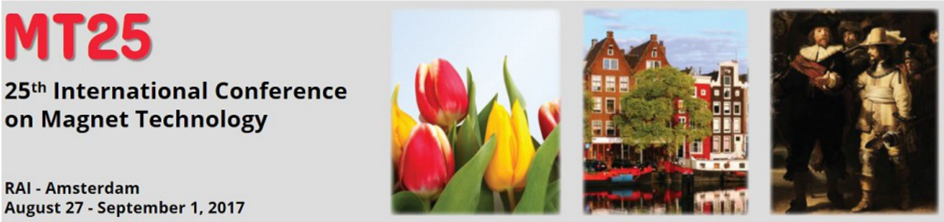

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Quench Propagation Velocity and Hot Spot Temperature assessments in Nb3Sn Racetrack Model Coils using analytical and Finite Element Modelling approaches

Monday 28 August 2017 13:15 (1h 45m)

Since 2010 to present, several sub-size magnet assemblies, designed as test beds for impregnated Nb3Sn-based coil technology validation, are tested at the CERN Superconducting Magnet Test Facility (SM18). These Short Model Coils (SMC) and Racetrack Model Coil (RMC) have been used to characterize two types of Rutherford cables foreseen for the coils of the Nb3Sn magnets for the HL-LHC and High Field Magnets program of CERN. During several SMC and RMC test campaigns, the Rod Restack Process (RRP) and the Powder In-tube (PIT) conductors have been characterized in terms of performance, transversal and longitudinal Quench Propagation Velocity (QPV). Hot Spot Temperature (HTS) increase during quenches were registered and signals analysed as function of current and energy. In this paper, the multi-physics problem of quench propagation is addressed by means of a set of analytical formulae and three Finite Element Models (FEM) using MATLAB, ANSYS Mechanical APDL and COMSOL packages aimed at describing the conductor behaviour in lumped 1D, 2D and 3D non-linear transient thermal framework coupled with electric constitutive laws for Nb3Sn and copper. The paper discusses in detail the relevance of the model assumptions taken at the composite cable boundaries (adiabatic condition, normal to superconducting state transition) needed for model reduction as computing time rapidly becomes an issue. The sensitivity of the models on the material properties distribution across the composite and on their temperature, as well the magnetic field dependence along the winding are presented. The comparisons of QPV and HST derived from the voltage and fibre optics sensors signals with the simulation results show a good stability of the models. The paper concludes with an attempt to normalise the QPV data sets from different tested coils.

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