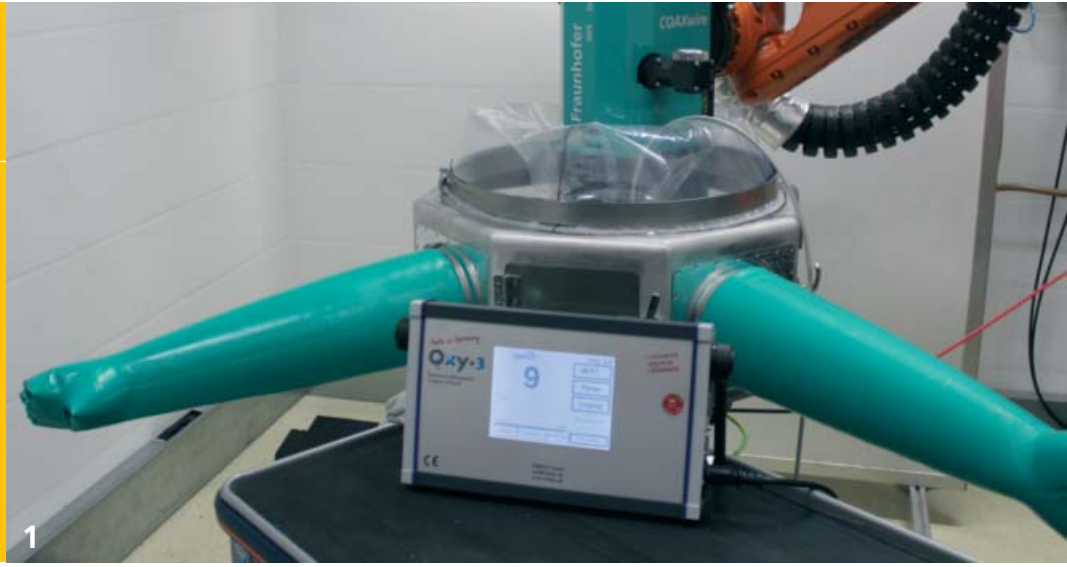

1

COAXIAL LASER WIRE BUILDUP WELDING WITH EXTENDED MATERIAL RANGE

THE TASK

Laser wire buildup welding – a material-efficient and clean process – is being used more and more in addition to classical wire and powder-based spraying technologies and arc welding techniques in the field of thermal surface technology. Figure 1 elucidates the connection and adaption of the robot and a wire optical unit COAXwire thus engineered. In this optical unit developed at the IWS, a beam coupled in through an optical fiber cable is coaxially split into three partial beams. Arranging them symmetrically around a central wire supply allows for many degrees of freedom in process guidance, as well as ideal preconditions for process automation.

Reproducible and reliable process conditions are required for the processing of demanding wire material for aerospace applications. For the implementation of the process, not only the laser processing optical unit itself, but also the peripheral systems, such as the laser beam source, process monitoring, wire supplier and CAM software, had to be qualified.

When processing reactive materials, such as aluminum and titanium, an inert environment is an additional necessity, wherein the residual oxygen content should not exceed 50 ppm. Typically used nozzles with annular gap or as trailer-type for local melt pool shieldings cannot maintain this value. Thus, a new protection concept based on shielding gas had to be engineered: it had to ensure quick and easy-to-perform adaption to the optical unit, as well as high gas quality and the processing of free formed surfaces in 5 axes, and be suitable for the additive manufacturing of large-sized components.

OUR SOLUTION

The principle of the COAX technology can be applied to almost any commercially available massive and cored wires on spool. The alloy range comprises light metals, iron and nickel-based alloys, as well as hard materials-binder filler metals. They are used for the coating of surfaces that are tribologically loaded, changes in dimension and shape or repairs to forming dies and cutting tools, as well as for the generation of complex components.

The COAXwire processing optics was refined for the use with the latest generation of diode lasers. Existing lasers have a socket efficiency of more than 30 percent and function in a wavelength range from 940 nm to 1060 nm.

The use of repeatable, highly dynamic wire feeding units was explored. Increased process reliability is achieved by low-friction guideways, sensors for real value capturing, a buffer system to decouple primary and secondary drives, as well as the use of four-roll drives.

The new development of a flexible shielding gas chamber makes it possible to guide the process in a highly clean shielding gas atmosphere. The chamber is designed so that it can be quickly mounted on the CNC machine table or the turn-tilt axis of a robot system. The design mainly consists of a compact basic frame and a flexible foil cap. Defined tool mounting can be performed inwardly using clamping devices. A new head adapter was installed for quick and leak-proof assembly with the optics.

2

RESULTS

The diode laser with a beam parameter product of 30 mm mrad makes possible the optimal illumination of the optical elements over the entire path of the laser beam by the processing optical unit. The resultant focus diameter is 2 mm at a fiber diameter of 600 µm. Having been adapted to this laser type, this coaxial laser wire processing optical component is now compatible with all laser beam sources generally used in material processing.

The shielding gas chamber can be used for these lasers. This chamber can be filled to a residual oxygen content of 20 ppm within 30 minutes by applying pure argon or a mixed gas supply adapted to the welding application on the bottom. This inert atmosphere is kept constant in the chamber constant even if the adapted optical components are moved, enabling especially stable process conditions (Fig. 3). During welding, a gas supply of only 10 l min^{-1} is sufficient due to the system's high permeability.

Coaxial laser wire buildup welding process

3

The refinement of the systems components makes it possible to implement new welding strategies and to extend the manufacturing possibilities for aluminum, titanium and nickel-based alloys as bulk wire, as well as for other alloy compositions as cored wires.

Figure 2 shows an example of a buildup welded pattern part with an external cylindrical shell, whose inner core tapers off, with connecting webs made of Inconel 718. The building rate is 120 cm^3 h^{-1} for a layer thickness of 0.8 mm and a 2.2 kW laser power. It takes 2.5 hours of process time to produce the component of 1.9 kg weight; pure welding time – excluding positioning and idle times – is only 2 hours.

1 Laser wire processing optics COAXwire with flexible shielding gas chamber
2 Welded sample part made of Inconel 718

CONTACT

Dipl.-Ing. Sebastian Thieme
☎ *+49 351 83391-3076*
✉ *sebastian.thieme@iws.fraunhofer.de*