



INDUSTRIAL SOLUTIONS FOR LARGE AREA LASER BUILDUP WELDING

THE TASK

A special feature of laser technology is its capability to deposit materials of micro- and macroscopic dimensions with one and the same tool. No other buildup welding technology can do this in comparable form. Laser based process variations are used in industry, which deposit tracks with widths ranging from 30 μm to 30 mm. These dimensions cover the enormous range of 4 orders of magnitude, which in turn results in a wide application spectrum spanning many areas.

Micro laser buildup welding often addresses challenges and requirements concerning precision and reproducibility of the deposition. The success of macro processes on the other hand is often related to the design of optical components and processing heads as well as to durability concerns of the systems technology. The use of highest laser powers and large sized melt pools radiates enormous heat toward the powered nozzles. Other challenges include melting parameters such as heating and cooling rates as well as the dynamics of laser induced melt pools with comparably low depths and wide widths.

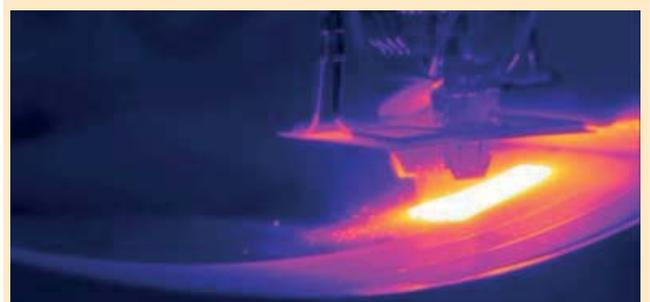
The development of modern laser processing heads presents scientific and technical challenges with respect to achieving a homogeneous, rectangular or line shaped powder jet profile and a long-term stable powder delivery under enormous heat loads. Simultaneously these processing heads have to be capable to meet the demands associated with the economical deposition over large areas.

OUR SOLUTION

Fraunhofer IWS developed a modular processing head system solution. The solution consists of a series of COAXn processing heads, which are continually improved and qualified for new applications. Recent development work has focused on the concept of the wide jet nozzle with rectangular powder jet cross section. This new and patented wide jet processing head has significant advantages compared to the current state-of-the-art: it includes a reworked powder delivery concept, which was particularly adapted to meet the requirements related to the use of highest laser powers and highest powder feed rates (Fig. 1).

The powder is delivered through special and exchangeable channel plates. These plates are adapted to the shape of the laser spot and to the required powder throughput. The standard configuration of the wide jet processing head has a focus size of 16 mm x 6 mm. In other configurations it can be adapted to laser focus widths of 45 mm. The working distance is adjusted between 20 mm and 30 mm depending on the process requirements and the component.

Thermal image during laser powder buildup welding with 15 kW laser power and wide jet nozzle





RESULTS

Figures 4 and 5 show typical welding results on flat and cylindrical samples, which were achieved with the 45 mm wide rectangular powder jet cross section. The special design of the powder channels guarantees that the mass flow is homogeneously distributed even for such wide jet widths. A typical sample with a single 45 mm wide Ni base alloy IN82 track was cross sectioned and polished (Fig. 6). Even for such an unusually large width, the cross section shows uniform and flawless track material that is metallurgically bonded to the substrate.

When using the highest available power from the 20 kW diode laser, the maximum deposition rate for the Ni base powders is 14 kg h^{-1} at 90 percent powder utilization. The rate is not limited by the powder delivery but by the available laser power. Laser build-up welding with a wide rectangular beam is different from using a laser with a circular beam. The process works with lower laser power density and slower welding speed to maintain a calm welding process and to reduce the risk of overheating

the melt pool. The slower welding speed causes reduced cooling rates, which are advantageous for processing powder materials that are prone to crack formation and for using substrate materials with temperature sensitive hardening properties.

The application spectrum benefits from the high deposition rates and efficient areal coverage of the process. Examples include large area coating of power plant and offshore components that are exposed to corrosion and wear. Figure 7 shows the coating of large container parts at an industry customer. This research and development project was the first test opportunity for the wide jet processing head with 45 mm track width.

System for large area laser buildup welding of container parts with IWS wide jet processing optics



- 1 *Wide jet processing head*
- 2 *Laser powder buildup welding process with 20 kW laser power and 45 mm wide jet nozzle*
- 4/5 *Parts coated with 45 mm track width*
- 6 *Polished cross section of a single IN82 track*

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