*** Swartz, M, "Improved Calculations Involving Energy Release Using a Buoyancy Transport Correction", Journal of New Energy, Fall 1996, Proc. Sec. Conf. of Low Energy Nuclear Reactions, 1, 3, 219-221 (1996)

IMPROVED CALCULATIONS INVOLVING ENERGY RELEASE USING A BUOYANCY TRANSPORT CORRECTION

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ABSTRACT

Measurement of energy release in the evaluation of fusion systems may rely upon flow calorimetric systems susceptible to Bernard instability which may have inadvertently impacted the calorimetry. Such thermal-driven convection can produce the appearance of "excess heat", or a magnified excess heat, because of unanticipated thermal-driven mass transfer. A semiquantitative correction to enthalpic calculations is suggested after separation of the observed Power output ($P_{derived}$) into two terms, the actual power out (P_{out}) and a second bouyancy-flow-related error term (P_{error}).

DISCUSSION

Measurement and documentation of energy release are critical in the evaluation of fusion, or other putative over-unity systems. Reliance upon flow calorimetric systems are being increasingly used by some 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], such as in certain cases where Bernard instability [7,8] may inadvertently have an impact upon 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 redistribution 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 may be an apparent error "signal" for zero flow because of the thermal instability which can create mass transfer. This brief note suggests a semiquantitative correction for the enthalpic calculations using a first order term 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 all of the heat transported including that by the applied solution convection, then the Q1D model of heat and mass transfer [6] indicates that what is generally correct for horizontal calorimetric systems may not be correct for vertical systems, when the non-dimensional number ($= \eta_B$) is significantly greater than zero.

The buoyant heat flow ratio, η_B, in real systems may also depend 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.

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

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

The error term is thus first order on the non-dimensional ratio η_B .

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

We assume that η_b is small and therefore $V_{total} \approx V_{convection}$. This is also an approximation because the chain rule from calculus, and consideration of possible coolant redistribution, suggest that there are other higher order terms also potentially arising from the impact of the buoyant flow.

$$\frac{\delta P_{error}}{\delta_{\eta_B}} \approx (C_p * \Delta T * V_{total}) + [C_p * V_{total} * \eta_B * \frac{\delta \Delta T}{\delta \eta_B}] \quad \text{(eq. 3)}$$

Thus, the second term in the equation, involving $\frac{\delta \Delta T}{\delta \eta_B}$, may depend upon several additional factors involving

at least the total tank volume just outside the reactor (or capacity of the thermal control) and the actual input temperature boundary condition.

Ignoring in this approximation the terms of higher order, and using the approximations above, the linear correction to the observed power becomes corrected as

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

Thus, a more accurate estimate of purported over-unity power gain (π) could be directly derivable, from the correction to first order, as

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

Since the submission of this manuscript, the correction technique of subtracting for the buoyant uplift in flow calorimetric systems has been experimentally applied independently by Dr. Barry Merriman and P. Burchard [9]. In that system, the correction is taken as a direct calibration to set the null signal. Based on this paper, it may also be possible to semiquantitatively derive both terms in some systems.

In summary, the extent of any such reported 'excess heat' may be inflated, if the information was collected with a vertical flow calorimetric system, without confirmatory calibrations under low to moderate flow conditions where the non-dimensional number (η_B) is not trivial. Equations 4 and 5 offer semiquantitative corrections to the observed calculations of present verticle flow calorimetric systems used to investigate heat producing reactions in the condensed phase. These can be used 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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