Extension of the hierarchical-domain decomposition boundary element method to the general multi-group diffusion equation

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The hierarchical domain decomposition boundary element method (HDD-BEM) is extended to deal with the general multi-group diffusion equation.

Keywords: Boundary element method, HDD-BEM, Diffusion equation

1. Introduction The neutron diffusion equation (NDE) serves a foundation equation in nuclear reactor analysis. Traditionally, the Finite Difference Method (FDM) or the Finite Volume Method (FVM) is used, however, recently the progress of HDD-BEM shows great potential compared with conventional methods [1,2]. The HDD-BEM can handle with only one-group/two-group problems, so we attempt to extend HDD-BEM to general multi-group problems.

2. Theory In HDD-BEM, multi-group NDE is transformed into a set of independent mode equations. A whole system is divided into homogeneous regions. Neutron multiplication factor of the system and mode flux on inner boundaries between neighboring regions are assumed. Then the boundary information of all regions can be calculated with BEM, and finally continuity condition of neutron current on inner boundaries is checked. If this condition is not satisfied, the assumed variables are modified by Newton's method until iteration converged. When 1-group/2-group problems are treated by HDD-BEM, only real variables is treated, however when the number of energy groups is larger than two, complex variables should be treated. In this work, we adopt a method proposed by Cossa et al.[3], and attempt to extend HDD-BEM for general multi-group problem.

3. Calculation results With the utilization of Python programming language, developing a computer program which can calculate complex variables for multi-group problems is possible. First step, a program which can only treat one-dimensional, two-group problems is developed. Considering a reactor core (width 30cm), sandwiched by infinite reflector regions. Figure 1 shows the neutron flux (half core) of with FVM (reference) and HDD-BEM. It shows good agreements between HDD-BEM solution and the references. The neutron multiplication factor based on HDD-BEM is 1.35885 which also agrees well with reference solution 1.35884.

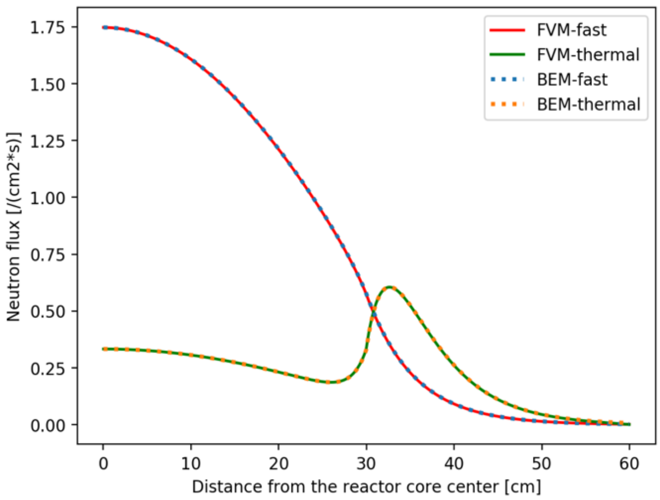

Fig. 1. Neutron flux distributions of FVM and HDD-BEM

4. Conclusion and future plan The satisfactory agreement between FVM and BEM indicates that HDD-BEM has been applied to the NDE successfully. For future plan, we will extend our program to treat complex buckling and apply it the general multi-group NDE and SP3 equation.

References

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