Progress in Magnetic Shims Development and Testing for the Series Connected Hybrid

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Introduction

Resistive shims are being tested in the 25 T Keck magnet to measure their performance and qualify the technology to meet the 1 ppm maximum inhomogeneity target in the 36 T Series-Connected Hybrid (SCH). A first shim prototype employing a modified-transverse (MT) shim technology has been tested resulting in a record 5.6 ppm correction at 25 T before being limited by heating in the modified transverse circuits. There is a degree of uncertainty in the required inhomogeneity correction specification due to changes in inhomogeneity when the resistive coils are replaced, as occurred in the Keck. As a result, a newly developed and more conservative specification has been developed for the SCH based on comprehensive analysis of a library of NMR maps taken in NHMFL medium-homogeneity resistive magnets and benchmarked against computed sources of manufacturing and operational inhomogeneities. A second higher-performing shim prototype using standard-transverse (ST) shim technology has been designed to demonstrate in Keck the ability to meet the new SCH inhomogeneity specification.

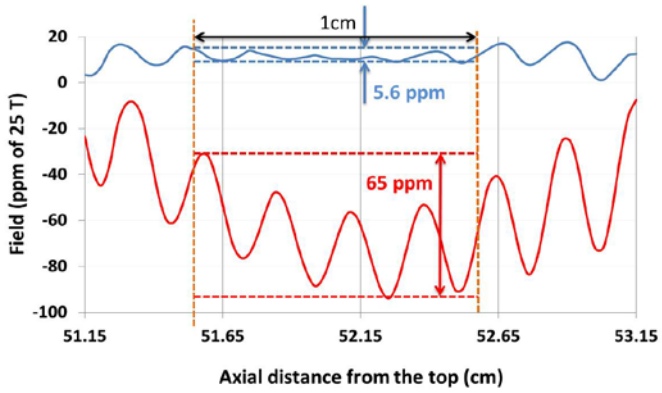

Figure 1: The MT shims prototype corrected the Keck inhomogeneities from 65 ppm to a record 5.6 ppm at 25 T.

Results and Discussion

Figure 1 shows the measured performance of the Keck MT prototype which corrected to a record 5.6 ppm before being limited by heating in the transverse circuits. The Keck MT prototype successfully demonstrated the ability to fabricate the complicated single-turn shim technology but also uncovered the necessity for a more conservative inhomogeneity specification to account for uncertainties in inhomogeneity predictions for the SCH. A higher performing ST prototype has been designed as shown in **Figure 2** using the same single-turn technology but in a slightly more complicated turn configuration.

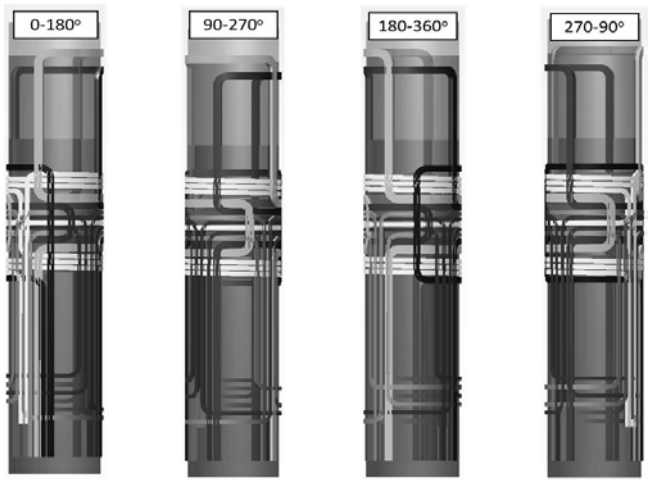

Figure 2: A higher performing Keck shim prototype has been designed to meet the more demanding, conservative inhomogeneity specification developed for the SCH due to unavoidable uncertainties in the SCH inhomogeneity map.

Conclusions

Testing of the MT shims prototype demonstrated the ability to fabricate the complicated single-turn shim technology but uncovered the necessity to conservatively specify the inhomogeneities in the SCH due to unavoidable uncertainties in the inhomogeneity map, which cannot be measured until after the SCH is installed.

Acknowledgements

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References

[1] Gan, Z., *et al.*, High Field NMR using Resistive and Hybrid Magnets, J. Magn. Reson., **191**, 135-140 (2008).
[2] Painter, T.A., *et al.*, Resistive Shims for High-Field Resistive and Hybrid Magnets, IEEE Trans. Appl. Supercond., **18** (2), 579-582 (2008).
[3] Toth, J., *et al.*, Homogeneity Study for the NHMFL Series Connected Hybrid Magnet System, Proc. Applied Superconductivity Conference, IEEE Trans. Appl. Supercond. (2012).