Numerical simulation of a natural circulation loop

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Introduction

Nowadays the natural circulation has been very much studied, experimentally and numerically, for the better understanding of this phenomenon and in order to increase the safety of the future nuclear reactors [1-2]. The use of computational codes for the study of this phenomenon has grown in the last years as a consequence of the great and fast increase in the velocity of computer processors. The numerical simulation is becoming a cheaper and faster way to study the fluid dynamics in this field of engineering than it was some years ago[3]. This work presents a numerical study of the natural circulation in an experimental model in reduced scale of a passive heat removal system similar to an advanced 600 MW PWR.

Natural Circulation Loop and Numerical Simulation

The natural circulation loop studied in this work is formed by three main components: a heat vessel, a heat exchanger and a column of expansion as it is shown in the figure below.

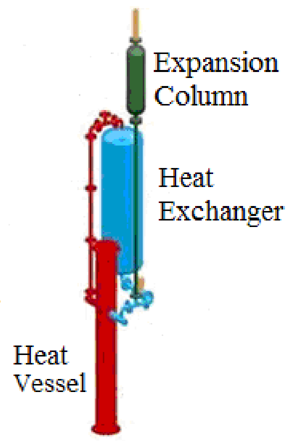

Figure 1. The natural circulation loop.

In this work it was used a commercial software for the numerical simulation of the loop called CFX 12.1 from Ansys [4]. To execute the simulation it was used the parallel processing in a machine with 12 processers.

Governing equations

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho U) = 0$$

$$\frac{\partial (\rho U)}{\partial t} + \nabla \cdot (\rho U \otimes U) = -\nabla p + \nabla \cdot \tau + S_M + S_{M,buoy}$$

$$\frac{\partial (\rho h)}{\partial t} - \frac{\partial p}{\partial t} + \nabla \cdot (\rho U h) = \nabla \cdot (\lambda \nabla T) + U \nabla \cdot p + \tau : \nabla U + S_E$$

$$\rho = \rho(p,T)$$

$$c_p = c_p(p,T)$$

Results

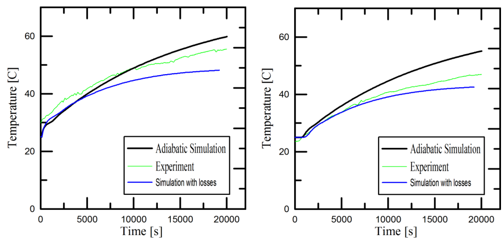

Figure 2. Hot and cold leg fluid temperature

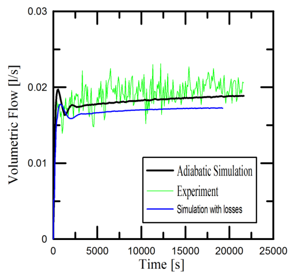

Figure 3. Volumetric flow

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