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P3.087 A quasi-3D thermal-hydraulic model for an HTS CroCo conductor

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The HTS CrossConductor (HTS CroCo) was recently proposed by Karlsruhe Institute of Technology as novel concept for the winding pack of future fusion magnets.
The conductor concept is based on a cable-in-conduit configuration (CICC), in which 6 HTS CroCo macro-strands are twisted around a round copper core, jacketed in a stainless steel conduit and cooled by forced-flow supercritical helium at 4.5 K. Each HTS macro-strand is composed of twisted and stacked REBCO tapes surrounded by a copper sheath. Similar conductor configurations are currently under development and testing at other research laboratories.
Due to the geometry and to the thermo-physical properties of the materials involved, i.e. very low thermal conductivity of the HTS tapes with respect to the surrounding copper, non-negligible temperature gradients are expected within the superconducting region during relevant transients, e.g., quench propagation. Therefore, while a mono-dimensional treatment of the coolant flow and the jacket along the CICC could still be acceptable, there are good principle reasons to doubt about the applicability of well-established 1D thermal-hydraulic models, used so far in LTS conductor (and coil) analyses, to the HTS macro-strands.
Based on the time scales of the phenomenon under investigation, two different approaches are proposed here in order to capture the transverse temperature gradients within the HTS region of each macro-strand. For slow transients, e.g., the plasma burn, the HTS and copper can be separately approximated by a 1D model along the macro-strand direction, thermally coupled through a 1D radial model of the HTS. For faster transients, e.g., quench propagation, a 2D axisymmetric model along each macro-strand, with a thermal coupling between neighboring macro-strands, is proposed. After suitable verification, the reliability of the two developed quasi-3D models (1D and 2D along each macro-strand) is benchmarked against a detailed full 3D model.

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