Application Note #16

Through Transmission Laser Welding (TTLW) of Polymer Composites with Fiber Lasers

Introduction

The use of lasers for welding polymers has become an established industrial technique but recent customer feedback shows there is significant commercial interest in laser welding of reinforced polymers. Industrial polymers are generally classified into two major types: thermoplastics and thermosets. Thermoplastics are more widely used and their ability to be heated and cooled without undergoing significant permanent chemical changes means they can be injection molded and also joined by straightforward thermal techniques. Many molded components used in under-the-hood automotive applications employ fillers or short 'chopped' glass reinforcing fibers but injection molding limits the amount of reinforcement and hence their maximum strength capabilities. Conventional laser transmission welding of these short fiber reinforced materials has some advantages over techniques such as ultrasonic welding where the reinforcing fibers may be damaged by the high frequency ultrasonic vibration, see Application Note 13.

Long Fiber Reinforced Composites

The well known thermoset composite materials have been available for many years reinforced with long fibers but as polymer chemistry has improved, long fiber reinforced thermoplastic polymer composites are also now accepted by the aerospace industry and others for semi-structural applications. The most popular matrix materials are PolyEtherEtherKetone (PEEK), PolyPhenyleneSulphide (PPS) and PolyEtherImide (PEI). These advanced engineering polymers are all difficult to process and join.

WELDING APPLICATION

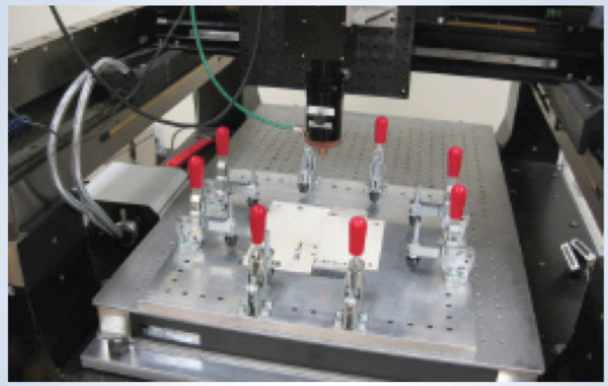

Figure 1: Tooling for Bonding Trials

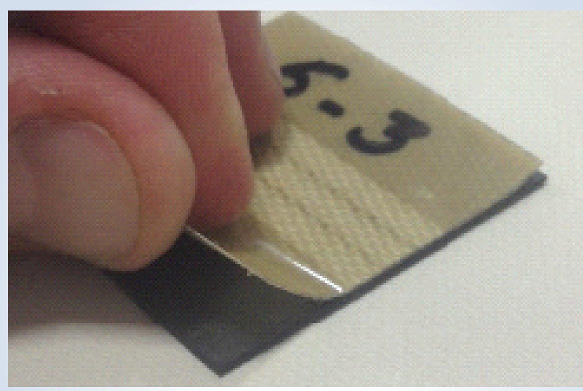

Figure 2: Bonded Facesheet to Stiffener, 3 Pass Joint

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TTLW for Continuous Fiber Composites

Glass and carbon fibers are the two major types of continuous fibers used for reinforcing polymer composites. As the TTLW technique relies on transmission of thermal energy through the upper layer to the interface to produce melting, wetting and bonding, glass reinforcement for the upper layer and carbon fiber for the lower absorbing layer are the best choices. The TTLW process uses a standard near- infrared fiber laser emitting at 1070 nm.

Proof of Principle welding trials were performed to demonstrate the possibilities of this technique; Figure 1 (Page 1) shows the tooling and beam delivery used for these trials, figure 2 (Page 1) shows a typical 3 pass joint produced with a 5 mm diameter collimated fiber laser beam, figure 3 (below) shows a cross-section of a porosity free joint and figure 4 (opposite) shows a series of mechanical strength results on different composite material combinations where different glass reinforced materials were welded successfully to AS4 CF reinforced substrates.

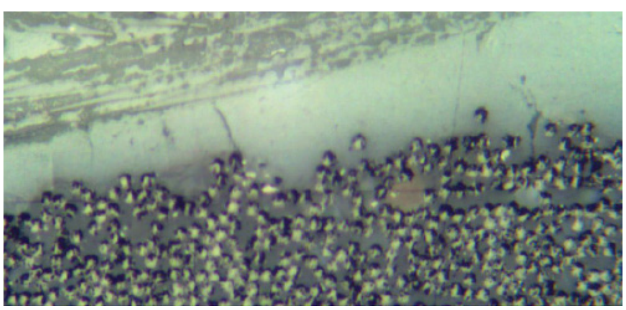

Figure 3: Porosity Free Joint Area for Glass Fiber to Glass Fiber Composite Joint

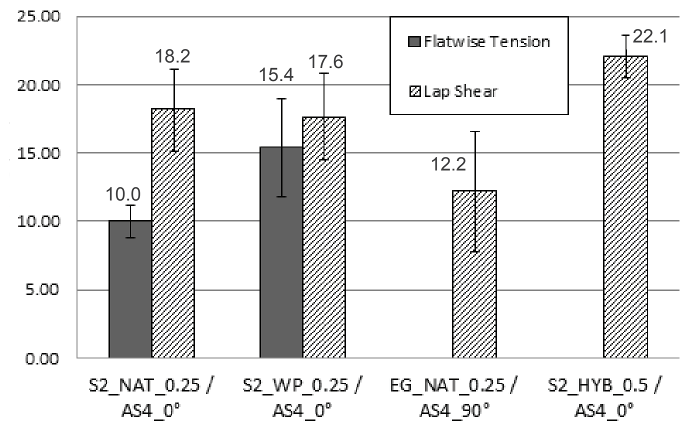

Figure 4: Flatwise Tension and Lap Shear Weld Strength

Summary

We have shown that high quality, high strength laser welded joints are possible in a wide range of thermoplastic composite materials that incorporate both glass and carbon fiber reinforcement.

IPG looks forward to helping our customers with their laser applications and future plans.
A laser solution should evaluate all project aspects including feasibility, productivity, metallurgy and part fixturing before a laser type and optical configuration is selected. Contact IPG's applications facilities for expert sample evaluation or process development.

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