wissen schafft nutzen

# Bobbin Tool FSW
# A Moving Geometry Model

GKSS FORSCHUNGSZENTRUM in der HELMHOLTZ-GEMEINSCHAFT

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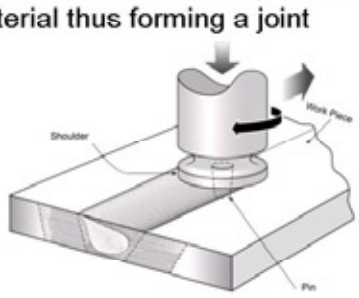
## Motivation

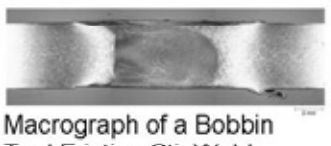
**Friction Stir Welding (FSW)**

- FSW is a solid state joining process
- A rotating tool is traversed along the joint line between two pieces of base material.
- It generates frictional heat, plasticizes and mixes the material thus forming a joint



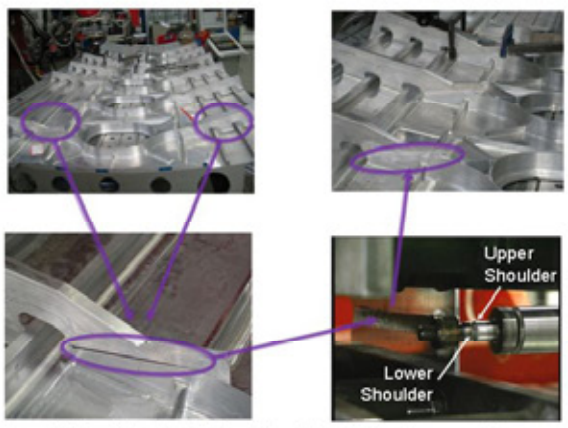


Example of a Bobbin Tool


Macrograph of a Bobbin Tool Friction Stir Weld

**Bobbin-Tool: Advantages**

- A FSW bobbin tool consists of two shoulders connected by the pin.
- Rigid backing to counter act the process forces **is not required**
- Suitable to applications such as tubes and hollow profiles
- Consolidation forces are applied by the shoulders and not by the handling system.
- No risk of root flaws

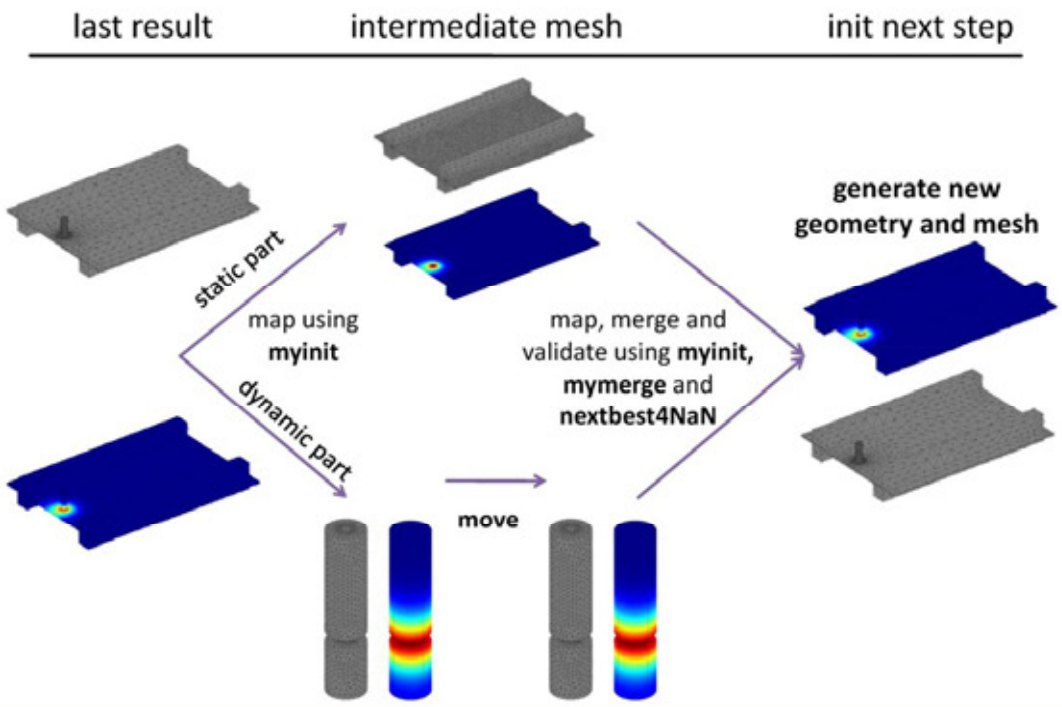


Robotic Bobbin Tool FSW of complex aircraft structure

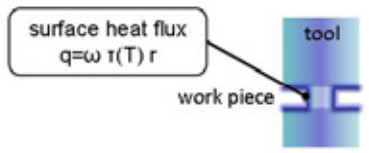
## Approach

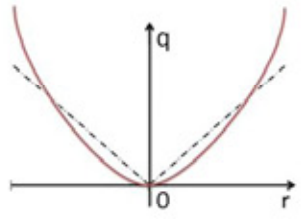
**Moving Geometry Model:**

- Matlab scripting allows for moving geometry
- The model is re-meshed for every time step
- Advanced mapping performed between time steps



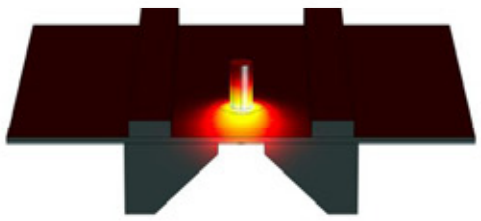

A Moving Geometry model based on a robust Thermal Pseudo Mechanical (TPM) heat source modelling approach has been developed.



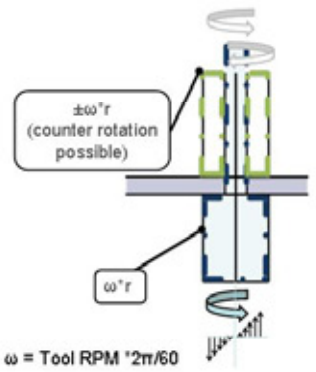




Heat is generated as a surface flux at the interface between the tool shoulders, pin and work piece.

TPM heat source: **q=ω τ(T) r**



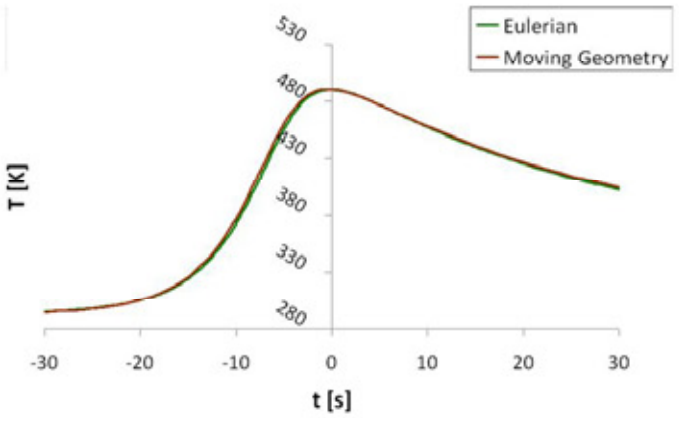
Tool rotation and translation are modeled as convective material flux




## Validation and Results

**Numerical Validation:**

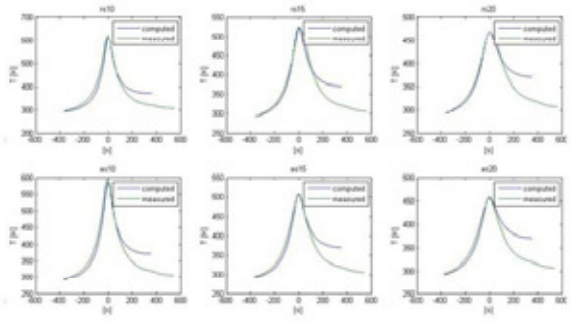
Model Comparison (RS, 10mm)




Comparison between Moving Geometry Predictions and a Eulerian reference model

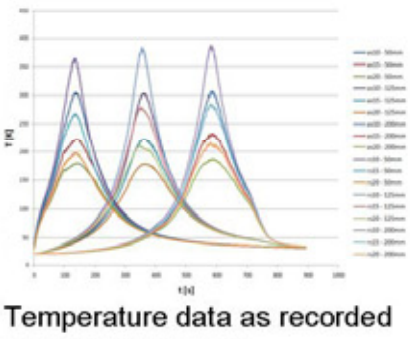
**Experimental Validation:**

- FlexiStir welding unit
- Aluminium 2024-T3, 4mm thick



Experiments show good agreement in $T_{max}$ and $\Delta P_{400}$ as well as temperature profile shape


FlexiStir unit


Temperature data as recorded with thermocouples

**Statistical Validation:**

| Variable | abs. mean | rel. mean | abs. std. deviation | rel. std. deviation |
|---|---|---|---|---|
| $\Delta T_{max}$ | -3.5 [K] | -0.6 % | 6.2 [K] | 1.1 % |
| ΔPeak width | 6.2 [s] | 3.3 % | 5.2 [s] | 2.9% |

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