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Void fraction of supersonic steam jet in subcooled water

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ABSTRACT

For most operations in process, petroleum and power industries gas-liquid two phase flows occurs, so an accurate estimation of void fraction is vital because it affects the calculations of heat and mass transfer as well as hydrodynamics. Any inaccuracy in estimation may lead to drastic incidents along with heavy monetary loss. An effort has been made here to estimate the approximate void fraction of supersonic steam jet into the sub-cooled water. Electrical Resistance Tomography (ERT) has been used for the purpose along with the Electrical Impedance Tomography and Diffuse Optical Tomography Reconstruction Software (EIDORS) to generate the conductivity scans obtained by ERT setup. Before the experimentation, for further assurance on our void fraction estimations, the measurement system has been calibrated by securing scans of heated Teflon rod of diameter 6 mm, which is approximately having the same cross-sectional surface area as the steam jet have and reported in previous studies at the same hydrodynamic conditions. Images of supersonic steam jet in subcooled water have been processed by the help of EIDORS and image processing technique. The over estimation in void fraction of Teflon rod is ranging from 46.17 to 83.44% and when it is subtracted from the total void fraction of supersonic steam jet (46.51–83.79%) at steam inlet pressure of 1.5–3.0 bar and surrounding water temperature 30–60 °C respectively, the actual void fraction of Teflon rod comes out to be ranging from 0.34% to 0.35% of the total cross-sectional area of vessel. When these results are compared with the previous studies, a close agreement has been observed between these two sets of results.

1. Introduction

An insight into a process reactor to yield accurate measurement of what is occurring in a vessel is vital for process intensification. The journey of mind storming and intense experimentation for around three and half decades has given birth to a relatively new class of non-invasive measurement technique that is called tomography. It has got birth some 35 years ago but for the level of maturity that it attains now, it has gone through rigorous tests and measurements since then. Yet obviously as its name implies i.e. “tomo” means slice and “graph” means image, its name is the true reflector of the way that it is functioning. This technique finds its use in the application areas wherever two or more phases interact with each other. These types of interactions mostly prevail in the process, nuclear and petroleum industries but with a fact that these industries do not cover the whole canvas, there are myriad other industries that have encountered or have to deal with these interactions. Out of these, the two phase flows that involve conversion of one phase into the other phase via mass, energy and momentum transfer are such that prevail mostly in the steam driven power industries. It is important to have in depth knowledge of the salient process parameters, which influence strongly on various operations such as transportation of the liquids or gases or mixtures of both of them in the pipelines, estimation of the storage capacity in the tanks during filling or evacuation, calibration of the meters or controlled transfer of fluids etc., All these need the accurate knowledge of the insight of the vessels where two-phase phenomena takes place and a single most important

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