

# Thermo-mechanical modelling of FSW Copper Canister

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## 1 Introduction

## 1 CFD

## 1 Model description

## 1 Oxide

## 1 Thermal model

## 1 Summary

- HBS Engineering focuses on numerical analysis of FSW
- 12 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

# Overview of FSW models

Thermo-  
mechanical  
modelling of  
FSW Copper  
Canister

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CFD

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description

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Thermal  
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Summary

- Flow model material flow (CFD)
- Thermo-mechanical model for residual stress and distortion

- unsymmetric features can be resolved
- viscous dissipation accounted for
- full sticking assumed
- frictional dissipation is not accounted for
- elastic response is not accounted for
- void formation is not accounted for

- Prescribed velocity boundary condition
- Sliding wall boundary conditions
- Tangential wall speed  $\omega r$
- Vertical velocity is not constrained
- Strain rate exponent  $m = 0.2 - 0.1$
- Johnson-Cook paper....Copper:  $m = 0.025$
- CPU time : 1.6 mill sec. - 18 days
- Development of HPC cluster reduced calculation time

- The joint line oxide interface is not sufficiently deformed
- Investigation of shifting welding direction
- The 4 mm offset in the canister will be shifted towards the advancing side
- What is the effect?
- Will the jointline be more disrupted?

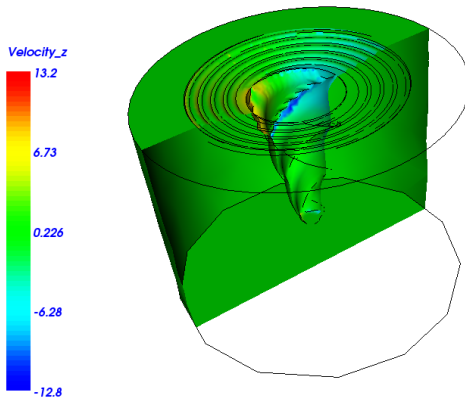


Figure: Flow field in model included scroll shoulder



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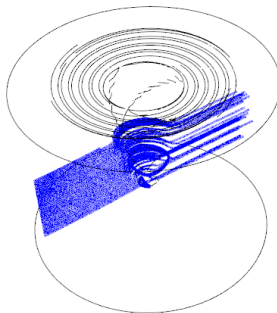


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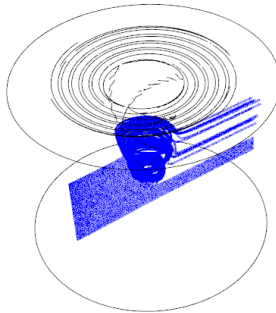
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**Figure:** Flow field in model with joint line offset towards the advancing side

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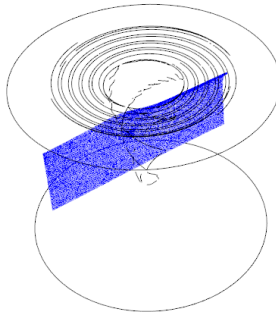
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**Figure:** Flow field in model with joint line offset towards the retreating side

- Development of thermal model to simulated temperature fields and thermal expansion
- Comsol for testing, Calculix/Abaqus for final application

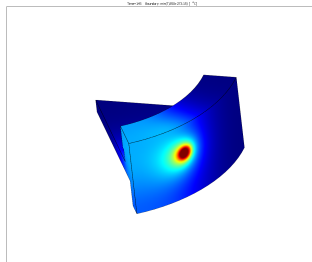


Figure: Temperature field in 60 degree section of canister

# Temperature history

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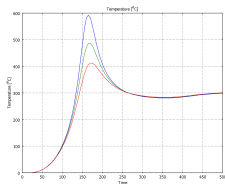
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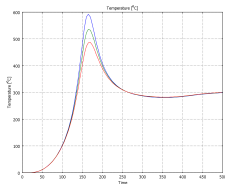
Oxide

Thermal  
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Summary



**Figure:** Temperature history in 60 degree section of canister.  
Transverse position 20, 30 and 40 mm



**Figure:** Transverse position 20, 25 and 30 mm

# Full model of canister - 360 degree

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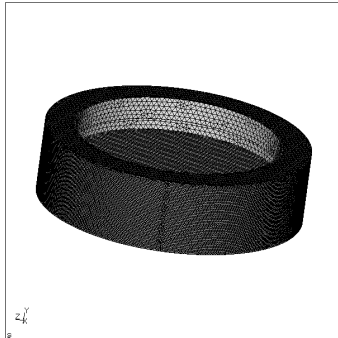
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Summary



E:\SKBrun\cannister360\Coppy of Mesh\_4\_3\_5\_run.fnd

Figure: Mesh in 360 degree model of canister

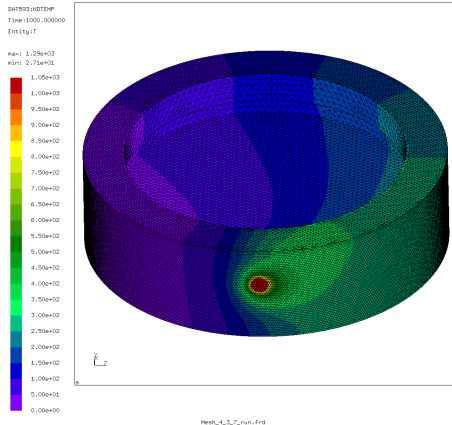


Figure: Temperature field during welding

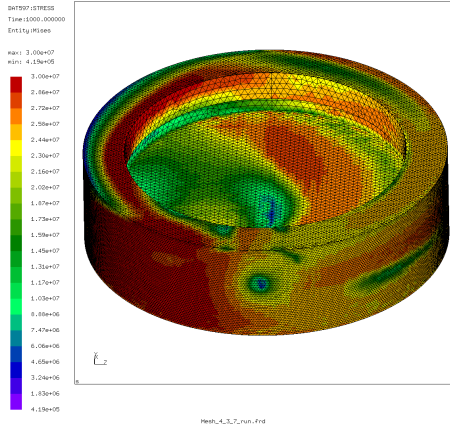


Figure: Stress field during welding



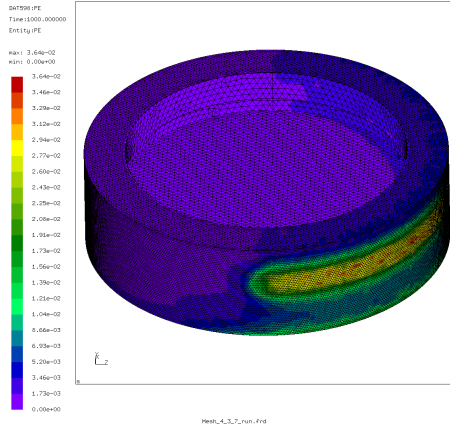


Figure: Plastic strain field during welding

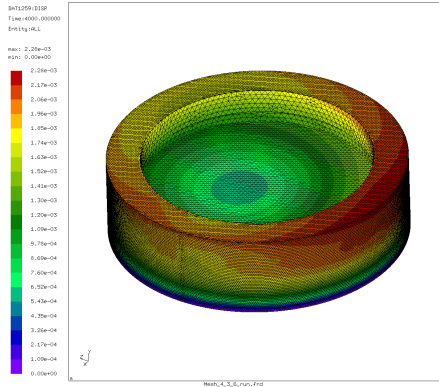


Figure: Displacement field after welding

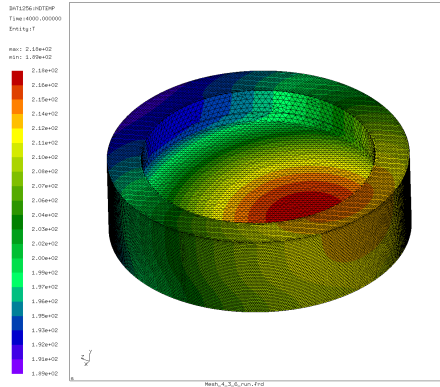


Figure: Temperature field after welding

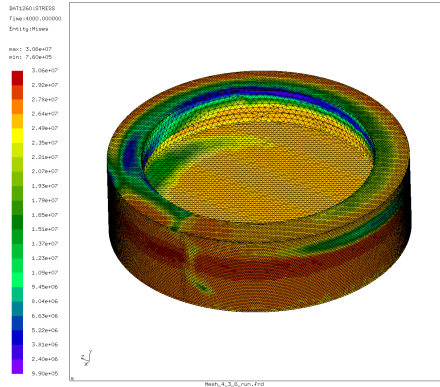


Figure: Stress field after welding

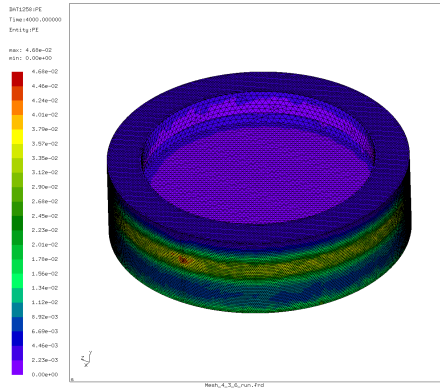


Figure: Plastic strain field after welding

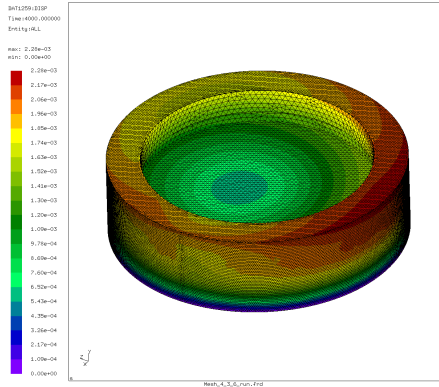


Figure: Displacement field after welding

- Preliminary results of CFD model
- Preliminary results of thermo-mechanical model
- Further improvement of the models.
  - Experimental material data of SKB specific copper
  - Far-field thermal boundary condition
  - Fine-tuning of heat source model to avoid over prediction
- Making coupling between the models