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Wed-Mo-Po.06-02: Dynamic AC loss and thermal analysis of high-temperature superconducting rotors in synchronous condensers

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High-temperature superconducting (HTS) synchronous condensers have demonstrated exceptional potential in enhancing grid stability and providing rotational inertia, particularly in power systems with a high proportion of renewable energy. By incorporating HTS magnets into rotor systems, these devices improve dynamic support performance, reactive power regulation, and grid inertia, addressing critical challenges in modern power grids.

This study focuses on the dynamic AC loss characteristics of racetrack-shaped HTS rotor magnets under transient strong excitation conditions. Through the development of a homogenized model based on the H-formulation, spatially resolved AC losses across linear and arc segments of the rotor are evaluated. The analysis incorporates electromagnetic coupling between the stator and rotor and considers the influence of back iron on loss distribution. The excitation process, characterized by rapid current ramps (up to 3.5 times the nominal current within 0.1-0.5 seconds), is thoroughly examined to quantify hysteresis, eddy current, and coupling losses.

The findings offer critical insights into the thermal behavior of HTS magnets during high-stress operational phases, providing guidance for rotor design and cryogenic system optimization. These results lay the groundwork for further studies on the integration of rotational effects and multi-field coupling in high-capacity HTS synchronous condensers, ensuring their reliability and scalability in future grid applications

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