LINEAR CORRECTION FOR HEAT TRANSPORT SECONDARY TO BUOYANT FORCES IN FLOW CALORIMETRIC CALCULATIONS

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Flow calorimetric systems are being increasingly used to detect enthalpic changes secondary to putative nuclear reactions in condensed phases[1,2,3,4,5]. The equation used to derive the estimated power output, and therefore the presence of any excess heat involves the applied fluid flow, the specific heat of the water, and the temperature differential. Although this equation may be dimensionally correct, it does not appear to be always valid for low flow rates[6], in certain cases where Bernard instability[7,8] may have inadvertently impacted the calorimetry. Previously qualitatively examined has been the time-varying distribution of temperature in a quasi-one-dimensional model, for both horizontal and vertical flow calorimetry, both with and without convection[6]. There can be thermal distribution in a vertical system with the addition of upward thermal-driven convection, driven by thermal-induced buoyancy instability. As a result, there can be shift of the isothermal lines away from the intrinsic symmetry exhibited by horizontal flow calorimetric systems with zero applied convective flow, producing the appearance of "excess heat", or a magnified excess heat, even in the absence of applied convection. Thus, the quoted efficiencies of energy generated by classical calculation may not be correct. There is an apparent error "signal" for zero flow because of the thermal instability, which then creates mass transfer. This brief note suggests a semiquantitative correction to the enthalpic calculations using a first order correction for heat transport secondary to buoyant forces generated by unstable thermal inhomogeneities.

If η_B is the ratio of heat transported by the buoyant forces to the heat transported by the applied solution convection, then the Q1D model of heat and mass transfer[6] has indicated that what is generally correct for horizontal calorimetric systems may not be correct for vertical systems, when the non-dimensional number (= η_B) is significantly greater than zero. η_B, in real systems, depends upon other non-dimensional factors including the Archimides non-dimensional number which is the ratio of the buoyant force to the viscous force, and possibly the Rayleigh non-dimensional number, which is the ratio of gravity to thermal conductivity.

We suggest the separation of the apparent observed Power output ($P_{derived}$) into two terms, the actual power out (P_{out}) and a second bouyancy-flow-related error term (P_{error}). Because the observed signal -- the delta-T in the face of the applied convention (v_C) and incidental thermal buoyant convection (v_B) -- results from the combined velocity, then to zeroth order one can write

$$P_{observed} = P_{out} + P_{error} = C_p * \Delta T * V_{total} \cong C_p * \Delta T * (V_{convection} + V_{bouyancy}) \quad \text{(eq. 1)}$$

where the error term thus becomes by the non-dimensional ratio η_B

$$P_{error} \approx C_p * \Delta T * V_{convection} * \eta_B \quad \text{(eq. 2)}$$

Both the chain rule in calculus, and consideration of coolant redistribution suggests that there are higher order terms from the impact of the buoyant flow.

$$\frac{\delta P_{error}}{\delta \eta_B} = (C_p * \Delta T * v_C) + \left[C_p * v_C * \eta_B * \frac{\delta \Delta T}{\delta \eta_B} \right] \quad \text{(eq. 3)}$$

The term containing $\frac{\delta \Delta T}{\delta \eta_B}$ depends upon many factors including the total tank volume just outside the reactor (or thermal control) and the actual input temperature boundary condition. However, that term appears to be higher order, and so the linear correction to the observed power becomes

$$P_{corrected} \approx P_{observed} - (C_p * \Delta T * v_C * \eta_B) \quad \text{(eq. 4)}$$

An improved estimate of the purported over-unity gains (π) then becomes, corrected to first order,

$$\pi_{corrected} = \pi_{observed} * (1 - \eta_B) \quad \text{(eq. 5)}$$

In summary, any such reported 'excess heat' parameters may be inflated, if the information was indeed collected with a vertical flow calorimetric system, in the absence of confirmatory calibrations under low to moderate flow conditions where the non-dimensional number (h_B) is not trivial. Equations 4 and 5 offer semiquantitative corrections to the observed calculations of present flow calorimetric systems used to investigate nuclear reactions in he condensed phase, even in the presence of buoyant flow in vertical flow calorimetric systems, using a linear correction based upon the measured, or estimated, values of η_B.

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