Modeling and Conversion of the Blanket Neutronics for the Fusion Reactor Concept

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1. Introduction

Tokamak reactor system analysis code has been developed at KAERI (Korea Atomic Energy Research Institute) to research the concept of a DEMO reactor [1-3]. In this concept, TBM (Tritium Breeding Module) is the dominant device to operate the tokamak reactor in the steady-state. The main functions of TBM are; firstly, to protect the magnets and the vacuum vessel from a collision and a heating of neutron and gamma radiation, secondly, to produce the tritium isotope necessary for a self-sufficient fusion, and to convert the neutron energy into heat and generate a electric power. In this work, we introduce the modeling of TBM and convert this model to neutronic analysis input file. Finally the simple evaluation of TBM neutronics was performed in this procedure.

2. Methods and Results

2.1 Procedure of evaluation

The block diagram for the procedure of neutronics evaluation is in the Fig. 1. After the modeling of TBM, MCAM [4] tool will convert the model to code input. MCNP [5] Mote Carlo code and Attila [6] analytic code will be utilized in the analysis.

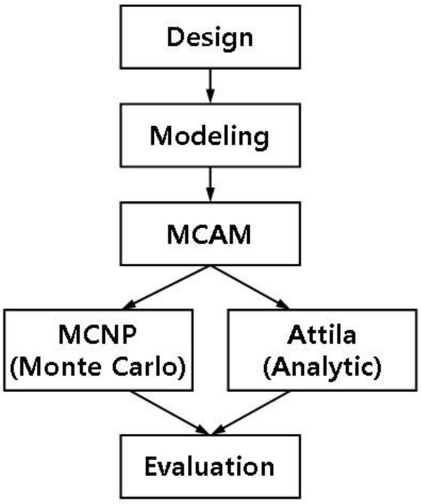

Fig. 1. Block diagram of evaluation procedure.

Fig. 2 shows the running shot of MCAM. MCAM (Monte Carlo Particle Transport Automatic Modeling System) is developed by FDS Team, ASIPP of China. As an integrated interface program between modern 3D CAD systems and Monte Carlo particle transport simulation codes, MCAM not only realizes the bi-directional conversion between CAD models and MCNP calculation files, but also integrates the functions of creation, pre-processing, analysis and edition for CAD models. With the help of MCAM, users are able to load the existing CAD models created by commercial CAD systems or create simple CAD models directly, then convert them into MCNP calculation files. Contrarily, users also can invert the existing MCNP calculation files into CAD models, then check or modify the models in CAD systems or directly in MCAM

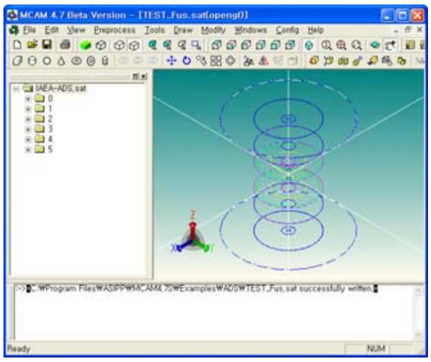

Fig. 2. MCAM Modeling Code.

2.2 TBM Model and Calculation

The 1D model for TBM was considered for the MCNP calculation. Standard Solid type of TBM is composed of 9.8% FMS (FM Steel), 69.2% Be multiplier, 5.5% He coolant, and 15.4% Li_4SiO_4. This model consists of a FW (First Wall), tritium breeder, structure wall, shield blocks, vacuum vessel, etc. Modeling and converting were performed by MCAM code. MCNP5, Attila were used for the evaluation of TBR, The tritium breeding ratio (TBR) [3] is the ratios between the amount of tritium generated in the TBM of the D-T fusion reactor and the amount of tritium consumed in the fusion reaction. The tritium breeding ratio must be greater than unity for self-sufficient operation.

2.3 Results and Analysis

For the self-sufficient operation of the fusion reactor, net TBR must be close to 1.01. So, design TBR value must be greater than net value to account for the deficiencies in nuclear data and uncertainties in design elements [7]. In the typical DEMO fusion reactor, this net TBR should be greater than 1.1 to satisfy the self-sufficiency.

For the comparison of each model, the TBM parameters were reviewed in the point of compositions and design. The ARIES-AT model has the concept of HCLL (He-Cooled Lithium Lead), the model of Wisconsin University is HCML (He-Cooled Molten Lithium) and HCLL. One of EU PPCS models is HCSB (He-Cooled Solid Breeder) [7]. The standard model of this work was used in the each calculation. The breeder with Be or Pb multiplier has high tritium breeding ratio, in the HCSB and HCLL model, and the reflector inside the blanket must be installed in the HCML model to enhance the tritium breeding ratio and improve the neutron transport.

3. Conclusions

The procedure of neutronic analysis was established to calculate the TBM performance. MCAM software was used as the modeling and converting tool, simplified model was evaluated by using the neutronics codes of MCNP and Atilla code, where tritium breeding ratios were calculated by the MCNP neutronics of the DEMO reactor concept. Recent TBM concepts were considered to compare the tritium breeding ratios. The optimum thickness and composition of TBM have been modeled by this evaluation study, and these design parameters will be necessary for the development of a fusion reactor concept.

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