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2D IAEA Benchmark problem

by

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In connection with the calculation on the 3D Benchmark problem we have performed some 2D-calculations. The 2D problem is the one specified in ref. 1 from which fig. 1 is copied.

To get a reasonably accurate independent reference solution Mr. G.K. Kristiansen has performed a series of FDT-calculations and from them obtained a solution by Richardson-extrapolation in each power assembly.

Table 1 shows the results from these calculations. In table 1 are further shown some calculations with FEMB, a twodimensional finite element flux calculation program using a rectangular mesh. From ref. 1 are taken two calculations with FEM2D, a finite element flux calculation program using a triangular mesh. The errors shown in table 1 are defined:

$$\epsilon_r = \text{Max}_i \left(\frac{|P_i - P_{i,\text{ref}}|}{P_{i,\text{ref}}} \right)$$

$$\epsilon_{\text{abs}} = \text{Max}_i \left(\frac{|P_i - P_{i,\text{ref}}|}{P_{\text{max,ref}}} \right)$$

(i denotes the assembly)

The error in the flux, defined as

$$\epsilon = \text{max}_g \left(\frac{\text{max}_i |\phi_i^g - \phi_{i,\text{ref}}^g|}{\phi_{\text{max,ref}}^g} \right)$$

(i denotes the spacepoint, g is a group-index)

is typically found to be twice as big as ϵ_{abs} in the power.

In fig. 2 the error as function of the mesh is shown for the different calculations.

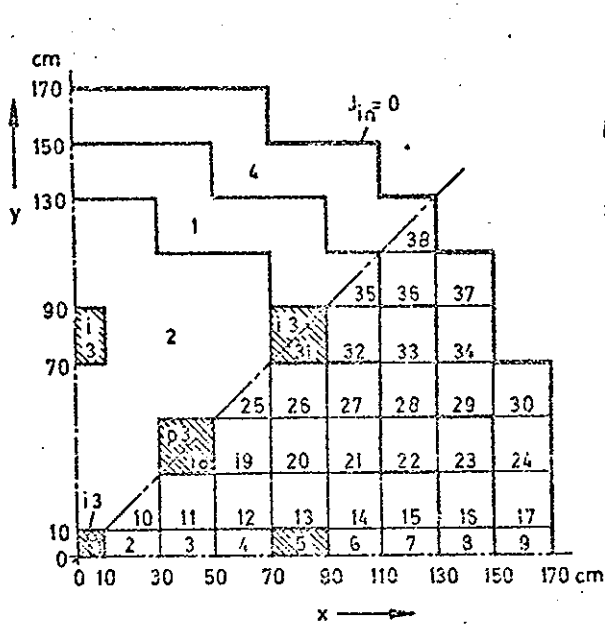
| Solution No | | description |
|-------------|--------|----------------------------------|
| 1 | tvedim | 17 x 17 |
| 2 | " | 34 x 34 |
| 3 | " | 68 x 68 |
| 4 | " | 136 x 136 |
| 5 | " | 170 x 170 |
| 6 | | extrapolated value |
| 7 | FEMB | 2. order 9 x 9 (19 x 19) |
| 8 | " | 2. order 18 x 18 (37 x 37) |
| 9 | " | 2. order 36 x 36 (73 x 73) |
| 10 | FEM2D | 1. order 182 fluxpoints 1/8 core |
| 11 | " | 2. order 606 fluxpoints 1/8 core |
| 12 | FEMB | 3. order 9 x 9 (28 x 28) |
| 13 | " | 3. order 18 x 18 (55 x 55) |

TVEDIM is a FDT fluxcalculation program using corner mesh points. FEMB is a finite-element flux calculation program using Lagrange interpolation in a rectangular mesh.

FEM 2D in a finite element flux calculation program using Lagrange interpolation in a triangular mesh. See ref. 1.

REFERENCES

1. Proceedings of the Conference on COMPUTATIONAL METHODS IN
NUCLEAR ENGINEERING
April 15 - 17, 1975
SESSION I
M.R. WAGNER: Current Trends in Multidimensional Static Reactor
Calculations.

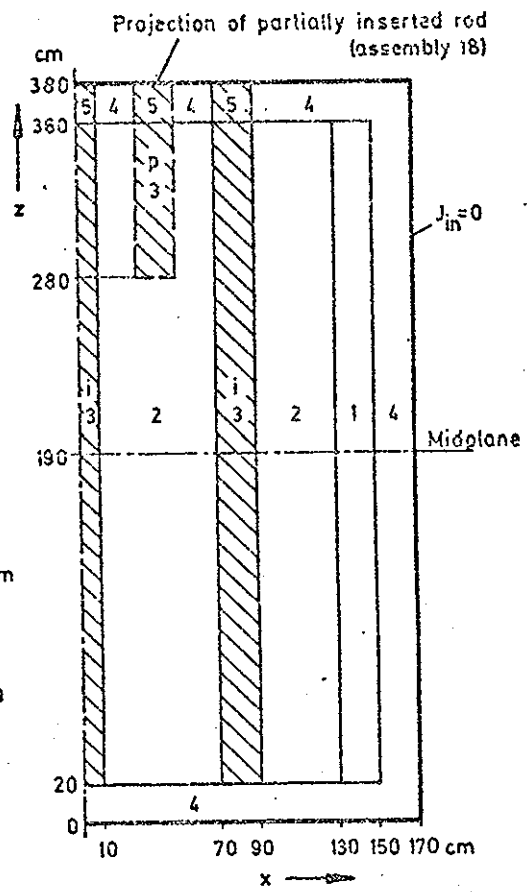


Upper Octant: Region Assignments
 Lower Octant: Fuel Assembly Identification

Boundary Conditions:

External Boundaries: $J_{in}^g = 0$

Symmetry Boundaries: $J_{ref}^g = 0$



Vertical Cross Section, $y = 0$

Group Constants for 3D IAEA Benchmark Problem

| Region | D_1 | D_2 | Σ_{1+2} | Σ_{a1} | Σ_{a2} | $\nu\Sigma_{f2}$ | |
|--------|-------|-------|----------------|---------------|---------------|------------------|--------------|
| 1 | 1.5 | 0.4 | 0.02 | 0.01 | 0.08 | 0.135 | Fuel 1 |
| 2 | 1.5 | 0.4 | 0.02 | 0.01 | 0.085 | 0.135 | Fuel 2 |
| 3 | 1.5 | 0.4 | 0.02 | 0.01 | 0.13 | 0.135 | Fuel 2 + Rod |
| 4 | 2.0 | 0.3 | 0.04 | 0 | 0.01 | 0 | Reflector |
| 5 | 2.0 | 0.3 | 0.04 | 0 | 0.055 | 0 | Ref. + Rod |

$$X_1 = 1.0, X_2 = 0.0, \nu\Sigma_{f1} = 0 \text{ all regions}$$

Note: 2D IAEA Benchmark Problem represents midplane $z = 190$ cm with constant axial buckling $B_z^2 = 0.8 \times 10^{-4}$ for all regions and energy groups

Fig.1 3D IAEA Benchmark Problem Specification

