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M1Po2A-04: Experimental and numerical study on thermoelastic properties of epoxy composites filled with zirconium tungstate powder at low temperatures

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Epoxy resins have been widely employed as impregnating materials in high field superconducting magnets, due to their electrical insulation, high elastic modulus and strong bond ability. However, epoxy resins usually have a large coefficient of thermal expansion (CTE). When the epoxy-impregnated magnets are cooled to cryogenic temperature, thermal mismatch stresses will be generated in different materials, leading to the risk of structural failure. Reducing the CTE of epoxy and making it close to that of superconducting composite wire/tape will effectively restrain the thermal mismatch stress and thus reduce the risk of structural failure. In this study, the thermal expansion and mechanical properties of epoxy composites filled with negative thermal expansion zirconium tungstate (ZrW_2O_8) powder were investigated within the temperature range of 77–300 K. The experimental results showed that the CTE of the composite epoxy (CE) decreased with the increase of the volume fraction of ZrW_2O_8, especially when the volume fraction of ZrW_2O_8 was 40%, the CTE of the CE was close to that of REBCO coated conductors. In addition, with the increase of ZrW_2O_8 volume fraction, the equivalent elastic modulus of the CE increased, but the tensile strength increased to the maximum and then decreased. To further explain the mechanism, a numerical finite element model (FEM) of representative volume element of CE was established. The FEM results were in good agreement with the experimental data, which explained the mechanism of the decrease of CTE and the enhancement of mechanical properties in CE.

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