Description

Process schematic

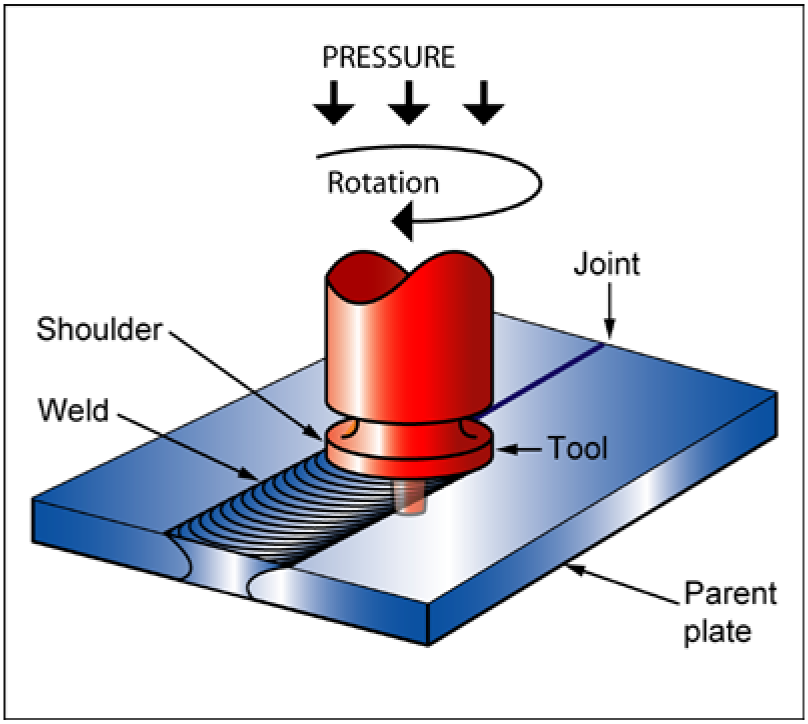

Figure caption

Friction-stir welding relies on frictional heating and intense plastic flow to create a bond.

The process

In FRICTION-STIR WELDING a non-consumable, rapidly rotating, tool is pushed onto the materials to be welded. The central pin and shoulder contact the two parts to be joined, generating frictional heat that plasticizes the material. As the tool is made to traverse the joint line, material from its front is swept around to the rear, creating an intimate bond.

The weld quality is excellent, and the process is environmentally friendly. No melting takes place so volume changes caused by solidification are avoided; residual stress and distortion are low. The process is at present used to weld aluminum, magnesium, zinc and lead alloys, but developments to allow welding of copper, titanium and steel are expected. Joints between dissimilar metals (e.g. Mg alloys to Al alloys) and between metal-matrix composites are practical.

Material compatibility

Metals - non-ferrous	✓

Function compatibility

Electrically conductive	✓
Thermally conductive	✓
Watertight/airtight	✓
Demountable	✗

Joint geometry compatibility

Lap	✓
Butt	✓
Scarf	✓

Load compatibility

Tension	✓
Compression	✓
Bending	✓
Peeling	✓

Economic compatibility

Relative tooling cost	medium
Relative equipment cost	medium
Labor intensity	low

Physical and quality attributes

Mass range	0.1	-	100	kg
Range of section thickness	1.2	-	50	mm
Unequal thicknesses	✓			
Processing temperature	100	-	700	°C

Process characteristics

Discrete	✓
Continuous	✓

Supporting information

Design guidelines

Butt, lap, T, fillet and corner welds are practical. Dissimilar materials can be

Technical notes

The quality of the weld is high - as good as the best fusion welds, and with less chance of flux or inclusions being trapped in the weld. Residual stress and distortion are low. The heat-affected zone is much smaller than for fusion welds. All wrought and most cast aluminum and magnesium alloys can be friction-stir welded -- the process is at present commercially used for 2000, 6000 and 7000 series aluminum alloys and AZ series magnesium alloys. Recent developments of the method are expected to allow welding of copper, titanium and steel. The process lends itself to automatic control. There are just three process variables: rotation speed, traverse speed and pressure.

Typical uses

The process has application in shipbuilding and marine structures, in land-based transport systems and in construction. Specific examples are listed below. Shipbuilding and marine: deck panels, hulls, superstructures, offshore accommodation, masts and booms. Aerospace: wings, fuselages, cryogenic fuel tanks for space vehicles, rocket casings, and fuel tanks. Rail transport; high-speed train carriages, rolling stock, tankers, goods cars. Road transport: wheel rims, space frames, truck bodies, caravans, motor cycle and bicycle frames, including joints between aluminum and magnesium. Construction: aluminum bridges, window frames, facade panels, pipe fabrication, heat exchangers.

The economics

The process is cost effective when a high-quality weld with minimal internal stress is

The environment

The process is environmentally friendly, produces no fumes or toxic waste, and creates no arc glare or reflected laser beams.

Links

MaterialUniverse

Reference