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On the Mechanical Behavior of a Nb3Sn Superconducting Coil During a Quench: Three-Dimensional Finite Element Analysis of a Quench Heater Protected Quench

New high-field accelerator magnets based on Nb3Sn are pushing the boundaries of magnet design and quench protection towards new limits. Their large stored energies and current densities result in a very challenging scenario for magnet protection. Furthermore, the strain sensitivity of Nb3Sn cables turns the electromechanical limits of the conductor into a parameter of the highest importance. The coupling of the abovementioned considerations during quench is a case of special interest that adds further complexity to the design and protection of Nb3Sn magnets.

The objective of this paper is to provide a complete three-dimensional analysis of the coil and magnet structure mechanics during a quench event. In a previous publication [1], we presented an innovative approach on how to use a Finite Element Model, coded in ANSYS APDL, for the multiphysics study of quench processes. In this paper, we further expand the work by including the 3D analysis of the magnet mechanics during the quench transient. The results from the thermal-electric model are directly transferred as loads to the magnet' s mechanical model, and thus, the coil and structure strain evolution during quench is obtained. We focus for this time in the analysis of a quench heater protected quench, where dynamic effects are of less importance in contrast to other protection systems. Finally, the results from the simulation are compared to experimental mechanical measurements performed during the quench heater protection tests of MQXFS6 model magnet.

[1] 3D Thermal-Electric Finite Element Model of a Nb3Sn Coil During a Quench, IEEE Transactions on Applied Superconductivity On page(s): 1-8 Print ISSN: 1051-8223 Online ISSN: 1558-2515 Digital Object Identifier: 10.1109/TASC.2019.2897234

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