Application Note #11

High Power Welding with Fiber Lasers

Introduction

Fiber lasers have consolidated their position at the high average power, multi-kW end of the industrial laser spectrum. The intrinsically scalable concept of fiber lasers has been used to scale multi-mode fiber lasers up to output powers >50 kW and single-mode fiber lasers up to 10 kW in power. The speed at which every industrial laser company has added fiber lasers to their product offerings is clear evidence of the many benefits of fiber laser technology.

Fiber lasers differ fundamentally from other laser types as the active medium that generates the fiber laser beam is dispersed within the fiber optic itself. This differentiates fiber lasers from fiber delivered lasers where the beam is simply transported from the laser resonator to the beam delivery optics. Fiber lasers are now widely accepted as being the most focusable (or highest brightness) of any multi-kW industrial laser type. The combination of high brightness, compact size, reliability and high wall-plug efficiency provides for favorable economics and process performance for accepted industrial laser processes including welding and cutting.

Fiber Laser Modularity and Scalability

A fiber laser can be an individual laser module or a number of combined modules for higher power. The laser module is a single-mode laser with a fiber core diameter of approximately 10 micron. Multi-mode, single-module fiber lasers are available as well. These modules can be combined to economically scale up laser power (Figure 1, Right). The majority of the industrial laser market for cutting and welding are lasers in the range of 500 - 6000 W. However, with the low cost, compact size, and high process performance of the fiber laser more installations of lasers >10,000 watts are being made.

WELDING APPLICATION

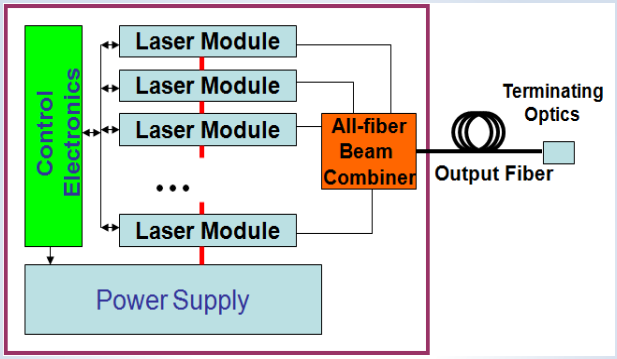

Figure 1: Laser Modules are combined to produce multi-kW lasers

Fiber Optic Beam Delivery for Fiber Lasers

A fiber optic beam delivery is a proven, reliable and economical method of delivering a laser beam to the work area. Typical lengths used in industrial environments range from 10 - 30 meters; significantly longer cables are practical and in use. A fiber laser can be delivered by its feed fiber or a longer fiber can be attached by means of a fiber coupler. A beam switch can be utilized to direct the laser down one of several output fibers. Beam switch time is <0.1 seconds. Beam switches with up to six ports are available. The use of a fiber coupler or a beam switch requires the outgoing fiber core to be twice the input fiber core. This is seldom a handicap due to the small originating feed fiber of the fiber laser.

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A wide range of materials processing applications can be addressed by the selection of the applications optics. Fiber optic cable core diameters for multi-mode fiber lasers range from 50 - 600 µm in 100 µm increments with diameters of 800 and 1000 µm occasionally used. Collimator focal lengths of 100, 120, 150 and 200 mm are common. Focus lens of 100, 150, 200, 250 and 300 mm are common but much longer focal lengths are used in special applications. Laser beam integrators and beam scanners are also used.

Fiber Laser Weld Performance

The single-mode fiber laser can weld thin materials at impressive speeds. Figure 2 (Page 3) shows a fuel cell component with three layers totaling 0.50 mm thick stainless steel, (Image A) welded at 80 meters per minute with 500 W of single-imode fiber laser, (Image B). The focus spot size used was approximately 20 microns.

The weld fusion zone geometry can be catered to the needs of the weld joint. In figure 3 (Page 3), image A, a 4000 watt fiber laser focused to 100 microns penetrated 8mm of carbon steel at 3.5 meters per minute. In image B of Figure 3, 4000 watts of fiber laser focused to 600 microns produced this lap weld in carbon steel at 3.5 meters per minute. In this case the 840 microns of weld width are important for weld strength in this assembly. The same laser is used in both examples; only the welding optics were changed to meet the weld joint requirements.

Figure 4 (Page 4) shows some welding results at 20,000 watts. Image A shows a section of a weld made in stainless steel, 1.4301 at 0.6 meters per minute at 20 kW. The weld was made from both sides to achieve a total of 50 mm weld penetration.

Image B shows a section of a weld made through two thicknesses of 15 mm stainless steel, 1.4301 at 1 meter per minute.
The total weld penetration was 26.5 mm.

Summary

A fiber laser can often surpass conventional welding processes on quality and economics if sufficient weld volume is required. An existing laser welding process can be improved dramatically on economics alone by a fiber laser. Many electron beam welding applications can be accomplished with a fiber laser at considerable cost savings.

IPG looks forward to helping our customers with their laser applications and future plans. A laser welding solution is a carefully crafted process. Considerations for metallurgy, joint configuration, fixturing, and productivity must be evaluated before a laser power and optics configuration can be selected. IPG Photonics supports well equipped and professionally staffed applications laboratories to fully explore and develop fiber laser welding solutions. Contact any of IPG's applications facilities to arrange free sample evaluation or process development.
Go to www.ipgphotonics.com for more information on all of IPG's products.

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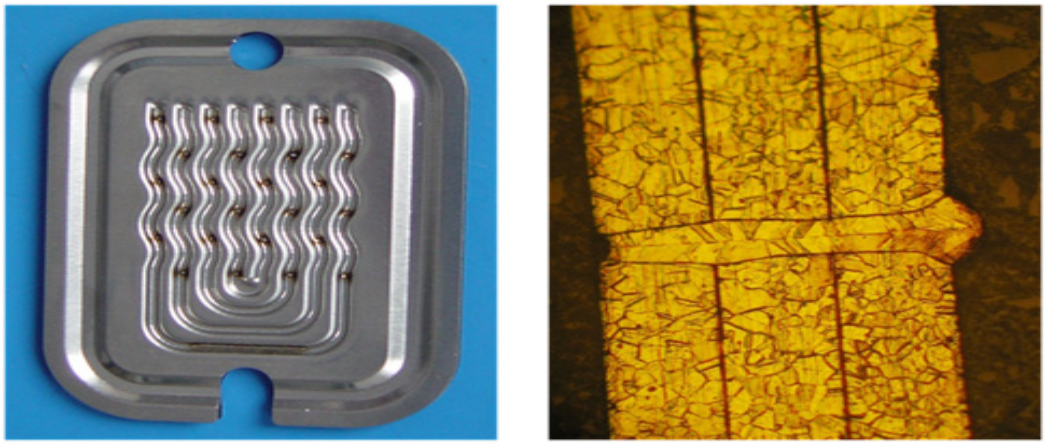

Image A Image B

Figure 2: Fuel Cell Component Welding

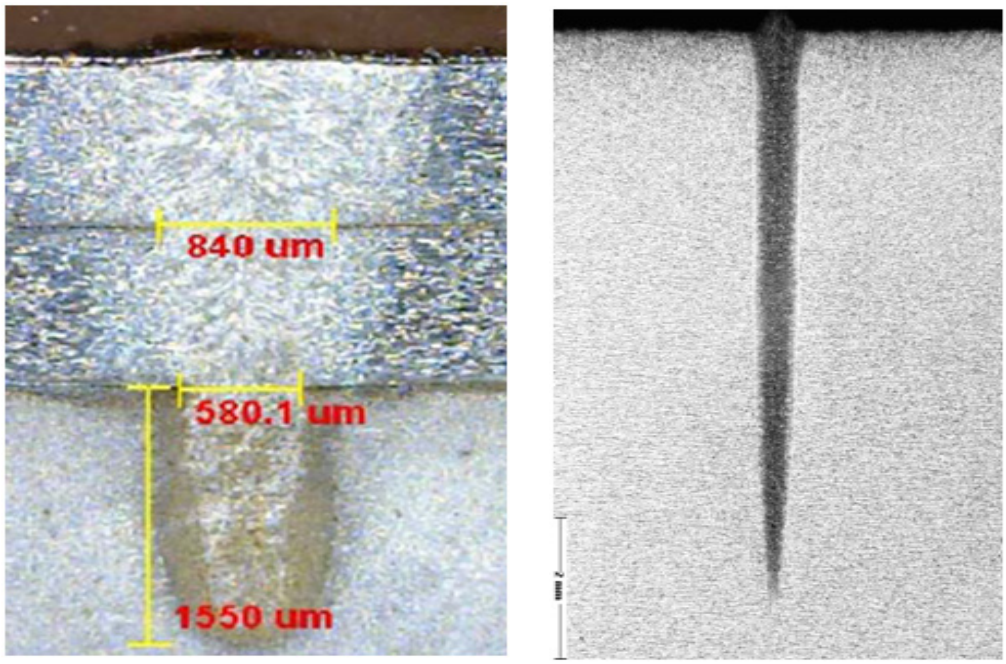

Image A Image B

Figure 3: Examples of 4000 W Fiber Laser Welding

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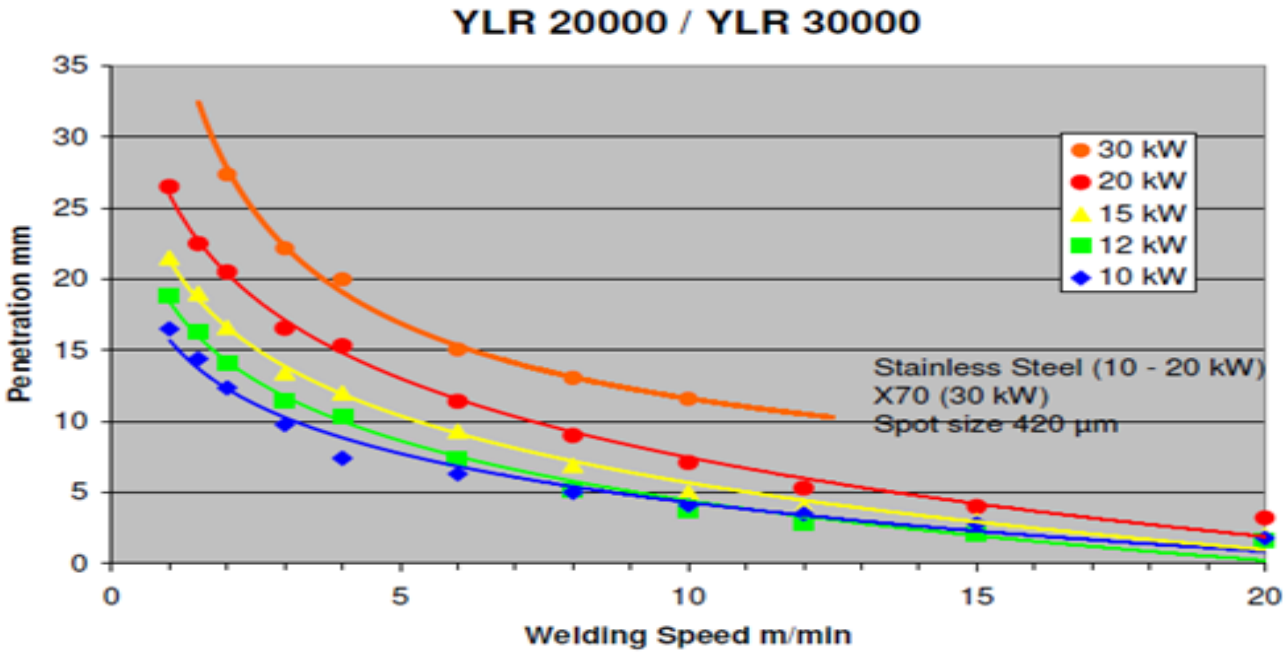

Figure 4: Welding Performance of High Power Fiber Lasers

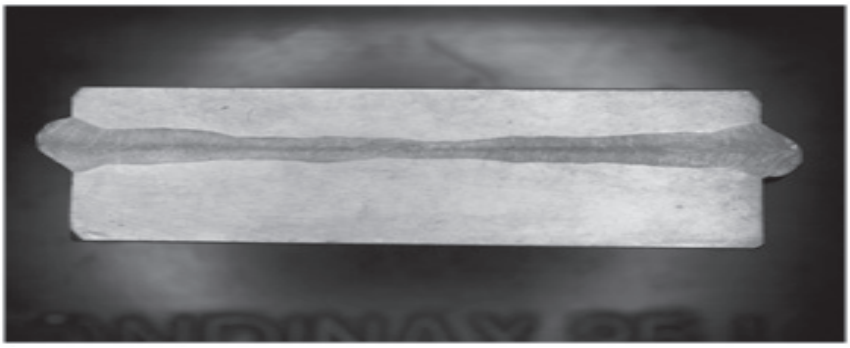

Figure 5: Fiber Laser Welding at 20 kW

Image A

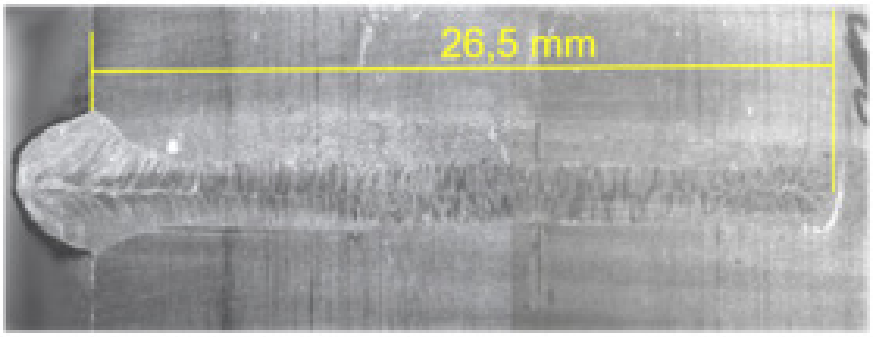

Image B

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