


▼ Adhesives distribute stress evenly along the bond line.
Photo courtesy of Henkel Technologies.



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The foremost authority on metal fabricating technology

www.thefabricator.com

 The official publication of the Fabricators & Manufacturers Association, Intl.

Technology Overview

DON'T GET STUCK WONDERING ABOUT COMPOSITES

If you have questions about joining composites and their relationship with metal, we have answers

By Michael Bishop,
Assistant Editor

With the price of metals increasing, manufacturers are modifying their designs to offset their rising costs. At the same time, more consumers want to purchase vehicles based on gas mileage ratings. As a result, automakers are interested in utilizing composites more in their manufacturing operations, according to Brian Noonan, market development manager for Henkel Technologies Industrial Group, Rocky Hill, Conn. Composites achieve a double benefit: They reduce the amount of metal in the vehicle, which reduces manufacturing costs, and they weigh less, which increases fuel economy.

Other industries—including aerospace and agriculture—are using composites wherever possible too, Noonan said.

For example, the wings and fuselage on the Boeing 787 Dreamliner are composed of more than 50 percent composites.

Despite these advantages, composites also come with their own set of challenges, and one of the most important challenges is how to join the engineered material to a metal correctly using an adhesive. *The FABRICATOR* presents the following questions and answers as a resource for those metal fabricators that might one day find themselves working with composites.

What Characteristics of a Composite Affect the Choice of Adhesive?

One of the most important characteristics is the types of materials that are blended into the composite, according to Noonan. He said adhesive choices are limited for polyolefins and similar materials that are difficult to bond because

they have low surface energy. Alternatively, a fiberglass-reinforced plastic—commonly used in boat manufacturing—gives manufacturers a wider choice of adhesives, allowing them to choose the one that has the best characteristics for their specific applications; for example, choosing an adhesive with a long open time to bond large parts or selecting one with additives like Kevlar® to increase the impact and peel resistance for increased toughness.

Mold releases are another important consideration.

“Typically when composites are molded and then pulled out of that mold, there’s some type of mold release used,” Noonan said. “That characteristic could impact your bond strength, depending on what was used for that mold release. There are different options that would have no effect on the adhesive bond, and others that might have a large effect.”

Current Uses of Adhesives in the World of Metal

Manufacturers currently use adhesives to join materials in applications such as agriculture; construction vehicles; work trucks; recreational vehicles; trailers, from 50-foot box models to small ATV versions; appliance; and automotive. They also have been used in the marine industry for several years for bonding boat hulls, as well as joining decks to hull bodies. In the aerospace industry, Boeing has been working on designing its aircraft to use composites wherever possible to reduce weight, said Brian Noonan, market development manager for Henkel Technologies Industrial Group, Rocky Hill, Conn.

"We're seeing a change in how [adhesives] are viewed," said Steve Webb, global product integrator for LORD Corp., Cary, N.C. "There's growing global acceptance. Traditionally, the aerospace and automotive industries have a lot of experience in that and that, growing acceptance and growing expertise are moving outward from those industries."

A truck body producing application illustrates how adhesives optimized a manufacturing process. Work trucks have rails on the sides where drivers can attach cables or bungee cords to hold down the material inside. Truck manufacturers can use through-bolts that extend down the sides of the truck to bolt the bracket to the wall. Over time, however, the truck might corrode where the bolts come through the body, with the corrosion visible and dripping down the sides of the truck.

Some manufacturers have eliminated the bolts and switched to adhesives to attach the bracket to the wall. The adhesive bond makes the bracket stronger than the bolts do because forces are distributed along the length of the bracket. The adhesive also looks better.

"It made a clean finish on the outside of the trailer," Noonan said. "You have a flat composite wall on the outside instead of these through-bolts, which is great for putting on graphics and reducing the corrosion you'd see over time with the bolts."

According to Noonan, eliminating the bolts reduced installation time by 20 percent.



▲ Used in place of through-bolts on truck bodies, adhesives help reduce corrosion and installation time. Photo courtesy of Henkel Technologies.

Steve Webb, global product integrator for LORD Corp., Cary, N.C., said the end use of the application affects the choice of adhesive the most. Choices include epoxies, urethanes, acrylics, and polysulfides.

"A good example would be selecting an epoxy-sized resin matrix in a carbon fiber where you're trying to get an extremely high-modulus composite, as well as a high heat resistance, and then that's going to lead you toward an adhesive that is better-suited for high heat resistance and providing that high-modulus application," Webb said.

How Does the Metal Substrate Affect the Choice of Adhesive?

Each metal has unique characteristics, and thus bonds better with some adhesives than with others. Galvanized steel, aluminum, copper, and easy-to-bend metals with low tensile strengths, for example, require close attention to the adhesive used with them, especially for outdoor applications. An adhesive with an acrylic base, such as a methyl methacrylate, works well on those types of metals.

Epoxies can join composites with many types of metals, Noonan added. However, they have challenges of their own that make them difficult to use in some applications.

"They tend to be very stiff once they're cured, so if you have a joint that's going to see lots of flexing or impact, epoxies might not be a great solution," Noonan said. "[However], heat-cure epoxies are used a lot in the automotive industry. Some technologies allow high toughness of those epoxies with additives like Kevlar and different things, which allow them to withstand [high] impacts."

Webb said most adhesive manufacturers are working to produce adhesives that can join most metals. The goal is to engineer adhesives that can join any metal regardless of the alloy.

“Where you get into differences on the metals themselves are particular metal treatments,” Webb said. “There are surface treatments that have been done to the metal, anodizing, chroming treatments on various zinc-coated steels, and so forth. Those are the surface treatments that affect adhesion far more frequently than the alloy or the choice of metal.”

Do the Benefits of Adhesives Outweigh the Shortcomings?

According to Webb, the main disadvantages of adhesives are a lack of understanding about how to efficiently join and fixture assemblies and move everything together in the manufacturing process so that fasteners such as screws and rivets can be replaced. The entire application process needs to be automated. Noonan said a benefit of adhesives is the even distribution of stress across the bond line. With rivets or screws, the substrate sometimes fails right around the area of the rivet.

Adhesives also eliminate the need for drilling; can join complex forms; evenly distribute stress across the entire bond line; and bond and seal in one step.

“A key reason people move to adhesives is the labor savings,” Noonan

said. “To apply 1,000 or 2,000 rivets over the roof of a trailer takes a significant amount of time versus drawing a single bead of adhesive around there. A thousand rivets might be cheaper than the amount of adhesive you put down on the roof, but when you factor in the time and labor savings and the increase in throughput you can achieve, it’s definitely a benefit.”

When Does It Make More Sense to Join Metals and Composites With Mechanical Fasteners Such as Screws and Rivets Instead of With Adhesives?

Not surprisingly, Noonan said adhesives almost always make more sense because they evenly distribute the load and reduce labor time. However, he added, the industry isn’t working to eliminate fasteners, just to change the way they are used. Potential uses include small, nonstructural applications.

“When you use an adhesive, there has to be some inherent time that the adhesive needs to cure,” Noonan said. “A lot of what we see today is not fastener elimination, but fastener reduction. People are going from thousands of rivets to maybe 10 rivets that just hold the pieces in place while the adhesive cures. For that reason, I think you might see a few of these pieces where fasteners are made as the fixturing method but not as the ultimate strength of the assembly.”

“[In some situations], it requires two people to put a fastener in, and so those labor costs are being looked at,” Webb said. “But you’ll never get away from mechanical fasteners in some applications. There are always applications in designs of joints where a mechanical fastener will make more sense than an adhesive, but increasingly, I think you’re seeing the cost savings afforded by adhesives being looked at and then re-engineering the process and/or the design of an assembly.”

What Does the Future Hold for Composite Materials in Product Design?

Many industries use composites extensively, and others that don’t use them yet are considering them for their future designs, according to Noonan. In the future, engineers might try to replace steel frames, brackets, or skins with reinforced composites, he said. Trailer manufacturers are working composites into more of their designs to reduce weight and increase payload capacity. RVs also offer an area of future growth.

“There are so many things you can do with an adhesive to make it work with a substrate and with the manufacturing process,” he said. “It’s a nice fit.” ■

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