7.1.2 Void fraction effect on reactivity

In most reactors it is important to recognize that any change in the geometry of the core or change of phase of its components may alter the reactivity of the reactor. Any positive change in the reactivity, ρ, (or multiplication factor, k) that resulted from an unexpected change in the geometry would clearly be a serious safety issue. Therefore an important objective in the design of a reactor core is to achieve as negative an effect on the reactivity as possible in the event of a change of the geometry of the structure or coolant in the core.

In so far as the design of the structure of the core (particularly the topological distribution of the fuel, coolant, moderator, etc.) is concerned the objective is to create an arrangement whose reactivity would decrease in the event of any structural deformation. Examples: (1) the CANDU reactor design incorporates such an effect (see section 4.4) (2) analyses of a hypothetical core disruptive accident in an LMFBR suggest that expansion of the core in a serious accident would also result in a decrease in the reactivity (see section 7.6.3).

However, perhaps the most important effect in this category occurs in liquid-cooled reactors where any change of phase, any boiling in a PWR or LMFBR or increased boiling in a BWR can substantially effect the neutronics of the core and the reactivity of the reactor. Thus, one important objective of the multiphase flow analyses of postulated accidents is to assess the *void coefficient*, the change of the reactivity, ρ, as a result of a change in the void fraction, α, or

$$\text{Void Coefficent } = \frac{d\rho}{d\alpha} \tag{1}$$

This may, of course, be a function not only of time and location in the core but of other topological effects. As discussed elsewhere, one of the substantial safety features of water-cooled thermal reactors is that boiling and the loss of coolant that results from overheating causes a strong negative void coefficient since the thermal neutron supply is decreased by the reduction in the moderator (section 7.4). In contrast, most LMFBR designs have a positive void coefficient (see section 7.6.3) because the loss of the neutron slowing effect of the sodium coolant results in an increase in the population of fast neutrons. However, modified design of the geometry of the LMFBR core could reverse this dangerous attribute.