Validation of the High Temperature Superconducting ENEA conductor thermal-hydraulic and electric model during quench propagation

Introduction

Several high-current, high-field conductor designs for fusion applications, adopting High Temperature Superconducting (HTS) tapes based on the Cable-In-Conduit Conductor (CICC) concept have been proposed worldwide. The most promising designs are based on REBCO tapes, twisted and stacked in few HTS stacks, e.g. the ENEA design, see Figure 1(a). A well-known issue in such conductors is the quench propagation because it is hard to be detected. For this reason, an experimental campaign in SULTAN on quench propagation in HTS CICCs is planned within the EUROfusion framework.

The lack of experimental results on quench in HTS conductors makes the thermal-hydraulic (TH) and electric modelling of these conductors of paramount importance, already in the conductor design phase. A preliminary quench analysis has been carried out in [1], see also Figure 1(b), according to the guidelines proposed in [2].

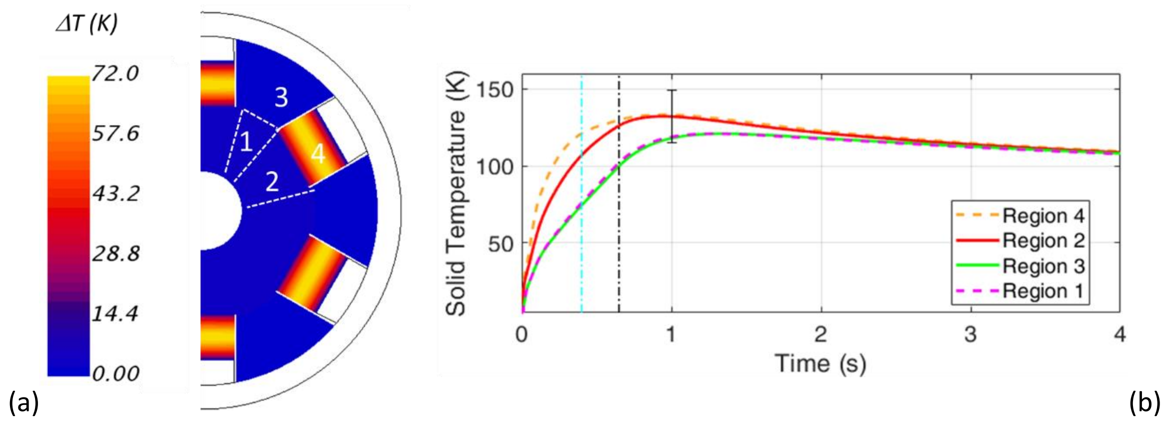

Figure 1: (a) Temperature increase during quench propagation in (half of) the ENEA HTS conductor cross section and (b) evolution of the hot spot temperatures in different regions of the cross-section.

Aim of the work

The aim of this work is to develop a detailed multi-region model of the CICC, suitably calibrated based on dedicated measurements performed on a short sample, in order to predictively analyze the quench propagation in the CICC.

As soon as the experimental data are available, after a careful data analysis of the relevant thermal, hydraulic and electric quantities, the comparison of the simulation results and those measured in SULTAN should be carried out in order to assess the reliability of the model.

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References

[1] A. Zappatore et al, “Modeling quench propagation in the ENEA HTS CICC”, presented at MT26, Vancouver, Canada, 2019, available at https://indico.cern.ch/event/763185/contributions/3415549/attachments/1912610/3187172/Mon-Mo-Or3-06_A_Zappatore_MT26_23sep2019_final_web.pdf.

[2] A. Zappatore, W. H. Fietz, R. Heller, L. Savoldi, M. J. Wolf, R. Zanino. “A critical assessment of thermal-hydraulic modeling of HTS Twisted-Stacked-Tape-Cable conductors for fusion applications”. Superconductor Science and Technology, May 2019.