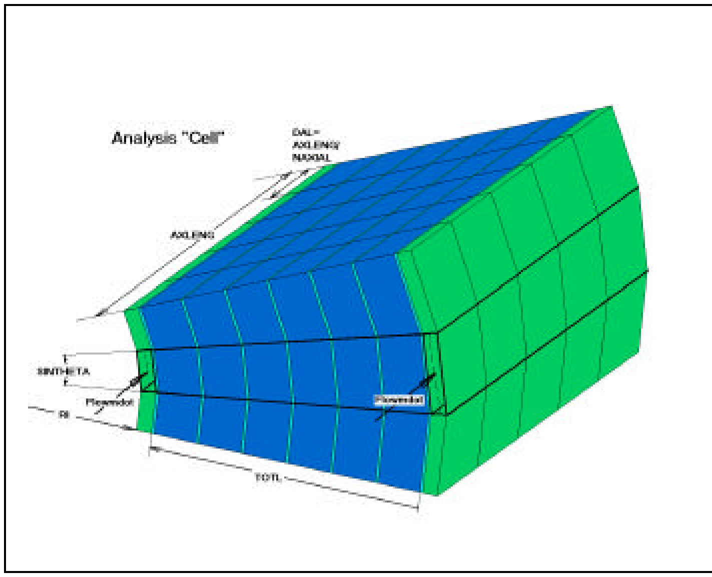
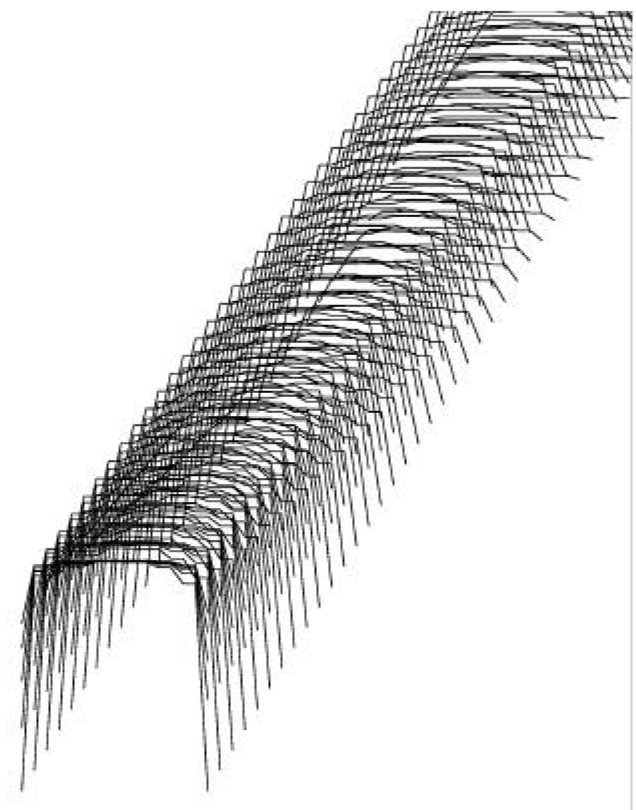
Memo to : Distribution
From: Peter Titus
Subject: Cooling time for 18MVA Pulsed Magnet
Date: Jan 16 2002



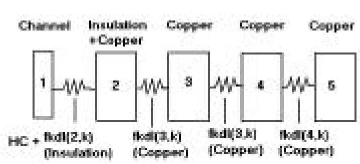
Results for 66K He cooling, .1kg/sec, 100 K end of pulse temp. 85 target Mag start temp. The cooldown time is 600 sec. to reach 85K bulk temp, but not thermal equilibrium.

Number of Atmospheres Operating Pressure ;10
Enter Channel Heigth in mm ;2
Rinner, radial build 0.1000000 7.6200157E-02
inner coil start temp 100.0000
outer coil start temp 100.0000
inner coil radius 0.1000000
model cell energy 1644.685J (100 to 85K bulk)
model cell volume 5.5099601E-05
volume cpp 1989954.
nlength, naxial, 120 5
Mass flow rate= 4.1666666E-05kg/sec
Volume flow rate= 5.5507730E-06
flow velocity= 2.120239
Hydraulic Diameter= 2.8944151E-03m
Velocity Head= 1.721665 Pascal
Pressure Drop= 31.46283 Pascal
Pressure Drop= 3.1041747E-04Atmospheres
Helium density= 7.506462 kg/m^3
Helium viscocity= 2.6448268E-07
Prandl #, Reynolds # 4.0756337E-02 174174.1
Heat transfer coefficient 115984. 9

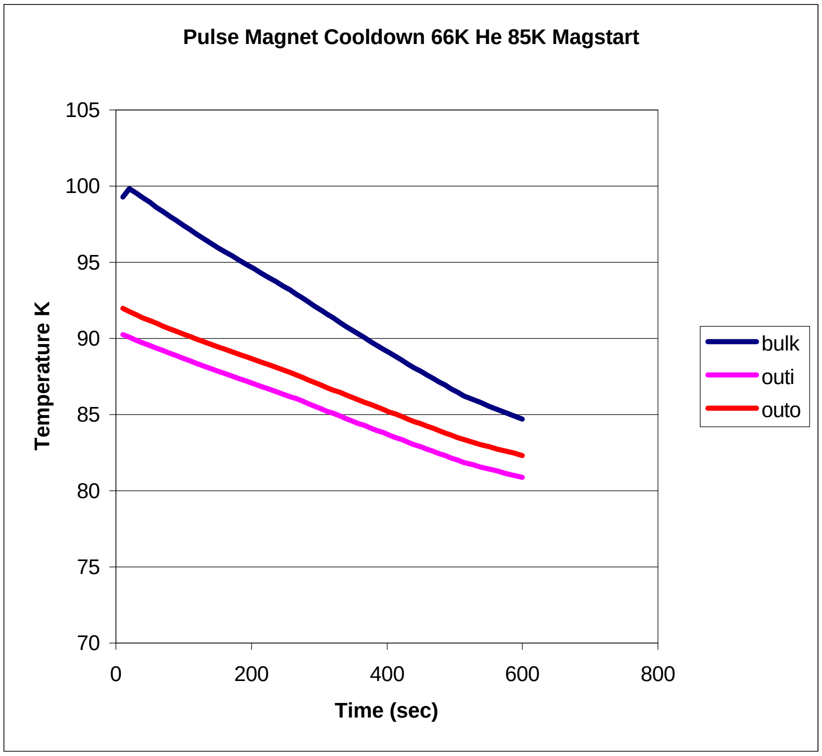


"Cell " Temperature profiles.

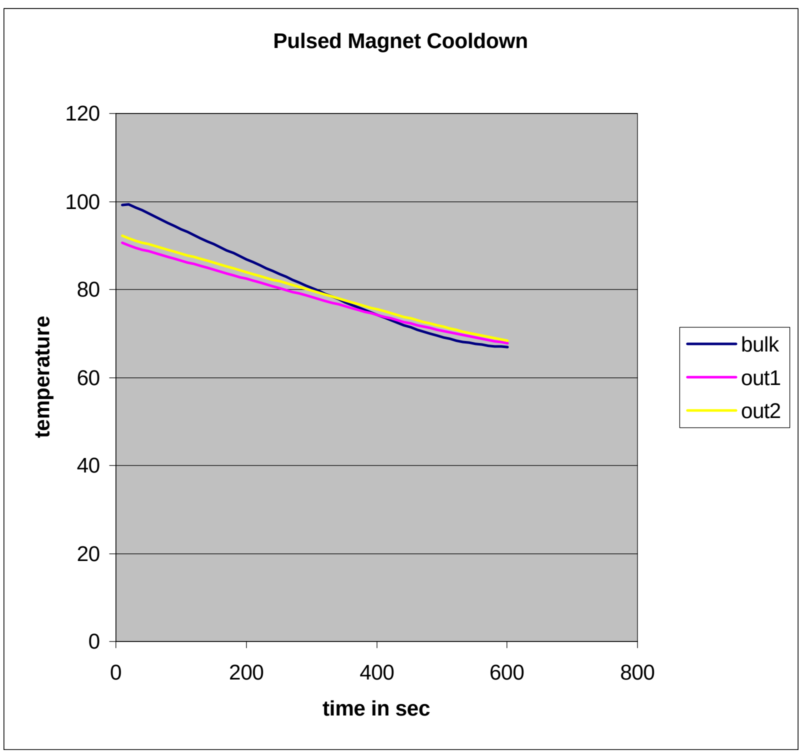
From mdot*cp*deltaT for a 20 deg inlet-outlet difference the cooldownb time is about 950 sec. The simulation with a finer time step (dtime=.0001 rather than .001) yields a 600 sec cooldown . The inlet outlet delta T ranges from 26K to 16K. The Energy balance or difference between the conduction heat flux and the channel heat flux. Is good at the finer time step



Channel Edge Thermal Model



66K inlet temperature, Dtime=.0001 sec **-** Energy Balance is good. The bulk temp is computed at a mid **-** axial slice



Dtime=.001

2.1.3 Convective Heat Transfer

It is important to estimate how much heat the superheated nitrogen gas ($T > 77$ K) could absorb before exiting the cooling channel. The convective heat transfer coefficient, h, could be obtained from[9]

$$h = \frac{KNu}{D_e} = \frac{0.023 Re^{0.8} Pr^{0.4} K}{D_e} . \qquad (14)$$

This coefficient is about 21×10^{-3} W/cm^2 K at a vapor temperature of 200 K, vapor velocity of 40 m/s, and hydraulic diameter of 2 cm. It drops to 17×10^{-3} W/cm^2 K at a vapor temperature of 100 K, keeping the mass flow rate constant. It is interesting to note that the heat transfer coefficient for film boiling at 200 K from Fig. 4 is about 12×10^{-3} W/cm^2 K, which partially justifies the third assumption in Sect. 2.1.

excerpt from: ORNL/FEDC-85-10 Dist Category UC20 c,d October 1986