Fibre lasers - A new high power beam source for materials processing

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In a very short time a new laser type from IPG Laser GmbH reached the multi-kilowatt range for laser materials processing. Within a time period of less then two years, high power fibre laser developers scaled the laser power from a few hundred watts up to 10 kW and more. Now at the door step to the industrial entry these laser sources have to demonstrate the industrial applicability. At the Bremer Institute für angewandte Strahltechnik (BIAS), investigations on laser welding of steel and aluminum with a fibre laser of 7 kW output power were carried out (Fig.1).

Fig. 1: 6,9 kW IPG Laser GmbH fibre laser at BIAS

The advantages of these new lasers are multiple: Besides a very high efficiency compared to lamp or diode pumped rod lasers, these beam sources have a very compact design, a good beam quality and robust setup for mobile applications. The scaling of the laser power is realized by a modular design. Due to the high beam quality, thin working fibres can be used which is aimed at small focus with high brightness. The guaranteed lifetime of the pumping diodes exceeds the expected lifetime of other diode pumped lasers which leads to low costs of ownership.

Due to the limit of the laser power from commercially available beam sources with the conventional rod setup, there are only a few known welding investigations with higher laser power. These were carried out with special beam sources or by combining the beams of two or more sources into a high power delivery system. In both cases the beam quality was poor. Now there is a laser source which combines both, the high power and the high beam quality, in a modular laser. The high laser power can be utilized either for welding of thick sheet metal with the goal of achieving a deep penetration or for processing thin sheets to shift the process limits to higher welding speeds where the choice so far has been to high power CO_2-lasers.

Specific to railway and aircraft welding applications, aluminum sheets and profiles of up to 6 mm thickness are used in large structures. For working on these structures the complexity of the beam guiding and machinery for accommodating CO_2-lasers is very high. In the automotive industry Nd:YAG lasers of the 4 kW class were typically installed. With higher laser power, the welding speed and thus the productivity could be increased significantly, however the dynamics of the robots could limit the performance.

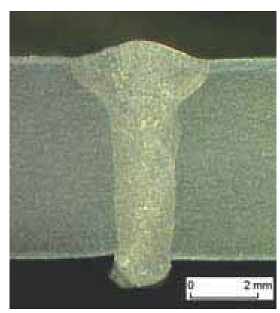

Fig. 2: Aluminum butt joint AA6056, t= 6 mm, P = 6.9 kW, v=3.0m/min, v_D = 8 m/min, gas Argon

With the 6.9 kW fibre laser installed at the BIAS labs, excellent welds on aluminum in butt and overlap joints were achieved. With a spot diameter of 0.5 mm the processes were very stable with a remarkable small number of defects like blowholes. Fig. 2 shows a butt weld in 6 mm aluminum AA6056 at a welding speed of v= 3 m/min. The welds show a slim geometry with a high depth to width ratio. Also tailored blanks could be welded with reasonable quality, Fig. 3.

Fig. 3: Aluminum butt joint (AA6181 2 + 4 mm); P = 6.9 kW, v= 4m/min, v_D= 4 m/min, gas Argon

Fig. 4 shows an overlap weld of three 1.5 mm zinc coated DC04 steel sheets with a total thickness of 4.5 mm. The welds show a pore-free cross section with sufficient fusion area. Also for thick sheet metals in the offshore or pipe industries which are typical applications for high power CO2-lasers today, the new fibre laser sources can find a wide application field. Fig. 5 shows a bead on plate weld in stainless steel with a welding depth of more then 6 mm with very slim weld geometry for a low distortion welding.

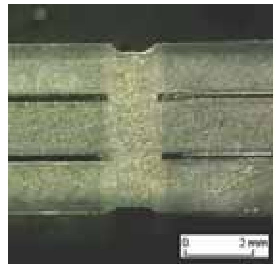

Fig. 4: overlap joint (3 x 1,5 mm DC04 Zn coated); P = 6.9kW; v=3.5 m/min, gap s = 0.2 mm, gas Argon

Fig. 5: Bead on plate weld, stainless steel, P= 6.9 kW, v=2m/min, gas Argon

The investigations at the BIAS labs showed very promising results for all tested materials. The process limits known up until now from applications of solid state lasers could be increased significantly by this new laser sources which combine high power and high beam quality. For many applications these beam sources can achieve technological and economical benefits. Due to a robust setup and high wall plug efficiency of over 20% these lasers may be suitable for mobile applications for in-fields laser processing which were not possible until now. In further investigations and long time tests it yet has to be shown that these laser sources can become an alternative or a substitute for the established laser sources.