Westinghouse

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TO: F. D. Retallick
J. G. Gallagher

From Reactor Analysis

Subject: SAMOOM Code by G. D. Duckworth and F. E. Sullivan

cc: W. H. Arnold
R. N. Nassano
L. D. Stephenson
G. D. Duckworth
H. C. Woodsum
L. O. Ricks

I. INTRODUCTION

The SAMOOM code calculates gamma and neutron heating rates (H_γ and H_n) at points in reactor components for times during startup, operation, or shutdown for any operating history. It also sums H_γ and H_n to obtain total heating rates H_T by point for various times.

The total heating in any reactor component is obtained by evaluating the volumetric integral:

$$\int_V H_T (r,z) \, dV = 2\pi \int_{Z_1}^{Z_2} H(z) \, dz \int_{R_1}^{R_2} rH(r) \, dr$$

In the past the integrals $\int_{Z_1}^{Z_2} H(z)dz$ and $\int_{R_1}^{R_2} rH(r)dr$ were evaluated by planimeter integration. The SAMOOM code will compute either $\int_{Z_1}^{Z_2} H(z)dz$

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or $\int_{R_1}^{R_2} rH(r)dr$ depending on the choice of input parameters. Both integrals can be computed in the same run if desired, by stacking cases.

The neutron heating at a point is computed according to the formula:

$$H_n = \sum_i \sum_g \phi_{ng} \, C \, Ni \, 6_{sgi} \, f_i \, \Delta E_g \, F_p$$

where

N_i = Atom number density of the ith material

ϕ_{ng} = PlMG computed neutron flux of energy group g

C = PlMG normalization constant

6_{sgi} = elastic scattering cross section of material i for neutrons in the gth energy group

f_i = fractional energy loss per scattering collision for material i

F_p = fission power at a given time = 1 at operation

The neutron fluxes and C are obtained from the PlMG code. The product $Ni \, 6_{sgi} \, f_i \, \Delta E_g$ can be obtained as punched output from the PUN code which uses the MUFT library as input.

The gamma heating rates are computed by a rather specialized method. A so called "flat" source (S_{og}) of 10^{10} mev/watt-sec in all groups is put into the 14-0 code. The output is a so called normalized flux for each group (ϕ_g). To obtain the true flux, this normalized flux must be multiplied by the ratioing factor (S_{Tg}/S_{og})

where S_{Tg} is the true gamma source. Since S_{Tg} is the only factor which varies with time it is necessary to compute only one set of "normalized" fluxes to obtain the flux at any time.

The gamma heating is therefore computed according to:

$$H_\gamma = \sum_i \sum_g \phi_g \ \mu_{gi} \ \rho_i \ V.\ F._i \ S_{Tg}/S_{og} \ K$$

where:

μ_{gi}	=	energy absorption coefficient for gammas of the gth energy group in material i.
$\phi_{\gamma g}$	=	"normalized" gamma energy flux for the gth energy group
ρ_i	=	density of material i
VF_i	=	volume fraction of material i
S_{Tg}	=	true gamma source for gammas of the gth energy group
S_{og}	=	"flat" gamma source for gammas of the gth energy group
K	=	a conversion constant (mev/sec to watts)
	=	1.6×10^{-13} (contained in the program)

II. LIMITATIONS

The code is limited to 30 neutron energy groups and 13 gamma energy groups in any single run. Mixtures of 20 different materials can be used and integrals obtained for 20 different times. The number of points at which the flux is given and the heating is desired is limited to 25. Because of the nature of the integration sub-routine these points must be equally spaced axially or radially.

III. SPECIAL FEATURES

As many cases as are desired can be stacked in a single run. This makes it possible to compute integrals for several different regions or compute axial and radial integrals in the same run. It is also possible to vary the neutron cross sections and densities of materials from point to point.

IV. INPUT (See Figure A)

A. The first input card contains the number 1 in the first column. Columns 2 to 72 contain a problem title (any combination of alphanumeric symbols.)

B. The second card contains the number of times to be considered in columns 1 to 5; the number of materials in columns 6 to 10; and the number of points in 11 to 15. Column 20 contains the number 0 if the cross sections are the same for all points and 1 if the cross sections are to vary from point to point.

C. The next group of cards contain the headings for the various times. These cards must be included in pairs. The first card of each pair contains headings in columns 26 to 35; 41 to 50' 56 to 65 and 71 to 72. The second card contains headings in 1 to 8; 14 to 23. If more headings are desired (up to 20) a new pair of cards must be started. The headings can be any combination of alpha numberic symbols. All other data is in floating point form in fields of 12.

D. The first card contains the PIMG normalization constant in floating point form in columns 1 to 12.

E. The second group of cards contain F_p at the various times (6 per card for a maximum of 20 times).

F. The next group of cards contain the neutron fluxes for point 1 (6 per card for 30 groups i.e. 5 cards per point).

G. The neutron ΔE f_i N_i 6_{is} are then included. First the group 1 cross section for all materials are included. When all materials have been exhausted a new group of cards must be started for cross sections in group 2 etc. for 30 groups. In most cases these cross sections will not vary from point to point and need be included only once.

H. Next the gamma fluxes for point 1 are included 6 per card for 13 groups (i.e. 3 cards per point).

I. The 13 gamma μE's (cm^2/g) are then included for material 1, then material 2 and so on.

J. Following the cross section the $\rho \times$ VF's are entered for each material (6 per card for a maximum of 20 materials). In most cases these will not vary from point to point and need to be entered only once.

K. The next 3 cards are the 13 S_T's for time 1, followed by 3 cards containing the 13 S_T's for time 2 etc. The last 3 cards of this group contain the 13 S_o's.

L. Then the neutron fluxes for point 2 are entered followed by the neutron ΔE f_i N_i 6_{is}'s if they are different from those at point 1.

M. The gamma fluxes for point 2 are entered followed by the ρ VF's for this point if they are different from those at point 1.

Steps L and M are repeated until all points have been exhausted.

N. The last card in any data deck is always one containing the width of the interval over which integration is to take place either axially or radially. This number is entered in columns 1 to 12. Columns 13 to 16 contain the number +0.0 for a radial case or + 1.0 for axial case.

V. OUTPUT

The code prints out the following data:

1. All input data

2. Neutron heating rates by material, time and point. $= H_n$.

3. Gamma heating rates by material time, and point. $= H_\gamma$.

4. Total heating rates by time and point, $= H_T$.

5. Axial or radial integrals for each time $= \int H(z)\, dz$ or $\int rH(r)\, dr$

SIGNED: _____

F. E. Sullivan