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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:

$$\varepsilon_r = \underset{i}{\mathrm{Max}} \left(\frac{|P_i - P_{i,ref}|}{P_{i,ref}} \right)$$

$$\varepsilon_{abs} = \underset{i}{\mathrm{Max}} \left(\frac{|P_i - P_{i,ref}|}{P_{max,ref}} \right)$$

(i denotes the assembly)

The error in the flux, defined as

$$\varepsilon = \underset{g}{\max} \left(\frac{\underset{i}{\max} |\phi_i^g - \phi_{i,ref}^g|}{\phi_{max,ref}^g} \right)$$

(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.

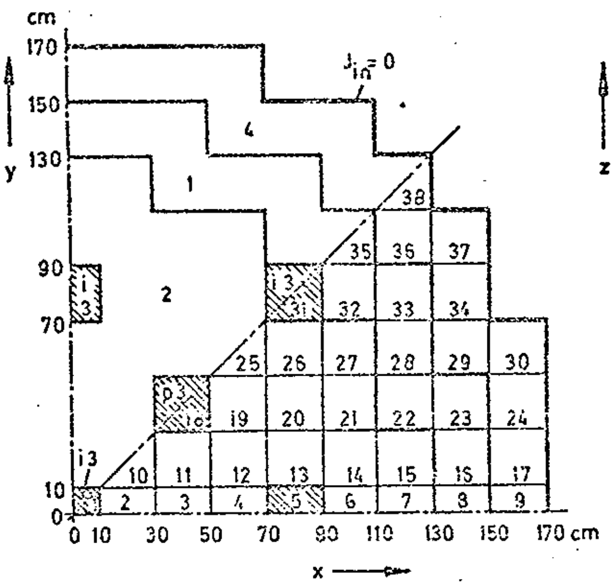
Solution No		description
1	tvedim	17 x 17
2	"	34 x 34
3	"	68 x 68
4	"	136 x 136
5	"	170 x 170
6		exstrapolated value
7	FEMB	2. order 9 x 9 (19 x 19)
8	"	2. order 18 x 18 (37 x 37)
9	"	2. order 36 x 36 (73 x 73)
10	FEM2D	1. order 182 fluxpoints 1/8 core
11	"	2. order 606 fluxpoints 1/8 core
12	FEMB	3.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

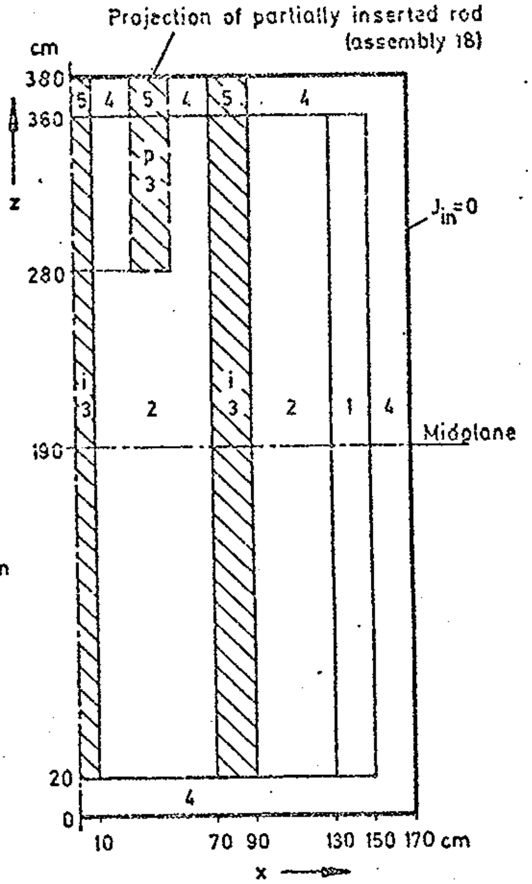


Upper Octant: Region Assignments
Lower Octant: Fuel Assembly Identification

Boundary Conditions:

External Boundaries $J^g_{in} = 0$

Symmetry Boundaries $J^g_{net} = 0$



Vertical Cross Section, y = 0

Group Constants for 3D IAEA Benchmark Problem

Region	D_1	D_2	$\Sigma_{1\to 2}$	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	Refl. + Rod

$\chi_1 = 1.0$, $\chi_2 = 0.0$, $\nu\Sigma_{f1} = 0$ 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

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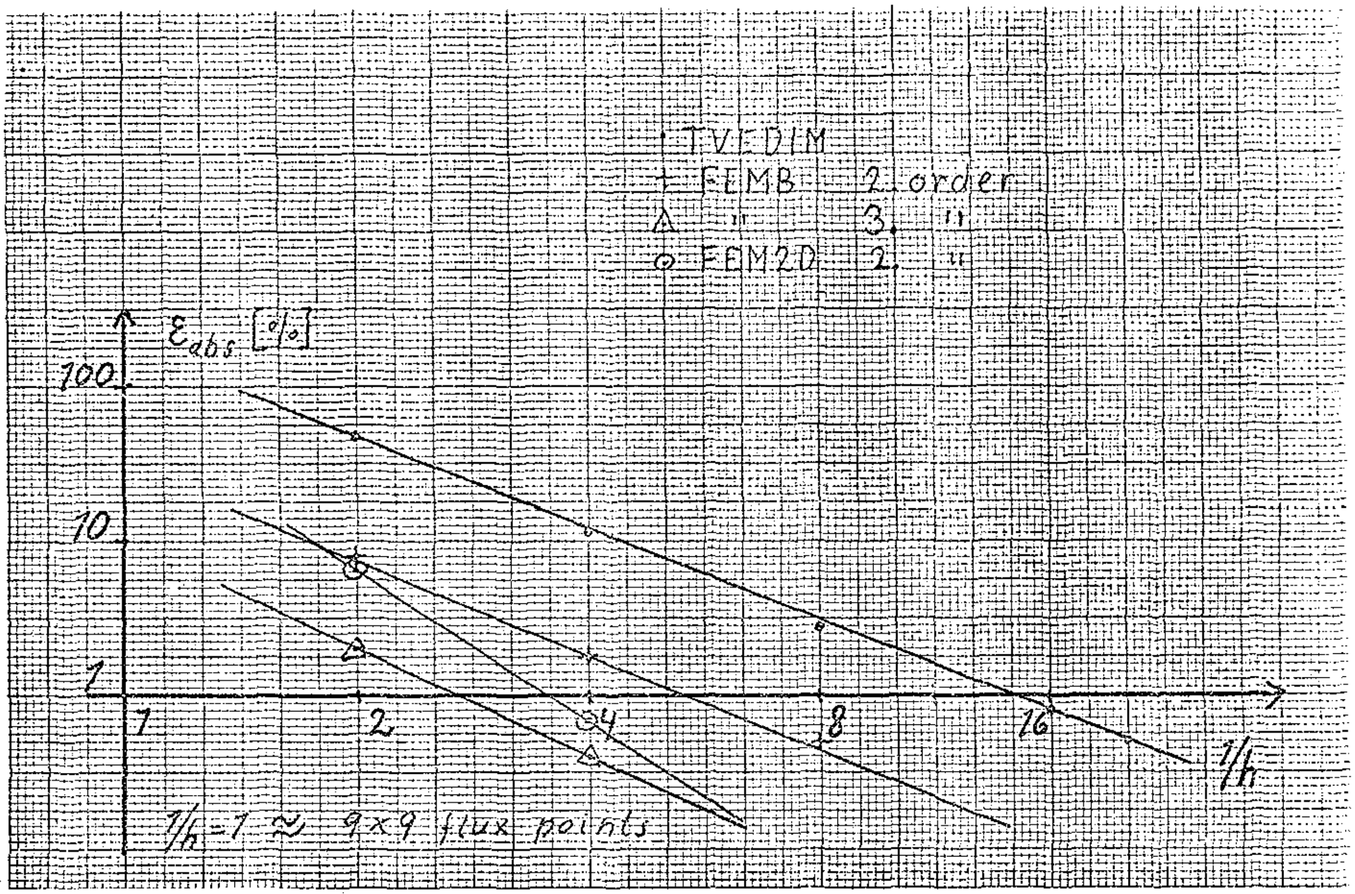

Fig. 2

Assembly	Solution No. 1	2	3	4	5	6	7	8	9	10	11	12	13
1	478	689	733	743	744	746	688	735	741	722	748	737	743
2	729	1147	1267	1298	1302	1308	1187	1286	1302	1235	1301	1287	1305
3	870	1301	1415	1444	1448	1454	1328	1431	1446	1382	1448	1434	1449
4	760	1088	1178	1202	1206	1210	1117	1192	1205	1150	1203	1191	1207
5	532	603	610	610	610	610	593	608	609	609	614	610	610
6	867	918	930	934	935	935	926	932	936	920	932	931	935
7	1083	978	946	937	936	934	975	941	938	953	934	940	937
8	1279	879	786	763	760	755	845	774	762	773	755	777	760
10	830	1275	1394	1425	1428	1435	1308	1412	1427	1367	1430	1414	1430
11	908	1333	1442	1470	1474	1479	1360	1458	1473	1413	1475	1460	1475
12	869	1202	1286	1307	1311	1314	1224	1298	1310	1264	1311	1299	1311
13	810	1002	1051	1065	1067	1070	1020	1060	1068	1034	1064	1060	1068
14	986	1030	1035	1036	1036	1036	1032	1036	1037	1033	1035	1036	1037
15	1136	1003	964	954	953	951	998	959	954	978	951	957	953
16	1267	862	768	744	741	736	836	755	743	766	734	755	741
18	952	1339	1437	1461	1464	1469	1362	1450	1463	1411	1465	1451	1465
19	947	1248	1321	1339	1342	1345	1265	1331	1341	1301	1342	1331	1342
20	959	1129	1167	1176	1178	1179	1135	1172	1178	1155	1178	1173	1178
21	1077	1081	1073	1071	1071	1071	1078	1072	1072	1082	1071	1072	1071
22	1248	1047	993	980	978	976	1038	986	979	994	976	984	978
23	1395	861	745	703	700	692	810	717	699	762	701	721	698
25	895	1121	1175	1188	1190	1192	1136	1182	1190	1166	1191	1182	1191
26	819	930	757	964	966	966	942	961	965	946	964	959	966
27	988	934	914	908	908	906	940	911	908	936	908	907	907
28	1353	977	880	855	852	847	947	865	851	918	853	866	850
31	547	498	479	473	472	471	487	475	471	496	476	476	471
32	867	723	695	688	687	685	739	691	687	698	685	684	686
33	1209	743	634	607	603	598	699	618	602	687	608	621	601
35	1132	721	620	594	591	585	685	605	589	673	594	607	588
ε_r	102	24	5.7	1.6	1.0	--	17	3.6	1.0	15	1.7	4.2	0.9
ε_{abs}	48	12	2.8	0.8	0.5	--	8	1.7	0.5	6	0.7	2.0	0.4

Table 1