Reaction Heat Treatment of a Large Nb_3Sn CICC Coil for a Series-Connected Hybrid Magnet

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Introduction

With the completion of conductor-winding and joint-preprocessing [1], the outsert coil for the Helmholtz Zentrum Berlin (HZB) Series-Connected Hybrid (SCH) magnet entered a reaction heat treatment process. The heat treatment process transforms the Nb_3Sn wire and allows the strands to have superconducting properties. The heat treatment temperatures are important for proper cable reaction and are monitored closely with a thermocouple imbedded in the coil windings, as well as multiple locations on the outside of the coil.

Experimental

The heat treatment system consists of a 75 kVA furnace that has six zones. The coil resides in a stainless steel retort, Fig 1, which is free of o-ring seals. During the reaction, it was desired not to exceed a 50 °C difference in temperature between the interior and exterior regions of the coil. A relatively slow ramp rate was required to achieve this, as low as 2.7 °C/hr at the upper temperature stage. The strand type is Oxford Superconductor Technology's RRP and the targeted reaction schedule was 210 °C for 48 hrs + 400 °C for 48 hrs + 640 °C for 60 hrs.

Fig. 1 Coil on retort base with all the connections

Results and Discussion

There was a 19 hr delay between the interior and exterior of the coil at the 210 °C stage. At the high temperature stage of the reaction (640 °C), the long delay between the interior and exterior would have produced a large variability in the level of Nb_3Sn formation throughout the windings. An overshoot to 650 °C for three hours was performed on the SCH outsert coil as shown in Fig. 2. A nominal temperature of 650 °C was selected as it was deemed to be better for the RRR.

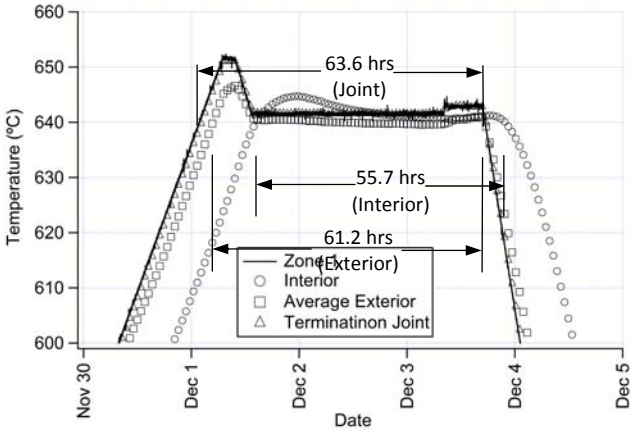

Fig. 2. High temperature stage reaction heat treatment profile of the SCH

Conclusions

Witness samples for RRR and I_C measurements were fabricated at the time of the coil reaction. The samples were placed inside of the purge plumbing circuit, one set at the inlet side and one set at the outlet. The results were surprising as the RRR values were lower than expected, at 41. The critical current was low at an average of 390 A (13.5 T, 4.2 K) in comparison to the results obtained during the qualification tests (at the time of strand procurement) but was still within specification.

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References

[1] I. R. Dixon, T. Adkins, H. Ehmler, W. S. Marshall, M. D. Bird, "Fabrication Progress of the Outsert Coils of the Series-Connected Hybrid Magnets," *IEEE Trans. Appl. Supercond.*, vol. 23, no. 3, 4300204, 2013.