2nd harmonic RF perpendicular biased cavity update (04 Apr – 16 May 2014)

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16 May 2014

Agenda

- How do we want to cool the ferrite?
  - Water
  - Paraffin
  - Fluorinert
- Matching measurements of AL400 to simulations
  - The amount of demagnetization N depends on geometry!
  - Resolving the difference in μ and μ' between measurement and theory and simulations.
    - This has a bearing on the losses in the ferrite!
- Mechanical engineer. Who?

Cooling

- Problems with AlN is that it hydrolyzes in the presence of water.
- Get away from AlN or BeO and use direct liquid cooling
  - Water
  - Paraffin
  - Fluorinert
- The above liquids considered by KEK for their Finemet cavities.

Water cooling Finemet cavities

- Direct water cooling not used because of concern over material erosion and LCW contamination.
- 1” thick watercooled copper plates are used instead.
  - Electrically isolated with Kapton film between cores and copper plate.

Parafin cooled Finemet

- Don't need to worry about rusting
  - Flow rate is higher 1 m/s but this gives turbulent flow. (compare 0.1 m/s laminar flow for water)
  - Fire hazard? 70 degC ignition!
  - Radiation effects on parafin?
  - Electrical breakdown
    - Water 280 – 400 V/mm, parafin > 4 kV/mm

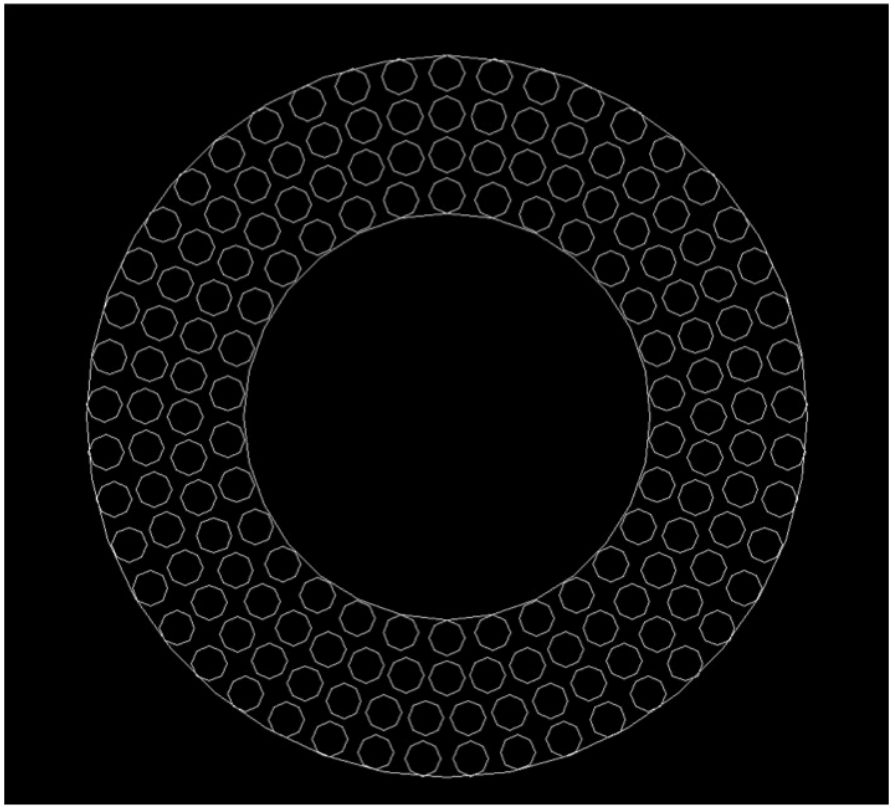
Fluorinert cooled Finemet

- Water causes corrosion.
  - Coatings that stop water interrupts heat transfer
    - Buckling occurs with insufficient cooling!
- Advantage of Fluorinert is that it does not contain oxygen.
  - Thermal conductivity 0.0624 W/m/K compared to water 0.628 W/m/K (10 x worse than water!)
  - Use turbulent flow to get same cooling as water in laminar flow? (page 56)
  - Must operate < 120 deg C because of ion decomposition.
  - $200 per litre!
  - ANSYS CFX to simulate flow.
    - Rudders used to remove stagnation points.
  - Flow rate 80 L/min.

Proposal to change ferrite geometry

- Inspiration came from demagnetization factor which is dependent on geometry of the ferrite
  - Demagnetization given by N_z 4π M_s
  - And N_z depends on geometry.
  - For annulus ID=8.661”, OD=15.354” and thickness=1”, N_z =0.74.
  - This is really a red herring because we can always overpower demagnetization with more B-field from the solenoid, especially at low field. For AL800 $4\pi M_s$ = 800 gauss.

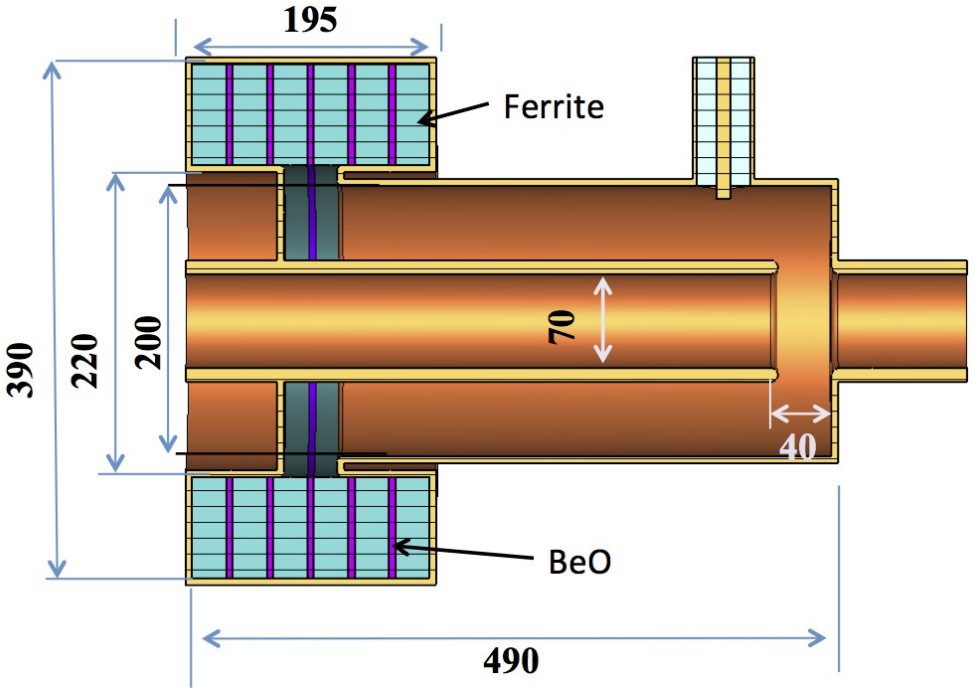
Change cavity ferrite geometry



0.75” diameter rods, 7.7” long.
Shortest distance between rod surfaces 0.1”.

Total number of rods 160.
Volume of rods is 544 cubic inches.

Nz = 0.04 for 7.7” and 0.03 for 10.5” long rods



Reference design, volume of annuli is 742.3 cubic inches. (Nz=0.74)

We lose (742.3-544)/742.3=27% in volume.

Can make rods longer to compensate from 7.7” to 10.5” to compensate to get same volume of ferrite.

Advantages of rods (1)

- More surface area
  - For rods
    - (2*π*0.375)*10.5 = 24.7 sq inches per rod
    - Total surface area = 160*24.7 = 3958 sq inches.
  - For annuli
    - Each annulus has surface area
    - $$2\times\left[\pi\left(r_2^2-r_1^2\right)\right]=2\times126=252.5 \text{ sq inches}$$
    - But there are 6 annuli, and so total surface area is 1515 sq inches < 3958 sq inches. Therefore, rods should be cooler

Advantages of rods (2)

- Possibly cheaper to buy.
- Easier to refurbish. Just pull rods out and put in new ones.
- Can use direct water cooling if we insulate the rods with inert material. (Does ferrite corrode in the first place? Recall formula $Y_3Fe_5O_{12}$, it's already has oxygen bonded to iron)
  - Must do this to prevent corrosion of rods.
  - Silica for insulate?
- Use sacrificial electrode like zinc????
- Expect maintenance/refurbishment schedule every 3 years?
  - Optimistic/Pessimistic?