Sabilility of boiling flows in a vertical heated channel by Asymptotic Numerical Method

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Résumé

In this talk we will present an efficient and powerful numerical model to compute bifurcation diagrams in liquid-vapor two-phase fluid flows in vertical heating pipe. This full range two-phase model enables to deal with both single phase (purely liquid or purely vapor) and mixed liquid-vapor configurations that span all flow regimes (laminar and turbulent) in forced, mixed and natural convections. The originality of the proposed methodology is to faithfully integrate the highly non-linear system of governing equations along branches of steady state solutions. This is performed by the means of a continuation algorithm based on the Asymptotic Numerical Method supplemented with Automatic Differentiation, implemented in the Diamanlab software [1-2]. Then, linear stability analyses are performed at various points of interest enabling to figure out stability limits within the parameter space. The relevant mathematical highlights from the Dynamical Systems Theory have been reported to support the inner workings of the approach which have been detailed. The resulting numerical model has been run in different continuation configurations, such as mass flow rate or pressure drop imposed at boundaries, which are indeed representative of experiments from the literature and reactors' experiments along a loss of flow transient. Interestingly, the method has proven capable of handling such a variety of situations.

This model problem aims at improving the understanding of dynamic instabilities that take place in many natural circulation two-phase flows, with a particular emphase on helping the design of potential next generation nuclear reactors, cooled with liquid sodium to face severe accident scenarios, e.g., Unprotected Loss Of Coolant [3].

References:

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Mots-Clés: Two, phase liquid, vapor fluid flows, drift flux model, thermo, hydraulic instabilities, bifurcation diagrams, path, following or continuation methods, linear stability analyses, Asymptotic Numerical Method.