Application Note #13

Through Transmission Laser Welding (TTLW) of Polymers with Fiber Lasers

Introduction

Industrial polymers can be broadly classified into two generic material types: thermoplastics and thermosets although some new polymers are blurring the distinction. Thermosets are not considered weldable but thermoplastics can be easily softened and melted by applying heat. Examples of thermally weldable thermoplastics are Polypropylene, ABS, Acrylic, Polycarbonate, Nylon and many others. The key factors for a successful plastic welding application are material compatibility, joint design and fixturing. Laser welding often has advantages over other processes such as vibration and ultrasonic welding as it yields cleaner hermetic welds with less residual weld stresses. Laser welding also produces less melt flash, has a higher process yield and better process control compared to the other welding techniques. The automotive industry has exploited this laser technology to weld sensor housings, tire pressure monitor sensors and electronic enclosures. Other notable fields using this technology are micro fluidics, medical and agricultural products.

The use of lasers to weld polymers is increasing in certain specialized areas of manufacturing. The technique covered in this note is through transmission welding, another technique using longer wavelength lasers is covered in Application Note #14. In this transmission welding technique, a transmissive and an absorptive material are held in intimate contact under a compressive force in a lap weld configuration. When a laser is passed through the transmissive layer, the absorptive layer underneath melts and fuses to the upper layer and a weld joint is formed at the interface.

WELDING APPLICATION

Figure 1: Examples of Plastics Components Welded with IPG Lasers

Checklist for Suitability of Plastic Welding

- Adequate Transmission through Top Part
- Absorption by Bottom Part
- Material Compatibility
- Good Joint Design
- Part Fixturing

Since the melt zone is confined to the interface region there is no surface modification and welds may be partially visible or aesthetic. The same process may also be used to join two transmissive plastics by applying an absorptive coating at the joint despite the additional cost and complexity involved. Transmission welding may be used for joining a wide range of material thicknesses – from thin films to thicker sheet and molded components with flanges of an appropriate width.

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Direct Diode and Ytterbium Fiber Lasers

Direct diode lasers and fiber delivered direct diode lasers have been used for welding polymers but the many advantages of fiber lasers are now recognized for polymer welding. IPG's YLR Series represents a new generation of diode-pumped CW Ytterbium fiber laser systems of near infrared spectral range (1060-1080 nm) with a unique combination of high power, ideal beam quality, fiber delivery and high wall-plug efficiency. The YLR Series features ultra-low amplitude noise, high stability and ultra-long pump diode lifetime. IPG's DLR Series direct diode systems are fiber delivered and are available from 5 W to multiple kw of power with wall-plug efficiencies approaching 50%. These systems are ideally suited for applications not requiring the smaller spot size capabilities of fiber lasers. Both these laser product lines are designed to be easily integrated into OEM manufacturing systems.

IPG's fiber lasers are currently used in production for joining thermoplastics on a wide range of materials and components. Compact direct diode lasers operating at 975 nm and fiber lasers at 1070 nm offer flexibility in choosing an appropriate laser source for the application. Both of these lasers can be focused down to a small spot or can be collimated to a large beam to accommodate welding a variety of parts. For instance, direct diode lasers are well adapted for applications requiring a wider melt zone for sealing of head or taillight automotive assemblies and the Ytterbium fiber lasers can be tightly focused for welding along intricate contours such as in micro fluidic applications. Depending on the material, thickness and desired process speeds, 50 - 200 W CW powers are typically required. The key to get a uniform melt zone with no weld flash or without out gassing the material is by controlling the power density and weld speed on the material. A common technique is by scanning the beam multiple times along the weld contour at high speeds, melting the material slowly in a controlled way. It is possible to create weld joints with energy density as low as 0.5 kw/cm2. Most applications require weld time to be under 3 seconds or less, but large automotive components may take longer. Post weld testing may comprise of a Helium leak test for hermeticity whereas burst tests are conducted for weld strength.

Summary

Almost any thermoplastic material that can be joined to itself using a thermal source can be welded using lasers. PP, PC, Acrylic, Nylon and ABS have all been welded with fiber lasers. Specific applications include welding of medical parts, automotive and electronic key fobs, headlight and tail-light assemblies, pump and valve housings, tire pressure sensors and electronic enclosures.

IPG looks forward to helping our customers with their laser applications and future plans. IPG supports well equipped and professionally staffed applications laboratories; contact IPG to arrange free sample evaluation or process development or go to www.ipgphotonics.com for more information.

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