Highlight

Aachen,
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Customized laser beam intensity profiles for reliable and robust welding of thermoplastics

For laser polymer welding the typical beam profile used has a Gaussian shape. Consequently, more energy is deposited in the middle of the laser spot than at its edges leading to an eventual overheating and burns in the center of the weld seam or to inaccurately defined weld seam widths. In order to avoid such situations and to increase the process robustness alternatives, based on the use of advanced beam shapers and high brilliance laser sources, could be developed and demonstrated recently by LIMO Lissotschenko Mikrooptik GmbH (Germany) and Leister Process Technologies (Switzerland) within the European POLYBRIGHT project.

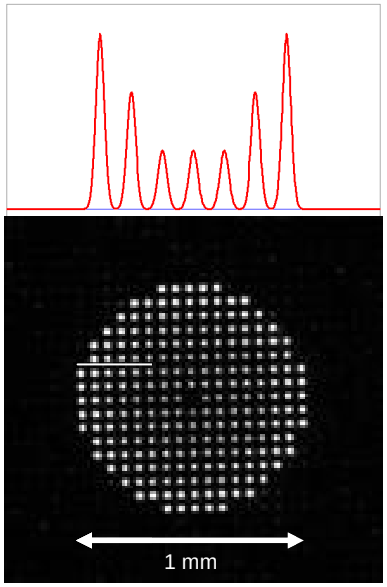

Figure 1: M-shaped beam profile generated using DOEs for a fiber laser

Customized laser beam profiles for polymer welding enable an optimal energy input into the joining area and lead to an enhanced process performance. Such beam profiles can be achieved using diffractive or refractive optical elements. In a first approach the company LEISTER, located in Sarnen (Switzerland), developed a set of diffractive optical elements (DOE) in order to achieve different beam profiles such as top-hat or M-shapes. These DOEs are taking advantage of the high focusability of fiber lasers and theoretically they act as a beam splitter. The small spot of the fiber laser is replicated many times across a desired beam diameter in order to achieve the desired profile. Furthermore, different weights are possible for each beam copy. As shown in Figure 1, an M-shaped beam profile with a diameter of one millimeter can be achieved with a DOE that copies the fundamental beam spot of the fiber laser within a 40 µm spaced grid. The replicas at the edge of the beam have a higher weighting factor than in the middle. Therefore, the laser intensity is higher in this area. This beam shaping approach works not only with fiber lasers but also with normal diode lasers. In this case the copies of the fundamental beams overlap and give a continuous intensity profile similar to the one shown in Figure 3.

The company LIMO, in Dortmund (Germany), demonstrated the possibility to achieve an M-shaped beam profile using refractive

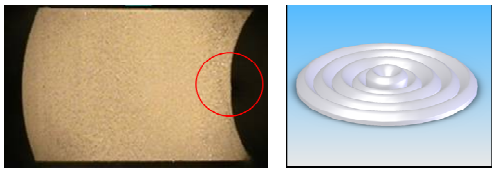

Figure 2: Bi-convex lens (left) and lens arrays (right) for generation of M-shaped beam profiles

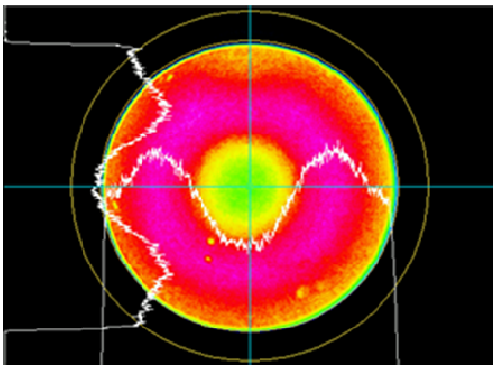

Figure 3: M-shaped beam profile generated using ROEs

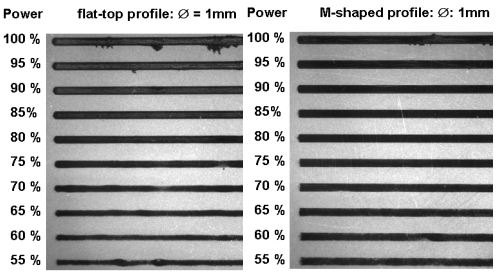

Figure 4: Comparison of the welding results for a top-hat (left) and an M-shaped beam profile generated using DOEs

optical elements (ROE) such as bi-convex lenses or radial symmetric lens arrays (Figure2). In the first case the developed bi-convex lens is mounted inside a LIMO diode laser module and generates the recorded M-shape profile shown in Figure 3. While for the second possibility to generate such a beam profile the lens arrays can be used for any laser source available. Nevertheless, the same beam profile can be achieved for both concepts. First experimental results were performed by each company. The DOEs indicate clearly that for the flat-top profile (Figure 4, left) the process window is narrower compared to the optimized M-shape profile (Figure 4, right). Additionally, the weld seam width for the flat-top profile changes with power whereas for the M-shaped profile the weld seam width stays nearly constant. Similarly the ROEs generated M-shape confirmed this result.

For any further questions our experts will be pleased to provide you assistance:

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SEVENTH FRAMEWORK PROGRAMME