LETTERS TO THE EDITOR

To the Editor:

Mesler's views on boiling in thin films (*AIChE J.*, 22, 246, 1976), as applied to forced convection two-phase annular flow (*AIChE J.*, 23, 448, 1977), are at variance with currently accepted views on annular flow, which consider the bubble nucleation mechanism to be suppressed and the film region to be devoid of entrained bubbles at high void fraction. Recent AAEC research results are consistent with the views of Mesler (1977).

An examination of fluid mechanical aspects of two-phase flow (Beattie 1977) has indicated that the film region of adiabatic or diabatic forced convection annular flow sometimes contains bubbles, some of which may be attached to the wall. The evidence is based on sublayer structure, as inferred from a comparison of two-phase flow data with expressions derived from mixing-length theory for velocity profile, friction factor, and void fraction. Different sublayer structures give rise to different forms of non-dimensional parameters appearing in these expressions. For nucleate boiling flows of the type considered by Mesler (1977), attached wall bubbles act as surface roughness elements of a magnitude determined by appropriate surface tension and shear forces. Consequently, such flows are characterized by a Weber number instead of a Reynolds number. Appropriate non-dimensional parameters for annular flows with attached wall bubbles are:

Weber number

$$We = G\langle j\rangle D/\sigma$$

Friction factor

$$f = 2\tau_w/(G\langle j\rangle)$$

Wall distance

$$y^+ = y\,We\,f/D$$

Local velocity

$$j^+ = \sqrt{2/f}(j/\langle j\rangle)$$

Void fraction relation

$$S^+ = (1 - \sqrt{\langle\alpha\rangle})We\,f/2$$

Liquid volume flow rate

$$Q^+ = We\sqrt{f/2}(1 - \beta)/(1 + \sqrt{\langle\alpha\rangle})$$

In the above, β is the ratio of the volume flow rate of gas to the total volume flow rate, and $\langle\text{---}\rangle$ denotes the average value over a cross-section. Other symbols follow usual notation.

Experimental data are compared in Figures 1-3 with theoretical expressions for an annular flow with attached wall bubbles. It is clear that the data are compatible with a model which allows bubbles within the film region. Further examples have been reported (Beattie 1977).

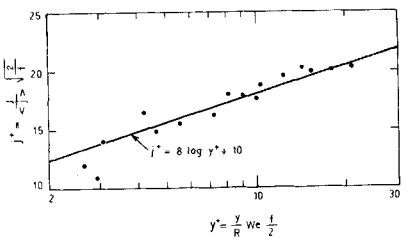

Fig. 1. Annular flow velocity profile (data from Kirilov et al (1973)).

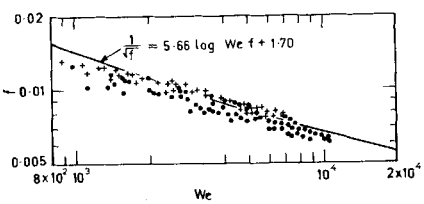

Fig. 2. Annular flow friction factor data from Alia et al (1968) (+) and Kirilov et al (1973) (●).

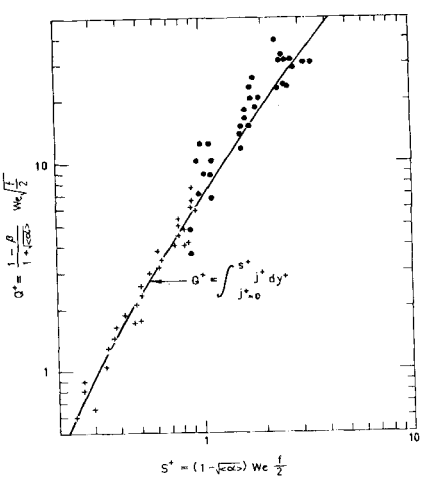

Fig. 3. Annular flow void relation [data from Alia et al (1963) (+) and Kirilov et al (1973) (●)].

Although the abovementioned AAEC work has concentrated on fluid mechanical aspects of two-phase annular flows, it has been found (Beattie and Lawther 1978) that, whenever the heat transfer characteristics in the approach to dryout show evidence of a marked local improvement in heat transfer through the film just before dryout is reached, then, in line with the heat transfer mechanism proposed by Mesler (1976), the corresponding friction factor data are consistent with the existence of attached wall bubbles in the film.

It is concluded that evidence from both fluid mechanical and heat transfer aspects is consistent with Mesler's hypothesis that the nucleate boiling mechanism can contribute to heat transfer in thin film annular flows.

D. R. H. Beattie
K. R. Lawther
Engineering Research Division
Australian Atomic Energy Commission
Research Establishment

LITERATURE CITED

Alia, P. et al., "Two-Phase (Gas & Liquid) Adiabatic Vertical Upflow: A Preliminary Study with a Rod Cluster Geometry," Report CISE-R-108 (1968).

Beattie, D. R. H., "Some Aspects of Two-Phase Flow Drag Reduction," 2nd Int. Conf. on Drag Reduction, BHRA Fluids Engng., Cranfield, UK (Sept. 1977).

Beattie, D. R. H., and K. R. Lawther, "Relationship Between Wall Shear Stress and the Heat Transfer Crisis Phenomenon with Vapour/Liquid Flows," Paper Accepted for 6th Int. Heat Transfer Conf., Toronto, Canada (August 1978).

Kirilov, P. L. et al., "Measurements of Some Characteristics of Steam-Water Flow in Round Tubes at a Pressure of 68.6 Bar," Report FEI-421 (1973).

Mesler, R. B., "A Mechanism Supported by Extensive Experimental Evidence to Explain High Heat Fluxes Observed during Nucleate Boiling," *AIChE J.*, 22, 446 (March '76).

Mesler, R. B., "An Alternate to the Dengler and Addoms Convection Concept of Forced Convection Heat Transfer," *AIChE J.*, 23, 448 (July 1977).