Validation of COMSOL Multiphysics for PWR Power Distribution Via 3D IAEA PWR Benchmark Problem

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Abstract

Design of the Pressurized Water Reactors (PWRs) involves extensive calculations to verify the reactor safety criteria such as power peaking factor during the reactor lifetime. Coupling of neutronic calculations, thermal hydraulic calculations and other reactor phenomena requires a multiphysics software to model the different reactor equations and solve it simultaneously without the need to use different computer codes. COMSOL Multiphysics® can solve the multigroup neutron diffusion equation using the finite element method. The power distribution from the output can be used for further thermal hydraulic calculations. The main purpose of the 3D IAEA light water reactor benchmark problem is to benchmark computer codes by calculating the core multiplication factor, flux and power distributions using the two group neutron diffusion method. A three dimensional model was constructed using COMSOL Multiphysics® to solve the two group neutron diffusion equations for the 3D IAEA PWR benchmark problem with adaptive mesh refinement option. Reactor effective multiplication factor Keff, , flux distributions and power distributions were calculated and compared to the results of VENURE code. Calculations give a difference of 31 pcm in the Keff and almost 2% in calculating the average assembly power distribution compared to VENURE code.
COMSOL was benchmarked against experimental results and other codes for research reactors core calculations by the author of the present work [1, 2]. Simulation of the High Flux Isotope Reactor (HFIR) core thermal hydraulics was developed using COMSOL Multiphysics® to facilitate the conversion from high enriched fuel (HEF) to low enriched fuel (LEF) [3,4]. This paper documents the use the commercial finite element multiphysics software package COMSOL Multiphysics® on a three dimensions benchmark problem for pressurized light water reactor [5]. Results show that the software is valid for PWR core calculations compared to VENURE code.

References

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Figures used in the abstract

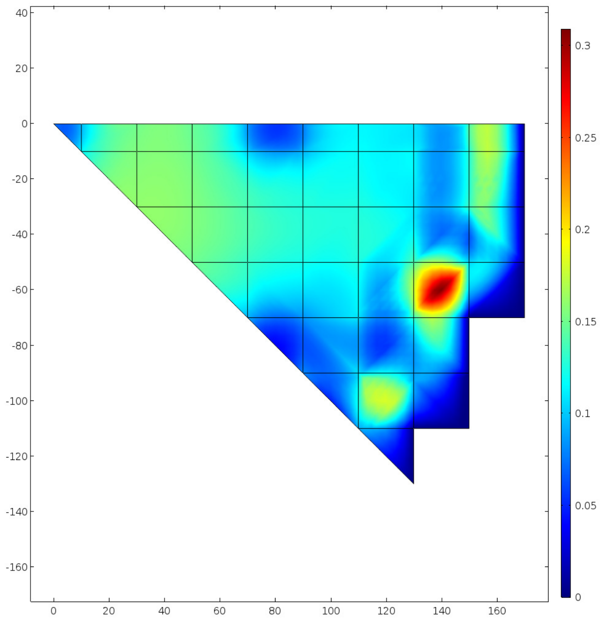

Figure 1: Normalized thermal neutron flux at the core mid-plane (z=190).