Effect of Anisotropic Scattering in UO_2 and MOX Fueled LWR Cells and Cores

Toshikazu Takeda, Akira Inoue

Osaka University

The effect of anisotropic scattering in UO_2 and MOX fueled LWR cells and LWR cores on neutronic characteristics has been evaluated. First, let us consider infinite cells with UO_2 and MOX fuel. As a cross section, the 70-group cross section set obtained from the JENDL-3.2 data was used, and the cell calculations were performed based on the method of characteristics (MOC). The anisotropic scattering has been treated by expanding the scattering cross section using Legendre polynomial up to P_5. As cell models, various cells with V_m/V_f of 1.0, 1.7 and 3.0 were considered. The cell with $V_m/V_f = 1.7$ corresponds to the conventional PWR cell. For the UO_2 fuel, the anisotropic scattering effect (the difference between k_∞ values for P_0 and P_5 scattering) is small, and within 0.1 %. However, for the case of MOX fuel, the anisotropic scattering effect becomes $0.1 \sim 0.2$ % $\Delta k/k$, and is not negligible. This large effect for the MOX cell is caused by the large neutron current in the moderator. The strong absorption of Pu leads to the large neutron current, and the scattering source term of the P_1 component is proportional to the product of neutron current and the P_1 component of the scattering cross section. So the anisotropic scattering effect is large for the MOX cell. For MOX fuel cells, the difference between k_∞ values for P_5 and P_0 anisotropic scattering cases are -0.146, -0.225, -0.200 % $\Delta k/k$ for $V_m/V_f = 1.0$, 1.7, and 3.0 respectively. The effect up to P_3 scattering is almost equal to that up to P_5 scattering (the difference is within 0.05 % $\Delta k/k$). So the anisotropic scattering effect up to P_3 scattering is enough to be considered for k_∞ and other neutronic characteristics. The decrease of k_∞ values due to anisotropic scattering effect is caused by the fact that neutrons passing the moderator towards the fuel in the lower energy range have moved more to the fuel due to forward scattering. Therefore the relative absorption rate in the fuel increases, and this leads to decrease of k_∞ when considering the anisotropic scattering. Furthermore it is interesting to investigate the effect of the transport cross section. The Kinf values calculated using the transport cross section in the MOX fuel are larger than those of P_0 scattering cases by 0.216, 0.165, 0.062 % $\Delta k/k$ for the cases of V_m/V_f =1.0, 1.7, and 3.0, respectively. This trend is opposite to the cases using P_5 scattering. So, one can say that the use of conventional transport cross section leads to erroneous results for the anisotropic scattering effect. The reason of this erroneous results and the results in 2-D core calculations will be shown in the presentation.

Email: takeda@nucl.eng.osaka-u.ac.jp