Development of a Steady State Critical Two-Phase Flow in a Nozzle

- new choking criterion

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Abstract

The use of two-phase ejectors to improve refrigeration systems encounters today a great interest. However, modeling of such devices with low void fraction at the entrance of the motive nozzle, presents significant challenges. The choking conditions and the discontinuities appearing in a two-phase flow in a nozzle are not well documented and some works are needed to better anticipated flow behavior under these conditions.

The purpose of this work is to improve the understanding of the critical multiphase flow for a complete range of void fraction in a convergent-divergent. In this paper, a steady state two-phase flow model including new choking criterion for two-dimensional conservative systems is presented. The present two-fluid model remains general since no assumption on pressure, temperature or velocity equilibrium is made. For this reason, it allows the use of pressure correlation between phases compared to those in literature which are dealing principally with single-pressure model. The model includes the turbulent, friction and heat and mass transfer phenomena affecting the behavior of the two-phase flow in a convergent-divergent nozzle. In addition, correlations for the friction phenomena and for the exchange area between phases are proposed as a function of void fraction. The complete mathematical model formulation allows the simulation of the complete void fraction range from liquid to gas flow including bubbly and droplet flows.

To achieve this goal, a new steady state compressible multiphase solver in OpenFOAM is under development. This solver will allow physical compressibility, turbulence, heat and mass transfer, phase interaction and different phase velocity. A new choking criterion developed by [1] is used to build the numerical scheme and ensure the stability and convergence.

As a first step, this model is used to study the flow in the motive nozzle of an ejector. This frame is then modeled numerically with this new solver and validated with experimental and numerical results from literature. Readily available data in [2] and [3] for two-phase critical flow in a nozzle is then used to evaluate the validity of the numerical scheme for a large range of initial void fraction.

Key words: Two Phase Flow, Critical Flow, Two-Fluid Model

References

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