# Stationary Shoulder Friction Stir Welding (SSFSW) for Joining Titanium Alloys

**PUBLISHABLE SUMMARY**

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## Background

Friction stir welding (FSW) has been the subject of very rapid development and exploitation across the world, since its invention, by TWI, in 1991. The range of components for which FSW is used is continuously expanding. However, for production use, the technology currently remains firmly focused on joining of aluminium alloys. FSW of materials other than aluminium has been a topic of much research since the early days of development of the technology, and significant interest exists in the application of FSW to titanium alloys, where the process may offer the following benefits:

- Production of high quality, solid-phase, welds.
- Achievement of excellent weld mechanical properties.
- Relatively low distortion/shrinkage of welded components.
- High efficiency welding with low energy consumption.
- Ability to join non-fusion-weldable grades.

TWI has been working on the development of FSW for Ti alloys since 1995, and has recently achieved a significant breakthrough in this area via the development of a new variant of the FSW process called Stationary Shoulder Friction Stir Welding (SSFSW). Initial trials at TWI using the SSFSW approach for the joining of Ti alloys have been very encouraging. This novel approach potentially offers a new welding process for Ti alloys that may offer significant technical and economic advantages over conventional methods. This Project further developed and assessed this important new variant of FSW and demonstrated its application to Ti alloys.

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## Objectives

This Joint Industry Project aimed to optimise the SSFSW process to deliver repeatable, high quality joints in Ti alloys, and to assess the benefits offered by this new approach. The project had the following key objectives:

- Demonstrate and assess the SSFSW of Ti alloys.
- Develop effective welding procedures for a range of test cases in Ti alloys.
- Improve SSFSW parameters, tool designs and tool materials for Ti alloys
- Assess weld stability and process reproducibility.
- Evaluate weld properties and weld integrity.
- Assess tool performance, lifetime and process economics.

## Project Outcome

Regular e-mail progress statements were issued during the project. In addition reports were issued in advance of scheduled six-monthly meetings during the project. The project outcomes included the following:

- Recommendations for welding parameters and tool designs to weld Ti alloys.
- The maximum permissible welding speed achieved for SSFSW of Ti for specific applications.
- Results to verify weld stability and process reproducibility.
- Metallographic and mechanical data from selected welds.
- Estimated tool performance and lifetime expectations.
- Economics of the application of the SSFSW process.

## Benefits

The development of SSFSW for the joining of Ti alloys offers the following potential benefits:

- A new welding approach capable of reliably producing high quality solid-phase welds in a wide range of Ti alloys.
- Achievement of near-parent mechanical properties in Ti alloy welds.
- Production of Ti welds with excellent surface finish and no reduction in cross-section.
- Improved control of process heat input to provide a high efficiency, low energy consumption, welding technique.
- Improved friction stir tool lifetime and process economics for the joining of Ti alloys.
- Improved flexibility for Ti applications via enhanced process stability and reduced shoulder reaction forces.

## Participants

The Sponsor Group Comprised:

- The Boeing Company
- Rolls-Royce plc

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## Scope of Work

## Price and Duration

The project had a duration of 2 years and a budget of £80,000. It was funded by 2 Sponsors each making a contribution of £40,000. The fee for additional companies buying back into the project results is £40,000.

## Further Information

For further information on Joint Industry Projects (JIP) and their operation, please visit

http://www.twi.co.uk/services/research-and-consultancy/joint-industry-projects/

**JIP Co-ordinator:** Tracey Stocks

**Ref:** 17779/13-1/15

**Email:** jip@twi.co.uk

**Project Leader:** Dick Andrews

**Email:** dick.andrews@twi.co.uk