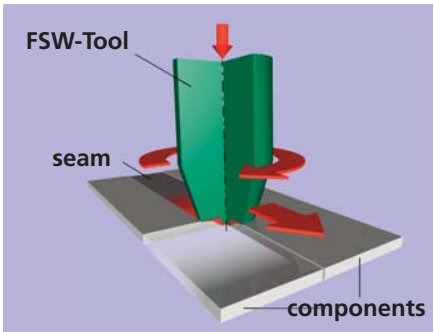
Fraunhofer IWS Dresden

FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS

FRICTION STIR WELDING OF 3D STRUCTURES

Cost- and energy-efficient joining of complex components made of aluminum materials



Principle of FSW

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Problem

Friction stir welding (FSW) is a cost-effective and energy-efficient alternative to conventional joining techniques. Given the high process forces and the correspondingly massive and costly construction of Cartesian FSW machines, however, applications in series production have so far been mainly limited to flat sheet metal parts, profiles or rotationally symmetrical components.

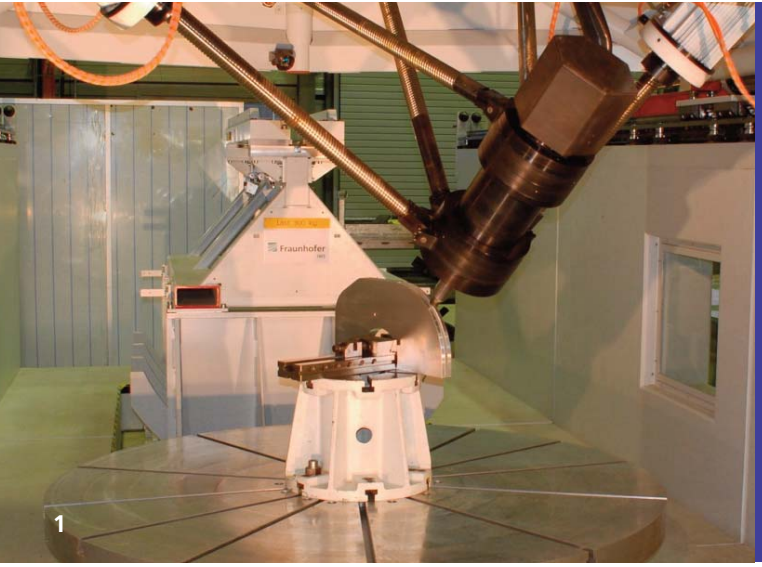
Tests on lower-cost robot systems show that, while they can process more complex component geometries, they are still subject to significant limitations regarding the achievable process forces (and maximum weld seam depth), path accuracy and working space.

Solution

Fraunhofer IWS is promoting the advancement of the FSW process onto complex, three-dimensional structures and flexible or slack components. The solution is based on a novel, fully 3D-capable parallel-kinematic machine concept.

Principle of FSW

FSW is a mechanical joining technique that joins butted pieces in solid phase. The FSW tool is a cylinder with a pin and a shoulder. The latter applies force to the material surface, softening the material. The pin, which penetrates into the material, regulates the flow of material. This produces a fine-grained, thermomechanically treated structure in the seam.



3D Motion Machine

The process was carried out on a 3D-capable milling centre based on the concept of parallel kinematics - a so-called pentapod (Fig. 1). The process control strategies were implemented in cooperation with the machine manufacturer Metrom GmbH. The machine concept permits both three-dimensional friction stir welding of complex components and upstream mechanical processing of the joints in a clamp. By simply replacing the conventional processing head with a laser deflection optics, developed at IWS (SAO series), this tool now allows the combination of laser welding and friction stir welding in one machine for the first time (Fig. 2a, 2b).

Advantages of IWS's Approach

Benefit from the typical advantages of FSW:

- joins materials that are difficult to weld using fusion welding techniques, such as Al casting materials
- low component distortion
- no filler materials required
- joins different metals without forming intermetallic phases (e.g. Al–Cu)
- high strength

Advantages of the New System Concept:

- more simple and less expensive system installation
- large working space
- high stiffness and position accuracy
- quick and flexible process control

Results

The presented system and control concepts have yielded reproducible, high quality welding results on planar and complex components.

Possible material thicknesses of Al sheet:

- max. 5.0 mm (one-sided FSW)
- max. 10.0 mm (two-sided FSW)

Possible Applications

Components with complex geometries from the industries:

Vehicle Manufacturing

- car body parts and tailored blanks made of Al sheet
- gearbox housing made of cast Al materials
- aluminum-copper joints for e-car batteries
- profile and sheet joints

Rail Vehicle Manufacturing

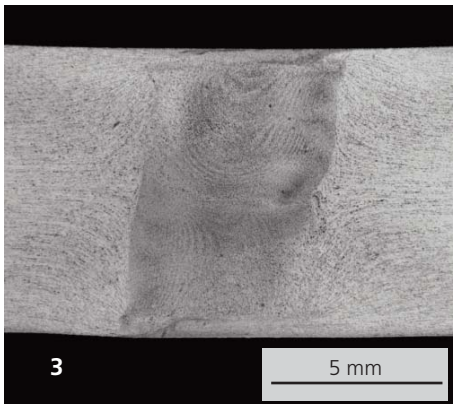
- body parts made of Al sheet

Shipbuilding

- Al sheet components
- Al hull structures

Aerospace

- aircraft fuselage structures
- Al profile joints (floor structures, stiffeners)



1 FSW process on 3D milling centre – Pentapod

2 Milling (a) and subsequent laser welding (b)

3 Micrograph, 8 mm sheet (two-sided FSW)

Characteristics of the Machine Tool

System:	fully 3D-capable, 5-axis parallel kinematics
Control principle:	force/torque/position control
Control frequency:	max. 500 Hz
Working space:	6.5 x 2.0 x 1.5 m^3 (L x B x H)
Working force:	1.0 to 12.0 kN