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Letters to the Editors

Comments on 'Boiling of suspension of solid particles in water'

THE PAPER by Yu Min Yang and Jer Ru Maa [1] provides a useful addition to the knowledge of enhanced boiling heat transfer. The authors observe that the addition of a small amount of suspended solid particles increases the boiling heat flux due to the thermal boundary layer disturbance caused by the motion of solid suspended particles. The sedimentation of suspended particles is prevented by constant agitation. It would be interesting to know whether the authors have considered or intend to consider the contribution of agitation in the enhancement of the boiling heat transfer coefficient of water with suspended particles. The application of forced convection due to stirring increases the convective contribution and results in early removel of the bubbles adhering at the surface, which increases the bubble frequency.

With reference to Fig. 4 of ref. [1], the enhancement of nucleate boiling heat flux is stronger when solid content in the suspension is higher for solid particles of the same size. The slope of the nucleate boiling curve for water with suspended solids is higher compared to the pure water curve although it does not follow a set pattern. However, it implies an increase in critical heat flux for water systems containing suspended solids. It would be instructive to study the maximum limit of solid content in the suspension and boiling heat flux enhancement.

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REFERENCE

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Comment on 'Measurement of high gas-stream temperature using dynamic thermocouples'

THE AUTHORS of ref. [1] recognized that the working equation usually employed in dynamic thermocouple temperature measurements [2–4]

$$T_g = T+\tau'\frac{dT}{dt} \quad (1)$$

or

$$\frac{T-T_{in}}{T_g-T_{in}} = 1-\exp(-t/\tau') \quad (2)$$

(the same symbols as in ref. [1] are used in this letter) is not always satisfactorily applicable. They included heat conduction and radiation terms in their modelling equation and obtained numerically correction factors due to these terms not being included in equation (1) or equation (2). Experimental results using a bunsen flame (~ 1700 K) were introduced to support their model.

However, ref. [1], like many previous papers [2–4], assumed that $\tau' = \rho A C_p/(\alpha P)$ was a constant independent of thermocouple temperature. This assumption does not represent a practical dynamic thermocouple such as a chromel–alumel or a Pt–Pt+10%Rh thermocouple. This situation, as shown in refs. [5–7], is mainly caused by the variation of the specific heat of these thermocouple materials with temperature, although both α and $\rho A/P$ are also weak functions of temperature. For example, for a chromel–alumel thermocouple, the average specific heat can be expressed as [5, 8]

$$C_p = C_{p0}[1+2.83\times10^{-4}(T-273)] \quad (3)$$

and for a Pt–Pt+10%Rh thermocouple a similar expression was expected [6, 7, 9]. The experimental data of the specific heat of platinum [9] can be expressed as

$$C_p = C_{p0}[1+2.11\times10^{-4}(T-273)]. \quad (4)$$

For Pt+30%Rh–Pt+6%Rh, the following expression of the specific heat was suggested [7]

$$C_p = C_{p0}[1+2.41\times10^{-4}(T-273)]. \quad (5)$$

If the temperature of the dynamic thermocouple increases in a measurement from 400 to 1273 K, the corresponding variations of the material specific heat and, thus, of τ' can be more than 18% from equations (3)–(5). It is obvious that such a great variation of C_p or τ' should not be ignored. Now, assume τ' in equation (1) varies linearly with temperature, i.e. $\tau' = \tau'_0[1+a(T-273)]$. Then the solution of equation (1) for the temperature–time curve can be written as

$$\frac{t}{\tau'_0} = [1+a(T_g-273)]\ln\left(\frac{T_g-T_{in}}{T_g-T}\right)-a(T-T_{in}) \quad (6)$$

as a is assumed to be a constant. When the temperature–time data predicted by equation (6) are forced to fit a curve of the