Impact of truncated coated fuel particles on neutronic characteristic of statistical geometry model in MVP code

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Abstract

This study investigated the impact of truncated coated fuel particles (CFPs) on neutronic characteristic of the fuel in a statistical geometry (STG) model. Calculation results showed that the effect of truncated CFPs makes the multiplication factor decrease by about 0.1 – 1.0 %Δk/k depended on packing fraction, uranium enrichment, and particle size.

Keywords: MVP, statistical geometry STG, coated fuel particles, effect of truncation, neutronic characteristic

1. Introduction Monte Carlo MVP code provides the STG model to treat the random placement of CFPs properly. However, some of the CFPs would be intersected with the boundary of compact or pebble so that a number of truncated CFPs is formed here. The purpose of this study is to show the impact of the truncated CFPs on the neutronic characteristic of the fuel in the STG model by changing some design parameters of the fuel, including CFPs packing fraction, uranium enrichment, and kernel diameter.

2. Method Effect of truncated CFPs was investigated by comparing the neutronic characteristic between the STG model and a realized random packing (RRP) model [1], which can treat random arrangement of CFPs explicitly without any truncation (as shown in **Fig. 1**). Neutronic calculations were carried out for a cubical geometry surrounded by the reflective boundary (**Fig. 1**) using MVP code with JENDL-4.0 cross section library. The temperature was assumed to be uniform of 300K throughout this study. The CFPs packing fraction was set from 0.1 to 0.3. The uranium enrichment varied from 5 to 20wt%. Also, the kernel diameter was changed from 200 to 700 μm.

3. Results and conclusions **Fig. 2** shows the difference in k_{inf} between the STG and RRP models. The truncated CFPs in STG model depresses the k_{inf}, the larger CFPs packing fraction, the greater the reduction in k_{inf}. The difference in k_{inf} also increases, for example from 0.36 to 0.48 %Δk/k in the cases of 0.1 PF, when decreasing the enrichment of uranium from 20 to 5wt%. The discrepancy in k_{inf} as a function of kernel diameter is shown in **Fig. 3**. It can be negligible at 200 μm kernel diameter but becomes considerable of about 1.37 %Δk/k at 700 μm kernel diameter. The results suggested that the effect of truncated CFPs should be considered attributing to the comprehensive uncertainty of a highly precise benchmark assessment of the HTGRs using MVP code.

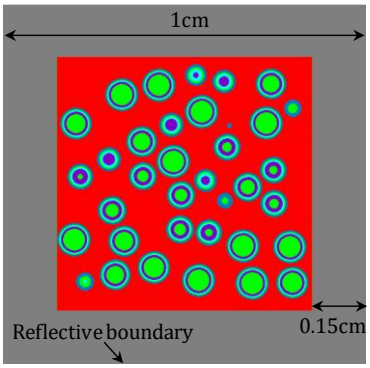

Fig. 1 RRP model, plotted by CGVIEW

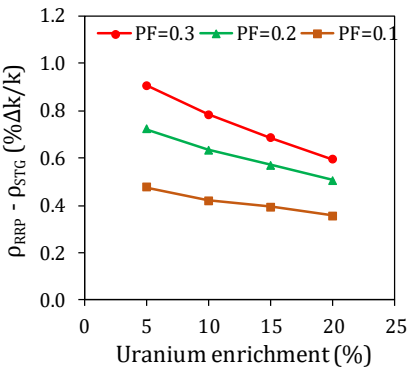

Fig. 2 Discrepancy of kinf in STG model with various packing fraction and uranium enrichment scheme

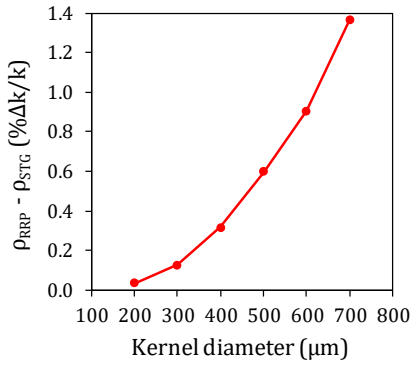

Fig. 3 Discrepancy of kinf in STG model with different kernel diameter (5wt% enrichment, PF=0.3)

References

[1] Ho, H.Q., Honda, Y., Goto, M., Takada, S. Annals of Nuclear Energy (2017) 114 – 121.