Thermoplastic Fabrication

INTRODUCTION

The preparation of thermoplastics for assembly by welding or other fastening methods is similar to the procedures used in metal fabrication. The pieces are laid out, cut, machined and joined with the same tools, equipment, and skills employed in the metal working trades. There are, however, special forming requirements for thermoplastics, not encountered in metal work. The degree of skill and the quality of preparatory work in layout and in various machining operations on components for fit up are very important in assuring accurate assembly and successful fabrication.

Fabrication of thermoplastics covers a wide field of operations on sheet, rod, tube, and special shapes in making them into finished products: cutting, sawing, machining, forming and joining or fastening together for the completed object. Machining may include beveling, routing, grinding, turning, milling, drilling, tapping, and threading. Once the different parts are shaped, they then may have to be joined.

Assembly techniques include use of self-tapping screws, threaded inserts, press fitting, snap fitting, cold heating, heat joining (like hotplate welding, hot-wire welding, induction heating, thermal-impulse heating, resistance-wire welding, or hot flaring, spin welding), cementing, and hot gas welding. Each operation requires its own tools and equipment.

CUTTING

Thermoplastic rods and shapes can be readily cut with an ordinary hand hacksaw, or power saws can be used. Using a circular power saw, a cutting speed of 6,000 rpm. Using hand pressure is recommended. With bandsaws, this should be reduced to 3,600 fpm with hand pressure. Under some circumstances a lathe can be used. Best results are obtained with fine-toothed saw blades (6 to 9 teeth per in.) and little or no set (maximum 0.025 in.).

THREADING

Thermoplastic pipe, rod and shapes can easily be threaded using either standard hand pipe stocks or power operated equipment. For optimum results in threading, use of new taps and dies is recommended; but in any case they should be clean and sharp and maintained in good condition. Power threading machines should be fitted with dies having 5° negative front rake and ground especially for this application, tapered guide sleeves are not required. For hand stocks, the dies should have a negative front rake angle of 5 to 10°. Dies which have been designed for use on brass or copper pipe may be successfully used. Carboloy dies give longer service.

Taps should be ground with a 0 to 10° negative rake, depending upon the size and pitch of the thread. Die chasers should have a 33° chamfer on the lead: a 10° front or negative rake; and a 5° rake on the back of relief edge. Self-opening die heads and collapsible taps, power threading machines and a slight chamfer to lead the tap or dies will speed production, however, taps and dies should not be driven at high speeds or with heavy pressure.

A tapered plug should be inserted into tubular ends when threading to hold the pipe round and to prevent the die from distorting or digging into the pipe wall. This insures uniform circumferential depth of threads. Pipe for threading should be held in a pipe vice since sawtooth jaws will leave marks. Thermoplastic materials are readily threaded without use of external lubricants. However, ordinary lubrication or cutting oil will be beneficial to the operation. In a pipe-threading machine, water soluble oil or plain cold water is used. Clearing of cuttings from the die is strongly recommended.

HEAT WELDING

The most important and most versatile of welding methods is hot gas and air welding which, in principle, is similar to oxyacetylene welding of metals, but with a difference in the technique involved. Specialized welding equipment has been developed in which the pressure and the rate and area of heating are precisely controlled in order to provide strong, tight bonds. Welding rods are available in different sizes to suit the individual jobs.

Hot gas welding of thermoplastics is accomplished with a welding torch and tips or tools. It is divided into three basic types of welding: tack welding, hand welding and high speed welding. Each type requires different tips or high speed tools.

FUSION WELDING

Industrial thermoplastics such as PVC, PP, PE, and PVDF can be fusion welded using modern temperature and pressure controlled fusion equipment. This relatively simple equipment is available to fuse PIPE and Tube products to 24" diameter. SHEETS and Plates can also be fused using micro processor controlled fusion machines. Weld efficiency, when using modern equipment, will develop weld strength of up to 98% of the unwelded parent material.

SOLVENT CEMENT WELDING

Cementing is a convenient technique for bonding PVC and CPVC (High-Temp) stock. Surfaces to be cemented must be clean and dry. They should be cut square and smooth and wiped clean of dirt, grease, etc. with a small amount of Fabco Pipe Cleaner.

When solvent-cementing, it is important to have close clearances between the surfaces to be joined. Solvent-cement should be applied with an ordinary small paint brush to each member. (Do not use synthetic hair brushes). Then the cemented surfaces should immediately be pushed snugly together. After the cemented joint has been pressed together the initial set takes place within several minutes.

Handling strength, however, is not developed for approximately 30 minutes. Relative motion between the cemented surfaces during the initial set period is undesirable. It is good practice to apply no more than 10% of the rated stress for four hours. Full strength of the joint is developed after about 48 hours.

FLANGING

One of the earliest methods of joining thermoplastics piping, flanging continues to be used extensively for process lines. Thermoplastic flanges and flanged fittings are available in a full size range and may be attached to pipe by solvent welding, by threading, or by thermal bonding, as required by the particular thermoplastics material.

MACHINING, CUTTING AND SAWING

Thermoplastics may be turned, threaded, grooved, milled, or polished to very close tolerances, with the same tools as are used for wood or metal.

The only requirement for machining of plastic that differs from metal machining is compensation for heating up of materials due to its poor heat-conductivity. The limitation of heat build-up is accomplished by use of sharp, high-speed tools, streams of air or water/soda cooling, and proper machine feeds.

In machining plastics on a lathe, tool bits should be sharpened as for machining brass. The tool should be ground with a front clearance of 10°, a 2° negative back-rake and no side rake. The tool should have a 10° side-clearance. Chips should be blown or washed away from the work to reduce frictional heat to a minimum.

The piece is set up in the lathe for turning or thread cutting as in metal work but with special protection provided for the plastic where it is held in the chuck jaws. The plastic should be wrapped in several heavy layers of heavy cardboard, held in place by masking tape, before being inserted into chuck.

A cutting speed of 200 fpm is recommended. Lathe speed for machining different diameters of plastic can be calculated as: 4 times the cutting speed (fpm) divided by the diameter of the plastic in inches. Example: With a plastic rod 1- in. diameter, the lathe speed would be 200 times 4 divided by 1 or 800 rpm. Light cuts are recommended - 0.030 to 0.060 in. cross-feed at a time.

In sawing plastic sheet, there is likely to be concentrated heat build-up in the saw blades. To allow for this, the blade used should be selected in accordance with the gauge of the material. The saw blade for cutting thicker materials should be heavier and should be hollow ground. The saw should make a slicing cut in the material: to do this, the teeth should have negative rake, with little or no set. The rate of feed should be very slow. The blade of a circular saw should just show through the material. If it extends too far through, it will increase the heat build-up, by increasing friction.

In cutting polyethylene and polypropylene on a circular saw, the saw blade required is different from that used in cutting PVC. PE and PP do not require a hollow ground blade and are cut by a well-set saw blade. Shears can be used for cutting of light gauge thermoplastic sheets. All shearing should be accomplished at room temperature. A cold sheet will crack or shatter. A 1/8-in. sheet of Type 1 PVC can be sheared easily. Heavier-gauge Type 1 PVC will tend to cut off-square and also show stress marks. Type 2 PVC, PP, PE and modified high impact PVC shear better and to a higher gauge than Type 1 PVC. In drilling plastics, the same problems are experienced as in drilling metal. The non-conducting characteristics of the material and the heat concentration in the tool must be allowed for. This is accomplished by grinding the drill differently than for drilling metals. If the holes are to be drilled in the fabrication at hand, the drill should be reground to a negative rake and the lip angle increased for 59° to 70°. The margin on the drill should be smooth and highly polished to reduce friction. Drilling speeds should be reduced: 50 to 150 rpm is a safe range, with 120 rpm being optimum. Very slow feeds should be used.