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# Abstract


Steam jet pump (SJP) is a non-conventional pumping device for pumping radioactive and hazardous fluids or slurries. It is also used for producing vacuum in various chemical and process industries. Comparing to conventional pumps, its main advantage is that it has no moving parts and hence is maintenance free. However, the transport phenomena occurring in SJP is highly complicated because of the direct-contact condensation (DCC) of steam. The present knowledge of SJP is limited mostly to experimental data, 1-D modeling and empirical correlations. In this study, the transport phenomena of DCC are studied theoretically, experimentally and numerically with particular focus on SJP. A mathematical model of DCC is developed and used to study, numerically, the transport phenomena across steam-water interface in SJP and in a supersonic steam jet injected into a subcooled water tank. The DCC model is validated by comparing the numerical simulation results with the experimental results. The experiments are performed on different geometries of SJP, designed, fabricated and assembled into an experimental setup in this research work. The experimental data is translated into characteristic curves to study the performance of SJP under different operating and geometric conditions. To rigorously validate the DCC model and study the two-phase flow in the mixing section of SJP, void fraction is measured by gamma-ray densitometry and the steam jet is visualized through high speed photography.

The experimental results of axial static pressure, axial static temperature and void fraction are compared with the computational results. A close agreement between the two results validates the DCC model and CFD simulations. These results also explain the flow behavior and transport phenomena in SJP. The characteristic curves of SJP in terms of entrained water mass flow rate, mass ratio and suction lift are generated as a

function of steam inlet pressure and water nozzle suction pressure. These curves help in understanding the performance of SJP at different operating conditions. The suction lift, calculated from experimental data using Bernoulli's equation, gives the idea of the depth from which the SJP is able to suck and pump water under different operating conditions. The maximum value of mass ratio and suction lift recorded in these experiments are 64.63 and 2.2 m respectively for the geometries studied. The computational results of volume fraction, mass transfer and axial steam velocity provide important information about the steam-water interface and the transport phenomena occurring in SJP. The results of flow visualization also explain the behavior of steam jet and validate the DCC model and gamma-ray densitometry results qualitatively. The mathematical modeling, based on the physics of the transport phenomena, and 3-D numerical simulation of complex phenomena of DCC in SJP is a valuable addition to the previously available 1-D and 2-D modeling.