Helmholtz - OCPC - Programme 2017-2021

for the Involvement of Postdocs in Bilateral Collaboration Projects with China

PART A

Title of the project

Experimental characterization and numerical modelling of high-temperature superconductor coils for efficient power applications

Helmholtz Centre and institute

Karlsruhe Institute of Technology (KIT), Institute for Technical Physics (ITEP)

Project leader

Priv.-Doz. Dr. Francesco Grilli

Web-address

http://www.itep.kit.edu/

KIT – International Affairs (INTL) Contact: Oliver Kaas Phone: +49 721 608 45323 Email: oliver.kaas@kit.edu

Description of the project:

In industrialized as well as developing countries, energy demand is constantly increasing, whereas power generation and transmission equipment is either lacking or aging and in need of replacement. Renewable forms of energy have begun to play an important role for energy production, and the hydrogen economy is gaining acceptance as a realistic alternative to fossil fuels. Yet, all these new technologies need an efficient way of generating, transporting and distributing energy. Only drastic changes to the current grid architecture together with the rapid introduction of new transmission technologies will be able to satisfy the world's increasing power needs and to prevent the high social and economic costs associated with a reduction in reliability and availability of electricity supply[1,2].

High-temperature superconductors (HTS) based on copper oxides, discovered in 1986, are very promising materials that can play an important role to achieve this goal. Their capability of carrying very large current densities (hundreds of times higher than copper) makes them the ideal solution for transporting large quantities of energy (cables), creating large magnetic fields (magnets for nuclear fusion), and manufacturing smaller and lighter generators and motors – just to name a few of the possible applications.

Nowadays rare-earth-barium-copper-oxide (REBCO) coated conductors are very attractive tapes, due to their extremely high critical current density, their excellent performance in large applied fields and their prospect for low manufacturing costs.

A substantial fraction of superconducting applications employs tapes wound into coils, in order to produce large magnetic fields: these applications include magnets for NMR and MRI, particle accelerators, transformers, superconducting magnetic energy storage systems and electrical machines. In spite of remarkable successes, like the magnet insert that allowed reaching a record 45.5-tesla DC magnetic field[3], the challenge of manufacturing REBCO coils with low power dissipation and good thermal stability remain, especially for AC application, where the AC losses in the superconductor material can constitute a very serious refrigeration burden.

HTS coils made of coated conductors without turn-to-turn insulation (in brief: non-insulated, or NI, coils)) have been validated with outstanding electrical and thermal properties, but in-depth characterizations in conditions close to those met in real applications are still missing. In this project, the electromagnetic and thermal performance of DC current-carrying NI and metal-insulated (MI), as well as insulated REBCO coils, under alternating magnetic field will be experimentally tested. The investigations will include the magnetic field evolution, the temperature rising as well as the dissipation. Furthermore, sophisticated 2D and 3D numerical models will be established, aiming at unveiling the underlying mechanism of the measured results.

[1] IPCC Fourth Assessment Report: Climate Change 2007, Working Group III Mitigation of Climate Change – Chapter 4: Energy Supply.

[2] European Commission: The Energy Roadmap 2050.

[3] Hahn et al. 2019 Nature **570** 496

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Description of existing or sought Chinese collaboration partner institute:

The Applied Superconductivity Laboratory (ASClab) in Southwest Jiaotong University was established in 1988, and is the first research-based laboratory built by Southwest Jiaotong University in Chengdu, China. In 2000, ASClab developed the world first man-loading HTS Maglev test vehicle. In 2014, the ASClab demonstrated "Super-Maglev": a 45-m-long HTS Maglev ring test line, combined with an evacuated tube transport approach. These installations have attracted worldwide interest. The work of the ASClab is anchored in the application of HTS technology to high-speed railway systems, with the aim of increasing the speed, improve the overall efficiency as well as reduce the cost. Research activities and projects undertaken in the ASClab mainly focus on superconducting maglev systems, superconducting linear motors, as well as superconducting high-field magnets.
In recent years, the ASClab has been very active in the field of applied superconductivity: they have published a series of high standard journal articles and presented their works at many international academic conferences, building strong links with our group and other famous institutes around the world.

Required qualification of the post-doc:

- PhD in Physics or Electrical Engineering
- Experience with electrical characterization of superconductors, numerical modelling of superconductors
- Additional skills in measurements of AC losses in superconductors, use of finite-element method programs.

PART B

Documents to be provided by the post-doc, necessary for an application to OCPC via a postdoc-station in China, which is affiliated to a research institution like a university:

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation
- Proof of command of English language

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PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 35 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team

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