Performance of the First Prototype Coil for the 32 T All-Superconducting Magnet

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Introduction

The HTS part of the 32 T all-superconducting magnet consists of two YBCO coated conductor coils. These nested coils are composed of 20 and 36 double pancake modules each, with quench protection heaters between the modules. A prototype coil (see Fig.1.) was built with all essential features and dimensions of the inner HTS coil, except for a reduced height, being 6 modules tall [1].

Experimental

Testing of this first prototype took place in a 4.2 K helium cryostat placed in the Large Bore resistive magnet in cell 4, creating a background magnetic field of 15 T. Instrumentation included many voltage taps, Hall-effect sensors to measure the effect of screening currents on the axial and radial magnetic field distribution, capacitive sensors to study the behavior of the helium gas bubble that forms in the bore and windings when the field·field-gradient product exceeds -2100 T^2/m and temperature sensors to monitor the temperature of the gas and parts close to the windings.

Results and Discussion

Twenty-seven quench initiation runs (with dump resistor protection) and 18 quench protection runs (without dump resistor protection) using the quench heaters correlated heater power with the time needed to create a large normal zone. Based on this data, a design of the electric circuit for the 32 T quench protection was developed. The Hall-data is used to develop a numerical model to predict shielding currents in 32 T, and develop field deviation mitigation strategies [2]. A helium gas bubble developed as predicted, while the inherent although limited thermal conductivity of the windings in combination with a cooling disk near the windings succeed in keeping the temperature of the windings stable [3]). Ramp-rate losses in the windings, assessed via helium boil off mass flow measurements appeared lower than expected, which is favorable, and the subject of further study [4]. The coil was operated above design current 55 times without degradation. However, a limiting section in module 6 near a terminal, and possibly a latent defect in the conductor, limited the peak current to 212 A and the peak stress to 281 MPa, which is below 32 T design peak stress of 360 MPa. The limiting module is being replaced and the terminal design reworked, so the prototype can be re-tested in 2014 together with a second prototype representing the outer HTS coil.

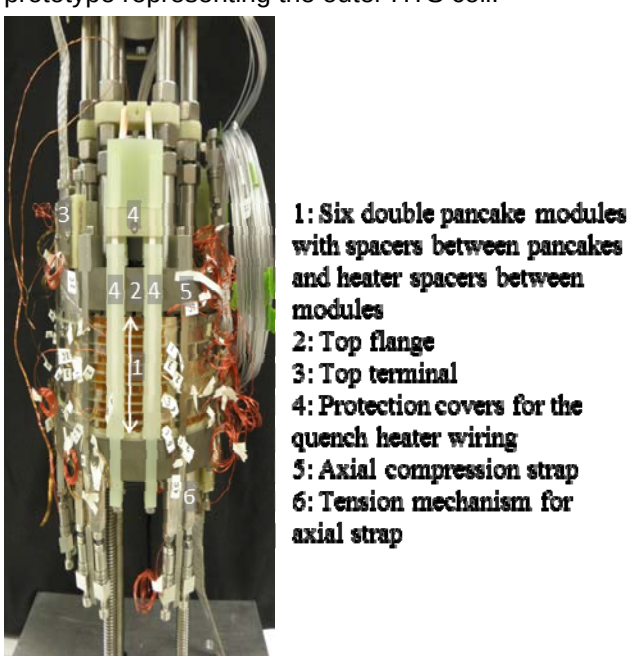

Fig. 1. Picture of the prototype coil with instrumentation.

Conclusions

Testing of the first prototype coil for the 32 T all-superconducting magnet was largely successful and provides both confidence and direction for the completion of this project.

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