DISCUSSION

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In this paper a physical model for burnout in flowing steam systems is postulated and applied to experimental data. We have independently developed a somewhat similar model [9].[7] One principal difference between the two models is that the one proposed in this paper assumes that a liquid film flows on the heat-transfer surface up to the point of burnout. The model proposed by us [9] assumes that the amount of liquid moving through a liquid film, if one exists at all, is negligible. Visual observations are needed to resolve this difference. In analyzing vapor volume fraction data [10] and liquid-film thickness measurements [11] it is apparent that a substantial fraction of the total liquid flows along the wall under adiabatic conditions, even in the so-called fog-flow regime. However, analysis of data in the same range of flow quality with heat addition [12] appears to substantiate our assumption of negligible liquid film flow at the wall. The authors of this paper also appear to reach this conclusion when applying their model to the data, since in setting $z = 1$ in equation (6) they found that the maximum difference in the predicted burnout quality was only about 6 per cent.

We also speculated that the evaporation process, even prior to burnout, involved vaporization of droplets which have diffused to a layer of superheated vapor adjacent to the heat-transfer surface. We had difficulty visualizing bubbles growing in a thin liquid film nor could we convince ourselves that film evaporation is the appropriate mechanism at these high heat fluxes.

Another difference in approach is that in the present paper, constants and exponents are evaluated from actual burnout data, thus raising questions of the empirical nature of the relations. Six such empirical constants, although the authors state that only three are required, must be evaluated for each experiment; namely, b, z_0, E_n, j, m, and n. On the other hand, we have hopes that an understanding of droplet diffusion and evaporative processes in turbulent streams may provide relations for mass-transfer coefficients and slip ratios which can be readily used in predicting burnout values over a wide range of conditions.

References

9 K. Goldmann, H. Firstenberg, and C. Lombardi, "Burnout in Turbulent Flow—A Droplet Diffusion Model," published in this issue, pp. 158–162.

10 H. C. Larson, "Void Fractions of Two-Phase Steam-Water Mixtures," MS thesis, University of Minnesota (1957).

11 Personal communiqué from Dr. M. Silvestri, Centro Informazioni Studi Esperienze (CISE), Milan, Italy.

12 R. A. Egen, D. A. Dingee, and J. W. Chastain, "Vapor Formation and Behavior in Boiling Heat Transfer," BMI-1163, February, 1957.

Authors' Closure

We wish to express our gratitude to Messrs. Goldmann, Firstenberg, and Lombardi for their many valuable comments. The question of liquid distribution is quite pertinent. So far as we know, it remains unanswered. Vaporization from droplets near the wall is a distinct possibility. However, it would seem likely that in the highly turbulent flow many of the droplets would penetrate to the heated surface. Whether or not a film of liquid exists on the surface under conditions approaching burnout, it would be expected that the surface would be wet at least intermittently. We would also agree that film evaporation could not accommodate the high heat fluxes which are found to be possible.

The 6 per cent difference upon setting $z = 1$ in equation (6) referred to above does not imply that the liquid film is negligible. Because of the density difference a liquid film at the wall may contain an appreciable fraction of the liquid while the vapor occupies most of the tube cross section (i.e., while z is nearly unity).

Of the six empirical constants referred to above, one (n) has been used at only two different values (depending on the tube shape). Another (j) has been kept at a fixed value in all applications of the model. A third (m) has, in effect, been dropped from the model by assuming a zero value in all applications. The more general equation including m is presented in the derivation of the model, but it was used in the simpler form.

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[7] Numbers in brackets from [9–12] designate References at end of discussion.