# APPENDIX K

## Friction Stir Welding

## presented by T. Khan

# Thermal Modelling of the Friction Stir Welding Process

Proposal for an Exploratory GARTEUR Group

## Goal

Friction stir welding is a promising solid state joining technique invented at TWI in 1991. Final static fracture of a friction stir welded age-hardenable aluminium alloy usually occurs in the heat affected zone (HAZ) near the weld in the parent material. The microstructural changes caused by frictional heat are therefore responsible for the loss in strength of the welded structure.

The final goal of the project is to develop a thermal model which predicts the temperature versus time history of selected zones in the HAZ. With this information the microstructural changes in the HAZ and therefore the optimum heat flow and balance during the weld can be identified.

In a given window of rotational and welding speeds producing sound welds, the backing plate and clamping materials could be chosen is such way, that their heat conductivity and capacity helps to achieve optimum heats and cooling rates in the HAZ.

## Thermal Model

The welding process is simply simulated as a heat source. The material flow during the stirring process is not investigated here. On the other hand, special emphasis is given to the heat losses and flow in the backing plate, the clampings and the surrounding atmosphere. As already stated before, the model can than be used for parametric studies in which the backing plate and clamping materials as well as the surrounding medium are varied.

## DLR's Contribution

With it's unique, fully instrumented friction stir welding machine, DLR will concentrate on input and verification data generation.
During FSW of 4 to 6 mm thick age hardenable aluminium alloys following data will be recorded :

- tool loads in x-, y- and z-direction
- tool axis (z) torque
- tool shoulder temperature
- data of up to 16 thermocouples positioned at various locations on the welded plates.

The tool loads and temperature are mainly needed to relate the action of the tool to the heat generation, whereas the model itself is verified by comparing the predictions with the temperature versus time profiles measured with the thermocouples.

## NLR and ONERA's Contributions

Both NLR and ONERA have already developped thermal modelling of FSW process, but in two different ways. These two models will be used in the project with special emphasis upon the effect of boundary conditions. The calculated temperature fields will be verified in two ways :

- by comparizon to experimental temperature measurements provided by DLR ;
- with reference to an analysis of microstructural variations induced by the welding process. In that respect, the metallurgical temper achieved in the different weld

zones will be determined by examinations of relevant microstructural parameters (such as hardening precipitation) and by measurements of hardness profiles through the joints. This microstructural work will be shared by NLR and ONERA.

**Provisional schedule**
This work is planned to be performed within one year.

**Extension of the Exploratory Group**
DLR, NLR and ONERA will favour extension of this EG. In a first step, industrial partners from aeronautics will be invited to take part to the project.

**Contact persons**


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|---|---|---|
| ONERA: | Gilles Lapasset, | Email: Gilles.Lapasset@onera.fr |
| DLR: | Claudio Dalle-Donne | Email: Claudio.Dalle-Donne@dlr.de |
| NLR: | Arij de Koning | Email: akoning@nlr.nl |
| | Ludmila Velterop | Email: velterop@nlr.nl |