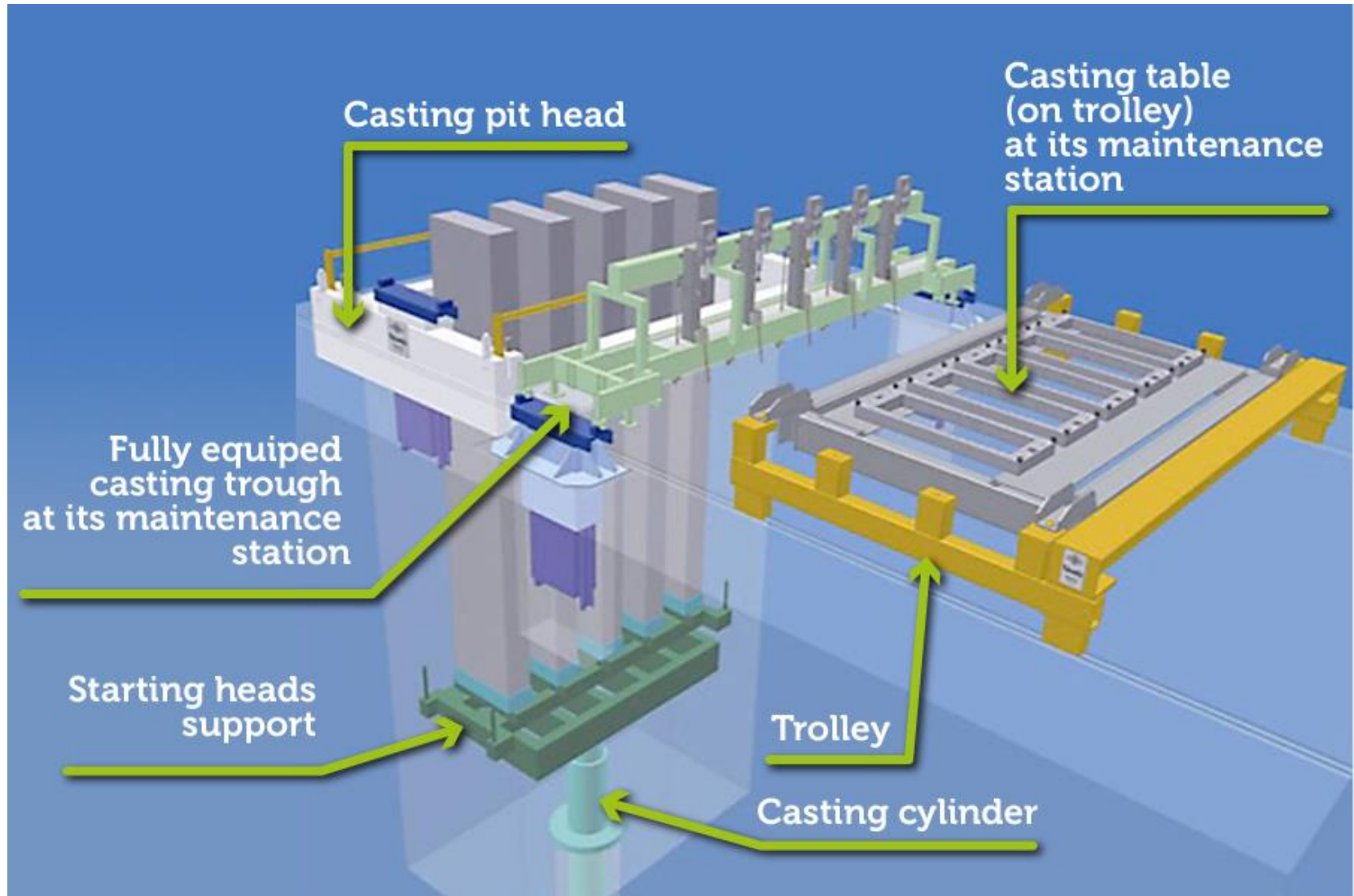


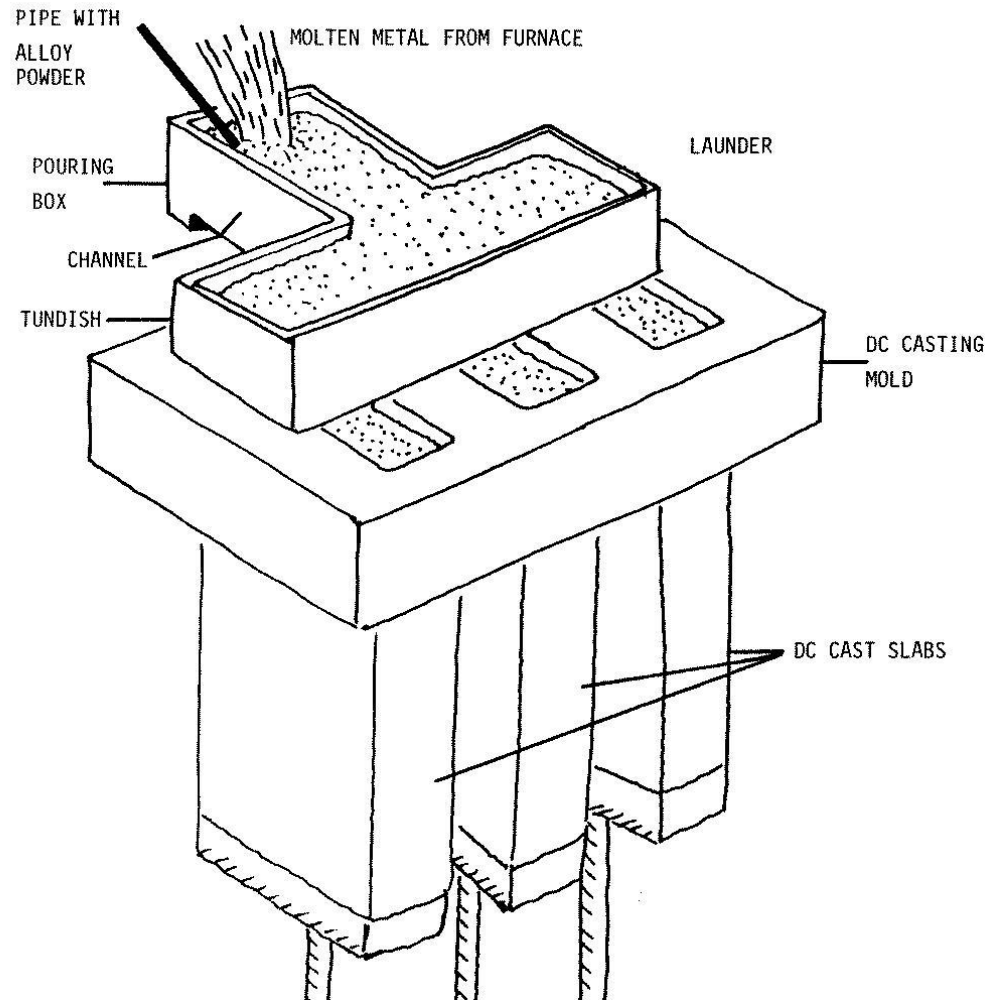
Modeling the Effects of Contact between a Solidifying Metal and a Water Cooled Mold

Ernesto Gutierrez-Miravete,
Rensselaer at Hartford

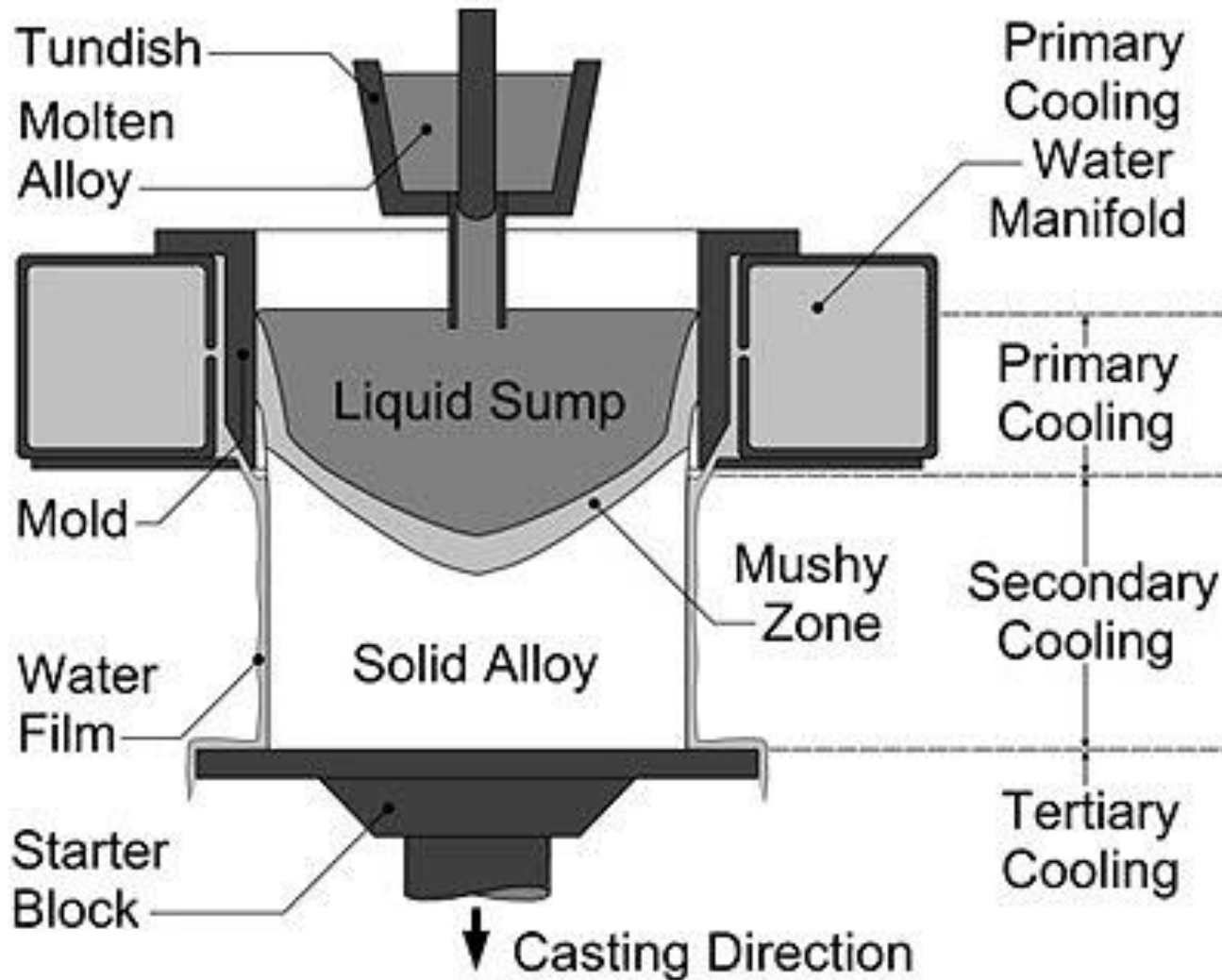
Direct Chill Casting Process



DC Casting Machine - Schematic



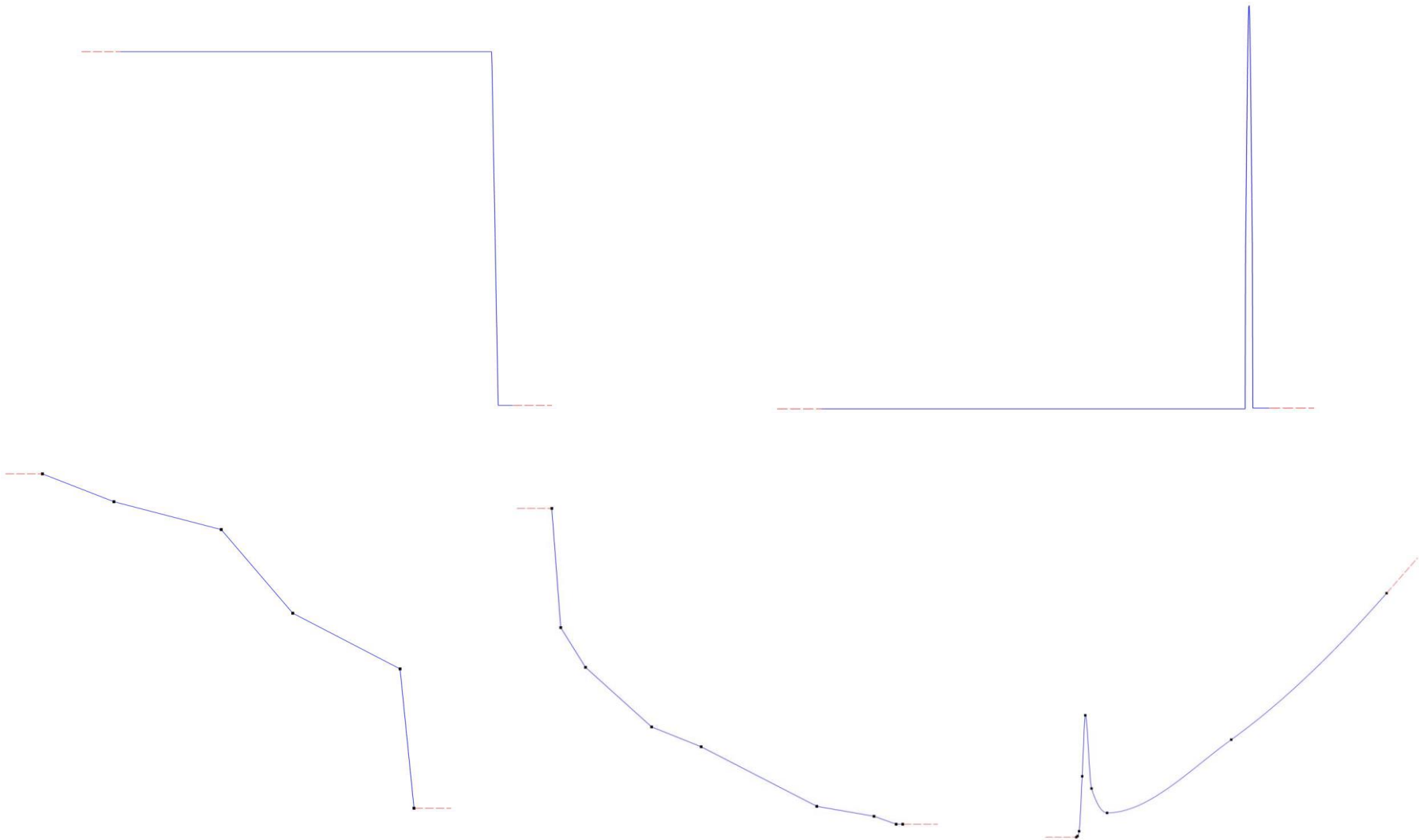
DC Casting – Broad Side View



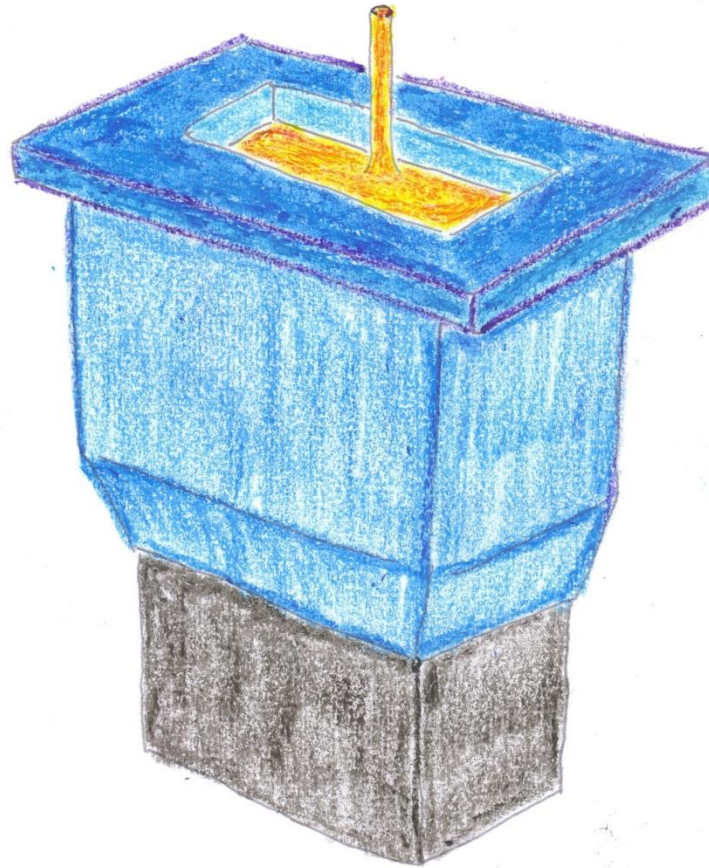
Characteristics

- Operational Objective: Steady State Conditions
- Multi-Physics: Continuum Mechanics and Heat Transfer with Change of Phase
- Temperature Range: 298 – 1400 K
- Temperature Dependent Material Properties
- Multiple Complex Boundary Conditions
- Deformation due to Thermal Stress
- Casting-Mold Contact sensitive to Deformation
- Multiple Non-Linearities

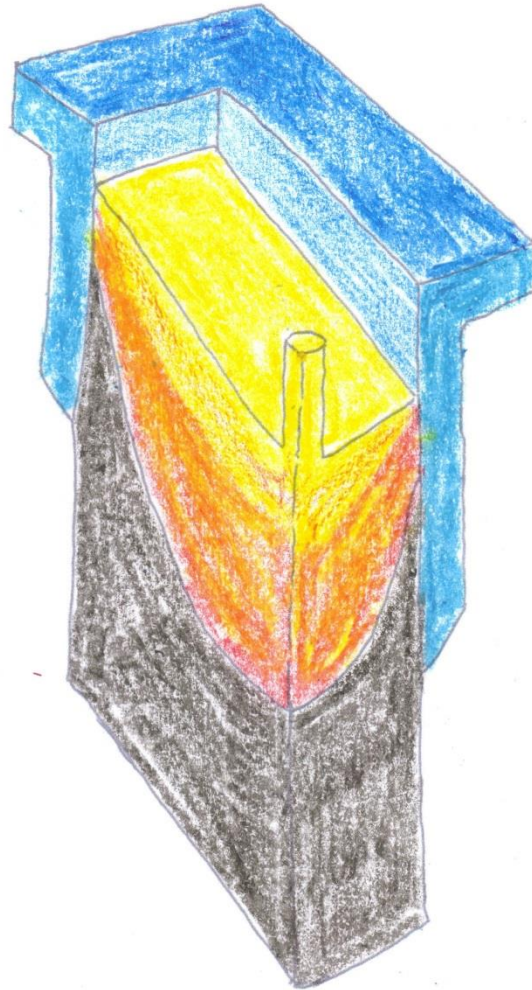
Temperature Dependent Input Data



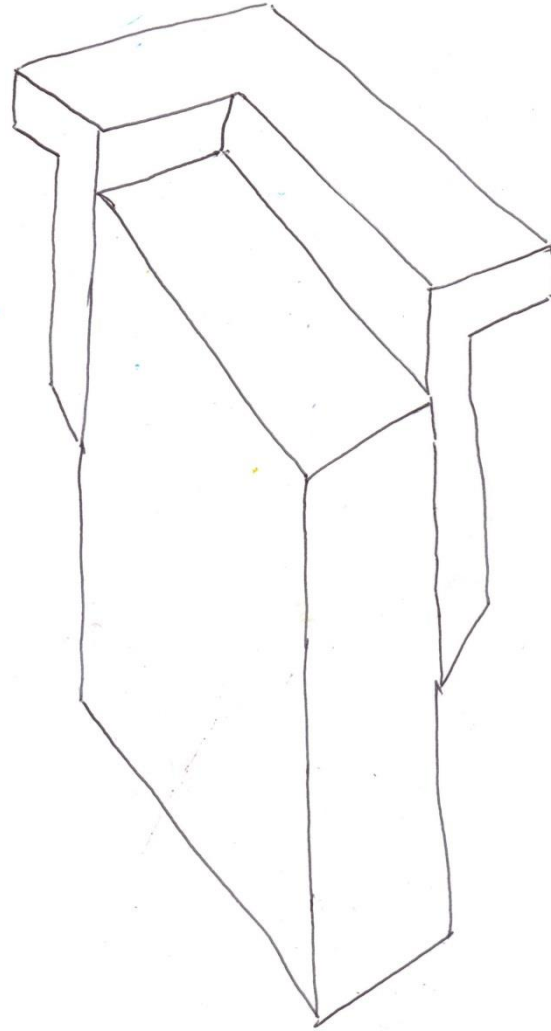
DC Casting Mold



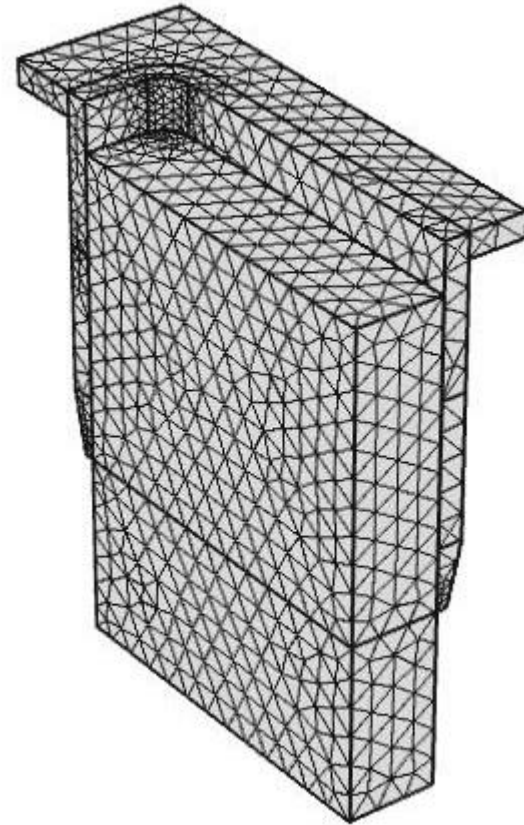
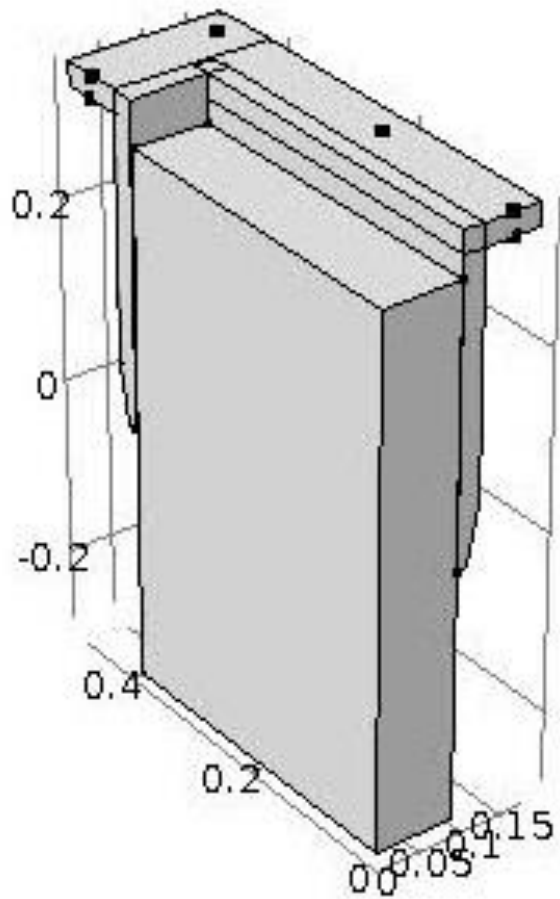
DC Casting Mold - Symmetries



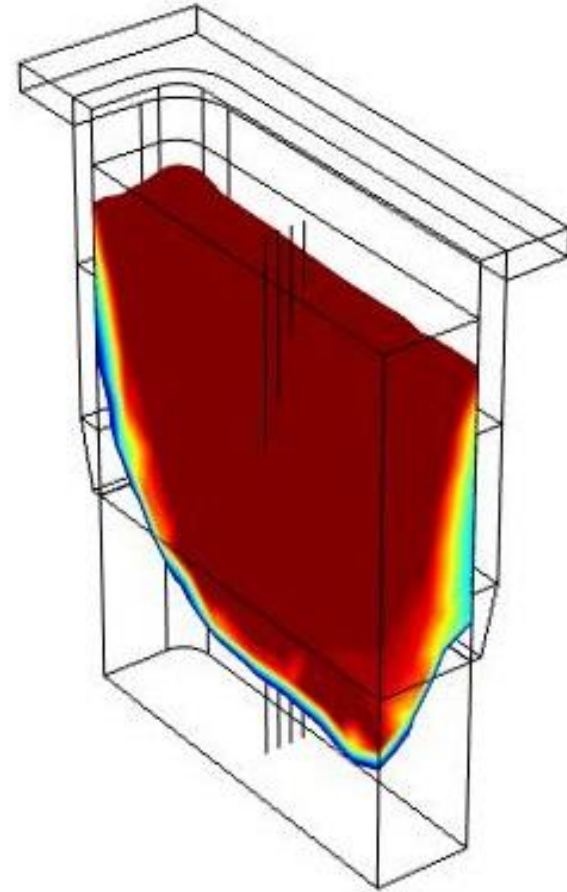
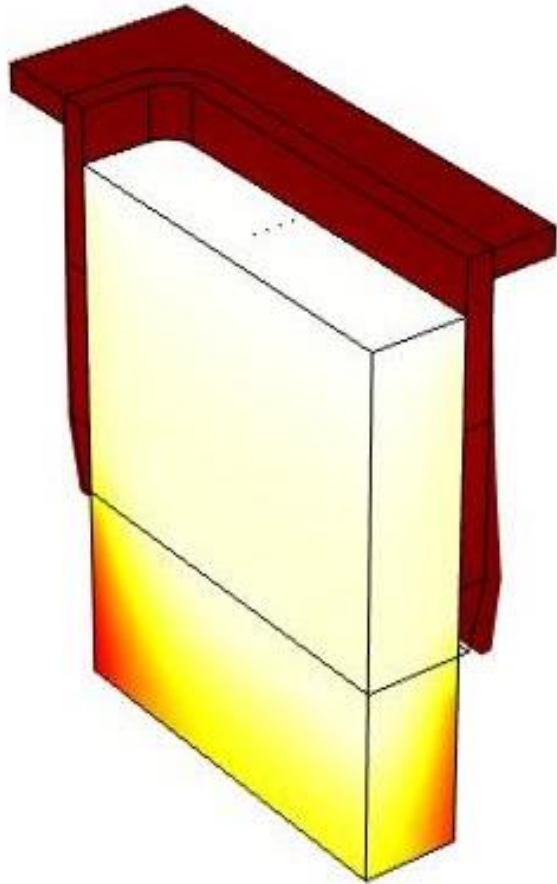
DCC Model -Symmetries



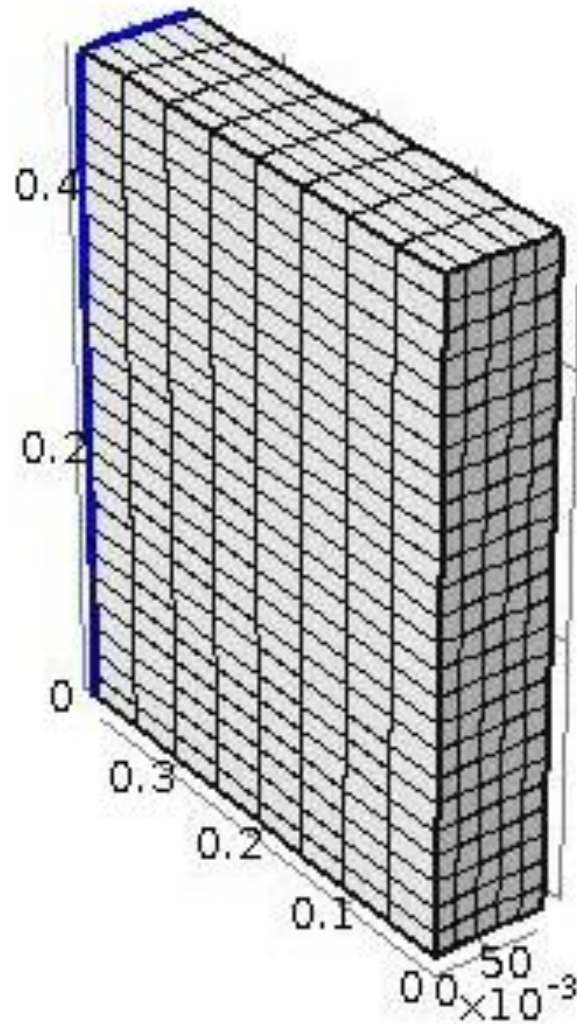
DC Caster – Geometry and FE Mesh



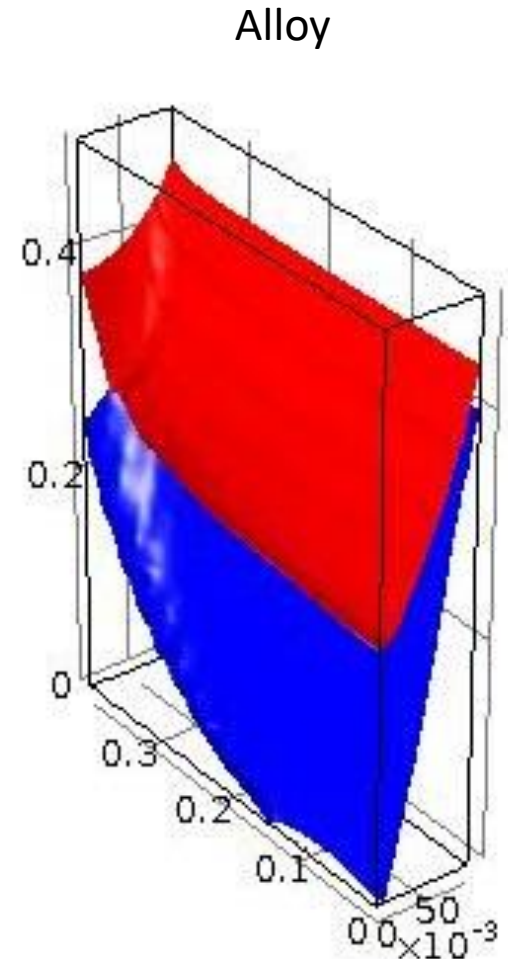
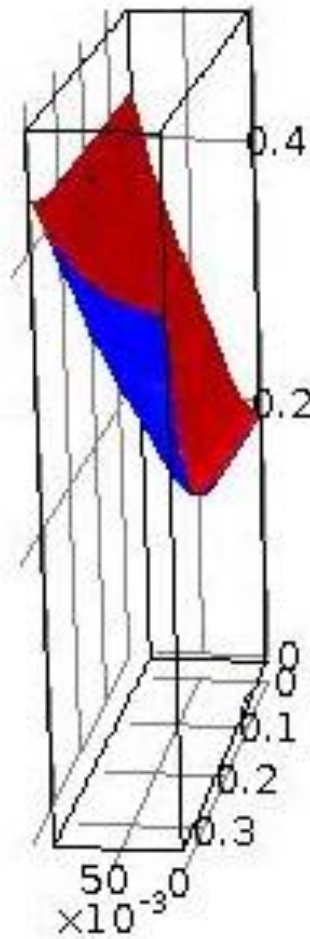
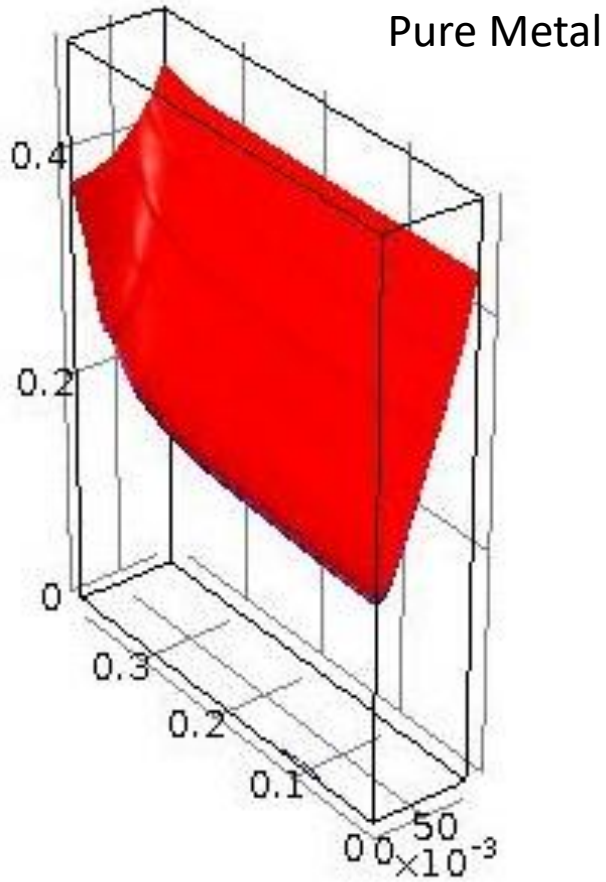
Computed Temperature Deformation and Solidification interface



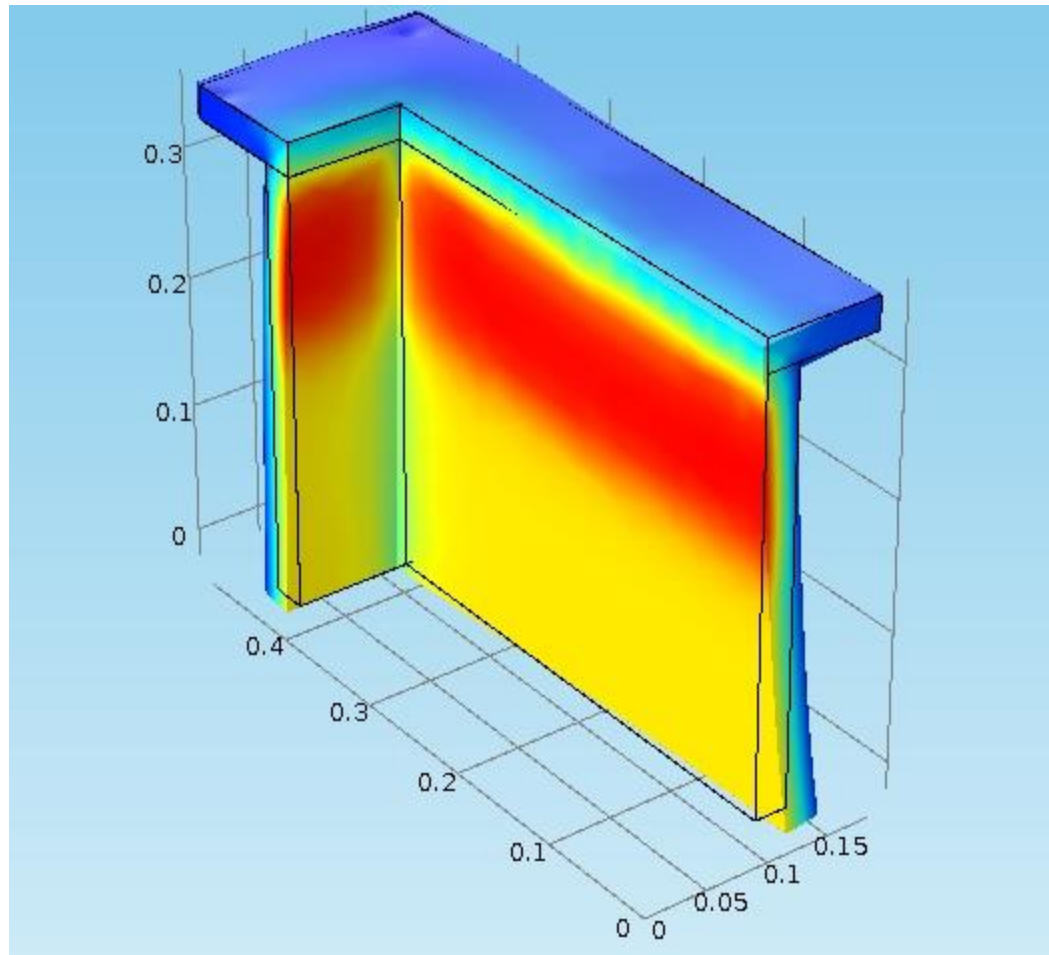
DC Cast Slab – FE Mesh



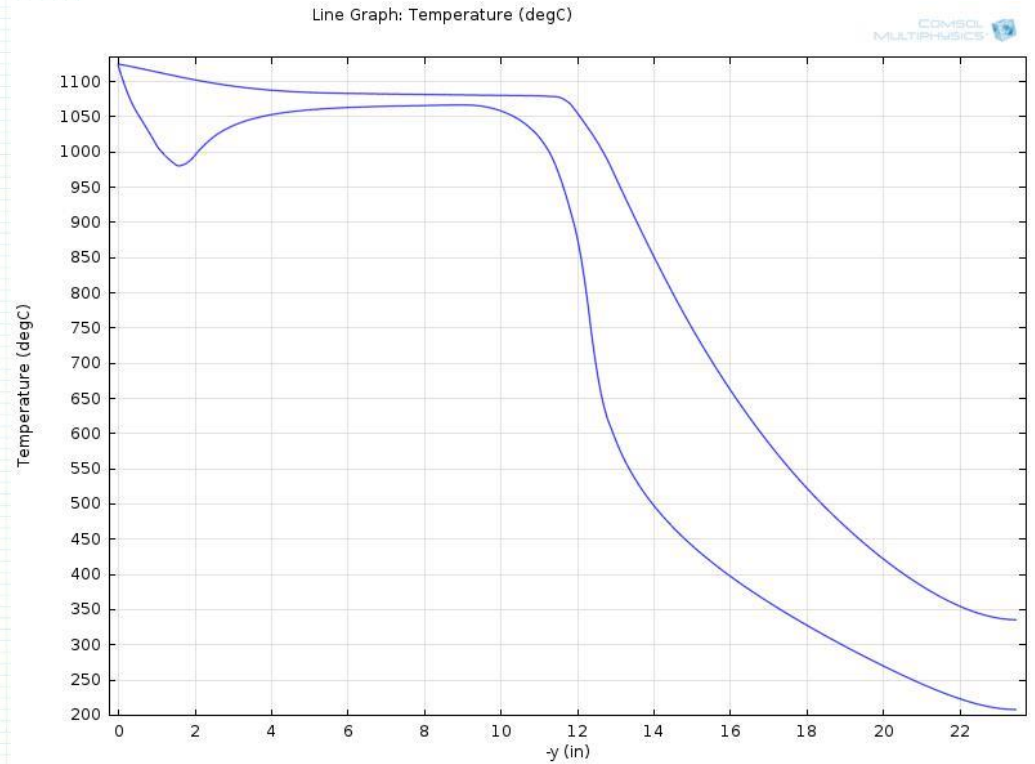
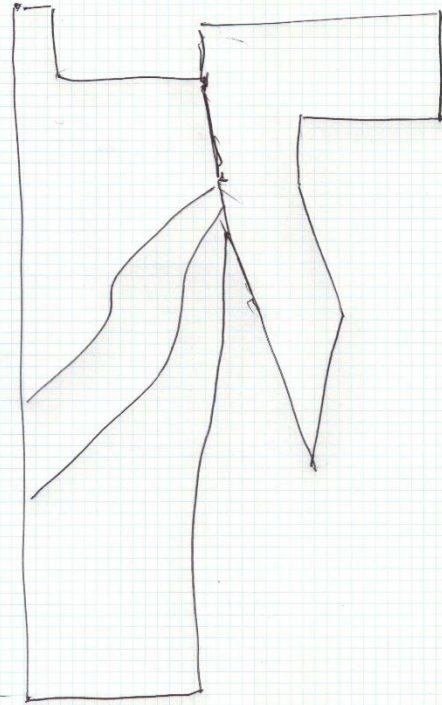
DC Cast Slab – Solid-Liquid Interfaces



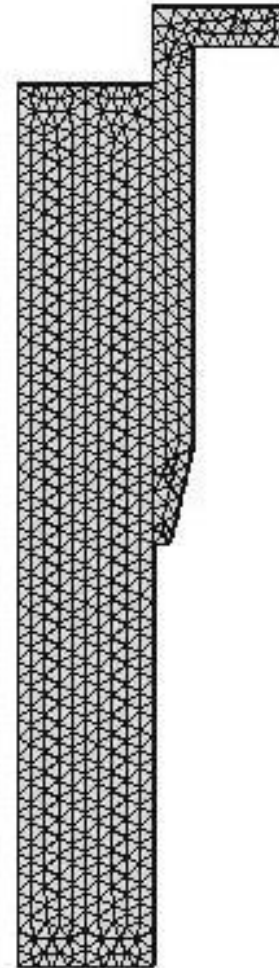
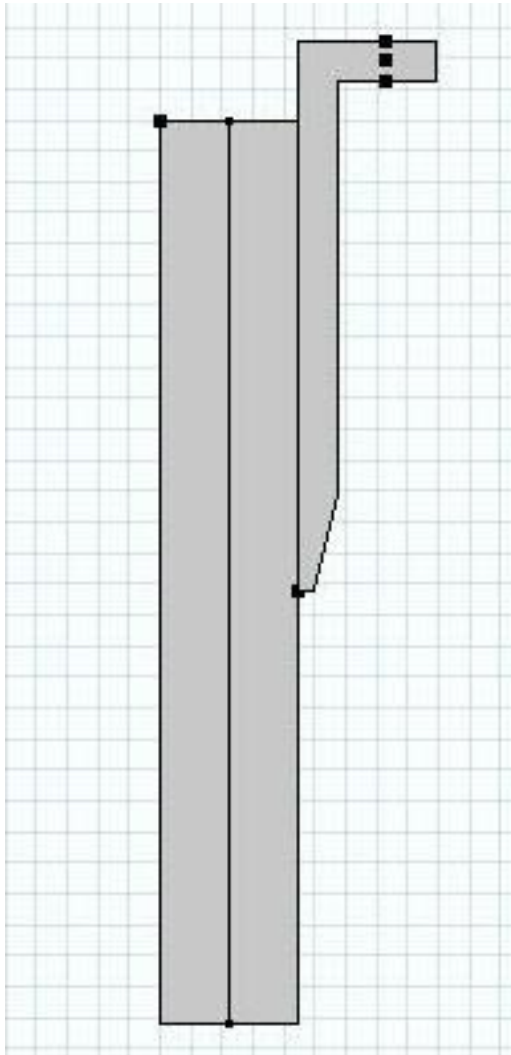
What Happens to the Mold?



Pathological Condition

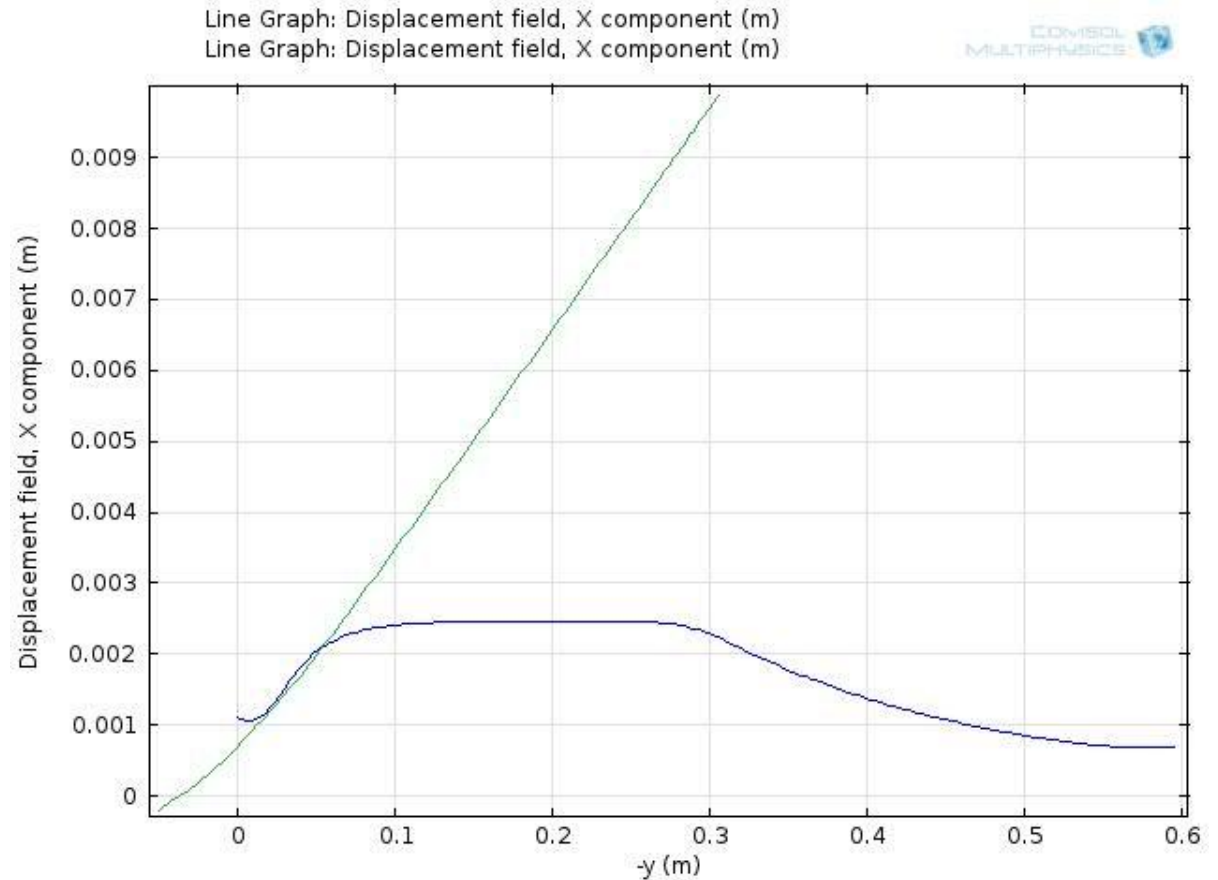
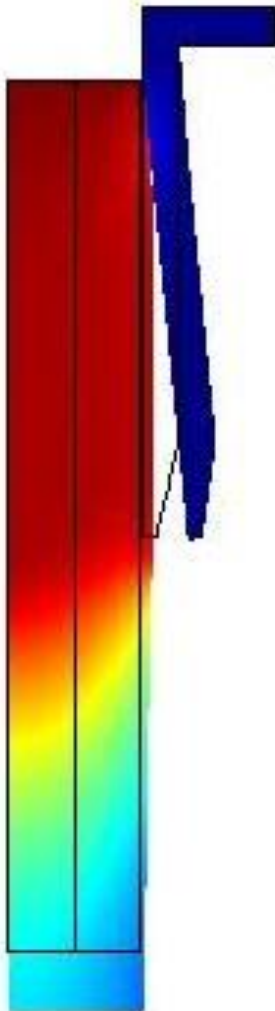


DC Casting - Broad Side View Geometry and FE Mesh



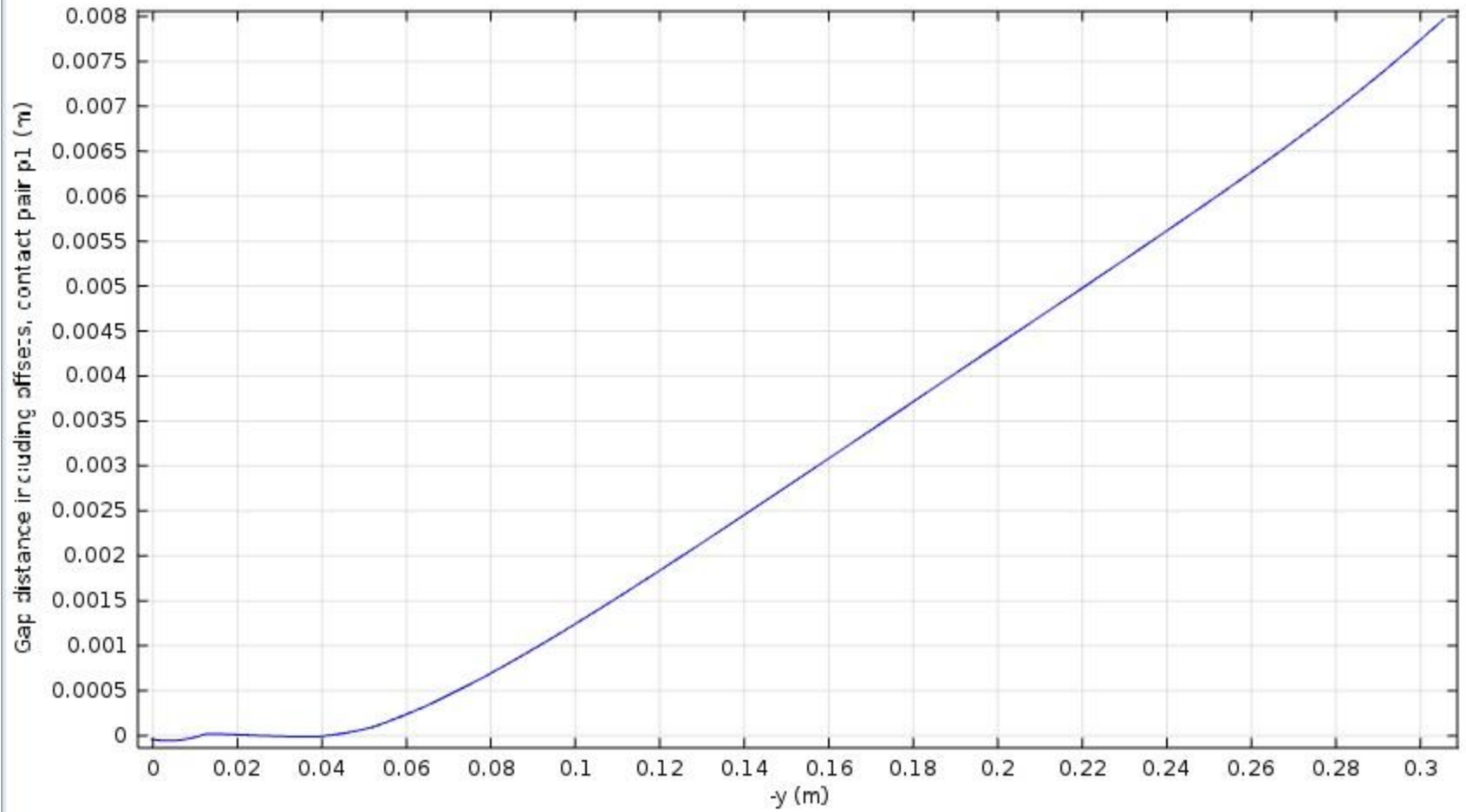
DC Casting - Broad Side View

Temperature Field and Deformation – Worst Case



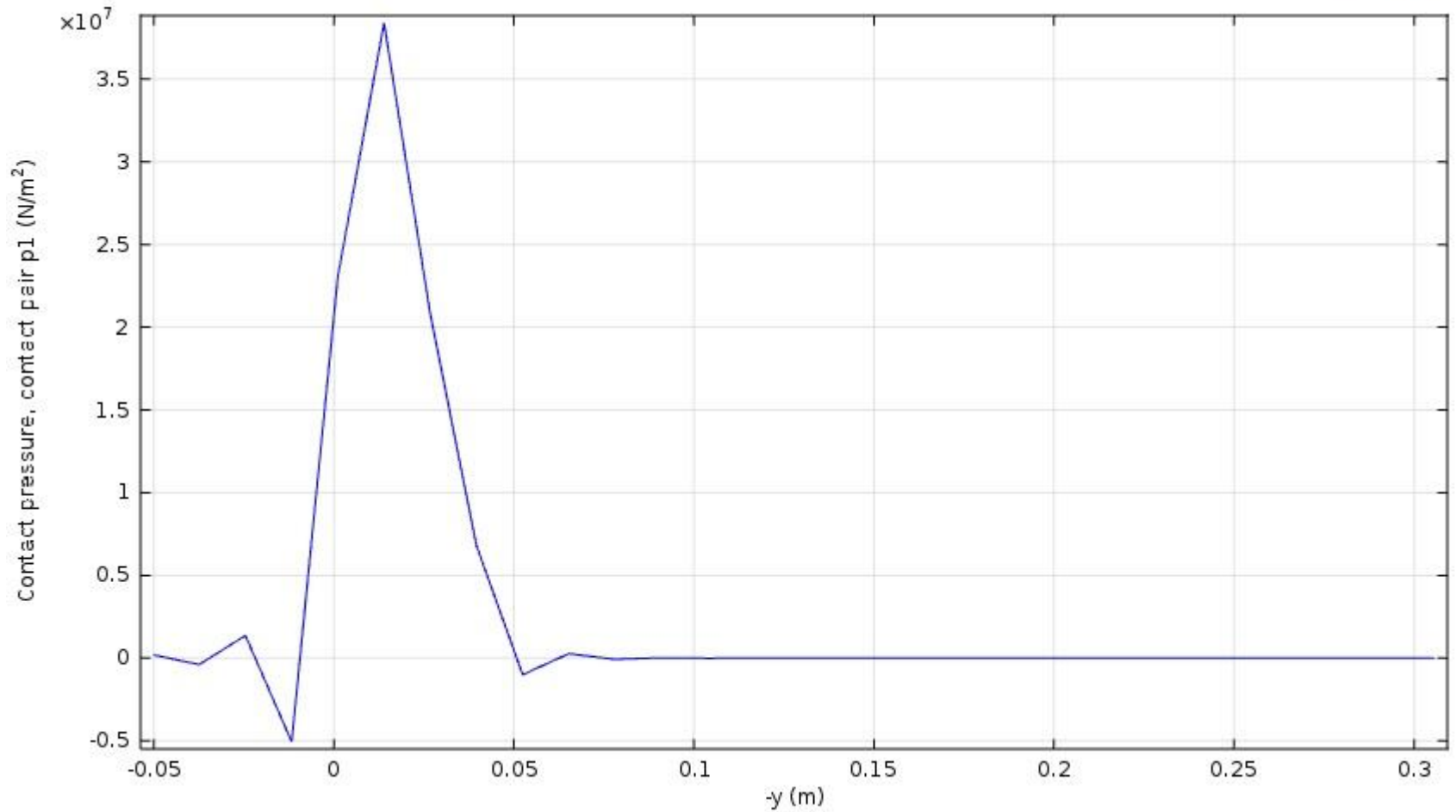
Gap

Line Graph: Gap distance including offsets, contact pair p1 (m)



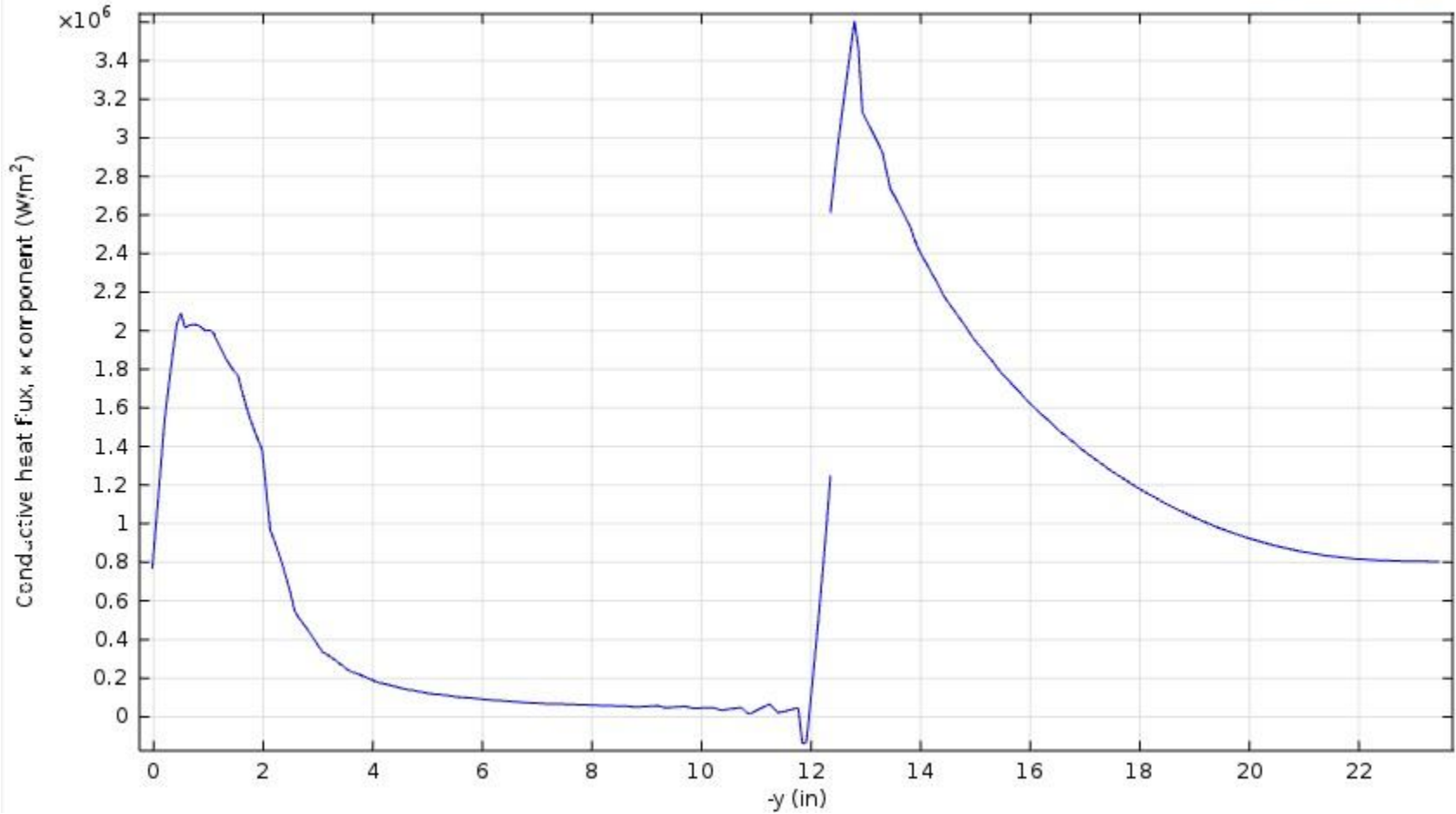
Contact Pressure

Line Graph: Contact pressure, contact pair p1 (N/m²)



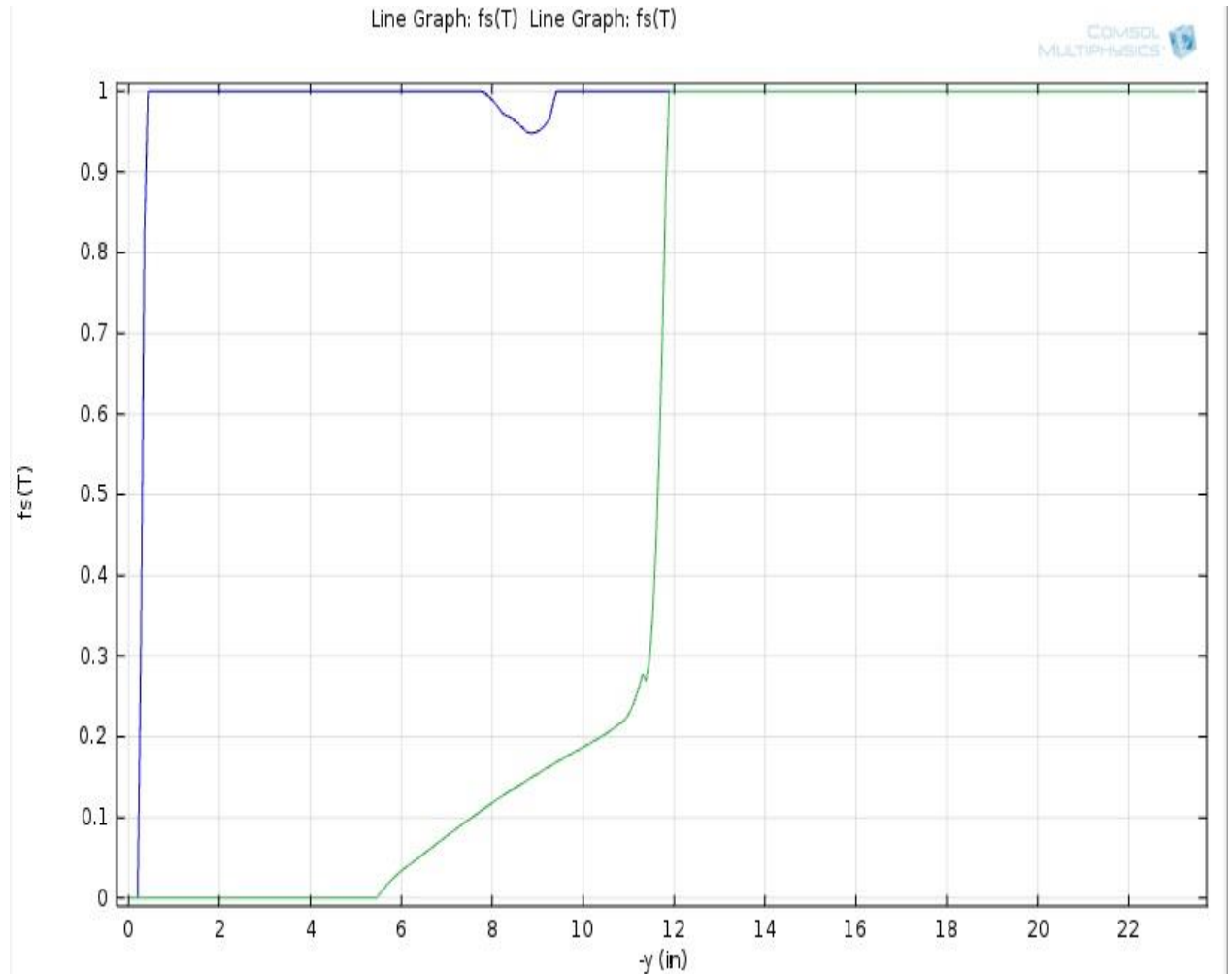
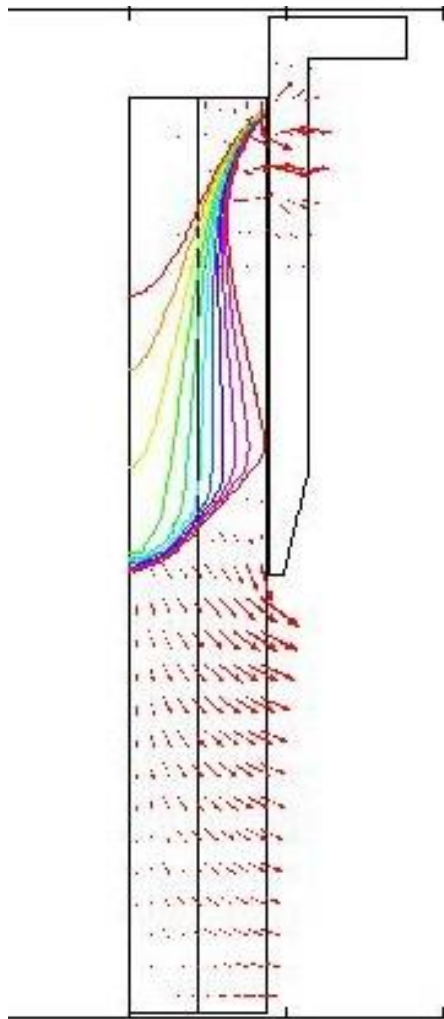
Gap Heat Flux

Line Graph: Conductive heat flux, x component (W/m²)



DC Casting - Broad Side View

Fraction Solidified and Heat Flux – Worst Case



Summary

- Coupled FE modeling of solidification heat transfer and solid state deformation in a casting-mold configuration typical of continuous casting operations is feasible using COMSOL Multiphysics.
- The main computational difficulties encountered were due to the multiple nonlinearities intrinsic to the problem.
- The complex details of the thermo-mechanical contact at the casting-mold interface are still an outstanding challenge.