Comparison of Modular Coil Temperatures due to Change of Insulation Thickness and Thermal Conductivity

By changing the coil turn insulation thickness from 0.02" to 0.03" and the outer wrap thickness from 0.02" to 0.03" in the modular coil, a thermal analysis for the modular coil model "A", which placed the cooling plate between pancakes, was performed. The resulting maximum temperature were compared with the previous run of 0.02"+0.02" insulation and listed below:

	With 0.04" insulation	With 0.06" insulation
At end of 1st heating cycle	124.11 K	123.42 K
At end of 1st cooling cycle	89.12 K	91.08 K
At end of 16th heating cycle	124.91 K	128.33 K
At end of 16th cooling cycle	89.79 K	93.75 K

The cooling was made by an 80 K of temperature constraint at the cooling gas inlet. The insulation material was based on kapton, whose cryogenic thermal properties were provided by the NIST Cryogenic Technologies Group. In a heating cycle, the current drives up the coil temperature about 39 K. With an increase of insulation thickness from 0.04" to 0.06", a 50 % increase, the temperature difference is 3.42 K at the end of 16th heating cycle. It indicates that a thicker insulation may turn out to produce lower insulation shear stresses because of the smaller thermal gradient through insulation thickness.

If the G-10 Fiberglass Epoxy (G10-CR) was used for the insulation, the thermal conductivity in the normal direction of G10-CR is more than twice of the values of Kapton as follows:

Temperature	Thermal Conductivity (W/m-K)	
	Kapton	G10-CR
80 K	0.1280	0.2840
100 K	0.1419	0.3096
150 K	0.1631	0.3737
200 K	0.1749	0.4447

A transient thermal analysis was run through the 16 heating and cooling cycles. The resulting maximum temperatures are given below for comparison:

	0.06" Kapton insulation	0.06" G10-CR insulation
At end of 1st heating cycle	123.42 K	122.94 K
At end of 1st cooling cycle	91.08 K	87.13 K
At end of 16th heating cycle	128.33 K	123.46 K
At end of 16th cooling cycle	93.75 K	87.89 K

The temperature is lower for using the higher thermal conductivity material in the insulation but the effects are not as significant as the change of thermal conductivity.