FUEL CYCLE ANALYSIS, MANAGEMENT, AND ECONOMICS — II

1. The Potential of the Thorium Cycle in PWRs, *W. J. Oosterkamp (IEA-Brazil)*

A substantial savings in uranium consumption can be obtained by substituting thorium and highly enriched uranium[1] for uranium. To explore this further we varied the moderator-to-fuel volume ratio, the burnup, the number of refuelings per year, and the fuel-pin diameter. A modified form of the cell code HAMMER was used. A slight increase in conversion ratio was obtained by reducing the lattice pitch. The burnup and the number of refuelings per year had the strongest influence on the conversion ratio and the initial enrichment. Fuel-pin-diameter variations had only a small effect. Corrections were made to account for leakage and the influence of ^{235}U, that has to be used as a makeup fuel (Figs. 1 and 2). The results are consistent with whole reactor calculations made for several cases. The uranium consumption with quarterly refueling and low burnup is about a third of that for the standard PWR case with Pu recycling. A 10% growth rate in the reactor population has been assumed, so that each year 10% of the total inventory has to be provided. The total necessities of enriched uranium are then a factor of 2 lower than the standard PWR case with Pu recycle. This is lower, in fact, than for a reactor strategy of PWRs and LMFBRs.[2] A comparison of costs with the uranium cycle shows that the thorium cycle is between 10 to 20% more expensive. This is due mainly to the higher enrichment requirements. The costs in the fuel cycle have been changing very rapidly. As uranium reserves are limited, ore prices are expected to increase relative to enrichment, reprocessing, and refabrication. The thorium cycle, consequently, will become competetive.

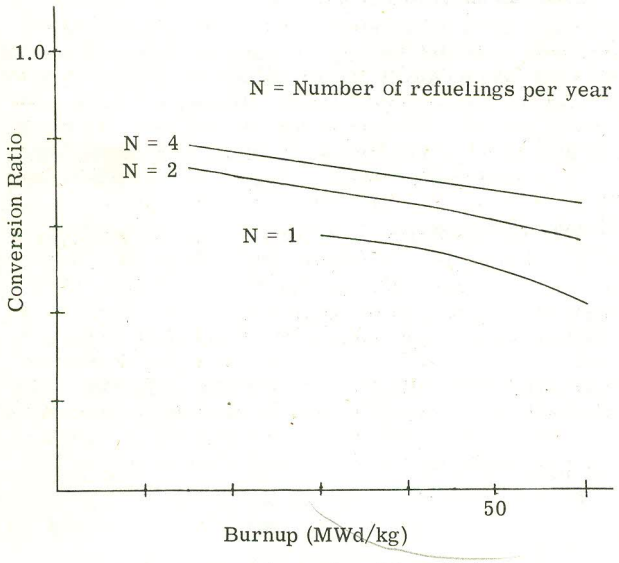

Fig. 1. Conversion ratio of the Th cycle.

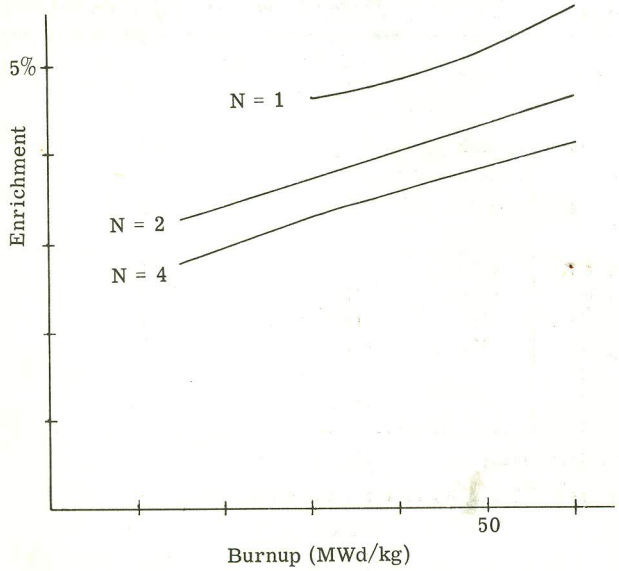

Fig. 2. Enrichment of the Th cycle.

1. F. CORREA and W. J. OOSTERKAMP, "Thorium Utilization in Angra dos REIS PWR," *Trans. Am. Nucl. Soc.*, 21, 261 (1975).

2. W. J. OOSTERKAMP et al., "Reactor Strategy Studies for Brazil," *Trans. Am. Nucl. Soc.*, 21, Suppl. 2 (1975).

2. Practical Considerations in the Use of a Thorium Cycle in PWRs, *R. A. Matzie, J. R. Rec (C-E)*

A comprehensive study, sponsored by EPRI, was performed to explore the use of thorium-based fuel cycles in large current-design PWRs. Results of the initial phase of the study, a survey of fuel cycle options in unmodified PWRs, indicated that for a given U_3O_8 ore resource, significant increases in the LWR-based electrical capacity can be realized by converting present PWRs and starting new PWRs on a thorium cycle.[1] The use of fully enriched ^{235}U in ThO_2 can reduce the annual U_3O_8 ore demand of a PWR by about 54% relative to the conventional UO_2 cycle with no fuel recycle, and by about 25% relative to the UO_2 cycle with uranium and plutonium recycle. Adoption of a thorium cycle would depend, to a large extent, on the ability to attain operating characteristics in the thorium-based cores which are comparable to those of conventional UO_2 cores.

The second phase of the study, presented in this paper, addressed the practical problem of determining core characteristics which directly impact safety and operational considerations. These characteristics include core power peaking and power sharing among fuel types, control-rod and soluble boron worths, moderator and fuel temperature coefficients, and delayed-neutron fractions in cores involving both the transition from a UO_2 cycle and the startup from a fully enriched $^{235}U/ThO_2$ initial core loading. The overall results indicate that the characteristics of the thorium-based cores are comparable to those typical of PWRs presently operating on the conventional UO_2 cycle and to those expected in UO_2 cores employing self-generated recycle (SGR) of plutonium.