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Thermal Analysis of Two Braze Alloys to Improve the Performance of a Contactor During the Temperature Rise Test

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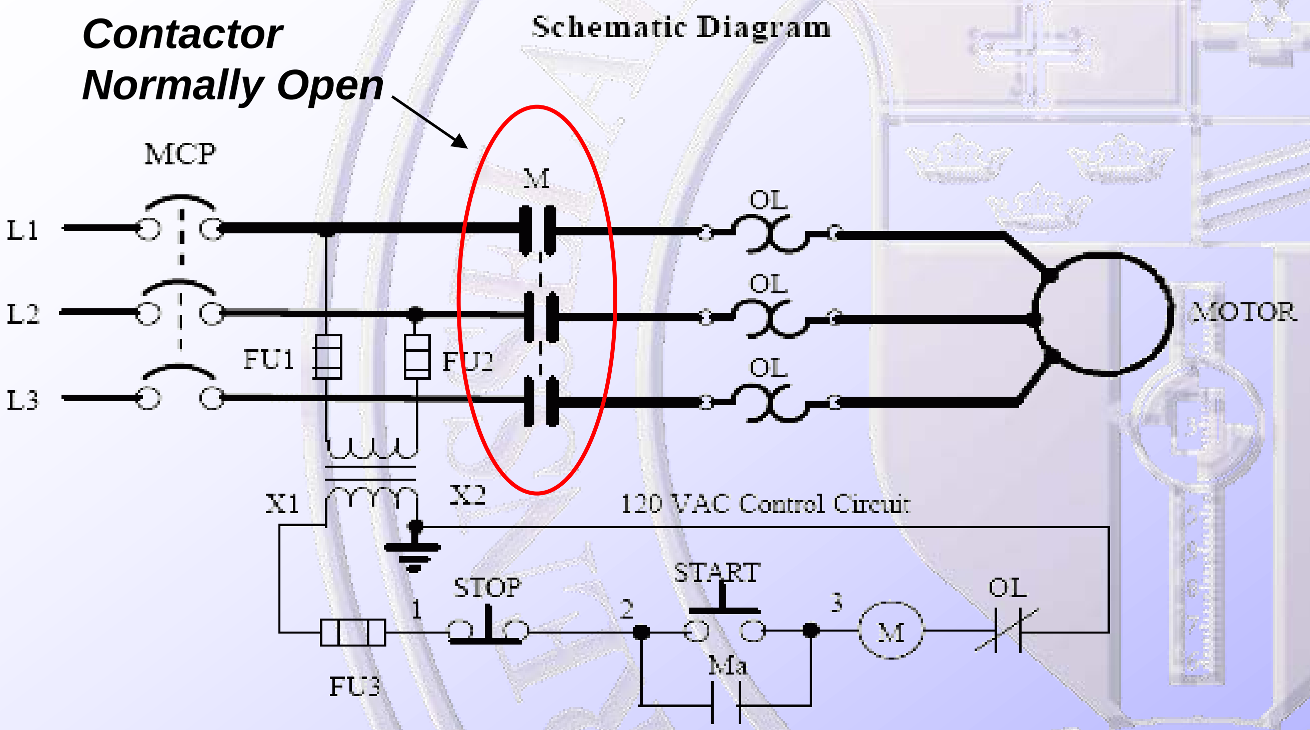
Overview

- Background - Contactor & Braze Alloy
- Material Considerations and Geometry of the model
- Temperature Rise
- Use of COMSOL
- Validation of work
- Results
- Conclusions / Future Works

Electrical Contactors

Contactor Normally Open



Contactor Components

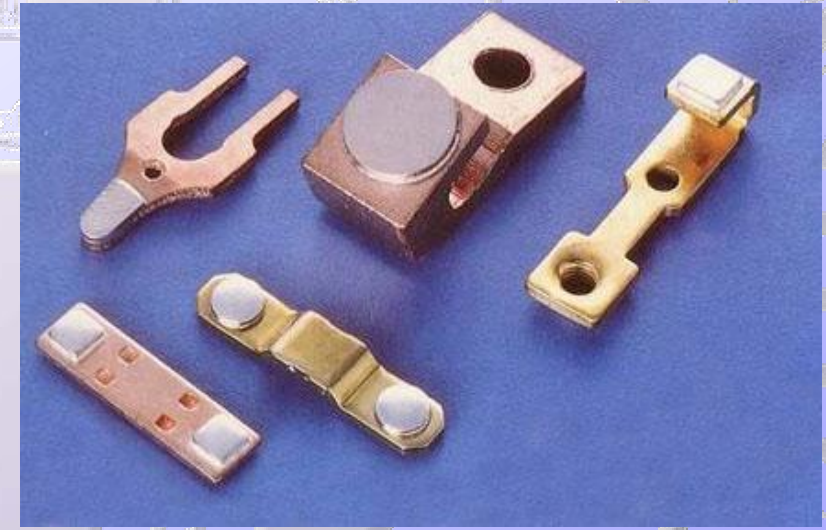
- *contact assemblies - current carrying part*
- *electromagnets - driving force*
- *enclosure - frame housing*

The Brazing Process for Contact Assemblies

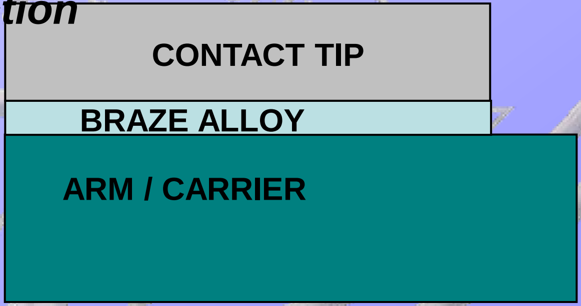
Brazing

- Metal Joining Process
- Use of a filler metal (*braze alloy*)
- Capillary action
- Filler Metal with lower Melting Temperature
- Temperatures to melt filler metal are above 450 C

Typical Contact Assemblies



Contact Assembly - Cross Section



Material Considerations

Contact Tip: Round Silver Cadmium Oxide (90/10)

Carrier: Brass

Braze Alloys: Braze750 & Silfos

PROPERTIES	**AgCdO**	**Brass**	**Braze 750**	**Silfos**
Electrical Resistivity (ohm-meter)	3.3×10^{-8}	5.39×10^{-8}	17.4×10^{-8}	3.2×10^{-8}
Temperature Coefficient of Resistance (1/K)	0.004	0.001	0.00369	0.00375
Thermal Conductivity (W/m*K)	386.17	140	40	30
Density (kg/m^3)	10000	8670	8440	9945.67
Heat Capacity (J/kg*K)	238.48	380	343.25	260

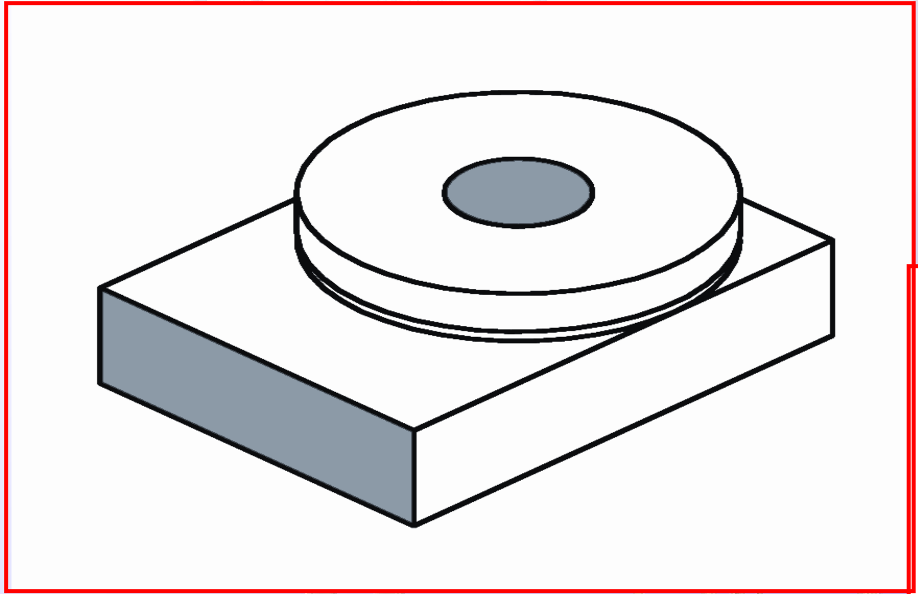
Geometry

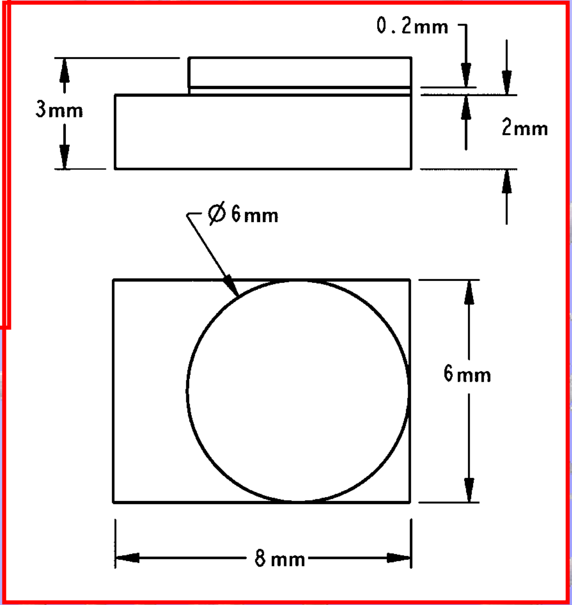
Contact Assembly - 3D Model

Contact Tip Diameter = 6 mm

Arm Length = 8 mm

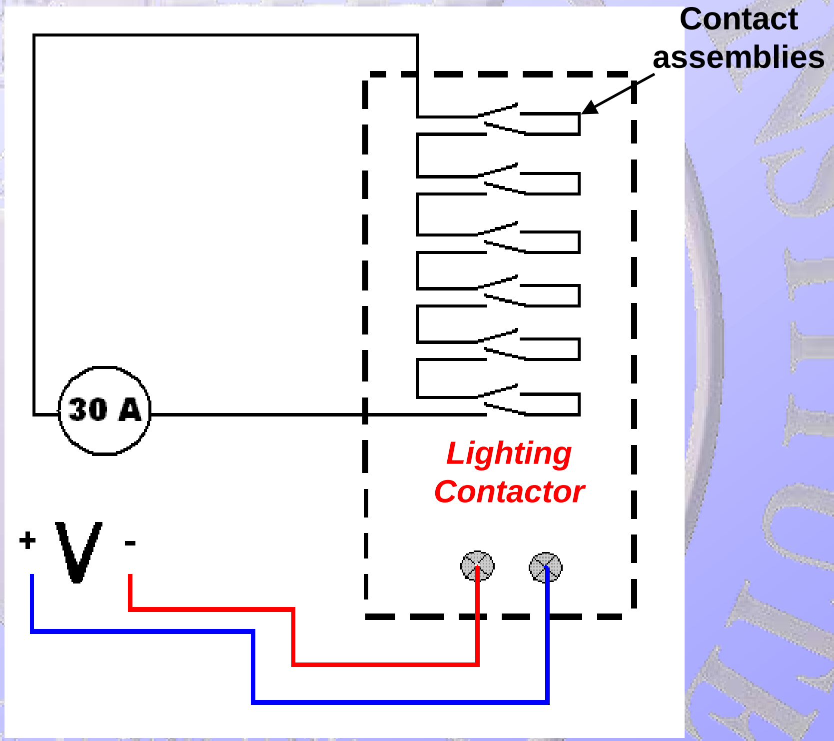
Width = 6mm





Temperature Rise Test

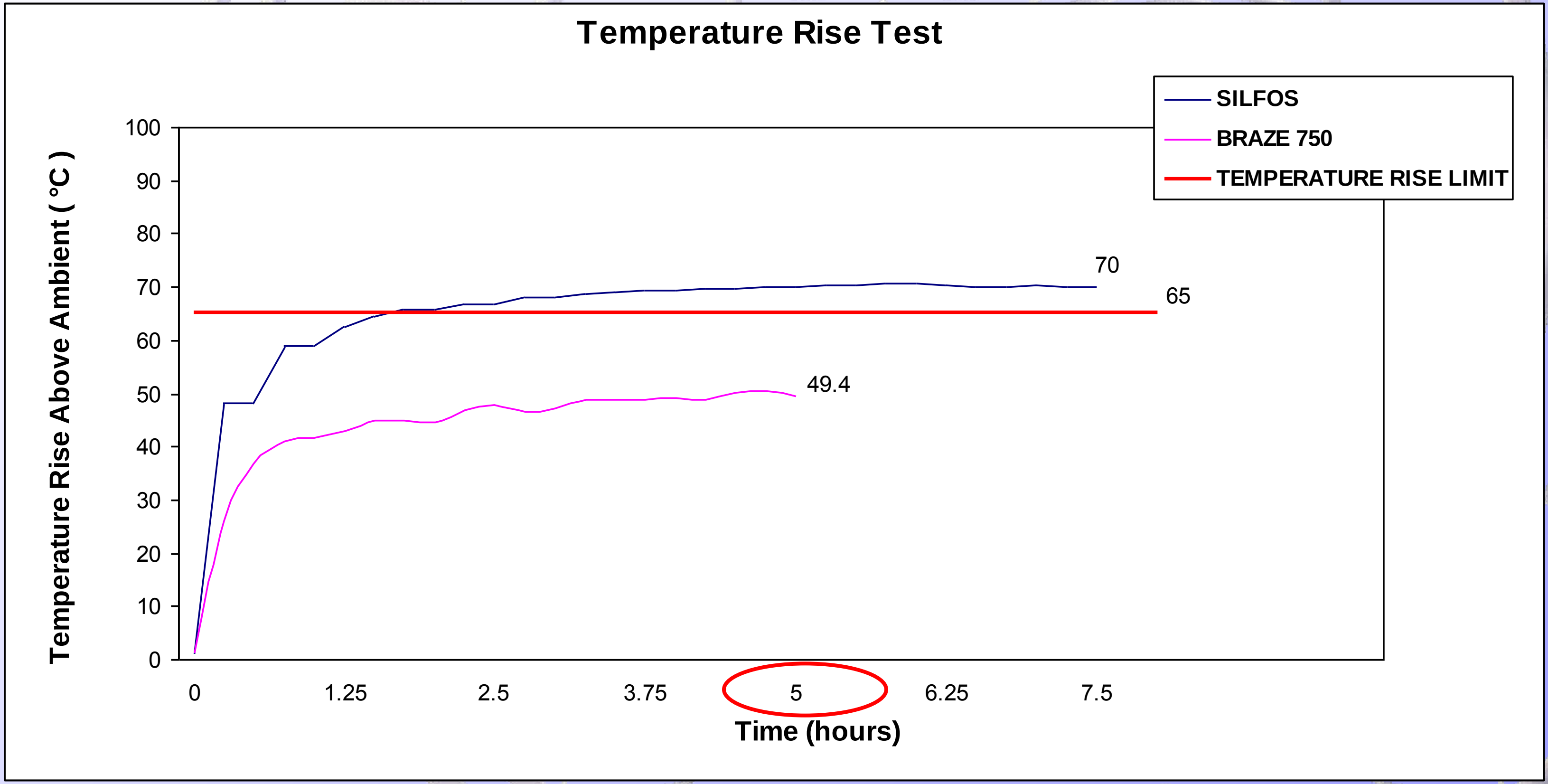
Determine the maximum steady state temperature reached by the contact terminals after passing the rated current of the contactor



- ❑ ***Test Required per UL508 Standard***
- ❑ ***Parameters***
  - Under normal conditions
  - While carrying its rated current continuously (30 amps)
  - While device is mounted as intended in use
  - Until temperature readings are constant (~ 5 hours)

Temperature Rise (experimental)

Two contactors were submitted for Temperature Rise Test to determine which braze alloy had a better performance.



Contact assemblies with Braze Alloy 750 had a better performance

Use of COMSOL

- **Determine the thermal response of the contact assemblies**
  - during the temperature rise test
- **Module: Joule Heating / Electro-Thermal Interaction**
  - Heat Transfer by Conduction (ht)
  - Conductive Media
- **2D Axis-symmetric Model (Arc - Transient)**
  - Overload Test - Validation by comparison to prior work
- **3D Model (Joule Heating - Steady State)**
  - Steady State conditions obtained during the temperature rise test - present work

Governing Equations

Joule Heating

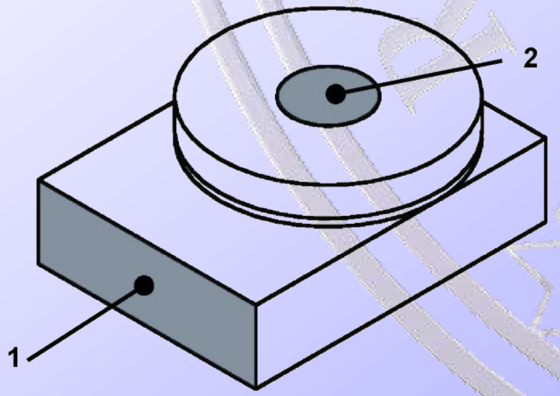
$$Q \propto |J|^2$$

Q = resistive heating [W/m^3]

J = current density [Amp/m^2]

σ = electric conductivity [S/m]

$$Q = \frac{1}{\sigma} \cdot |J|^2 = \frac{1}{\sigma} \cdot |\sigma \cdot E|^2 = \sigma |\nabla V|^2$$



- The resistive heating Q is the Joule heat due to current flow.
- Term is predefined as the source term when using the Joule-Heating predefined Multiphysics coupling.

Validation of Simulation

☐ Thermal-electric solid element from ANSYS

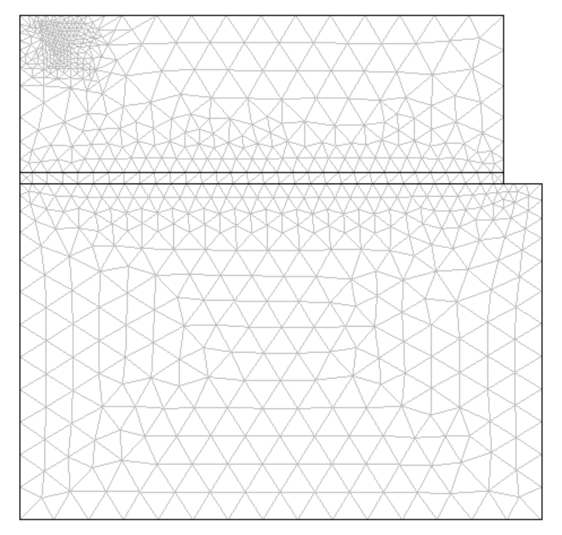
☐ Analysis for a locked rotor test that is rated 240 amps

☐ Joule Heating was imposed as current coming into the model

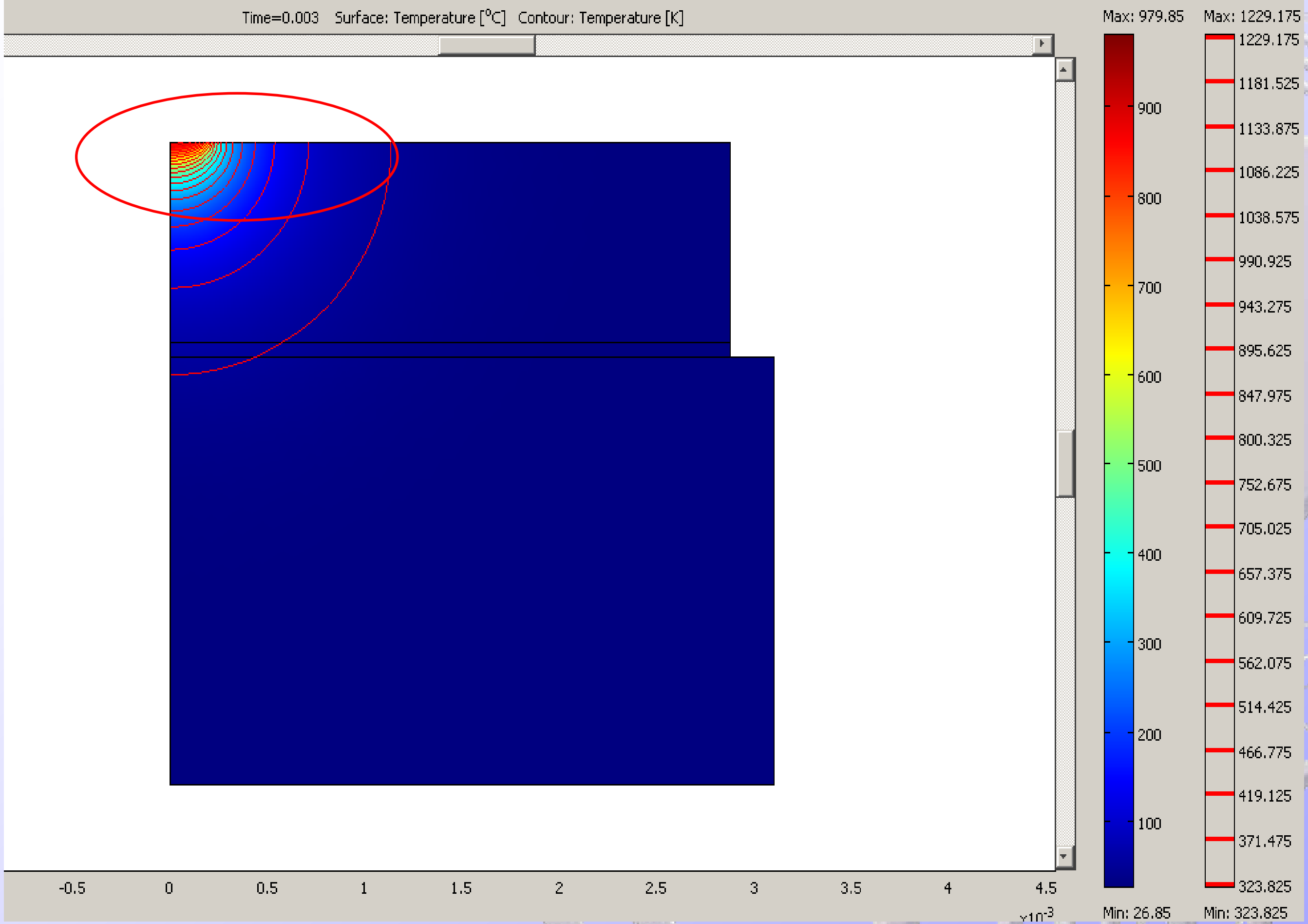
☐ Arc Heating was imposed on the model as heat flux

☐ Temperature reached on the contact surface when arc heating is applied for 3 milliseconds.

☐ Same model was developed in COMSOL using the electro-thermal module with triangular quadratic elements.

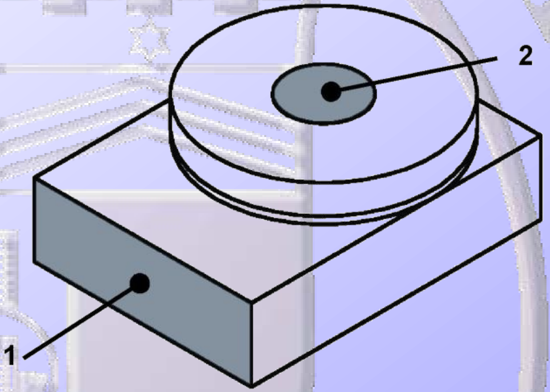


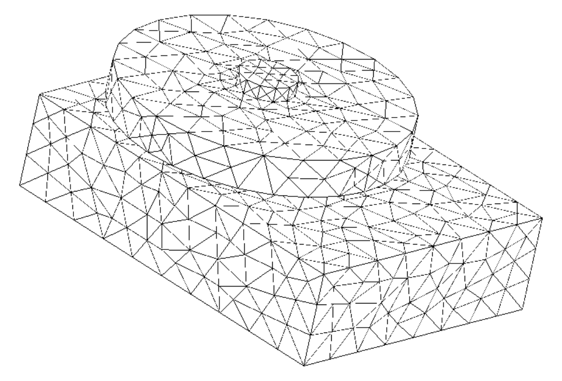
Validation of Simulation using Comsol



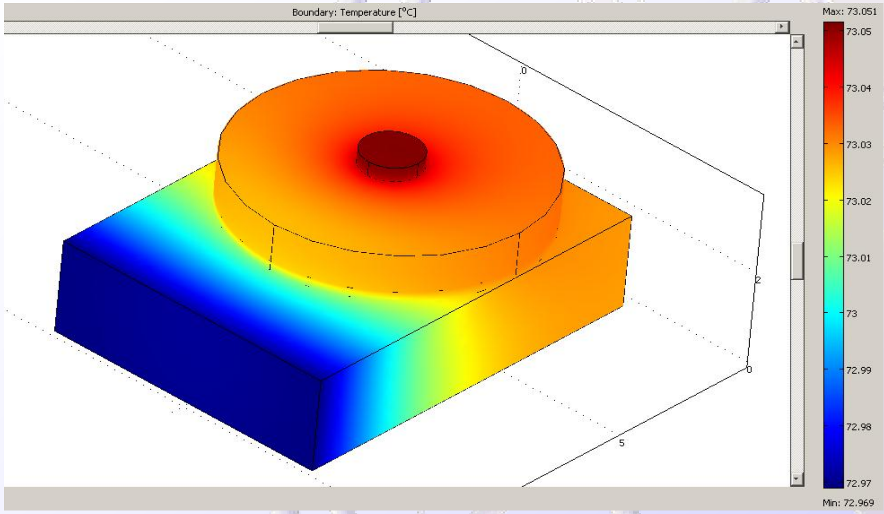
3D Model (Joule Heating-Steady State)

Boundaries	Conductive Media	Heat Transfer
B_1	Ground	Heat Flux (h=55)
B_2	Inward Current	Themal Insulation
Others	Electric Insulation	Heat Flux (h=1)





Analysis Results - temperature rise

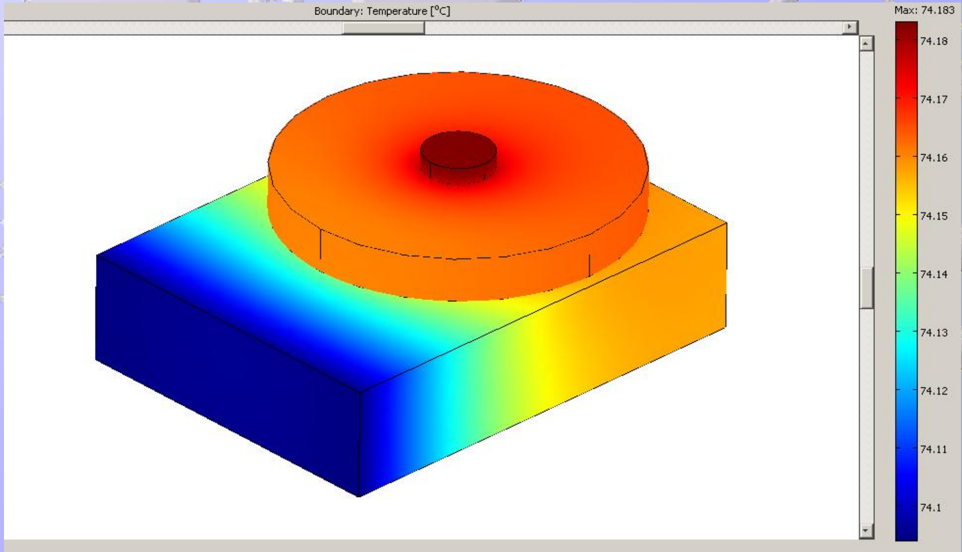


Braze 750 with perfect bonding

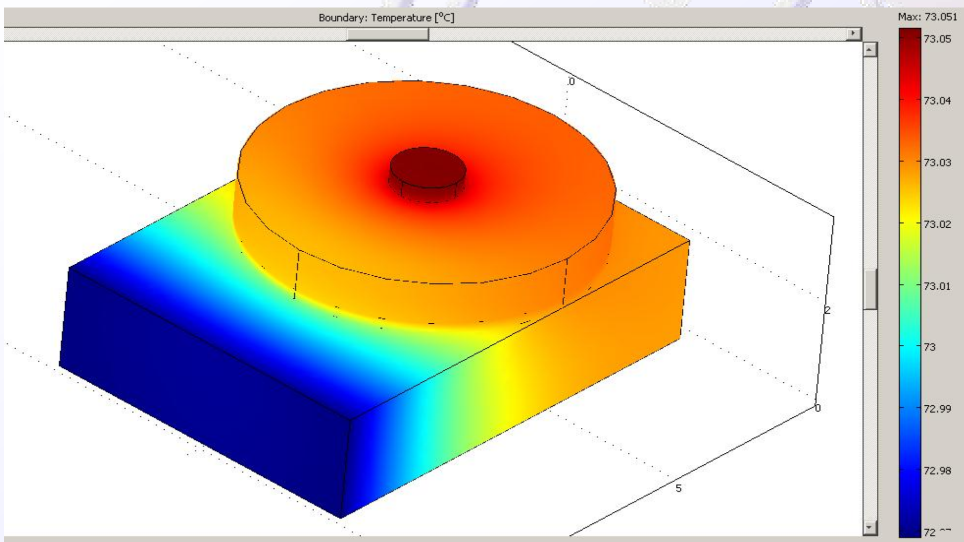
Temperature Rise is 51 C

Braze 750 with imperfect bonding

Max temperature reached on the terminal surface is 53 C

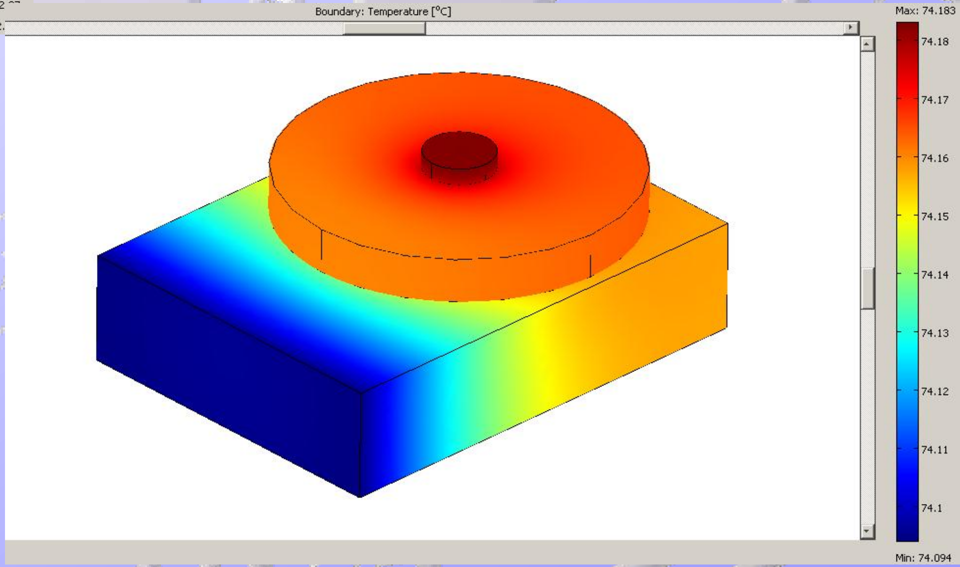


Analysis Results - temperature rise



Silfos with perfect bonding

Temperature Rise is 57C



Silfos with imperfect bonding

Temperature Rise is 60C

Conclusions

- COMSOL proved to be a reliable tool as we were able to able to predict the same results from previous jobs (locked rotor)
- Same methodology was applied with a 3D model to predict the performance during a temperature rise test
- Experimental data showed that Braze 750 had a better performance on the temperature rise test
- Validation in COMSOL was in agreement with experimental data
- Present evaluation was made for two braze alloys with contact tips using Silver Cadmium Oxide
- New materials on contact tips (RoHS requirements) will require extensive testing