Contribution ID: **20** Type: **Poster**

Thu-Af-Po.08-01: Development of a Glass-Carbon-Glass Reinforced Pulsed High-field Magnet at the WHMFC

Thursday 3 July 2025 14:00 (2 hours)

Pulsed high-field magnets are commonly reinforced with Zylon fiber to counterbalance the inter-radial Lorentz forces. However, these magnets usually undergo unintended axial disruptions. Previous studies have shown that Zylon fiber-reinforced polymers (ZFRPs) exhibit limited transverse and in-plane shear strength. This limitation results in substantial transverse damage at the ends of the magnets, where both radial and axial forces are significant.

To address this issue, a glass-carbon-glass reinforcing scheme was developed, and a double-coil prototype was constructed. The carbon fiber component serves as the "sandwich layer", which is responsible for bearing external loads, while the glass fiber component fully wraps the carbon fiber composites to provide electrical insulation. HS6 glass fiber and T600 carbon fiber were selected as inter-reinforcing materials due to their exceptional strength and elastic modulus. Both fibers exhibit favorable impregnation characteristic with epoxy, and the transverse strength of their composites were about twice that of ZFRPs. Additionally, the wet-winding technique was employed to minimize carbon fiber splashing during winding. The glass fiber was cross-wound at ±60° relative to the hoop direction (90°), while the carbon fiber was cross-wound at ±5°. This reinforcing strategy aimed to enhance the axial strength and stiffness of the reinforcement while maintaining its radial reinforcement capacity. The interlayer dielectric strength of the structure was confirmed above 18kV through high-voltage insulation testing.

The prototype was originally designed to operate at a maximum magnetic field of 96 T. The inner and outer coils were discharged by 1.6-MJ and 24-MJ capacitor banks, respectively. Unfortunately, the prototype failed at 70 T. Disassembly revealed that a localized defect in the CuNb wire may have been the cause of the failure. Despite this, the project provided valuable engineering insights for us. Future work will focus on refining the layup design of the reinforcement, and a new pulsed high-field magnet will be constructed.

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Session Classification: Thu-Af-Po.08 - Materials for Pulsed Magnets