Abstract

Theoretical and experimental study of transient heat transfer parameters related to downward flowing water in a circular concentric annular channel is conducted. The cooling channel is exposed internally to sinusoidal heat flux and has an adiabatic outer surface. The present theoretical study investigated the heat transfer and thermodynamic parameters during of 25%, 50%, and 75% flow reduction transients. The related experiments to such flow reductions simulates the loss of flow accidents (LOFA) in the research nuclear reactors initiated by loss of main power supply, pump failure, heat exchanger blockage, pipe blockage or valve closing. The results of steady state condition set as an initial condition for the transient model which is evaluated by using M-file-MatlabR2013a written computer program. The theoretical transient approach involved a mathematical model based on the analytical solution for first order ordinary differential equations supported by experimental correlations for axially, symmetric, simultaneously developing laminar water flow in a vertical annulus cooling channel which takes under consideration the nucleate boiling, film boiling and two phase flow formulation. The mathematical model is based on one dimensional downward flow. Unit step flow reduction function is implemented in the present model to simulate the flow reduction transient. It is noteworthy that the unit step reduction function is used first time in the recent study among the related previous study. The present experimental investigation included a set of experiments...
carried out to investigate the thermal-hydraulic behavior and evaluate their boiling safety factor, K. The present work is based on the following initial and boundary conditions: heat flux of 50 kW/m², mass flux values of 192.6, 128.4, and 64.2 kg/m².s to simulate the 25%, 50% and 75% flow reduction transients as the nominal mass flux is 256.8 kg/m².s accompanied with keeping the inlet cooling water pressure around 1.06 bar, inlet water temperature equal 80°C and L/D=38.89. Before initiating the flow reduction transient scenario, the acceptable thermal-hydraulic safety level of the cooling system is set to be close from the acceptance criteria (K ? 1.6) that implemented in the Iraqi nuclear reactor (14th Tammuz 5000 kW Reactor) referred to the final safety analysis report that done by (A. W. Ezzat and H. M. Taki, 1988). It is concluded that K value reaches around unity for 25% and 50% of flow reduction percentage transient at around 5 and 3 seconds respectively from transient initiation while the K value dropped below the unity at 75% of flow reduction transient. The surface dry out takes place during 75% and 100% flow reduction at normalized distance of 0.65 away from the cooling channel entrance based on experimental observation due to the onset of flow instability (OFI) that encounter the downward flow direction at low pressure and low velocity system (LPLV). It's also conclude that the elapsed time required for the surface temperature to reach its steady state values after each transient scenario is less than that related to bulk water temperature as long as the water temperature kept below its saturation temperature. Generally, the present experimental and theoretical results showed good agreements.

References

Computer Science

Keywords

Loss of flow accident  Dry out  Nucleate boiling and film boiling  Heat transfer parameters

Downward flow

circular concentric annular channel

Two phase flow

Onset of flow instability.