Conf. 790602 - 14

BNL-NUREG-25635

Submitted to 1979 Annual Meeting - American Nuclear Society - June 3-8, 1979
Atlanta, GA

One-and Two-Dimensional Heating Analyses of Fusion Synfuel Blankets*

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Comparisons between one-and two-dimensional neutronics and heating analyses were performed on a Brookhaven designed fusion reactor blanket featuring synthetic fuel production.(1)

In this two temperature region blanket design, the structural shell is stainless steel. The interior of the module is a packed ball of high temperature ceramic material. The low temperature shell and the high temperature ceramic interior are separately cooled. They are also thermally insulated by a fibrous material compatible with the interior material. Process steam (∿1500°C) is then produced in the ceramic core for the production of H_2 and H_2-based synthetic fuels by a high temperature electrolysis (HTE) process.

The analyses consist of the following steps:

1. Determination of the geometry and atomic concentrations of the blanket module based on the current design as shown in Figure 2.

2. A one-dimensional neutron transport calculation was run for this blanket module using the computer program ANISN.(2) The cross sections from Radiation Shielding Information Center (RSIC) data library DLC-37D(3) were used. These are 121 coupled energy groups (100 neutron and 21 photon groups) isotropic (P_o) and anisotropic (P_3) cross sections.

* Work performed under the auspices of The Department of Nuclear Energy.

3. One-dimensional heating analysis was performed, using the 121 group kerma (kinetic energy released in material) factors.

4. Appropriate collapsed energy group structure was chosen. This library of 20 collapsed energy groups (14 neutron + 6 photon groups) will be used in the two-dimensional calculation.

5. Two-dimensional cases are run with the computer program TWOTRAN-II.[4] R-Z cylindrical geometry was used, with Z-axis lying along the magnetic axis (the minor axis of the plasma), and the R-axis going into the blanket (the minor radius - see Figure 1). Care was taken in redistributing the mass while squaring the curve section of the blanket module for this calculation.

6. Two-dimensional heating analysis was performed with neutron and gamma fluxes, the collapsed 20 group kerma factors, and appropriate atomic concentrations.

The results of the heating analyses of an MgO blanket module are summarized in Table 1. Results from P_3S_8 one-dimensional run and both P_oS_4 and P_3S_8 two-dimensional runs are compared. From the one-dimensional result, the fraction of neutron and gamma heat energy deposited in the hot interior region of the blanket module is 0.63. This is to be compared with 0.57 from both the P_oS_4 and P_3S_8 two-dimensional results, which are virtually identical. If the alpha particle energy is included, the fractional energies absorbed are 0.53 and 0.48, respectively.

The fraction of heating energy absorbed in the hot interior is about 0.6 (0.5 if alpha energy is included) for both a one-and two-dimensional model of the blanket module. The good agreements for these cases should not be overly stressed since the results may be design dependent.

Acknowledgment

The authors are extremely grateful to Arnold Aronson, Brookhaven National Laboratory, for his valuable assistance.

References

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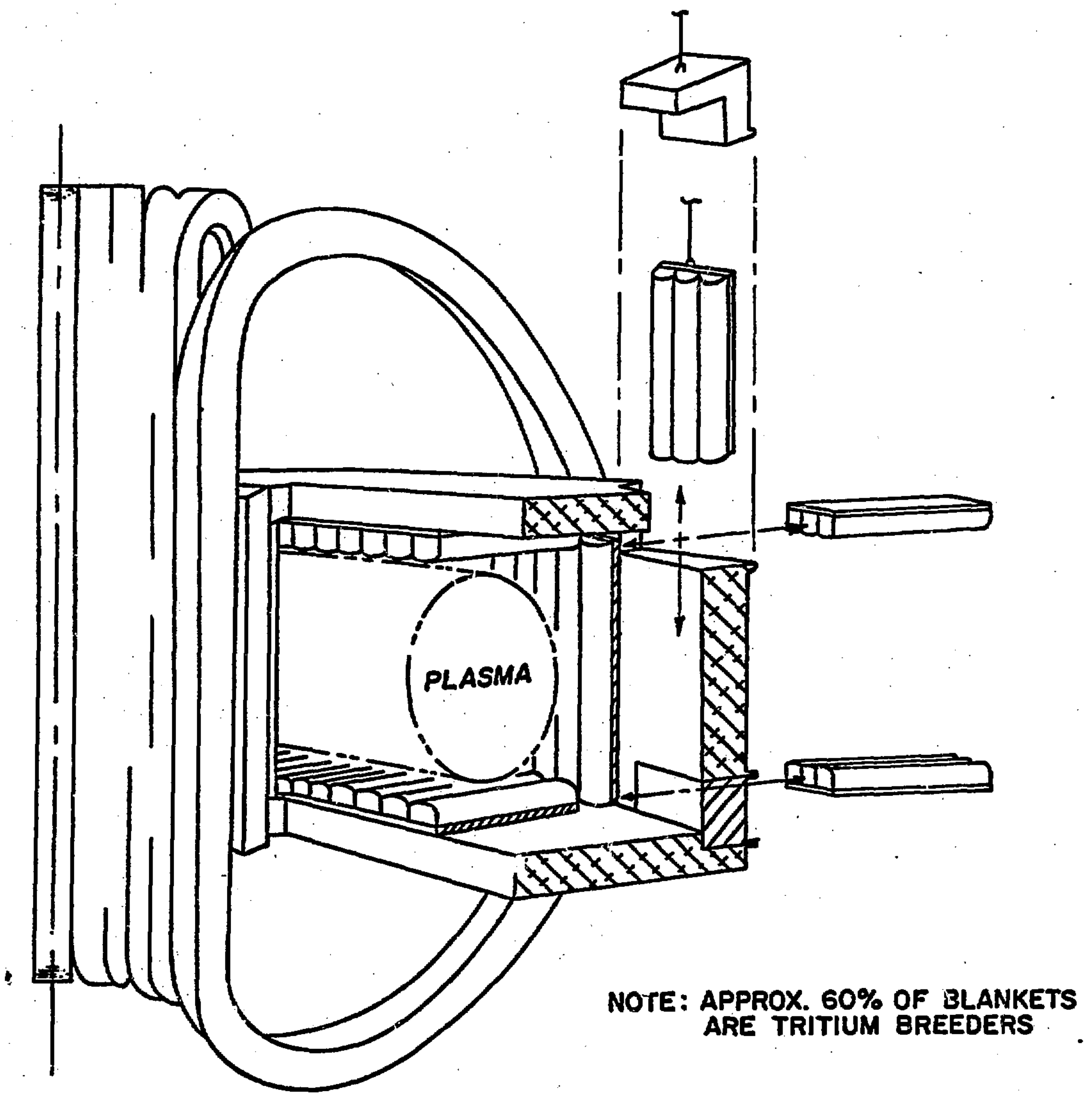
Table 1

Geometry and Fractional Neutron and Photon Energies

		Two-Dimensional Case (P_oS_4 and P_3S_8)				One-Dimensional Case (P_3S_8)
		0.0 – 0.9	0.9 – 1.65	1.65 – 4.65	4.65 – 24.15	
		Tube	Shell	Fiber	Hot Interior	
Plasma	0.0 – 225.88	0	0	0	0	.00
Vacuum	225.88 – 282.10	0	0	0	0	.00
Tubes	282.10 – 282.90	<.006	<.006	<.006 .01*	.06	.11
Shell	282.90 – 283.57	<.006	<.006	.01	.07	.12
Fiber	283.57 – 286.23	.01	.01	<.006	.04	.05
Hot Interior I	286.23 – 293.55	.02	.02	.01	.254 .253*	.25
Hot Interior II	293.55 – 355.44	.04 .05*	.06	.02	.314 .319*	.45ǂ
Fiber	355.44 – 358.83	<.006	<.006	<.006	<.006	.00
Backing Plate	358.83 – 370.13	<.006	<.006	<.006	.02	.01
Shield	370.13 – 483.13	<.006	<.006	<.006	<.006	.00

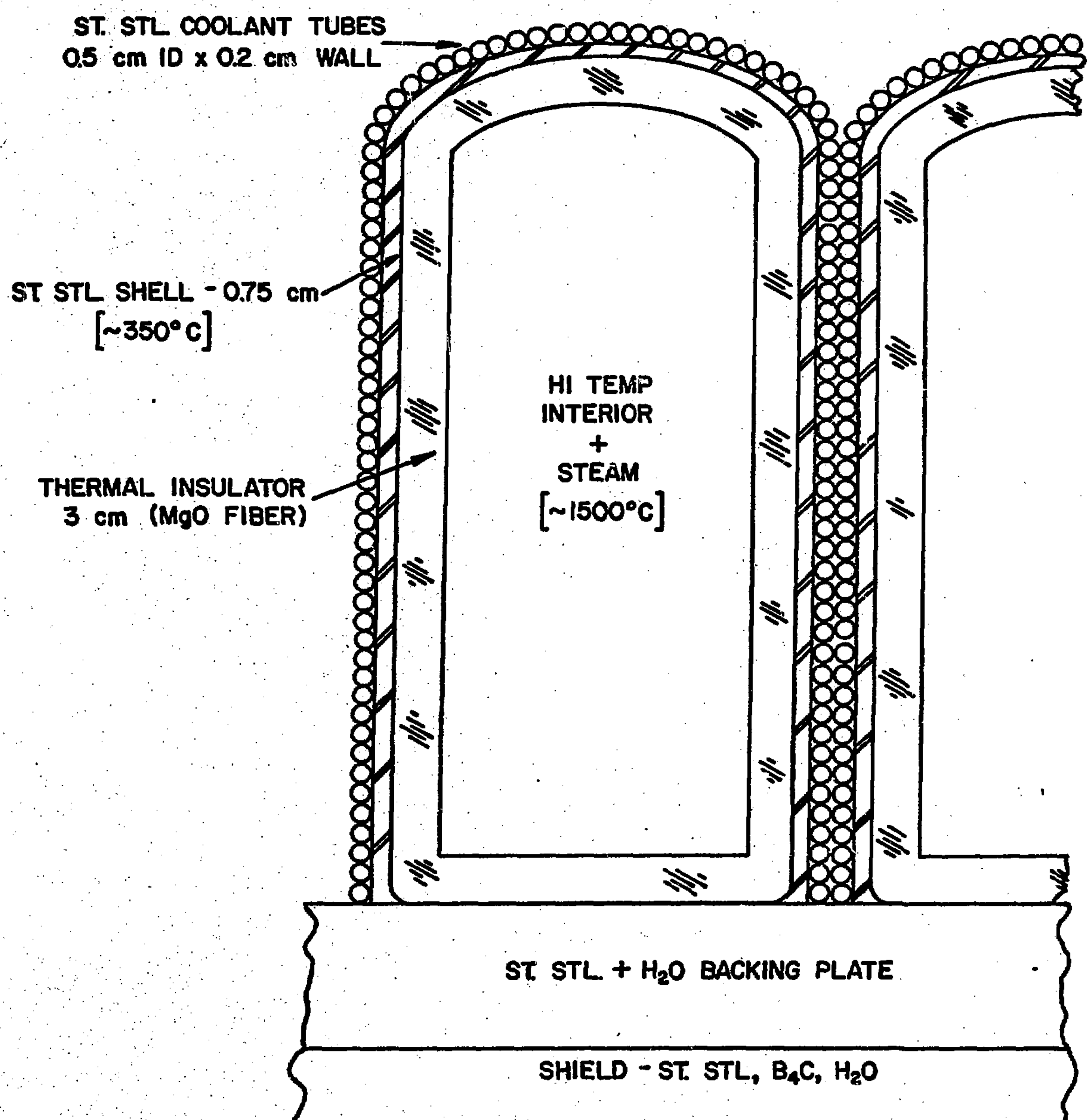
* P_3S_8 result which is different from P_oS_4.

ǂ Included fiber and wall.



SCHEMATIC SHOWING MODULE REMOVAL

Figure 1



BLANKET CROSS SECTION

HTE PROCESS HEAT MODULE

Figure 2