Characterization of Nb_3Sn Superconducting Wires Under Pure Bending Loads and Triplets Under Transverse Loads

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Introduction

Pure bending experiments on single Nb_3Sn strands were continued to investigate discrepancies of bending behaviors obtained with the previous three-beam method (low, medium and high beams) using our bending apparatus [1-2]. The strand was sitting in a neutral axis position inside a Ti-alloy plate sample-holder beam, and was bent using a gear system controlled with a long motor shaft which is rotated outside the dewar [3]. A new two-beam method (low and high beams) to cover the wide range of bending strain up to 1.25% on the strand surface has been developed and tested. The two-beam sample holders were redesigned and optimized following extensive FEM analysis to reduce strain fluctuations [4]. The bending strain range is covered by two beams: low and high bending beams for 0-0.6% and 0.6-1.25% respectively. The beams have supporting ribs designed to react the electromagnetic Lorentz loads for a wire in 12 T field carrying 300 A. Most recently, the electrical performance of internal tin and bronze route ITER wires under pure bending strain were tested and compared with previous results. The experimental data behavior indicate that the new design is appropriate and that the results obtained with previous holders might have experienced some unpredicted deformations that affected the electrical performance of the samples. This year we also performed experiments at 4.2 K to verify the working principles and calibrate a new device to apply transverse loads to 3-strand samples [5]. The device was successfully tested and additional experiments will be necessary to continue the work on the electromechanical characterization of Nb_3Sn triplet under transverse mechanical loads. This work is essential to understand and predict the behavior of a large Cable-In-Conduit-Conductor under transverse.

Experimental

All experiments (pure bending and transverse load) were performed in cell 4 using the 20 T, 195 mm bore solenoid. Calibration data for the transverse load device are discussed in [5] and in this report we discuss only data collected with the pure bending experiment. Hitachi (bronze type) and Oxford (internal tin) wires were tested with the low (0–0.6%) and high (0.6–1.25%) beams. Critical currents as a function of bending were measured at 15 T and several loading cycles were applied to evaluate the recovery process for the samples.

Results and Discussion

Figure 1 shows the preliminary results obtained with the ITER Oxford and Hitachi wires. The bending behaviors obtained with the two different beams are smoothly connected. Several bending cycles were applied to the samples to study the irreversibility behavior. Irreversible degradation was observed for the Oxford wires while the Hitachi wires did not exhibit a clear irreversibility behavior.

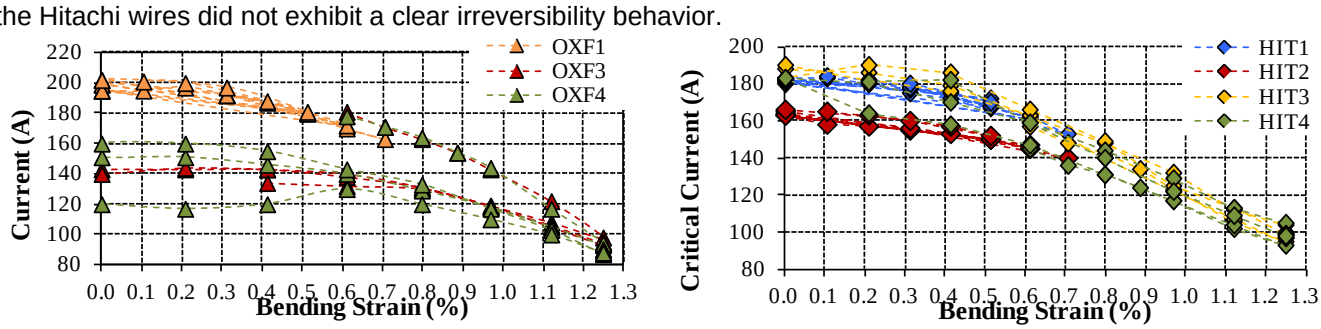

Figure 1. Experimental results of critical current as a function of bending strain for Oxford wire (left) and Hitach wire (right): Samples 1, 2 cover the low and 3, 4 the high bending strain ranges respectively. OXF2 is not shown because this sample quenched prematurely.

Conclusions

Two types of Nb_3Sn wires were tested at high bending strain with newly optimized pure bending sample holders. The two bending beam holders allowed a pure-bending test with strains up to 1.25%. A new transverse load device was built and calibrated in cell 4. 3-strand samples will be tested in 2013.

Acknowledgements

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References

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