Current Sharing and AC Loss Measurements of a Cable-in-Conduit Conductor with Nb_3Sn Strands for the High Field Section of the Series-Connected Hybrid Outsert Coil

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Introduction

Performance verification of the Nb_3Sn cable-in-conduit conductor (CICC) for the Series-Connected Hybrid magnets at the National High Magnetic Field Laboratory (NHMFL) and Helmholtz Centre Berlin is performed through short sample testing. The superconducting outsert coil consists of three CICC configurations, graded for the applied magnetic field. The CICC for the high field section of the coil is tested in the SULTAN facility at EPFL-CRPP. Measurements of the current sharing temperature at field current combinations comparable to what is expected in the magnet are made. Electromagnetic cycling is performed to investigate the Nb_3Sn strand sensitivity to transverse loads. In addition, measurements of AC loss and pressure drop along the conductor are made.

Experimental

The test sample consists of a 7 m long CICC bent to form two legs with a hairpin turn in the center. The helium inlet is made at the hairpin bend and outlets near the terminations. Voltage taps are centered around the magnet high field region with a 300 mm spacing. The cross-section of the CICC is shown in Fig. 1.

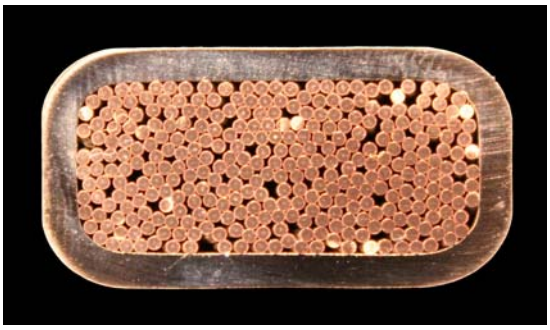

Fig. 1. Cross-section of the high field CICC.

Results and Discussion

Most of the transverse load cycling was performed equivalent to the current-field product that is expected in the high field section of the SCH. The self-field at 20 kA has a linear gradient through the sample with 0.45 T at the inner face and -0.32 T at the outer face. On average it is only 0.065 T; field corrections are not made in the results that follow. The results of the current sharing temperature measurements are shown in Fig.2 for each of the sample legs along with the peak cycle current. For all of the data shown, the sample current was 25 kA with a background field of 11.0 T. The two temperature sensors on each leg are averaged together. The temperature uniformity was better than 0.1 K and typically better than 0.05 K.

Conclusions

Electromagnetic load cycling resulted in less than a 0.2 K reduction in the current sharing temperature over 600 cycles at the nominal operational transverse pressure. The current sharing temperature was also seen to be insensitive to thermal cycling. An additional 140 cycles to high currents up to 65 kA were conducted with an apparent degradation of less than 0.1 K. The degradation in the critical current is within the noise of the measurement. AC loss measurements show higher coupling time constants than what was assumed but do not affect the magnet operations. The measured pressure drop was comparable to calculations. The high field CICC has been demonstrated to be acceptable for use in the SCH magnets.

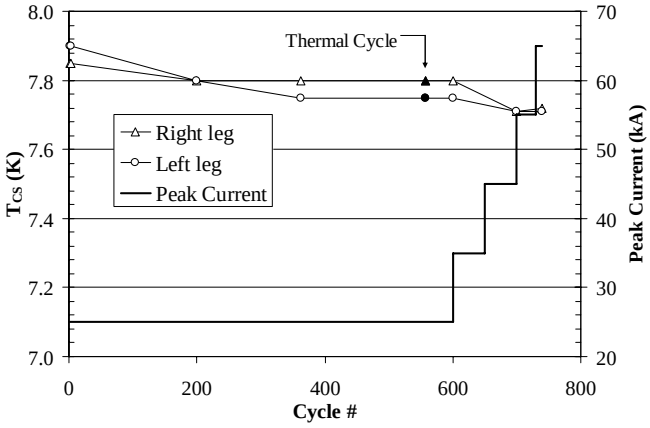

Fig. 2. Current sharing temperature at 11.0 T and 25 kA as a function of electromagnetic cycle for the high-field CICC, right and left legs.

Acknowledgements

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