NONTRADITIONAL MACHINING AND THERMAL CUTTING PROCESSES

The term nontraditional machining refers to the group of processes that removes excess material by techniques involving mechanical, thermal, electrical, or chemical energy (or combinations of these energies) while they do not use a sharp cutting tool in the conventional sense.

The nontraditional processes have been developed since World War II largely in response to new and unusual machining requirements that could not be satisfied by conventional methods.

These requirements, and the resulting commercial and technological importance of these processes include:

1. The need to machine newly developed metals and non-metals often have special properties (e.g., high strength, high hardness, high toughness) that make them difficult or impossible to machine by conventional methods.

2. The need for unusual and/or complex part geometries that cannot easily be accomplished and in some cases are impossible to achieve by conventional machining.

3. The need to avoid surface damage that often accompanies the stresses created by conventional machining.

Many of these requirements are associated with the aerospace and electronics industries, which have become increasingly important in recent decades.

There are literally dozens of nontraditional machining processes, most of which are unique in their range of applications. We will discuss only those most important commercially.

The nontraditional processes are often classified according to principal form of energy used to effect material removal. By this classification, there are four types:

1. Mechanical. Erosion of the work material by a high velocity stream of abrasives or fluid (or both) is a typical form of mechanical action in these processes.

2. Electrical. Using electrochemical energy to remove material; the mechanism is the reverse of electroplating.

3. Thermal. Using thermal energy to cut or shape the workpart. The thermal energy is generally applied to a very small portion of the work surface, causing that portion to be removed by fusion and/or vaporization. The thermal energy is generated by the conversion of electrical energy.

4. Chemical. Most materials (metals particularly) are susceptible to chemical attack by certain acids or other etchants so the process depends on selective material removal from portions of the workpart by chemicals, whereas other portions of the surface are protected by a mask.

MECHANICAL ENERGY PROCESSES

ULTRASONIC MACHINING (USM)

Machining process in which abrasives of oxide, carbide, or diamond contained in slurry are driven at high velocity against the work by a tool vibrating at low amplitude and high frequency. The amplitudes are around 0.075 mm, and the frequencies are approximately 20,000 Hz. The tool oscillates in a direction perpendicular to the work surface, and is fed slowly into the work, so that the shape of the tool is formed in the part. However, it is the action of the abrasives, impinging against the work surface that performs the cutting. The general arrangement of the USM process is depicted in figure. Common tool materials used in USM include soft steel and stainless steel.

The vibration amplitude should be set approximately equal to the grit size (abrasive particulates size), and the gap size should be maintained at about two times grit size. To a significant degree, grit size determines the surface finish on the new work surface. Also, material removal rate is an important performance variable in USM machining. For a given work material, the removal rate in USM increases with increasing frequency and amplitude of vibration.

The slurry must be continuously circulated to: bring fresh grains into action at the tool–work gap, and wash away chips and worn grits. The development of USM was motivated by the need to machine hard, brittle work materials, such as ceramics, glass, and carbides. It is also successfully used on certain metals, such as stainless steel and titanium. Shapes obtained by USM include non-round holes, holes along a curved axis, and coining operations, in which an image pattern on the tool is imparted to a flat work surface.

For better understanding, See video: https://www.youtube.com/watch?v=fEvo5jarlW4

PROCESSES USING WATER JETS

Water jet cutting (WJC) uses a fine, high-pressure, high-velocity stream of water directed at the work surface to cause cutting of the work, as in Figure. To obtain the fine stream of water a small nozzle opening of diameter 0.1 to 0.4 mm is used. To provide the stream with sufficient energy for cutting, pressures up to 400 MPa are used, and the jet reaches velocities up to 900 m/s. The fluid is pressurized to the desired level by a hydraulic pump. The nozzle unit consists of a holder made of stainless steel, and a jewel nozzle made of sapphire, ruby, or diamond. Diamond lasts the longest but costs the most. Filtration systems must be used in WJC to separate the swarf produced during cutting.

Cutting fluids in WJC are polymer solutions, preferred because of their tendency to produce a coherent stream. Important process parameters include standoff distance, nozzle opening diameter, water pressure, and
cutting feed rate. It is generally desirable for this distance to be small to minimize dispersion of the fluid stream before it strikes the surface. A typical standoff distance is 3.2 mm. Size of the nozzle orifice affects the precision of the cut; smaller openings are used for finer cuts on thinner materials. To cut thicker stock, thicker jet Streams and higher pressures are required. The cutting feed rate refers to the velocity at which the WJC nozzle is traversed along the cutting path. Typical feed rates range from 5 mm/s to more than 500 mm/s, depending on work material and its thickness. The WJC is usually automated using computer numerical control or industrial robots to manipulate the nozzle unit along the desired trajectory.

WJC can be used effectively to cut narrow slits in flat stock such as plastic, textiles, composites, floor tile, carpet, leather, and cardboard. Robotic cells have been installed with WJC nozzles mounted as the robot’s tool to follow cutting patterns that are irregular in three dimensions, such as cutting and trimming of automobile dashboards before assembly.

Advantages of WJC:
(1) No crushing or burning of the work surface typical in other mechanical or thermal processes
(2) Minimum material loss because of the narrow cut slit
(3) No environmental pollution
(4) Ease of automating the process

Limitation is that it is not suitable for cutting brittle materials (e.g. glass) due to their tendency to crack during cutting.

**Abrasive Water Jet Cutting**

It is used on metallic workparts, where abrasive particles must usually be added to the jet stream to facilitate cutting. This process is therefore called **abrasive water jet cutting (AWJC)**. Among the additional parameters are: abrasive type, grit size, and flow rate. Aluminum oxide, silicon dioxide, and garnet (a silicate mineral) are typical abrasive materials, at grit sizes ranging between 60 and 120. The abrasive particles are added to the water stream at approximately 0.25 kg/min after it has exited the WJC nozzle.

The remaining process parameters include those that are common to WJC: nozzle opening diameter, water pressure, and standoff distance. Nozzle orifice diameters are 0.25 to 0.63 mm somewhat larger than in water jet cutting to permit higher flow rates and more energy to be contained in the stream before injection of abrasives.

Water pressures are about the same as in WJC. Standoff distances are somewhat less to minimize the effect of dispersion of the cutting fluid that now contains abrasive particles. Typical standoff distances are between 1/4 and 1/2 of those in WJC.

**OTHER NONTRADITIONAL ABRASIVE PROCESSES**

Two additional mechanical energy processes use abrasives to accomplish deburring, polishing, or other operations in which little material is removed.

**Abrasive Jet Machining**

It is a material removal process caused by the action of a high-velocity stream of gas containing small abrasive particles. The gas is dry, with pressures of 0.2 to 1.4 MPa to propel it through nozzle orifices of diameter 0.075 to 1.0mm at velocities of 2.5 to 5.0 m/s. Gases include dry air, nitrogen, carbon dioxide, and helium.

The process is usually performed manually by an operator who directs the nozzle at the work. The work station must be set up to provide proper ventilation for the operator. AJM is normally used as a finishing process rather than a production cutting process. Applications include deburring, trimming and deflashing,
polishing). Grit sizes are small, 15 to 40 µm diameter, and must be uniform in size for a given application. It is important not to recycle the abrasives because used grains become fractured (and therefore smaller in size), worn, and contaminated.

**Abrasive Flow Machining (AFM)**

This process was developed in the 1960s to deburr and polish difficult-to-reach areas using abrasive particles mixed in a viscoelastic polymer that is forced to flow through or around the part surfaces and edges. The polymer has the consistency of putty. Silicon carbide is a typical abrasive. Abrasive flow machining (AFM) is particularly well-suited for internal passageways that are often inaccessible by conventional methods. The abrasive-polymer mixture, called the media, flows past the target regions of the part under pressures ranging between 0.7 and 20 MPa. In addition to deburring and polishing, other AFM applications include forming radii on sharp edges, removing rough surfaces on castings, and other finishing operations. These applications are found in industries such as aerospace, automotive, and die-making. The process can be automated to economically finish hundreds of parts per hour.

A common setup is to position the workpart between two opposing cylinders, one containing media and the other empty. The media is forced to flow through the part from the first cylinder to the other, and then back again, as many times as necessary to achieve the desired material removal and finish.

**ELECTROCHEMICAL MACHINING PROCESSES**

Electrical energy is used with chemical reactions to accomplish material removal. It is a reversed electroplating.
conductive workpiece by anodic dissolution, in which the shape of the workpiece is obtained by a formed electrode tool in close proximity to, but separated from, the work by a rapidly flowing electrolyte. ECM is basically a deplating operation. As in Figure, the workpiece is the anode, and the tool is the cathode. The principle underlying the process is that material is deplated from the anode (the positive pole) and deposited onto the cathode (the negative pole) in the presence of an electrolyte bath. The difference in ECM is that the electrolyte bath flows rapidly between the two poles to carry off the deplated material, so that it does not become plated onto the tool.

The electrode tool, usually made of copper, brass, or stainless steel, is designed to possess approximately the inverse of the desired final shape of the part. An allowance in the tool size must be provided for the gap that exists between the tool and the work. To accomplish metal removal, the electrode is fed into the work at a rate equal to the rate of metal removal from the work where it is determined by Faraday’s First Law which states that the amount of chemical change produced by an electric current (i.e., the amount of metal dissolved) is proportional to the quantity of electricity passed (current time).

For better understanding, See videos:
https://www.youtube.com/watch?v=VzmVrJA1hew
https://www.youtube.com/watch?v=iuCsRrtY5s4
https://www.youtube.com/channel/UC5AZJxIO6ku3jledDhUMPYg

We use for such calculation a constant called the **specific removal rate** that can be determined experimentally or from the standard tables for most common workpart materials. **Specific removal rate** depends on atomic weight, valence, and density of the work material.
The important process parameters for determining metal removal rate and feed rate in electrochemical machining: gap distance, electrolyte resistivity, current, and electrode frontal area. Gap distance needs to be controlled closely. If it becomes too large, the electrochemical process slows down. However, if the electrode touches the work, a short circuit occurs, which stops the process altogether. As a practical matter, gap distance is usually maintained within a range of 0.075 to 0.75 mm.

Water is used as the base for the electrolyte in ECM. To reduce electrolyte resistivity, salts such as NaCl or NaNO₃ are added in solution. In addition to carrying off the material that has been removed from the work piece, the flowing electrolyte also serves the function of removing heat and hydrogen bubbles created in the chemical reactions of the process. The removed work material is in the form of microscopic particles that must be separated from the electrolyte through centrifuge, sedimentation, or other means. The separated particles form a thick sludge whose disposal is an environmental problem associated with ECM.

Large amounts of electrical power are required to perform ECM. As the equations indicate, rate of metal removal is determined by electrical power, specifically the current density that can be supplied to the operation. The voltage in ECM is kept relatively low to minimize arcing across the gap.

ECM is generally used in applications in which the work metal is very hard or difficult to machine, or the workpart geometry is difficult (or impossible) to accomplish by conventional machining methods. Work hardness makes no difference in ECM, because the metal removal is not mechanical. Typical ECM applications include:

1. Die sinking, which involves the machining of irregular shapes and contours into forging dies, plastic molds, and other shaping tools
2. Multiple hole drilling, in which many holes can be drilled simultaneously with ECM and conventional drilling would probably require the holes to be made sequentially
3. Holes that are not round, because ECM does not use a rotating drill
4. Deburring

Advantages of ECM include: (1) Little surface damage to the workpart (2) No burrs as in conventional machining (3) Low tool wear (the only tool wear results from the flowing electrolyte) (4) Relatively high metal removal rates for hard and difficult-to-machine metals

Disadvantages of ECM are: (1) Significant cost of electrical power to drive the operation (2) Problems of disposing of the electrolyte sludge

**ELECTROCHEMICAL DEBURRING AND GRINDING**

**Electrochemical deburring (ECD)** is an adaptation of ECM designed to remove burrs or to round sharp corners on metal workparts by anodic dissolution. One possible setup for ECD is shown in Figure. The hole in the workpart has a sharp burr of the type that is produced in a conventional through-hole drilling operation. The electrode tool is designed to focus the metal removal action on the burr. Portions of the tool not being used for machining are insulated. The electrolyte flows through the hole to carry away the burr particles. The same ECM principles of operation also apply to ECD. However, since much less material is removed in electrochemical deburring, cycle times are much shorter. A typical cycle time in ECD is less than a minute. The time can be increased if it is desired to round the corner in addition to removing the burr.

**Electrochemical grinding (ECG)** is a special form of ECM in which a rotating grinding wheel with a conductive bond material is used to augment the anodic dissolution of the metal workpart surface. Abrasives used in ECG include aluminum oxide and diamond. The bond material is either metallic (for diamond abrasives) or resin bond impregnated with metal particles to make it electrically conductive (for aluminum oxide). The abrasive grits protruding from the grinding wheel at the contact with the workpart establish the gap distance in ECG. The electrolyte flows through the gap between the grains to play its role in electrolysis. Deplating is responsible for 95% or more of the metal removal in ECG, and the abrasive action of the grinding wheel removes the remaining 5% or less, mostly in the form of salt films that have been formed during the electrochemical reactions at the work surface.
Because most of the machining is accomplished by electrochemical action, the grinding wheel in ECG lasts much longer than a wheel in conventional grinding. The result is a much higher grinding ratio. In addition, dressing of the grinding wheel is required much less frequently. These are the significant advantages of the process. Applications of ECG include sharpening of cemented carbide tools and grinding of surgical needles, thin wall tubes, and fragile parts.

**THERMAL ENERGY PROCESSES**

Material removal processes based on thermal energy are characterized by very high local temperatures—hot enough to remove material by fusion or vaporization. Because of the high temperatures, these processes cause physical and metallurgical damage to the new work surface. In some cases, the resulting finish is so poor that subsequent processing is required to smooth the surface. In this section we examine several thermal energy processes that have commercial importance: (1) electric discharge machining and electric discharge wire cutting, (2) electron beam machining, (3) laser beam machining, (4) arc cutting processes, and (5) oxyfuel cutting processes.

**ELECTRIC DISCHARGE PROCESSES (EDM)**

Electric discharge processes remove metal by a series of discrete electrical discharges (sparks) that cause localized temperatures high enough to melt or vaporize the metal in the immediate vicinity of the discharge. The two main processes in this category are: (1) Electric discharge machining, (2) Wire electric discharge machining. These processes can be used only on electrically conducting work materials.

For better understanding, see video: [https://youtu.be/L1D5DLWWMp8](https://youtu.be/L1D5DLWWMp8)

**Electric Discharge Machining (EDM)** is one of the most widely used nontraditional processes. An EDM setup is illustrated in Figure. The shape of the finished work surface is produced by a formed electrode tool. The sparks occur across a small gap between tool and work surface. The EDM process must take place in the presence of a dielectric fluid, which creates a path for each discharge as the fluid becomes ionized in the gap. The discharges are generated by a pulsating direct current power supply connected to the work and the tool. Figure shows a close-up view of the gap between the tool and the work. The discharge occurs at the location where the two surfaces are closest. The dielectric fluid ionizes at this location to create a path for the discharge. The region in which discharge occurs is heated to extremely high temperatures, so that a small portion of the work surface is suddenly melted and removed. The flowing dielectric then flushes away the small particle (call it a“chip”). Because the surface of the work at the location of the previous discharge is now separated from the tool by a greater distance, this location is less likely to be the site of another spark until the surrounding regions have been reduced to the same level or below. Although the individual discharges remove metal at very localized points, they occur hundreds or thousands of times per second so that a gradual erosion of the entire the area of the surface occurs in the gap.

Two important process parameters in EDM are discharge current and frequency of discharges. As either of these parameters is increased, metal removal rate increases. Surface roughness is also affected by current and frequency. The best surface finish is obtained in EDM by operating at high frequencies and low discharge currents. The high spark temperatures that melt the work also melt the tool, creating a small cavity in the surface opposite the cavity produced in the work. Tool wear is usually measured as the ratio of work material removed to tool material removed (similar to the grinding ratio). This wear ratio ranges between 1.0 and 100 or slightly above, depending on the combination of work and electrode materials. Electrodes are made of graphite, copper, brass, copper tungsten, silver tungsten, and other materials. The selection depends on the type of power supply circuit available on the EDM machine, the type of work material that is to be machined, and whether roughing or finishing is to be done. Graphite is preferred for many applications because graphite does not melt. It vaporizes at very high temperatures, and the cavity created by the spark is generally smaller than for most other EDM electrode materials. Consequently, a high ratio of work material removed to tool wear is usually obtained with graphite tools.

The hardness and strength of the work material are not factors in EDM, because the process is not a contest of hardness between tool and work. The melting point of the work material is an important property, and metal removal rate can be related to melting point.
Dielectric fluids used in EDM include hydrocarbon oils, kerosene, and distilled or deionized water. The dielectric fluid serves as an insulator in the gap except when ionization occurs in the presence of a spark. Its other functions are to flush debris out of the gap and remove heat from tool and workpart.

Applications of electric discharge machining include both tool fabrication and parts production. The tooling for many of the mechanical processes discussed in this book are often made by EDM, including molds for plastic injection molding, extrusion dies, wire drawing dies, forging and heading dies, and sheet metal stamping dies. As in ECM, the term die sinking is used for operations in which a mold cavity is produced, and the EDM process is sometimes referred to as ram EDM. For many of the applications, the materials used to fabricate the tooling are difficult (or impossible) to machine by conventional methods.

Certain production parts also call for application of EDM. Examples include delicate parts that are not rigid enough to withstand conventional cutting forces, hole drilling where the axis of the hole is at an acute angle to the surface so that a conventional drill would be unable to start the hole, and production machining of hard and exotic metals.

**Electric Discharge Wire Cutting (EDWC)**, commonly called **Wire EDM**, is a special form of electric discharge machining that uses a small diameter wire as the electrode to cut a narrow kerf in the work. The cutting action in wire EDM is achieved by thermal energy from electric discharges between the electrode wire and the workpiece. Wire EDM is illustrated in Figure. The workpiece is fed past the wire to achieve the desired cutting path, somewhat in the manner of a bandsaw operation.

**Definition of kerf and overcut in wire EDM**

Numerical control is used to control the workpart motions during cutting. As it cuts, the wire is slowly and continuously advanced between a supply spool and a take-up spool to present a fresh electrode of constant diameter to the work. This helps to maintain a constant kerf width during cutting. As in EDM, wire EDM must be carried out in the presence of a dielectric. This is applied by nozzles directed at the tool–work interface as in our figure, or the workpart is submerged in a dielectric bath.

Wire diameters range from 0.076 to 0.30 mm, depending on required kerf width. Materials used for the wire include brass, copper, tungsten, and molybdenum. Dielectric fluids include deionized water or oil. As in EDM, an overcut exists in wire EDM that makes the kerf larger than the wire diameter, as shown in Figure. This overcut is in the range 0.020 to 0.050 mm. Once cutting conditions have been established for a given cut, the overcut remains fairly constant and predictable.

Although EDWC seems similar to a bandsaw operation, its precision far exceeds that of a bandsaw. The kerf is much narrower, corners can be made much sharper, and the cutting forces against the work are nil. In addition, hardness and toughness of the work material do not affect cutting performance. The only requirement is that the work material must be electrically conductive.

The special features of wire EDM make it ideal for making components for stamping dies. Because the kerf is so narrow, it is often possible to fabricate punch and die in a single cut, as suggested by Figure. Other tools and parts with intricate outline shapes, such as lathe form tools, extrusion dies, and flat templates, are made with electric discharge wire cutting.

For better understanding, see video: https://www.youtube.com/watch?v=pBueWfzb7P0
ELECTRON BEAM MACHINING

Electron beam machining (EBM) uses a high velocity stream of electrons focused on the workpiece surface to remove material by melting and vaporization. A schematic of the EBM process is illustrated in Figure. An electron beam gun generates a continuous stream of electrons that is accelerated to approximately 75% of the speed of light and focused through an electromagnetic lens on the work surface. The lens is capable of reducing the area of the beam to a diameter as small as 0.025 mm. On impinging the surface, the kinetic energy of the electrons is converted into thermal energy of extremely high density that melts or vaporizes the material in a very localized area.

Electron beam machining is used for a variety of high-precision cutting applications on any known material. Applications include drilling of extremely small diameter holes—down to 0.05 mm diameter, drilling of holes with very high depth-to-diameter ratios—more than 100:1, and cutting of slots that are only about 0.025 mm wide. These cuts can be made to very close tolerances with no cutting forces or tool wear. The process is ideal for micromachining and is generally limited to cutting operations in thin parts—in the range 0.25 to 6.3 mm thick. EBM must be carried out in a vacuum chamber to eliminate collision of the electrons with gas molecules. Other limitations include the high energy required and expensive equipment.

LASER BEAM MACHINING (LBM)

The term laser stands for light amplification by stimulated emission of radiation. A laser is an optical transducer that converts electrical energy into a highly coherent light beam. A laser light beam has several properties that distinguish it from other forms of light. It is monochromatic (theoretically, the light has a single wave length) and highly collimated (the light rays in the beam are almost perfectly parallel). These properties allow the light generated by a laser to be focused, using conventional optical lenses, onto a very small spot with resulting high power densities. Depending on the amount of energy contained in the light beam, and its degree of concentration at the spot, the various laser processes identified in the preceding can be accomplished.

LBM uses the light energy from a laser to remove material by vaporization and ablation. The setup for LBM is illustrated in Figure. The types of lasers used in LBM are carbon dioxide gas lasers and solid-state lasers (of which there are several types). In LBM, the energy of the coherent light beam is concentrated not only optically but also in terms of time. The light beam is pulsed so that the released energy results in an impulse against the work surface that produces a combination of evaporation and melting, with the melted material evacuating the surface at high velocity.

LBM is used to perform various types of drilling, slitting, slotting, scribing, and marking operations. Drilling small diameter holes is possible—down to 0.025 mm.

For larger holes, above 0.50 mm diameter, the laser beam is controlled to cut the outline of the hole. LBM is not considered a mass production process, and it is generally used on thin stock. The range of work materials that can be machined by LBM is virtually unlimited. Ideal properties of a material for LBM include high light energy absorption, poor reflectivity, good thermal conductivity, low specific heat, low heat of fusion, and low heat of vaporization. Of
course, no material has this ideal combination of properties. The actual list of work materials processed by LBM includes metals with high hardness and strength, soft metals, ceramics, glass and glass epoxy, plastics, rubber, cloth, and wood.

ARC-CUTTING PROCESSES
The intense heat from an electric arc can be used to melt virtually any metal for the purpose of welding or cutting. Most arc-cutting processes use the heat generated by an arc between an electrode and a metallic workpart (usually a flat plate or sheet) to melt a kerf that separates the part. The most common arc-cutting processes are (1) plasma arc cutting and (2) air carbon arc cutting.

Plasma Arc Cutting
A plasma is defined as a superheated, electrically ionized gas. Plasma arc cutting (PAC) uses a plasma stream operating at temperatures in the range 10,000°C to 14,000°C to cut metal by melting, as shown in Figure.

Cutting operates by directing the high-velocity plasma stream at the work, thus melting it and blowing the molten metal through the kerf. The plasma arc is generated between an electrode inside the torch and the anode workpiece. The plasma flows through a water-cooled nozzle that constricts and directs the stream to the desired location on the work. The resulting plasma jet is a high-velocity, well-collimated stream with extremely high temperatures at its center, hot enough to cut through metal in some cases 150 mm thick.

Gases used to create the plasma in PAC include nitrogen, argon, hydrogen, or mixtures of these gases. These are referred to as the primary gases in the process. Secondary gases or water are often directed to surround the plasma jet to help confine the arc and clean the kerf of molten metal as it forms.

Most applications of PAC involve cutting of flat metal sheets and plates. Operations include hole piercing and cutting along a defined path. The desired path can be cut either by use of a hand-held torch manipulated by a human operator, or by directing the cutting path of the torch under numerical control (NC). For faster production and higher accuracy, NC is preferred because of better control over the important process variables such as standoff distance and feed rate. Plasma arc cutting can be used to cut nearly any electrically conductive metal. Metals frequently cut by PAC include plain carbon steel, stainless steel, and aluminum. The advantage of NC in these applications is high productivity. Feed rates along the cutting path can be as high as 200 mm/s for 6-mm aluminum plate and 85 mm/s for 6-mm steel plate. Feed rates must be reduced for thicker stock. For example, the maximum feed rate for cutting 100-mm thick aluminum stock is around 8 mm/s. Disadvantages of PAC are: (1) the cut surface is rough, (2) metallurgical damage at the surface is the most severe among the nontraditional metalworking processes.

OXYFUEL-CUTTING PROCESSES
A widely used family of thermal cutting processes, popularly known as flame cutting, use the heat of combustion of certain fuel gases combined with the exothermic reaction of the metal with oxygen. The cutting torch used in these processes is designed to deliver a mixture of fuel gas and oxygen in the proper amounts, and to direct a stream of oxygen to the cutting region. The primary mechanism of material removal in oxyfuel cutting (OFC) is the chemical reaction of oxygen with the base metal. The purpose of the oxyfuel combustion is to raise the temperature in the region of cutting to support the reaction.

The cutting mechanism for nonferrous metals is somewhat different. These metals are generally characterized by lower melting temperatures than the ferrous metals, and they are more oxidation resistant. In these cases, the heat of combustion of the oxyfuel mixture plays a more important role in creating the kerf. Also, to promote the metal oxidation reaction, chemical fluxes or metallic powders are often added to the oxygen stream.

Acetylene burns at the highest flame temperature and is the most widely used fuel for welding and cutting. However, there are certain hazards with the storage and handling of acetylene that must be considered. OFC processes are performed either manually or by machine. Manually operated torches are used for repair work, cutting of scrap metal, trimming of risers from sand castings, and similar operations that generally require minimal accuracy. For production work, machine flame cutting allows faster speeds and greater accuracies. This equipment is often numerically controlled to allow profiled shapes to be cut.