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NEUTRONICS PARAMETER VARIATION STUDIES FOR THE LOS ALAMOS ATW CONCEPT

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The purpose of the Los Alamos ATW (Accelerator Transmutation of nuclear Waste) project is to utilize a high-energy (800-1600 MeV), high current (25-60mA) proton beam to generate a large neutron flux for the transmutation of nuclear wastes. Our theoretical modeling efforts have been directed toward designing a device that will transmute the 2000 kg of Tc and I in the Hanford waste depository along with significant quantities of actinides. Previous system studies[1] have indicated the feasibility of such a device. However, it required thirty years to transmute 2000 kg of Tc and 400 kg of Np. In the present work, we have expanded on the previous study and focused on a device which will significantly reduce the time required for the transmutation of the fission products.

The device under consideration contains ^{239}Pu from the waste depository, which is placed in a region next to the proton target-neutron source. Through subcritical multiplication of the neutron source, a significant increase in the flux occurs and reduces the time required for the transmutation of the fission products. The ^{239}Pu itself is destroyed through fission. This paper presents the salient results of numerous neutronic calculations in systematic sensitivity studies made to examine this design.

The model ATW target/blanket system for this study is a concentric cylindrical modular configuration consisting of the central proton target of a lead-bismuth eutectic, surrounded by a double wall of stainless steel and Zircalloy. The target is followed by a region containing ^{239}Pu in a D_2O slurry. A double wall of Zircalloy separates the next region which contains ^{99}Tc in a D_2O slurry. A single wall of Zircalloy follows.

The neutronic calculations were made with the one dimensional S_n code ONEDANT[2]. The cross sections were prepared from the 69 energy group ENDF/B V MATSX7[3] library with the code TRANSX[3]. A S_8P_1 approximation and intervals of .5 cm were used in the calculations.

The variable design parameters in this study were the thicknesses of the regions containing ^{239}Pu and ^{99}Tc and their concentrations in each region. The results of each case calculated were the absorptions, fission and leakage per source neutron. Given a particular proton beam strength, these results may be translated to kilograms of material transmuted or fissioned per year. The results may be utilized to choose a design that meets specific goals, as for example here, to reduce the time necessary for the transmutation of 2000 Kg of ^{99}Tc.

In Table 1, the results of the variation of concentrations ^{239}Pu and ^{99}Tc with fixed regional thicknesses, and the results of varying the regional thicknesses with fixed concentrations of ^{99}Tc and ^{239}Pu, are given. All results are based on one source neutron. Three cases were run in which the reactor contained no ^{99}Tc. These cases were made to insure the the system would remain subcritical even with an accidental loss of the ^{99}Tc. As expected, the results show that the total absorption, i.e., the sum of the Tc and Pu absorption, and k_{eff} change significantly as a result of a change in concentration or volume. Which of the results would produce the best or most feasible design will be affected by many conditions, such as the available amount of waste ^{239}Pu or the desirability of producing power.

Considering Case 7 in Table 1, should enough waste ^{239}Pu be available for such concentrations, the 1.2207 absorptions per source neutron in the ^{99}Tc would translate to a transmutation of 99 kg per year for a 50 mA proton beam producing 50.28 neutrons per incident proton. A 2000 kg inventory would be consumed in 20 years. For this case, 135 kg/yr of ^{239}Pu would be converted to ^{240}Pu, not necessarily a desirable situation, while 306 kg/yr of ^{239}Pu would be fissioned producing 783 MW of power. While this design presents a possible scenario, it may be noted from the results in Table 1, that a wide variety of scenarios are available to the designer, some of which also offer the possibility of rapid transmutation.

REFERENCES

1. R.J. LaBauve, M.W. Cappiello, and R.T. Perry, "Neutronic Analysis of LANL's Accelerator Transmutation of Waste," Trans. Am. Nucl. Soc., **63**, 89 (1991)

2. R.D. O'Dell, F. W. Brinkley, Jr., and D.R. Marr, User's Manual for ONEDANT, Los Alamos National Laboratory Manual LA-9184-M (February 1982)

3. R. E. MacFarlane, TRANSX-CTR, Los Alamos National Laboratory Report LA-9863-MS (February 1984)

Table I. ONEDANT results for a six-zone ATW model[a] with two active transmutation zones

Active zone thicknesses (cm)		Concentrations (atom/barn-cm)			Tc	Pu	Pu	O
^{239}Pu	^{99}Tc	$^{239}Pu \times 10^7$	$^{99}Tc \times 10^4$	k_{eff}	absorption[b]	absorption[b]	fission[b]	lea
40	40[c]	6.0221	0.0000	0.4296	0.0000	0.3954	0.2731	0.4
40	40	6.0221	1.8066	0.3481	0.4581	0.3026	0.2086	0.1
40	40	6.0221	5.4199	0.3071	0.5981	0.2623	0.1807	0.0
40	40	19.7208	0.0000	0.9006	0.0000	4.8395	3.3313	2.4
40	40	19.7208	1.8066	0.7719	1.2061	1.9549	1.3426	0.3
100	27.5[d]	5.0706	0.0000	0.9000	0.0000	3.9885	2.7690	2.0
100	27.5	5.0706	3.6133	0.8262	1.2207	2.2425	1.5562	0.3
60	67.5[d]	5.0706	3.6133	0.4719	0.4841	0.4841	0.3350	0.0

[a] Zone 1: $0 \leq r \leq 25$ cm target Pb-Bi.
Zone 2: $25 \leq r \leq 27$ cm structure steel 24% (volume), Zirc-4 26%, vacuum 50%.
Zone 3: $27 \leq r \leq r_{outer}(Pu)$ active $^{239}Pu/D_2O$.
Zone 4: 3-cm interval structure Zirc-4 50%, vacuum 50%.
Zone 5: $r_{inner}(Tc) \leq r \leq r_{outer}(Tc)$ active $^{99}Tc/D_2O$
Zone 6: 2.5-cm interval structure Zirc-4 100%.

[b] Normalized to 1.0000 source neutron.

[c] Outer radius = 112.5 cm.

[d] Outer radius = 160.0 cm.