Multiphysics Analysis of Inductive Brazing Process

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Introduction: The objective is to analyze temperature rise and distribution in different parts of an inductive brazing process. This process includes three physics - electromagnetic excitation- eddy heating- heat transfer in solids. AC Inductive heating physics coupled to heat transfer in solid including conduction, convection and radiation effects are modeled using COMSOL Multiphysics

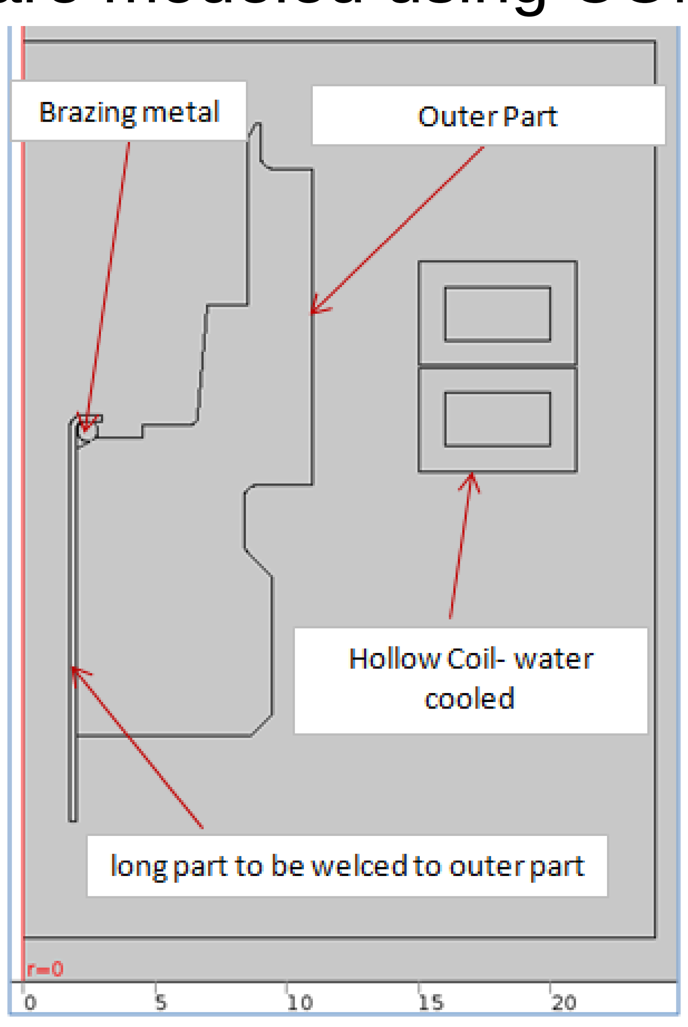


Figure 1. Brazing Assembly Axisymmetric Representation

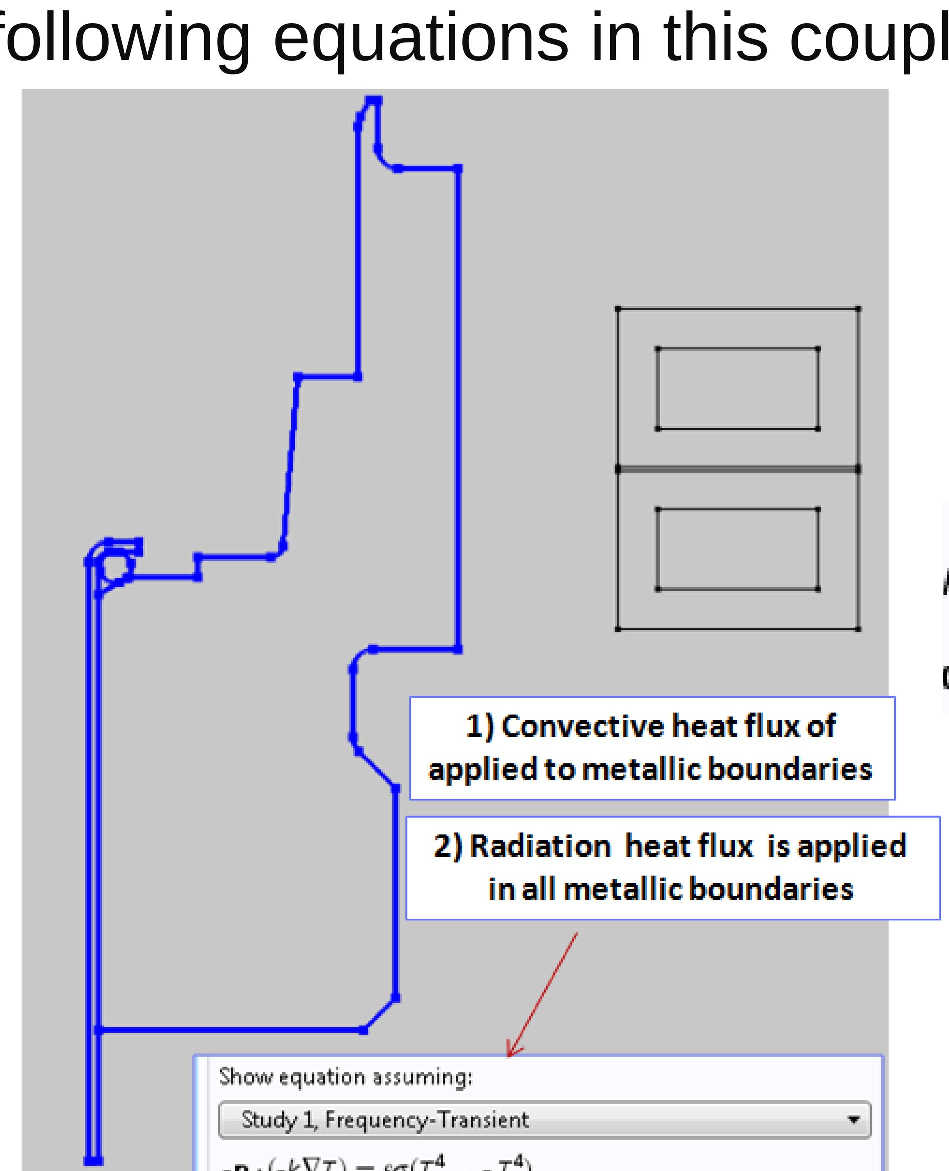
Computational Methods: AC inductive heating physics with heat transfer in solid including conduction, convection and radiation effects are modeled using COMSOL Multiphysics. Water cooling is modeled inside coils with a high effective thermal conduction and a homogeneous convective heat loss so that there should not be any temperature rise in coils

Metals are modeled with a temperature dependent electrical resistivity to account resistivity change of materials during the heating process

Electrical conductivity:
σ Linearized resistivity

$$\sigma = \frac{1}{\rho_0(1+\alpha(T - T_{ref}))}$$

Magnetic field and heat transfer in solid are solved using following equations in this coupled physics analysis



$$(j\omega\sigma - \omega^2\epsilon_0\epsilon_r)\mathbf{A} + \nabla\times\mathbf{H} = \mathbf{J}_e$$
$$\mathbf{B} = \nabla\times\mathbf{A}$$
$$\rho C_p\frac{\partial T}{\partial t} + \rho C_p\mathbf{u}\cdot\nabla T + \nabla\cdot\mathbf{q} = Q + Q_{ted}$$
$$\mathbf{q} = -k\nabla T$$

Figure 2. Convection and Radiation Heat Boundary Conditions

Results: Temperature rise in different parts of brazing assembly predicted after specific time. Temperature prediction with multiphysics simulation closely matched with test results [~98%]

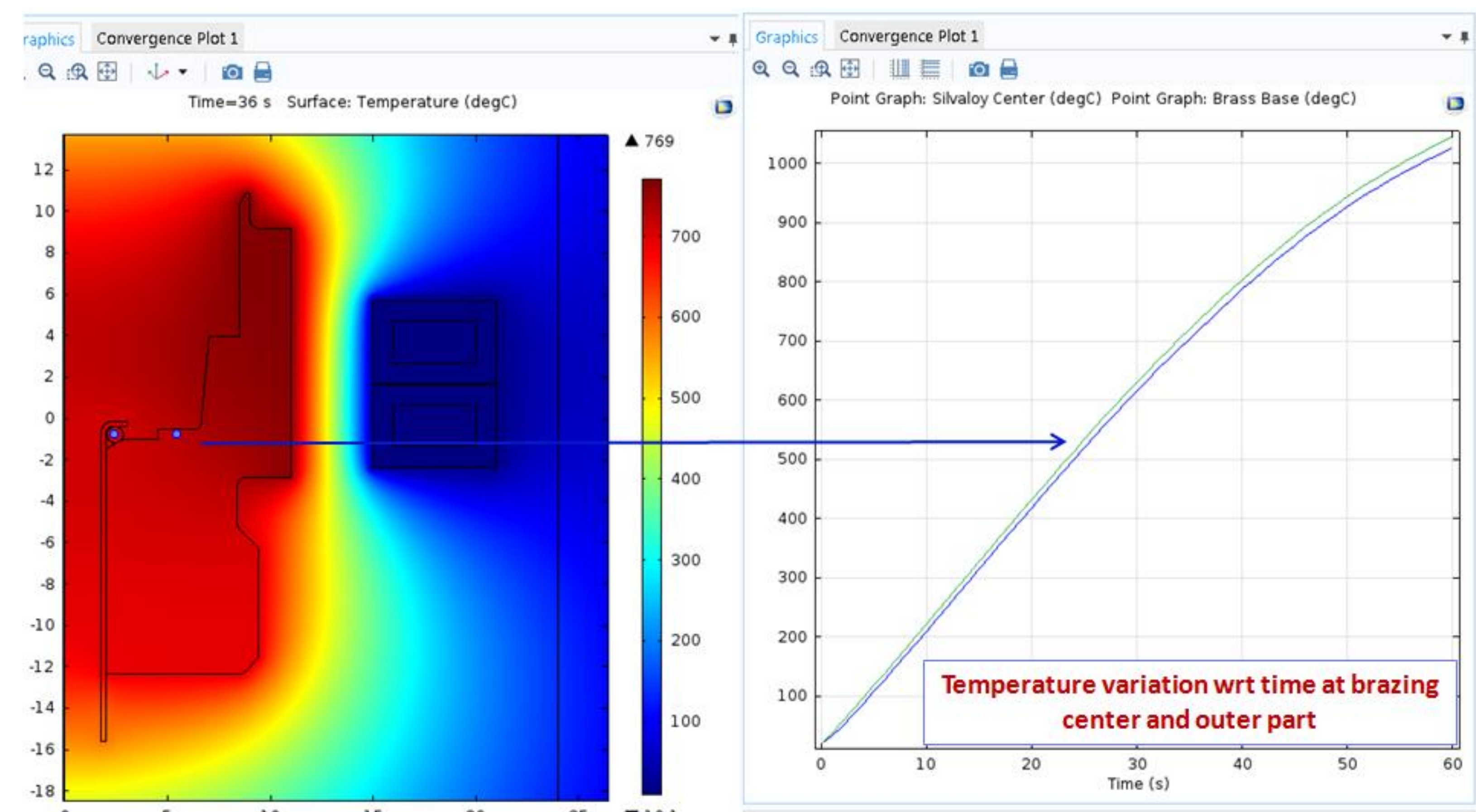


Figure 3. Temperature rise in brazing material and outer part

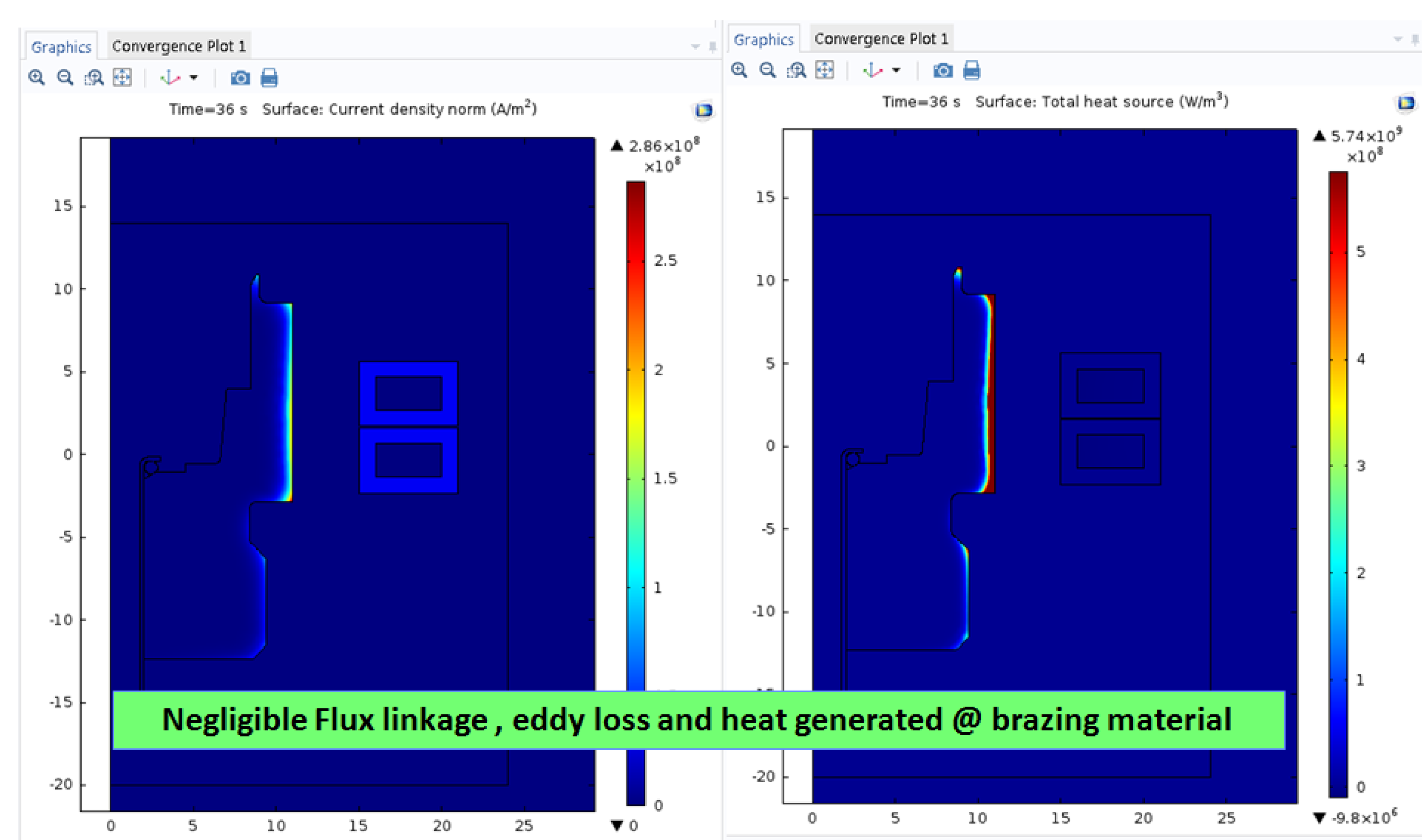


Table 4. Current Density **Figure 5**. Total Heat Source

Conclusions:

Comsol Multiphysics analysis of this inductive brazing process helped design team to understand and control different process issues.

This simulation approach could effectively used for characterizing inductive brazing process by doing a complete parametric study.

References:

1. AC DC Inductive Heating Process help from COMSOL Multiphysics
2. COMSOL Reference Manual

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