ACCELERATOR-DRIVEN TRANSMUTATION: A HIGH-TECH SOLUTION TO SOME NUCLEAR WASTE PROBLEMS

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Summary

This paper discusses current technical and political issues regarding the innovative concept of using accelerator-driven transmutation processes for nuclear waste management. Two complex and related issues are addressed. First, the evolution and improvements of the design technologies are identified to indicate that there has been sufficient technological advancement with regard to a 1991 scientific peer review to warrant the advent of a large-scale national research and development program. Second, the economics and politics of the transmutation system are examined to identify non-technical barriers to the implementation of the program.

Transmutation of waste has been historically viewed by nuclear engineers as one of those technologies that is too good to be true and probably too expensive to be feasible. The concept discussed in the present paper uses neutrons (which result from protons accelerated into spallation targets) to transmute the major very long-lived hazardous materials such as the radioactive isotopes of technetium, iodine, neptunium, plutonium, americium, and curium. Although not a new concept, accelerator-driven transmutation technology (ADTT) lead by a team at Los Alamos National Laboratory (LANL) has made some significant advances which are discussed in the present paper.

The major attributes of the ADTT concept are: (1) it addresses issues of waste management storage capacity by efficiently destroying transuranics, transmuting long-lived fission products to more benign or stable isotopes, and partitioning of all fission products for optimal disposition, (2) it is reactor-like in scale and function and is able to be economically viable by producing usable energy by destroying hazardous components of spent nuclear fuel, (3) its components are based on proven technology, and (4) the radiotoxicity of the residual material from a transmutation facility after 300 years is lower than direct-disposal of spent nuclear fuel after 100,000 years.

Transmutation is not a new technology, in fact, scientific knowledge of transmutation has been around since 1919 when Ernest Rutherford bombarded nitrogen with alpha particles and converted it to hydrogen and oxygen. In 1980, the U.S. Department of Energy began to look at strategies for high-level radioactive waste management, including transmutation of waste to a more benign form, and selected mined geologic disposal as the approach for waste isolation in the U.S. (presuming reprocessing of spent nuclear fuel and waste form optimization would occur first).

In June 1991, a 19-member interdisciplinary committee sponsored by the U.S. government felt that any transmutation process would not eliminate the need for a high-level radioactive waste repository and would be less economically attractive than the current once-through fuel cycle. They recommended that any research undertaken by the U.S. should be modest.

In defense of the committee, they acknowledged that accelerator-driven transmutation systems were in a far less developed state than those of light-water and liquid-metal fission reactors they evaluated. In fact, the system they reviewed was changed so significantly that the accelerator-driven transmutation concept was reviewed again in 1998 by the Nuclear Engineering Department of the Massachusetts Institute of Technology which included some of the original committee reviewers.

The previous design reviewed by the committee used a critical nuclear assembly, a thermal neutron spectrum, liquid fuels, molten salt, and centrifuge separations. The current design has evolved significantly and now uses a subcritical assembly, a fast neutron spectrum, liquid lead-bismuth coolant and spallation target, solid fuel, and pyrochemical processing.

As discussed in this paper, the current design has matured to the point that it is now based on engineered concepts as opposed to its 1991 predecessor. There is much optimism among eight national laboratories and many at research universities that the interfacing of the ADTT's complex engineered components is achievable. Unfortunately, the U.S. Congress did not provide the necessary funding to support the required research in 1998 and 1999.

In 1998, the U.S. Congress did mandate that a roadmap for the development of accelerator transmutation of waste be prepared. The method and results of these investigations will be reviewed.

The success of accelerator-driven transmutation technology will have a great impact on the State of Nevada more so than any other state because it will greatly mitigate the hazards of the proposed Yucca Mountain repository. Living in the host state and the communities most likely to be affected by a high-level radioactive waste repository, Nevadans have shown a remarkable interest in this technology and may be on the front lines fighting for its funding and success.