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New single coupling loss time constant scaling relation for CICC conductors subjected to fusion magnet conditions

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New cable concepts for the magnetic field coils of the upcoming fusion reactors are under development, with circular or rectangular cross-section. Some prototypes have been tested for DC transport current and AC loss in the Sultan facility (SPC) and for inter-strand contact resistance and AC loss at the University of Twente. The facilities both provide experimental data on the AC loss properties of the tested conductors but the conditions are different from the most severe Plasma Operating conditions. The classical single time constant based on sinewave applied fields with low frequency, leads to an over assessment of the coupling loss during plasma operation conditions. In order to provide a suitable scaling relation for the use of a simple single coupling loss time constant system, two applied magnetic field pulse profiles are considered; sinewave and trapezoidal, and the effect on the AC loss and current distribution are studied with the JackPot model. The code JackPot-ACDC provides the full current distribution versus time in all strands for applied magnetic field and transport current variations. The experimental results from interstrand contact resistance measurements carried out at the University of Twente, are used to calibrate and benchmark the simulations.
The analysis of coupling loss and current distribution shows the impact of the magnetic field changes on the conductor AC loss, translated into a single effective time constant depending on the shielding effect. One notable outcome of the study is the significantly simplified scaling of the level of coupling loss in the conductors with relevance to the magnetic field profiles under Plasma Scenario conditions. With this method, a more accurate real time calculation of the coupling loss is feasible without time demanding complex numerical computations or conservative overestimation by using the classical single time constant.

Category

Multi-scale and multi physics design methods

Keywords

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