Transverse Modulus of ITER Toroidal Field Superconducting Cables

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Introduction

The transverse compliance of a superconducting cable affects its resistance to deformation during magnet operation and ultimately the cable's critical current performance. The purpose of this research is to measure the 295 K effective transverse modulus of cables with various cabling patterns. Short lengths of prototype scale size ITER-TF cables were produced in 5 different cable patterns and tested using a split-die compression mold, designed to emulate conduit cable space. The split-die mold allows single axis compression of the cable in the transverse direction. The force-displacement data is plotted to characterize the transverse compliance and used to estimate the 295 K effective transverse modulus.

Experimental

The tests are conducted at 295 K on a 250 kN capacity hydraulic test machine equipped with the split die mold (Fig. 1). The relative displacement of the two halves of the split-die is monitored at three points along the length using linear-variable-displacement transducers (LVDT's). Fig. 1 shows the cable placed in the fixture before testing.

Results and Discussion

A typical Load-Displacement curve (for specimen Alt B) is shown in Fig. 2. All the samples behaved similarly, exhibiting non-linear behavior at low force and relatively linear behavior at higher loads. The slope of the load-displacement curve is analyzed for the initial compaction of the cable and for the unloading and reloading of the cable after initial compaction to 250 kN. The difference in the unload/reload slopes is attributed to the thought that the compacted cable does not recover or spring-back as quickly as the load fixture retracts (1 mm/min) during unload. This being the case, the reload compliance or modulus is probably more representative of the actual in-service performance of the cable after the first service cycle.

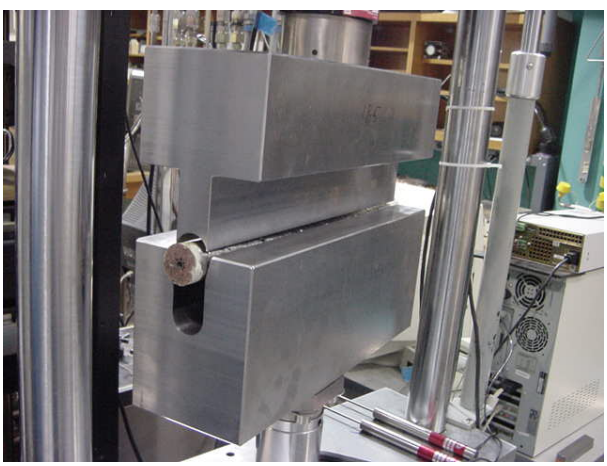

Fig. 1. The split-die mold with a TF Cable in place.

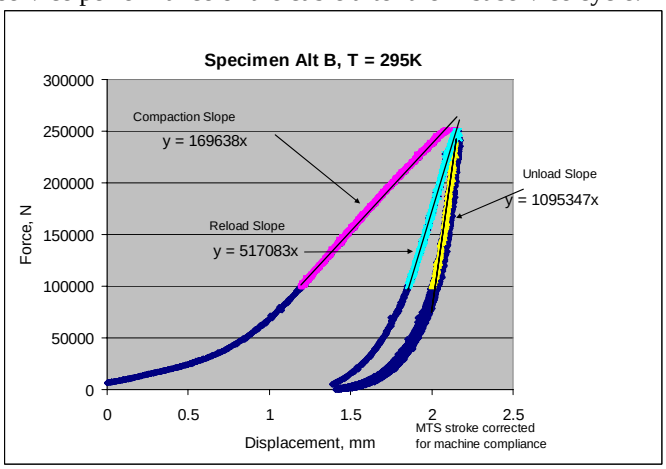

Fig. 2. Force vs displacement behavior of a TF cable.

Conclusions

The transverse compressive characteristics of 5 prototype ITER TF cables have been measured and used to estimate the cable's transverse modulus. There are distinct differences in the cables, the four alternate cable patterns (Alt-A, -B,-C, -D) behaved similarly and have reload moduli all within 2.5% of their average (1013 MPa). The baseline cable design is more compliant and exhibits a reload modulus (658 MPa) that is 35% lower than the average of the four alternate cables.

Acknowledgements

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