World Academy of Science, Engineering and Technology
International Journal of Mechanical and Industrial Engineering
Vol:11, No:08, 2017

Transient Heat Transfer: Experimental Investigation near the Critical Point

Authors : Andreas Kohlhepp, Gerrit Schatte, Wieland Christoph, Spliethoff Hartmut

Abstract : In recent years the research of heat transfer phenomena of water and other working fluids near the critical point experiences a growing interest for power engineering applications. To match the highly volatile characteristics of renewable energies, conventional power plants need to shift towards flexible operation. This requires speeding up the load change dynamics of steam generators and their heating surfaces near the critical point. In dynamic load transients, both a high heat flux with an unfavorable ratio to the mass flux and a high difference in fluid and wall temperatures, may cause problems. It may lead to deteriorated heat transfer (at supercritical pressures), dry-out or departure from nucleate boiling (at subcritical pressures), all cases leading to an extensive rise of temperatures. For relevant technical applications, the heat transfer coefficients need to be predicted correctly in case of transient scenarios to prevent damage to the heated surfaces (membrane walls, tube bundles or fuel rods). In transient processes, the state of the art method of calculating the heat transfer coefficients is using a multitude of different steady-state correlations for the momentarily existing local parameters for each time step. This approach does not necessarily reflect the different cases that may lead to a significant variation of the heat transfer coefficients and shows gaps in the individual ranges of validity. An algorithm was implemented to calculate the transient behavior of steam generators during load changes. It is used to assess existing correlations for transient heat transfer calculations. It is also desirable to validate the calculation using experimental data. By the use of a new full-scale supercritical thermo-hydraulic test rig, experimental data is obtained to describe the transient phenomena under dynamic boundary conditions as mentioned above and to serve for validation of transient steam generator calculations. Aiming to improve correlations for the prediction of the onset of deteriorated heat transfer in both, stationary and transient cases the test rig was specially designed for this task. It is a closed loop design with a directly electrically heated evaporation tube, the total heating power of the evaporator tube and the preheater is 1MW. To allow a big range of parameters, including supercritical pressures, the maximum pressure rating is 380 bar. The measurements contain the most important extrinsic thermo-hydraulic parameters. Moreover, a high geometric resolution allows to accurately predict the local heat transfer coefficients and fluid enthalpies.

Keywords : departure from nucleate boiling, deteriorated heat transfer, dryout, supercritical working fluid, transient operation of steam generators
Conference Title : ICHTFM 2017 : International Conference on Heat Transfer and Fluid Mechanics
Conference Location : Paris, France
Conference Dates : August 28-29, 2017