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M2Po3E-03: Mechanical characterization and critical current irreversibility limit of different ReBCO tapes

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High-magnetic fields of up to 20 T in coils in tokamak-type fusion devices, such as in the Central Solenoid of European DEMO and the Chinese BEST, require use of High-Temperature Superconductors (HTS) and promising candidates are high-current cables comprising ReBCO tape. The large Lorentz force occurring under these operating conditions can locally generate very high values of mechanical stress, which can irreversibly degrade the critical current of the ReBCO superconductor. For the design of the cables, detailed structural finite element analysis (FEA) based on accurate electromagnetic and mechanical material properties under relevant electromagnetic load levels is needed for achieving reliable analysis results and defining optimal operating conditions. Knowledge of the axial tensile and compressive strain irreversibility limits of the critical current of ReBCO tapes is therefore essential.
For this purpose, axial tensile stress–strain measurements on ReBCO tapes from several manufacturers have been performed in the upgraded TARSIS-2 facility. In addition, compressive strain imposed by bending on different core diameters with various winding angles have been performed to mimic closely the CORC cabling conditions. Critical current and n-value were measured at 77 K in self field for stepwise increasing tensile load, and also the effect of cyclic loading were studied. For comparison and reference, the tensile stress strain characteristics were also measured at room temperature.
Full-scale 3D FE models of the tapes have been developed and validated using electrical and mechanical material properties of the used superconducting tapes. Based on these data, simplified stress-strain relations for engineering purposes are proposed. The model predictions are well in agreement with experimental results and are being used to predict quantitively the effect of Lorentz force based loads on ReBCO-CORC based high current Cable In Conduit Conductors in order to achieve performance optimisation.

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