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Thu-Af-Po.08-02: A Novel Radial Reinforcing Scheme for High-field Pulsed Magnets

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Conventional high-field pulsed magnets employ layered reinforcement techniques, where high-strength fiber composites are inserted around each conductor layer within solenoid coils to withstand the substantial Lorentz forces. For magnets exceeding 80 T, the required reinforcement layer thickness exceeds 5 mm. However, this design reduces the conductor filling factor and increases the coil inductance, resulting in higher energy requirements. Furthermore, the stress distribution within the reinforcement layers is uneven in this structure, with maximum stress concentrated on the inner layers, while the outer layers remain underutilized in terms of mechanical capacity, leading to decreased material efficiency. To address these issues, the WHMFC team has proposed a novel pancake magnet structure based on radial reinforcement. In this design, thin reinforcement layers are radially stacked around each conductor layer of the pancake coil, effectively counteracting the radial Lorentz forces. This paper presents a theoretical investigation into the mechanical advantages and efficiency of this new magnet structure and provides a comparative analysis with the traditional hoop-reinforced structure. Starting from the fundamental equations of mechanics, approximate analytical stress formulas for both the conductor and reinforcement layers under radial and hoop reinforcement are derived. The conductor filling factor and reinforcement volume efficiency of both methods are then analyzed in detail, along with the factors influencing these parameters. Subsequently, stress distribution within the magnet is analyzed by establishing mid-plane stress calculation methods for both radial and hoop reinforcement. Based on this, the optimal reinforcement layer thickness for both single pancake magnets and axially stacked pancake magnets is determined and further compared with corresponding hoop-reinforced magnets. The results demonstrate that radial reinforcement leads to a more uniform stress distribution and higher conductor filling factors, as well as improved reinforcement volume efficiency within the magnet structure. Therefore, the proposed radial reinforcement scheme exhibits significant advantages in terms of mechanical performance and reinforcement efficiency for high-field magnet systems.

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