Seminar

Institute for Plasma Research

Title : Study of two phase flows in fusion magnets

Speaker: Mr. Gaurav Kumar Singh
Institute for Plasma Research, Gandhinagar

Date : 11th October 2019 (Friday)

Time : 11.00 AM

Venue : Seminar Hall, IPR

Abstract:

Any two chemically different species having similar/dissimilar phases or a combination of the gas-liquid, liquid-liquid or gas-solid phases of the same fluid can co-exist in principle. These two phases can move together. Such a state of flow is commonly known as `Two Phase (TP) Flow'. Two phase flows are frequently avoided in cryogenic devices due to its inherent complexity and lack of detailed information of its hydraulic behavior in systems. However there are cases, where two-phase flows are unavoidable due to heat- in leaks. Cryogenic two phase flows are commonly found in LNG (liquefied Natural Gas) plants, aerospace applications, superconductivity applications, and many other engineering applications. Due to such frequent occurrences in cryogenic industrial processes, two phase flow has been a study of continued practical interest. The cryogenic systems under TP cooling are cryogenically stable as it provides the enhanced 'heat transfer coefficient' as compared to the single phase cooling. Therefore, study of two phase operation in fusion grade magnets wound from CICC superconductors is worth investigating. In this thesis work, several aspects of TP flow characteristics of cryogens (liquid helium and liquid nitrogen) have been studied experimentally. The experimental results have been calibrated with models predicting and validating the effective temperatures, pressure drops, quality factors, void fractions, flow patterns and flow regimes etc

The thesis work comprises of a systematic experimental study of two phase flow characteristics in a representative cryo line appropriate for applications such as to SST-1 (Toroidal Field) TF magnets as a test case. Next, the experimentally observed enhanced cryostable performance in long operation of TP cooled SST-1 TF magnets in several campaigns have been analyzed and duly explained. The general helium TP cooling influenced essential characteristics such as effective temperature, pressure drops and voids etc are then explained in the context of fusion relevant prototype CICC. Since the two phase flow regimes and flow patterns are critical information in tuning process parameters and thermodynamics conditions of the cryogenic loads, an experiment has been designed to address these issues from first principle. In this laboratory set-up, horizontally flown liquid nitrogen has been parametrically studied for a number of input conditions aimed at visualizing the various flow patterns and flow regimes as expected in practice. The results obtained are then calibrated with well known TP models for common fluids. The quality factor (x_0) and void fraction being extremely important for a TP cooled system another experiment has been custom designed. A new capacitance based measurement diagnostics for void fraction measurement has also been developed and validated in this context for liquid nitrogen flow in horizontal configurations.