Computer Code Abstract

NESTLE

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1. Program Identification: NESTLE is a few-group neutron diffusion equation solver utilizing the nodal expansion method (NEM) for eigenvalue, adjoint, and fixed-source steady-state and transient problems.[1]

2. Function: NESTLE is a FORTRAN77 code that solves the few-group neutron diffusion equation utilizing the NEM. The NESTLE code can solve the eigenvalue (criticality), eigenvalue adjoint, external fixed-source steady-state, and external fixed-source or eigenvalue initiated transient problems. The eigenvalue problem allows criticality searches to be completed, and the external fixed-source steady-state problem can search to achieve a specified power level. Transient problems model delayed neutrons via precursor groups. Several core properties can be input as time dependent. Two- or four-energy groups can be utilized, with all energy groups being thermal groups (i.e., upscatter exits) if desired. Core geometries modeled include Cartesian and hexagonal. Three-, two-, and one-dimensional models can be utilized with various symmetries. The thermal conditions predicted by the thermal-hydraulic model of the core are used to correct cross sections for temperature and density effects. Cross sections are parameterized by color, control rod state (i.e., in or out), and burnup, allowing fuel depletion to be modeled. Either a macroscopic or microscopic model may be employed.

3. Method of Solution: The few-group neutron diffusion equation is spatially discretized utilizing the NEM. Quartic or quadratic polynomial expansions for the transverse integrated fluxes are employed for Cartesian or hexagonal geometries, respectively. Transverse leakage terms are represented by a quadratic polynomial or constant for Cartesian or hexagonal geometries, respectively. Discontinuity factors are utilized to correct for homogenization errors. Transient problems utilize a user-specified number of delayed-neutron precursor groups. Time-dependent inputs include coolant inlet temperature and flow, soluble poison concentration, and control bank positions. Time discretization is done in a fully implicit manner utilizing a first-order difference operator for the diffusion equation. The precursor equations are analytically solved, assuming the fission rate behaves linearly over a time step.

   Independent of problem type, an outer-inner iterative strategy is employed to solve the resulting matrix system. Outer iterations can employ Chebyshev acceleration and the fixed-source scaling technique to accelerate convergence. Inner iterations employ either color line or point successive overrelaxation iteration schemes, dependent upon problem geometry. Values of the energy group–dependent optimum relaxation parameter and the number of inner iterations per outer iteration to achieve a specified L_2 relative error reduction are determined a priori.

   The nonlinear iterative strategy associated with the NEM method is employed. An advantage of the nonlinear iterative strategy is that NESTLE can be utilized to solve either the nodal or finite difference method representation of the few-group neutron diffusion equation. Thermal-hydraulic feedback is modeled employing a homogeneous equilibrium mixture (HEM) model, which allows two-phase flow to be treated. However, only the continuity and energy equations for the coolant are solved, implying a constant pressure treatment. The slip is assumed to be one in the HEM model. A lumped parameter model is employed to determine the fuel temperature. Decay heat groups are used to model decay heat. All cross sections are expressed in terms of a Taylor's series expansion in coolant density, coolant temperature, effective fuel temperature, and soluble poison number density.

4. Related Material: An electronic dictionary program and a database that is used to define variables.

5. Restrictions: The NEM option works only for two- and four-energy groups, and depletable isotopes are limited to the principle fissile and fertile isotopes and lumped and transient fission products.

6. Computers: UNIX workstations, specifically the IBM/6000, the HP9000/700, the DEC5000, and the SUN platforms.
7. Running Time: The sample problems provided take from <1 s to 40 min on an HP9000/735 in double precision. A state-point calculation of a typical three-dimensional problem takes 1 to 2 s of CPU time.
8. Hardware Requirement: A workstation with at least 16 megabytes of memory.
9. Programming Languages: FORTRAN 77.
10. Operating Systems: AIX, HPUX, ULTRIX, and SUN OS.
11. Additional Programming Information: The source code has ~25 000 lines of coding.
12. Material Available: Source code, makefiles, test problem input/output, electronic dictionary and database, and documentation available from the Energy Science and Technology Software Center for U.S. government laboratories and universities. Other interested parties should contact Dr. Ed Vickery of NCSU (E-Mail: wevickery@power-client2.ncsu.edu, Phone: 919-515-5203).
13. References:

[1]P. J. TURINSKY, R. M. K. AL-CHALABI, P. ENGRAND, H. N. SARSOUR, F. X. FAURE, and W. GUO, "NESTLE: A Few-Group Neutron Diffusion Equation Solver Utilizing the Nodal Expansion Method for Eigenvalue, Adjoint, Fixed Source Steady-State and Transient Problems," EGG-NRE-11406, EG&G Idaho (June 1994).