TECHNICAL SESSION VI – SUMMARY
Transmutation Systems (Critical and Sub-critical): Design and Safety

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Papers presented: 19

Most papers are related to reactors at conceptual or preliminary design stage in critical or subcritical configuration, intended to fission actinides and to transmute long-lived fission products: it appears that a great number of options are still under evaluation and that accelerator-driven test facilities are proposed for construction in the short term, relying as much as possible on existing installations.

Safety of accelerator-driven systems has also been largely dealt with in several papers.

The following basic options/topics have been considered in the session:

Neutronic

Reactors in critical as well as subcritical configuration have been presented, in general with fast spectrum. An approach to the determination of the operational subcritical level of an 80 MW lead-bismuth-cooled, pool-type ADS has been proposed, which, basing on the results of the safety analysis, excludes criticality while demanding reasonable accelerator performances.

Primary coolant

While Pb-Bi is the preferred target material, it is also mostly selected as the primary coolant for the subcritical reactor. Use of Pb-Bi as well as Na, gas or molten salts is proposed for critical reactors.

Fuel

Proven MOX fuel is proposed for Demo Plants. More advanced fuels are also considered and their potentialities investigated: metallic thorium-based fuels, mixed uranium-transuranics carbide, molten-salts containing Pu and MA, nitride fuels.

Target

Liquid Pb-Bi or solid tungsten cooled by sodium are under consideration as the target material.

Pb-Bi is proposed both for the window and the windowless target units.

The window target unit is the reference solution worldwide. In Europe, however, two Pb-Bi cooled ADS designs propose the windowless target unit, a solution which exempts from the need to develop and test materials able to withstand irradiation from high-energy protons.

Power level

Power level ranges from the 40 MW of MYRRHA and the 80 MW of the eXperimental Accelerator-Driven System (XADS), currently under study in the frame of the 5th European Framework Programme, to the 100 MW of the Accelerator-driven Test Facility (ADTF) proposed in the frame of the U.S. Advanced Accelerator Application (AAA), and to the 1 000 MW of the Korean Hybrid Power Extraction Reactor (HYPER).

Safety aspects

A comparative analysis between Na and Pb-Bi cooled reactors shows the advantage of the Pb-Bi in case of unprotected loss of flow scenarios, indicating that with a proper design it would be possible to provide sufficiently high natural circulation cooling capability of the reactor core to prevent cladding and fuel overheating. This is confirmed by the safety analysis made on the basis of a detailed plant design and RELAP model simulations presented for the 80 MW European PDS XADS cooled by Pb-Bi.

Design aspects

In USA emphasis is put on the spallation target technology. In Europe a great effort is being made on the system integration of accelerator, target unit and sub-critical system: in particular the impact of the Target Unit on the Core and Primary System design as well as on the Fuel and Primary Component Handling System is object of detailed study.

Future (short-term) experimental facilities

Two papers propose facilities (SAD and TRADE) able to provide in short term valuable data for implementation in large-scale designs.

SAD can make use of an existing accelerator and can provide fast neutron flux, but no reactivity feedback owing to the low power density (big core and low power, ≈20 kW).

TRADE can make use of an existing core, and cannot provide fast flux, but reactivity feedback can be tested. In TRADE, experimental investigations can be performed over a wide range of core power (till about 0.5 MW) and sub-criticality from in “source dominated” deeply sub-critical configurations to “core dominated “ near criticality configurations when the standard feedback effects are dominant.