Cavities in Heat Transfer Models

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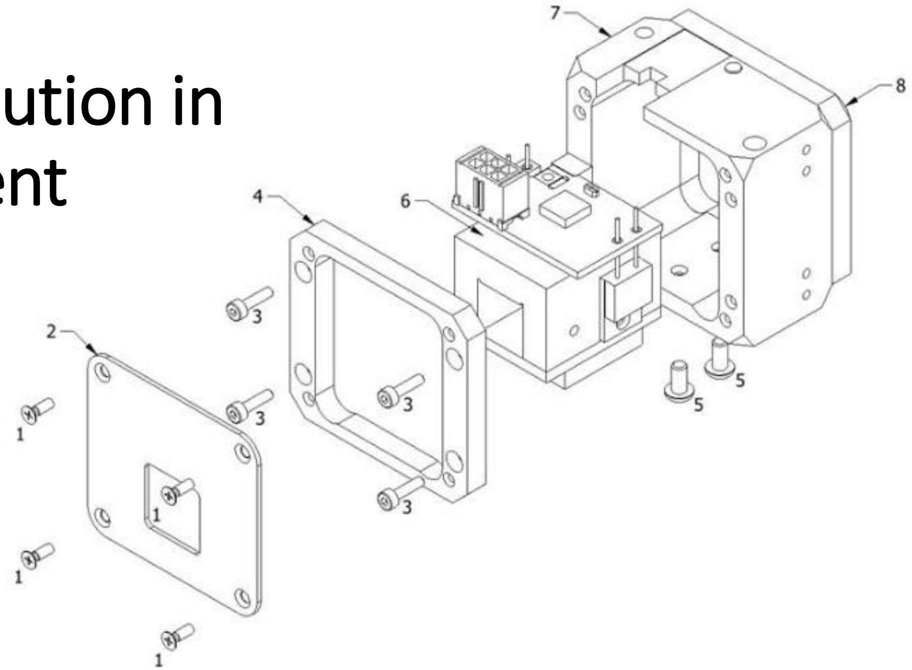
SUPERLASERS FOR THE REAL WORLD

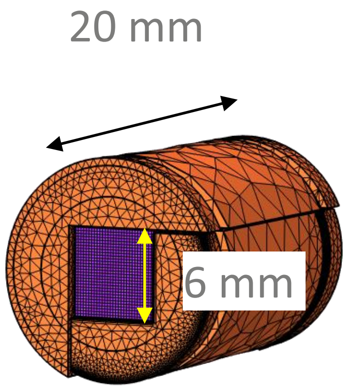
Crystal heating on specific temperature

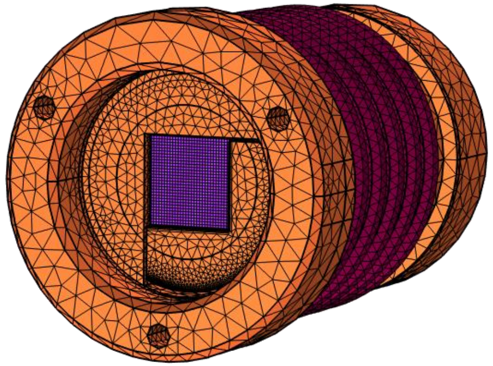
The LASER crystal must be heated on specific temperature, to provide optimal optical parameters

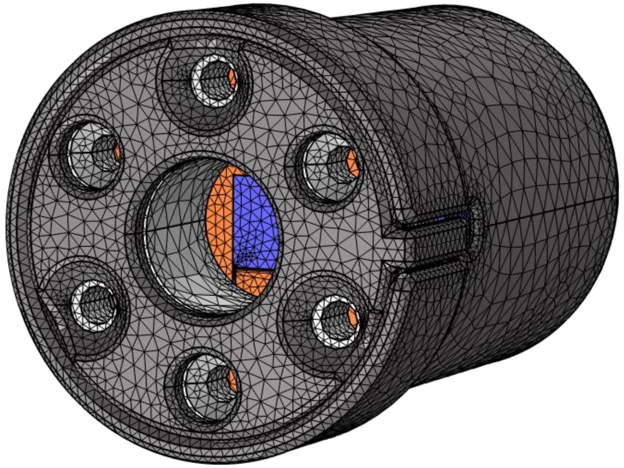
More important than exact temperature is the temperature distribution in crystal and T Gradient minimization



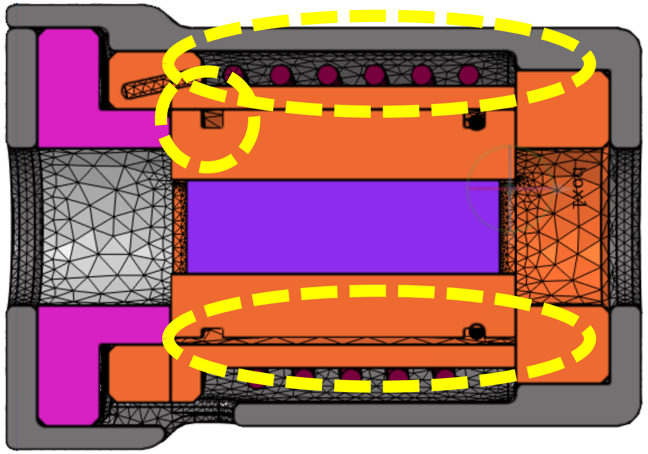
Model of specific geometry for crystal oven



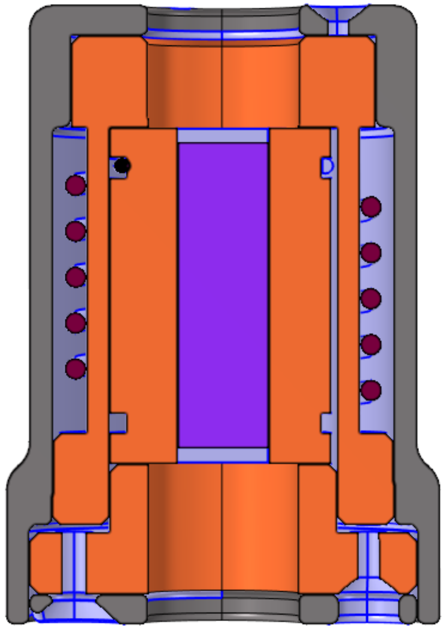




Many air cavities in the 3D geometry



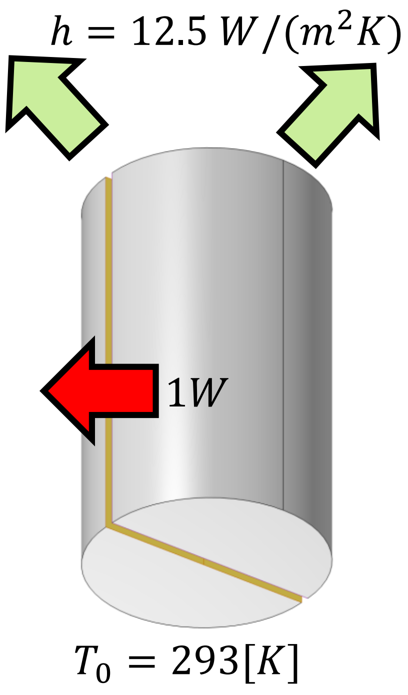
Default boundary condition:
Thermal insulation



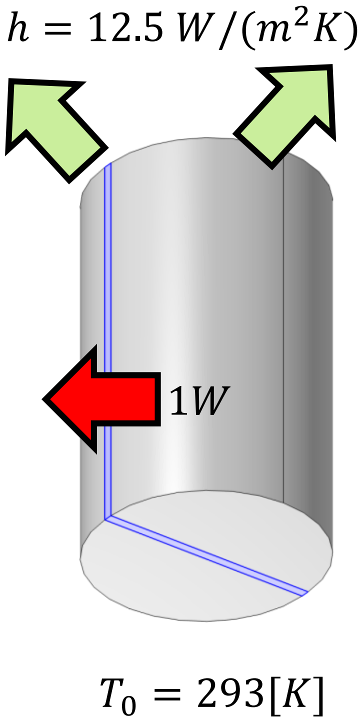
Choices how to handle the cavities

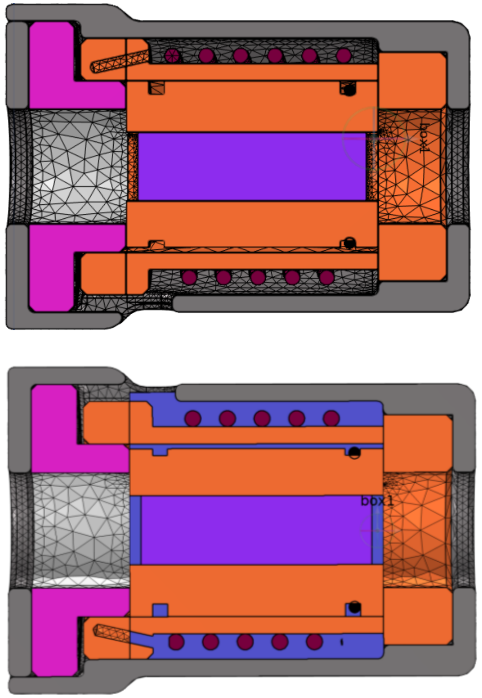
Numerical vanishing of the cavities ?

Contact pair

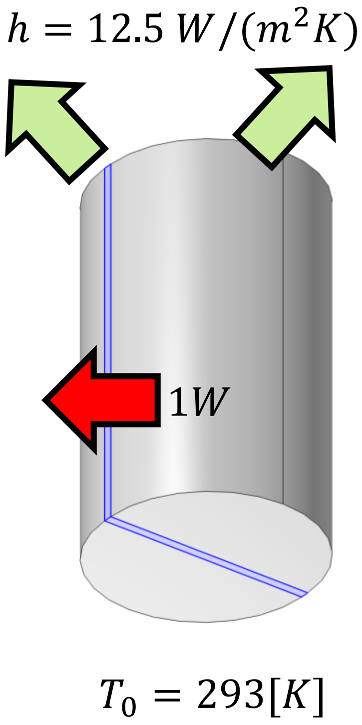


Add fluid to cavities





Add fluid to cavities
+ Convectively
Enhanced Conductivity



Contact pair model

Thin structures → Thermal contact

Constriction Conductance with Interstitial Gas

h_c h_g $+h_{rad}$

$\boldsymbol{h_c}$ - Constriction conductance = f(P, H_c, $K_{contact}$)
- Can be calculated by: Cooper-Mikic-Yovanovich Correlation (CMY)
  Mikic Elastic Correlation

$\boldsymbol{h_g}$ - Gap conductance = f(P, H_c, $K_{contact}$)

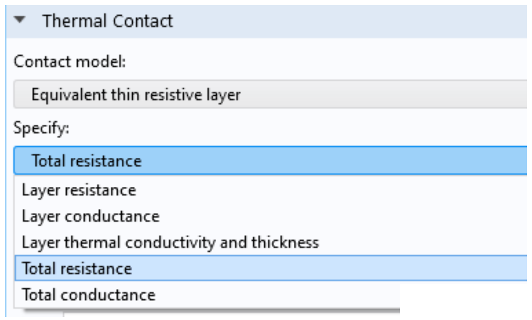
$$h_c = 1.25 \cdot K_{contact} \frac{m_{asp}}{\sigma_{asp}} \cdot \left(\frac{p}{H_c}\right)^{0.95}$$

$$h_g = \frac{k_g}{Y + M_g}$$

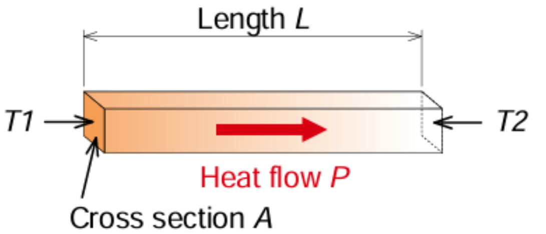
Coefficients calculated by Comsol (with user defined values) / user defined inputs

Equivalent Thin Resistive Layer

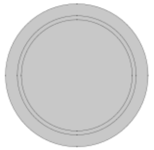
More possibilities how to set – see the [unit]



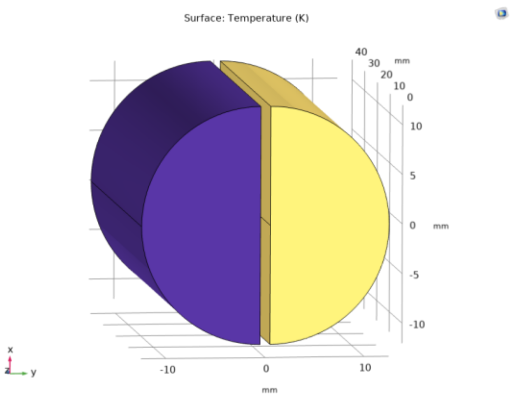
$$R_{th} = \frac{T2 - T1}{Q \cdot A} = \frac{1}{\lambda} \frac{L}{A} \left(\frac{K}{W}\right)$$



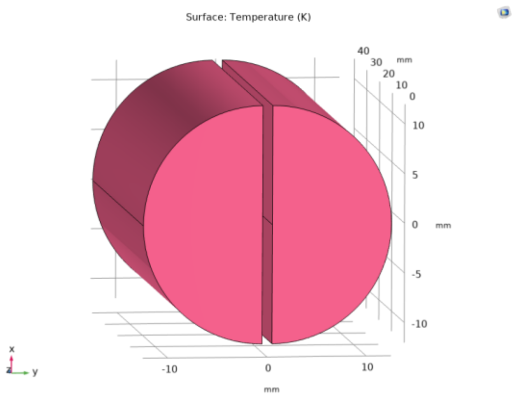
$$R_{th} = \frac{\ln(\frac{r2}{r1})}{k \cdot 2 \cdot Pi \cdot l} \left(\frac{K}{W\, m^2}\right)$$



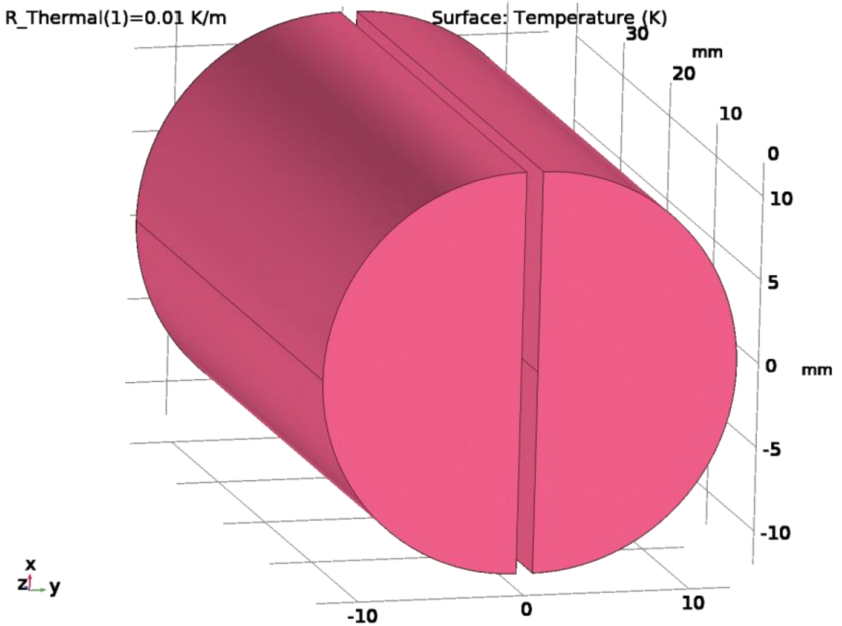
Contact pair model - results

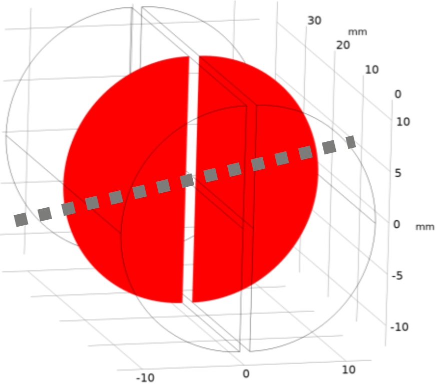


Without contact pair

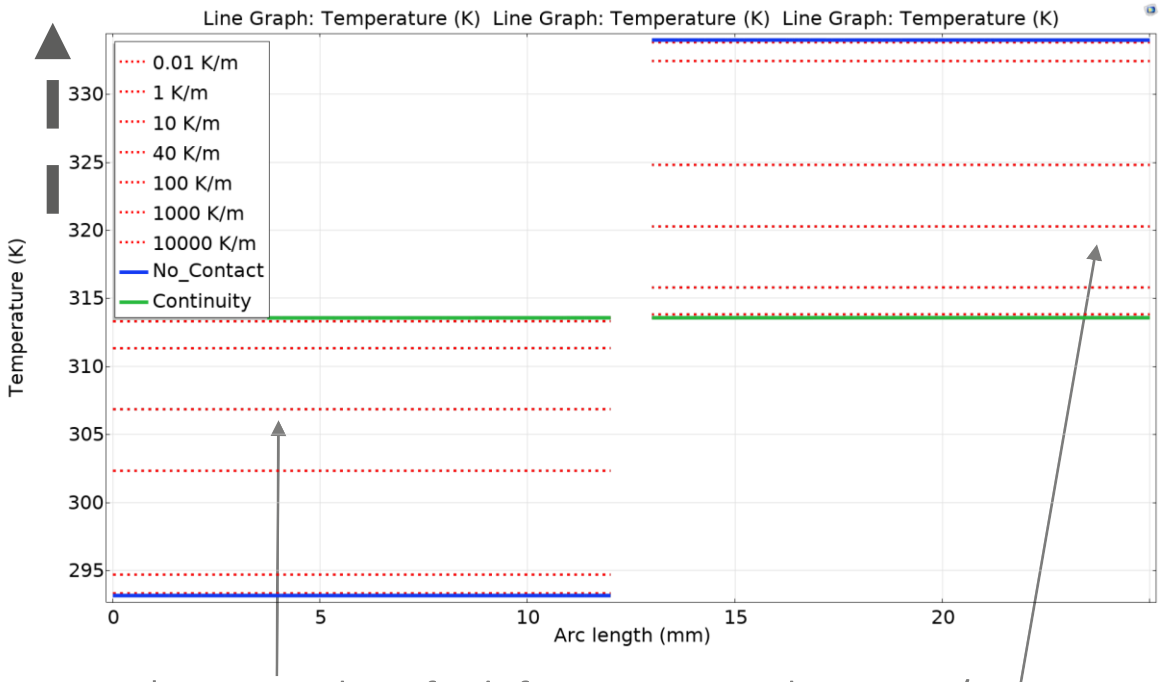


Continuity

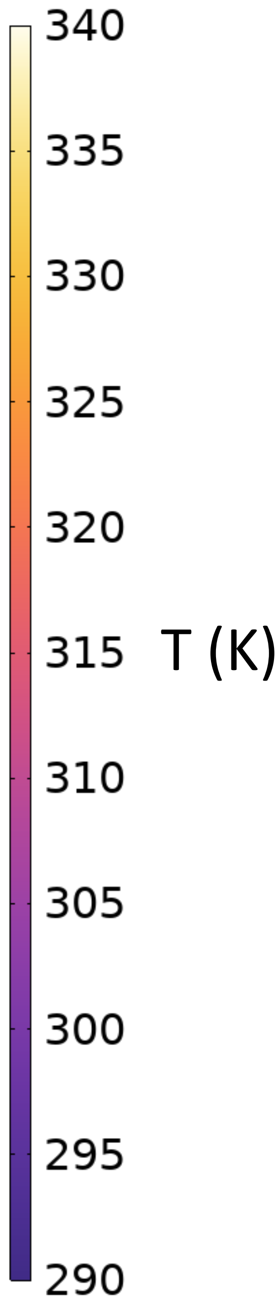




>Rth



*correct value of Rth for our case is about 40 K/W.
Than it becomes:
T= 306.8 K
T= 320.3 K



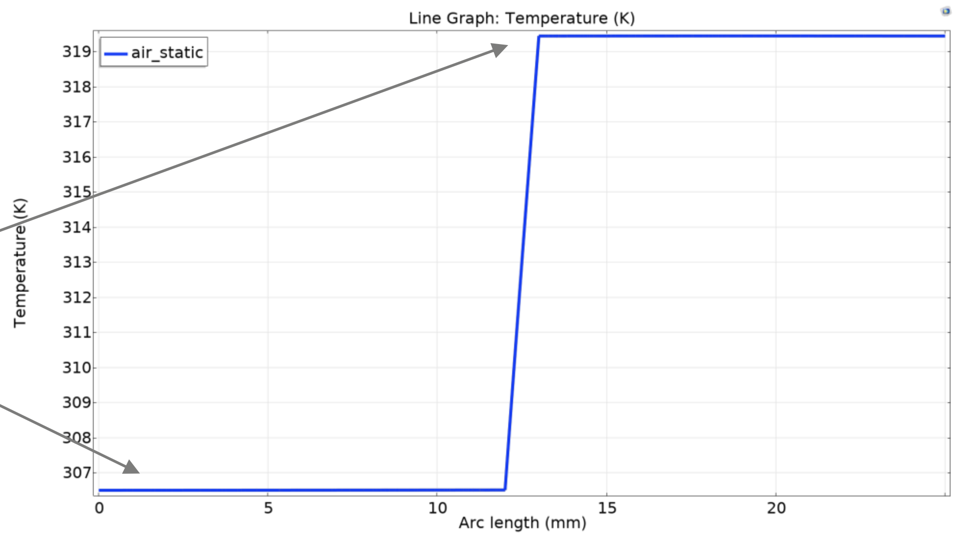
hilase

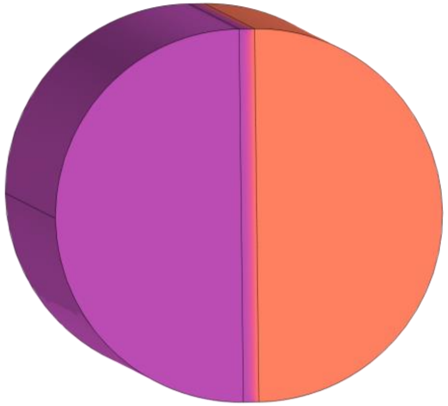
Static fluid model

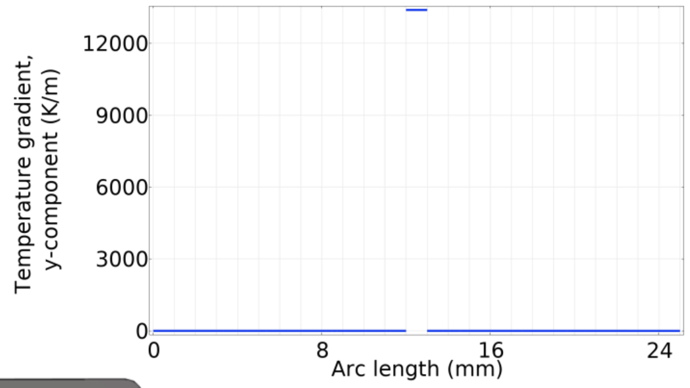
Added new domain between half-cylinders.
Air material properties defined
=simulation with static air

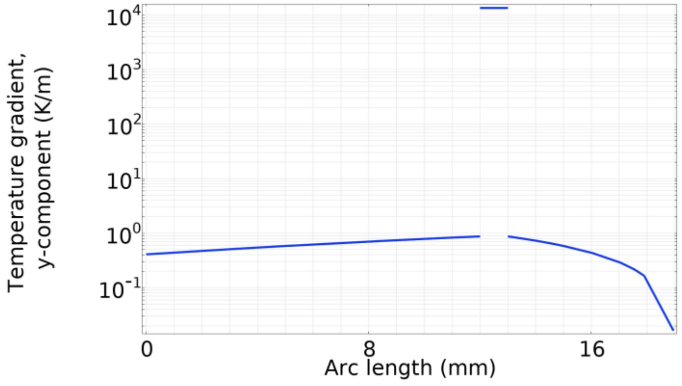
T= 319.7 K

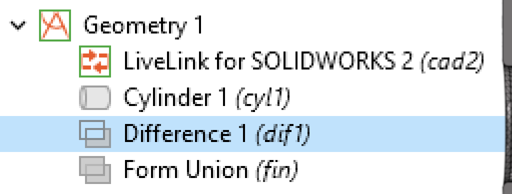
T= 306.3 K

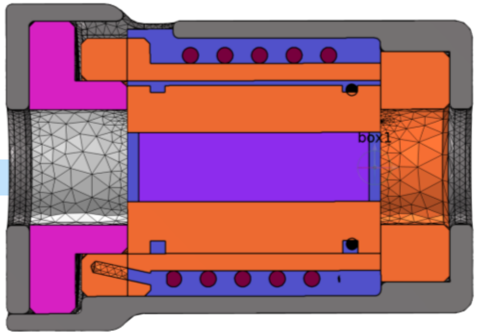


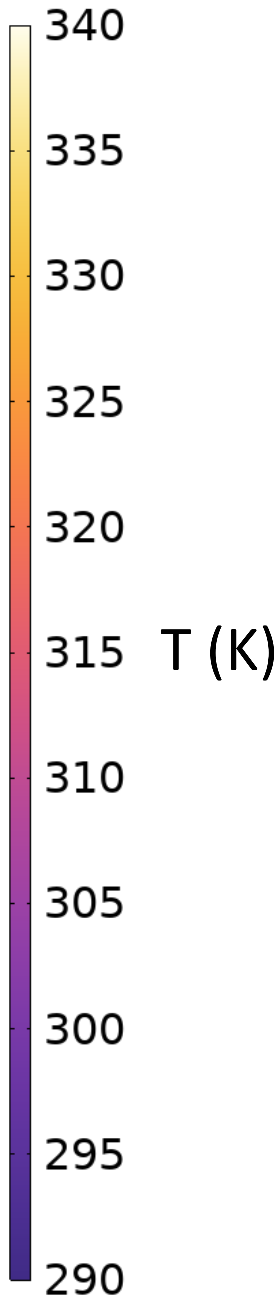






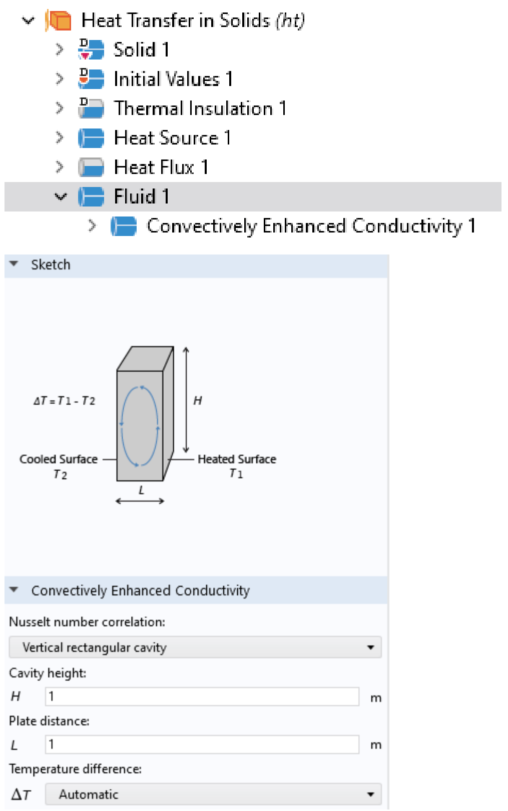




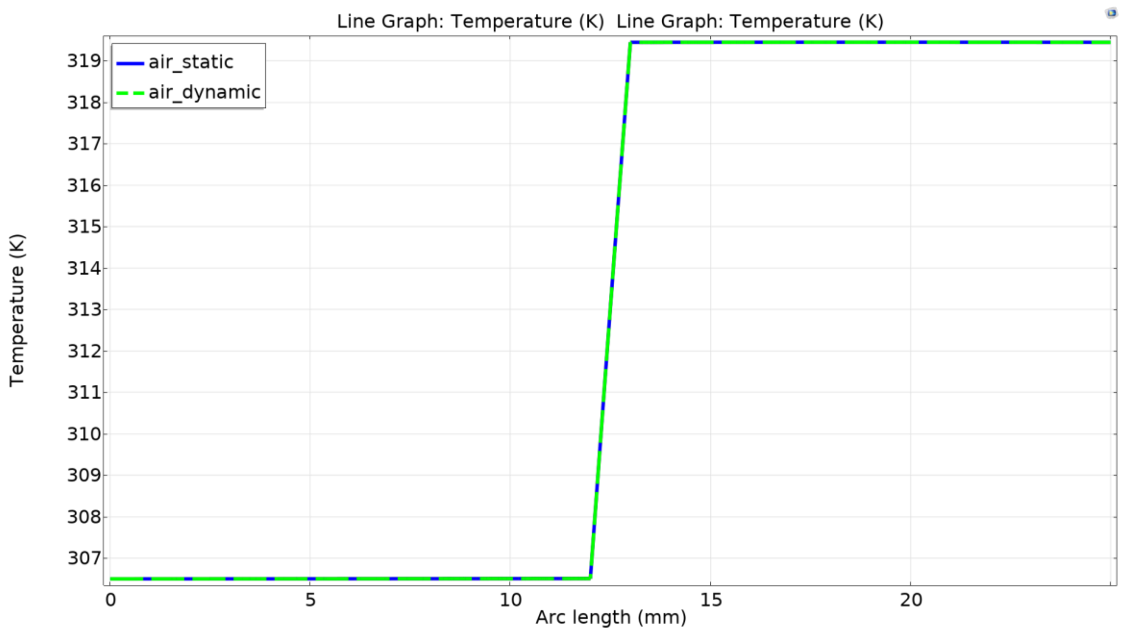


Dynamic fluid model

Add FLUID volume condition to the ht physics. Than select:
Convectively Enhanced Conductivity

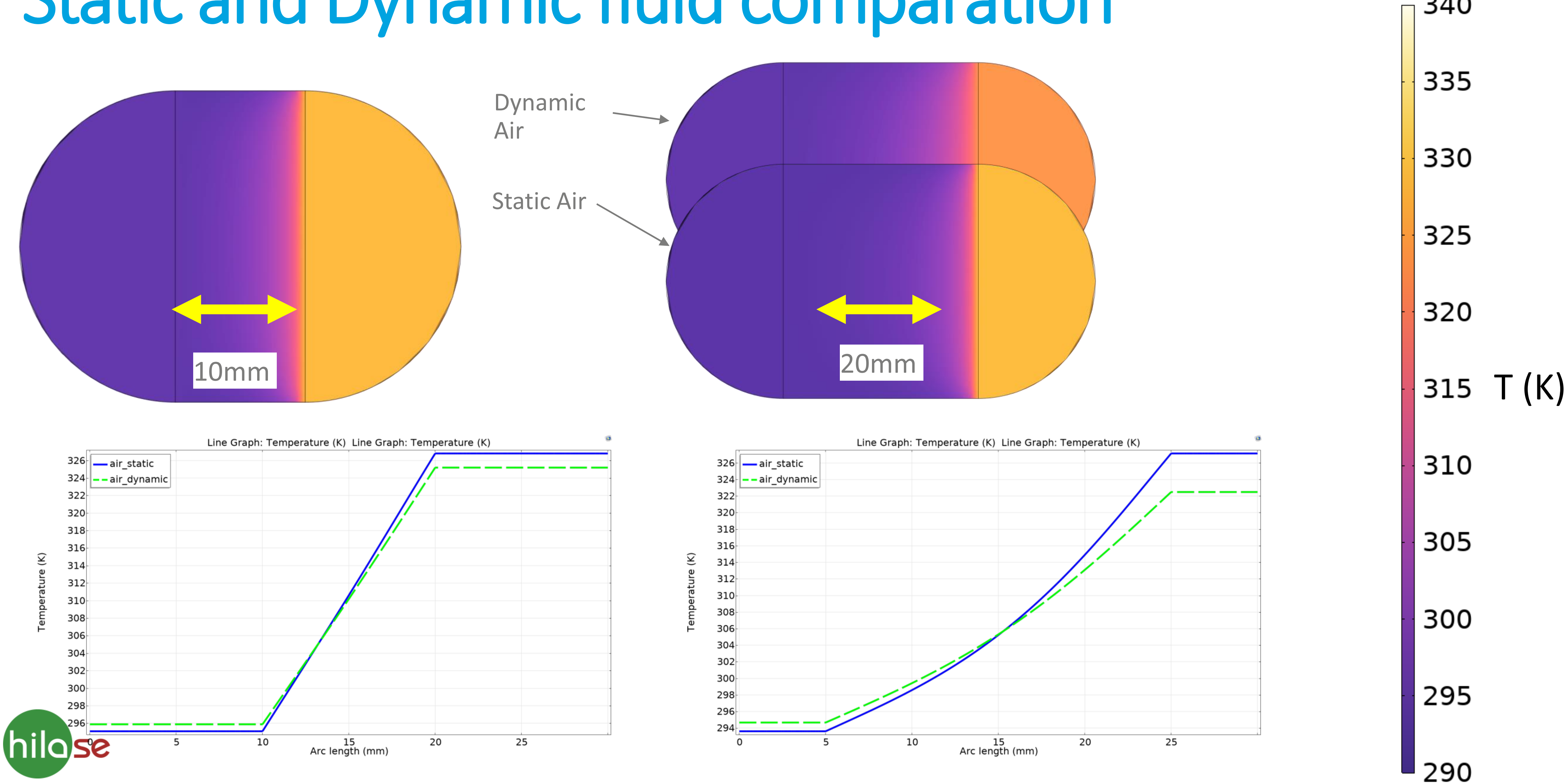


Uses Nusselt correlations for calculating heat transfer in cavity

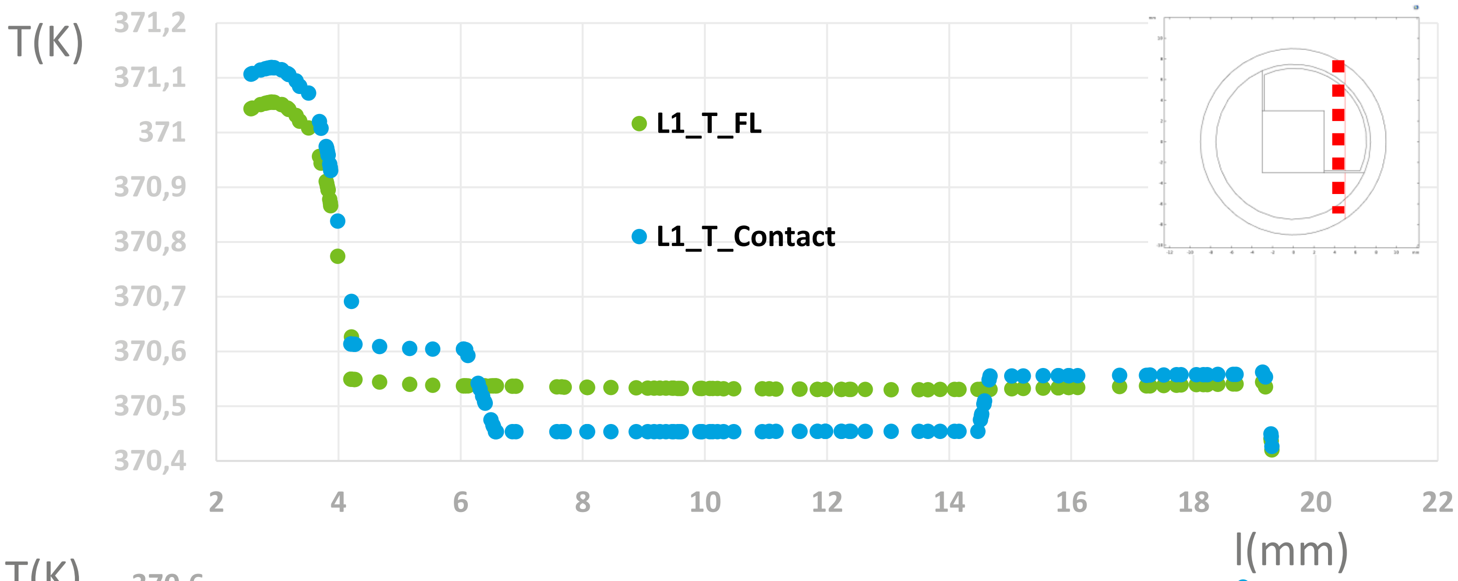


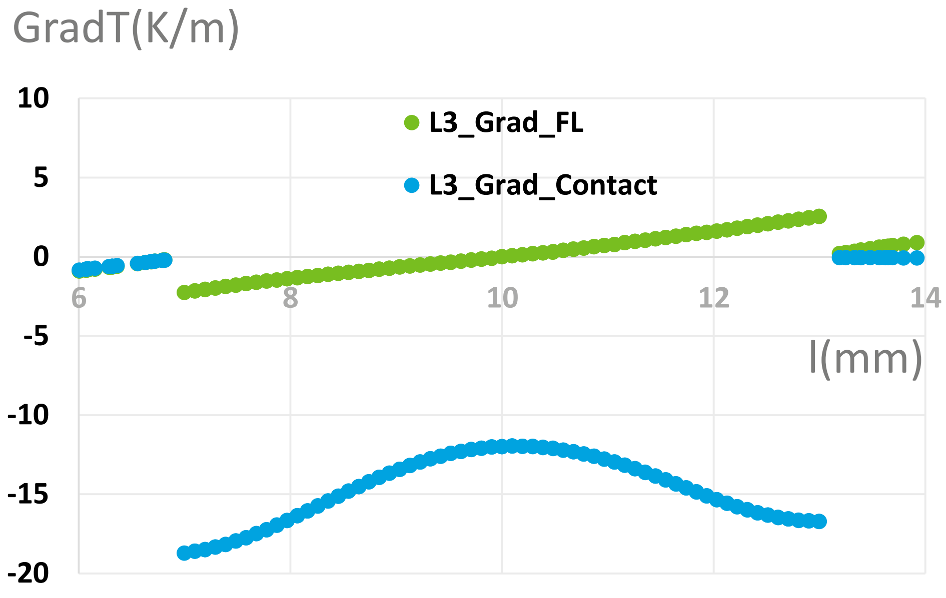
For current settings there is no significant difference between static and dynamic fluid model

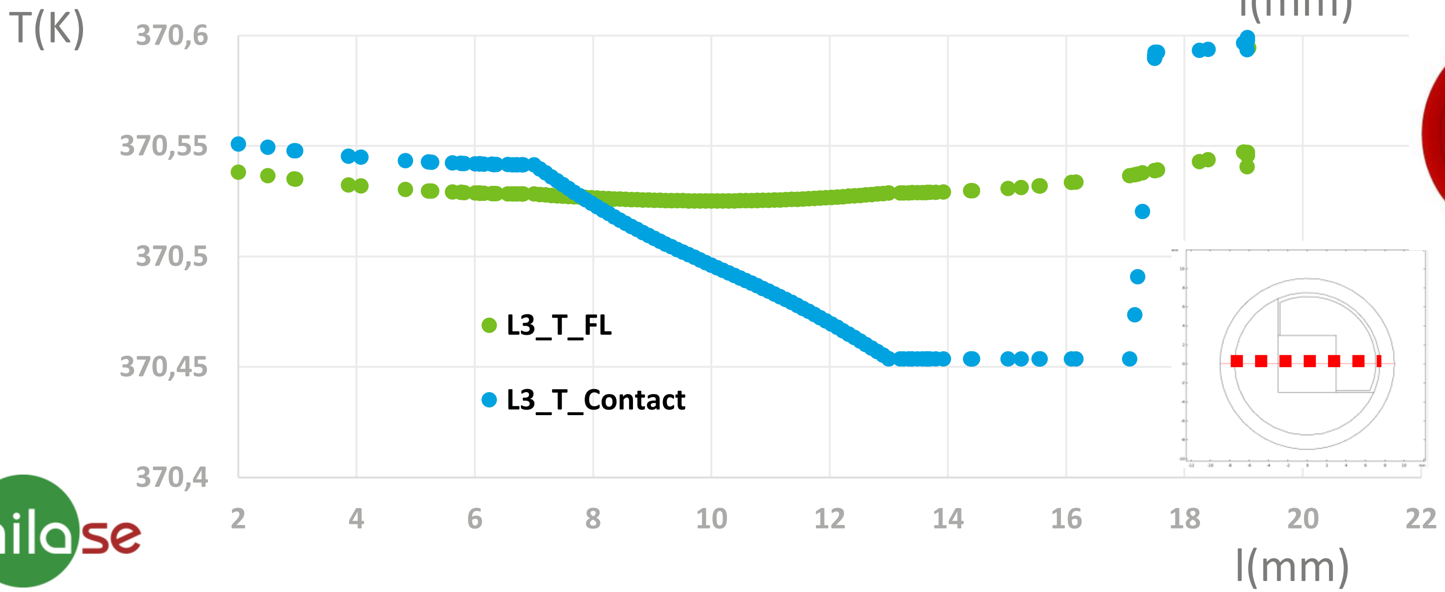
Static and Dynamic fluid comparation

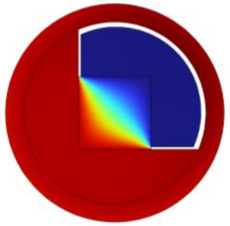


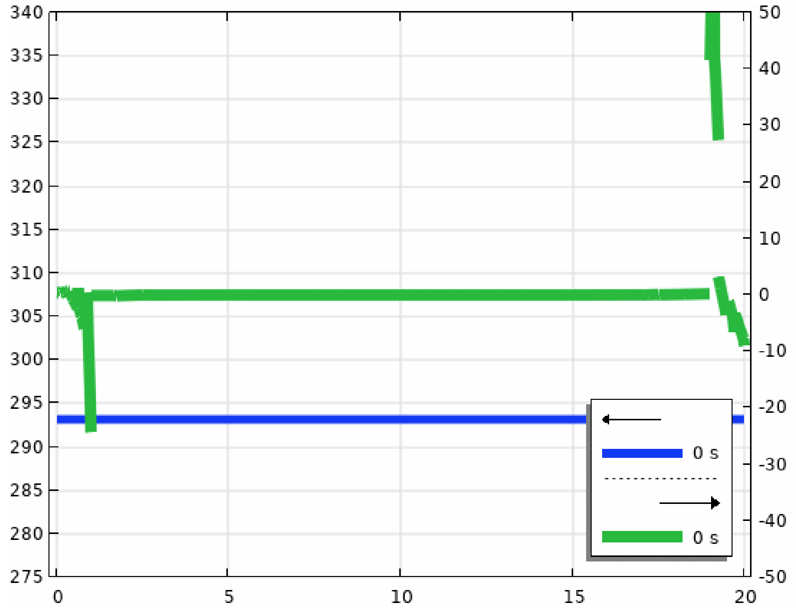
Cavities in (semi) real geometry



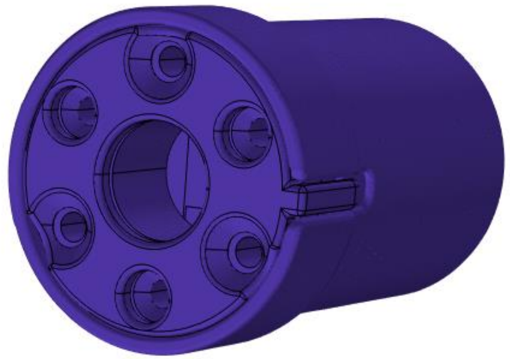








Cavities in Heat Transfer Models



Cavities could be handled via:

Equivalent thermal resistances

Fluid infill of cavities

For real geometry *Convectively Enhanced Conductivity* was used mostly because „smooth“ gradient

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<u>Other possible (future) ways:</u>

Thermal resistances (thermal connection / lumped thermal port)

2-component model

Add radiation

Heat Transfer in Shells (Composite Thermal Barrier model from library)

References:

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