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## AC losses in JT-60SA magnets during commissioning: experimental analysis and simulations

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During the integrated commissioning of JT-60SA tokamak, the superconducting magnets have experienced several tests such as current ramps or fast discharges. The time variations of the associated magnetic field have induced AC losses in the winding pack (WP) of the magnets, i.e. hysteresis and coupling losses, and in the casing, i.e. eddy currents losses, of the toroidal field (TF) coils.

From the thermo-hydraulic sensors installed in the tokamak in the inlet and outlet of the coils and of the TF casings, we have carried out enthalpy balances to estimate the total transient heat loads generated by AC losses. For the TF magnet, we have focused our analysis on fast discharges tests as they were producing more AC losses than the slow ramp ones.

In parallel, we have computed the AC losses generated in the magnets from the knowledge of the magnetic field map and the current profiles measured during the fast discharges. The hysteresis losses modeling is achieved using magnetization measurements at strand level, the coupling losses one using magnetization measurements at CICC level, and the eddy currents losses one in the TF casings using the inductance model presented in JT-60SA Plant Integrated Document (PID).

We then assess and discuss the consistency between these experimental and first theoretical analyses from the energy balance point of view. In a second step, we present and compare the results of several quasi-3D coupled thermal/thermo-hydraulic simulations performed using TACTICS code with the temperature sensors measurements during the experiment. These simulations aim at representing the TF magnet thermal and thermo-hydraulic response to transient heat loads at a more detailed scale to better anticipate the magnet stability in future operations.

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