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Boiling in porous media: toward a local non-equilibrium model

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ABSTRACT

Developing a macro-scale model describing accurately intense boiling in porous media, like in the case of the re-flooding of a debris bed reactor with strong solid heat source terms, is a real challenge. The existence of local non-equilibrium effects has been recognized in the past based on strong experimental and theoretical evidences. Three-temperature models have been proposed coupled with two-phase macro-scale momentum balance equations taking into account inertia effects (see discussion in [1,2]). They seem to offer a good modelling framework, however, many questions remain unresolved. This paper discusses several issues associated to this challenging up-scaling problem.

In a first part, experimental results are presented at both the pore-scale (micro-model made of a network of heat resistors) and the macroscopic-scale (porous medium column). Pore-scale results emphasize clearly the existence of various boiling regimes but with significant differences when compared to classical pool boiling or boiling in channels experiments. In particular, classical Nukiyama curves are not strictly recovered, quantitatively and qualitatively, because of the various interactions due to the porous medium structure and tortuosity. This calls for porous medium specific expressions of the heat exchange terms in the macro-scale models, and also suggests that the pore-scale phase repartition is very specific to the boiling regimes and that the resulting macro-scale two-phase flow properties must be adapted.

In a second part, the up-scaling problem is reviewed pointing out the many different assumptions that must be made in order to establish a model candidate taking as much as possible the information coming from the experimental program.

REFERENCES

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