3D ANSYS UNMITIGATED QUENCH SIMULATION OF SUPERCONDUCTING COILS

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ABSTRACT

The basic process of a quench is the conversion of stored electromagnetic energy into heat when a superconducting magnet is operated above its critical parameters. Although this is quite a common occurrence due to the relatively low energy input needed to trigger a quench, several methods can be implemented to mitigate the effect of such disturbances. However, proving that, even in the extremely unlikely event that the coil detection and protection systems failed, the magnets cannot endanger either the primary or secondary containments, is needed to be consistent with safety claims made as part of new fusion reactor licensing processes.

The objective of this work is to discuss a comprehensive model for the analysis of fault conditions in superconducting magnets. ANSYS, a well-known validated industry standard tool, in combination with its parametric design language, is being used to model and understand the consequences of an unmitigated quench. Lumped circuit elements representing the external electrical network drive a high resolution 3D Finite Element model of one of the magnet coils. Voltage, temperatures and volumes of melted material can be estimated in order to predict the likelihood of arcing. Several types of arc can be formed requiring integration of a model for each type, including its thermo-physical effects. The accident will continue to progresses until the inductive magnetic energy stored in the system is dissipated as Joule and local arc heating.

The paper describes the details of the computational procedure and applies it to a representative magnet model.