Chapter 40

Liquid Crystal Polymer

Welding

Hoechst AG: Vectra

As yet, no firm experience has been obtained with hot tool, vibration, spin and electromagnetic welding methods. Suitable data are presently being prepared. Contact Hoechst for advice on technical feasibility and ways of solving problems.

Reference: *Vectra Polymer Materials*, supplier design guide (B 121 BR E 9102/014) - Hoechst AG, 1991.

Spin Welding

BASF: Ultrax 4002

Four point bending tests on samples spin welded for 3.4 seconds were performed. Data were collected for neat LCP, 10% glass filled LCP, 20% glass filled LCP, and 30% glass filled LCP. As glass fiber content is increased a significant increase in strength is observed. In nearly all cases, the results show that maximum strength occurs at an optimum pressure and rotation speed which usually occurs in the intermediate region of the range tested. It can also be seen that strength typically decreases as rotation speed exceeds 2500 RPM. This occurs as a result of increases in fiber axis orientation in the theta direction at high rotation speeds. The addition of glass fibers to liquid crystalline polymers appears to be a viable means of improving weld strength.

Reference: Festa, D., Cakmak, M., *Influence of Glass Fibers on the Spin Welding of Thermotropic Liquid Crystalline Polymer*, ANTEC 1993, conference proceedings - Society of Plastics Engineers, 1993.

LCP

Thermotropic liquid crystalline polymers (LCP) exhibit low coefficients of friction in the solid state, high melting temperatures and low melt viscosities. When the LCP chains are oriented in the flow field, the orientational relaxation times are quite long even at high temperatures. These characteristics make them a challenging class of materials to join using the spin welding process.

Reference: Festa, D., Cakmak, M., *Spin Welding Behavior and Structure Development in a Thermotropic Liquid Crystalline Polymer*, ANTEC 1992, conference proceedings - Society of Plastics Engineers, 1992.

Ultrasonic Welding

Hoechst AG: Vectra

Moldings made from Vectra can be joined by ultrasonic methods such as welding, riveting, flanging, staking and insertion. Shear joint welds are the most suitable design. Near-field placement of the weld area is an advantage. Vectra can be welded with the usual ultrasonic welding machines (20, preferably 40 kHz). Choice of welding conditions (amplitude, welding time, welding pressure, etc.) depends on the Vectra grade and joint geometry. The conditions must be optimized in each case by carrying out practical trials.

Particular attention must be devoted to the production of high-quality parts for welding and to suitable joint design. The alignment and joint contours must be exactly matched to the application. It is important for the ultrasonic horn to be positioned vertically above the joint area. If horn wear occurs or surface marks are caused on the plastic part, these problems can be remedied by carbide-tipping the horn or using PE film interlayers.

Reference: *Vectra Polymer Materials*, supplier design guide (B 121 BR E 9102/014) - Hoechst AG, 1991.

Snap Fit Assemblies

Hoechst AG: Vectra

If snap fit joints are to be used in Vectra moldings, then consideration must be given to the product's relatively low extensiblility. Maximum strain during assembly should be restricted to about half the elongation at break. For this reason, barbed-leg snapfits (for example) designed as flexible springs are an advantage because they can readily accommodate strain through variation in length and thickness. Weld lines in the strained zone are inadvisable because they can break during assembly.

Reference: *Vectra Polymer Materials*, supplier design guide (B 121 BR E 9102/014) - Hoechst AG, 1991.

Adhesive and Solvent Bonding

Hoechst AG: Vectra

Vectra has a high resistance to solvents so solvent bonding is not possible. Bonding with adhesives can be successful, especially if suitable pretreatment operations such as mechanical surface roughening, etching with chromosulphuric acid or low pressure plasma treatment are carried out.

Table 40.1: Adhesive systems which can be used to bond Vectra liquid crystal.

Adhesive system	Basis
Two-pack adhesives	epoxy resin methacrylate polyurethane
Single-pack adhesive	cyanoacrylate hot-melt adhesives

Selection of the correct adhesive depends on the service conditions which the bonded molding will encounter and on a variety of other factors. Preliminary trials and close contact with the adhesives industry are recommended in each case.

Reference: *Vectra Polymer Materials*, supplier design guide (B 121 BR E 9102/014) - Hoechst AG, 1991.

Adhesive Bonding

Amoco Performance Products: Xydar

A study was conducted to test for bond strength on a representative matrix of commonly used plastics and the adhesives best suited to them. For many of the plastics evaluated, the effect of polymer composition on bond strength was evaluated by compounding plastic formulations with each of the most commonly used additives and fillers for that plastic; common grades were used for the remaining resins. The effect of each additive and filler was determined by comparing the bond strength achieved with the specially compounded formulations to that of the neat plastic. In addition, the effect of surface roughening and chemical treatment of the plastic surface on bond strength was examined.

The block-shear (ASTM D 4501) test was chosen as the test method because it places the load on a thicker section of the test specimen that can withstand higher loads before experiencing substrate failure. In addition, the geometry of the test specimens and the block-shear fixture helps minimize peel and cleavage forces in the joint. How well the block-shear test method reflects the stresses that an adhesively bonded joint will experience in real world applications should be considered. Also, limitations on the data due to the variety of additives and fillers used by different companies should not be ignored.

Black Max 380, a rubber toughened cyanoacrylate adhesive, Prism 401 and Super Bonder 414, both cyanocrylate adhesives, Depend 330, a two-part no-mix acrylic adhesive, and Loctite 3105, a light curing acrylic adhesive, all achieved moderate bond strengths on LCP.

Surface Treatments
Surface roughening caused a large, statistically significant increase in the bond strengths achieved on LCP for all the adhesives evaluated except Loctite 3105, for which surface roughening had no statistically significant effect. Although the process of surface roughening did not result in a significant increase in the surface roughness of the LCP, it removed a surface layer, which resulted in higher bond strengths. The use of Prism Primer 770, in conjunction with Prism 401, resulted in no statistically significant change in the bondability of LCP.

Other Information
LCP is compatible with all Loctite adhesives, sealants, primers, and activators. Recommended surface cleaners are isopropyl alcohol and Loctite ODC Free Cleaner 7070.

Table 40.2: Shear strengths of LCP to LCP adhesive bonds made using adhesives available from Loctite Corporation. Values are given in psi and (MPa).[a,b]

Plastic Material Composition (Amoco Performance Products Xydar)		Loctite Adhesive					
		Black Max 380 rubber toughened cyanoacrylate (200 cP)	**Prism 401** surface insensitive ethyl cyanoacrylate (100 cP)	**Prism 401/ Prism Primer 770** polyolefin primer for cyanoacrylate	**Super Bonder 414** general purpose cyanoacrylate (110 cP)	**Depend 330** two-part no-mix acrylic	**Loctite 3105** light cure acrylic (300 cP)
G-540	40% glass reinforced 63 rms	500 (3.5)	300 (2.1)	400 (2.8)	350 (2.4)	450 (3.1)	650 (4.5)
G-540 roughened	58 rms G-930	1050 (7.2)	1100 (7.6)	1050 (7.2)	1100 (7.6)	1150 (7.9)	650 (4.5)
G-930	30% glass reinforced 106 rms	350 (2.4)	300 (2.1)	500 (3.5)	350 (2.4)	500 (3.5)	500 (3.5)
G-930 roughened	G-930 roughened 113 rms	1200 (8.3)	1450 (10.0)	1550 (10.7)	1250 (8.6)	900 (6.2)	500 (3.5)

[a] All testing was done according to the block shear method (ASTM D4501).
[b] For more information on data presented in this table, contact Loctite Corporation at 800-562-8483 (1-800-LOCTITE). Request the "Design Guide for Bonding Plastics."

Reference: *The Loctite Design Guide for Bonding Plastics,* supplier design guide (LT-2197) - Loctite Corporation.