

Initial Study of Supercritical Fluid Blowdown

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Improved efficiency of fusion power plants can be achieved with higher operating temperatures and pressures. By taking advantage of the large change in the specific heat at the pseudo critical point of fluids, fusion power plants could gain efficiency improvements as high as 30% in the secondary side. There are however several issues that need to be resolved including possible accident situations where a tube or pipe rupture ensue fluid from the break. This would result in a rapid depressurization of the system governed by the critical flow rate from the tube rupture. The paper first presents a brief review of the previous work done on critical flow of supercritical water (SCW) by United Kingdom Atomic Energy Authority (UKAEA) and concerning supercritical CO₂ depressurization of vessels by the University of Hamburg. Then a model based on a steady state Homogeneous Equilibrium Model (HEM) and conditions with and without friction is also presented. Calculations indicating three different possible regimes in a blow down scenario are calculated with this model. The single-phase flow in the supercritical region and the transition either in to sub-cooled water, a two-phase fluid or a superheated gas near the critical point results in an interesting flow with a wide range of behavior. Indeed depending on the initial conditions and the geometry either vaporization or condensation can occur either in the pipe or at the exit. A comparison between the results and the experimental data from UKAEA and University of Hamburg-Harburg is discussed. Moreover those results are attempted to be extended to other fluids like CO₂, R22 or R134a by comparing its thermodynamic and dynamic evolution to dimensionless SCW results. Finally experiments with the depressurization of a supercritical water system are presented and designs of an experimental apparatus to observe this phenomenon during a pseudo steady state or a transient blowdown with several different fluids is discussed.