Contribution ID: **20** Type: **not specified**

Multiphysics modelling of a sub-sized HTS fusion conductor cable concept

Monday, September 20, 2021 2:40 PM (25 minutes)

Conventional cables for fusion magnets make use of low temperature superconductors (LTS) to achieve high current densities, which are necessary to generate the magnetic field for fusion plasma confinement. Compared to LTS, high temperature superconductors (HTS) offer the possibility to increase the magnetic field strength for plasma confinement, as well as the operation at higher temperatures. The most promising HTS material for fusion applications, REBCO, is commercially available as coated conductor tapes. This conductor geometry leads to fundamentally different cable designs compared to conventional low temperature superconductor (LTS) cables for fusion application.
A common approach is to combine multiple HTS tapes to macro strands, which allow easier handling and processing during the cable fabrication. One of these concepts is the HTS CrossConductor (HTS CroCo), where HTS and intercalated copper tapes form a cross-shaped stack, embedded in a round solder matrix for high current density in the round strand cross-section. During operation, fusion cables experience high mechanical stresses through Lorentz forces and thermal expansion. Depending on the reactor type, these stresses can be static or cyclic. From the thermal-hydraulic point of view, the cable is part of the cryogenic system. In case of quench incidents, local hotspots produce an immense heat load that has to be taken away.

The quench behavior of HTS cable-in-conduit-conductors (CICC) for fusion magnets is substantially different from state-of-the-art LTS CICC. Within an international collaboration, different high-current HTS CICC will be developed, tested at high field and analyzed. KIT is preparing a HTS CICC sample for quench investigations based on HTS CroCo strands.
In this contribution, the analyses in the design phase of a HTS CICC to be tested at high Lorentz loads will be presented and include structural mechanic, thermal-hydraulic and electro-magnetic simulations. Based on previous work [1], first predictive calculations of the response of the HTS CroCo-based triplet sample at quench were refined and updated to the final sample geometry.

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

[1] M. J. Wolf, R. Heller, W. H. Fietz, K.-P. Weiss, "Design and analysis of HTS subsize-conductors for quench investigations towards future HTS fusion magnets," Cryogenics, Volume 104, 2019

Keywords

Fusion Magnets, High Temperature Superconductors, HTS CrossConductor, Quench

Category

Quench experiment, simulation and analysis for all classes of LTS and HTS magnets

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Session Classification: Quench D1