Friction Welding

Friction welding is classified as a solid-state welding technique, where joining takes place through intensive friction which locally heats the workpiece material into a plastic state in conjunction with an applied force. Since there is no bulk melting of the workpiece, common problems associated with fusion welding such as solidification cracking, porosity and the loss of volatile alloying elements are avoided.

Due to the high temperatures and cooling rates, as well as the extensive thermomechanical deformation associated with friction welding techniques, there are considerable changes in the microstructure and texture of the weld region leading to changes in the mechanical properties. Transient thermal cycles and mechanical deformation also lead to the development of strong residual stresses within the weld, albeit they are much lower than in conventional fusion welds.

Research work has combined microstructural characterisation using electron and optical microscopy, structural integrity (i.e. mechanical property) assessment and neutron and X-ray diffraction to improve the understanding of the process mechanisms.

Project Description:

Title (Sarah Baker – EngD)
Friction Stir Welding (FSW) of Titanium Alloys:

Description:
The main obstacle of FSW titanium alloys is the development of a tool material that can withstand the high temperatures (≥1000°C) and strains associated with the process, whilst being inert with the highly reactive titanium workpiece at typical FSW temperatures. This severely limits the choice of tool materials. There has been a growing interest in the use of FSW to join aerospace titanium structures, especially to replace other joining technologies (e.g. electron beam welding). However commercial advancement awaits the development of cost effective and durable FSW tools, that can avoid wear and deposition of wear tool debris and resist the likelihood of sudden brittle failure whilst rotating and traversing through the workpiece material.

In the project, a number of tools of different materials (refractory based and ceramic) have been used to join 8 mm thick titanium sheets. Although the different tools seemed to produce sound welds, in-depth microstructural, mechanical property and residual stress characterisation was necessary to assess the tool influence on the weld properties.

The project also focuses on developing a fully coupled thermomechanical FEA model of the FSW process, capable of predicting the microstructure, mechanical property and residual stress development within a friction stir weld. Therefore
reducing the costly expense of weld trials and enabling optimisation of the welding process parameters.

**Title (jian Yang – PhD):**
Process Characterisation and Structure-Property Modelling of Ni-based Superalloy Linear Friction Welds

**Description:**
Ni-based superalloy is a class of high temperature alloys, which have been widely used in the critical components of gas turbine engines. This project utilizes Linear Friction Welding (LFW), a novel solid-state joining process, to manufacture nickel-based bladed disk (blisk). It is believed that the development of Ni-based blisks through LFW can result in more significant weight saving and cost saving benefits.

There are two aims in this project. First, utilising residual stress, microhardness, microstructural characterisation to study the effect of process parameters on welds microstructure and property. Second, to model the phase variation during LFW by understanding the phase transformations kinetics under rapid heating.

**Key Partners:**
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The EBSD image of grain size variation at the weld line of IN718-IN713LC LFWs