Curved HTS Coils Cooled by Cryo-coolers

Construction and Test Results

R. Gupta, M. Anerella, H. Hocker, W. Sampson, J. Schmalzle, BNL
S. Kahn, R. Johnson, Muons, Inc.
• Muons, Inc. and BNL team was awarded a Phase II SBIR for developing curved HTS dipole technology for FRIB

• FRIB dropped the plans of using HTS magnets

• Muons, Inc. and BNL team adjusted the program
  ➢ Muons, Inc. continued the design on the curved dipole
  ➢ BNL built and tested curved coils with cryo-coolers

• Curved HTS coil technology with cryo-coolers has a broader application
  ➢ Accelerators and beam lines
  ➢ Medical and industry
>>> Issue: Curved coil requires dealing with negative curvature

>>> Strategy: Wind with positive curvature and then push back on one side (common in LTS)

>>> Concern: Possible damage to HTS which is brittle
Practice Winding with SS Tape (1)
Practice Winding with SS Tape (2)
Practice Winding with SS Tape (3)
Practice Winding with SS Tape (4)
Test Winding of 5-turn HTS Coil with Negative Curvature

12 mm wide HTS Tape from SuperPower

250 A @ 77 K
No observable damage seen
A Walk-through of Making of a HTS Coil with Negative Curvature with Computer Controlled Machine
Start of HTS Coil Winding
3-d printed parts
Superconducting Magnet Division

Curved HTS Coils with Cryo-coolers

Ramesh Gupta, …

ASC2016 September 5, 2016
One Side of the Coil Pushed for Negative Curvature
Negative Curvature Clamped
Epoxy on the Surface to Hold Shape
Second Coil Wound

~145 turns with SuperPower 12 mm
Two Single Pancakes

Curved HTS Coils with Cryo-coolers

Ramesh Gupta, ...
77 K Test Results

Coil #1 and Coil #2

Coil doesn’t seem to degrade
Cryo-cooled HTS Magnet

Cooling and Cryostat Design
Layout of the cryo-cooled system design (from outside)
Superconducting Magnet Division

Layout of the cryo-cooled system design (from inside)

Coil Box Assembly

The existing coils (shown) will be removed from the box and replaced with the new coil stackup

HTS Lead

Width to increase to 12MM

Leads
Assembly of HTS Coils inside the Cryostat with Cryo-coolers
Coils with Insulation being Assembled in Support Structure
HTS Coils Getting Installed in Support Structure
HTS Coils Getting Installed in Cryostat
HTS Leads Getting Installed (Cooling fins can also be seen)
Copper Lead Length Adjusted
All Structure Assembled (prior to closing of cryostat)
Cryo-cooled Magnet Being Tested
Test Results

1st 10-turn of one coil when both coils powered in series at ~48 K

Magnet Reached the Expected Performance
Conclusions

- Construction techniques used did not cause observable degradation in shifting HTS conductor in coils with positive curvature to coils with negative curvature.

- Curved HTS magnet cooled with cryo-coolers has been built and tested.

- The technology developed here can be useful in other accelerator, medical, industrial and research facilities.