Contribution ID: **13** Type: **not specified**

Analytical modeling of coupling losses in CICCs, extensive study of the COLISEUM model

Wednesday, 22 September 2021 15:05 (25 minutes)

Magnetic field and current variations are responsible for AC losses in superconductive magnets. These losses may induce an increase of temperature within the material and negatively affect the performance of the magnet. In case of fusion energy experiments, it is essential to model and predict AC losses to ensure safe and reliable tokamak utilisation.

Developed at CEA, the new fully analytical model named COLISEUM (COupling Losses analytIcal Stages cablEs Unified Model) aims at predicting the coupling losses at various scales only from geometrical and electrical parameters. In this model, a multiplet is composed of several elements. Those elements can represents either a strand, a multiplet of strands or multiplet of multiplets. COLISEUM simulates those elements through tubes of current that are characterised by several geometrical parameters such as their twist pitch, their cabling radius or their compaction. The most recent model version addresses the coupling losses for a full Cable in Conduit Conductor (CICC), accounting contributions from the strand to the nth-stage of the cable.

In the present work, we conduct an extensive parametric study on those geometrical parameters and investigate the output of the COLISEUM model, with associated interpretations on the link between inputs relevance and resulting outputs. We compare simple COLISEUM configurations with a full numerical approach. In addition, tomographic studies, conducted at INFLPR, on real cable designs (of JT-60SA TF type) allow us to investigate and validate our theoretical results on the cabling radius.

We conducted a crosscheck between experimental AC loss measurements and the COLISEUM model on various geometries of CICCs. Samples were tested at CEA Cadarache in the JOSEFA facility using the magnetization method and in SULTAN facility using calorimetric method. We compared the measured AC losses with the losses predicted by COLISEUM using the experimental geometrical and electrical parameters as inputs for the model. It allows us to evaluate the predictive capabilities of the model for various geometries.

We discuss the possible contribution of the model to stability studies. Unifying the COLISEUM model with an analytical description of the thermal behaviour of a CICC could consolidate and broaden the range of the model for future developments.

Category

Electromagnetics modelling of LTS and HTS magnets

Keywords

AC losses, Cable in Conduit Conductors CICCs, superconducting

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Session Classification: Electromagnetics D3