CERMET FUEL BEHAVIOUR AND PROPERTIES IN ADS REACTORS

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ABSTRACT

Within the EUROTRANS Integrated Project co- financed within the 6th Framework Programme of the European commission, the sub-critical Accelerator Driven System (ADS) is now being considered as a potential means to burn long-lived transuranium nuclides. Within the EUROTRANS Programme, the domain AFTRA is responsible to develop and provide the data basis for the fuels to be used in the European Facility for Industrial Transmutation (EFIT). The preferred fuel for such a fast neutron reactor is uranium-free, highly enriched with plutonium and minor actinides. Requirements for ADS transmuter fuels are strongly linked with the core design and safety parameters, the fuel properties and the ease of fabrication and reprocessing. This study concerns the behaviour and properties of fuels with molybdenum as inert matrix. The status of the development work was presented at the last ICENES conference [1]. Since then, the design of the European Facility for Industrial Transmutation (EFIT) was developed and the transmutation capability, the burn-up behaviour, the reactivity swing and power peaking factors, and the safety performance were determined for different cores with inert matrix fuels like MgO and Mo. For the EFIT, the CERMET with the Mo matrix is recommended as the reference fuel and CERCER with the MgO matrix as a back-up solution. The thermal diffusivity and specific heat of the CERMET fuels (loaded with Pu and Am) were measured, and the thermal conductivity was deduced. The thermal conductivity of the CERMET fuels was also predicted using a model proposed in [1], with a microstructure corresponding to a random distribution of spheres, with overlapping. This model microstructure takes into account the negative effects arising from the possible formation of small agglomerates of inclusions in the CERMET fuels. The agreement between the theoretical and calculated values is relatively good (the error is between 0 and 15% of the value of the thermal conductivity).Irradiation programmes are in the final stage of preparation (and will start in 2007) to determine the in-reactor performance of the material. CERMET fuel pins are incorporated in two experiments:

- Two pins will be loaded in the PHENIX reactor in Marcoule, within the FUTURIX FTA experiment [2]. These fuels have been fabricated at ITU in 2005-2006, according to the reference fabrication process in the Minor Actinide Laboratory, namely the infiltration of minor actinide solution in solid particles. These fuels have been fully characterised in terms of pellet structure, thermal properties, re-sintering behaviour, etc...The aim of the experiment is the investigation of the fuel behaviour under high fast neutron flux condition, and its comparison with other fuel types (CERCER, nitride and metallic).The completion of the irradiation is foreseen in 2009.

- Two further CERMET fuel pins will be irradiated in the HFR reactor in Petten: the HELIOS experiment [3]. There the aim is the study of the gas (including Helium, produced by Am241 transmutation chain) production and release, in comparison with Am targets supported in a pure zirconia matrix. The post-irradiation examinations to be performed after 10 irradiation cycles will be concluded in 2009.

Safety studies for optimised EFIT core designs, developed within the AFTRA domain were performed. The safety coefficients and indicators were determined for each core, and various transients were investigated. For the new low power cores of EFIT with a power class of ~ 400 MWth and a fuel power density of ~ 250 MW/m^3 it can be demonstrated that the CERMET cores behave favourably and the design limits of the fuels are not violated [4]. Results indicate that the T91 cladding used as clad more severely restricts possible design options. This report will present the status of the neutronic and safety studies for the EFIT core, the CERMET thermal properties determination results, as well as the final results of the fabrication, characterisation and irradiation conditions in these two new fuel irradiation experiments.

References

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