Pancake Coil Compliance Testing

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Introduction

The compliance of the dry-wound, double-pancake modules being developed for the 32T All Superconducting Magnet is an important aspect of the mechanical design. As the tape conductors are not perfectly flat, modules can show a slight amount of dishing after removal from the winding fixtures. The shape of the modules causes them to behave as springs. Even an assembly of perfectly flat modules and module spacers has some level of compressibility, but with a different spring constant. These characteristics cause the coil to compact when energized and must be understood in order to adequately support and center the coils. Therefore, steps must be taken in order to quantify and accommodate these effects.

Experimental

Several compliance tests have been conducted with the use of MTS machines in the Mechanical Testing Lab. Modules were compressed both individually and in a series stacking configuration to measure the displacement of the modules under load. The testing was performed in the 250 kN capacity MTS servo-hydraulic test machine in C-101. The load was measured on a load cell with an error of ±5 N in the load range used and displacement was tracked by the LVDT in the actuator, with a resolution of 0.01 mm. Measurements for a single module were collected by pressing the module between two steel plates, as shown in Fig. 1. The stack of modules was tested in a compression fixture specifically designed to maintain a load on the modules. For the stack of modules, the fixture was placed in the MTS machine, load was applied and measured, then the load on the modules was transferred to the axial compression straps of the coil structure and the fixture removed from the MTS machine.

Results and Discussion

The plot of load vs. displacement shown in Fig. 2 shows a transition in the initial compliance of a single module. The module is relatively soft and then stiffens as indicated by the slope of the curve. This transition corresponds to the near elimination of the initial air gap shown in Fig. 3, which is caused by the dishing of the conductor during winding. Testing at higher loads also gave an indication of the module compliance that may be anticipated in the low end of the operational load for the 32T magnet.

Fig. 1 Setup for module compression.

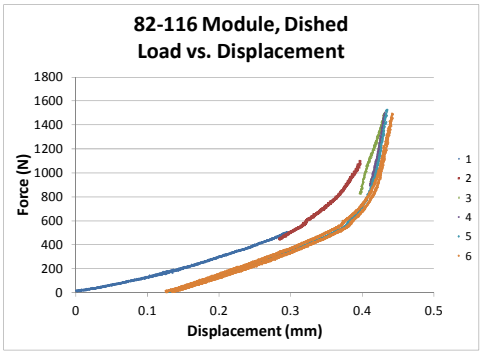

Fig. 2 Force vs. displacement under light loading.

Fig. 3 Initial air gap in module.

Conclusions

The results from this testing give a good indication of the pre-load and displacement needed to compress the modules from an initially dished state. More testing will be conducted in order to precisely identify the compliance of the coil at higher loads and aid in the mechanical design of the 32T coil assembly.

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