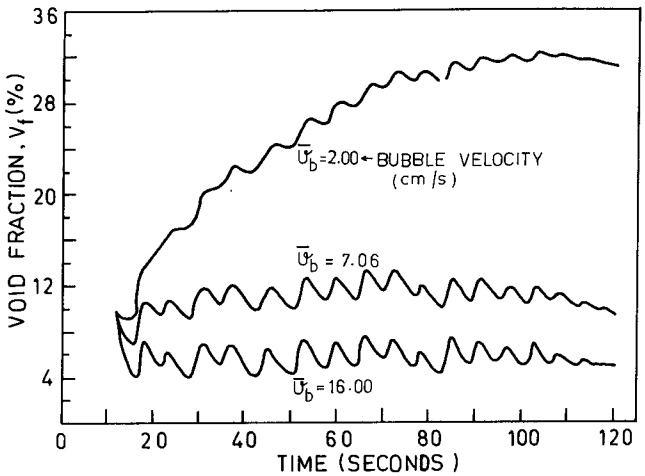

Fig. 4. Computed time variation of void fraction obtained from analysis of experimental data.

defined as the ratio of void volume (bubble volume plus increase in volume due to thermal expansion) to the total volume (void volume plus the solution volume)—at any instant of time was computed from the following simple equation taking the radiolytic gas yield G_{H_2} as 0.005 cm^3/J and the time interval $\Delta t = 10^{-3}$ s.

Note that

$$\Delta V_b = G_{H_2} \cdot \Delta E - A \cdot \bar{V}_b \cdot V_{bf}(0) \cdot \Delta t \ ,$$

where

$\Delta V_b, \Delta E$ = incremental changes in the volume of bubbles and energy, respectively, during Δt

A = cross-sectional area of the core tank

$\bar{V}_b$ = average bubble velocity

$V_{bf}(0)$ = bubble fraction at the beginning of Δt

$\Delta E = \int P.$

The term Δt was computed from the experimental power data of Fig. 3. Figure 4 gives plots of V_f against time for three different values of $\bar{V}_b$. It is seen that for $\bar{V}_b \sim 7.1$ cm/s, the void fraction oscillates with an amplitude of ~2 to 3% around an average value of ~12%. The number of oscillations in power equals the number of oscillations in void fraction, and their points of maxima and minima occur at the same time points. During the oscillation period (~15 to 120 s), the system crosses delayed criticality 35 times, and the void fraction at $k = 1$ increases from ~6 to 13%. After the termination of the solution addition at $t \approx 39$ s, at points where $k(t) = 1$, the excess reactivity (~97 mk) in the system exactly balances the 13% void fraction. Therefore, the observed swing of ~20 mk in reactivity after solution addition has stopped should correspond to the 2 to 3% swing in V_f. Thus, the oscillations in reactivity and power are due to the appearance and disappearance of the gas bubbles. The figure also shows that the total number of oscillations in void fraction (and hence reactivity and power) is relatively insensitive to the actual magnitude of the bubble velocity. The magnitude of $\bar{V}_b$ obtained from the foregoing analysis of the experimental power trace was found to be much more sensitive to the value of V_{f0} immediately after the first prompt-critical power burst than to the value of G_{H_2}.

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Response to "Comment on 'Reactivity Feedback Mechanisms in Aqueous Fissile Solutions'"

Thank you for bringing to my attention the work you have performed regarding excursions in fissile solution assemblies. Reference 1 discusses the reactivity effects that arise from temperature changes in the assembly. It is correctly noted that temperature-related reactivity effects are permanently present in the dynamics of an excursion and that void reactivity effects are more difficult to model as bubbles move vertically through regions of varying worth and eventually out the solution's surface. Void reactivity effects are not discussed in Ref. 1, as it focuses strictly on the effects of temperature on reactivity feedbacks, where the temperature feedback is divided into two parts: density effects and flux spectral shifting effects. A goal of the temperature feedback analysis was to determine if low-concentration plutonium solution assemblies could have a net positive temperature feedback coefficient. In an excursion in such an assembly, the shutdown mechanism is void production. It is certainly true that void reactivity effects play a crucial role in the dynamics of solution assemblies.

The reactivity effects of voids in solution assemblies are included in a manuscript that will soon be submitted to the editor of this journal. The focus of the manuscript is the dynamic modeling of excursions in fissile solutions where the power and pressure traces are followed. These studies were performed by Kimpland at the University of Arizona. His models use a reactivity feedback equation given by

$$\rho_f = \alpha\Delta T + \phi\Delta V + \psi V_g \ ,$$

where

α = neutron spectral feedback coefficient

ϕ = liquid volume expansion coefficient

ψ = void reactivity feedback coefficient.

The results from this analysis are very pleasing and produce some of the best power and pressure traces seen thus far in the field of solution dynamics modeling. I will defer discussing specific results from the manuscript in anticipation of publication.

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REFERENCE

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