Bending Effect on Nb_3Sn Superconducting Wires

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Introduction

Bending effects on Nb_3Sn wires have been investigated to understand the critical current degradation of large Nb_3Sn superconducting cables, such as the ITER conductors. A variable-bending device has been constructed for characterizing the critical currents of Nb_3Sn superconducting strand under pure bending without axial tension or compression. This device has been successfully developed [1] and has tested several Nb_3Sn wires: ITER TF US wires of Luvata and Oxford internal-tin wires, and other ITER related Nb_3Sn wires (European EAS bronze and EM-LMI internal tin, and Japanese Furukawa bronze wires).

Experimental

Pure bending experiments for various Nb_3Sn wires were performed with our pure-bending device using the 20 T, 195 mm Bitter magnet at NHMFL. Our bending test device allowed applying pure bending strains to a strand during test operation in liquid helium [1]. The strand samples were placed on a support beam plate made of Ti-6Al-4V that was bent through an series of pure bending states. This device can apply a large range of bending, up to 0.8% of the nominal bending strain at the wire surface. The actual peak bending strain of the filaments of the tested wires was about 65% of the nominal bending strain values, depending on copper/noncopper ratio. The critical currents were measured at every 0.1% bending up to 0.8%. Irreversible degradations of the critical current due to bending were measured by releasing bending after each 0.1% increment.

Results and Discussion

We tested five different Nb_3Sn wires which were developed by the ITER parties. Three of them were internal-tin wires of recently developed ITER TF US Oxford and Luvata wires and EU EM-LMI wire, and two of them were bronze wires of EU EAS and Japanese Furukawa wires. The critical currents degraded with increasing the bending strains. At 0.8% nominal bending strains the critical currents of the internal tin wires were degraded by 47% for Oxford wire, 40% for Luvata wire and 30% for EM-LMI wires. Higher current density wire such as the Oxford wire seems to degrade more than lower current density wires. On the other hand with the same 0.8% nominal bending, bronze wires of Furukawa and EAS wires both degraded by only 10%. After 0.8% bending, Oxford and Luvata wires showed 13% and 1.3% irreversible permanent degradation, respectively of their initial critical current values. However, permanent degradations of the EM-LMI, Furukawa and EAS wires were negligible. It is noted that some wires such as the Furukawa wire show small improvements of the critical currents with applied bending up to about 0.3%.

Acknowledgements

This work was supported by the U.S. Department of Energy, Office of Fusion Energy Science under Grant Number: DE-FC02-93ER54186 and the US ITER Project Office.

References

[1] D.L. Harris, et al., “Pure bending strand test of high performance Nb_3Sn wires,” CEC-ICMC 2007, Chattanooga, Tennessee, July, 2007.