Remark About "Finely-Divided Metal as Nuclear Reactor Fuel"

W. Van Snyder

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Abstract

Finely-Divided Metal as Nuclear Reactor Fuel recommended that experiments ought to be conducted to determine the relationship between the volumetric density of fuel particles in sodium, and thermal conductivity. That work had already been done in the more general context of two-phase liquid-solid systems.

In [4], Till and Chang remark on the importance of the relationship of the thermal conductivity of fuel to the inherent safety of a reactor.

Finely-Divided Metal as Nuclear Reactor Fuel [3] recommended that experiments ought to be conducted to determine the relationship between the volumetric density of fuel particles in sodium, and thermal conductivity. That work had already been done in the more general context of two-phase liquid-solid systems, and should have been used and cited. Equation (6.4) from [2] provides an estimate:

$$\frac{\kappa_p}{\kappa_{Na}} = 1 + 3\beta\phi + 3\beta^2\phi^2 \left(1 + \frac{9\beta}{16(\beta+5)} + \frac{\beta}{4} + \frac{\beta^2}{2^6} + \ldots\right) + O(\phi^3)\,, \tag{1}$$

where where $\alpha = \kappa_f/\kappa_{Na} \simeq 0.556$, κ_{Na} = the thermal conductivity of liquid sodium $\simeq 62.9$ W/m/K [1, p. 101], κ_f = the thermal conductivity of uranium $\simeq 35$ W/m/K, and $\beta = (\alpha - 1)/(\alpha + 2) \simeq -0.314$. With ϕ, the volume fraction occupied by metallic fuel, ranging from 0.6 to 0.95, κ_p declines nearly linearly from about 40 to about 36 W/m/K.

At all volumetric densities of fuel particles in sodium, the thermal conductivity of the mixture is greater than the thermal conductivity of solid metal.

References

[1] Joanne K. Fink and Leonard Leibowitz. Thermodynamic and transport properties of sodium liquid and vapor. Technical Report ANL-RE-95/2, Argonne National Laboratory, 9700 Cass Avenue, Argonne, Illinois 60440, January 1995.

[2] D. J. Jeffrey. Conduction through a random suspension of spheres. *Proceedings of the Royal Society of London Series A Mathematical and Physical Sciences*, 335(1602):355–367, November 1973.

[3] W. Van Snyder. Finely-divided metal as nuclear power reactor fuel. *Nuclear Technology*, 208(9):1416–1432, November 2022.

[4] Charles E. Till and Yoon Il Chang. *Plentiful Energy: The Story of the Integral Fast Reactor*. CreateSpace, 2011.