Possible Recycle of Most Components from LWR Spent Fuel Including Uranium, Cladding and Transuranium Elements

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INTRODUCTION

Nuclear energy represents a large and economical source of clean energy without carbon emissions. The present track record related to safety and reliability has been exceptionally good and the public perception is becoming favorable toward an expanded role of nuclear energy in the U.S. However, what to do with the 55000 tonnes of spent nuclear fuel accumulated to present and growing at about 2300 tonnes per year is a major issue that needs to be resolved.

BACKGROUND

As shown in Fig. 1, the transuranium components, mainly plutonium, constitute less than 1% of the average stored spent fuel. Conventional reprocessing as presently practiced recycles plutonium as mixed oxide (MOX) in light-water reactors (LWRs) only once because the spent fuel used is processed after a relatively short cooling period. [1] The bulk of the spent fuel is to be disposed of as wastes. The proposed wastes are (1) mainly uranium (as low-level waste in a site not yet identified, and (2) fission products, plus the secondary wastes generated in the process (high-level wastes [HLWs] to be disposed of in geological repositories. This approach is hardly an acceptable solution.

Segregating some of the major components as low-level wastes may present some advantages. However, the best approach is to recycle and reuse, at a reasonable cost, most of the spent fuel so that wastes are no longer wastes.

This new approach of near full recycle along with minimization of emissions and secondary wastes (both geological and LLW) should allow for enhanced public acceptance and consensus building in the environmental community.

DESCRIPTION OF THE ACTUAL WORK

The goals are to recover more than 95% of the spent fuel mass including (1) separation and purification of uranium for re-enrichment and reuse in LWRs or direct reuse in CANDU reactors, (2) separation of all transuranium species and recycle as transmutation fuels, (3) separation, purification and reuse of Zircalloy cladding and possibly noble metals, (4) capture of volatile species and long-lived fission products, (5) manage major heat sources to maximize repository capacity.

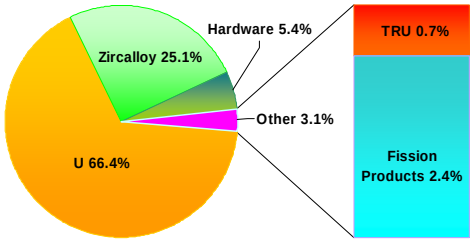

Fig. 1. Average composition of the spent fuel accumulated in the U.S.

RESULTS

Uranium can be directly recycled into existing heavy-water reactors (HWRs) such as CANDU reactors [2] or re-enriched and reused existing LWRs [3,4] or into future breeder reactors. Zircalloy cladding can be refined and purified for fabrication of new cladding, high integrity containers for nuclear wastes, and repository components. Hardware can be re-cast into HLW containers

All fissile transuranics can be recycled into the existing fleet of reactors (LWRs) and into planned future reactors such as the dual use gas reactors (hydrogen generation, electricity), and fast reactors (burners and or breeders). Other selected fission products such as the noble metals (Ru, Rh, Pd, Ag) and Xe can be also be recycled.

The approach to be presented is a gradual deployment based on economic considerations [3,5] firstly the existing fleet of LWRs but with

the implicit flexibility to accommodate other future types. The economy of scale gained by using a very large plant to minimize the unit cost and taking advantage of the special situation in the U.S. of having a very large inventory of aged fuel. [6] Proliferation resistance and cost reductions can be achieved by close-coupling of separation and fuel fabrication along with strong site security and safeguards. Potential industrial partners and significant details will be presented in the full paper.

REFERENCES

1. E. D. COLLINS, G. D. DEL CUL, J. P. RENIER, B. B. SPENCER, Preliminary Multicycle Transuranic Actinide Partitioning Transmutation Studies, ORNL/TM-2007/24 (Feb. 2007).

2. R. J. ELLIS, "Prospects of Using Reprocessed Uranium in CANDU Reactors, in the US GNEP Program," ANS 2007 Winter Meeting, November 11-15, 2007.

3. L. D. TROWBRIDGE, J. P. RENIER, and G. D. DEL CUL, "Evaluation of Reuse of Reprocessed Uranium in the Context of the U.S. GNEP Program," ANS 2007 Winter Meeting, November 11-15, 2007.

4. J. P. RENIER , et al.,"Reactor Neutronics Paper…", ANS 2007 Winter Meeting, November 11-15, 2007.

5. K. A. WILLIAMS, "The Economics of Recycling Reprocessed Uranium", this conference (2007).

6. G. D. DEL CUL, B. B. SPENCER, E. D. COLLINS, "Fuel Cycle Advantages Resulting from the Significant Inventory of U.S. Spent Fuel," in *Proceedings of Global 2003*, New Orleans, Louisiana, November 16–20, 2003, pp. 724–727, American Nuclear Society, La Grange Park, Illinois (2003).