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Friction factor of a forced-flow cooled HTS subsize-conductor for fusion magnets

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Thermal–hydraulic analyses of forced-flow cooled superconducting conductors designed for fusion magnets are typically based on 1-D mathematical models, which demand reliable predictive correlations for the transverse mass-, momentum- and energy transport processes occurring between different conductor components. Friction factor correlations, derived from pressure drop tests or Computational Fluid Dynamics (CFD) simulations of conductor samples, describe momentum transfer.
High Tc Superconductors (HTS) are promising materials to be applied in future fusion magnets, since they offer operating magnets at higher magnetic fields or higher temperatures as compared to the current conductors made of Low Tc Superconductors. Various concepts of HTS cables for fusion applications are being developed, characterized and analyzed. Recently three concepts of triplet HTS subsize-conductors for a quench experiment have been proposed by KIT. Each of them consists of three twisted CrossConductor (CroCo) strands enclosed in a stainless steel jacket, but they differ from each other in copper stabilizer geometry. In Option 1 and 2 conductors CroCo strands are contained in copper sheaths of different thickness, whereas in the Option 3 they are embedded in copper profiles with larger contact area. Hydraulic characteristics of such kind conductors was unknown. Three dedicated short dummy conductors with the geometry identical to Option 1-3 conductors were prepared by KIT to be tested for pressure drop. Option 1 and 2 samples were prepared and characterized earlier.
In the present study we present the results of the hydraulic test of the Option 3 conductor, performed using demineralized water at different temperatures, and the outcomes of the CFD simulation of flow in the Option 3 conductor using the ANSYS FLUENT commercial code. Based on these results we develop a friction factor correlation valid in a very wide range of Reynolds number which could be used in thermal-hydraulic analyses of the quench experiment.

Category

Multi-scale and multi physics design methods

Keywords

HTS conductors, hydraulic test, friction factor, CFD

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