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Numerical analysis of quench behavior in a Cable-In-Conduit-Conductor cooled by stagnant superfluid helium

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In a dark matter Axion research context, the MADMAX project acts as a figurehead in the physics research field. The purpose of the project is to use a dipole, composed of 18 coils, with a Figure of Merit of 100 T^2m^2. The MADMAX's coils have several specific features though, as the use of Cable-In-Conduit-Conductor (CICC) in a copper stabilizer or the use of stagnant superfluid helium inside the CICC channel. With such a small helium's cross-section and several hundreds of meters of conductor before reaching the helium bath, the quench dynamics appears then as a key issue of the design phase.

In order to solve the issue of quench propagation in the Madmax coils, we designed a MADMAX-like solenoidal prototype, for experimental quench studies, based on a numerical design phase made with THEA®. This numerical study allowed us to analyze the equations and physics behind the quench phenomenon. This numerical study was also the way to define the relevant current range for the experimental quench studies. Nevertheless, as THEA® has been rarely used with superfluid helium, its results will have to be validated by the quench testing campaign on this prototype.

The different calculations made with THEA® show that the quench propagation is divided in two different phases: a propagation with a constant speed at around 3 m/s and an acceleration phase where the propagation speed could reach 18 m/s, at the nominal current. Among the different possible phenomena, we have found that the friction forces are responsible of this two-phase propagation because they initiate the pre-heating of the magnet before the quench, reducing then the local temperature margin.

Keywords

Category

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

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