Seminar

==========

Institute for Plasma Research

==========

Title: Design aspects of High-Temperature Superconducting power cable

Speaker: Dr. Ipsita Das
Indian Institute of Technology, Kharagpur

Date: 07th March 2025 (Friday)

Time: 10.30 AM

Venue: Seminar Hall, IPR

Abstract

High Temperature Superconducting (HTS) cables can transmit huge electrical power in compact size with minimum Joule loss. Researches are being carried out on its design and development worldwide. The design procedure of HTS cable mainly involves an understating of three different aspects other than electrical one e.g., structural aspect (electro-mechanical behavior of HTS tape and cable), hydraulic and thermal aspects (cooling of cable to maintain superconductivity using LN2 flow).

In structural analysis, the strains developed in the YBCO layer of tape because of the mechanical loadings are studied. The HTS tapes are helically wound around a circular former and undergoes different types of mechanical loadings during cable production, transportation and installation. A finite element (FE) structural analysis is carried out to investigate the electro-mechanical behavior of HTS tape during production and post production processes with five different winding pitches. The results illustrate a minimum winding pitch above which critical current degradation is not observed.

For hydraulic and thermal analyses, the flow behavior and convective heat transfer enhancement of LN2 flow are studied. In cable, LN2 flow experiences a bilaterally heated annulus with uniform but unequal heat fluxes, whereas the annulus is having two different walls i.e., inner smooth and outer corrugated wall. The corrugations in outer wall of annulus increase the heat transfer area and also responsible for increase in flow friction. Therefore, in hydraulic analysis to realize the effect of corrugation (i.e., corrugation pitch and depth) on flow friction, nine different corrugation geometries with three different pitches(6,10,14mm) and depths(5,7,9mm) are considered. This analysis results a combination of pitch and depth (i.e.,10,5mm) having minimum flow friction. Thereafter, to realize the effect of corrugation shape on both hydraulic and heat transfer performances, this particular combinations of pitch and depth is considered. The analyses are carried out with four corrugation shapes i.e., curved, rectangular, trapezoidal and triangular. The nature of LN2 flow is turbulent and the numerical modeling carried out for hydraulic and thermal analyses using k-ϵ model in ANSYS FLUENT. Further, it is also necessary to establish a comprehensive performance of heat transfer enhancement with pumping power penalty. Therefore, a performance evaluation criterion (PEC) is introduced to take both heat transfer enhancement and pressure drop into account.

A 22kV/3kA HTS cable is designed based on the Indian power grid scenario, considering all the aforementioned design aspects and safety measures into account.