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NEUTRON SOURCE GEOMETRY EFFECTS ON FUSION REACTOR BLANKETS

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In neutronics calculations for the blanket of a D-T fueled reactor, a number of source distributions have been used.[1-3] Table I summarizes some of the more important results obtained in this study.

In carrying out neutron flux calculations for a cylindrical or toroidal containment system, it was found that the results were sensitive to the one dimensional geometry chosen and to the source representation. This is particularly true of results for the first wall and the highest energy groups. To bring this out, a study has been made of a standard model system consisting of ten zones. Zone 1 contains the plasma, zone 2 a vacuum, 3 and 5 are the first and second walls, 9 is a graphite region and the remainder are breeding regions containing Lithium and structural material (94%Li - 6%Nb).

The system has been represented as both an infinite slab and an infinite cylinder. The source distribution has been represented in a number of ways to reflect that expected under different assumptions about the plasma and those in common use. The calculations used the discrete ordinates program ANISN[4] and make a six group determination of the flux, reaction rates, and heating for neutrons with energies from 8 to 14.1 MeV. The Nb(n,2n) and $Li^7(n,\alpha n)T$ reaction rates are quoted becuase of their importance to the tritium breeding; the Nb(n,α), Nb(n,p), and Nb displacements per atom are particularly relevant to materials problems as well as for decay heating effects; and the heating rate and leakage affect cooling and shielding studies. The energy range was chosen to reduce costs but still includes almost all (n,2n), (n,α), and (n,p) reactions and about 65% of the dpa and 85% of the breeding from Li^7.

The source choices include isotropic line and shell sources and uniform and parabolic volumetric sources in both slab and cylindrical geometries. The first two choices are convenient and have been used in the literature. The other choices are simulations of some common assumptions about the plasma distribution.

The results in Table I reflect these alternatives and the general study also shows the influence of the order of the discrete ordinates and of the scattering anisotropy on the important quantities.

The results in Table I can be understood approximately on the basis of analytical results and are qualitatively as expected. From the table it is seen that the slab representation is unacceptable since it gives results that are much too large in the walls. The differences, from both geometry and distribution, are due primarily to their influence on the angular neutron flux at the first wall boundary, were it is highly anistropic.

TABLE I

Neutron Source Geometry Results for Heating and High Energy Reactions

Results normalized to unit current density

Geometry Source	Zone	Cylinder Volumetric (Parabolic)^2	Cylinder Volumetric Uniform	Cylinder Line Isotropic	Slab Volumetric Uniform	Slab Shell Isotropic
Niobium	3	4.42	4.56	3.57	7.77	5.27
$(n,\alpha)\times 10^4$	5	3.01	3.09	2.77	3.68	3.32
	T^a	15.01	15.21	14.1	18.4	16.02
Niobium	3	1.46	1.50	1.18	2.56	1.74
$(n,p)\times 10^3$	5	1.01	1.03	.926	1.23	1.11
	T^a	5.07	5.13	4.77	6.17	5.41
Niobium	3	7.48	7.72	6.06	13.06	8.90
$\mathrm{dpa}\times 10^{21}$	5	5.24	5.38	4.80	6.40	5.78
Niobium	3	2.11	2.18	1.70	3.72	2.51
$(n,2n)\times 10^2$	5	1.42	1.46	1.31	1.74	1.57
	T^a	7.04	7.13	6.59	8.66	7.52
Lithium-7	4	.062	.064	.054	.089	.071
$(n,\alpha n')T$	T^b	.395	.394	.404	.361	0.387
Neutron	3	.81	.83	.65	1.41	0.96
Heating	4	15.78	16.27	13.77	22.84	18.07
Rate in	5	0.55	0.57	0.51	0.675	0.61
$\mathrm{watts}\times 10^{14}$	T^b	95.95	95.58	97.94	87.62	94.07
Leakage $\times 10^4$	T^c	37.8	34.4	43.3	17.6	26.1

a. sum over all zones (for neutrons above 8 Mev)
b. sum over breeding zones (for neutrons above 8 Mev)
c. sum for neutrons above 8 Mev (assuming no reflection)

References

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