

ScanSTIR - A HPC framework for modelling friction stir welding

Henrik Schmidt, HBS Engineering ApS

Beijing, May, 2014

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3 FEM model

4 CFD model

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- HBS Engineering focuses on numerical analysis of FSW
- 13 years experience in development of different models
- Modelling is used to get further understanding of FSW mechanism
- FSW is multi-physical in "nature" - calling for a palette of different models
- ScanSTIR is

- ...is the integrated modelling framework collecting all models developed by HBSE
- Super Computer Assisted Numerical Simulation of Thermo-mechanical Induced stResSES
- Super Computer Assisted Numerical Simulation of Thermo-mechanical Induced Responses
-or just Scan for Scandinavian

Overview of presentation

ScanSTIR - A
HPC
framework for
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- Modelling:
- ScanStir - HPC modelling framework
- Inspection:
- SignaStir - Laser Ultrasound testing system

Multi-disciplinary fields of ScanSTIR by HBSE

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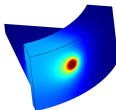
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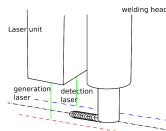
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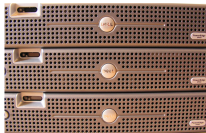
Computational Welding Mechanics



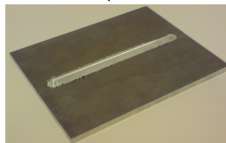
Laser Ultrasonic Testing



HBS Engineering



High Performing Computing



Friction Stir Welding

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Figure: 9 DELL PowerEdge Servers (50 cores / 128 GB)



Figure: Tesla M2070 GPU

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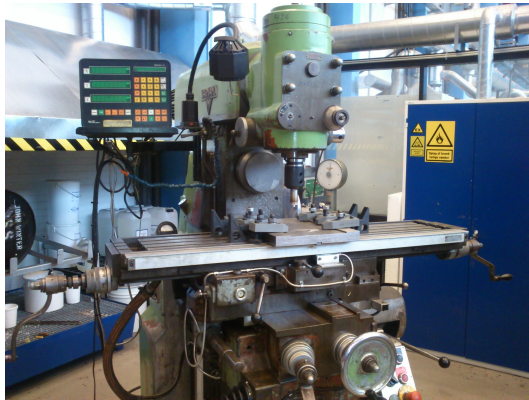


Figure: Rigid (old) milling machine

ScanSTIR FSW machines

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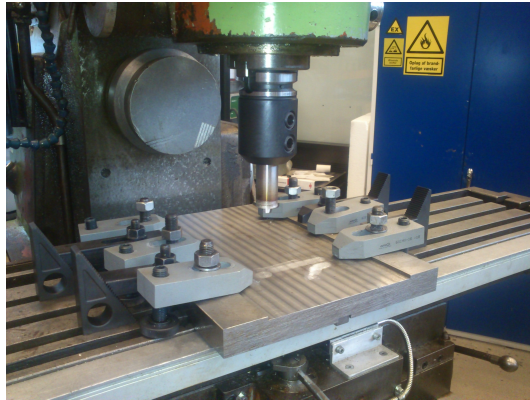


Figure: Welding Setup

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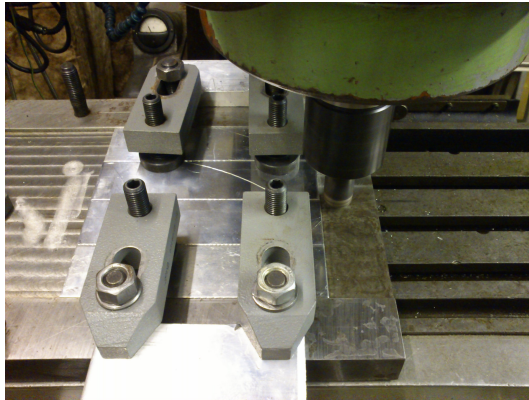


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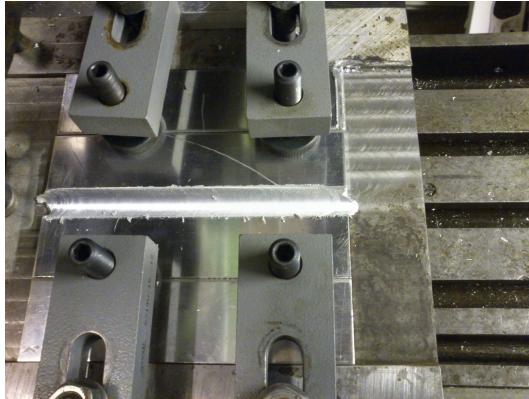


Figure: Welding Setup

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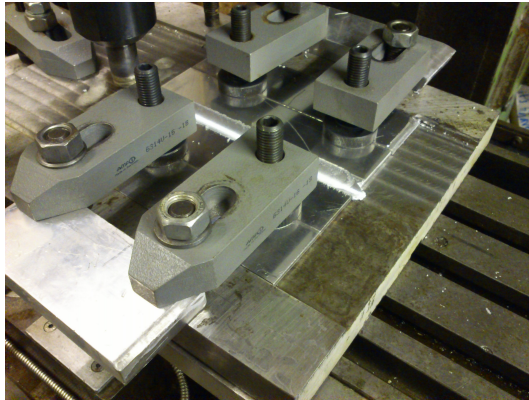


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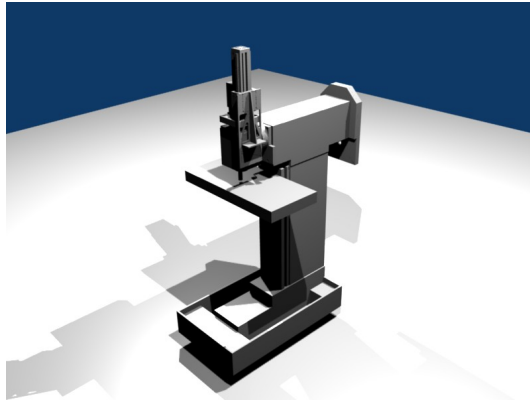


Figure: Modified CNC with modern Control System

- Simple analytical heat source models
- Thermal Pseudo mechanical model (TPM)
- Pseudo Frictional Flow model (PFF)
- Thermomechanical (residual stress and distortions)
- Laser Ultrasound Testing model

Benchmark residual stress model

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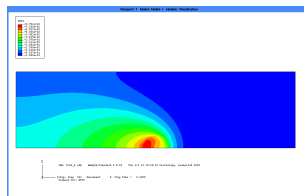


Figure: Abaqus model

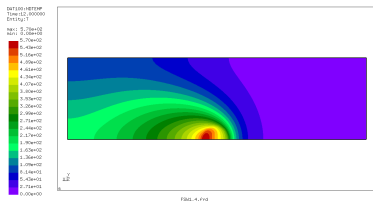


Figure: Calculix model

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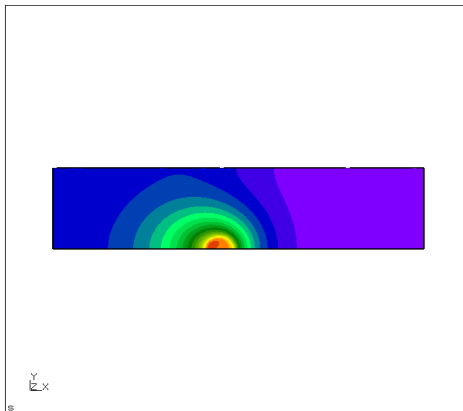
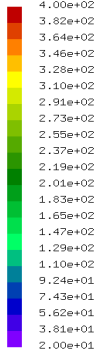
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min: 2.05e+01



calc06-mech.frd

Figure: Thermal distribution in Benchmark FSW weld

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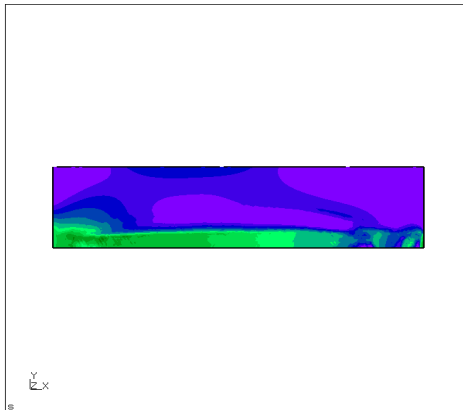
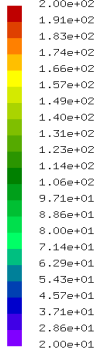


Figure: Stress distribution in Benchmark FSW weld

Benchmark residual stress model - 200 MPa yield stress alloy



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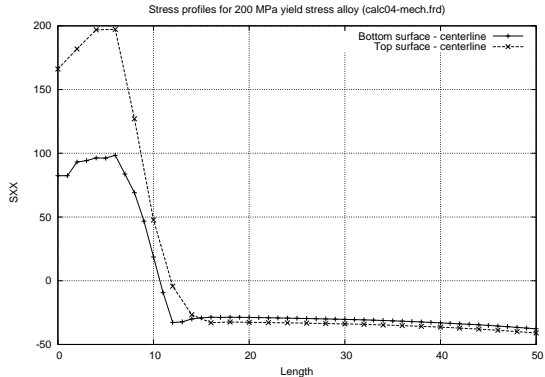


Figure: Stress distribution in Benchmark FSW weld

Benchmark residual stress model - 100 MPa yield stress alloy



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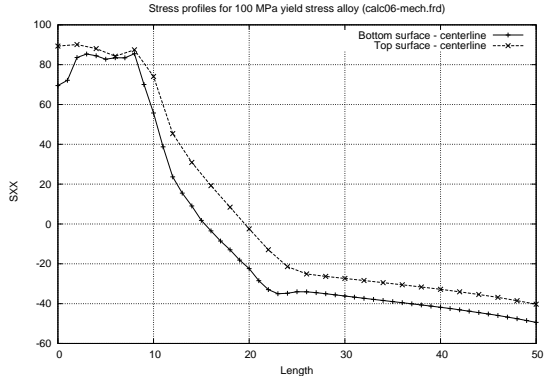


Figure: Stress distribution in Benchmark FSW weld

Benchmark residual stress measurements

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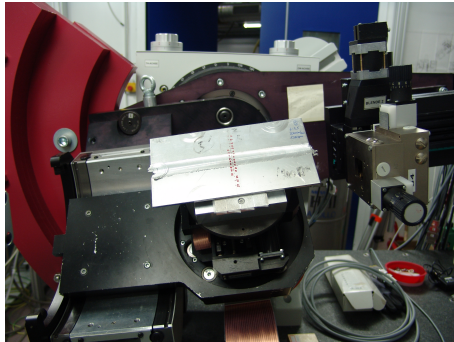


Figure: Helmholtz-Zentrum Berlin, Synchrotron Radiation Facility BESSY II, EDDI - Energy Dispersive Diffraction Station within the Science-Link EC FP 7 project

Benchmark residual stress measurements

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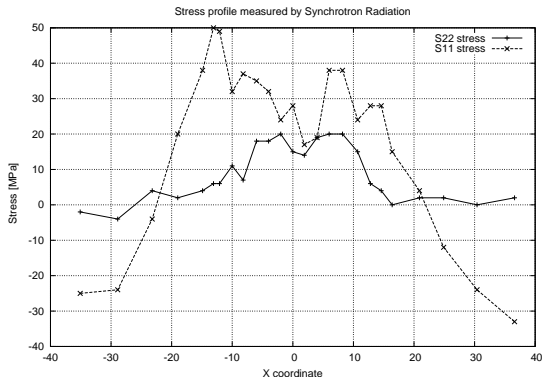


Figure: Measured stress distribution in Benchmark FSW weld

- Steady state CFD model with symmetrical tool - 2D flow pattern is expected
- The present transient CFD model with symmetrical tool shows transient unstable flow!
- The high mesh density model solved by the ScanStir HPC show:
 - upward (vertical) material flow at the leading retreating side
 - downward (vertical) material flow at the trailing advancing side

Flow model with non-uniform contact condition

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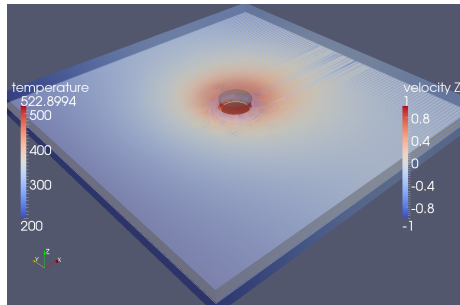


Figure: 3D flow field around FSW tool with conical probe

Flow model with non-uniform contact condition

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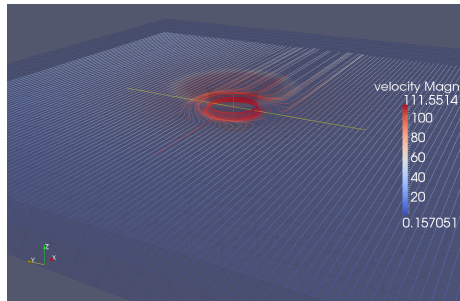


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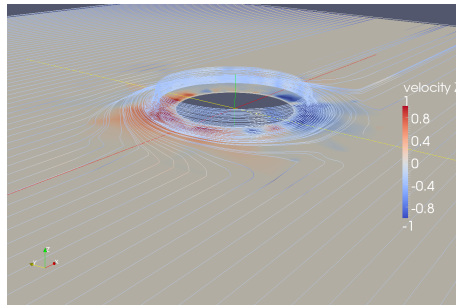


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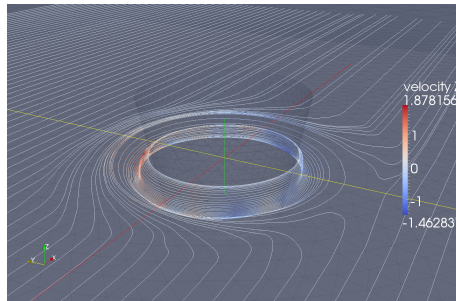


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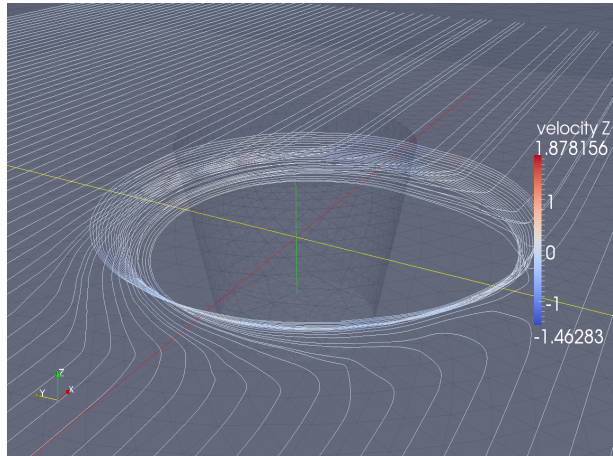


Figure: 3D flow field around FSW tool with conical probe

- Calculix as alternative to Abaqus
- Elmer as alternative to Comsol
- Octave as alternative to Matlab
- FreeCAD as alternative to Creo
- Benefits of Open-Source

- ISPL (Polish Welding Institute)
- SKB copper cannister project
- Science Link
- SignaSTIR EU project

SKB Copper Canister - Residual stress field

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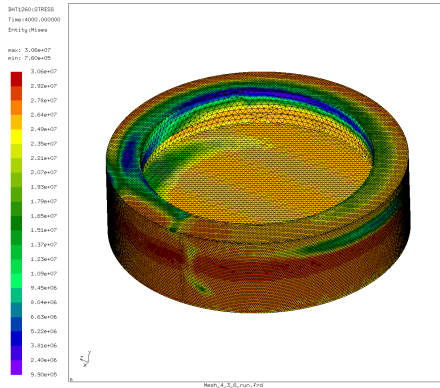


Figure: Stress field after welding

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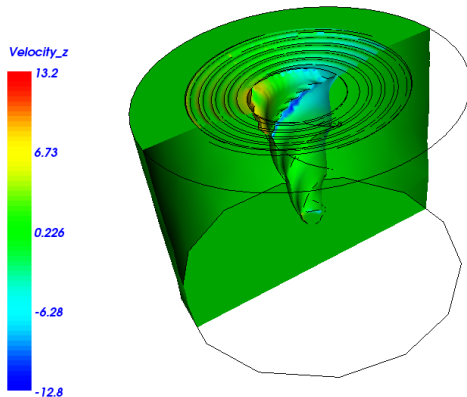


Figure: Flow field in model included scroll shoulder

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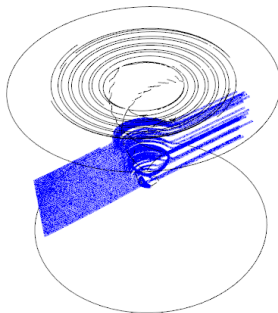


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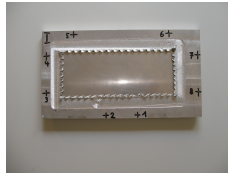


Figure: Cooler workpiece

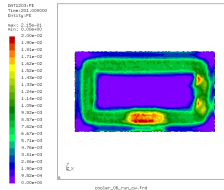


Figure: Plastic strain field after welding

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- SignaStir - Laser Ultrasound testing system
- RTDs: TWI, ISPL, Swerea Kimab
- End Users: SAPA
- SME's: Inspectahire, Rubitech, BCT and HBS Engineering

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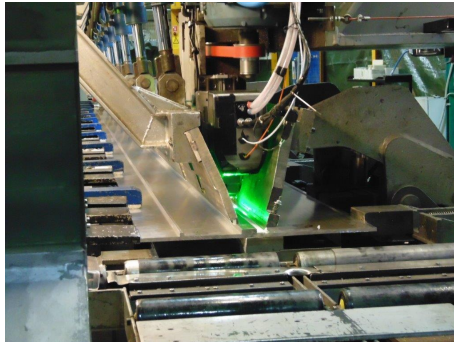


Figure: Experimental trial at SAPA

Inspection - SignaSTIR LUT

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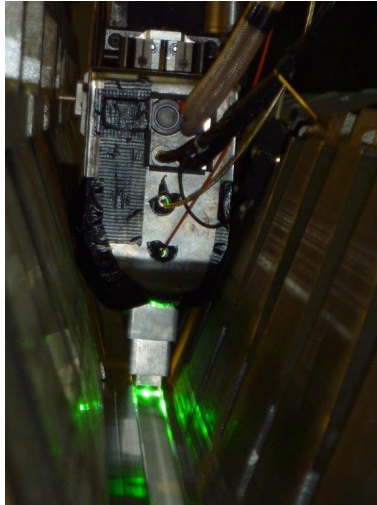


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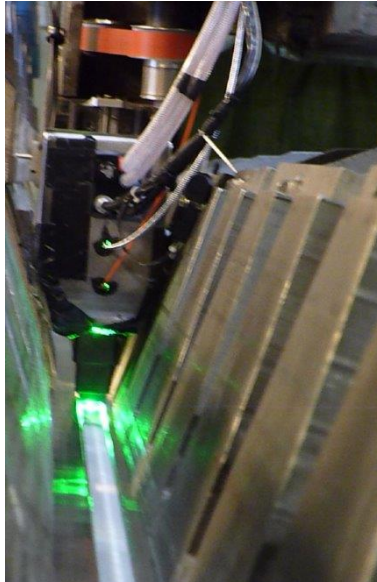
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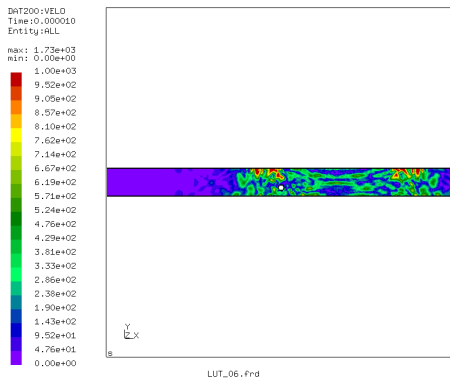


Figure: Wave propagation

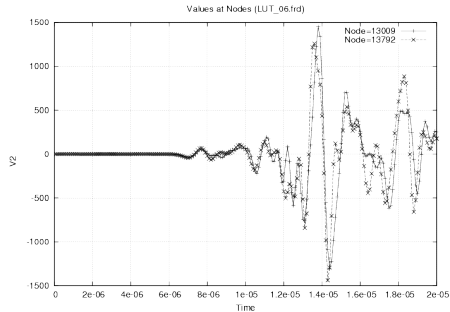


Figure: Velocity history with and without voids

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- Acknowledgment:
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 - Science-Link - funded by EC FP 7
 - Helmholtz-Zentrum Berlin and Technical University of Denmark

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