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Thermal Analysis of Electronics Cabinet

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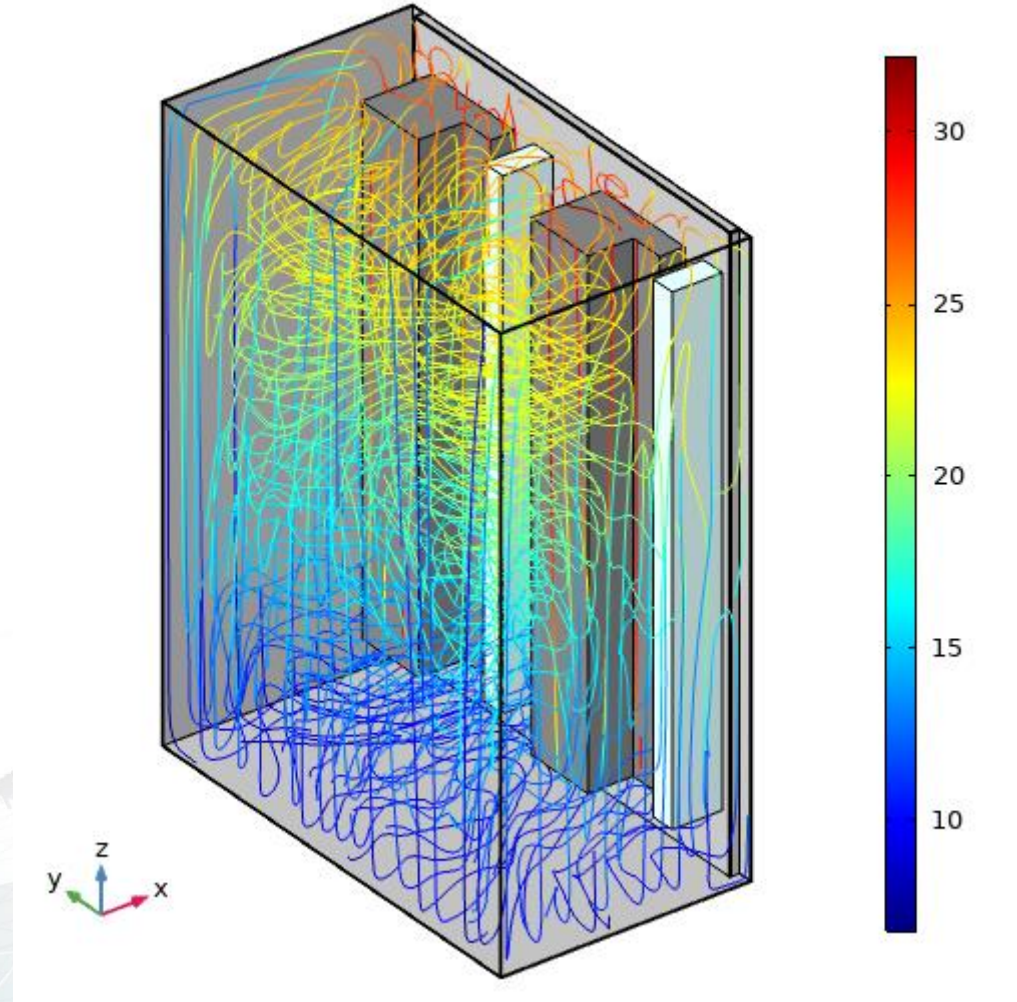
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Outline

- Objective
- Geometry
- Physics
- Spacing sensitivity

Streamline: Velocity field Color: Temperature Rise (°C)



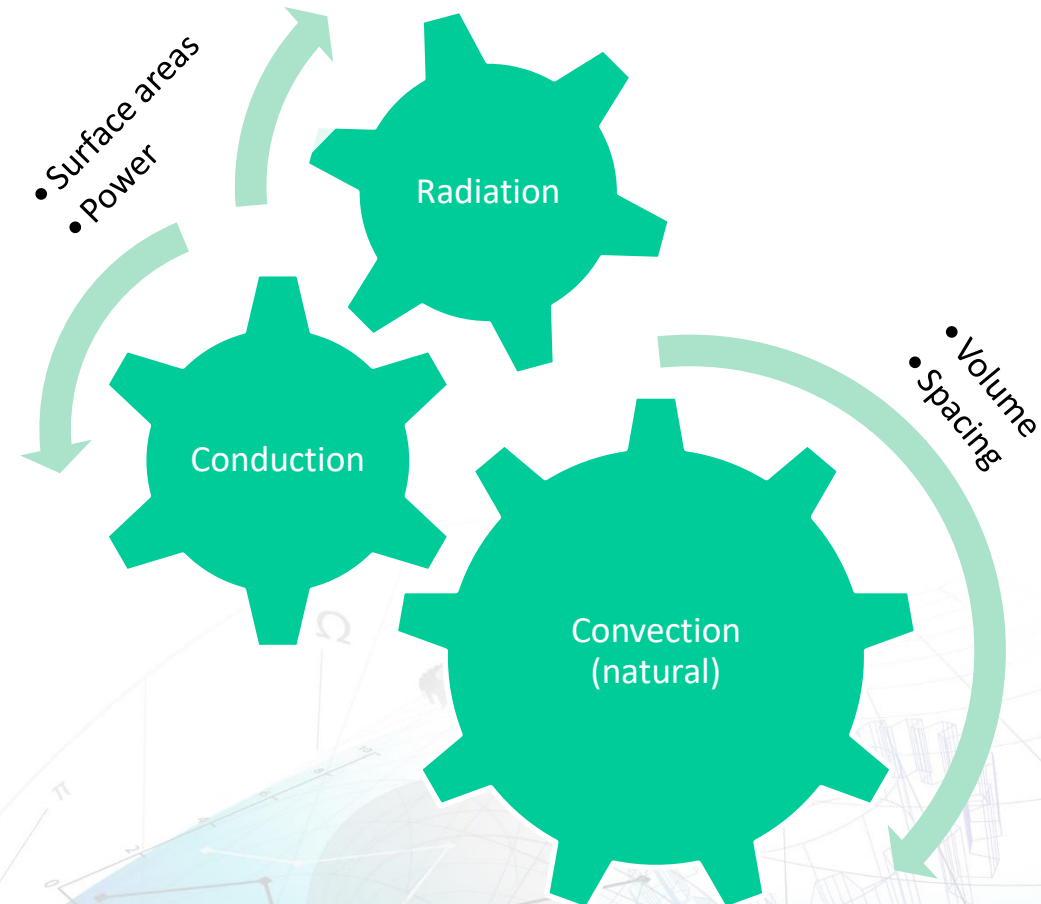
OBJECTIVE



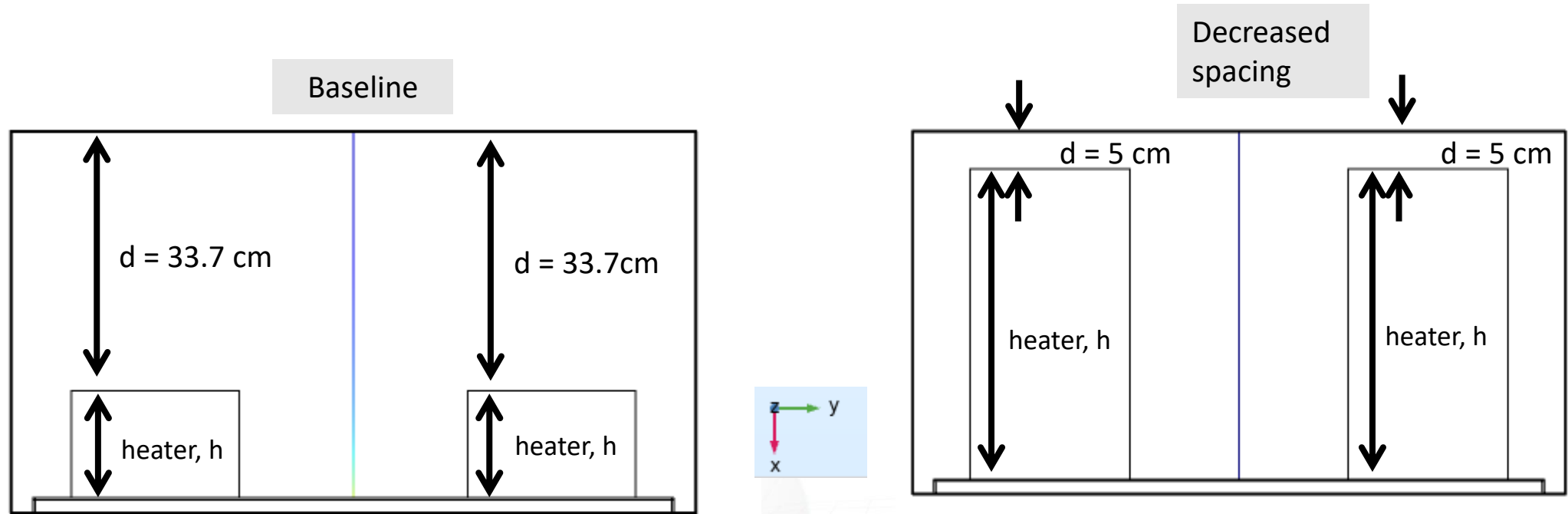
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Use multiphysics modeling to understand passive energy dissipation in electronics cabinets



Specifically, we seek to understand effect of spacing parameter on maximum temperature rise



PHYSICS



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Conjugate heat transfer with radiation

- Intimately coupled, multiphysics analysis
- Solids
 - Heat equation
 - Surface-to-surface radiation
- Fluid
 - Conservation of mass, momentum, and energy
 - $\rho(T,p)$
- Non-default solver strategy

See *AltaSim Tips & Tricks Article*

<http://www.altasimtechnologies.com/>

- Heat Transfer in Solids and Fluids (*ht*)
 - Solid 1
 - Fluid 1
 - Initial Values 1
 - Thermal Insulation 1
 - Heat Source 1
 - Heat Flux 1: Ext. nat. conv. (Vertical Walls)
 - Heat Flux 1: Ext. nat. conv. (Horiz. Upside)
 - Heat Flux 1: Ext. nat. conv. (Horiz. Downside)
 - Surface-to-Ambient Radiation 1
 - Equation View
- Turbulent Flow, Algebraic $yPlus$ (*spf*)
 - Fluid Properties 1
 - Initial Values 1
 - Wall 1
 - Gravity 1
 - Pressure Point Constraint 1
 - Equation View
- Surface-to-Surface Radiation (*rad*)
 - Diffuse Surface 1
 - Initial Values 1
 - Opacity 1
 - Equation View
- Multiphysics
 - Nonisothermal Flow 1 (*nitf1*)
 - Heat Transfer with Surface-to-Surface Radiation 1 (*htrad1*)

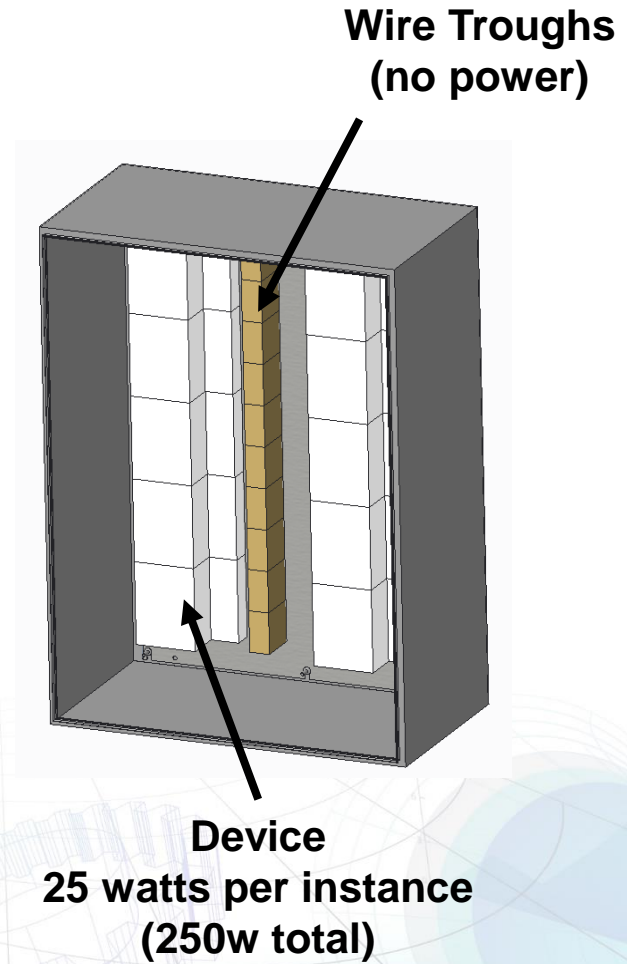
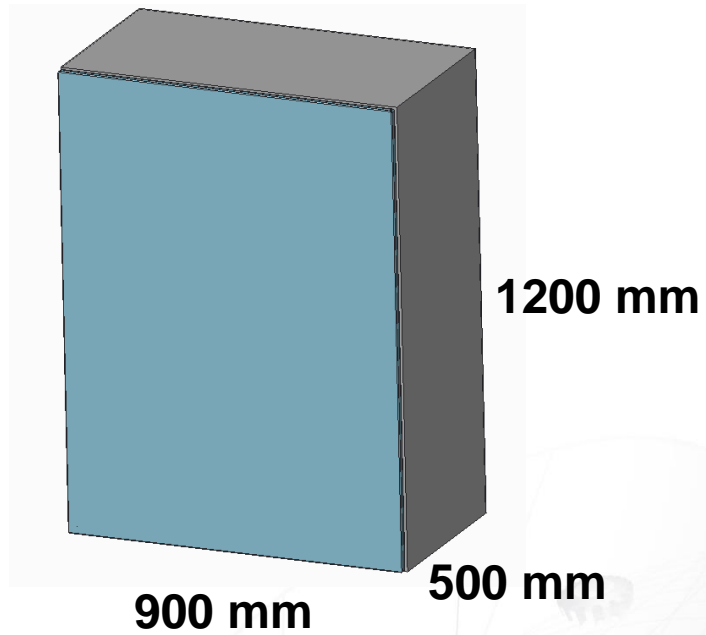
GEOMETRY



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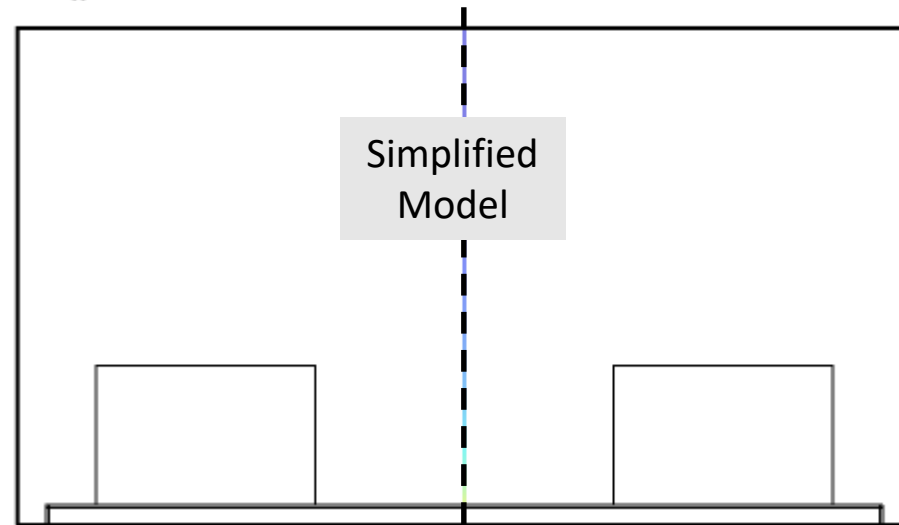
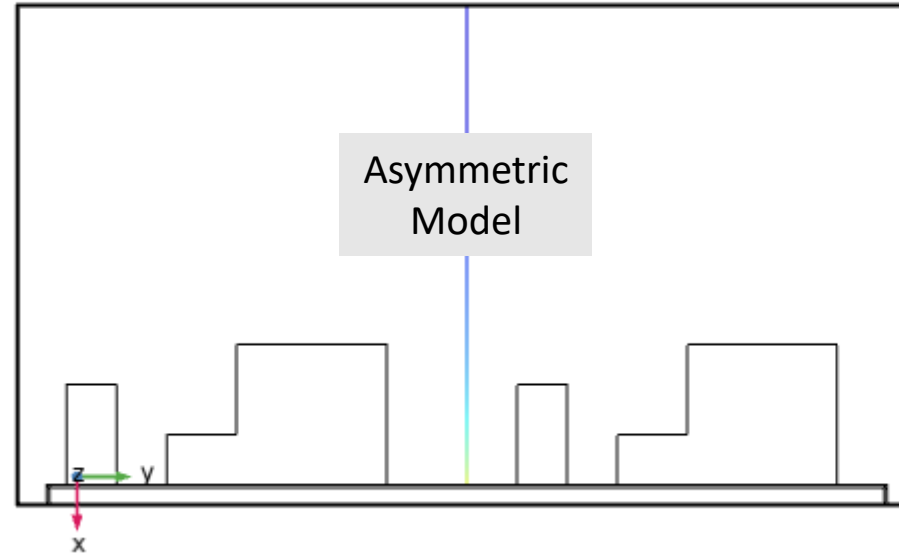
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Geometry simplified for parametric studies

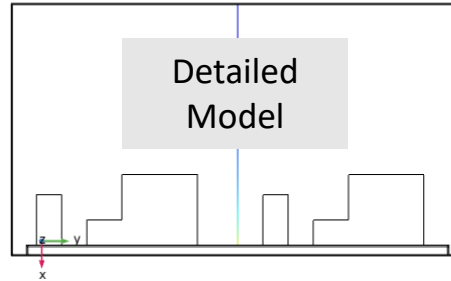


Simplification for half symmetry

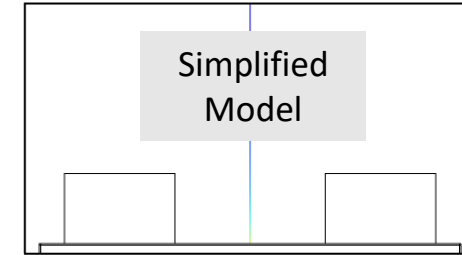
- Heater geometry simplified
- Wire troughs removed
- Half symmetric



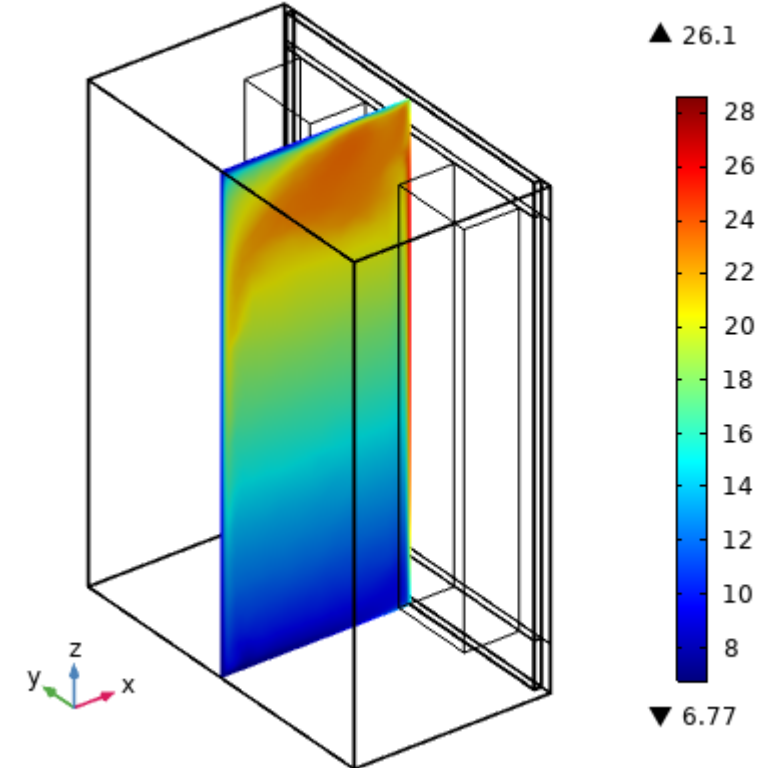
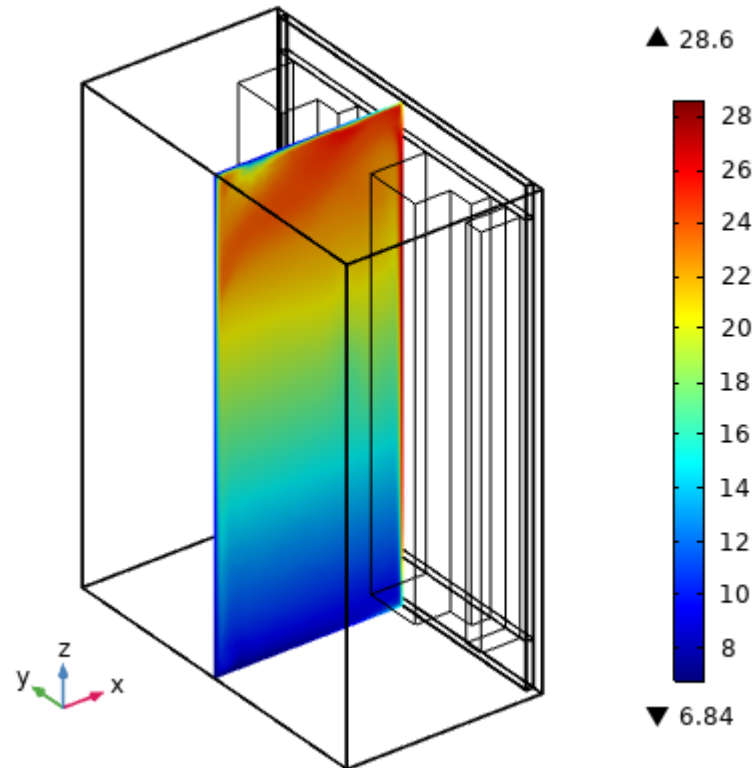
Confirm simplified model is representative



Slice: T-T_amb (K) Line: 1 (1)



Slice: T-T_amb (K) Line: 1 (1)



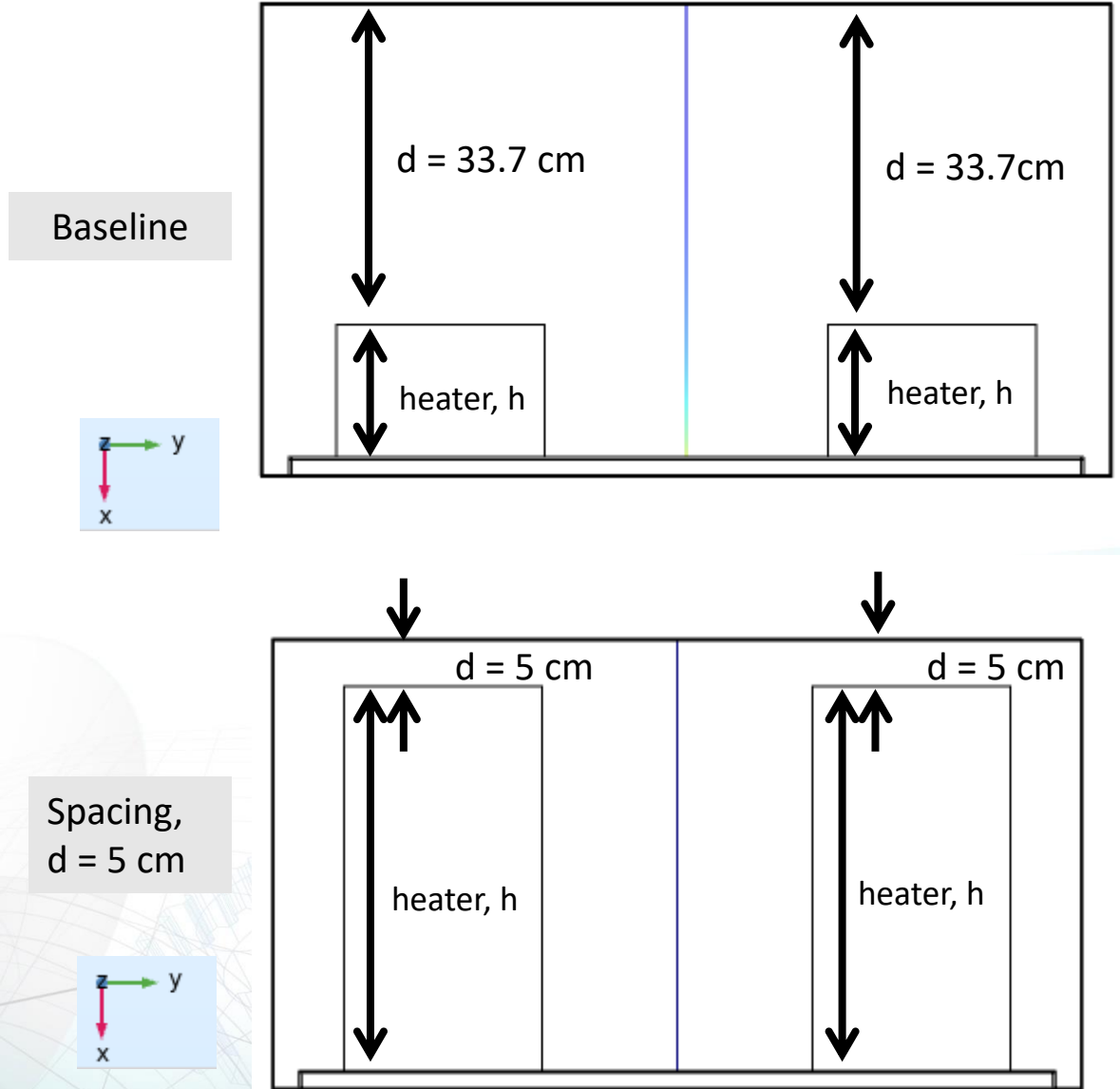
SPACING "GAP" SENSITIVITY



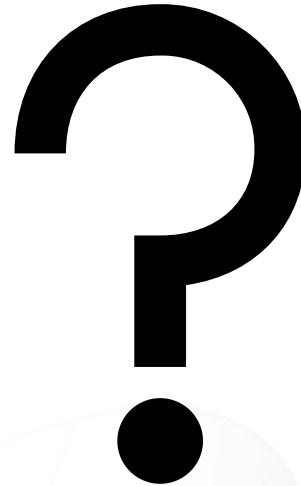
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Spacing geometric parameter

- Spacing between heater and front face of cabinet, d
- Decrease d by increasing heater size, h
- Keep power the same at 250 W



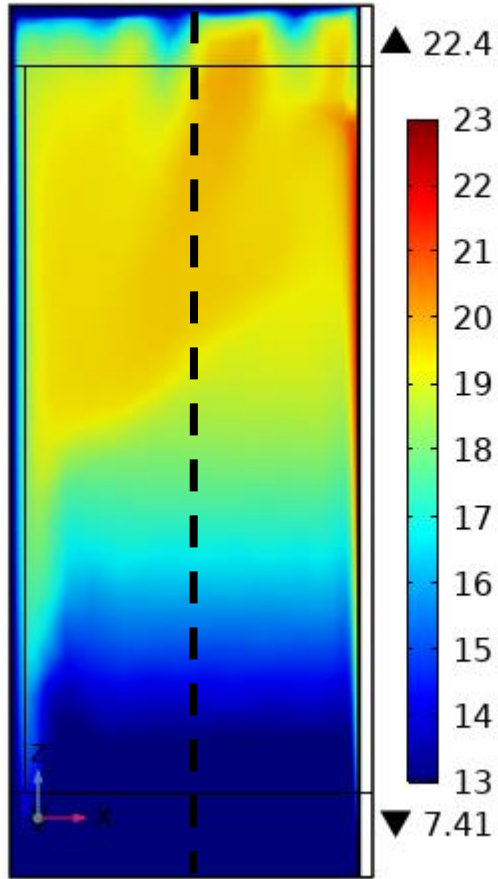
What effect will decreasing the spacing have on the peak temperature?



Temperature variation: Effect of spacing

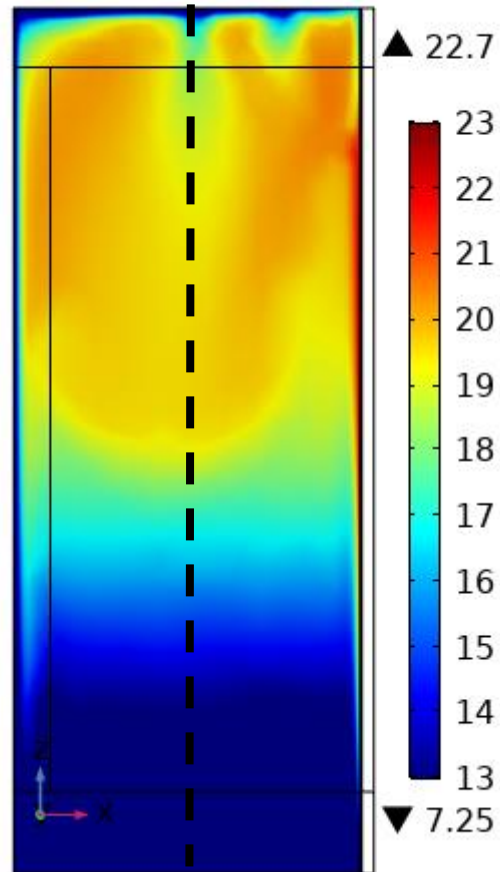
2 cm

Slice: T-T_amb (K) Line: 1 (1)



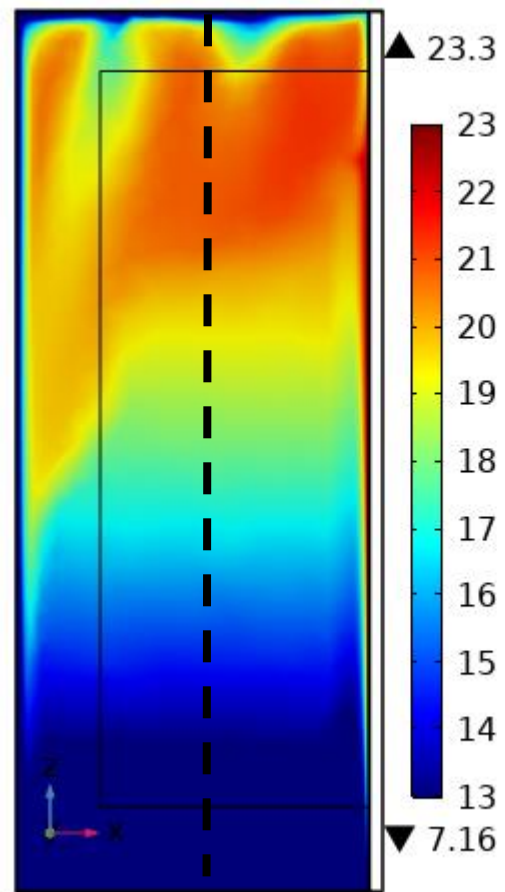
5 cm

Slice: T-T_amb (K) Line: 1 (1)



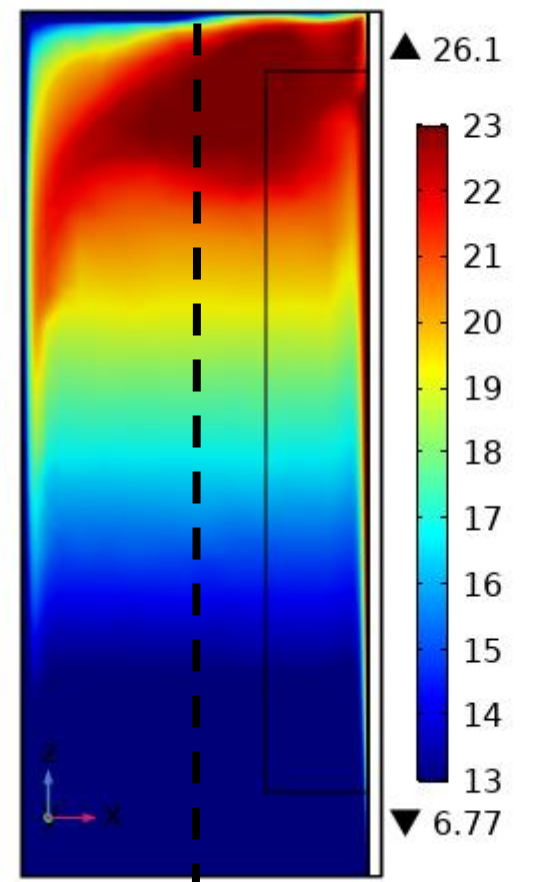
11.3 cm

Slice: T-T_amb (K) Line: 1 (1)

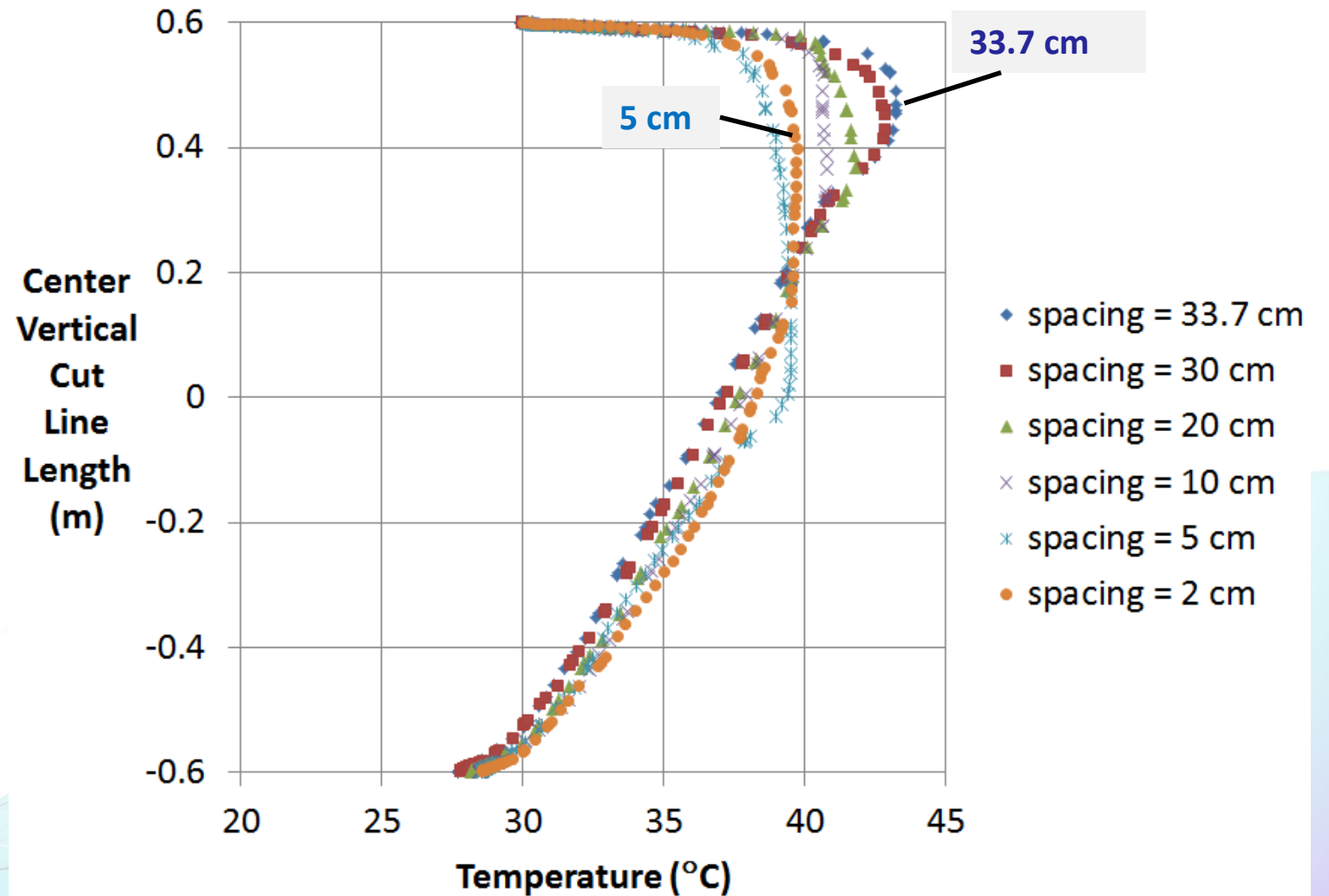
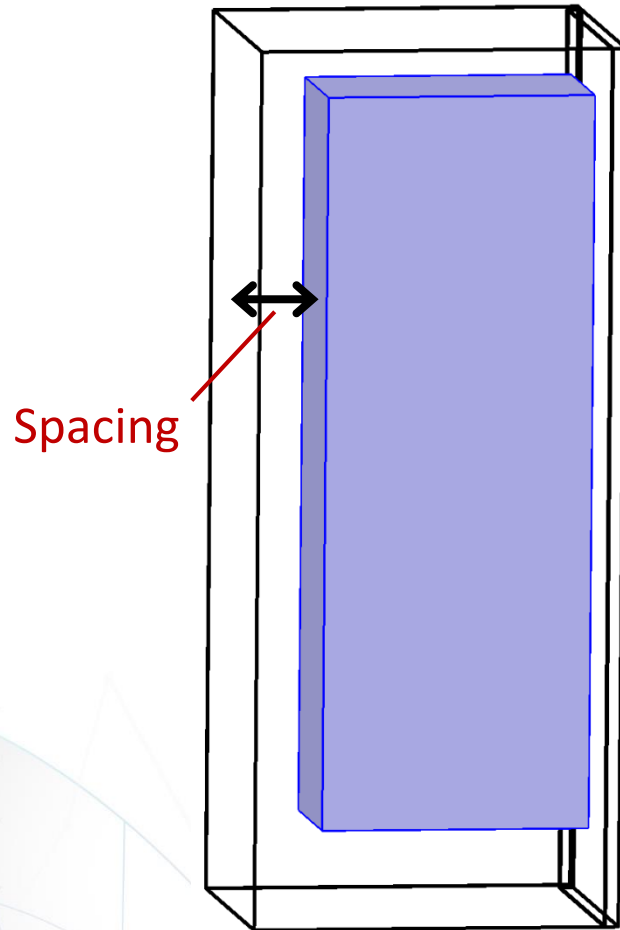


33.7 cm

Slice: T-T_amb (K) Line: 1 (1)

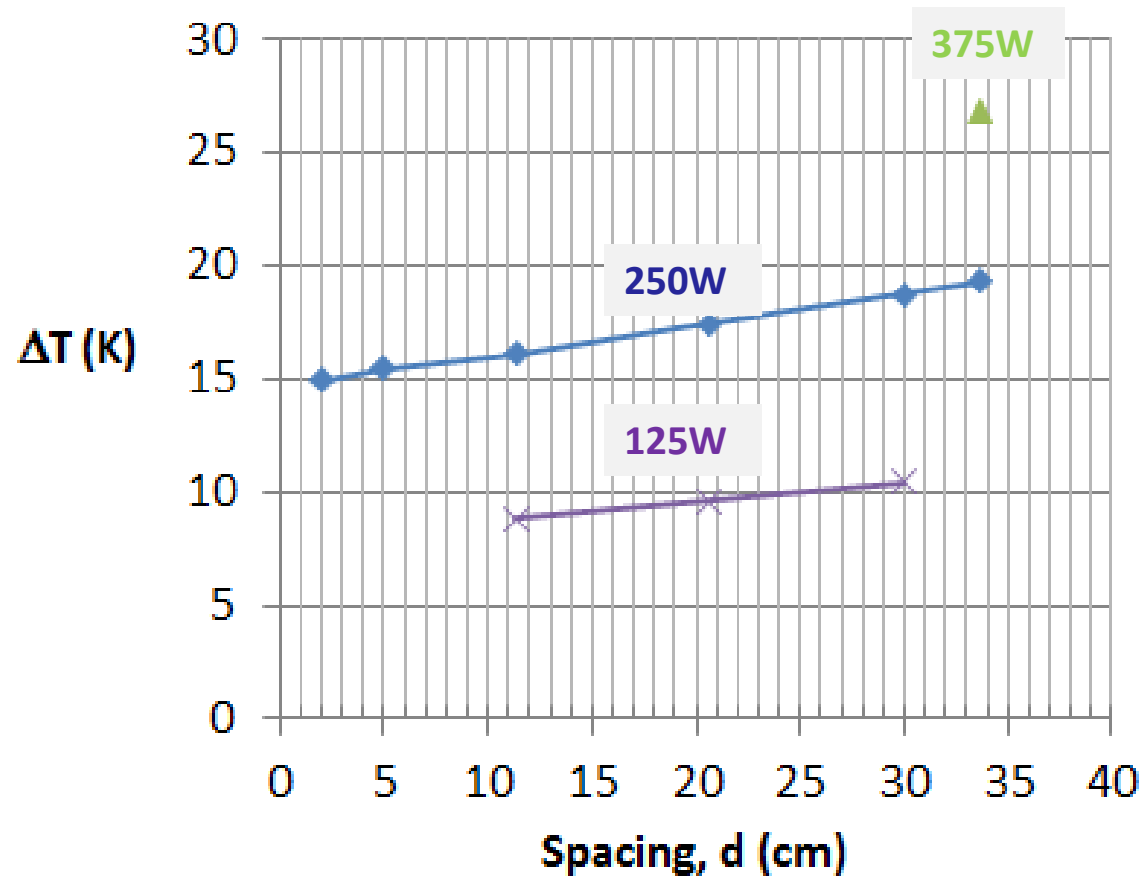


Peak temperature increases as spacing increases

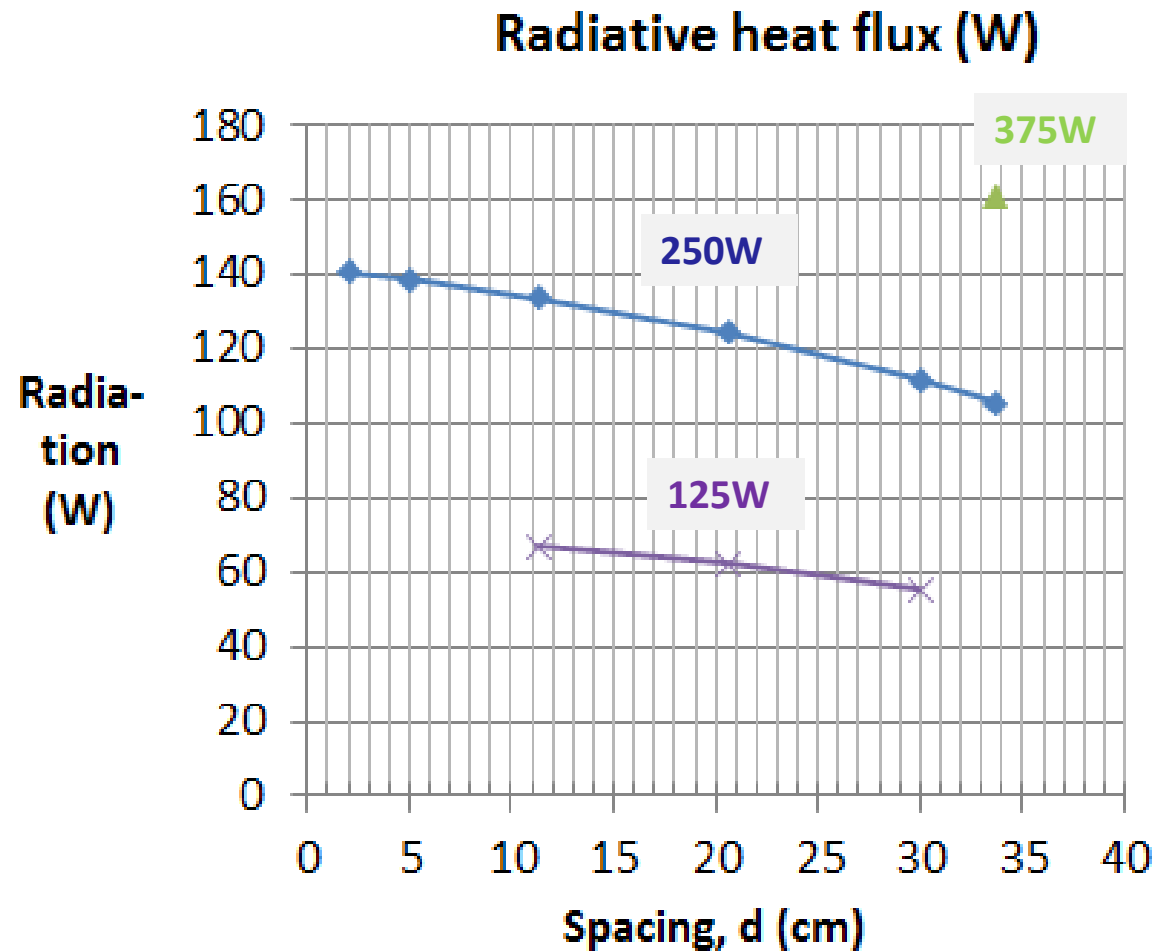


ΔT top to bottom: Effect of spacing and power

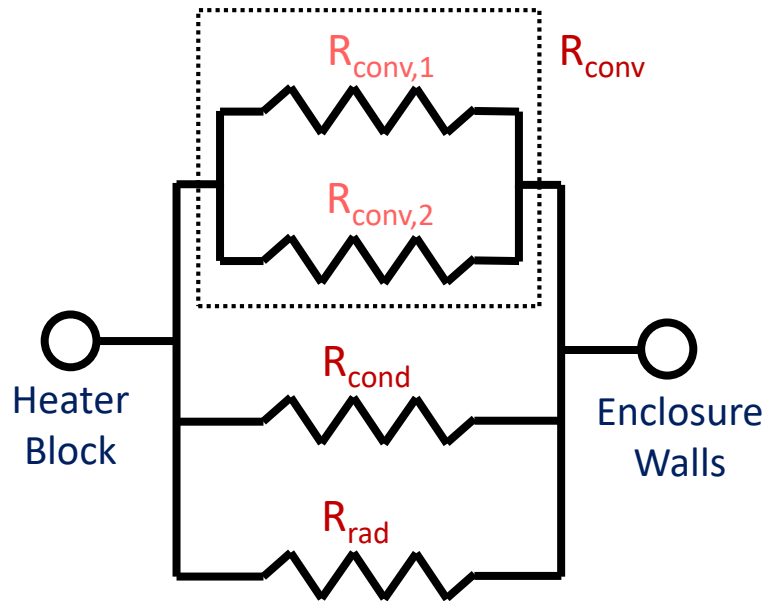
Max. T minus Min. T on Center Slice in Cabinet (K)



Radiative heat flux: Effect of applied power



Effect of spacing on thermal resistances in cabinet model



Thermal Resistances ($^{\circ}\text{C}/\text{W}$) at 250 W							
		Thermal Path					R_{total}
		R_{rad}	R_{cond}	R_{conv}	$R_{conv,1}$	$R_{conv,2}$	
Spacing (cm)	11.3	0.119	0.322	0.238	1.345	0.289	0.063
	20.7	0.143	0.316	0.260	1.182	0.333	0.071
	30.0	0.183	0.301	0.291	1.074	0.399	0.082

R_{rad} : Radiation from heating block to enclosure walls
 R_{cond} : Conduction from heating block into back plate
 R_{conv} : Total convection from heating block to enclosure walls
 $R_{conv,1}$: Convection from "front" face of heating block
 $R_{conv,2}$: Convection from all other faces of heating block

↑
 Convective resistance from front face does indeed go down as spacing increases.

Proportion of heat transfer mode versus spacing

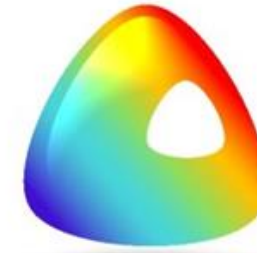
Spacing (cm)	Mode of Heat Transfer		
	Convection	Conduction	Radiation
11	26%	21%	54%
21	26%	24%	50%
30	28%	27%	45%

Lessons learned

- Generally:
 - Radiation effect (even at “low” temperatures) is important due to relatively low convection and conduction fluxes
- Specifically:
 - Negative effect of chocking of natural convection from front face not as important as positive effect of increasing surface area for radiation improvement and convection from other side faces

Further reading

- August 2019 - AltaSim COMSOL Tips Tricks - Solver Speed-up for Conjugate Heat Transfer with Radiation
- <https://www.comsol.com/blogs/the-importance-of-thermal-radiation-in-your-models/>
- [https://www.comsol.com/offers/Predicting-the-Thermal-Performance-of-Electronic-](https://www.comsol.com/offers/Predicting-the-Thermal-Performance-of-Electronic-Devices)
[Devices](https://www.comsol.com/offers/Predicting-the-Thermal-Performance-of-Electronic-Devices)



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COMSOL Tips & Tricks

COMSOL Blog

The Importance of Thermal Radiation in Your Models



by Phillip Oberdorfer

August 23, 2019



COMSOL APPLICATION NOTES
SIMULATION-DRIVEN DESIGN
for the Thermal Management of Electromagnetic Devices

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