

Non-conventional machining

Non-traditional Machining or Advanced Machining or Nonconventional machining such as WJC, AWJC, EDM, USM, LBM, etc. It 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. Non-conventional machining (advanced manufacturing processes) is used to cut materials when there is difficult (hard and brittle materials) to cut with conventional methods or to improve the conditions of working. Also it is using if very hard brittle materials difficult to clamp for traditional machining or when the work piece is too flexible or slender when the shape of the part is too complex. Some types of non-traditional machining processes as outlined below.

Why Nonconventional machining is using?

Nonconventional machining is using when there is;

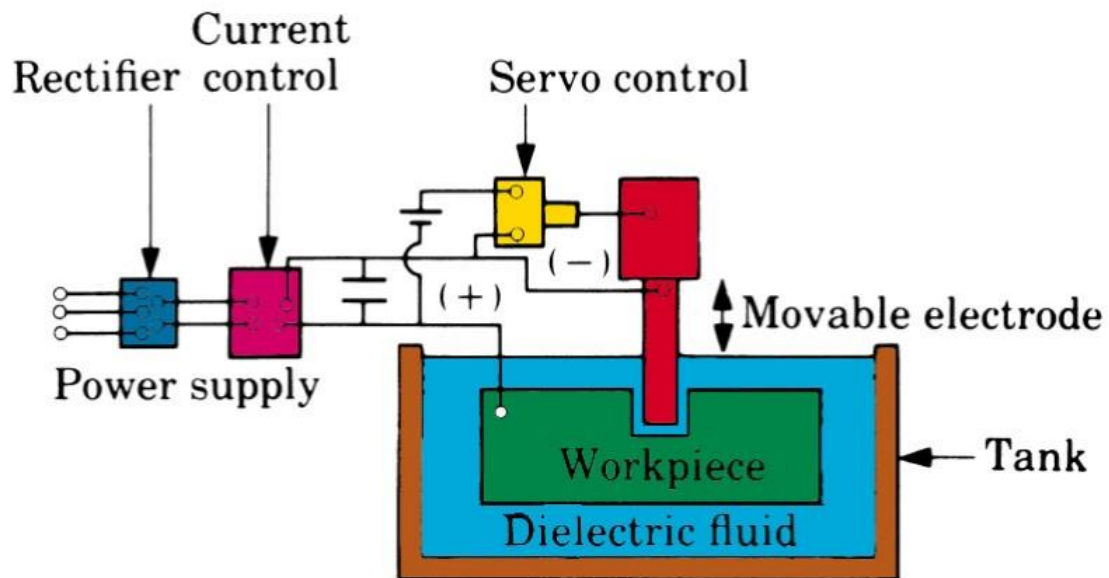
- Workpiece material is too hard, strong, or tough.
- Workpiece is too flexible or too difficult with clamping.
- Workpiece shape is very complex with internal or external profiles or small holes.
- Good surface finishing with high accuracy.
- Conditions Improvement of working.
- Temperature rise or residual stresses are undesirable or unacceptable.

Electrical Discharge Machining (EDM)

Electrical Discharge Machining (EDM) is a controlled metal-removal process that is used to remove metal by means of electric spark erosion. In this process an electric spark is used as the cutting tool to cut (erode) the workpiece to produce the finished part to the desired shape. The metal-removal process is performed by applying a pulsating (ON/OFF) electrical charge of high-frequency current through the electrode to the workpiece. This removes (erodes) very tiny pieces of metal from the workpiece at a controlled rate.

Electrical discharge machining (EDM) is one of the most widely used non-traditional machining processes. The traditional machining processes depend on harder tool or abrasive material to remove the softer material whereas non-traditional

machining processes such as EDM uses electrical spark or thermal energy to erode unwanted material in order to create desired shape. So, the hardness of the material is no longer a dominating factor for EDM process. Schematic of an EDM process is shown in Figure below.



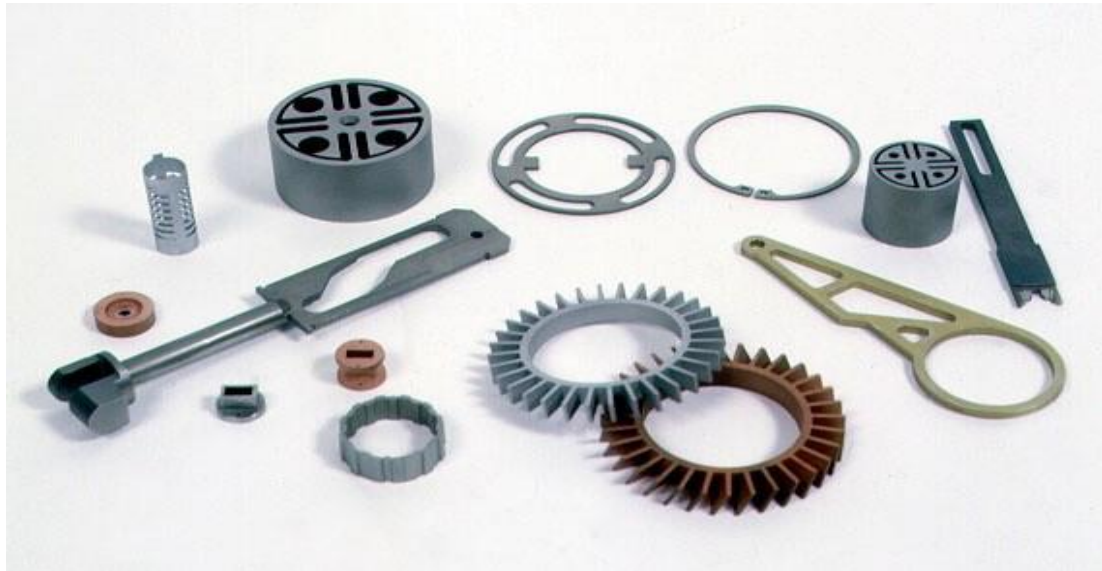
EDM process

During EDM process the workpiece and the electrode are submerged in the dielectric fluid, which is an electrical insulator that helps to control the arc discharge, acts as an insulator until the potential is sufficiently high, acts as a flushing medium (conductor the sparks between cathode and anode) provides a cooling medium and push or carry the chips.

The EDM system consists of a shaped tool or wire electrode, and the part. The part is connected to a power supply to create a potential difference between the workpiece and the tool. When the potential difference is sufficiently high, a transient spark discharges through the fluid, removing a very small amount of metal from the workpiece. The main mechanism of EDM is that technique using thermoelectric process to erode undesired materials from the work piece by a series of discrete electrical sparks between the work piece and the electrode. EDM removes material by discharging an electrical current, normally stored in capacitor, across a small gap between the tool (cathode) and the workpiece (anode) typically in the order of 50 volts/10amps, where the tool and the workpiece are immersed in a dielectric fluid.

-Application of EDM

The EDM process has the ability to machine; hard materials, machine difficult materials, parts with complex and irregular shapes, press tools, extrusion dies, difficult internal shapes for aerospace and medical applications can be made by EDM process. Some of the shapes made by EDM process are shown in Figure.



Advantages of EDM

The main advantages of EDM are:

- 1- By this process, materials of any hardness can be machined.
- 2- No burrs are left in machined surface.
- 3- One of the main advantages of this process is that thin and brittle components can be machined without distortion.
- 4- Complex internal shapes can be machined.

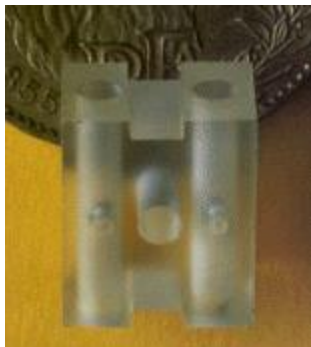
Limitations of EDM

The main limitations of this process are:

- 1- This process can only be employed in electrically conductive materials.
- 2- Material removal rate is low and the process overall is slow compared to conventional machining processes.
- 3- Unwanted erosion and over cutting of material can occur.
- 4- Rough surface finish when at high rates of material removal.

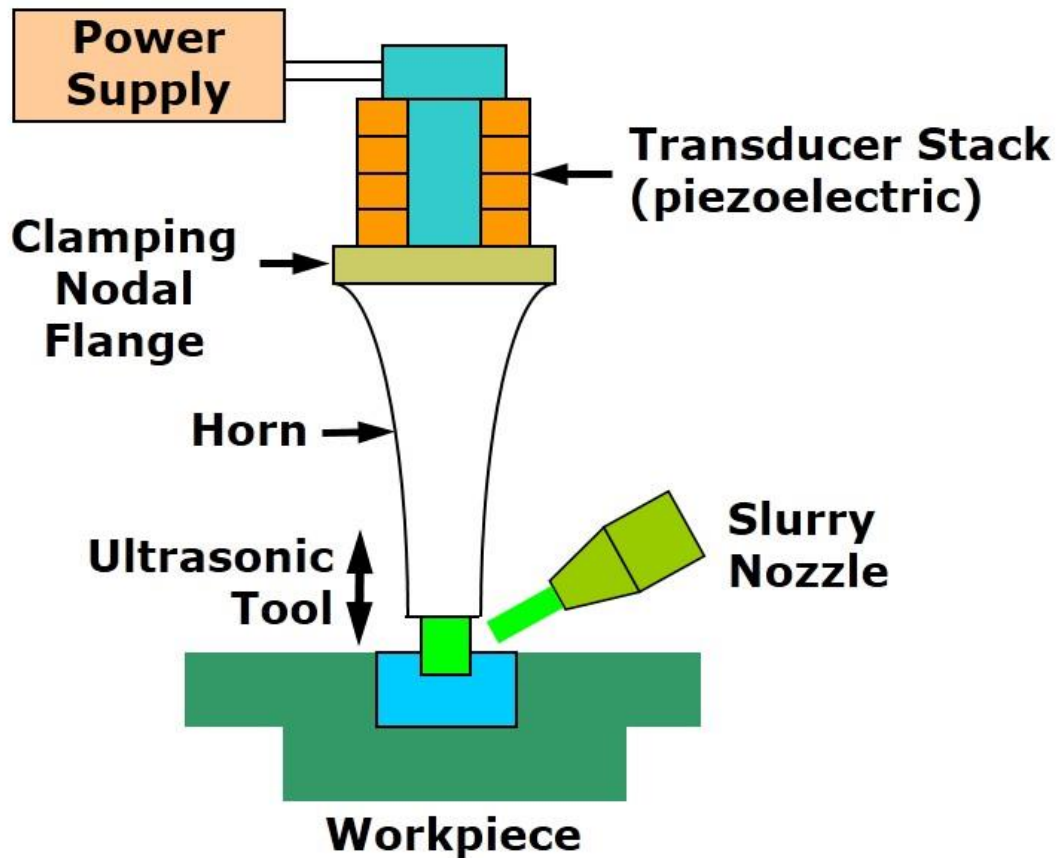
Ultrasonic Machining (USM)

USM is mechanical material removal process or an abrasive process used to erode holes or cavities on hard or brittle workpiece 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 workpiece profiles. It is therefore used extensively in hard machining and brittle materials that are difficult to machine by traditional manufacturing processes. The hard particles (as silicon carbide and aluminium oxide) in slurry are accelerated toward the surface of the workpiece by a tool oscillating at a frequency up to 100 KHz through repeated abrasions, machines a cavity identical to tool cross section. USM is best suited for hard, brittle materials, such as ceramics, carbides, glass, precious stones, and hardened steels.



Ceramic machining by
USM Process.





USM Process.

USM is primarily targeted for the machining of hard and brittle materials (dielectric or conductive) such as boron carbide, ceramics, titanium carbides, rubies, quartz etc. USM is a versatile machining process as far as properties of materials are concerned. This process is able to effectively machining all materials whether they are electrically conductive or insulator. Precision abrasive machining processes such as ultrasonic machining are commonly employed to machine glasses, single crystals and ceramic materials for various industrial applications.

Until now, precision machining of hard and brittle materials are poorly investigated from the fundamental and applied point of views. Taking into account the major technological importance of this subject to the production of functional and structural components used in high performance systems, it is often desired to estimate the machining rate for productivity while maintaining the desired surface integrity. The success of this approach, however, requires not only the fundamental understanding of the material removal on the microstructural scale but also the

relationship between the machining characteristics and material removal rate in ultrasonic machining.

Advantage of USM

- 1- Process is a non-thermal, non-chemical, and it can make non round shapes.
- 2- No changes in the microstructures and chemical or physical properties of the workpiece.
- 3- Any materials can be machined regardless of their electrical conductivity.
- 4- Especially suitable for machining of brittle and hard materials.
- 5- Machined parts by USM possess better surface finish.

Some disadvantages of USM

- 1-USM has higher power consumption and lower material-removal rates than traditional fabrication processes.
- 1-Tool wears fast in USM.
- 3-Machining area and depth is limit in USM.