INCREASED EFFICIENCY DURING LASER BUILDUP WELDING BY COMBINING ENERGY SOURCES

THE TASK

Excellent precision, highest mechanical strength and tailored properties of surface coatings and generated 3D structures: these characteristics led to the industrial breakthrough of laser buildup welding processes in series manufacturing. However, low deposition rates and limited energy efficiency set barriers for the technology – in particular for simply shaped parts. Examples include long hydraulic cylinders in offshore applications, oil production and mining tools as well as large screw-conveyors, which require high strength surfaces. In terms of the coating properties required for these applications, there are no alternatives to laser buildup welding. However, the comparatively high coating costs have been limiting the use of this technology for these applications.

Laser buildup welding, just like any buildup welding process, suffers from energy losses. These are principally connected to the welding process and affect its efficiency. Heat conduction into the base material assumes a key role. On the one hand this cooling process enables the solidification of the laser-induced melt. It also represents the major loss component of the expensively generated and precisely applied laser energy. Up to 90 % of the absorbed energy drains into the workpiece. The fast heat conduction in combination with the laser beam tool leads to especially high cooling rates and spatial temperature gradients, which may become critical for crack prone coating materials.

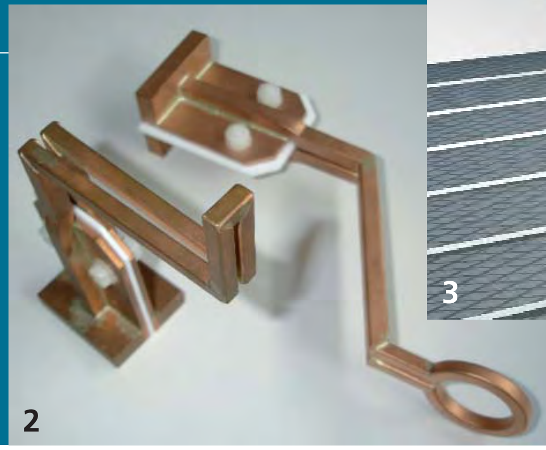
OUR SOLUTION

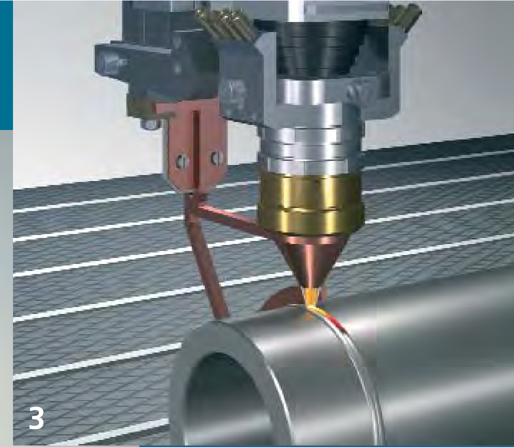
The here presented solution implements a simultaneous support of the laser beam by local inductive heating. The basic principle of this single stage hybrid technology is the combination of two energy sources with very different power densities. This approach allows the superposition of two independent temperature-time regimes, which cannot be achieved by laser beam buildup welding on its own.

The technical implementation occurs in the form of a modular coaxial laser coating head of a new generation. The head integrates an induction module for localized and directionally independent application (Fig. 1). The new COAXpowerline processing head is part of the IWS-COAXn series.

RESULTS

The powder delivery principle is coaxial. All media (powder, gas, cooling water) are fed through an internally and protected medial line. The weld track width is CNC controlled by moving the z-axis during the running process. The inductive heating module is integrated into the processing head. Inductors are selected from an assortment depending on the processing task (Fig. 2). Inductors, which run in front of the laser, help to maximize the deposition rate. Laser trailing inductors reduce the temperature gradients and minimize crack formation in the coatings. A ring shaped inductor in coaxial arrangement with laser and powder jet axes provides direction independent processing capability.





The first application of the new processing head was the fabrication of corrosion protective coatings from INCONEL 625 on large cylindrical steel parts (Fig. 3). A 4 kW diode laser was combined with 12 kW induction power. The deposition rate was 8 kg / h and the welding speeds reached 3 m / min. This means that smaller and less expensive lasers achieve welding performance in the order of plasma powder buildup welding. A record deposition rate of 21.5 kg / h for INCONEL 625 was achieved with 10 kW diode laser and 14 kW induction powers.

Crack prevention due to localized process simultaneous additional heating: cross section of an area coating from Stellite 20, 62 HRC

4

To judge the economic impact of this technology, it needs to be considered that the investment costs drop by 50 % per kilowatt total power while the energy efficiency doubles.

In addition to efficiency and productivity, the combination of energy sources is also beneficial to expand the available material spectrum. As a consequence of the increased local heating the $t_{8/5}$ cooling time extends. The reduced temperature gradients make the process accessible in terms of crack prevention to hard and wear resistant metal alloys. An example is a defect-free wear protective coating made from Stellite 20 with a hardness of 62 HRC (Fig. 4).

1 *COAXpowerline: coaxial laser processing head with integrated induction module*

2 *Easy to change inductors, which are mostly independent from the part geometry and were optimized via simulations*

3 *Process of large area buildup welding on cylindrical parts with inductive preheating*

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