Contribution ID: **257** Type: **Poster Presentation of 1h45m**

Frequency domain Diagnosis Methods for Quality Assessment of Nb3Sn coil Insulation systems and impedance measurement

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

Abstract - In recent years, the Superconducting Nb3Sn cable material became the privilege mature candidate for the High Field magnets in new projects like High Luminosity LHC (HL-LHC) accelerator at CERN. The technology needs in the years 2017-2021 to be deployed through unprecedented magnet series production with dedicated on-line quality control. The key fabrication stage of the Vacuum pressure impregnation after heat treatment reaction of Nb3Sn coils like on the new 11 T dispersion HL-LHC dipole enhances both the structural integrity and the dielectric strength of winding packs. The final epoxy CTD-101K resin impregnated insulation system composed of mica-fiber glass is commissioned under 5 kV high voltage test to ground. The global vacuum impregnation pressure method exhibits various merits in insulation performance and high dielectric strength reliability which strongly dependent on the success of the resin filling cycle. There is currently limited information and understanding on what could be a good dielectric frequency domain response of Nb3Sn coils. Due to importance of this issue, the monitoring of the resin content is introduced on using capacitance measurement and the quantitative dielectric response analysis both in the time and frequency domain. This proposed method enables during the VPI cycles to derive comparative master trend curves of various coils. These quantitative measurements enable to improve the quality of the composite insulation by possibly optimizing the heat and pressure cycle. Optimally, a combination of above methods can further help taking decision during manufacture on the wetting extent and bring insights on the impacts of resin type, the degree of curing, effects of void contents and coil geometry on the dielectric response. An independent insulation dielectric permittivity measurement provides a reference for the impregnation manufacture quality. The frequency impedance measurement of first short dipole model provides the distributed network lumped circuit fitting electrical parameters.

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Session Classification: Mon-Af-Po1.01

Track Classification: A1 - Superconducting Accelerator Magnets