Fabrication of the Coils for the 60 T Controlled Waveform Pulsed Magnet

Iain Dixon[1], Todd Adkins[1], Ke Han[1], Rongmei Niu[1], Doan Nguyen[2]

1. National High Magnetic Field Laboratory, FSU; 2. National High Magnetic Field Laboratory, Los Alamos National Laboratory

Funding Grants: K. M. Amm (NSF DMR-2128556)

The 60 T Controlled Waveform (CW) magnet has been one of the MagLab's flagship instruments, but it has experienced two significant failures over its lifetime. The first occurred in 2000 due to a brittle reinforcement shell, and the second in 2014, likely caused by inclusions or flaws in the conductor of coil 7. After being out of service for more than a decade, the magnet is now being rebuilt and prepared to serve users once again.

Florida State University (FSU) has taken on the responsibility of fabricating the large-scale pulsed coils in-house, which has strengthened the collaboration between the magnet design and operations teams at Los Alamos National Lab (LANL), the materials development team at FSU, and the FSU fabrication team. Of the nine coils that make up the 60 T magnet, three of them, coils 3, 4, and 7 that needed repair have been rebuilt and shipped to LANL.

Several design changes and quality improvements have been implemented in the rebuilt coils. To reduce the risk of shortened fatigue life, non-destructive evaluation using eddy currents was performed over every inch of the wire to detect inclusions or flaws. Damaged sections were either repaired or rejected. Thanks to the diligent efforts of the FSU materials team in strengthening the pulsed conductor supply chain, the conductor for coil 7 was changed from Al60 to CuCrZr, which offers improved strength and quality. An added benefit of CuCrZr is the availability of long continuous lengths, which eliminates the need for interlayer joints—a time-consuming process that introduces additional risks during coil production. The coils also feature an improved high-strength resin insulation system, which has already been successfully demonstrated in several large superconducting coils. Additionally, the reinforcement modulus has been increased by overwrapping the Nitronic shell with Zyon.

The final step in the process is to complete the magnet assembly and install it in its test cell. Full operations will resume once the refurbished generator is installed.

Figure left: View down the bore of coil 7 after epoxy impregnation at FSU. The epoxy impregnation is one of the many detailed procedural steps that includes conductor fabrication, quality control inspections, winding, joint and termination fabrication, outer shell fabrication, epoxy impregnation, Zylon reinforcement application and break out of the coil from the epoxy monolith after impregnation,

Figure right: Winding Zylon fiber with epoxy over the external shell at LANL is a process that further strengthens the pulsed coil against the huge magnetic forces that are generated in fractions of a second within the pulsed magnets. Zylon was implemented by the MagLab and is now one of the state-of-the-art reinforcement methods employed in the MagLab pulsed magnets.

Facilities and instrumentation used: NHMFL Magnet Science & Technology Department, Large Coil Fabrication Facility.

Citation: Nguyen, D.N.; Vo, T.; Michel, J.; Dixon, I.R.; Adkins, T.; Han, K., *Redesign of the Coils for the 60T Controlled-Waveform Magnet at NHMFL,* **IEEE Transactions on Applied Superconductivity**, **32** (6), 4300504 (2022) **doi.org/10.1109/TASC.2022.3151836**