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Modelling the effect of anisotropic elasticity of REBCO on the mechanics of high field magnets with screening currents

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The development of high temperature REBCO superconducting (HTS) REBCO tapes are promising for high field magnets. However, the mechanical properties of these tapes are transversally isotropic a special case of anisotropy, where the elastic behavior is determined largely by the thickness of the Hastelloy substrate and the electroplated copper stabilizer. Furthermore, for such high magnetic field applications, there are high electromechanical forces which can lead to possible damage and thus concern for mechanical degradation. Also, the magnet design is not straightforward due to complex interplay of large screening currents. In this workarticle, we present a novel 2D axisymmetric finite element tool programmed in MATLAB. The stack of pancakes and the large number of REBCO tapes turns are approximated as anisotropic bulk hollow cylinder. Here, we study the following configuration.Firstly, the current is ramped up to a value below the critical current and we calculate the screening currents and the magnetic forces that they cause using the MEMEP model . This electromagnetic model can now takeallows to take into account non-insulated and metal insulated high field magnets into account. With this method, we study REBCO HTS inserts for 32 T magnets under a the background magnetic field of a low-temperature superconducting (LTS) outsert of 19 T. In particular, we study the effect of anisotropic REBCO laminated tape and on the mechanical quantities. We show that the stresses within the HTS magnet coil can be decreased by increasing the thickness of the stabilization layer of REBCO tapes within a realist range. The total tape thickness is kept constant by reducing the thickness of the substrate layer. We then, take these different tape configurations and calculate hoop strains, radial stresses, and hoop stresses. The study show that stresses generated in the magnet depends on an anisotropic factor κ (ratio of radial, , to circumferential , elastic modulus). We have also calculated the self-heating effects during ramp and the thermal stresses due to quench. In conclusion, the numerical analysis shows that by adjusting the thickness of stabilizer and of substrate in a realistic range the mechanics of HTS magnet specifically stress generated can be controlled. The presented modelling method is suitable for multi-physics design of high-field magnets.

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