Contribution ID: **1003** Contribution code: **FRI-OR6-701-08** Type: **Oral**

Variable inductance observed in the HTS non-insulation (NI) coils

Friday 19 November 2021 09:15 (15 minutes)

With only 1 μm thickness of high temperature superconducting (HTS) material, HTS tapes are very fragile and can easily undergo an irreversible damage when operated near to its rated values. When wound into coils, this phenomena intensifies, limiting the operating values to only 50-80 % of its rated values. This is mainly due to the restricted HTS current path and poor thermal conduction between the turns. By adding a low resistive turn to turn conduction path, this risk can be mitigated. This was proven as an effective solution for the HTS coils, enabling the magnet engineers to operate them up to 100 % of its rated values. However, under dynamic operating conditions this parallel turn-to-turn conduction path will alter the current path, resulting in varied inductance. Also, due to the high aspect ratio of the HTS tapes and varied Jc(B,θ) characteristics, the current distribution along the width of the HTS tape is not uniform and will also contribute towards the varied inductance. To date the entire literature on NI coils considers the inductance of the coil to remain constant. With the recent advancements in the NI coil modelling, it is now possible to model the NI coil using the stand-alone finite element (FE) model. Using this FE model, we have evaluated the inductance of the coil while varying the applied current magnitude and the ramp rates. For slow ramp rates (< 1 A/s), the inductance of the coil is observed to vary up to 10 % with varying applied current. This change is more evident for higher ramp rates (> 1 A/s). Finally, the effect of this varied inductance is visualised using the magnetic field decay characteristics. These results are key for understanding the NI coil behaviour and will determine the operating conditions of the high field magnets.

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Session Classification: FRI-OR6-701 Design and Analysis