Seminar

Institute for Plasma Research

Title : Experimental and computational study to Suppress thermal stratification in a water pool with shrouds

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Time : 03.30 PM

Venue : Committee Room 3, (New Building), IPR

Abstract :

Advanced nuclear reactors of generation III+, use active and passive safety systems both to remove decay heat from the core. During normal shutdown of the reactor, decay heat from core is removed using active safety system, which require external power source. But, in the case of a Station BlackOut (SBO) condition, no power source is available and active safety systems fail to function their intended functions. In these scenario, decay heat from core of the nuclear reactor is removed with the help of passive safety system, which does not require external power source and work on basis of natural convection. Passive safety system use large pool of water with an immersed heat exchanger to reject core decay heat. The GDWP of AHWR is example of such a system. The steam generated in the core of reactor is condensed in IC tubes and heat is rejected to surrounding water volume. Upon receiving heat, pool water volume loses density, becomes lighter and start moving upward by virtue of buoyancy force. At the free surface the hot water volume spreads in the form of a layer. The continuation of this process keeps piling the layer of hot water over colder one leading to development of vertical temperature gradient known as thermal stratification. The problem of thermal stratification become more critical for the water pools located within the containment building. Because, thermal stratification leads to early saturation of the pool water at the free surface leading to loss of mass inventory due to vaporization and pressurization of the containment building.

The present study is focused on suppression of thermal stratification in large water pools. Experimental studies performed in ITL at BARC followed by numerical analysis using RELAP5/MOD 3.2 leads to characterization of thermal stratification in large pools. The study also finds and suggest the use of modified RELAP nodalization to simulate thermal stratification in pool having immersed IC (or a heat source). The study is carried forward to characterize thermal stratification in prototype GDWP, which also help in estimating the approximate time for the entire pool inventory to saturate. Use of shrouds around immersed IC has been proposed to suppress thermal stratification in the pool. A parametric study performed by varying shroud flow area and shroud height for the case of single and three shrouds around IC show that three-shroud system enforce the whole pool water to circulate and participate in heat transfer process most effectively. The study also recommend to use nonconductive and non-leaking shroud plates for best performance. The knowledge and experience gained from these studies is applied to prepare a scaled transparent experimental setup suitable for PIV measurements. The objective of the PIV measurements is to capture the multidimensional flow behavior of pool water in the presence of shrouds and estimate the effect of shrouds on suppression of thermal stratification. The PIV measurements were performed for both the cases of pool without shroud and with three shrouds installed around heater assembly. CFD simulation using OpenFOAM for all set of PIV measurements were performed. The study shows development of flow circulation in the pool with shrouds, which leads to participation of whole pool water in heat removal process. Also, while flowing through the flow path obtained by combination of shrouds, the relatively hot water volume gets mixed with the cold water volume leading to suppression of thermal stratification. The study indicate that installation of three shrouds around IC can significantly delay the pool saturation by suppression of thermal stratification during a SBO.