Contribution ID: **32** Type: **not specified**

Comparative Thermal-hydraulic Study of High-Field Superconductors Nb3Sn and REBCO suitable for the HELIAS Stellarator Reactor

Within the EUROfusion Roadmap, the helical-axis advanced stellarator (HELIAS) is investigated as a possible long-term alternative to a tokamak fusion power plant. Its superconducting magnet system is based on modular field coils with a complex 3D shape (similar to but a lot larger than Wendelstein 7-X coils), and faces therefore several engineering challenges. The W7-X magnet system is based on the low temperature superconductor (LTS) NbTi, which cannot be used as a starting point for the development of HELIAS magnets due to the much higher magnetic field of up to 12.5 T at the conductor. HELIAS requires the use of more advanced "high-field" superconductor materials, e.g. the LTS Nb3Sn or High temperature superconductor (HTS) REBCO which lead to additional challenges. One critical aspect is the behavior of the superconductor in case of a quench. For LTS cable-in-conduit-conductors (CICC), thermal-hydraulic models for stability and quench of the conductors were developed and qualified in detail, for example during the design of the ITER magnet system and its conductors. For the HTS materials, the minimum quench energy (MQE) is orders of magnitudes higher but the normal-zone-propagation velocity is orders of magnitude smaller due to the different material properties. Additionally, the geometry and dimensions of LTS and HTS "strands" is fundamentally different, with LTS being fabricated as multi-filamentary wires of about 1 mm in diameter and most HTS REBCO-based conductors being proposed as ˜1 cm thick strands of several flat tapes (of several mm in width).
In this contribution, three different conductor options for the HELIAS magnet system, one with Nb3Sn and two with REBCO, are presented. Different winding options, e.g. layer versus pancake winding for REBCO and Nb3Sn, and related cooling options are elaborated. The THEA software is used to model the thermal-hydraulic performance of the three conductors in case of quench and to determine the MQE and hot-spot temperatures.

Disclaimer: 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.

Keywords

Category

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

Primary author: Dr WOLF, Michael J. (KIT - Karlsruher Institut für Technologie)

Co-authors: Dr FIETZ, Walter (KIT - Karlsruher Institut für Technologie); Dr HELLER, Reinhard (KIT - Karlsruher Institut für Technologie); Dr WEISS, Klaus-Peter (KIT - Karlsruher Institut für Technologie)