Electromagnetic Cycling and Strain Effects on Nb_3Sn Cable-in-Conduit Conductors with Variations in Cabling Design and Conduit Material Properties

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Introduction

A parametric study has been conducted to quantify the effect in performance of cable-in-conduit conductors (CICC's) to changes in cable and conduit design. Measurements of current sharing temperature and critical current as a function of electromagnetic cycling and longitudinal strain were systematically performed on CICC's with common Nb_3Sn internal tin strand. The designs varied in void fraction (0.30 or 0.36), long or short cable twist pitch, cable core patterns (6 around 1 or triplet), and conduit material property (stainless steel 316 or Haynes 242). Measurements were performed at the NHMFL in a test facility for conductor characterization with capability to 12 T, 20 kA, and 250 kN axial tensile load now modified to deliver temperature controlled supercritical helium to the CICC samples.

Experimental

Table I contains a summary of the CICC test matrix. The Large Component Magnet Test Facility at the NHMFL (Cell 16) was used to perform the measurements. It has recently been upgraded to include variable temperature control of supercritical helium.

TABLE I. TEST MATRIX OF CICC SAMPLES

Sample	Conduit	Void	Cable Pattern	Twist Pitch (mm)
A	316 LN	36%	6/1x3x5x5	19/56/112/223
B	316 LN	30%	6/1x3x5x5	19/56/112/223
C	316 LN	30%	3x3x3x4x5	25/57/88/116/147
D	316 LN	30%	3x3x3x4x5	57/88/103/136/147
E	Haynes 242	30%	3x3x3x4x5	57/88/103/136/147
F	316 LN	30%	3x3x3x4x5	57/88/103/136/147

Results and Discussion

The samples were cycled to a level that would simulate the expected transverse electromagnetic loading present in the SCH magnet. Fig. 1 shows the level of degradation in current sharing temperature for each sample with cycling.

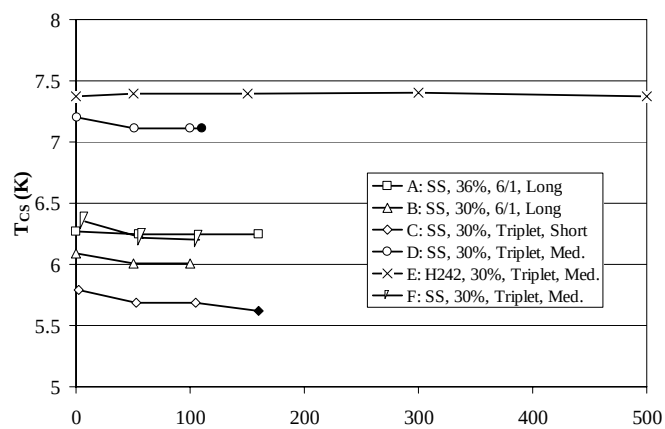

Fig. 1. Current sharing temperature (14 kA, 10.5 T) of the CICC samples with electromagnetic cycling to 14.5 kA and 10.5 T. The closed point of Sample C and D indicates an overcurrent of 19 kA and 10.5 T.

Conclusions

A Haynes jacketed sample shows a peak TCS value that is significantly higher than that of stainless jacketed cables but at the lower applied strain value of 0.3%, evidence of reduced thermal precompression and implying a higher temperature margin in operating conditions. The stainless jackets induce a compressive strain of ~0.6% to 0.7% on the cable. Measurements on stainless jacketed cables suggest that a preferred geometry is a cable with relatively long twist pitch.

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