Comparison of Two-Phase Liquid Fraction Data for Potassium with Other Fluids

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Comparison of the potassium liquid fraction data of Smith et al. (*1*) with limiting values of liquid fraction and with data for other fluids, on a physical property basis, shows the reported values to be very high.

Figure 1 shows liquid fraction as a function of the Martinelli flow modulus X_{tt} for the water-air data of Hewitt et al. (*2, 3*) and the mercury-nitrogen data of Kiraly and Koestel (*4*). These data are identical to those included by Smith et al. (*1*). The Lockhart-Martinelli data (*5*) and a calculated maximum curve based on X_{tt} are also presented. These data were shown (*6*) to be systematically capable of correlation when the liquid to gas viscosity and density ratios:

$$[(\mu_l/\mu_g)^{.2}/\rho_l/\rho_g]^{*}$$

were utilized as an additional parameter. This correlation (*6*) also demonstrated good agreement with data for steam (14.7 to 2,000 lb./sq.in.abs.), Santowax R, and recently (*7*) for Freon-22 and sodium-potassium–nitrogen.

The upper shaded areas in Figure 1 show the ranges of the potassium (*1*) and sodium (*8*) data and the associated values of the property index. It can be seen that the property index ranges for potassium (0.00004 to 0.00076) and sodium (0.000063 to 0.00036) approximate and span that for the mercury-nitrogen (0.00026) data cited. On this basis, these data would be expected to fall into the area of the mercury-nitrogen data. However, the data are generally not only an order of magnitude greater, but also exceed, by a substantial amount, the maximum liquid fraction[†] possible for a given value of X_{tt}. The upper curve was derived by Martinelli-Nelson for the critical point of steam where the liquid to gas viscosity and density ratios are identically unity. As this derivation was formulated, it was independent of fluid properties; subsequently, its interpretation was extended (*6*) to include all fluids. Since the bulk of the potassium and sodium data exceeds the maximum liquid fraction indicated by X_{tt}, the propriety of utilizing X_{tt} as a means of correlation appears questionable.

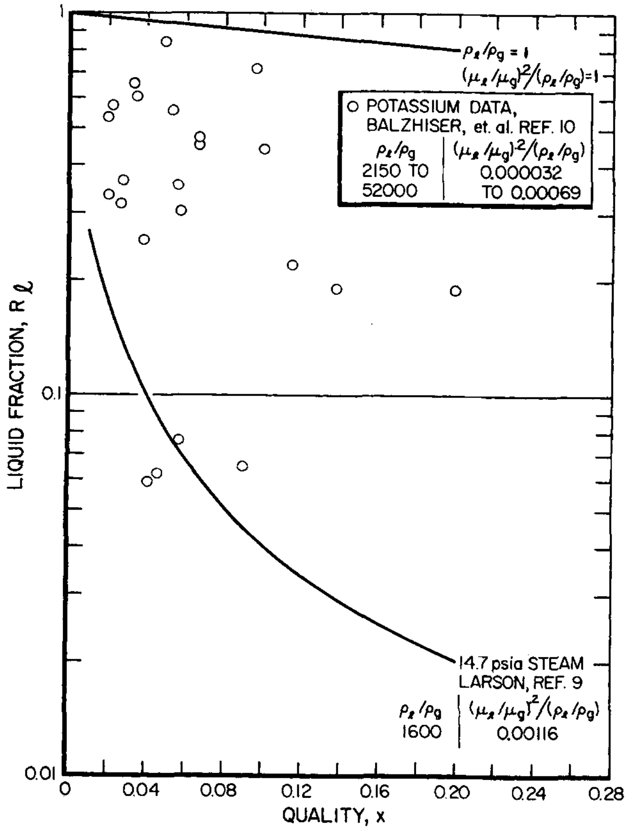

Fig. 2. Liquid fraction vs. quality.

Figure 2 shows liquid fraction as a function of quality for the critical point ($R_l = 1 - x$), and for the atmospheric pressure steam data of Larson (*9*). Each curve is identified as to liquid to gas density ratio and property index. Liquid fraction data for steam at pressures greater than atmospheric—and other fluids (*6*)—will form a consistent family of curves intermediate to those shown. The potassium liquid fraction data of Balzhiser et al. (*10*) are plotted in relationship to the described curves. Except for the inclusion of five additional data points and a slightly different property index range, these data are those of Smith et al. (*1*). On the basis of either liquid to gas density ratio or property index, it can be seen that the potassium liquid fraction data would be expected to fall below the lower curve. However, virtually all of the potassium data occupy a region about fivefold greater and some points approach the values existing at the critical point. Although not shown, presentation of the sodium data (*8*) on this basis will show a similar condition. Thus, despite the apparent agreement between these liquid metal data and those for mercury (*11*), there is a contradiction between the measured liquid fractions and those anticipated from physical property ratios which other investigators have demonstrated to be valid for

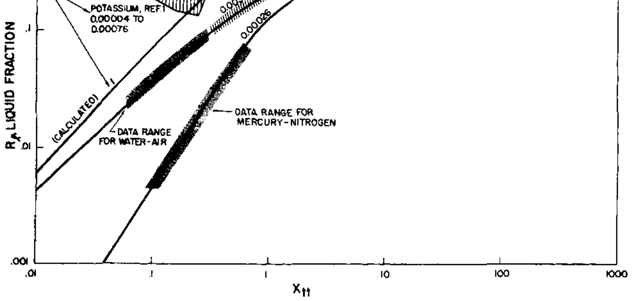

Fig. 1. Liquid fraction vs. X_{tt}.

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[*] This grouping is called the property index.

[†] $R_l = \left(\dfrac{X_{tt}^{1.11}}{X_{tt}^{1.11} + 1}\right)$.

wetting and nonwetting, single- and two-component, two-phase fluids.

My comments are not intended to diminish the authors' accomplishments and contributions in this important, complex, and difficult field of experimentation. Rather, they are to show that if we accept the premise that liquid fraction data for all fluids should fit into an orderly scheme, then the enigma posed by single-component liquid metal data challenges us to examine further both the methods of prediction and the experimental data.

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Effect of Surface Alignment on Hydrodynamic Stability in Falling Liquid Films

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Recent communications (*1* to *3*) concerning the properties of falling liquid films, with particular reference to velocity profiles and nature of surface waves, have provided theoretical equations to represent these phenomena. Experimental verification of the theories has not however been conclusive. In studies of liquid film flow over vertical surfaces little reference has been made to the importance of surface alignment.

Friedman and Miller (*4*) have shown that for vertical laminar films flowing over the outside surface of a tube ($N_{Re} < 300$) the surface velocities agreed well with the value predicted by the Navier-Stokes equation. However, when the tube was inclined at an angle of 6 min. from the vertical, the surface velocities measured increased by between 100 to 200%.

We have observed a similar phenomenon when investigating mass transfer of ethanol vapor into vertical laminar water films, which resulted in film rupture due to surface tension differences induced.

Results are presented in Figure 1 that illustrate that deviations from the vertical of more than 8 min. produce large hydrodynamic changes in the system. This underlines the importance of specifying accurately surface alignment in any experimental study and may account for discrepancies in some reported values.

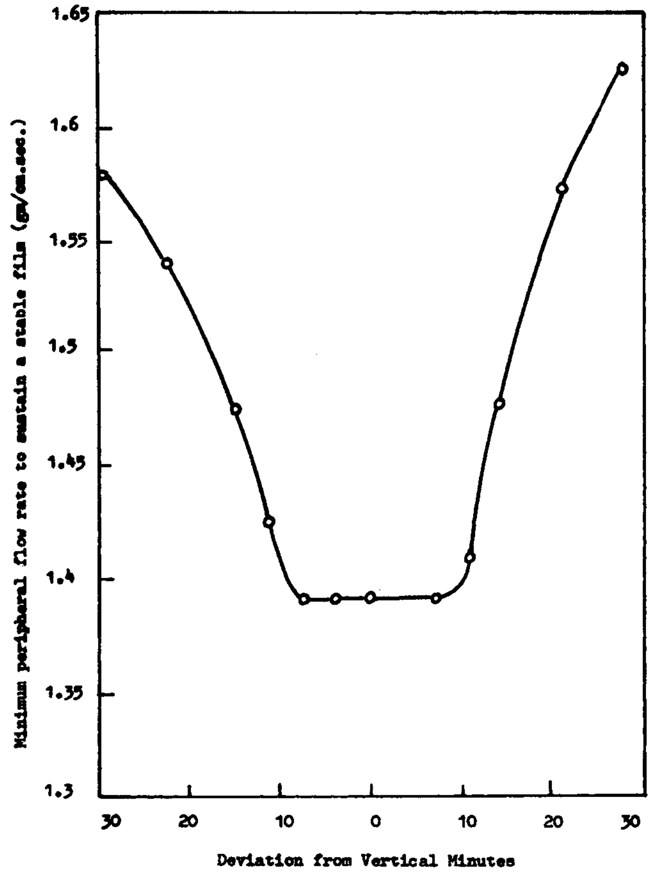

Fig. 1. The effect of surface inclination on the minimum flow rate to maintain a water film in a saturated ethanol-air environment.

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