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Plans in the Netherlands to study incineration of nuclear waste

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Since the end of 1989, ECN renewed its interest in incineration of transuranium elements and fission products. With respect to the transmutation of minor actinides ECN was requested by the clutch government to start a study of a scenario based upon thermal reactors and to work on incineration by means of new fast reactor designs. There are also plans for a study on the possible use of accelerators for this purpose. These plans are preliminary, but worth mentioning in relation with the subject of this meeting.

Many experimental and technical aspects of present studies of the LWR-FR based approach, are relevant to accelerator based methods of incineration, to reduce the hazard of radioactivity in waste. Irradiations at the Petten-HFR of the European Joint Research Institute, could simulate a fast neutron spectrum (up to 10 MeV) by removing the thermal neutrons with boron and cadmium absorbers. Experimental studies, which are related to research on Np- Am-and Cm- bearing fuel, as well as the evaluation of cross-sections, reactor physics and transport codes are planned or in progress.

In connection with earlier nuclear physics experiments of the FOM-ECN nuclear structure group, the possibility to polarize nuclei of Np-237 and other actinides has been proven. Experiments at high-energy polarized neutron beams, would enable the solution of some fundamental nuclear physics problems regarding spin dependence of cross-sections . At present possibilities are being investigated.

Contributions of ECN, specific to accelerator based incineration are considered in the field of cross-sections, and transport-codes for high-energy neutrons. Regarding accelerator based methods, it is clear that the transmutation rate is high in theory, but that the technical feasibility has not yet been proven. Spallation in a high-energy (1000 MeV) proton beam will produce many (10-30) neutrons per spallation, with an energy spectrum in the 0-100 MeV range. In such a spectrum fission will occur and minor actinides might be incinerated with a high rate. A program of measurements in an experimental study, would involve calculation of neutron flux spectra, metrology requirements, and post irradiation examinations. Collaboration with groups, specialized in high energy-accelerator research is sought for.

Experimental research on neutrons from a spallation source will be of interest. When these neutrons are thermalized, it might become economically feasible to breed Pu-239 in u-238 blankets (see for example ref.1) and even direct breeding of u-233 by the irradiation of Th-232 with 800 MeV protons has been reported2) . Breeding of U-233, is also an option for making extra gains from actinides, in a scenario, which has been suggested by Weinberg to be easy to incorporate in a system of safeguards) .

Three different scenarios, which are based on LWR, FR, and high-energy accelerators respectively, are not so much felt as different alternatives, but rather as complementary. This can be illustrated on four radio-isotopes: The chemically mobile and long lived radio-isotopes such as Tc-99, 1-129, and Np-237, which pose a long-term problem, and the Cm-244, which presents a short-term problem:

Whereas the possibility to incinerate Tc-99 and 1-129 in an intense neutron field of an HFR ought to be studied, the heterogeneous recycling of for instance Np-237 in a thermal neutron field would on the short term only increase the radio-toxicity by production of Pu-238 after capture of slow neutrons. In case that this short-living Pu-238, is not soon transmuted for example by capture of another neutron, it decays in long lived (natural but bothersome) U-234 . So it seems that Np-237, which is not the most toxic actinide but which still presents a long-term hazard, would be a good candidate for a high energy-accelerator based transmutation. It seems that the toxic Cm-244 should be transmuted in special fast reactors . This technology is well established, and although high power accelerator technology in general shows a high transmutation rate, fast reactor irradiation may be more economic.

Finally also KEMA, the research institute of the Dutch electricity utilities, is actively planning experimental research on the subject of transmutation. Current ideas involve the experimental determination of the inventory of a target irradiated with either protons or with fast neutrons from a nuclear reactor. Existing equipment i.e. high-temperature mass spectrometry an micro-tomography may be used.

References

1. Proceedings of the Workshop on “Partitioning and transmutation of minor actinides” Karlsruhe, 16-18 October 1989.
2. J.S. Gilmore et al, Nucl. Science and Engineering 99, 41 (1988) .
3. A.M. Weinberg “Nuclear energy and proliferation: a longer perspective” in A.M.Weinberg, M. Alfonso and J.N. Barkenbus, eds, The nuclear connection: a Reassessment of nuclear Power and Nuclear Proliferation, Paragon House Publ., New York, 1985, 221.