Research Note

Neutronics Calculations for Normal Conducting Copper Riggatron™ Tokamaks

T. J. Seed¹ and R. Perkins¹

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Tritium breeding is found to be achievable for water cooled normally conducting copper magnet tokamaks that would be placed inside a cell containing the tritium breeding blanket.

KEY WORDS: Riggatron; tritium breeding; neutronics.

1. INTRODUCTION

Thermonuclear fusion ignition and controlled burn tests are planned to be performed in normally conducting, high magnetic field, ohmically heated RIGGATRON™ tokamaks by 1985.¹ Commercial descendents of these devices will be very small (ca. 3 m in diameter) in contrast with superconducting magnet tokamaks, and would be placed within the blanket and shield cavity that performs the tritium breeding and thermal energy recovery function. Figure 1 depicts a conceptual design of a RIGGATRON tokamak fusion power core within its blanket cell. Since the positions of the magnets and the blankets are interposed in this system, in comparison with very much larger conventional tokamak reactor concepts, it is important to determine the neutron transport and tritium breeding characteristics. Assessments of the tritium breeding potential have been the objective of a number of computational efforts (2-4) starting in 1978 and continuing to the present. These efforts reveal that the necessary tritium production rate is achievable for toroidal copper magnets that appear to satisfy structural and electrical power requirements.

2. PREVIOUS CALCULATIONS (1978)

In previous studies of the RIGGATRON tokamak concept, extensive one-, two-, and three-dimensional neutronic calculations of several FPC models were made at the Los Alamos Scientific Laboratory (LASL) in 1978. Initial one-dimensional discrete ordinates (Sn) analyses were performed (2) to test different blanket designs and to evaluate the adequacy of the available nuclear data (cross sections). Following this work, a comparison was made between a multigroup, one-dimensional Sn calculation and a continuous energy Monte Carlo (MCNP (5)) calculation of a one-dimensional cylindrical model with a magnet thickness of 7 cm. The tritium breeding ratios (TBR) from the MCNP calculation and the one-dimensional Sn calculations were 1.10 and 1.05, respectively.

Also analyzed (3,4) was the two-dimensional model shown in Fig. 2. The TBR for this model was determined by MCNP (a code capable of calculations in up to three dimensions) and a two-dimensional triangular mesh Sn code, TRIDENT-CTR. (6) The resulting MCNP TBR was 1.01. The Sn analysis yielded a TBR of 0.87 with a 30 energy group unshielded cross-sec-

¹International Nuclear Energy Systems Company, Inc., 11077 North Torrey Pines Road, La Jolla, California 92037.
Fig. 1. RIGGATRON fusion power core and tritium breeding blanket.


Recent calculations have been performed at INESCO, Inc., using the current nuclear data to bench mark the earlier results. A similar unshielded cross-section library (ENDF/B-V instead of ENDF/B-IV) and TRIDENT-CTR have been obtained and efforts are underway to acquire MCNP. To bench mark these calculational tools, the 1978 model was reanalyzed with the available unshielded cross-section set and TRIDENT-CTR. This calculation yielded a TBR of 0.85 as compared with the 1978 LASL TBR of 0.87. When the cross-section set was modified by an approximate shielding technique based on the 1978 MCNP results, a TBR of 0.94 was computed. The spectral dependence