

The Interstrand Contact Resistance of a Nb₃Sn Cable for the 45 T Hybrid Upgrade

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Introduction

Nb₃Sn cable-in-conduit conductor (CICC) is used in large superconducting magnets such as hybrid magnets at the NHMFL. The interstrand contact resistance (R_c) in a Nb₃Sn cable is closely related to the AC loss [1] which is one of the key conductor parameters. In this work, we measured the R_c of a Nb₃Sn cable for the 45 T hybrid upgrade as function of transverse load cycle numbers. This setup will also be used to test cables for the series-connected hybrid at the NHMFL.

Experimental

A ~ 300 mm long 45T hybrid upgrade Nb₃Sn cable was heat treated inside a fixture designed to apply transverse load during the low temperature tests. It is speculated that after heat treatment a thin layer of graphite is formed on the surface of each strand due to the Mobile One oil used in the cabling process. This may result in desirable interstrand contact resistances. The tests were performed in a liquid helium dewar (4.2 K) with a 100 N MTS machine to apply transverse loads and load cycles as shown in Fig. 1. For all the measurements a 50 A current source and a nanovaltmeter were used.

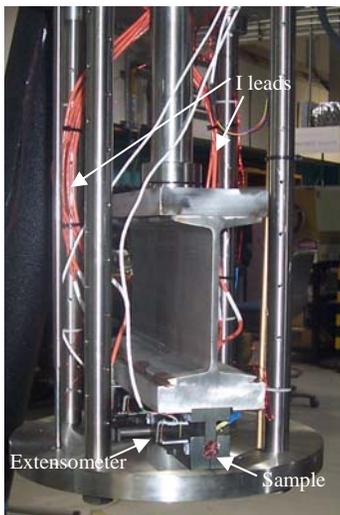


Fig. 1. Experiment setup

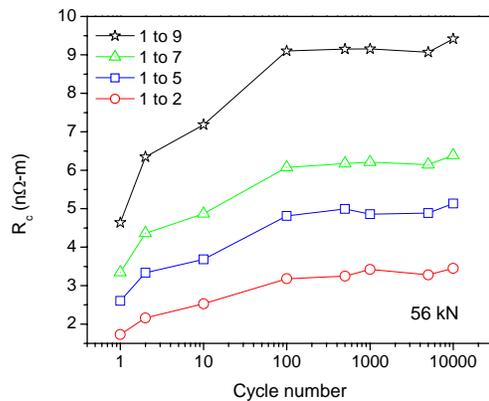


Fig. 2. R_c at 56 kN vs. cycle number. 1 to 2, 1 to 5, 1 to 7 and 1 to 9 in the legend represent respectively the R_c between two strands in the first, the second, the third and the fourth cabling stages

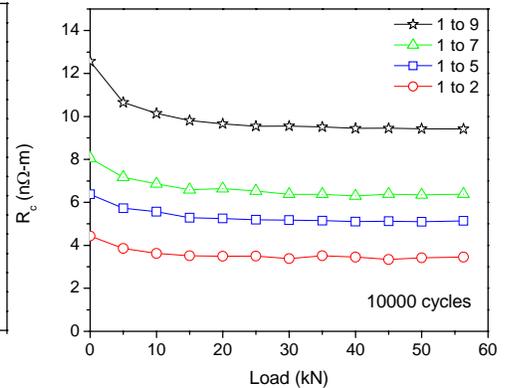


Fig. 3. R_c vs. load after 10000 load cycles. 1 to 2, 1 to 5, 1 to 7 and 1 to 9 in the legend represent respectively the R_c between two strands in the first, the second, the third and the fourth cabling stages

Results and Discussion

Fig. 2 show the R_c measured at 56 kN (equivalent of 18 MPa pressure) as function of cycle numbers. The fact that R_c increases with cycling number indicates the gradual breaking of the interstrand sintering. Fig. 3 plots the R_c as function of load after 10000 cycles. As expected, the R_c decreases with transverse load. The R_c behavior of our sample with Mobile One oil between strands is similar to that of the cable with chromium plated strands reported in the literature.[1]

Conclusions

The 45 T hybrid upgrade Nb₃Sn cable with Mobile One oil between strands has R_c of 1 - 10 nΩ·m. Similar to the cable with Cr plated strands, R_c increases with number of transverse load cycles and with decreasing transverse load.

References

- [1] A. Nijhuis, *et al.*, IEEE trans. Appl. Supercond., **15**(2), 1633, (2005).