3D Modelling of Electromagnetic, Flow and Thermal Characteristics of Molten Metal in Channel Induction Furnaces

Monash University

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Overview

Channel induction furnaces play an important role in process metallurgy for melting and holding ferrous and nonferrous metals. The casestudy presents some results of 3D modelling of the complex physical phenomena (electromagnetics, Joule heating and turbulent flow of molten metal) in a twin-channel induction furnace under steady state condition.
The primary coils induce very large current densities in the secondary winding (channels) generating heat in the metal by Joule dissipation. The interaction between the electromagnetic flux generated by the primary induction coils and the induced current in the melt produces electromagnetic forces.
The simulation is based on the solution of Maxwell's equations With magnetic flux boundary conditions applied to the surfaces of 300-mm air layer. The calculated finite element solution DOFs are magnetic and electric potentials and the derived DOFs are magnetic field flux density, current density, energy, forces and losses. The source of the electromagnetic excitation high voltage high current AC power supply at 50 Hz. The applied current density (A/m2) to the coils is calculated from the total current supply and coil cross sectional area.

Testimonial

Aspects of work appear in:

• Modelling of electromagnetically excited turbulent flow of molten metal in a twin-channel induction furnace, Progress in Computational Fluid Dynamics, Vol. 6, No. 7, 2006

• 3D Computer Modelling of Electromagnetic, Flow and Thermal Characteristics in Channel Induction Furnaces, International Heat Transfer Conference (IHTC-13), August 13-18, 2006, Sydney, Australia

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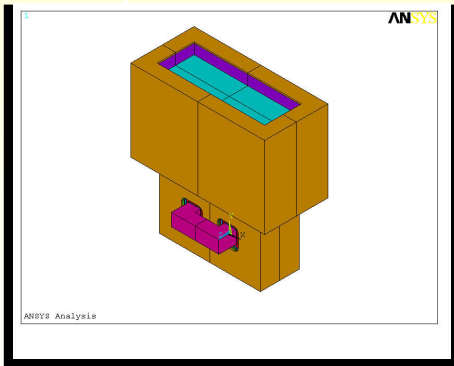
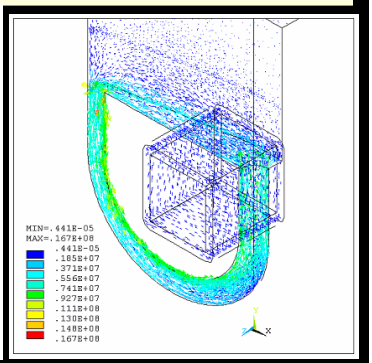
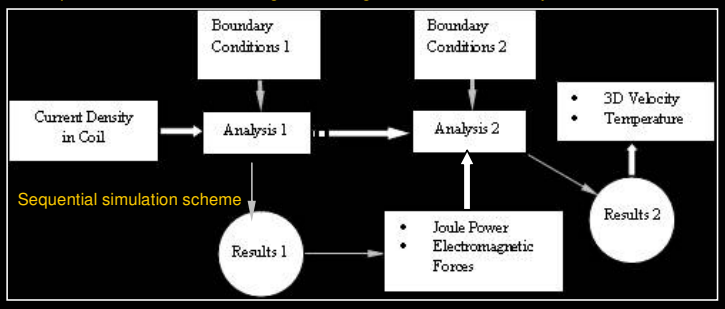
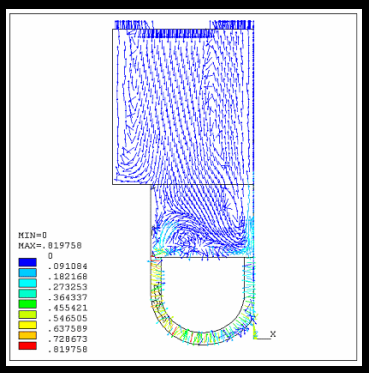


Twin-loop inductor furnace for melting and holding

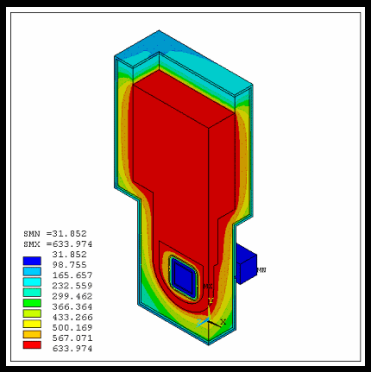


Current density in the melt in the inductor





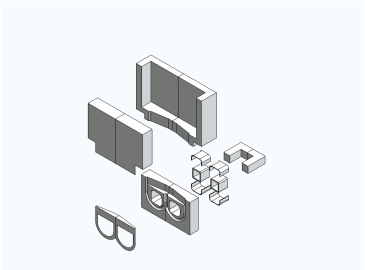
Velocity profile in the furnace (SST model)



Temperature profile of the model

Challenge

Modelling multiphysics environment in realistic complex 3D geometry using a limited version of ANSYS (University Research).



Solution

- Generate 3D solid model externally
- Convert to IGIS format
- Import into ANSYS through Mechanical Toolbar (direct import into ANSYS did not work)
- Select mesh size manually
- Experiment with different solvers and turbulence models

Benefits

- Entire system (melt, inductor, holding pot) is modelled
- Qualitative assessment of effect of furnace geometry on flow and thermal characteristics
- Assessment of effect of melt properties
- Assessment of effect of operating conditions
- Significantly more cost effective than direct measurements or experimentation