IMPLEMENTATION OF THE MULTIGROUP TELEGRAPH BASED P1 APPROXIMATION AND COMPARISON TO THE MULTIGROUP DIFFUSION BASED P1 APPROXIMATION IN GEN-FOAM

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ABSTRACT

In this paper, we implemented the multigroup time dependent Telegraph equation, which is the P1 approximation including the neutron current time derivative, in the newly developed Multiphysics code GeN-Foam (General Nuclear Foam) and compared the kinetics behavior against the multigroup time dependent diffusion sub-solver inside the same code for a 2D Liquid Fuel Molten Salt Reactor (LFMSR) design. Not neglecting the neutron current derivative will introduce a new physical parameter called the relaxation time τ_g that will improve the diffusion solution. A step insertion of reactivity without feedback is modeled to assess the difference between both models. It is found that the relaxation effect generally attributed and accounted for by the telegraph equation is also persistent and shows similar behavior to the point kinetics one group model. The relaxation effect depends on the value of τ_g which in turns depends on the type of the reactor and the medium. It is found that the power increase in the prompt jump portion is lower than the one predicted by the diffusion, hence imitating more exact models. Both Mathematical and physical reasoning is given in the paper for this behavior.

Key Words: Relaxation Effect, Nuclear Reactor Kinetics, Reactivity Insertions, P1 approximation, Molten Salt Reactors.

1. INTRODUCTION

Dynamics of nuclear systems are of importance concern for designing and maintaining a safe operating system. In this regards, the P1 approximation is largely used due to its simple implementation, fast iteration especially for time dependent analysis, and acceptable accuracy especially for homogenized mediums. In the P1 Approximation, the first order linear approximation to the angular part of the neutron angular flux $\psi(\mathbf{r}, \mathbf{\Omega}, E, t)$ (Here $\mathbf{r}$ is the spatial vector, $\mathbf{\Omega}$ is the direction vector, E is the energy, and t is time), is used to simplify the neutron transport equation and its calculations. The P1 approximation is constituted from a system of two equations in which one equation is the neutron balance equation, while the other equation is the relation between the scalar flux $\phi(\mathbf{r}, E, t)$ and the vector flux or the neutron current $\mathbf{J}(\mathbf{r}, E, t)$. In its most general form including delayed neutrons and the neutron current time derivative, the multigroup P1 Approximation is given by (spatial and temporal dependence have been omitted but should hold unless stated otherwise):