

Production of ^{242m}Am in the MONJU Fast Reactor

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There is a growing interest in the use of ^{242m}Am as a nuclear fuel. Since the thermal absorption cross section of ^{242m}Am is very high ($\sigma_a = 8950$ barn) the best way to obtain ^{242m}Am is by a capture of fast or epithermal neutrons in ^{241}Am . As a result, we have considered to replace the radial blanket of fast reactor which is usually depleted uranium with $^{241}\text{AmO}_2$.

We have considered the 714 MWth MONJU reactor [1] and we replaced some of the radial blanket and the outer core assemblies with 10676 kg of $^{241}\text{AmO}_2$ fuel. The parameters of the MONJU reactor are given in Table I.

The reactor core is presented in Fig. 1. We have calculated the reactor core using the MCNP Monte Carlo code [2]

For burnup calculation we have used the burnup chains of the actinides. The obtained results of the ^{242m}Am breeding is given in Fig. 2 and Table II.

The amount of the ^{242m}Am enrichment is given in Fig 3. We see an increase of the enrichment with burnup. Although the total amount of ^{242m}Am is stabilized after 16 years, but the enrichment is not. In our calculation about 7.2% enrichment is obtained after 6570 days. However higher enrichments can be obtained. Obtaining such higher enrichments might indicate that in quite many cases ^{242m}Am nuclear fuel can be used without further enrichment.

References

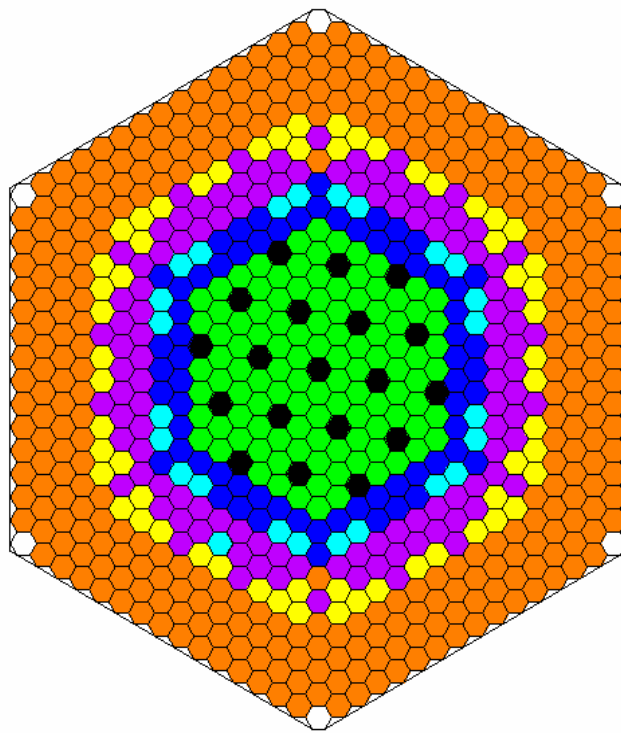
1. T. Takahashi, O. Yamaguchi, T. Kobori, "Construction of the MONJU Prototype Fast Breeder Reactor", Nuclear Technology, **89**, 162 (1990).
2. "MCNP4, Monte Carlo Neutron and Photon Transport Code System", CCC-200, Oak Ridge national Laboratory (Oct. 1991).

Table II
^{242m}Am Breeding and core reactivity

²⁴¹ Am Irradiation [days]	K _{eff}	^{242m} Am production [kg]	^{242m} Am (²⁴¹ Am+ ^{242m} Am) [o/w]
0	1.02975 ± 0.00062	0	0.000
365	0.99998 ± 0.00059	45.921	0.502
365 (refueling)	1.03722 ± 0.00060	45.921	0.502
730	1.00734 ± 0.00060	87.992	0.991
730 (refueling)	1.03939 ± 0.00062	87.992	0.991
1095	1.01234 ± 0.00061	126.504	1.470
1095 (refueling)	1.04289 ± 0.00059	126.504	1.470
1460	1.01714 ± 0.00058	161.125	1.934
1460 (refueling)	1.04842 ± 0.00059	161.125	1.934
1825	1.01919 ± 0.00060	192.354	2.388
1825 (refueling)	1.05171 ± 0.00060	192.354	2.388
2190	1.02312 ± 0.00058	220.178	2.831
2190 (refueling)	1.05355 ± 0.00060	220.178	2.831
2555	1.02460 ± 0.00057	244.644	3.260
2555 (refueling)	1.05775 ± 0.00058	244.644	3.260
2920	1.02545 ± 0.00057	265.839	3.675
2920 (refueling)	1.05726 ± 0.00057	265.839	3.675
3285	1.02654 ± 0.00058	284.102	4.078
3285 (refueling)	1.05964 ± 0.00059	284.102	4.078
3650	1.02826 ± 0.00054	299.514	4.470
3650 (refueling)	1.05929 ± 0.00057	299.514	4.470
4015	1.02762 ± 0.00058	312.253	5.097
4015 (refueling)	1.05914 ± 0.00058	312.253	5.097
4380	1.02814 ± 0.00058	322.476	5.217
4380 (refueling)	1.05832 ± 0.00056	322.476	5.217
4745	1.02708 ± 0.00053	330.347	5.573
4745 (refueling)	1.05975 ± 0.00055	330.347	5.573
5110	1.02607 ± 0.00054	335.960	5.914
5110 (refueling)	1.05975 ± 0.00055	335.960	5.914
5475	1.02413 ± 0.00055	339.579	6.245
5475 (refueling)	1.05900 ± 0.00055	339.579	6.245
5840	1.02172 ± 0.00052	341.336	6.565
5840 (refueling)	1.05783 ± 0.00054	341.336	6.565
6205	1.02013 ± 0.00051	341.387	6.872
6205 (refueling)	1.05634 ± 0.00052	341.387	6.872
6570	1.05634 ± 0.00052	339.887	7.167

Table I
Principal Design Data of MONJU

Reactor type	Sodium-cooled loop-type
Thermal power [MW]	714
Electrical power [MW]	280
Fuel material	PuO ₂ -UO ₂
Core equivalent diameter [m]	1.79
Core height [m]	0.93
Core volume [m ³]	2.335
Plutonium Enrichment (inner core/ outer core) [% fissile plutonium]	15/20
Core fuel inventory (uranium + plutonium metal) [kg]	5900
Blanket fuel inventory (uranium metal) [kg]	17500
Average burnup [MWd/kg]	80
Number of inner core assemblies	108
Number of outer core assemblies	90
Number of radial blanket assemblies	172
Number of control rods	19
Number of pins per core assembly	169
Number of pins per radial blanket assembly	61
Cladding material	Type 316 stainless steel
Cladding outside diameter/thickness (in core) [cm]	0.65/0.047
Cladding outside diameter/thickness (in radial blanket) [cm]	1.16/0.05
Power density [W/cm ³]	283
Upper blanket thickness [cm]	30
Lower blanket thickness [cm]	35
Radial blanket thickness [cm]	30
Breeding ratio	1.2
Reactor inlet/ outlet sodium temperature [°C]	397/529
Refueling interval [days]	180



- Control rod (19)
- PuO₂-UO₂ inner core 15% fissile Pu (108)
- PuO₂-UO₂ outer core 20% fissile Pu (66)
- ²⁴¹AmO₂ outer core (24)
- ²⁴¹AmO₂ radial blanket (112)
- UO₂ radial blanket (60)
- Neutron shield (325)

Figure 1. MONJU reactor with americium assemblies

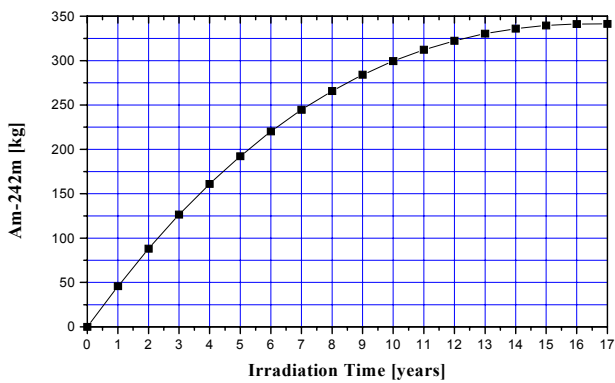


Figure 2. ^{242m}Am buildup during ²⁴¹Am irradiation

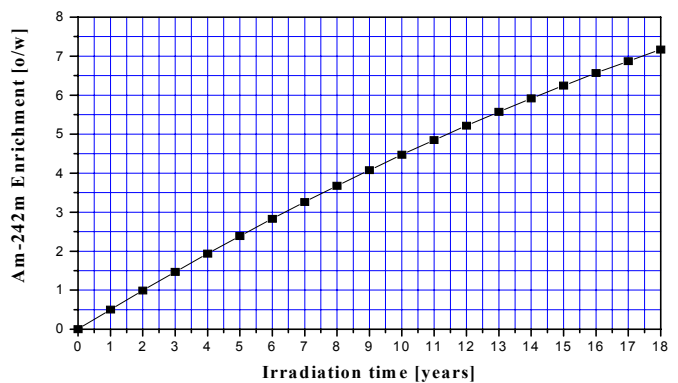


Figure 3. ^{242m}Am enrichment during ²⁴¹Am