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EFFICIENT PROCESSING OF LARGE SURFACES BY LASER AND PLASMA TECHNOLOGIES

THE TASK

Efficient solutions for lightweight design in the automotive and aircraft industries demand flexible production and processing technologies for sheet-like semi-finished products made of several materials. This, in turn, requires new and flexible equipment concepts for a combination of different manufacturing technologies, such as welding, cutting, ablation and structuring. These technologies should be equally applicable to processes and technologies for metal, plastics and textiles. To fulfill the conditions mentioned, laser-remote processes with radiation sources adapted to the material properties offer a promising approach.

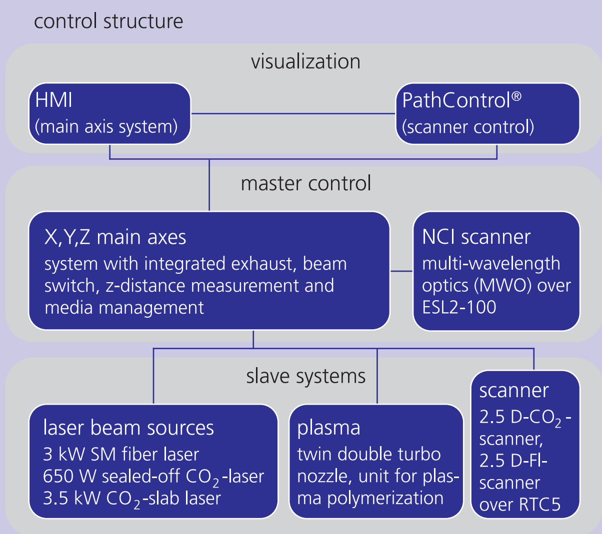
The availability of extremely bright cw radiation sources of different wavelengths opens up new opportunities for remote applications. The scanner working ranges used for beam scanning currently limit the applications. Extensions of the working range can be implemented by combining scanners with Cartesian kinematic systems. The two-dimensional on-the-fly coupling of scanner and axis system has already shown the potential of an optimized axis superposition in practice. The combination of large field scanners with highly dynamic spindle drives promises high-precision and high-speed manufacturing.

The Fraunhofer IWS intends to offer the systems and process engineering potential of these field extensions prospective customers from industry. Together with industrial partners, the IWS is developing a multifunctional prototype system for high-speed manufacturing of plane, moderately shaped, sheet metal and textile prepregs.

OUR SOLUTION

The equipment concept is based on a single column design with a travelling Z axis carrier, holding a platform for the optical devices (Fig. 1). The setup consists of a fixed positioned scanner system, which is linked with a highly dynamic XY travelling unit for on-the-fly material processing. To this setup were added different laser beam sources and equipment for plasma processing at atmospheric pressure. To guarantee reliable processing of fiber-reinforced composite materials, such as CFRP, both the laser and the electrical components of the machine axis system are encapsulated to make them dustproof. A suction chamber that can be adapted to the work distance efficiently removes the by-products from the workspace; the by-products are sub-sequently filtered by means of special equipment and are separated out.

Flexibly expandable control structure of the multifunctional remote system (based on Beckhoff-SPC and PLC)



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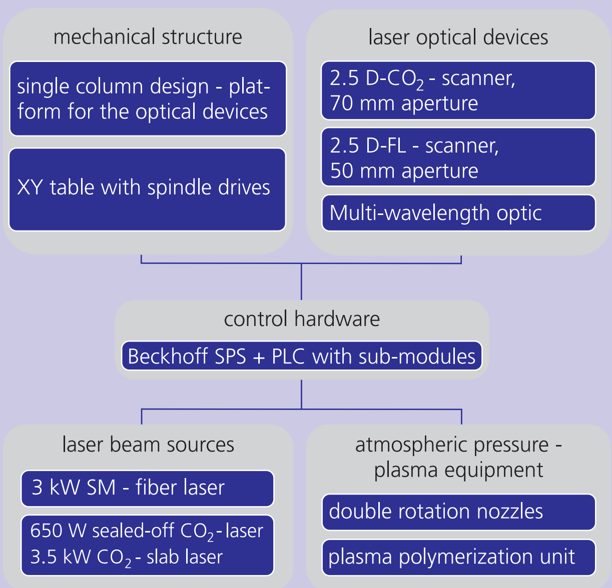
A flexible controlling structure enabling user-friendly programming of all components and embedding of the sensor units was designed for highly dynamic triggering of the driving unit and the coupling with the scanner systems (Fig. 2). The details of the functional components are summarized in Figure 3.

RESULTS

The laser remote processes, which can be implemented by means of the prototype system, are profitably used in multi-material lightweight design for direct thermal joining of metal with thermoplastic fiber-reinforced compounds. Thus, laser macro-structuring by means of a fiber laser allows flexible pre-processing of the metallic joint partners. In the joining step itself, the parts, which overlap one another, are adhesively bonded by laser-induced heating of the metallic joint partner on the rear side, from which heat is conducted into the metal-thermoplastic interface.

System component overview of the multifunctional remote system for laser and plasma processing of large surfaces



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If the task is to produce hybrid laminates from metals and thermoplastics or organosheets continuously, then heating by the laser directly occurs in the joining gap between the two prepregs. The surface of the locally molten thermoplastic is bonded to the metal between pressing rolls (Fig. 4). Using the remote technology with integrated laser power control, depending on the scanner position, sheets up to 0.5 m width can be joined.

The equipment can also be used for pre-processing of surfaces before adhesive bonding. In aeronautics, GLARE® composite sheets – a mulitlayer structure of aluminum films and fiberglass-reinforced resin layers are regarded as an alternative to pure aluminum alloys. The individual metallic layers, each a few tenths of a millimeter thick, are conventionally pre-processed on both sides in chemical solutions and subsequently adhesively bonded with the fiberglass rovings or fabrics. Similar adherence strength values can be obtained if chemical pre-processing is replaced by laser pre-processing, which enables an increase in surface and boosts oxide layer growth. Laser-remote processing is one way to replace chemical pre-processing and can significantly contribute to a higher level of resource efficiency and environmental protection.

1 Multifunctional remote system at the Fraunhofer IWS

4 Experimental setup for continuous joining of metal and organosheet

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