

Training Objective

After watching the video and reviewing this printed material, the viewer will gain knowledge and understanding of the methods of machining and assembling plastics into a wide variety of manufactured products.

- Types of plastic material and their characteristics are explained
- Methods of machining plastics are shown
- Cutting tool materials and geometries are discussed
- The various assembly and joining methods are demonstrated

Plastic parts are produced by various methods with the primary types being: injection molding, thermoforming, and blow molding. After manufacturing, plastic parts may also be machined to final specifications, and assembled to other plastic components.

Plastics Machining

Machining processes are sometimes used as secondary operations on molded and formed parts, but are most commonly used in the fabrication of flat plastic sheet, or rod and bar stock into finished products.

There are several key differences between machining plastics and metals:

- Plastics exhibit greater thermal expansion, up to 10 times more than that of metals
- Plastics dissipate heat at a slower rate than metals
- Plastics have more elasticity than metals
- Plastics have lower melting temperatures than metals

These differences require changes in both cutting tool speeds and feed rates.

Cutting tool materials also affect the machining of plastics. High speed steel cutting tools can be used in short run production, but tungsten carbide or diamond tipped tooling are required for higher production rates.

The range of plastic materials respond to machining differently and are typically divided into three main categories:

- Soft plastics, such as polyethylene and polypropylene, which will produce long curly chips when machined
- Hard plastics, including Acrylonitrile Butadiene Styrene, or 'ABS' and polycarbonate, which result in short crystal like shards when machined
- Reinforced plastics, which contain abrasive fibers requiring very sharp tooling of specific geometries for machining

Because of heat buildup both in part and in the tool bit, coolants are often used to control temperatures. Coolant mediums can include:

- Clean compressed air
- Mist sprays
- Water soluble oils
- Light cutting oils

Careful selection of a coolant is needed to avoid any adverse reactions with the plastic being machined.

Machining Processes

The primary types of processes used to machine plastics include:

- Sawing
- Milling
- Routing
- Drilling
- Turning
- Waterjet Cutting
- Laser Cutting

Sawing is typically used to reduce in size plastic sheet stock, and bar and rod stock for subsequent machining. The most common saws used include table and miter saws, as well as computer numerical control, or CNC, saws.

Milling is a versatile machining process that uses the relative motion between a rotating, multi-edge cutter and the workpiece to cut flat and curved surfaces.

Routing is a type of milling operation commonly used to machine flat plastic sheet stock. Routing is typically performed using an end-mill cutter, and done manually, or automatically with CNC machine tools or routers.

Drilling is accomplished with either fixed or rotating workpieces presented to the drill bit. The drill bit may be helically fluted or straight fluted and carbide or diamond tipped. In either case it is desirable that the drill flutes be highly polished. Twist drills should be a high helix or fast spiral angle of from 35° to 40°. Once drilled, hole finishing operations such as tapping and reaming can be performed. Tapping uses a rotating tap having sharp cutting edges on its periphery. The threads are cut internally as the tap works its way into the hole. Reaming enlarges the hole to its final and most accurate size, removing only a small amount of material.

In turning, a plastic workpiece is rotated about its axis on a lathe. Single-point cutting tools are fed into the workpiece shearing off unwanted material to create the desired cylindrical, axially symmetric shape. Cutting is also performed on internal surfaces and the exposed end.

Waterjet cutting uses a high pressure stream of water, or abrasive particles in water, to cut plastics. Typical waterjet pressures range from 20,000 to 60,000 psi.

Laser cutting for plastics is used when a fine, polished cut is required. The most common types of lasers are the Carbon Dioxide, or CO₂, gas laser and the Neodymium-Doped Yttrium-Aluminum Garnet, or 'YAG', solid-state laser.

Plastics Assembly

There are many methods of assembling, or joining, plastic-to-plastic, and plastic-to-metal parts together. These assembly operations can be done manually or automatically using:

- Snap-Fits
- Hinges
- Mechanical Fasteners
- Bonding
- Welding

Snap fits are integral fasteners molded into plastic parts, which when assembled lock into place. Snap fits are quick and easy to use in permanent assembly, and for when disassembly is required.

Hinges are used in assemblies requiring repeated opening and closing. The three basic types of hinges include, one-piece integral hinges, two-piece integral hinges, and multi-part hinges. Each hinge type has a particular use with multi-part hinges being used for heavy duty applications.

Common mechanical Fasteners for plastics include screws, eyelets, and rivets. These fasteners are installed manually or automatically. For retention strength, threaded metal inserts may be added to parts to firmly hold the mating screw.

Bonding is used to effect strong and permanent joints. The two principle bonding methods are adhesive bonding using specific adhesive materials followed by a curing, and solvent bonding in which the surfaces to be joined are melted resulting in molecular cohesion.

Welding involves the fusion, or coalescence, of thermoplastic components. Several different welding methods are used, including:

- Spin Welding
- Hot-Gas Welding
- Ultrasonic Welding
- Vibration Welding
- Staking

In spin welding, one component is rapidly rotated against a stationary component at up to 5,000 RPM. The frictional heat generated effects the weld.

Hot-gas welding is performed by passing either air or inert gas over heating elements within a welding gun. As this heat exits the gun, it melts a plastic welding rod, as well as the plastic to be joined, fusing the materials.

Ultrasonic welding uses high-frequency longitudinal vibrations in the 15,000 to 40,000 cycles per second range, resulting in intermolecular and surface frictional heat that quickly melts and fuses plastic components together.

Vibration welding uses frictional heat generated by vibrating one component against a stationary component at a frequency of 120 or 240 hertz. Vibration may be in an orbital or lineal direction. Parts are then positioned and joined under pressure until solidification occurs.

Staking involves applying either heat or ultrasonic energy to a protrusion that is passed through a to-be-assembled component. The energy then softens the protrusion which is mechanically formed into a head, retaining the component.

Review Questions

1. High speed steel cutting tools can be used:
 - a. in short run production
 - b. only with reinforced plastics
 - c. in long production runs
 - d. for prototyping

2. An important consideration in selecting a machining coolant is:
 - a. ability to break chips
 - b. recoverability
 - c. viscosity
 - d. no adverse reaction with the machined plastic

3. Waterjet cutting pressure for plastics typically range from:
 - a. 20,000 to 100,000 psi
 - b. 60,000 to 100,000 psi
 - c. 5,000 to 20,000 psi
 - d. 20,000 to 60,000 psi

4. In hinged assembly the strongest type is the:
 - a. one-piece integral hinge
 - b. two-piece integral hinge
 - c. multi-part hinge
 - d. compound hinge

5. In plastic assembly, to more firmly hold a screw to a mating part:
 - a. threaded metal inserts may be used
 - b. large screws are selected
 - c. adhesives are often applied to fasteners
 - d. deep threads are cut in the parts

6. The common operational factor in spin, ultrasonic, and vibration welding is:
 - a. low-pressure
 - b. high-amperage
 - c. long cycles
 - d. friction

7. Staking involves:
 - a. joint alignment
 - b. pinning
 - c. hinging
 - d. protrusions in a mating part

Answer Key

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