



# Temperature Calculations with Mathematica

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# Last Weeks Studies with KLCPS64 Model

- Study temperature in the absorber only using Mathematica.
- Check consistency with Tim's calculations with ANSYS
  - Tim calculated temperature for KLCPS64 with rectangular grid.
  - I calculated temperature for KLCPS64 with cylindrical grid with the same cooling model (cooling holes off-center by 8cm in each direction).
  - The results for  $T_{\max} = 205 \text{ }^{\circ}\text{C}$  match within  $5 \text{ }^{\circ}\text{C}$  .
- Checked rectangular grid in Mathematica (without cooling holes).
  - $T_{\max}$  seems to be dependent on the mesh size (currently 2mm).
    - My cylindrical grid for now provides better sensitivity (x10) at the location of the triangular wedge.
  - The results for rectangular and cylindrical model in Mathematica match within  $15 \text{ }^{\circ}\text{C}$  .
- I noticed an x-asymmetry in the solutions for temperature around triangular wedge when solving in cylindrical coordinate system.
  - This is related to how  $2\pi$  periodic boundary conditions are imposed in the cylindrical coordinates.
  - It apparently can cause about  $10 \text{ }^{\circ}\text{C}$  difference in  $T_{\max}$ , based on my tests.
    - After fixing the asymmetry  $T_{\max}$  seems to go up by  $10 \text{ }^{\circ}\text{C}$
  - I will switch to  $\phi \in [-\pi/2, 3\pi/2]$  range and stitch the solution at those limits instead of  $\phi \in [-\pi, +\pi]$  .
    - It would be great if Pavel can provide cylindrical grid with those limits.

# Temperatures from Pavel's Tests

- I looked at some of the tests that Pavel did with KLCPS64 model to estimate the temperature in the absorber.
  - $\pm 10\%$  B-field and  $\sigma^{(x,y)}_{\text{beam}}$  widths are kind of extreme conditions that are highly unlikely to occur during running.
- Used water temperature  $T_{\text{water}} = 40^\circ\text{C}$  with cooling holes offset at 7cm in each direction.
- All tests were solved using similar conditions and parameters for consistency.
- None of the tests produces high maximum temperature or requires high temperature at the water boundary.
  - The highest  $T_{\text{max}}$  so far happens with -1 mrad angle in Y as well as 110% B-field, when the beam hits the forward corner of the absorber.
- The current vertical beam position may not be optimal for the B-field.
  - Can be addressed at a later stage when B-field is better defined
- There are other tests that Pavel did that I have not checked yet.

Test Name	Hot Spot Location Section	$R_{\text{max}}$ (cm)	$\phi_{\text{max}}$ (deg)	$Z_{\text{max}}$ (cm)	$T_{\text{max}}$ ( $^\circ\text{C}$ )	$T_{\text{holes}}$ ( $^\circ\text{C}$ )	Comment
Nominal ( $\sigma^{(x,y)}_{\text{beam}} = 1 \text{ mm}$ )	Triangular	0.3	70	8	$240 \pm 25$	55	x-asymmetry
$\sigma^{(x,y)}_{\text{beam}} = 100 \mu\text{m}$	Triangular	0.0	N/A	44	$240 \pm 25$	65	No asymmetry
90% B-field	Rectangular	0.2	90	59	$230 \pm 25$	60	x-asymmetry
110% B-field	Triangular	0.2	70	8	$305 \pm 25$	70	x-asymmetry
-1mm shift in Y	Triangular	0.2	70	8	$255 \pm 25$	65	x-asymmetry
+1mm shift in Y	Rectangular	0.1	90	57	$180 \pm 25$	60	x-asymmetry
-1mrad angle in Y	Triangular	0.15	70	8	$335 \pm 25$	70	x-asymmetry
+1mrad angle in Y	Rectangular	0.2	90	59	$240 \pm 25$	60	x-asymmetry