TESTING OF MODEL COILS USING REINFORCED LTS WIRES IN BACKGROUND FIELDS

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Introduction

A main consideration in design and manufacturing of high-field superconducting magnets for MRI applications is the strain limitations of the coils that make up the magnet. The strain limitations are strongly affected by the mechanical properties of the wires used in the coils. This research project proposed that NbTi and Nb_3Sn wires clad with material of relatively high elastic modulus and yield strength can be effective in allowing solenoid coils of high-field magnets to operate at higher current densities, and that coils made from such wire would be adequately stable. One aspect of the research project was to fabricate and test two model coils made from reinforced wires to confirm acceptable superconducting and quench characteristics. One coil would use reinforced NbTi wire and the other Nb_3Sn.

Experimental

The first model coil used 1.2 km of a conventional NbTi wire, with copper over superconductor ratio of 0.9:1, reinforced with stainless steel 304. The wire was used to fabricate a coil having 14 layers, 163 turns/layer, 108 mm i.d. by 140 mm o.d., by the “wet-winding” method. The 14th layer was instrumented with a number of voltage taps, three resistive heaters, and a temperature sensor. After instrumentation the coil was wrapped with 6 layers of glass braid cloth and then impregnated with wax to insulate the quench triggering heaters from direct contact with liquid helium. The model coil was installed on a probe made available by the user facility of the NHMFL. The coil was then tested and quenched in background fields of up to 8.5 T with various transport currents in the bore of the 195mm inner diameter 20T bitter magnet of the NHMFL. The model coil was quenched numerous times by triggering the surface quench heater at various currents and background fields. Except for a few voltage taps, all instrumentation worked correctly and data was collected.

The second model coil was similar to the coil above but used Nb_3Sn wire reinforced with stainless steel 304. The coil was fabricated by using the wind and react approach and was tested in background fields of up to 12T.

Results and Discussion

Characterizing and testing the reinforced NbTi wire in short lengths and in a model coil showed that the superconducting properties of NbTi filaments are not affected by the stainless steel cladding. The reinforced NbTi model coil behaved well, surviving many triggered quenches, and achieved short sample performance.

Because the thermal contraction of stainless steel is larger than that of Nb_3Sn, the J_c of the core wire was reduced. However the model coil made from the stainless steel clad Nb_3Sn wire survived many triggered quenches with reasonable quench characteristics. (Stainless steel reinforced Nb_3Sn wire was selected because of fast turnaround in manufacturing to meet the time constraint of the Phase I SBIR program. Shorter sections of the same type Nb_3Sn wire reinforced with alternative proprietary cladding materials showed that the cladding had no appreciable effect on the J_c of the core Nb_3Sn wire.)

Conclusions

This work demonstrated that NbTi wires reinforced with stainless steel might be viewed as qualified for applications in MR magnets. Also, Nb_3Sn wires clad with reinforcing materials with low thermal conductivity can be used to fabricate stable coils with reliable quench characteristics.

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