Author's Accepted Manuscript

Chemical Engineering Science

www.elsevier.com/locate/ces

The influence of the wall thermal inertia over a single-phase natural convection loop with internally heated fluids

A. Cammi, L. Luzzi, A. Pini

PII: S0009-2509(16)30355-4
DOI: http://dx.doi.org/10.1016/j.ces.2016.06.060
Reference: CES13040

To appear in: *Chemical Engineering Science*

Received date: 27 March 2016
Revised date: 6 June 2016
Accepted date: 27 June 2016

Cite this article as: A. Cammi, L. Luzzi and A. Pini, The influence of the wal thermal inertia over a single-phase natural convection loop with internally heate fluids, *Chemical Engineering Science* http://dx.doi.org/10.1016/j.ces.2016.06.060

The influence of the wall thermal inertia over a single-phase natural convection loop with internally heated fluids

A. Cammi[a], L. Luzzi[a,*], A. Pini[a]

[a]Politecnico di Milano, Department of Energy, CeSNEF (Enrico Fermi Centre for Nuclear Studies), Milano, Italy

Abstract

This paper deals with the influence of the piping material thermal and geometrical properties on the dynamic stability of single-phase natural circulation loops. To this purpose, a semi-analytical approach is developed by adopting the tools provided by the linear analysis. By considering a generic natural circulation loop configuration with a localized heat flux and a homogenously distributed Internal Heat Generation (IHG), the governing equations (mass, momentum and energy balance) are linearized around a steady-state solution of the system and treated by means of the Fourier transform to obtain dimensionless stability maps. Moreover, in order to verify the linear analysis methodology, a numerical strategy is adopted to solve the nonlinear governing equations and to investigate the natural circulation dynamics in the time domain. In principle, both the developed approaches can be applied to any natural circulation loop configuration. In the present work, the linear and the nonlinear analyses are applied to a specific natural circulation loop geometry, namely the Horizontal Heater Horizontal Cooler (HHHC) one. In this regard, an Object-Oriented (O-O) one-dimensional model of the HHHC loop is developed. For the assessment of the O-O model, the obtained results are compared with RELAP5 and Computational-Fluid-Dynamics (CFD) time-dependent simulations.

Keywords: Natural circulation, Internal heat generation, Stability analysis, Thermal-hydraulics, Object-oriented modelling, RELAP5.

1. Introduction

In presence of density gradients induced by temperature differences, convective motions can arise in a fluid due to the buoyancy force. Systems which are able to adopt this kind of flows in order to transfer heat between a hot source and a cold sink are known as natural circulation loops. Although forced convection can be a more efficient cooling strategy, natural convection does not require any active component and thus it can be used for high reliability engineering applications. In this regard, the high-level safety requirements (which are being even more stringent after the Fukushima accident) needed in the nuclear industry have demanded research on emergency systems based on natural convection. As for the drawbacks of natural circulation systems, they can be subject to dynamic oscillations of both velocity and temperature fields that

* Corresponding author: Politecnico di Milano, via La Masa 34, 20156 Milano, Italy. Tel.: +39 02 2399 6326.
Email address: lelio.luzzi@polimi.it (L. Luzzi).