GAKIT

1. Name of Program: GAKIT, A One Dimensional Multigroup Kinetics Code with Temperature Feedback.

2. Computer for Which Program is Designed and Programming Language Used: Written for UNIVAC-1108 in FORTRAN IV.

3. Nature of Physical Problem Solved: The multigroup, one dimensional, time-dependent diffusion-theory kinetics equations are solved including delayed-neutron effects and temperature feedback based on two-dimensional heat transfer calculations. For the one-dimensional multigroup kinetics equations, an arbitrary scattering matrix and arbitrary fission transfer are allowed, and plane, cylindrical, or spherical geometry might be used. A piecewise linear time-dependent inhomogeneous source can be specified. Feedback is available from xenon buildup and temperature dependence of cross sections. The heat transfer calculation is performed for two-dimensional r-z fuel element models assuming predetermined axial-power shape functions and time-dependent power amplitudes obtained from the one-dimensional kinetics calculations. For the fuel elements, average fuel and moderator temperatures are calculated which determine, based on tables, the temperature-dependent cross sections. Transients may be introduced by step changes of cross sections, by piecewise linear time-dependent cross sections (rod withdrawal accidents), by step changes of the flow rates, or by step changes of the coolant inlet temperatures.

4. Method of Solution: The multigroup, one-dimensional, time-dependent diffusion-theory kinetics equations are solved by a semi-implicit time integration method.[1-3] The heat transfer equations are solved by a quasi two-dimensional method, assuming the axial heat conduction is negligible compared with the heat transport due to coolant flow. For the numerical solution of the kinetics equations and also for the solution of the heat-transfer equations, finite difference methods in space and time are employed. The material properties are assumed to be regionwise constant and the time-step size is held constant in each time zone.

5. Restrictions on the Complexity of the Problem:

   a) One-Dimensional Kinetics Calculation:

Maximum number of prompt-neutron energy groups	10
Maximum number of delayed-neutron groups	6
Maximum number of homogeneous regions (channels)	10
Maximum number of mesh points	100

   b) Fuel Element Geometry for Heat Transfer Calculation: In the axial direction, the fuel element may consist of a bottom reflector, a core section, and a top reflector. The bottom and top reflectors must have uniform densities and uniform thermal properties, while within the core section of the fuel element up to five radial regions may be used.

Maximum number of radial mesh points	15
Maximum number of axial mesh points	20

   The fuel elements in all the channels must have the same geometry, the same thermal properties, and the same inlet temperature; but the fuel elements of different channels may have different coolant flow rates and different axial power shapes.

6. Typical Running Time: The running time is strongly dependent upon the problem type and a closed formula cannot even be derived for one time step due to the use of an iterative procedure. In general, the running time will increase linearly with the number of mesh points and the number of prompt-neutron groups. For a typical rod withdrawal accident problem (2 prompt-neutron groups, 6 delayed-neutron groups, 4 channels, and 29 mesh points), the running time per time step on the UNIVAC-1108 was 0.18 sec.

7. Unusual Features of the Program:

   a) The time integration procedure is numerically stable for relatively large time steps. The procedure is asymptotically stable for time steps of arbitrary length.

   b) The method is especially suited for multigroup calculations because the running time increases roughly linearly with the number of energy groups.

   c) The code has the capability of calculating steady-state conditions for the combined diffusion and heat transfer equations assuming a certain power level.

   d) The limits for the number of energy groups, mesh points, etc., can easily be changed by recompiling the FORTRAN program.

   e) The input of the code is flexible. For example, the user can supply his temperature-dependent cross sections in table form, or he can generate transients by piecewise linear time-dependent cross sections.

8. Related and Auxiliary Programs: GAKIN, a one-dimensional kinetics code without temperature feedback.[4]

9. Status: The program has been in production use since September 1968 and may be obtained from the Argonne Code Center.

10. Machine Requirements: 65 536 words of core storage and the facility for segmenting programs.

11. Operating System or Monitor Under Which Program is Executed: EXEC-II GAX 23; but any other system with segmenting facility can be used.

12. *References*:

[1] R. FROEHLICH, S. R. JOHNSON, and M. H. MERRILL, "GAKIT, A One Dimensional Multigroup Kinetics Code with Temperature Feedback," GA-8576, Gulf General Atomic Incorporated (September 1968).

[2] J. B. ANDREWS and K. F. HANSEN, *Nucl. Sci. Eng.*, **31**, 304 (1968).

[3] J. B. ANDREWS, "Numerical Solution of the Space Dependent Reactor Kinetics Equations," PhD Thesis, M.I.T. (May 1967).

[4] K. F. HANSEN and S. R. JOHNSON, "GAKIN, A One Dimensional Multigroup Kinetics Code," GA-7543, General Dynamics, General Atomic (August 1967).

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