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POTENTIAL FOR POSITIONAL VARIATION IN FLOW CALORIMETRIC SYSTEMS

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Although many aspects of calorimeters have been discussed, including issues of potential problems with the thermometry (i.e. thermocouples, thermistors and thermometers, as well as electrical grounding and crosstalk, thermal mixing and sensor positioning problems), the potential impact of the positional effects of the flow calorimetry has not been mentioned. The positional orientation refers to the direction of the flow, and not to the orientation of any temperature probes therein. Despite the reported advantages for flow calorimetry in detecting enthalpy from putative fusion reactions, these studies theoretically suggest that there may be effects from positional variational in the calorimetry of such flow systems. Rather than 'ease of calibration' usually touted for such systems, it is suggested that calibration may be more complicated for vertical flow calorimetric systems. In the absence of additional calibration, it may be critical to keep semiquantitative calorimeters horizontal.

One recent series of reports using vertical flow calorimetry [1,2,3,4] involves the *CETI* microspheres, reported to use a few percentages of the metal of other systems. The microspheres have multilayer metallic coats and are used as a distributed electrode bed. The cell is 10 cm long, 2.5 cm in diameter, and contains 1 to 40 ml of beads. Electrolyte percolates through, removing the heat, and exits from the top. The flow causes a temperature gradient. The observed delta-T, between the top and bottom is in the range of 1.5 to 20C (flow rates is 1.0 - 1.5 liters per minute, with the water circulated by a magnetic impeller pump, total power consumption ~85 watts). At the ICCF5, the *CETI* cell was reported to have an input of 0.14 watts and a peak excess of 2.5 watts, a ratio of 1:18. At SOFE '95, the *CETI* cell had 0.06 watts input and 5 watts peak output, a ratio of 1:83. At Power-Gen, the ratio reportedly ranged from 1:1000 to 1:4000.

There have been several complaints regarding the *CETI* demonstrations in relation to recombination, flow measurement, and heat ejection [3]. Assuming the thermometry is correct, it is instructive to closely examine the calorimetry using a computer model representing heat and mass transfer. The equation used to derive the output, and therefore the presence of any excess heat involves the flow, the specific heat of the water, and temperature differential. Although this equation may be dimensionally correct, it may not be valid for low flow rates in certain cases discussed below. The role of the Bernard instability [5] has not been previously mentioned, even though it may have inadvertently impacted the calorimetry [4].

The following describes the result of a quasi-one-dimensional (Q1D) analysis which further examined the impact of the flow orientation, with respect to the gravitational field, during flow calorimetry. The model generated to test the hypothesis examined convection, conduction, and gravity-thermal instabilities. Figures 1 through 4 show four groups of curves which show the time-varying distribution of temperature in such a quasi-one-dimensional model. The four groups of curves represent horizontal and vertical flow calorimetry, both with and without convection. In each graph, the spatial distribution of heat (in one dimension) is represented as a single curve. There is one curve for each point in time. There is heat input from a single point source - at midposition along the x-axis - during the entire time subtended by each series of curves. The earliest curves, in each group, are those closest to the x-axis where the heat arise out of the central point source. Thus the dynamics can be followed from the graphs generated for the model.

After the heat enters at the midposition along the x-axis it can be redistributed by thermal conduction, by convection and by redistribution secondary to the changes in specific gravity resulting from the temperature changes (as with the Bernard instability). Radiative loss is not considered in this simplified model. The first group of curves in Fig. 1, which is labeled "Horizontal Flow - Thermal Diffusion" to indicate that the flow is horizontal to the Earth's surface and that thermal diffusion is included. Fig. 1 shows both the midline exogenous heat component and a slow thermal diffusion away from the point-source of heat. The velocity is zero; that is, there is no convection. The second group of curves, Fig. 2, show the impact of convection upon the spatial distribution of heat. This figure shows how the redistribution of heat is used in typical flow calorimetry to generate a temperature gradient, from a sampling of which a calculation is made to determine the output heat (energy). The two groups of curves, Figs. 3 and 4, labeled "Vertical Flow" represent the output from a vertical system, both with and without the addition of upward convection. The extreme along the x-axis away from the point source of heat input, previously 'right' and 'left' in Figs. 1 and 2, are now 'top' and 'bottom' in Figs. 3 and 4. Upon examination of the curves on the lower left, gravity is observed to now play a role in the distribution of the warmed water. It is saliently obvious that because the thermal-driven buoyancy which also leads to the Bernard instability -- where hot water rises due to its lower specific gravity -- the curves in Fig. 3 do shift in position away from the symmetry exhibited by horizontal flow calorimetric systems even in the absence of convection (compare to Fig. 1). There may be, for such conditions, an apparent "signal" for zero flow because of the thermal instability, which simulates the effect of flow (the group of curves in Fig. 3; compare to the group of curves in Fig. 2). The addition of convection produces additional contribution to the heat shift in the vertical flow system (Fig. 4), quite similar to that which it does for horizontal systems (Fig. 2).

One observation from the model is that the boundary condition from zero to negligible flow conditions is different for the horizontal and vertical flow calorimetric systems. It is important to consider that generally, quoted efficiencies of energy generated from putative over-unity devices are calculated assuming the standard equation is always correct. Another salient observation resulting from this theoretical Q1D study is that simple equations which apply for horizontal calorimetric systems may not be strictly applicable for vertical flow calorimetric systems for low flow conditions. But which?

We now define η_B as the ratio of heat transported by the buoyant forces to the heat transported by solution convection.

$$\eta_B \equiv \frac{\text{heat transported by boyant forces}}{\text{heat transferred by solution convection}}$$

This Q1D model of heat and mass transfer has indicated 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. Any apparent amplification of the 'excess heat' (if any, and there does appear to be some) would be greatest at the low levels. Increased flow makes the positional error less important. As a corollary, any false excess heat, or excess heat magnification, should also reduce with increased flow.

In summary, thermometry may not be the only rate limiting factor for obtaining high-quality information from flow calorimeters if the non-dimensional number η_B {defined as the ratio of heat transfer by buoyancy to the heat transfer by convection} is greater than zero. η_B, in a real system where viscosity, turbulence, and other parameters play a role, depends upon other non-dimensional factors including the Archimedes 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. Studies are underway to explore this. It is also proposed that a simple test of the theory would be to build a rotatable flow cell with a resistive heat element, perhaps mounted on a goniometer for any system to check sensitivity. This hypothesis, and Q1D model of heat and mass transfer, do not imply that such systems do not exhibit 'excess heat.' But rather that 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 (η_B) is not trivial.

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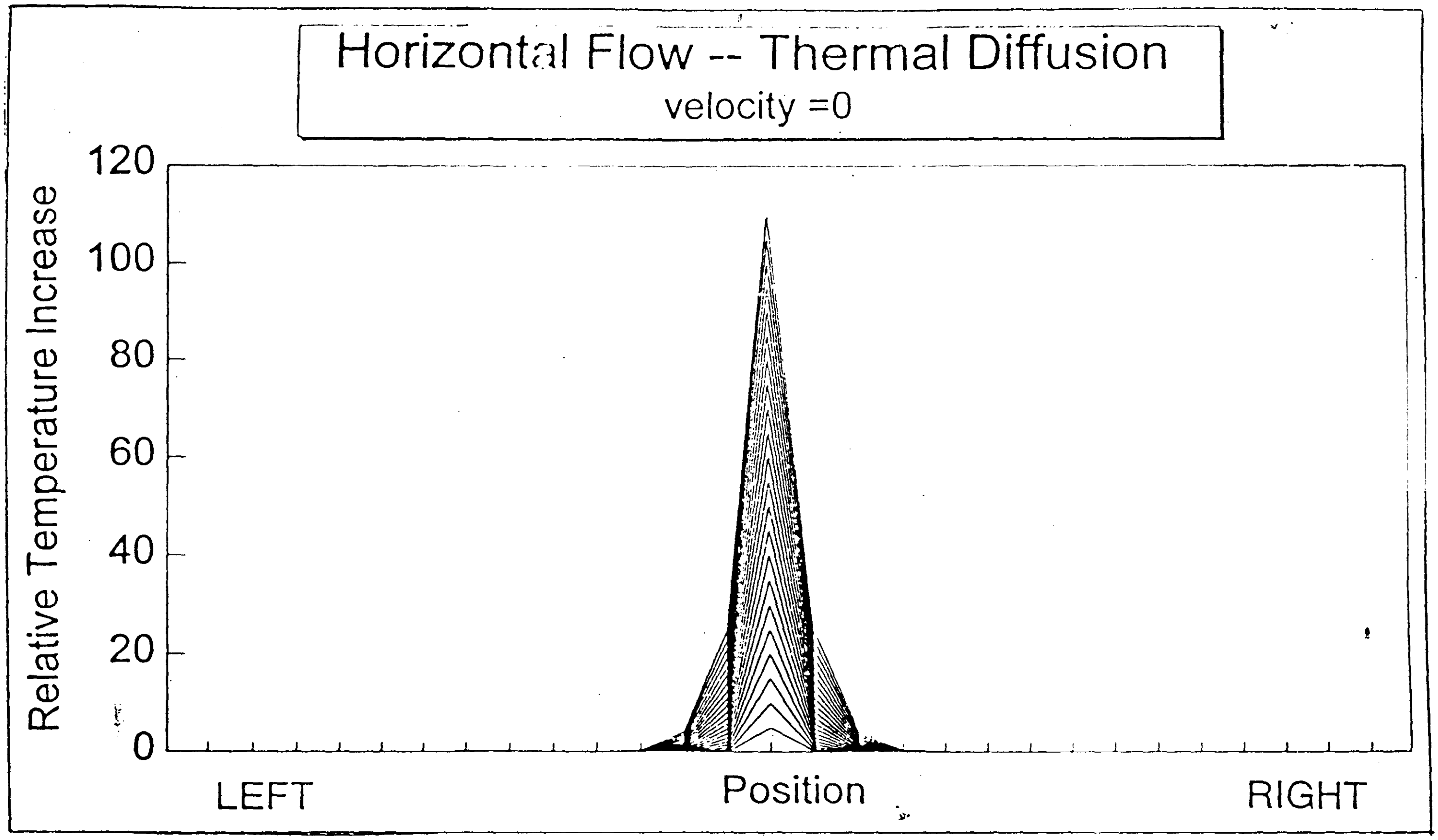
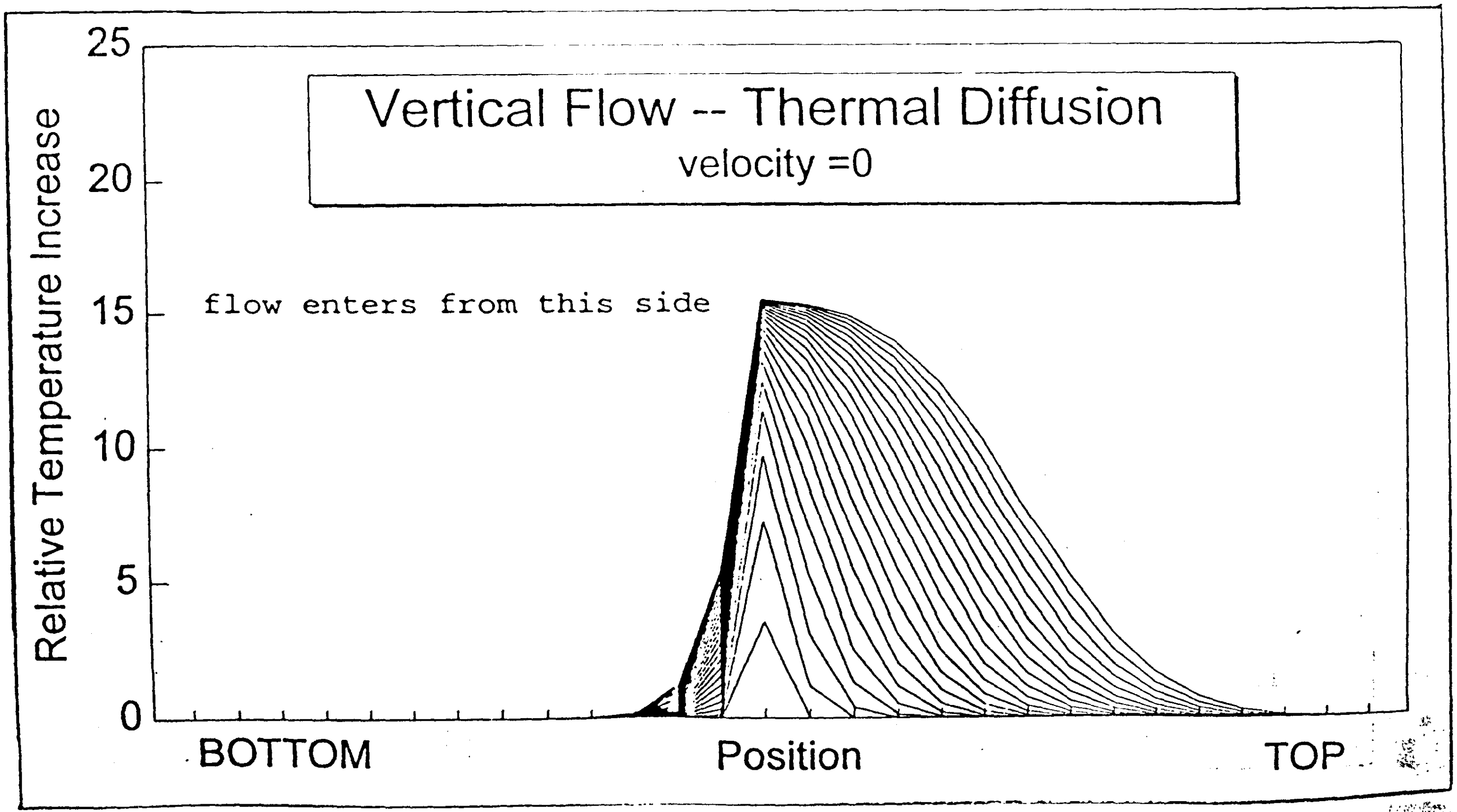

Horizontal Flow -- Thermal Diffusion
velocity =0
Relative Temperature Increase
120
100
80
60
40
20
0
LEFT
Position
RIGHT

FIG. 1

FIG. 2


Vertical Flow -- Thermal Diffusion
velocity =0
Relative Temperature Increase
25
20
15
10
5
0
flow enters from this side
BOTTOM
Position
TOP

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