Background

The EUROTRANS project is an integrated project in the 6th European Framework Program in the context of Partitioning and Transmutation (P&T). The objective of this project is the step-wise approach to a European Transmutation Demonstration. This project aims to deliver an advanced design of a small-scale Accelerator Driven System (ADS), XT-ADS, as well as the conceptual design of a European Facility for Industrial Transmutation (EFIT). The partners of this project accepted to use the MYRRHA "Draft-2" design file as a starting basis for the design of the short-term XT-ADS demonstration machine. Instead of starting from a blank page, this allowed optimising an existing design towards the needs of XT-ADS, and this within the accepted limits of the safety requirements. Many options have been revisited and the framework is now set up.

Objectives

The main two objectives of the XT-ADS machine are the following: to demonstrate the feasibility of the ADS concept and its performance as a multi-purpose irradiation facility. Special attention is paid to the possibility of testing fuel dedicated to transmutation of minor actinides and long-lived fission products. During the demonstration phase, the core will be loaded with MOX fuel in a "clean core" configuration. Since the XT-ADS must be a representative prototype, it has to operate at a reasonable power, a minimum of 50 MW_{th} was set in the objectives. After this phase, the core will house In-Pile-Sections of different types for irradiating material samples and new types of fuel pins. We aim to be able to provide irradiation conditions that are close to EFIT conditions so that XT-ADS can be used as a test-bed for EFIT parts.

Principal results

The main part of the work has been done in the framework of the so-called TaskForce: a group of scientists working in the different work packages of the project. In this way, different options were investigated by a team of reactor physicists, reactor safety engineers, mechanical engineers and material scientists.

A first issue that received much attention in the TaskForce is the damage the different structural components undergo due to the neutron irradiation. In particular, the core vessel and core top grid plate are two components very close to the reactor core. The displacement-per-atom (dpa) was calculated in both the clean core and core loaded with In-Pile-Positions conditions. Combining these results with the temperature and stress distribution in these components led the TaskForce to the advice to enlarge the original core by two extra rows. Effects on the core performance of loading these rows with boron carbide pellets and steel to increase the shielding were too penalising. But already the effect of adding two extra rows, i.e. a larger amount of lead-bismuth coolant between the last ring filled with fuel elements and the core vessel, was sufficient to reduce the damage in this core vessel. Figure 1 shows this new core layout. The core contains the original 99 positions and 84 extra positions summing up to a total of 183 positions.

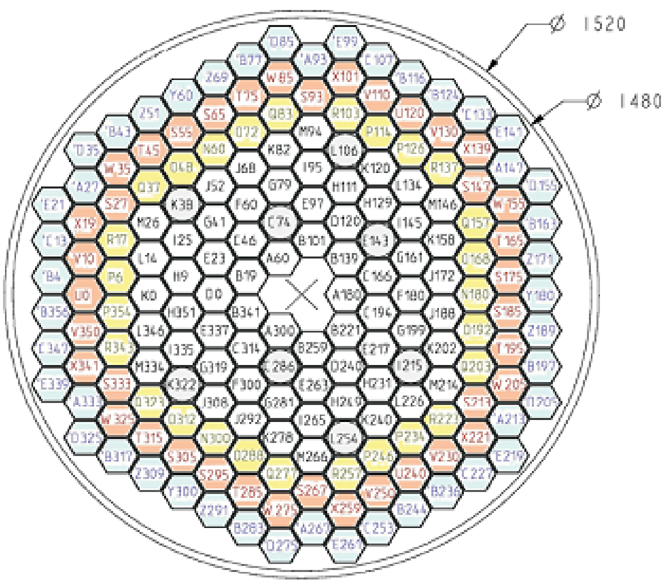

Figure 1: core layout of XT-ADS

Using the clean core configuration as a basis, a core configuration was set-up in which for eight positions the fuel assembly has been replaced by an In-Pile-Section (IPS). In Figure 2 you can see the core layout with eight IPS positions. These In-Pile-Sections are accessible from above by a penetration through the reactor cover. In this way, these In-Pile-Sections can be used to insert, for example, loops providing an environment (temperature, surrounding material, pressure) which is different than the reactor coolant environment. This allows MYRRHA/XT-ADS to house experiments of different types. To have a general idea on the impact of the presence of these In-Pile-Sections on the reactor core (reactivity loss, neutron fluxes at the positions), the Task Force proposed four generic designs: two designs containing only non-fissile material (steel rods to be irradiated) and two designs containing fuel pins (for fuel testing in the framework of a fuel qualification programme). Figure 3a and 3b show these generic elements.

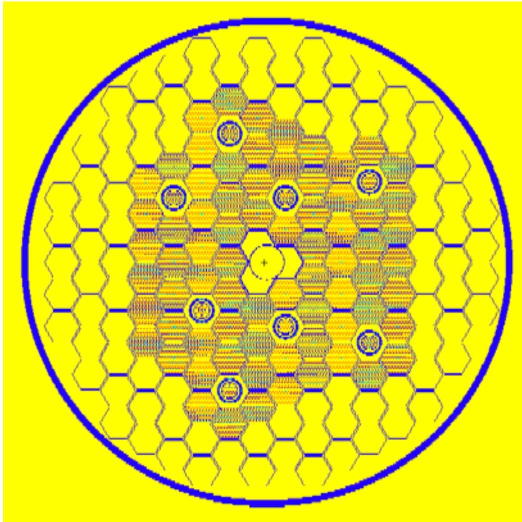

Figure 2: A core loaded with 8 IPSs

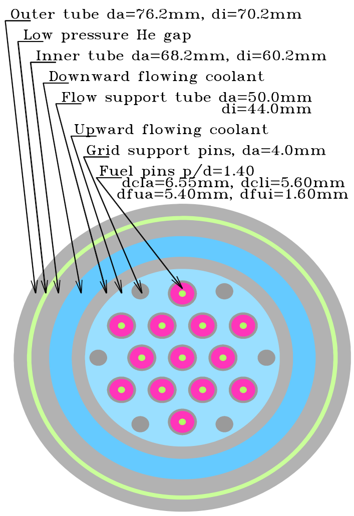

Figure 3a: IPS with fuel pins

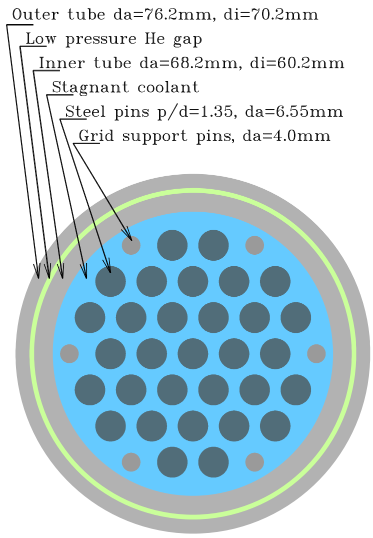

Figure 3b: IPS with steel samples

Finally, the TaskForce initiated a first series of burn-up calculations to study the neutronic behaviour of the core during the foreseen cycle. The k_{eff}-drop was calculated, together with other important parameters like the change in Doppler and moderator temperature coefficient and the effect of core compaction. These calculations were done in a simplified manner using an equilibrium cycle approach.

Future work

In the coming months, the neutronic calculations for the reference cases should be finalized. In parallel, a loading scheme for the first cycles should be calculated.

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Main reference

G. Van den Eynde et al., Neutronic design of the XT-ADS core with In-Pile-Positions, HPPA5 conference proceedings, Mol 2007