NUCLEAR WASTE MINIMISATION USING INNOVATIVE LWR-HTR-GCFR SYMBIOTIC FUEL CYCLES

N. Cerullo[1,2], G. Lomonaco[3] and V. Romanello[2]

[1]Energy and Environmental Conditioning Department (DITEC) - University of Genova
via all'Opera Pia n. 15/a - I-16145 Genova - ITALY
[2]Department of Mechanical, Nuclear and Production Engineering (DIMNP) - University of Pisa
via Diotisalvi n. 2 - I-56126 Pisa - ITALY
[3]Department of Energetic - University of Pisa
via Diotisalvi n. 2 - I-56126 Pisa - ITALY
e-mails: cerullo@ditec.unige.it
cerullo@docenti.ing.unipi.it

Abstract

Nuclear energy is today a cheap, abundant and convenient source; in fact it is more and more widespread all over the world. However, considering that a large size LWR (1000 MW_e) produces annually about 30 tons of high level waste (of which about 2.5 tons of plutonium and about 250 kg of minor actinides) it is mandatory to reduce actinides amount in final nuclear waste. In fact these products, due to their high radiotoxicity (which drops back to the level of original uranium ore only after time longer than 200000 years) and very long decay chains represent a heavy heredity for the future generations.

In this frame we studied symbiotic fuel cycles coupling initially current LWRs with HTRs and finally closing the cycle by using, as a new option, the GCFRs (Gas Cooled Fast Reactors). Particularly we analyzed the capability to burn actinides trough Pu-Th fuel cycle: thorium is in fact much more abundant on earth surface than uranium (about 2.5 times), but is fertile (so non directly fissionable), and it can be used in addition with fissile Pu (deriving from LWR exhaust fuel) to produce a great quantity of energy while reducing the actinides produced in LWRs (in terms of both radiotoxicity and volume). In conclusion we improved plutonium exploitation by optimizing Pu/Th ratios in the fuel loaded in a pebble bed HTR: the obtained results showed that Pu can be significantly reduced. Then we used GCFRs to burn minor actinides and remaining Pu (which are the greatest contributors to radiotoxic inventory).

Considering the positive characteristics of HTR in terms of waste burning due to their excellent neutronic economy, and coupling it with GCFR (fast neutronic spectrum and high fluence), the geological disposal issues concerning high level radiotoxicity of actinides can be considerably lightened.