

## Training Objectives

After watching the video and reviewing this printed material, the viewer will gain knowledge and understanding of the primary thermal cutting and waterjet cutting processes and the operational aspects of each.

- the basis for specific process selection is detailed
- the oxy-fuel gas process is presented
- plasma and laser cutting applications are explained
- abrasive waterjet cutting is detailed

## Thermal and Waterjet Cutting

The four most commonly used non-contact methods of metalcutting are oxy-fuel gas, plasma, laser, and abrasive waterjet. The first three cutting processes are thermal in nature, while the waterjet method cuts by abrasive erosion. These four processes are primarily used to make precision external and interior cuts on flat sheet and plate material. These processes are also used to trim previously formed parts.

The selection of the most efficient process for a specific application is based on several factors:

- the type of work material
- work thickness
- intricacy of the cut
- quality of cut
- the desired cutting speed
- metallurgical effects
- environmental concerns
- cost of system
- cost per foot, or meter of cut

The advantages of these four non-contact cutting processes include not having to rely on perishable cutting tools to shape parts, or elaborate workholding methods and systems to clamp parts. These processes do, however, use consumable items such as torch tips, gases, and abrasive materials.

The thermal processes and the oxy-fuel gas process in particular share two disadvantages. First, heat changes the structure of metal in a "heat-affected zones" adjacent to the cut. This may degrade some metallurgical qualities at the cut's edge, requiring pre-treatment or trimming. Secondly, tolerances may be less accurate than a machined cut, except for laser cutting. The thermal processes also present several safety and environmental concerns including:

- fuel gases
- flames
- hot slag
- electrical shock
- high noise levels
- intense arc radiation and laser light exposure

All four cutting processes typically cut material on two-axis "x"- "y" tables, but in some applications have been teamed with articulated-arm robots or five-axis gantry systems. These robots can carry a plasma torch, laser, or abrasive waterjet cutting head for a wide range of cutting applications. Typically, multiple parts are arranged or "nested" on a blank sheet of material for maximum cutting productivity.

## Oxy-Fuel Cutting

Oxy-fuel gas cutting, usually with acetylene gas, was once the only method of thermal cutting. The oxy-fuel torch has a pre-heating flame that heats either the iron or carbon steels to it's "kindling temperature" of around 900° F or 480° C. Then, a stream of pure oxygen is introduced causing the rapid combustion reaction between the steel and the oxygen. The resulting molten material, or slag, is blown through the metal by the stream of cutting oxygen, providing a relatively smooth and regular cut. The variables encountered in oxy-fuel cutting include:

- oxygen purity
- rate of oxygen supply
- torch tip size and type
- distance of torch from work
- fuel gas flow rate
- cutting speed
- the work material type
- surface condition of the material
- the angle of cut

Oxy-fuel cutting is accomplished manually with single torches. Machines for oxy-fuel cutting range from portable units to gigantic automated machines with multiple cutting heads.

## Plasma Cutting

Plasma cutting uses an extremely high temperature, high velocity stream of ionized gas to cut the metal. Plasma temperatures range from about 10,000° F, or 5500° C to 50,000° F, or 28,000° C. Depending upon the material to be plasma cut, the gases used include: standard compressed shop air, oxygen, argon and hydrogen, or nitrogen and hydrogen. Gas shielding is accomplished with air, water, or carbon dioxide.

Plasma cutting requires a torch, a power supply, and an arc-starting circuit. The plasma cutting power supply is a constant-current DC power source. A high-frequency AC starting circuit ionizes the gas to make it conductive. When gas is fed to the torch, part of the gas is ionized by the high-voltage arc starter between the electrode, or cathode, in the torch, and the torch tip. When the power supply's small "dc" current meets this high voltage gas, it creates a pilot arc. This pilot arc leaves the torch tip as a plasma jet and becomes the path for the main plasma arc. Once the pilot arc contacts the metal's surface, or anode, the main arc forms. The pilot arc then shuts off, and the cutting torch beings operation.

As a thermal process, plasma cutting generally produces a narrower kerf and smaller heat-affected zone than oxy-fuel. Plasma cutting is particularly useful on stainless, aluminum and other non-ferrous metals and on other non-oxidizing materials. Plasma cutting is often coupled with CNC, or computer numerically controlled, punching machines to enhance productivity.

## Laser Cutting

Laser cutting utilizes a beam of light as a heat source for cutting. A laser is a beam of "coherent" light as opposed to the "random" light from an ordinary bulb. Of the thermal cutting processes, laser cutting produces the narrowest kerfs and smallest heat-affected zones. Laser cutting is done on sheets or plates of almost any alloy up to one half inch (13mm) thick. Contoured shapes and holes can be cut with exceptionally high speeds. Often laser cuts require no secondary finishing.

A laser beam can be a continuous wave or a series of bursts or pulses. Cutting is enhanced by the use of gases and liquids to increase cutting speed, enhance cut quality, and to cool the work. Lasers are of two types, the CO<sub>2</sub> gas laser and the "Neodymium-doped Yttrium-Aluminum Garnet" or YAG solid-state laser.

There are a variety of laser cutting machines for flat plate and sheet stock. Some YAG lasers are used with five or six axis robot controllers for work on previously formed shapes. Like plasma cutting, lasers are often added to CNC punching machines. Additionally, lasers are particularly suited for various non-contact holemaking operations.

## Abrasive Waterjet Cutting

The abrasive waterjet erosion process uses abrasive garnet particles suspended in a high pressure stream of water to cut a wide variety of metallic and non-metallic materials. Using pressures from 30,000 to 60,000 PSI, the waterjet process can cut work several inches in thick, while producing no heat, fumes, toxic wastes, or dust.

The components of a waterjet system include:

- an intensifier pump
- a water delivery, holding and pumping system
- a gantry, robot, or other torch nozzle guiding device
- a nozzle assembly to create the jet stream

Additionally, the abrasive system requires a hopper, a metering device, and a mixing chamber to introduce the abrasive to the water stream within the cutting head. Here the water stream accelerates the abrasive particles to supersonic speeds as they exit the torch nozzle. The abrasives perform 90 percent of the cutting. The resulting kerf is about equal to the nozzle diameter and relatively smooth. Cutting speeds determine the cut quality as does the water pressure, cutting angle, and size and type of abrasive. Waterjet cutting can utilize multiple head arrangements and are very noisy in their operation.

## Review Questions

1. Of the four processes detailed, abrasive waterjet cutting:
  - a. is the most expensive per foot, or meter, of cut
  - b. is non-thermal
  - c. requires a numerical control system
  - d. the fastest cutting process
  
2. The one process that usually does not require any secondary finishing is:
  - a. abrasive waterjet cutting
  - b. oxy-fuel gas cutting
  - c. plasma cutting
  - d. laser cutting
  
3. The "kindling" temperature of steel is around:
  - a. 600° F or 320° C
  - b. 900° F or 480° C
  - c. 1900° F or 1040° C
  - d. 2200° F or 1200° C
  
4. Gases used in plasma cutting is said to be:
  - a. combustible
  - b. heated
  - c. supersonic
  - d. ionized
  
5. A laser beam of light is said to be:
  - a. coherent
  - b. energized
  - c. diffused
  - d. radioactive
  
6. Besides the YAG type laser, the second type is called a:
  - a. hydrogen laser
  - b. H<sub>2</sub>O laser
  - c. CO<sub>2</sub> laser
  - d. radium laser
  
7. Waterjet pressures can range from:
  - a. 500 to 1,000 PSI
  - b. 10,000 to 20,000 PSI
  - c. 20,000 to 40,000 PSI
  - d. 30,000 to 60,000 PSI
  
8. A significant problem in abrasive waterjet cutting is:
  - a. dust accumulation
  - b. slow speeds
  - c. rough finishes
  - d. noise levels

## Answer Key

1. b
2. d
3. b
4. d
5. a
6. c
7. d
8. d