OAK RIDGE National Laboratory

Research reactor source terms with ORIGEN for safeguards applications - Tutorial

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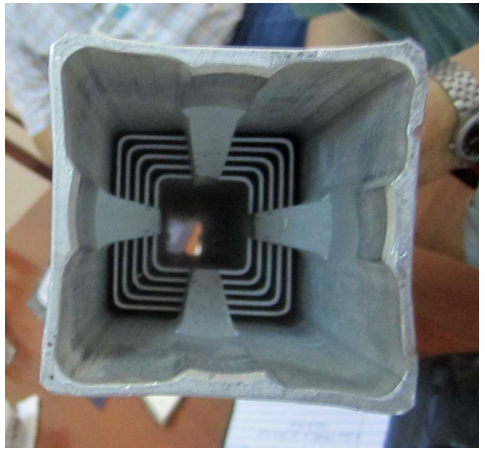
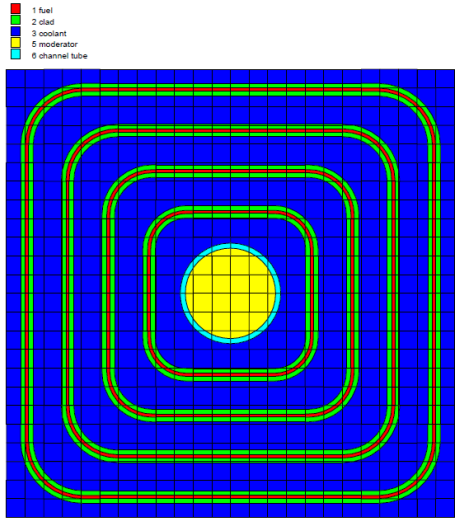
Problem Description

- Generate neutron and gamma spectra for IRT research reactor spent fuel using ORIGEN.
- Calculate total U and total Pu inventory in spent fuel at 5 years after discharge.
- Perform calculations for LEU fuel (IRT-4M 6-tube 19.75% ^{235}U) and HEU fuel (IRT-3M 6-tube 90% ^{235}U) and compare LEU and HEU results.

Learning Goals

- How to use existing or user-generated ORIGEN research reactor libraries with ORIGEN under Fulcrum or Origami GUI.
- How to calculate isotopic inventories, neutron and gamma sources using an available ORIGEN research reactor library.
- Estimate the difference in radiation sources between LEU and HEU spent fuel.





ORIGEN Reactor Libraries in SCALE

- Fuel/reactor specific ORIGEN libraries reside in the SCALE subdirectory SCALE-6.2\data\arplibs\
- The file *arpdata.txt* contains information on the libraries
  - Fuel type (name of the reactor library)
  - Number of values for each variable parameter
  - Parameter values
  - Burnup values for each library position
  - Filenames for parameter-dependent libraries
- The file *arpdata.txt* is located in SCALE-6.2\data\

Example - Information in arpdata.txt for IRT-4M 6-tubes

```
!irt4m6tube
 1 1 32
 19.7500
 0.9890
 'irt4m6t_e19.f33'
    0.00   900.00  3600.00  8100.00 13500.00
 18900.00 24300.00 29700.00 35100.00 40500.00
 45900.00 51300.00 56700.00 62100.00 67500.00
 72900.00 78300.00 83700.00 89100.00 94500.00
 99900.00 105300.00 110700.00 116100.00 121500.00
126900.00 132300.00 137700.00 143100.00 148500.00
153900.00 159300.00
```

library name
1 enrichments, 1 moderator density, 32 burnups
enrichment (wt% U-235)
moderator density (g/cm3)
names of library files

burnups (in MWd/MTU)

How to use arpdata.txt

- ORIGEN (and Origami) will look for reactor library information in arpdata.txt in the SCALE-6.2.3/data directory and for reactor library files in SCALE-6.2.3/data/arplibs/
- Unless… arpdata.txt and library files exist in the SCALE temporary directory!
- You can copy your arpdata.txt and library files to the SCALE temporary directory using a shell command at the beginning of your Origami (or ORIGEN) input file:

```
=shell
  cp path/to/files/myarpdata.txt   ${TMPDIR}/arpdata.txt
  cp path/to/files/libraryfile1    ${TMPDIR}
  cp path/to/files/libraryfile2    ${TMPDIR} etc…
end
=origami …
```

Problem Input Data

- ORIGEN reactor libraries for the two IRT assembly types are available in SCALE under the names
  - **irt4m6tube** for IRT-4M 6-tube 19.75% ^{235}U
  - **irt3m6tube90enrich** for IRT-3M 6-tube 90% ^{235}U
- Initial mass of U in assembly
  - assume 1MTU initial for convenience
  - results can be scaled to actual assembly U mass (e.g., U ~ 1.3kg for **irt4m6tube** assembly)
- Assumptions for each assembly type:
  - 10 operating cycles (30d each, with 30d downtown between cycles)
  - specific power 300MW/MTU

Sources of data for ORIGEN IRT reactor libraries:
1. A. Rakhmanov, J. R. Deen, N. A. Hanan, and J. E. Matos, ``A Neutronic Feasibility Study for LEU Conversion of the WWR-SM Research Reactor and Uzbekistan'', International Meeting on RERTR, Sao Paulo, Brazil, ANL/TD/CP-9749, 1998.
2. 2. P. L. Garner and N. A. Hanan, ``Transient Analyses for the Tajoura Critical Facility with IRT-2M HEU Fuel and IRT-4M LEU Fuel: ANL Independent Verification Results'', RERTR Program, Argonne National Laboratory, ANL-05/58, 2005.
3. 3. J. R. Deen, V. A. Hanan, J. E. Matos, P. M. Egorenkov, and V. A. Nasonov, ``A Neutronic Feasibility Study for LEU Conversion of the IR-8 Research Reactor'', International Meeting on RERTR, Sao Paulo, Brazil, ANL/TD/CP-97537, 1998.

Let’s work on this together!