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FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS

LASER PROCESSING OPTIC COAXwire

Cladding, repair and additive manufacturing using wire as feedstock material

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Overview

The Fraunhofer IWS offers the newly developed laser wire processing optic COAXwire as a compact technical solution for the processing of metallic wires with the latest generation laser systems. As solid or cored wire, in fine or standard dimensions it is possible to use nearly all commercially available welding and brazing wires.

For this optics the collimated beam of an up to 4 kW fiber or disc laser is symmetrically split into three partial beams and subsequently focused on a circular spot. The set-up of the optical elements allows for a wire supply precisely into the beam axis. Thus, the wire directly meets the center of the laser induced melt bath. This enables a complete directional independence for all technical welding positions.

The industrial user takes advantage of the complete material utilization as well as of the high productivity and the clean process conditions.

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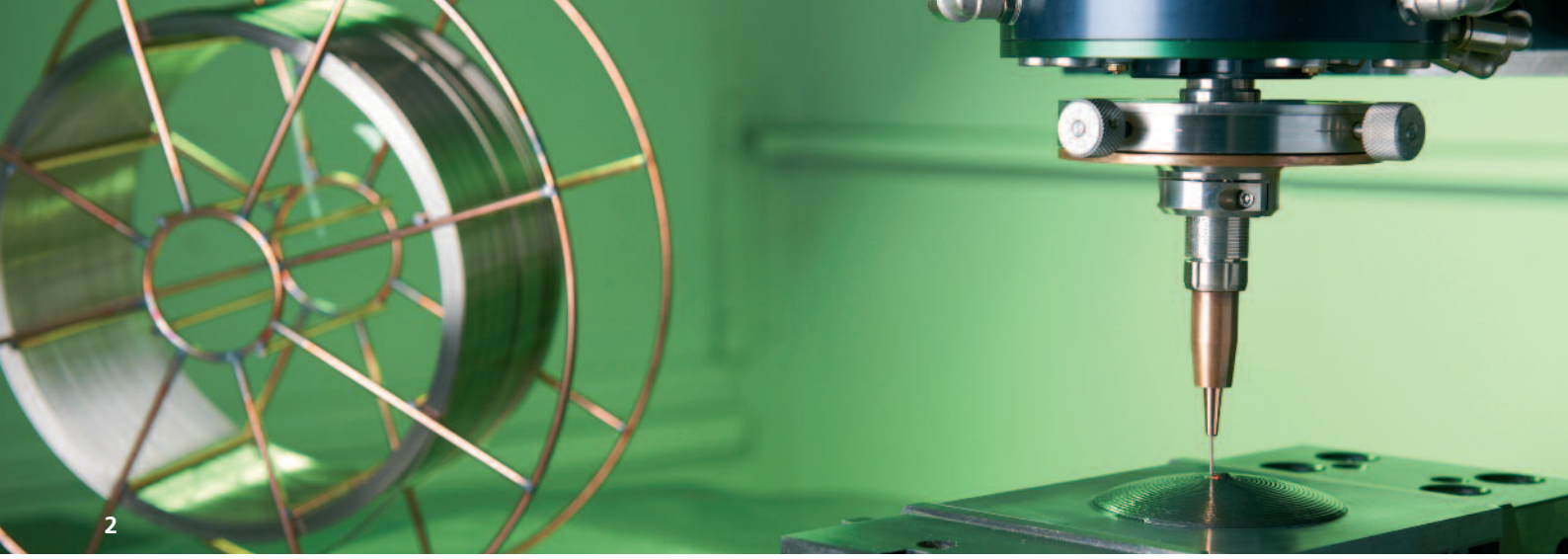

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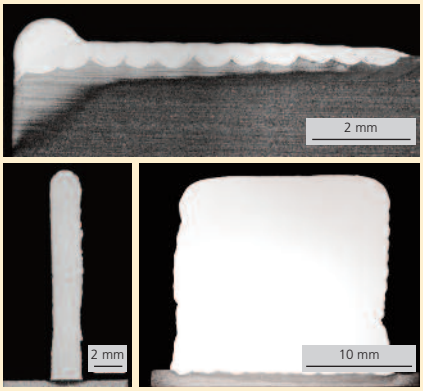
Optic design

The laser beam is guided through a fiber coupler into the COAXwire optic, where it is split into three single beams using a specially designed optical element. These single beams are aligned at 120 degrees to one another around the optic's centric axis. They are then merged by deflecting elements to a common triple focus in such a way, that the wire-shaped filler material can be supplied exactly into the centric axis. With a fixed optical aspect ratio of 1:3, the focus diameter can be easily set by the choice of the fiber diameter according to the wire dimensions.

Process

In order to deposit the filler material on the part's surface, a defined local melt pool is generated by the laser beam. The wire penetrates into that melt pool where it is completely molten. Simultaneously, the substrate material is slightly molten, which guarantees the required and characteristic metallurgical bonding between the deposited material and the surface of the substrate. By overlapping the resulting single tracks, area claddings can be performed, and the layer-by-layer deposition leads to real three-dimensional metallic structures.

The deposition rates lie in the range of 100 to 250 cm³/h, depending on material and the part's geometry. The utilization of the wire is always 100% - in fact independently from the track geometry and welding position, and even at a complex and filigree metal build-up.



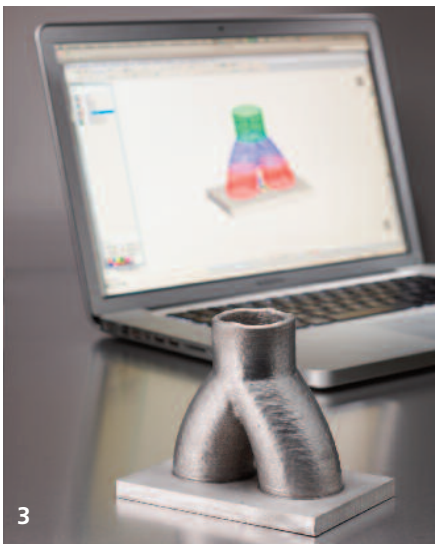
Cross sections of representative examples: cladding on edges, thin wall structures and generation of volume parts

Shape, size, and properties of the generated structures are primarily determined by the process parameters laser power, wire speed and welding speed with respect to the selected wire material. Hereby, as major precondition for a successful process, a constant melt flow of the metallic material has to be realized.

The heat accumulation under multilayer processing leads to changes in the track geometry. For this reason, component-specific process strategies or an online laser power control can be used to minimize the heat input as well as deviations.

CAD/CAM

For the common applications, CAM systems can be used for programming the tool paths in accordance with the build-up welding strategy. Apart from process parameters, the track width and overlapping as well as start positioning and wire management can be freely selected to perform application-specific welding strategies.



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Technical properties

The COAXwire optic is characterized by its modular design, based on one-inch optical components. The total weight of the head amounts to 13 kg. The assembly includes a mechanical mount to the machine tool as well as interfaces for the optical fiber, the wire feed, and a camera system for process monitoring. Media supplies for cooling water and shielding gas are integrated, and a cross-jet of compressed air protects the optical elements from dust and splatter.

The laser fiber is coupled via LLK-D, LLK-B or QBH connectors. Designed for high beam quality, the numerical aperture of the fiber should range from 0.1 to 0.2.

Metallic wires from 0.4 to 1.6 mm in diameter can be processed, and normal wire feeders from any manufacturers are suitable. The integrated emergency-stop module protects the optic and machine tool in the case of collision or process irregularities.

The electro-mechanical principle allows for precise reset accuracy and is normally integrated into the safety circuit of the laser unit.

Optional process monitoring

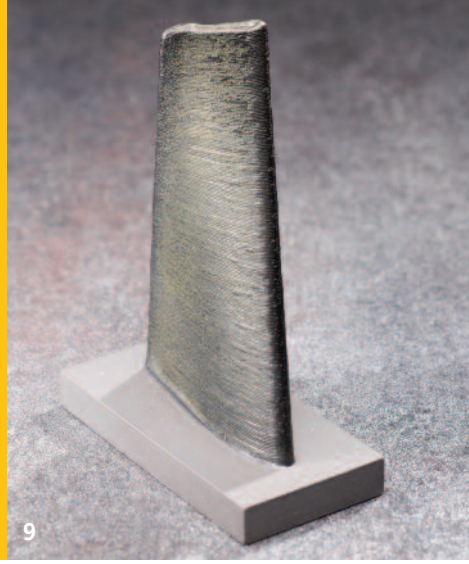
For the monitoring and control of the cladding process, a camera-based control system can be adapted optionally to the optic via standard interface. Therefore, the IWS system E-MAqS and the software package LompocPro are well-proved products. This system regulates local temperature deviations of the melt pool via control of the laser power. The measuring frequency of 200 Hz is adequate to the dynamics of the laser-induced metal melt.

Additionally, an external off-axis camera can be used for the documentation of the cladding process for purposes of quality assurance. Both systems can be connected via additional software in such a way that a structured data recording is possible.

COAXwire: most important features at a glance

- modular and compact design
- 3 beam optic concept
- central wire supply with xyz-adjustment
- splatter and dust protection
- collision and safety shutdown
- camera-based process control and monitoring (optional)

1 Technical set-up in a robotic cladding system
2 Typical welding arrangement
3 Generated aluminum tube; realization of the CAM strategy
4 Schematic of the three beam concept
5 Deflection of the safety module in case of a process failure
6 Adapted off-axis camera



COAXwire: technical data

main sizes	
height	500 mm (without fiber and wire feed)
width	160 mm (245 mm with E-MAqS camera)
depth	210 mm
weight	~ 13 kg
outer beam aperture angle	40°
laser	
type	diode, disc, fiber
power	up to 4 kW
beam parameter product BPP	≤ 30 mm·mrad
fiber connector	LLK-D, LLK-B, QBH (other on request)
filler wire	
material	all commercially available solid and cored wires
diameter	0.4 - 1.6 mm
supply speed	0.5 - 20 m/min
collision and safety shutdown	
principle	electro-mechanical
xy-deflection	7°
z-deflection	3 mm
release torque	35 Nm
integrated functions	
inert gas supply	shielding of process zone
protective glass cartridge	protection of optical elements
cross jets	deflection of splatters
dust protection	protection against metal vapor
cooling circuit	water cooling of optic and wire supply
optional process monitoring	
E-MAqS camera	online process control
off-axis camera	sideward process monitoring

Service offer

- consulting with respect to welding process and material
- feasibility studies and application-specific process development
- system technology for laser wire cladding with customized adaptations
- technology transfer, on-site installation service, and user training

Application

The application field of the COAXwire optic includes cladding, repair, and additive manufacturing processes.

Examples:

- wear protective coatings of Fe, Co, Ni, and Cu alloys
- repair of cutting and forming tools for sheet metal forming
- repair of high-value components made of Ti and Ni aerospace alloys
- additive manufacturing of functional metallic parts

7 Smooth surface of a coated steel cylinder
8 Manufacturing of curved surfaces
9 Additive manufacturing of a nickel turbine blade

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fig. 1, 6: Frank Höhler