

SYSTEM ENGINEERING FOR POWDER-BASED LASER CLADDING



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DIN EN ISO 9001:2015
Reg.-No. 069572 QM15

Fraunhofer Institute for Laser Technology ILT

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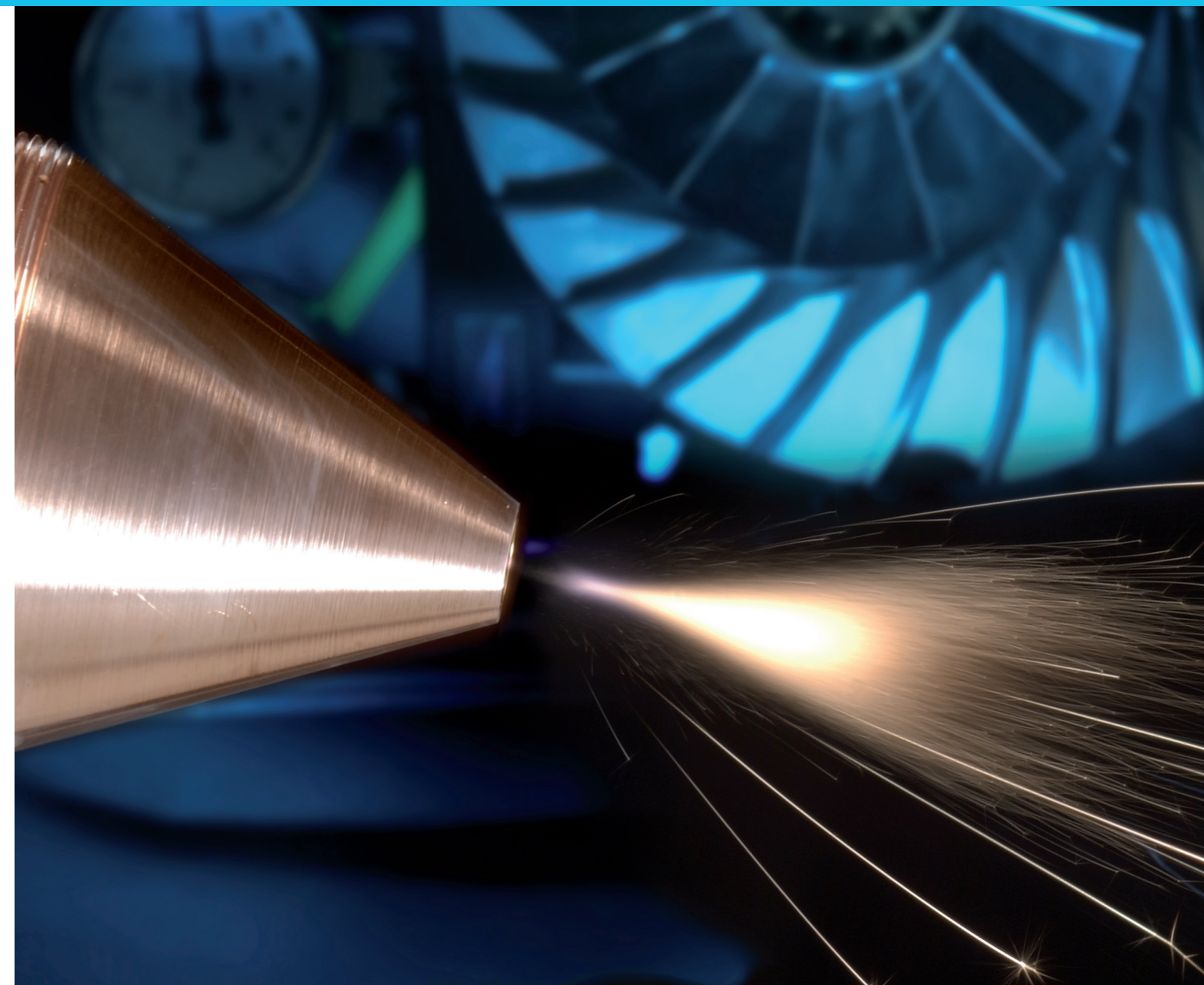
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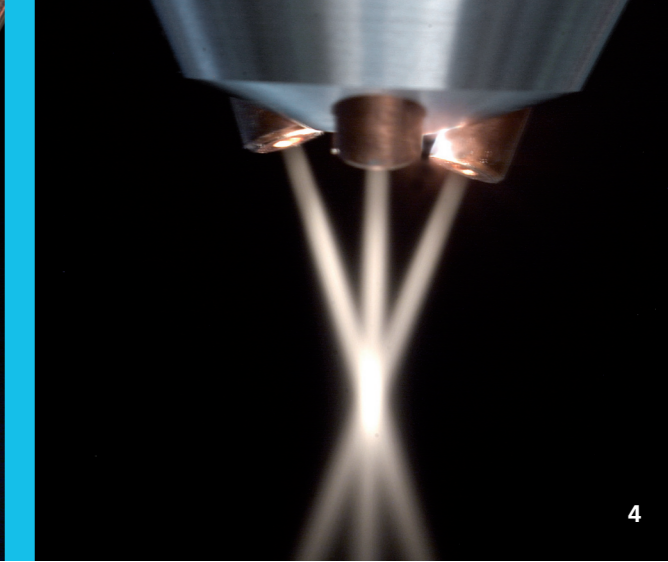
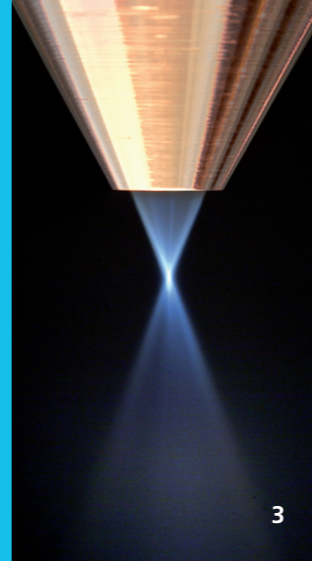
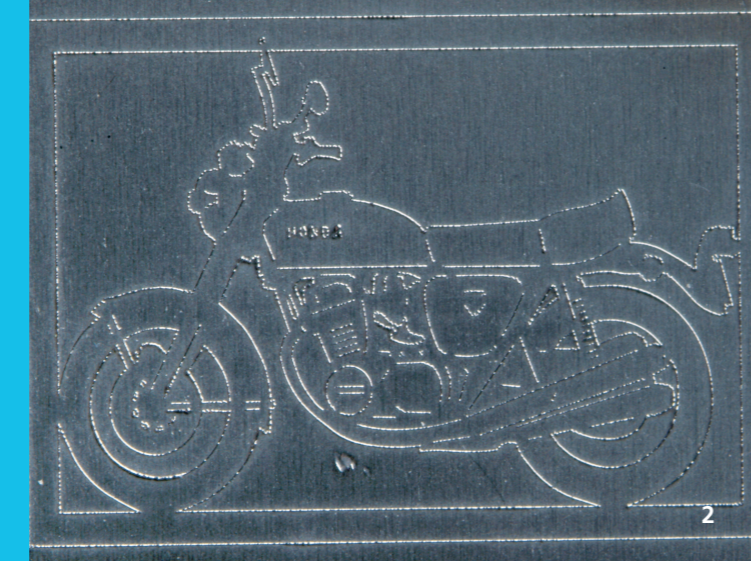
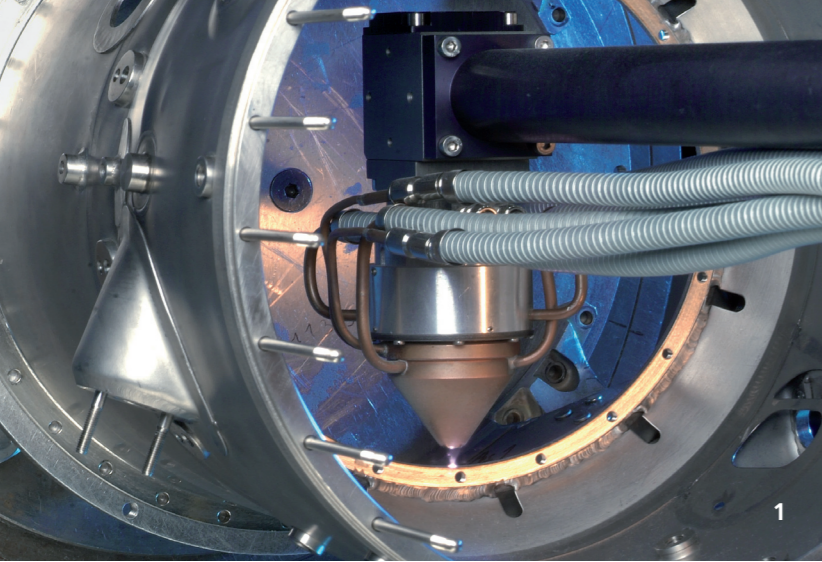
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Fraunhofer Institute for Laser Technology ILT

The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing technology and industrial laser processes. This includes laser cutting, ablation, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, Fraunhofer ILT develops photonic components and beam sources for quantum technology.

Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing lines. The institute focuses on research and development for industrial and societal challenges in the areas of health, safety, communication, production, mobility, energy and environment. Fraunhofer ILT is integrated into the Fraunhofer-Gesellschaft.





SYSTEM ENGINEERING FOR POWDER-BASED LASER CLADDING

The powder feed is a crucial aspect of laser cladding. The Fraunhofer Institute for Laser Technology ILT offers its customers standard products and tailor-made solutions in this field.

The Process

Powder-based laser cladding involves melting a powdery filler material using a laser beam and forming a layer on the base material with a metallurgical bonding. The powder feed plays a key role in this respect, having a decisive influence on the dimensional accuracy of the deposited material, the quality of the replaced material and layers produced, as well as the cost-effectiveness of the process. Based on the basic principles of lateral or coaxial powder feeding for cladding processes, the Fraunhofer ILT has developed specific powder feed systems that meet the high demands for precision for this technology. Together with our customers we are also developing specific solutions, e. g. powder feed units with integrated optics that ensure optimum processing results. The powder feed nozzles can deposit powdery materials with grain fractions of 20 to 150 μm for macro layers ($d > 100 \mu\text{m}$) and less than 20 μm for micro layers ($d < 100 \mu\text{m}$). The nozzles are suitable for all high-power lasers that are currently used for laser cladding (CO_2 , Nd:YAG, disc, fiber and diode lasers).

Lateral Powder Feed

With the lateral powder feed nozzle the powder is fed into the laser beam from the side. This configuration is ideally suited for laser cladding of rotationally symmetric components or for processing areas that are difficult to access (e.g. grooves). With a rectangular nozzle high deposition rates of up to 6 kg/h can be achieved.

Coaxial Powder Feed

Coaxial powder feed involves feeding the powder along the axis of the laser beam. A distinction is drawn between a discreet and continuous powder feed. With the discreet feed at least three powder gas streams running coaxially to the laser beam generate a »powder-gas beam focus«, which has a core diameter of 1-3 mm. This »three-beam nozzle« is particularly suited for depositing thicker layers with high laser outputs ($> 2 \text{ kW}$) and also depositing 3-D contours even in overhead conditions. With continuous powder feed, the powder is distributed in a conical ring-shaped cavity, forming a hollow powder cone which encloses the laser beam. This »coaxial nozzle« allows the powder-gas beam focus to be reduced to under 0.2 mm, thus enabling cladding to be applied with optimum precision and efficiency even with a small laser beam diameter. Adaptation of a telescopic optical system allows the coaxial powder feed nozzles to be used for processing internal areas, providing the interior has a diameter of 100 mm or higher.

Zoom Optics with integrated Powder Feed Nozzle

The zoom optics allows a flexible modification of the laser beam diameter. Because of the constant working distance there is no need for a complex adjustment. In cooperation with the company Reis Lasertec, the Fraunhofer ILT has developed adaptive optics to generate a variable beam diameter with an integrated coaxial powder feed nozzle. The zoom optics provides a variable beam diameter on the working plane by moving lenses, also ensuring an approximately top hat power density distribution. The zoom optics can be designed for outputs of several kilowatts and track widths of 0.5 to 4 or from 4 to 9 mm respectively.

Processing Heads for inside Processing

Conventional optics and the aforementioned powder feed nozzles can not handle inside contours with an internal diameter of less than 100 mm due to the restricted access. Inside processing heads have been developed at the Fraunhofer ILT which can be used on work pieces with an internal diameter of 25 mm and up to a depth of immersion of 500 mm. The optical components, the powder feed, the water cooling system and the lines for the shielding gas are integrated in a compact cylindrical housing. The power output can range from 0,5 to 3 kW.

Applications

Thanks to the wide product range of powder feed nozzles and processing heads, the Fraunhofer ILT is able to offer its customers the appropriate tool for each application. For large-scale wear and corrosion protection, which essentially involves large deposition rates in the region of several kg/h, lateral powder feed nozzles with a large cross-section are best suited. Coaxial nozzles are primarily used for the precise repair of components, tools, molds or engine components, while relatively slim lateral nozzles are used where access is limited. Inside processing heads tend to be used to provide wear protection for inside surfaces of bearings or valves. For the 3-D repair of large tools and machine components, the three-beam nozzle offers optimum efficiency and flexibility. The zoom optics come into their own where superior flexibility is required with cladding.

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- 1 Laser cladding with a telescopic optical system
- 2 Micro laser cladded demonstrator
- 3 Powder gas stream of a coaxial nozzle
- 4 Powder gas stream of a three-way nozzle