Temperature Calculations with Mathematica

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Studies with KLCPS64 last week

- 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 8cm in each direction).
  - The results for T_{max} =205 ^{0}C match within 5 ^{0}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 ^{0}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 2π periodic boundary conditions are imposed in the cylindrical coordinates.
  - It apparently can cause about 10 ^{0}C difference in T_{max} , based on my tests.
    - After fixing the asymmetry T_{max} seems to go up by 10 ^{0}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.
  - ±10% B-field and $\sigma^{(x,y)}_{beam}$ widths are kind of extreme conditions that are highly unlikely to occur during running.
- Used water temperature T_{water}=40 ^{0}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_{max} so far happens with -1mrad angle in Y and 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 looked at yet.

Test Name	Hot Spot Location Section	R_{max} (cm)	ϕ_{max} (deg)	Z_{max} (cm)	T_{max} (^{0}C)	T_{holes} (^{0}C)	Comment
Nominal ($\sigma^{(x,y)}_{beam}$ = 1 mm)	Triangular	0.3	70	8	240 ±25	55	x-asymmetry
$\sigma^{(x,y)}_{beam}$ = 100 μm	Triangular	0.0	N/A	44	240 ±25	65	No asymmetry
90% B-field	Rectangular	0.2	90	59	230 ±25	60	x-asymmetry
110% B-field	Triangular	0.2	70	8	305 ±25	70	x-asymmetry
-1mm shift in Y	Triangular	0.2	70	8	255 ±25	65	x-asymmetry
+1mm shift in Y	Rectangular	0.1	90	57	180 ±25	60	x-asymmetry
-1mrad angle in Y	Triangular	0.15	70	8	335 ±25	70	x-asymmetry
+1mrad angle in Y	Rectangular	0.2	90	59	240 ±25	60	x-asymmetry