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

Results for 66K He cooling, 0.1kg/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 Height in mm :2  
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.  
 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 viscosity= 2.6448268E-07  
Prandl #, Reynolds # 4.0756337E-02 174174.1  
Heat transfer coefficient 115984.9

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=0.0001 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.
66K inlet temperature, Dtime=.001 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 \(^9\)

\[
\frac{h}{D_e} = \frac{K_{Nu}}{D_e} = \frac{0.023 \text{Re}^{0.8} \text{Pr}^{0.4} \text{K}}{D_e}.
\]

(14)

This coefficient is about \( 21 \times 10^{-3} \) 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 \( 17 \times 10^{-3} \) 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 \( 12 \times 10^{-3} \) W/cm\(^2\) K, which partially justifies the third assumption in Sect. 2.1.

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