Seminar

Institute for Plasma Research

Title : Investigation on the flow distribution within the rod bundle of AHWR

Speaker : Mr. Mohit P Sharma
DGFS PhD, HBNI, BARC, Mumbai, India

Date : 08th November 2016 (Tuesday)

Time : 03.30 PM

Venue : Seminar Hall, IPR

Abstract:

The Advanced Heavy Water Reactor (AHWR) is a vertical pressure tube type, heavy water moderated and boiling light water cooled natural circulation based reactor. The coolant flow distribution in single and two phase flow condition is very important for AHWR rod bundle to ensure its safety and performance. Single phase flow condition exists in reactor rod bundle during start-up condition and up to certain length of rod bundle when it is operating at full power. However, being a natural circulation BWR, transition from single phase to two phase flow condition occurs in reactor rod bundle with increase in power. Prediction of thermal margin of the reactor has necessitated the determination of inter-subchannel mixing of coolant amongst these subchannels. The inter-subchannel mixing consists of three independent phenomena; turbulent mixing, void drift and diversion cross flow.

Of course, two phase turbulent mixing studies are not new especially for conventional BWRs. However it is important to assess the models developed so far for these reactors for their accuracy and applicability to AHWR condition. In this study, assessment of two phase turbulent mixing models applicable to BWRs has been performed against existing experimental data for various subchannel geometries of BWRs. It is found that there are large errors between predictions by the empirical models and measured experimental data. Even there are large differences in prediction among the models and experimental data of turbulent mixing rate from one subchannel array to another. This is because mixing phenomena are highly geometry and operating condition dependent. It may be noted that, the subchannel geometry of AHWR rod bundle is completely different from conventional BWRs. The rods in AHWR bundle are arranged in circular subchannel array unlike conventional BWRs geometry in which rods are arranged in square-square, rectangular-rectangular and square-rectangular subchannel array. In the view of above, data obtained from conventional BWRs cannot be used for AHWR. In addition, AHWR being a natural circulation BWR, the effect of variation of mass flux in the subchannels on two phase mixing phenomena for AHWR specific geometry needs to be investigated.

Since it is difficult to develop mechanistic model for different aspects of mixing (i.e. turbulent mixing, void drift and diversion cross flow) in the rod bundle, experiments were carried out in a scaled test facility of AHWR rod bundle. The facility simulates 1:1 geometry of 1/12th symmetrical section of AHWR rod bundle. Water and air was used as the working fluid and the inter-subchannel mixing tests were carried out. The turbulent mixing rate, void drift and diversion cross flow was experimentally measured for AHWR operating condition.

Our results indicates that

i. The turbulent mixing and void drift both are found to be dependent on void fraction and flow regimes even for low mass flux condition typical to AHWR geometry.
ii. The magnitude of turbulent mixing rate due to turbulent mixing and diffusion coefficient due to void drift is found to be higher for AHWR subchannels geometry compared to conventional BWRs geometry for the same mass flux.
iii. Also the magnitude of turbulent mixing rate and diffusion coefficient found to be increase with increase in superficial liquid velocity
iv The cross flow resistance coefficient due to diversion cross flow in two phase flow is higher as compared to single phase flow.

Empirical models were developed based on experimental data which could predict the inter-subchannel mixing due to turbulent mixing, void drift and cross flow quite accurately with an average error of ± 9 %. These models can be used to assess AHWR flow distribution and thermal margin.