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ELECTROMAGNETIC MODELING OF AN ITER FULL SIZE CONDUCTOR TEST

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ABSTRACT

The ITER (International Thermonuclear Experimental Reactor) will be the first prototype of fusion reactor based on the magnetic confinement of the plasma. ITER is presently going to be built in the Cadarache site (France). The strong magnetic field used to confine the plasma will be generated by a set of large superconducting coils made with a cabled conductor [1].

The characterization of short samples of these conductors is of crucial importance for the successful realization of the coils. The cable is of the "Cable in Conduit" (CIC) type and is realized with many strands twisted in a multi-stage lay-out. In turn, each strand is made of thousands of superconducting (SC) Nb_3Sn or NbTi microscopic filaments embedded in a copper matrix. The conduit, also referred to as "jacket", provides a cooling channel for the forced flow of liquid helium and transfers the electromagnetic forces from the cable to the reactor mechanical structure.

During the tests on these cable samples, it is practically impossible to directly measure the currents and the voltages in the individual strands, so that the only available experimental electrical data are the voltages between taps positioned on the cable jacket. An accurate modeling of the cable by means of suitable numerical codes can be very useful to correctly interpret the voltage experimental signals, thus improving the understanding of the complex electromagnetic behaviour of the cable

To this purpose, several codes have been developed, which describe the evolution of the current and voltage distribution in the cable samples. Among them, the THELMA code can analyse cable samples in transient regime, taking into account both the coupled electromagnetic and thermal-hydraulic aspects [2] [3].

The work describes the electromagnetic model implemented in the THELMA code and its application to the modeling of the tests performed in the SULTAN facility in Villigen (CH), in which the sample "critical current" (Ic) and the "current sharing temperature" (Tcs) are usually measured [4].

The standard SULTAN sample is made of two parallel cable segments, series connected by means of a copper joint and fed by a superconducting transformer through two cable copper terminations. The electromagnetic model is obtained by the coupling of the cable model with the termination and the joint models. These models have been implemented in the THELMA code since its origin. As the influence of the stainless steel jacket on the measured voltage signals has been demonstrated [5], a model of this component was recently developed and integrated in the code [6].

In the present work the complete electromagnetic model of the sample in the Tcs and Ic test is described and discussed. The influence on the calculated voltage signals and current distribution of the boundary conditions between the cable, the jacket and the joint, and of the conductance between cable and jacket are analyzed. A comparison with experimental data is reported and discussed.

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