

8.2 Impact of burnable absorber Gd on nuclide composition for VVER-440 fuel (Gd-2), part 2

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ABSTRACT

The latest version of Russian fuel VVER-440 includes burnable absorber in 6 pins. In this article is impact of burnable absorber on nuclide composition and criticality analyzed. In part 1 was analyzed whole burnup interval 0 - 50 MWd/kgU [3]. In present part 2 are detailed analysis only for first cycle (burnup 0 - 10 MWd/kgU)

USED CODES

The SCALE 6 system (distributed in 2009) [1] and the HELIOS 1.10 code [2] was used.

The nuclide composition was calculated with the TRITON module (2 dimensional, multigroup constants (NITAWL)/continuous energy (CENTRM), library 44GROUPNDF5/238GROUPNDF5) and with the HELIOS code (2 dimensional, 190 group library (hy190n48g110a)). The TRITON module is a control module, working modules are NITAWL/CENTRM (data preparation), NEWT (2D flux distribution) and ORIGEN-S (depletion).

The criticality was calculated with the KENO VI. module (3 dimensional, multigroup constants (NITAWL)/continuous energy (CENTRM), library 44GROUPNDF5/238GROUPNDF5).

RESULTS

The 2nd generation working assembly with/without burnable absorbers with the average enrichment 4.25 % U235 was analyzed (Fig.1). The symmetry 30° was used - the calculation area is whole assembly (126 fuel pins + central tube), but divided into 15 symmetrical pins.

Operation history consisted from 1 period, 300 days full power. The first period was analyzed by time step 10 days. The pin was divided in finer grid than in part 1.

For safety analyses connected with BUC application is final result criticality. We have analyzed criticality of burned assembly with and without Gd. By criticality calculation we used only following nuclides:

- U: 235, 236, 2238
- Pu: 238, 239, 240, 241, 242
- Am: 241, 242m, 243
- Cm: 244, 245, 246
- O: 16
- Gd: 152, 154, 155, 156, 156, 157, 158, 160

In SCALE 6 calculations have been carried out 4 possibilities to prepare constants: CE+44, CE+238, MG+44, MG+238. In depletion calculation and in criticality calculation was always used the same way.

On Fig. 2 the criticality dependence on burnup is shown. In the first year is strong impact of Gd. The differences between CE+44, CE+238 and MG+238 are very small - less than 0.1%. MG+44 has systematic higher values 0.2 - 0.4%. HELIOS has differences 0.2 - 0.4% with Gd and without Gd less than 0.1%.

We see that results in criticality are very similar by all way of depletion calculation. Other point of view is computational time:

Depletion calculation		Criticality calculation			
model	Computational time	Data preparation		KENO VI	total
		model	Computational time	Computational time	Computational time
TRITON, MG 44	7,7 h	MG 44	1,4 m	9,5 m	10,9 m
TRITON, MG 238	31,8 h	MG 238	2,4 m	9,9 m	12,3 m
TRITON, CE 44	43,5 h	CE 44	18,3 m	9,7 m	28 m
TRITON, CE 238	109,6 h	CE 238	73 m	10 m	83 m
HELIOS, 190 groups	2 h	CE 238	70 m	9,8 m	79 m

CONCLUSION

The impact of burnable absorber on criticality is significant in the first year of burning (to 10 MWd/kgU).

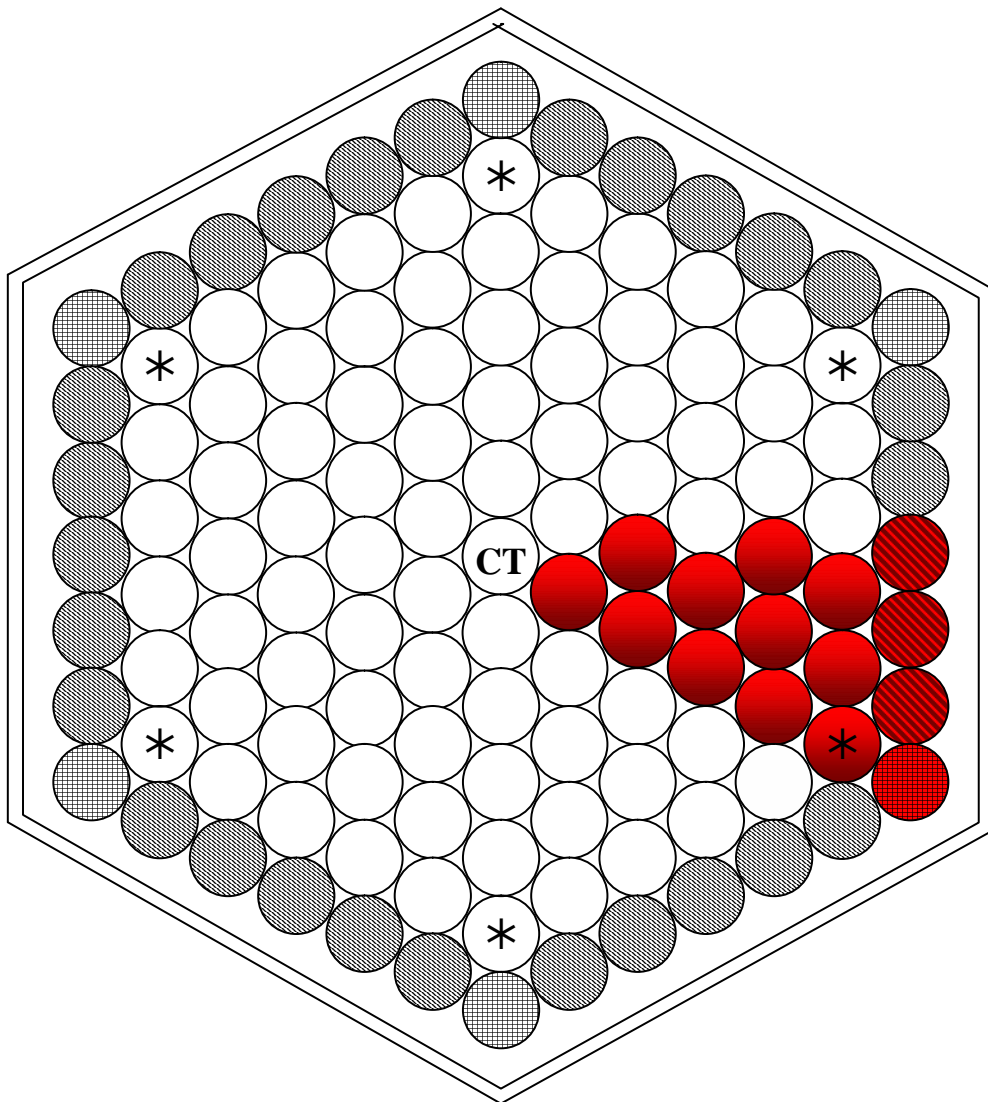
The way CE+44, Ce+238, MG+238 and HELIOS by calculation without Gd are practically the same (differences less than 0.1%), the way MG+44 is systematically 0.2 - 0.4% higher.

The way CE+44, Ce+238 and MG+238 by calculation with Gd are practically the same (differences less than 0.1%), the way MG+44 and HELIOS is systematically 0.2 - 0.4% higher.

REFERENCES

- [1] SCALE 6, Oak Ridge National Laboratory, 2009
- [2] HELIOS 1.10, Studsvik Scandpower, 2008
- [3] Zajac R., Chrapčiak V., Impact of burnable absorber Gd on nuclide composition for VVER-440 fuel (Gd-2), WG E, Řež 2010

Fig. 1 Working assembly with average enrichment 4.25%








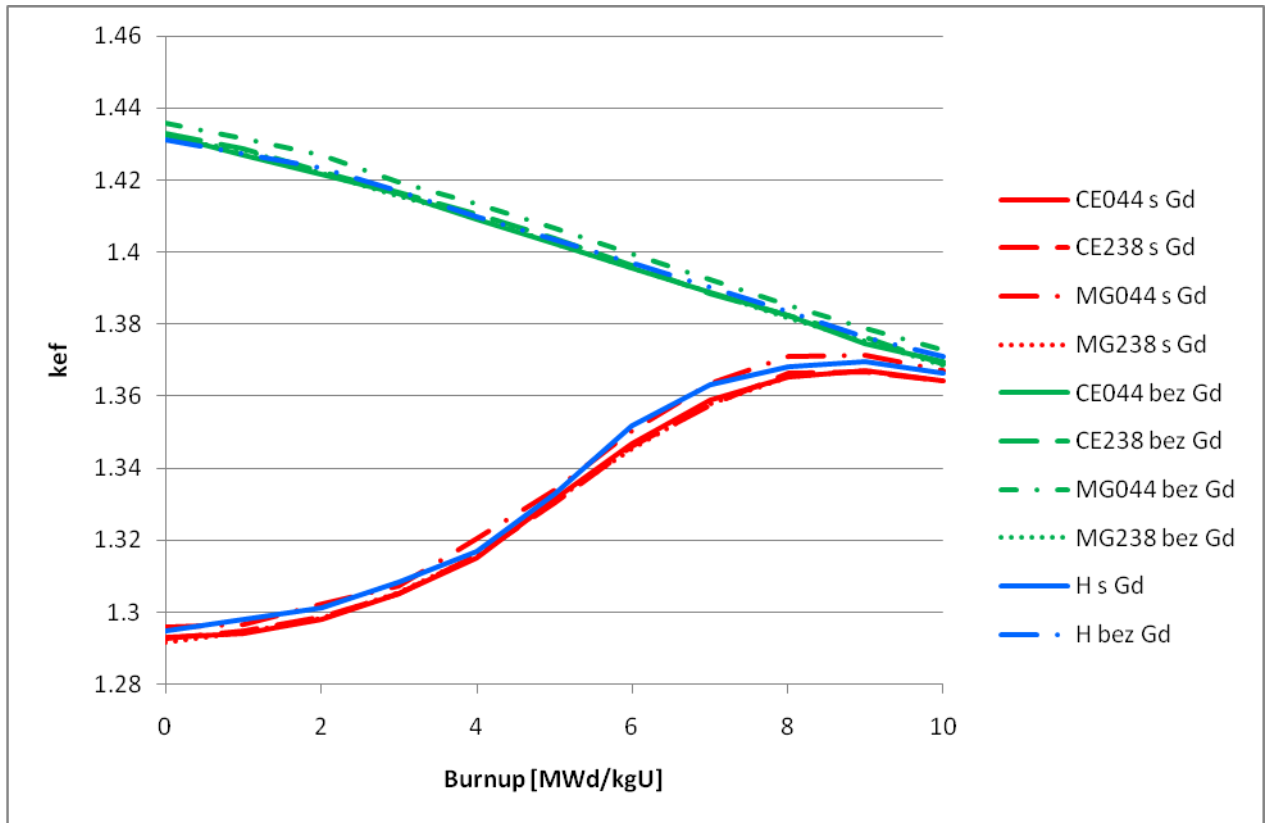
-  4,4% (84)
-  4,0% (30)
-  3,6% (6)
-  4,0% U235 + (3,35% Gd₂O₃)(6)
-  **CT** Central tube

Fig. 2 Criticality (infinite lattice, only actinides)



CE044 = Continuous Energy (modul CENTRM), library 44GROUPNDF5
 CE238 = Continuous Energy (modul CENTRM), library 238GROUPNDF5
 MG044 = MultiGroup (modul NITAWL), library 44GROUPNDF5
 MG238 = MultiGroup (modul NITAWL), library 238GROUPNDF5
 H = depletion calculation with the HELIOS

s Gd = with Gd
 bez Gd = without Gd