

Letter to the Editor

Comments on the comment S.A. Kovalev, V.M. Zhukov, S.V. Usatikov, comment on the paper W.W. Lin, J.C. Yang, D.J. Lee, “Metastable pin fin boiling,” IJHMT 43 (9) (2000) 1629–1635

Kovalev et al. commented on our work on metastable pin fin boiling [1]. Unfortunately, IJHMT did not forward their comments to us for a reply before the publication of the comments [2]. We noted their comments recently and would like to include in this letter our reply to their comments.

Kovalev et al. first criticized that we overlooked in [1] their studies on fin boiling written during the sixties and seventies. In particular, [3] explored the meta-stability of fin boiling by defining a Liapunov’s functional, J , from the one-dimensional heat conduction equation along a boiling fin. Accordingly, we should not have claimed in [1] that we had, “for the first time, numerically and experimentally proved the existence of metastable regimes in fin boiling processes.” We apologize for this oversight, and should have included in [1] the references cited in [2]. However, as discussed in the following paragraph, the commentators’ work, although elegant and mathematically comprehensive, are utterly useless in practice.

Kovalev’s Letter described in some detail the Liapunov functional J derived in [3]. If could be appropriately evaluated, the functional could be used to differentiate the stable and metastable regimes of fin boiling. The Liapunov approach is attractive since it can analyze the finite-amplitude behavior of a nonlinear system without really solving the relevant equations. However, the evaluation of their functional J depends on information about the *complete* boiling curve. Restated, not only are data on the stable and metastable nucleate and film boiling required, but also the “true” transition boiling curve connecting the nucleate to the film boiling on the local fin surface is needed a priori to evaluate the functional J . However, as stated in [4,5], the true transition boiling curve can never be experimentally determined as required. All the transition boiling curves reported in the literature are in fact “temporally and spatially averaged” rather than “intermittent, real-time” or “true” curves; the former are primarily determined by the heating method and from the disturbances imposed to the boiling. Hence, the functional J of Kovalev et al. cannot be evaluated from their (or others’) boiling data. Similar difficulties also arise in the evaluation of the so-called

“Maxwell cut” in the vapor–liquid equilibrium system, because the unstable, intermediate regime that connects the vapor phase to the liquid phase is experimentally unrealizable [6].

The stable and metastable boiling regimes can thus be identified by either allowing the nucleate and film boiling modes to compete on a single heated surface [7–10], or by observing the response of the nucleate or film boiling by inducing disturbances of a controlled magnitude [1]. Restated, Ref. [1] provided the first experimental “proof” of the existence of metastable fin boiling. Although the commentators’ work cited in [2] were conducted 30 years ago, it is not pertinent since the approach adopted is based on an invalid assumption. Similarly, the numerical results presented in [1] noted the threshold temperature disturbance to induce transition between steady-state fin boiling modes, and hence provided the first numerical “proof” of metastable fin boiling. However, this latter part of work should not be considered complete since it still relied on some unjustifiable assumptions about the transition boiling curve.

Finally, if the commentators had referred to the aforementioned Refs. [4–10], they might have noted their fundamental difficulty in [3] before submitting their Letter [2].

References

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