Modeling of Nb_3Sn CICC Performance Degradation due to Strand Bending and Inter-filament Current Transfer

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Introduction

The Florida electro-mechanical cable model (FEMCAM), previously benchmarked against 40 different conductor tests, is used to study the influence of bending strain and current non-uniformity on the critical current and n-value of Nb_3Sn strands and CICC cables. The new model predicts that critical current degradation of bent strands initially follows the curve of full inter-filament current transfer but starts deviating with large bending strain and falls between the curves of full current and no current transfer. The results are consistent with recent TARSIS measurements.

Model Description

The new numerical model combines thermal bending effects during cool-down, electromagnetic bending effects during magnet operation and resistive transition in strands with filament fracture. The thermal bending model is incorporated into an electromagnetic bending model that describes strand mechanical interactions in a CICC by bending of clamped beams and contact stress at strand crossing. The total bending strain is used to compute transverse load degradation from the Summer scaling law and Ekin integration. We assume that filament critical current drops to zero if filament strain is greater than the strand irreversible limit.

Results and Discussion

Fig. 1 presents correlation of the FEMCAM predicted critical current degradation on the 1st cycle with various CICC tests. Fig. 2 presents the FEMCAM simulated critical current and n-value reduction due to bending for the OST dipole strand used for the SCH CICCs.

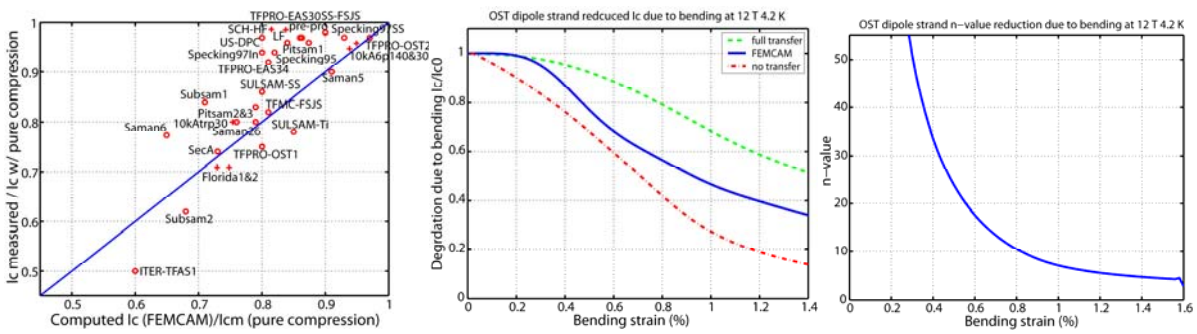

Fig. 1. Correlation of FEMCAM with CICC tests. Fig. 2. FEMCAM simulated critical current and n-value reduction due to bending for OST dipole strand.

Conclusions

FEMCAM simulated strand and cable n-values are compared with various CICC measurements. The results imply that FEMCAM is a useful tool for the design of Nb_3Sn-based CICCs and that both the thermal bending and the electromagnetic bending play important roles in CICC performance.

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References

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