The Product Enabler

Polyurethane resins increase the possibilities for FRP composites

SuperLoc™ Sheet Pile System with polyurethane cap

By Dustin L. Troutman

Almost. It's a little word that carries a lot of weight. No manufacturing company wants to hear that its innovative new product *almost* meets a customer's requirements.

Like all cutting-edge products, there's a long list of pultruded composites that *almost* made the cut. For example, many years ago a project required a round tube for a simple application. The tube was pultruded and met all of the mechanical requirements, tight wall tolerances and the brilliant blue color match. However, the project failed to meet impact requirements associated with an employee dropping the tube on its edge during normal use. The resin was not tough enough to resist the interlaminar delamination caused by the impact force.

During the last several decades, pultruded profiles manufactured with traditional resins, such as polyester and vinyl esters, have made great inroads in the construction market. Applications include FRP bridge decks, field erected cooling towers and FRP transmission poles for electrical utilities. The degree of success and speed of acceptance in the marketplace is directly related to performance. Often, even a slight edge in material performance can impact the success of pultruded FRP composites.

These composites are praised for their inherent strength, stiffness and corrosion resistance. However, every material has an Achilles' heel. Vulnerabilities of

Full section bend test of polyurethane dead end cross arm.

pultruded FRP composites include the in-plane and interlaminar shear strength and low impact and abrasion performance. Add to that issues with connections, and you realize that for many applications, traditional composites manufactured with polyester and vinyl ester based resins have some limitations.

There is a solution—polyurethane resin pultrusions. Used in pultruded FRP composites, polyurethane resins demonstrate interlaminar shear strength, impact strength and material toughness. During the past five years, Creative Pultrusions, Inc. in Alum Bank, Pa., has conducted numerous studies and developed technology to successfully pultrude a two-component polyurethane resin in a pultrusion production environment. This article discusses some of the technology's ideal markets.

Electrical Utility Applications

Electrical utility cross arms are a prime example of product optimization made possible with a polyurethane resin matrix system. Utility cross arms, which have been pultruded for more than 10 years, are beginning to make a mark in the electrical utility business. Cross arms are primarily used for tangent and dead end wire support configurations. Tangent arms typically require an ultimate load of 5,000 pounds per phase, while a dead end arm requires an ultimate load of 10,000 pounds per phase. Two distinct load scenarios with such a delta would normally require two different pultrusion dies.

Creative Pultrusions developed one pultrusion profile that satisfies both requirements, thus eliminating a second pultrusion die. When manufactured with an iso-polyester resin, a thin wall rectangular tube satisfied only the tangent requirement. By using a two-component polyurethane resin, however, the same tube met both the tangent and the heavy dead end load requirements.

The two-component polyurethane resin matrix increased the strength by more than double and allowed for a very efficient design. In fact, the polyurethane heavy dead end arm is approximately 20 percent lighter than a traditional polyester resin matrix pultruded dead end arm. The production of one structural profile simplified the manufacturing process and reduced production costs because it only required one pultrusion die and product set-up.

Another important application in the electrical utility market is pultruded FRP composite utility poles, which have been adopted as part of the National Electrical Safety Committee (NESC) 2007 code. The *American Society of Civil Engineers (ASCE) 111 Reliability Based Design of Utility Pole Structures* publication permits composite poles to be treated like steel poles as a result of the low coefficient of variation between pole breaks. The FRP composite poles and arms continue to erode the wood, steel and concrete pole market. The niche will continue to grow until composite poles and arms are commonplace.

The enabler pushing the growth of this market is the robust polyurethane resin matrix, which allows for refined, streamlined designs and decreases material weight. FRP poles are typically a third of the weight of wood poles and are procured for their lightweight attributes. In many cases involving difficult terrain access or swamps, the poles can be hand ➤

Powertrusion Distribution Pole

set in the ground, whereas wood poles require a helicopter set. The savings in labor offset the initial price difference between wood and FRP.

The real test, though, is in the field. When you introduce a new material into an old marketplace, such as electrical utilities, unfortunately some people mistrust the "new-fangled" material. The polyurethane resin matrix poles and cross arms are robust and tough enough to take the abuse and are winning the support of engineers, lineman and utility owners.

Highway Guard Rails

When a car veers off the road and into the guard rail, traditional steel rail systems tend to redirect the car into traffic. Conversely, polyurethane composite guard rails direct the car parallel to the rail and help stop it along the highway shoulder. This is just one benefit of using polyurethane resin pultrusions for guard rails.

Highway guard rails require the combination of process technology, material characterization, impact engineering and above all, toughness. Creative Pultrusions created a two-component polyurethane resin pultrusion for composite guard rails for the highway transportation market. The SuperRail™ composite guard rail system was developed through a Small Business Innovative Research (SBIR) program sponsored by the Federal Highway Administration (FHWA).

The project began with extensive engineering and computer simulation on a polyester resin/E-glass reinforced multicellular profile design. Several full section crash tests revealed that an extremely tough resin was required to make the all-composite rail. Creative Pultrusions developed a new direct inject technology to manufacture products using a two-component polyurethane system for this product line. The technology allowed process engineers to redesign the guard rail around the polyurethane material properties. The result was a National Cooperative Highway Research Program (NCHRP) 350 compliant guard rail that is now approved for use by the FHWA.

The SuperRail™ composite guard rail reduces the occupancy hazard by decreasing the deceleration rate during impact. As mentioned earlier, another major performance criterion is the ability to redirect the vehicle at a trajectory parallel to the rail.

Polyurethane composite guardrail test - ¾ ton pickup truck traveling at 62 Mph: Impact angle 25°

Field Erected Cooling Towers

Until the last decade, the cooling tower market was dominated by redwood timber and concrete. But now, 70 percent of all new cooling tower structures are manufactured with pultruded fiberglass profiles.

The transition to FRP composites is aided by the introduction of polyurethane FRP beams into the cooling tower market. Specifically, pultruded polyurethane double web I-sections are being utilized as fill support beams in tower structures. Creative Pultrusions designed an ultra thin, lightweight, high modulus, extremely tough profile. The robust lightweight beam exhibits a flexural capacity of 60,000 psi and a Modulus of Elasticity of 5.5E6

Photo courtesy of Composite Cooling Solutions LLC

Composite cooling tower fill support beam

psi. Polyurethane resin is the enabler that allows for an extremely lightweight thin wall pultrusion to satisfy construction site demands for impact strength and installation speed.

FRP Composite Sheet Piling

In the mid 1990s, an FRP composite sheet piling was introduced into the marine waterfront infrastructure market. After initial feedback, the FRP composite sheet pile section was further developed, resulting in a full-blown system of sheet piling and cap profiles. The composite sheet pile system was enhanced using the two-component polyurethane resin system.

Creative Pultrusions manufactured two cosmetic caps with the polyurethane resin matrix. The application required an extremely robust profile that would be impervious to the wear and tear associated with weed eaters, lawn mowers, ice impact and waves. The utilization of polyurethane resin resulted in a thin wall channel section that caps the sheet piles, forming a robust, aesthetically-pleasing closeout.

No matter what the market, the future is bright for polyurethane resins, which act as an enabler and drive pultruded FRP composites into new areas. Demand for polyurethane resins in electrical utility, highway safety, cooling towers and other applications ensure that *almost* is a word of the past. CM

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