Joining and painting polycarbonate sheet

FABRICATION AND PLASTICS MACHINING

by Elizabeth Grimes

While a one-piece thermoformed part provides the best performance, size limitations and other factors often call for fabricating a polycarbonate part from several components. Typical joining techniques include: solvent cementing, adhesive bonding and mechanical fastening. Your choice of method depends on strength requirements and whether the components must be disassembled periodically for repair or replacement. Avoid cemented joints if high impact resistance is necessary. Also included here are tips for decorating the polycarbonate sheet with paints and inks.

This article is last in a series on thermoforming and fabricating polycarbonate sheet. Previous installments to this series include "Guide to Thermoforming Polycarbonate Sheet," February/March 2002 issue and "Guidelines for Fabricating Polycarbonate Sheet," December 2002/ January 2003 issue.

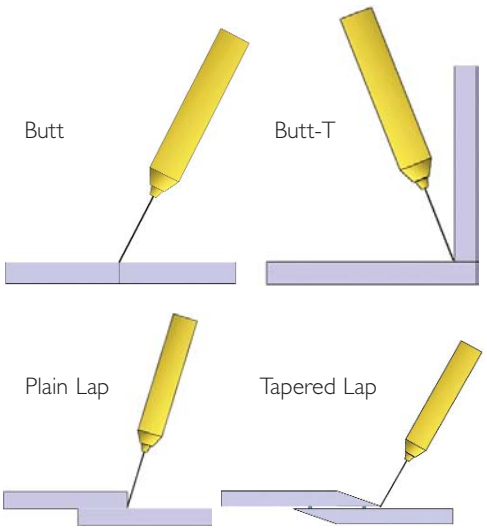


Figure 1. For strong joints, use a fine hypodermic syringe to apply solvent cements along the edge of a joint, allowing capillary attraction to penetrate the joint.

Solvent cementing

Cementing joints with a solvent represents the simplest method of joining polycarbonate sheet to itself. You can use a pure solvent, polymerizable monomer/solvent or a thickened solvent. Close fitting and mating surfaces are required for solvent joints.

A good solvent joint should have a tensile strength of 2,500 psi. For strong joints, use a fine hypodermic syringe to apply solvent cements along the edge of a joint, allowing capillary attraction to penetrate the joint (Figure 1). The alternative, soaking the mating edges in solvent and then pressing them together, creates a weaker joint. For parts requiring service at elevated temperatures, force dry them in an oven. For a clear joint, apply pressure using a press while the solvent dries.

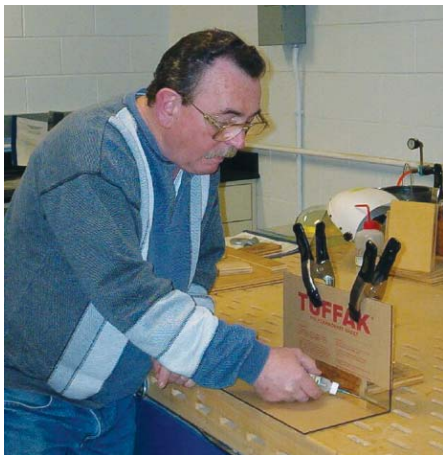
The most common pure solvent is methylene chloride (MDC). MDC quickly dries and reaches handling strength.

Polymerizable monomer cements, such as Weld-On® 55 and 58 (Industrial Polychemical Science Corporation [IPS], Compton, CA, USA) and PS-18 and PS-30 (Caseway Industrial Products, Fort Myers, FL, USA), give a better-looking joint than solvent cement since voids can be eliminated. These joints are less brittle and they blush less than a solvent cemented joint.

Thickened cements, with 10 to 15 percent of the parent material dissolved in a solvent, are helpful when two mating joint parts do not fit well together. The polymer fills some voids. The strength is not as high as a solvent joint. Thickened cements cannot enter the joint by capillary attraction like MDC; they require open access to the joint.

Adhesive bonding

Adhesive bonding creates the weakest type of joints. Resort to adhesive only when other methods are not suitable, such as when joining polycarbonate to metal. Pick an adhesive with flexibility over a wide temperature range since dissimilar materials have different coefficients of thermal expansion.



Jim Eastwood of Atoglas applies solvent cement to join two polycarbonate sheets.

Thermoplastic — Not recommended for polycarbonate sheet because these adhesives lack strength and exhibit poor heat and solvent resistance. If necessary, use only in light duty applications. Typical thermoplastic adhesives are acrylics, acrylonitrile, cellulosics, vinyls, acetates and butadiene/styrene. They can be hot melts, contact cement or pressure sensitive.

Thermoset — Compared to thermoplastics, these adhesives have superior strength, better heat and chemical resistance and no creep. Epoxies, urethanes, crosslinked acrylic and silicone rubber are all two-component systems that fit into this category and cure at or near room temperature. The flexibility of these systems allows absorption of impact and thermal movement during temperature cycling.

Since the tensile and adhesive strengths of these adhesives are low, design your joints with plenty of surface area to carry a shear load (rather than a peel or tensile load). Tongue and groove, double scarf and tapered joints, shown in Figure 2, are all satisfactory for adhesives.

Carefully prepare the mating surfaces to optimize the effectiveness of adhesive bonds. Roughen the mating surfaces and clean away all loose dust and foreign material. Use a 0.010-inch wire spacer to ensure even spacing of joined parts. High pressure is unnecessary for good penetration of the adhesive into the surfaces.

Mechanical fastening

While mechanical fastening of polycarbonate sheet represents the slowest and most costly joining method, it is also the strongest and most positive, particularly when joining to a dissimilar material — like metal. Mating surfaces require less preparation, and the polycarbonate does not suffer degradation at the joint. Use this joining method for all high impact situations and when joined parts require disassembly. Make sure all fasteners are clean of any cutting oil, which may cause crazing of the polycarbonate sheet.

For threaded fasteners, use a predrilled hole. Either cut the threads with the self-tapping fastener or use a bolt held with a nut. When pre-drilling for bolts, drill oversize to allow for ample clearance since the hole will shrink more than the fastener under thermal contraction. A tight fit might crack the hole.

The diameter of predrilled holes for self-tapping screws should be half way between the root and outside diameter of the screw. Vibrational service may rule out self-tapping screws because high stresses can lead to cracks that emanate from the hole. For machine screws, pre-thread the hole with a tapping tool. The material thickness must be great enough to allow engagement of at least four threads.

While fasteners hold well in holes pre-tapped into the polycarbonate, this kind of joint is vulnerable because plastic threads are susceptible to breaking, chipping and cross-threading. If you anticipate frequent disassembly, which risks cross threading, then press fit or weld a threaded insert into a pre-drilled hole. Use a coarse, Type 25 thread for both screws and inserts. Metal inserts give the strongest joint and the press-fit inserts hold well. Expansion-type inserts perform better than press-fit inserts.

Permanent fasteners for polycarbonate include rivets, pins, staples, clinching fasteners, stitching, grommets and eyelets. Fasteners should not have sharp edges because polycarbonate sheet is notch sensitive.

Speed rivets have two heads that fit inside each other to provide a longer lasting joint. One-sided, blind rivets must have a washer on one side to prevent digging into the polycarbonate surface. Use aluminum rivets or add a soft washer to protect the soft polycarbonate sheet surface. Spring clips and V&J fasteners, used for holding two parts lightly together, can also be used successfully.

Snap fits, if designed properly, can work well for joining polycarbonate. They have low creep characteristics compared to other plastics and maintain the required interference over a long time.

Table 1 rates several joining techniques against a scale of 1 to 10, with 10 representing the best score for various parameters.

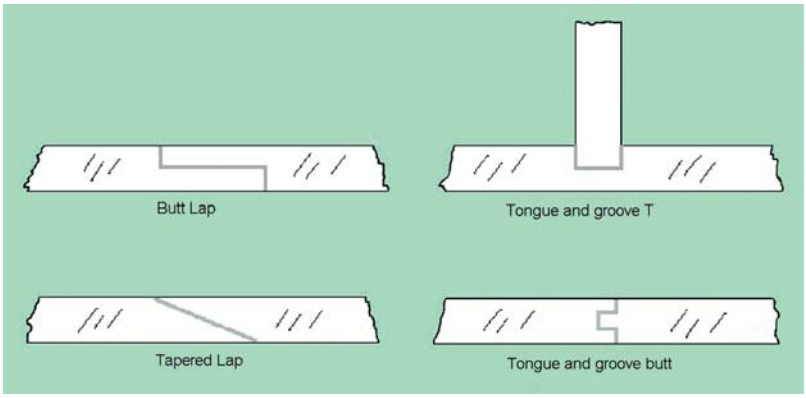


Figure 2. Satisfactory joint designs for adhesives.

TABLE 1: COMPARISON OF JOINING METHODS

Method	Solvent Cementing	Adhesive Bonding	Self-tapping Screws	Medium Screws	Rivets	Hot gas Welding	Hot blade or Plate welding	Ultrasonic Welding	Vibration Welding	Spin Welding	Ratings Legend 10 = best	Ratings Legend 1 = worst
Tensile Strength	8	4	10	10	10	10	10	10	10	10	parent material strengths	poor
Speed	3	2	2	1	3	2	7	10	6	6	fast	slow
Tooling	-	1	1	1	3	5	7	8	8	5	costly	inexpensive
Labor	1	2	2	1	3	2	9	10	9	10	high	low
Capital Investment	1	1	2	2	2	4	6	9	8	5	highest	lowest
Cosmetic Appearance	10	3	5	5	5	2	8	9	9	8	best	worst
Setup Preparation	1	2	3	3	3	6	8	8	7	5	long	short
Part Size	10	10	10	10	10	8	6	2	4	6	unlimited	small
Dissimilar Materials	yes	yes	yes	yes	yes	perhaps	no	no	OK	no		
Part Design	9	10	1	10	10	5	6	1	8	3	simple	limited, complex
Cost of Materials	9	6	4	1	3	10	10	10	10	10	most expensive	least expensive

SAFETY PRECAUTIONS: Some cements and adhesives contain volatile components that may be harmful if inhaled for extended periods of time. Individuals should be protected from direct skin or eye contact. Check with the manufacturer for appropriate protective safety equipment and Material Safety Data Sheets.

Painting polycarbonate

Spray painting and screen printing are common techniques for decorating polycarbonate. To accommodate special polycarbonate properties, you must use specific paints, solvents and procedures.

To prepare the surface, first remove static and surface contamination with a damp chamois. Then wipe the sheet with a soft cotton flannel cloth dampened with a 50 percent isopropyl alcohol solution.

Table 2 on the following page lists two sign paint systems recommended for polycarbonate sheet. *continued*

Applications of both Spraylat Corporation's Lacryl® 400 and AKZO Coatings, Inc.'s Grip-Flex® FR-2 paints are covered in detail by technical bulletins from their manufacturers. Brochures cover all aspects of spray masks, equipment and techniques for spraying each paint. Read the appropriate manual before attempting any decorating job.

Cutting sheet masks

Low-volume decorating projects such as custom signs lend themselves to cutting the desired design from the sheet masking and then spraying onto the exposed polycarbonate sheet. Grip-Flex GM2-501 and Spraylat New Blue Size Strip are good paint choices. Spray several light passes to prevent uneven color buildup and sagging, while providing fast drying.

When using a frisket tool to cut masking, take care to minimize cuts or notches in the polycarbonate sheet. Cuts or notches weaken the material. To minimize the depth of cut, round off sharp edges of the tool. Edges should not exceed 3 mils in depth.

If the polycarbonate is thermoformed, you must use proper techniques to minimize stresses so crazing will not result when paint is applied. The alternative is to paint the flat sheet in a distorted pattern before thermoforming. The distortion is such that the thermoforming process creates the desired pattern as an end result. This technique minimizes the crazing problem.

TABLE 2: PAINTS RECOMMENDED FOR POLYCARBONATE SHEET

MANUFACTURER	SPRAY	SCREEN
Spraylat Corporation Mount Vernon, NY, USA (914) 699-3030	Lacryl® 400 Series 205-T Thinner 206-T Cleaner/Remover	Lacryl® 800 Series 208-T Thinner 218-R Retarder 205-T Thinner 206-T Cleaner/Remover
AKZO Coatings Inc Norcross, GA, USA (770) 662-8464	Super Grip-Flex® FR-2 Series T-1003 Retarder T-2003 Reducer T-2004 Reducer T-4000 Remover	Super Grip-Flex® FR-1 Series Super Grip-Flex® SM-1 Series T-1003 Reducer T-1008 Retarder

Screen printing

High volume production of polycarbonate sheet lends itself to screen printing. This highly economical technique works best on flat, cut-to-size sheet. The inks chosen for screen printing must be suitable for polycarbonate. Polyester screens, with a mesh size of 8xx to 16xx, produce satisfactory results.

Distorted screens for sheet that will be later thermoformed must be designed specifically for polycarbonate sheet. In this case, screens made for acrylic sheet will not register correctly on polycarbonate sheet, because polycarbonate sags more and has less elastic memory than acrylic. Always use the sag method when thermoforming decorated sheet so the design will register with the shape of the finished part. See the section on Heating Methods in "Guide to Thermoforming Polycarbonate Sheet," *The IAPD Magazine,* February/March 2002.

Because of the directional shrinkage of polycarbonate sheet, always screen in the same direction — either the machine or the cross direction. Never mix directions. Print on the same side of the sheet (top or bottom).

Paint and ink removal

Take care when choosing a solvent for removing paint and ink from the surface of the sheet. Lacquer thinner, toluene, xylene and Solvesso™ 100 will craze polycarbonate sheet. Use Grip-Flex T-4000 or Lacryl 206-T solvents. Remove the solvent with fresh water as soon as the paint loosens.

By following the steps outlined here for joining and decorating polycarbonate sheet, you'll greatly improve your chances of producing a successful, long lasting fabrication project. ■

Grip-Flex® is a trademark of Akzo-Noble Coatings Inc.
Lacryl® is a trademark of Spraylat Corporation.
Solvesso® is a trademark of the Standard Oil Company of New Jersey.

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