



Contribution ID: 861

Type: **Invited Oral**

Sat-Af-Spe1-01: [Invited] Status, Advances and Challenges of HTS Conductors for Fusion Magnets

Saturday 5 July 2025 14:00 (15 minutes)

The quest to produce energy from fusion power with magnetic confinement follows two main lines of research and development, as far as the generation of the magnetic field is concerned. On the one hand, several national and international roadmaps to fusion rely on tokamak designs obtained scaling up ITER, i.e. based on low temperature superconducting (LTS) magnets. The use of high temperature superconductors (HTS) is only considered as an option to increase the magnetic flux generated by the Central Solenoid. On the other hand, an increasing number of private companies are developing HTS magnets to achieve commercial fusion power on an earlier time horizon. HTS magnets potentially represent the enabling technology for the achievement of high-field fusion with a significant reduction in machine size, complexity and cost.

This paper will review the status, advances and open challenges in the design, qualification, and manufacturing advances of high-current / high-field conductors employing HTS materials, which are crucial for fusion as well as for so many other applications requiring high magnetic field. The main lessons learned during the development of the LTS cable in conduit conductors (CICCs) for the ITER project are recalled, with special reference to the performance degradation due to electromagnetic and thermal cyclic loading. The advances in the development of HTS conductors for fusion from the early short samples to the present model magnets are discussed, describing the different cabling configurations and the remarkable steps made to reach the present high current carrying capacity, current sharing temperatures and mechanical robustness. The characteristic time constants of these conductors, their quench behavior and losses during electrodynamic transients are discussed, also by comparison with the corresponding characteristics of LTS conductors. The paper finally points out the open challenges in this development, along with the ongoing experimental and theoretical R&D activities performed to address them.

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Session Classification: Sat-Af-Spe1 - [Special Session] High Current HTS Cables for Fusion and Beyond