ASSESSMENT OF THE TRANSMUTATION CAPABILITY OF AN ACCELERATOR DRIVEN SYSTEM COOLED BY LEAD BISMUTH EUTECTIC ALLOY

F. Bianchi(1), V. Peluso(1), R. Calabrese(1), X. Chen(2), W. Maschek(2)
(1) ENEA - Italian National Agency for New Technologies, Energy and the Environment, Via Martiri di Monte Sole 4, 40129 Bologna (Italy)
(2) FZK - Research Centre Karlsruhe, D-76021 Karlsruhe (Germany)
E-mail: *fosco.bianchi@bologna.enea.it*

ABSTRACT

1. PURPOSE

The reduction of long-lived fission products (LLFP) and minor actinides (MA) is a key point for the public acceptability and economy of nuclear energy. In principle, any nuclear fast reactor is able to burn and transmute MA, but the amount of MA content has to be limited a few percent, having unfavourable consequences on the coolant void reactivity, Doppler effect, and delayed neutron fraction, and therefore on the dynamic behaviour and control. Accelerator Driven Systems (ADS) are instead able to safely burn and/or transmute a large quantity of actinides and LLFP, as they do not rely on delayed neutrons for control or power change and the reactivity feedbacks have very little importance during accidents. Such systems are very innovative being based on the coupling of an accelerator with a subcritical system by means of a target system, where the neutronic source needed to maintain the neutron reaction chain is produced by spallation reactions. To this end the PDS-XADS (Preliminary Design Studies on an experimental Accelerator Driven System) project was funded by the European Community in the 5th Framework Program in order both to demonstrate the feasibility of the coupling between an accelerator and a sub-critical core loaded with standard MOX fuel and to investigate the transmutation capability in order to achieve values suitable for an Industrial Scale Transmuter. This paper summarizes and compares the results of neutronic calculations aimed at evauating the transmutation capability of cores cooled by Lead-Bismuth Eutectic alloy and loaded with assemblies based on (Pu, Am, Cm) oxide dispersed in a molybdenum metal (CERMET) or magnesia (CERCER) matrices. It also describes the constraints considered in the design of such cores and describes the thermo-mechanical behaviour of these innovative fuels along the cycle.

2. DESCRIPTION OF THE WORK

The U-free composite fuels (CERMET and CERCER) were selected for this study, being considered at European level the most promising among the various technologies foreseen for designing ADS core with enhanced waste transmutation. The neutronic calculations were performed with a special ERANOS Procedure (MECONG) that utilizes a RZ core models for the description of the core geometry and represents the various regions in homogeneous manner. A multi-recycling scenario was hypothesized and a proper amount of plutonium and minor actinides was supplied at the beginning of each cycle in order to ensure the same operating reactivity (keff=0.97). Moreover some core design parameters were changed in order to investigate the capability of such cores to burn/transmute MA with acceptable safety features. The behaviour of fuels pin during the cycle in terms of fuel temperature, internal pressure, stresses and strains was investigated by using TRANSURANUS code.

3 RESULTS AND CONCLUSIONS

The preliminary analysis shows that a good compromise between transmutation and core performance can be achieved for both fuels increasing the core power. Of course the increase of the core size has a significant implication on the overall plant architecture, in particular on accelerator and spallation module.