Chapter 45

Polyetheretherketone

Welding

Victrex plc: Victrex PEEK

Victrex PEEK can be welded using ultrasonic, friction and hot plate welding techniques. When welding Victrex PEEK it must be remembered that the melting point is very high and therefore considerable amounts of energy must be put into the polymer during welding to achieve a good bond.

Reference: *Victrex Polymers For Medical Applications,* supplier technical report - ICI Advanced Materials.

Ultrasonic Welding

Victrex plc: Victrex PEEK

Tests carried out on the near field ultrasonic welding of Victrex PEEK 450G to itself have shown that optimum results are obtained using a projection joint rather than a shear joint. With a high vibration amplitude (70 mm) a good weld strength can be obtained using 5 MPa weld pressure and a weld time of 1.0 second. Increasing the weld pressure above this level leads to an unacceptable amount of flash at the joint line. Far field ultrasonic welding is not suitable for Victrex PEEK.

Reference: *Victrex Polymers For Medical Applications,* supplier technical report - ICI Advanced Materials.

PEEK (note: unidirectional; reinforcement: APC-2)

Ultrasonic welding of composites with thermoplastic-only energy directors produced excellent bonds. The short beam shear strength of the welded composites was equal to the short beam shear strength of compression molded parts. For PEEK composites (PEEK APC-2) as with other semicrystalline polymers, high power inputs are necessary in order to heat the material to a temperature above the melting temperature. Therefore, attempts to weld the parts using 1:1, 1:1.5, and 1:2 boosters were generally not successful. However, using a 1:2.5 booster (amplitude 0.028 mm), pressures over 414 kPa and weld times greater than 4 seconds resulted in good welds. Control of the weld time is critical to the formation of strong bonds without distorting the parts.

Reference: Benatar, A., Gutowski, T.G., *Ultrasonic Welding of Thermoplastic Components,* ANTEC 1989, conference proceedings - Society of Plastics Engineers, 1989.

Adhesive and Solvent Bonding

Victrex plc: Victrex PEEK

Many adhesive types can be used for bonding Victrex PEEK either to itself or to other materials. The bond strength will be very dependent on the surface preparation prior to bonding.

Adhesive Types
Epoxy, cyanoacrylate, anaerobic and silicone adhesives will all bond Victrex PEEK. The epoxy adhesives, however, give by far the strongest bond. No stress cracking problems have been encountered.

Surface Preparation
Surfaces to be bonded must be clean, dry and free from grease. Genklene solvent may be used to degrease the surface. More aggressive surface activation procedures such as surface roughening, flame treatment, or etching with chromic acid may help to increase bond strengths. Using a general purpose Araldite 100 epoxy adhesive, flame oxidation improves bond strength by 20% over degreased surfaces and chromic acid etching improves bond strength by about 30% over degreased surface bond strengths.

Reference: *Victrex Polymers For Medical Applications,* supplier technical report - ICI Advanced Materials.

Adhesive Bonding

PEEK

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.

Loctite 3105, a light curing acrylic adhesive, consistently achieved the highest bond strengths on PEEK. Depend 330, a two-part no-mix acrylic adhesive, achieved the second highest bond strengths followed by Prism 401 and Super Bonder 414, both cyanoacrylate adhesives. Black Max 380, a rubber toughened cyanoacrylate adhesive, achieved the lowest bond strengths on PEEK.

Surface Treatments
Surface roughening caused either no effect or a statistically significant increase in the bond strengths achieved on PEEK. Prism Primer 770, used in conjunction with Prism 401, had no overall statistically significant effect on the bondability of PEEK. However, Prism Primer 770 did result in a statistically significant increase in the bond strengths achieved on the PEEK 450 CA 30 and Thermocomp LF-1006 grades.

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

Table 45.1: Shear strengths of PEEK to PEEK adhesive bonds made using adhesives available from Loctite Corporation. Values are given in psi and (MPa).[a,b]

Plastic Material Composition		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)
Victrex 450G control	unfilled resin courtesy of Victrex, USA 4 rms	150 (1.0)	250 (1.7)	250 (1.7)	200 (1.4)	350 (2.4)	1100 (7.6)
450G roughened	22 rms	700 (4.8)	350 (2.4)	350 (2.4)	300 (2.1)	350 (2.4)	1100 (7.6)
PEEK 450 CA30	30% carbon fiber courtesy of Victrex, USA	150 (1.0)	200 (1.4)	450 (3.1)	250 (1.7)	450 (3.1)	950 (6.6)
Thermocomp LF-1006	30% glass fiber courtesy of LNP Engineering Plastics	100 (0.7)	250 (1.7)	550 (3.8)	400 (2.8)	500 (3.5)	1200 (8.3)
Lubricomp LCL-4033 EM	15% carbon fiber, 15% PTFE courtesy of LNP Engineering Plastics	100 (0.7)	400 (2.8)	300 (2.1)	250 (1.7)	500 (3.5)	900 (6.2)

[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.

Bonding to Metals and Substrates

PEEK (product form: lamination; reinforcement: carbon fiber)

The resistance heated fusion bonding of 7075-T6 aluminum alloy to carbon fiber (IM-7)/Polyetheretherketone (PEEK) laminates with a glass (S-2)/PEEK coated heating element was investigated.

The feasibility of using the resistance heated fusion bonding process to produce high quality joints between 7075-T6 aluminum and CF/PEEK composites was demonstrated. The C-scans and optical micrographs of the joint appeared uniform throughout the majority of the bond regions, which indicated that high quality fusion bonds are achievable. Lap shear strengths approaching 20 MPa were obtained, with process times from start to completion of several minutes. The fundamental process-performance relationships were established for the resistance heated fusion bonded aluminum/thermoplastic composite joints. This preliminary study also provided direction for new efforts into the joining of metals to thermoplastics through resistance heated fusion bonding.

Definite trends between processing parameters, such as dwell time and applied pressure, and joint quality and performance were observed. However, additional experiments were deemed necessary to establish the optimum process parameters for maximum joint quality and strength.

The high thermal conductivity of the aluminum creates large temperature gradients along the bond area which may be detrimental to the final joint quality and performance. Modifications to the process may be needed to ensure reproducible bond uniformity.

Clearly, the development of quality heating elements must be an area of primary focus. The failure of the joints often occurred at the metal foil glass/PEEK interface. Thus, techniques must be developed to improve upon the adhesion of the foil to the thermoplastic polymer. Furthermore, overheating at the exposed portions of the heating element must be controlled. This can be accomplished with active cooling, or through the use of an embedded heating element connection.

Reference: McKnight, S.H., Holmes, S.T., Gillespie, J.W., Lambing, C.L.T., Marinelli, J.M., *Resistance Heated Fusion Bonding of Carbon Fiber/PEEK Composites and 7075-T6 Aluminum,* ANTEC 1993, conference proceedings - Society of Plastics Engineers, 1993.