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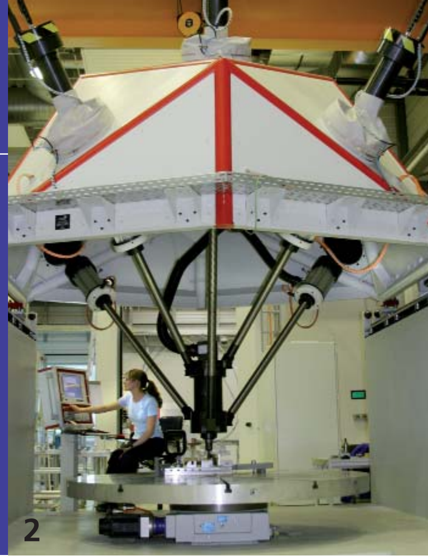

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PENTAPOD MACHINE TOOL FOR WELDING AND HYBRID TECHNOLOGIES

THE TASK

An important component of Fraunhofer IWS project work is the transitioning of processing and technologies to industrial manufacturing. Customer desires to overcome current technical limitations and their wishes for greater flexibility in using existing manufacturing equipment and for lower investment costs require new ideas and concepts for machines and system technologies. The development presented here was initiated during a feasibility study. The goal, the reconditioning of gas turbines on site, was impossible to achieve with conventional system technology. Inquiries from the aerospace industry also indicated a deficit in the available machine concepts. Therefore the following objectives had to be fulfilled:

- precise 3D processing of large parts with a length exceeding 10 m including the option of laser beam welding at depths of up to 20 millimeters,
- optional friction stir welding,
- integrated seam preprocessing (precise milling of the seam forming edges) without changing the part clamping,
- quick and easy alternation between milling and welding,
- optional mobile use of the process (on site processing at construction site) with low time and cost effort for transport and setup of the system.

OUR SOLUTION

The solution is based on expanding the application areas of a so-called Pentapod milling machine tool. Such machines are based on a parallel kinematic principle and need to move much less weight (about 10 %) than conventional CNC machines with similar working room, stiffness and positioning precision. Typically these machines are stationary (Figs. 1, 2). However, a proper modular design can transform them for mobile applications.

The IWS developed laser beam deflection optics (SAO series) was adapted to be used in Pentapod machines as an interchangeable tool. The optics is simply moved into position just like a conventional milling cutter. As a result these machines can now easily switch between milling (for example to prepare the seam) and welding operations. Fraunhofer IWS engineers also developed a multi layer narrow gap welding process, which is used for the mentioned large welding penetration depths.

In addition to laser beam welding the Pentapod is also applicable for friction stir welding applications (Figs. 3, 5). Again, the flexibility of using different processes proves advantageous: the combination with milling and laser welding helps to overcome known limitations of friction stir welding. For example, the friction stir welding process requirement of high contour precision can also be achieved for less precise parts by a preprocessing milling step. There is also the risk of shifting parts due to the high processing forces. A preprocessing laser tacking step reduces this risk. Gap formation and warpage are minimized when processing low stiffness structures such as aircraft fuselage structures.

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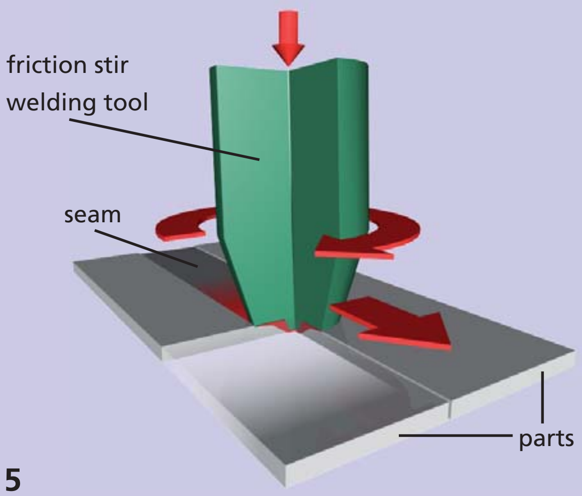
We also envision thermal and mechanical post processing steps for example to improve the long-term vibration strength by introducing compressive stresses or better material micro-structures.

RESULTS

At IWS laboratories we demonstrated the feasibility to expand the Pentapod concept to new joining and process combinations as well as mobility. We used an equally easy to transport fiber laser. Fig. 4 shows examples of tools that can be interchangeably used in the machine: a laser welding head, a milling cutter and a tool for friction stir welding.

Recently the IWS received substantial funding from the State of Saxony and the EU to invest in a large field Pentapod machine (workroom 5 x 2 x 2 m^3) for in-house development work (Figs. 1, 2). The goal is to develop further process technologies and to introduce the concept to the aerospace industry.

Principle sketch of friction stir welding



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1 *Outside view of the new stationary large field Pentapod system at the Fraunhofer IWS*

2 *Large field Pentapod with far extended main spindle*

3 *Deployment of the stationary system for the friction stir welding of aluminum structures*

4 *Adapted beam deflection optics as an interchangeable tool for the Pentapod, as well as milling cutter and a friction stir welding tool for comparison*

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