) is a non-traditional abrasive process that removes material from hard, brittle workpieces using high-frequency vibrations and abrasive slurry

**Working principle** A tool vibrates at ultrasonic frequencies (typically 20-40 kHz) with low amplitude, driving abrasive particles in a slurry against the stationary workpiece. This causes micro-chipping and material erosion without generating heat that could alter properties, ideal for materials like ceramics, glass, and composites.




Advantages

- High precision for intricate shapes and good surface finish on brittle materials.
- No thermal damage or burrs, unlike conventional machining.
- Versatile for holes, cavities, and profiles difficult to machine traditionally

Video On Ultrasonic Maching

https://www.youtube.com/watch?v=5w6szZtOg5w

**Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM**) are non-thermal, high-precision processes that erode material using high-velocity fluid streams, ideal for composites and brittle materials in your research context. WJM uses pure water for soft materials, while AWJM adds abrasives for enhanced cutting power on metals and carbon fiber composites.

**Working Principle**

High-pressure pumps generate water pressure up to 90,000 PSI (620 MPa), converting it to kinetic energy via a sapphire/diamond orifice (0.1-0.4 mm diameter) for jet velocities near 900-1200 m/s. In WJM, pure water erodes through hydraulic impact and micro-fractures; AWJM entrains abrasives (garnet, 80-120 mesh) in a mixing tube, where particles accelerate and perform micro-cutting via deformation wear followed by erosion. The jet creates a narrow kerf (0.8-1.5 mm), with a catcher basin dissipating residual energy to protect surroundings.

**Material Applications**
WJM suits soft/thin materials: rubber, plastics, foam, food, textiles (up to 25 mm thick). AWJM handles virtually anything: titanium (150 mm), Inconel, ceramics, glass, carbon fiber composites (your beam research), stone—up to 200-300 mm thick without delamination or HAZ. Real example: Aerospace uses AWJM to cut carbon fiber panels for UAVs, preserving fiber integrity unlike sawing

# Video



https://www.youtube.com/watch?v=v8zVS3cyUpE

**Chemical Machining (CHM**), also known as chemical milling or etching, removes material from workpieces through controlled chemical dissolution using etchants, ideal for flat or thin parts in aerospace and electronics. Unlike mechanical processes, it generates no forces or heat, producing burr-free surfaces on hard-to-machine metals and alloys.

Working Principle

The process exploits selective chemical attack: unprotected areas exposed to etchant (acids like ferric chloride or alkalis) undergo atomic dissolution, forming soluble metal salts that are continuously flushed away. Etching proceeds isotropically (laterally and vertically), creating slight undercutting controlled by immersion time, temperature (typically 40-60°C), and agitation to ensure uniform rates (0.01-0.1 mm/min).

Video on Chemical and Electro chemical Machining



https://www.youtube.com/watch?v=aOPUzJeHk3k

**Electrochemical Machining (ECM)** is a non-traditional process that removes material from conductive workpieces through controlled anodic dissolution, acting as reverse electroplating with no mechanical forces or tool wear. The workpiece serves as the anode and a shaped cathode tool as cathode, separated by a small gap (0.1-2 mm) filled with flowing electrolyte, producing precise complex shapes on hard metals like titanium alloys.

**Electrical Discharge Machining** (EDM) removes material from conductive workpieces through rapid, controlled electrical sparks that generate intense localized heat, melting and vaporizing tiny craters without physical tool contact. Ideal for hard metals like tool steel or carbide, EDM produces intricate shapes, sharp corners, and fine details unattainable by conventional methods, commonly used in mold-making and aerospace components.

**High-Energy Beam Machining (HEBM) u**ses focused energy beams—laser (LBM) or electron (EBM)—to vaporize or melt material with extreme precision, suitable for micro-holes and thin sections in hard materials like ceramics and composites.

https://www.youtube.com/watch?v=tTnXn498F90