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Study of power distribution in the CZP, HFP and normal operation states of VVER-1000 (Bushehr) nuclear reactor core by coupling nuclear codes

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ABSTRACT

In this research, the simulation of one-sixth of VVER-1000 (Bushehr) reactor core is carried out by WIMS-D4 nuclear code, based on symmetry of core and also by information obtained from FSAR. The cross sections of some nuclides are obtained by WIMS-D4 from the beginning of cycle (BOC) to the end of cycle (EOC), and they are transferred into the CITATION code as inputs. In the next stage, the amounts of neutron fluxes and power of reactor core are obtained by CITATION code in the CZP and HFP states. Then, the received products are returned again into the extended program cycle, thereby distributions of neutron fluxes and power are finally depicted. In the meantime, the space distribution of neutron fluxes and power throughout the core are presented during the normal operation by this simulation. It can be inferred that if the reactor operation continues, a flat power distribution will be made in the reactor core that might cause maximum power.

1. Introduction

Since, the power distribution in the core of nuclear reactor is very significant, in this article, the behavior of power is studied in the VVER-1000 reactor core. VVER-1000 is a Russian type which is a pressurized water reactor (PWR). The major difference between the VVER and Western PWR is more related to the design of the fuel assembly and the core geometry. In the PWR, about one-third of the fuel assemblies are annually vacated, and the others are reloaded with them. Therefore, the fuel management field is also one of the most important areas of this case study which involves the optimized arrangement of hundreds of fuel assemblies in the core (Rafiei Karahroudi et al., 2013).

Nowadays, the optimized methods are applied for designing and analyzing the safety of nuclear reactors, instead of the conservative method, which has already been applied. In the conservative method, neutronic designing of the core is carried out by the neutronic codes, and thermal hydraulic designing is done by the thermal hydraulic codes. But, in the optimized methods, designing the reactor core is simultaneously performed through coupling the thermal hydraulic and neutronic codes (Mazrou and Hamadouche, 2006). There are some examples for codes coupling such as RELAP5/PARCS and TRACE/PARCS in which the RELAP5 and TRACE are used for thermal hydraulic computation and PARCS for neutronic computation (Aumiller et al., 2001).

2. Materials and methods

The VVER-1000 reactor core has two symmetry options including 1/6 and 1/12. First, one-sixth of the core is simulated by WIMS-D4 code according to core symmetry and based on its material characteristics, and also through information of FSAR.[1] Then, after applying the given simulation, the cross sections of cell calculations are obtained by WIMS-D4 code in the specific temperatures of CZP[2] and HFP[3] states, according to the initial data of one-sixth of the symmetry of VVER-1000 reactor core fuel assemblies (Ministry of Russian Federation of Atomic Energy, 2003).

In order to couple the nuclear codes, the cross sections obtained by WIMS-D4 are inputted into the CITATION code (Aldama et al., 2003), and then the amounts of neutron fluxes and power of reactor are obtained by CITATION code in the CZP and HFP states (Fowler et al., 1971). The results are finally returned again into the extended program cycle (Aldama and Trkov, 2000; Lockheed Martin Energy Research Corporation, 1991).

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[1] Final Safety Analysis Report.
[2] Cold Zero Power.
[3] Hot Full Power.

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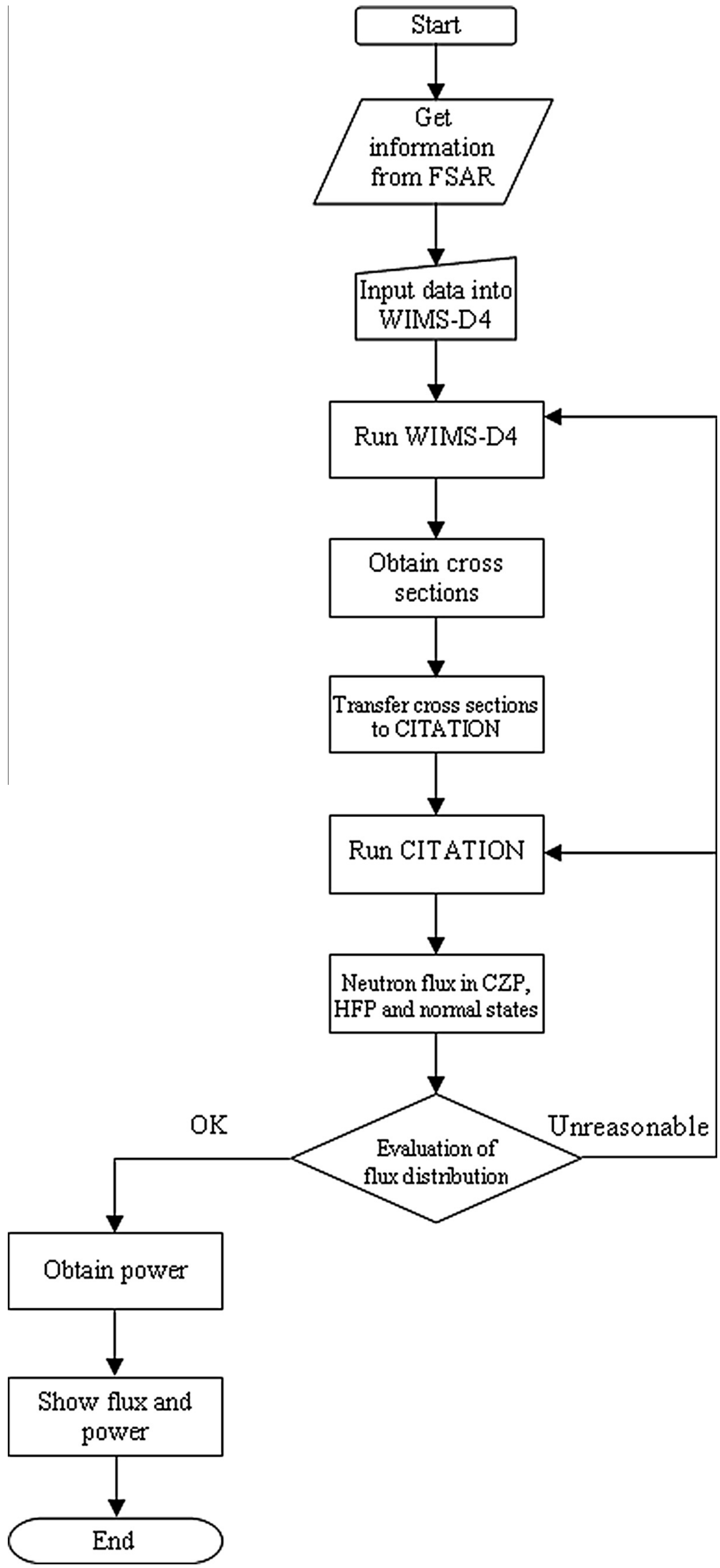

Fig. 1. The flowchart related to coupling procedures between WIMS-D4 and CITATION codes.