THORIUM CYCLE AS A WASTE MANAGEMENT OPTION

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Abstract

As part of the European Union Fourth Framework Programme on “New Concepts” an investigation is made on the thorium cycle from the perspective of nuclear waste minimisation. The objective of the work is a re-assessment of thorium cycles in the context of limitation of nuclear waste production and prospects for waste burning. The aim is to obtain a review of the major steps of the fuel cycle, focusing to the waste aspect. A restriction is made to European reactor types: PWR and FBR and the Fast Energy Amplifier (FEA).

A number of six working packages has been defined, including: 1. Mining, 2. Fuel fabrication, 3. Reactor Assessments, 4. Reprocessing, 5. Residual risks of disposal, 6. Non-proliferation aspects. This 3-years programme is in the final stage.

The results of the above-mentioned working packages are discussed. A synthesis of the results shows that there are important advantages of thorium cycles with respect to the waste issue. Long-lived radiotoxicity of mining waste is expected to be relatively small, which leads to more manageable waste. Fabrication of Th fuels is comparable with MOX fabrication methods as long as fresh Th, U and recycled Pu are used. Recycling of U, however, needs remote handling. Open cycles are possible in PWRs, but require make-up fuel. To reduce the radiotoxicity of PWR waste, make-up fuel like ^{233}U or highly-enriched ^{235}U should be added to Th. Advantages are seen during the first 10,000 years of storage. The long-term risk of directly stored fuel in a thorium matrix is still not known very well, but there are speculations on improved performance. Further experimental work is needed to clarify this point. Recycling gives a further reduction of radiotoxicity up to 10,000 to 50,000 years of storage.

Th-assisted Pu burning in a PWR is an attractive option with respect to mass reduction of Pu, which could be twice that of U/Pu MOX in a 100% core loading. In open cycles the produced ^{233}U is somewhat disturbing from the point of view of proliferation; spiking with ^{238}U could help. For all scenarios a quantitative non-proliferation metric is developed.

Fast reactors and accelerator-driven systems, like FEA, offer the possibility of a closed Th cycle without make-up fuel, reducing mining needs and risks. Full recycling of actinides gives impressively low radiotoxicity results. Initially, these systems could be used for Th-assisted Pu-burning and simultaneous ^{233}U breeding, providing fuel for a new generation of low-actinide-waste producing energy systems.

It is expected and recommended that the introduction of the thorium cycle will be realised in steps. A recommended first step could be once-through Pu-burning in LWRs with a mixture of thorium and plutonium oxide. To this end an irradiation experiment has been proposed and further work on nuclear and thermodynamic data.