Evaluation of Rate of Dissolution of UNF for Indian PHWR

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Dissolution of used spent nuclear fuel (UNF) of Indian PHWR is a key step for fuel reprocessing and the plant through put is guided by the rate of reaction. The rate of reaction depends on the reactant concentration and reaction temperature. The rate of the dissolution reaction can be calculated by shrinking core model because the reaction takes place at the surface of the solid and the reaction zone moves into the solid core leaving behind the converted material. Further, a few methods available in the literature [1] are also applied to compute the rate of reaction for irradiated PHWR fuel. The rate of reaction is only controlled by reaction and the reaction is pseudo-first order with respect to HNO_3 [2]. The schematic representation of dissolution with typical chopped fuel piece has been shown in Fig.1.

The heterogeneous reaction has been carried out in several steps and the rate constant of the dissolution reaction can be calculated from the slope of the equation given below:

$$\left(1-\frac{[U]_t}{[U]_f}\right)^{\frac{1}{3}} = 1-\frac{2}{3}\,\frac{kC_B}{n\delta\rho_B R}\,t$$

The rate of dissolution has been computed using shrinking core model (SCM) and found to be in the range of 5.27×10^{-3} to 5.70×10^{-3} m/s using zone averaging method. The calculated value is in well agreement with the reported value. Further, the rate has been improved for irradiated fuel in presence of cracks and the rate of reaction is obtained as 4.1×10^{-2} m/s. Hence, the present calculation method can be applied to calculate the rate of dissolution for fast reactor fuel reprocessing.

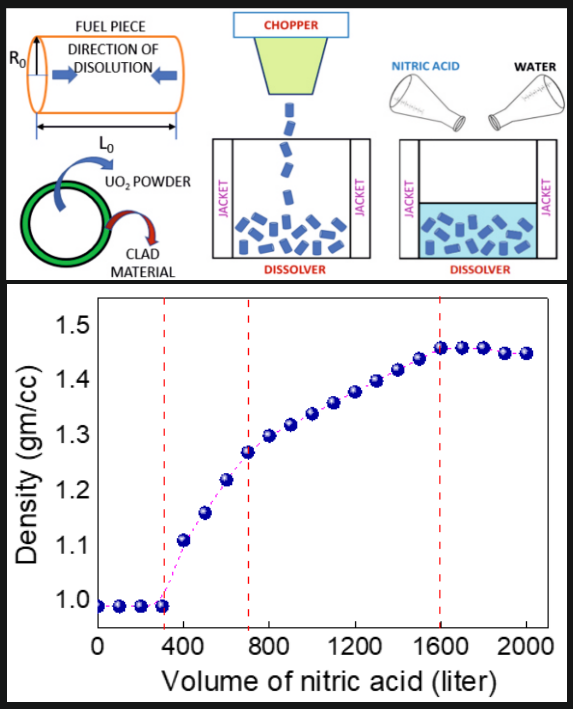

Fig.1: Schematic representation of a typical chopped fuel piece of SNF and the chopper dissolver system where the chopped pieces are dropped into water and the concentrated nitric acid has been added for dissolution. The profile represents the density of dissolved solution as a function of volume of 12M nitric acid.

References

[1] Mineo, H., Isogai, H., Morita, Y., Uchiyama, G., 2004. Journal of Nuclear Science and Technology, 41(2), 126-134.

[2] Desigan, N., Augustine, E., Murali, R., Pandey, N. K., Mudali, U. K., Natarajan, R., Joshi, J. B., 2015. Progress in Nuclear Energy 83, 52-58.