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Fri-Mo-Po.06-05: Time and Frequency Domain Reflectometry for Quench Monitoring in Superconducting Magnets

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High-temperature superconductors (HTS) are increasingly being used to build electromagnets to generate strong magnetic fields for a wide range of applications, from medical devices and electric motors to future fusion reactors. These superconductors are subject to quenching, a phenomenon that manifests itself as a rapid rise in the temperature of the HTS material, leading to a loss of the superconducting state and interruption of magnet operation. The timely and rapid detection of the quenching is currently one of the most active areas of development. A technique based on frequency and time domain reflectometry (FTDR) is suggested in this presentation for the quench monitoring. We use the detection and analysis of microwave electromagnetic signals propagating in the coolant gas channels to monitor the temperature of the coolant enabling the quench monitoring. The techniques suggested should allow both a real-time quench detection capability, as well as, facilitating the acquisition of valuable information regarding the health of the whole magnet system throughout its operation time.
The methodology presented here is based on the established correlations between thermodynamic gas variables such as temperature and pressure with its electromagnetic properties i.e. refractive index. The technique has been recently subjected to both numerical and experimental validations. Numerical simulations were conducted using CST Microwave studio and it was found that a localised hotspot can be detected with minimal time delay, a crucial consideration for systems necessitating rapid response monitoring for safety purposes. The experimental data observed agree well with the theoretical understandings and it will be presented. While the technique holds significant potentials for quench monitoring it also offers valuable opportunities to develop new monitors in areas encompassing many devices which are applying complex gas cooling, such as fusion reactors, MRI systems and others.

Authors: Dr KONOPLEV, Ivan V. (United Kingdom Atomic Energy Authority); Dr CHOUHAN, Shailendra Singh (United Kingdom Industrial Fusion Solutions Ltd.)

Co-authors: Dr ZHANG, Heng (United Kingdom Atomic Energy Authority); Dr ZHANG, Jin (Queen Mary University of London, School of Electronic Engineering and Computer Science); Prof. ZHANG, Min (Department of Electronic and Electrical Engineering, University of Strathclyde); Mr FERNÁNDEZ-SERRACANTA, Oriol (United Kingdom Atomic Energy Authority / Department of Electronic and Electrical Engineering, University of Strathclyde); Prof. CHEN, Xiaodong (Queen Mary University of London, School of Electronic Engineering and Computer Science); YANG, Yisong (Queen Mary University of London, School of Electronic Engineering and Computer Science)

Presenter: Dr CHOUHAN, Shailendra Singh (United Kingdom Industrial Fusion Solutions Ltd.)

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