FLEXIBILITY OF CO_2 COOLED FAST REACTORS FOR PLUTONIUM AND MINOR ACTINIDE MANAGEMENT

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Summary

In recent years there has been increased interest in gas cooled fast reactor systems for the management of plutonium and minor actinides. Gas-cooled fast reactors have a number of advantages over liquid metal fuelled concepts. There are obvious safety, economic and technical advantages of using a relatively benign, readily available and optically transparent, gaseous coolant which is compatible with both air and water, compared to sodium which reacts explosively with water and requires specialist handling and disposal. The absence of a significant positive coolant void reactivity effect in gas-cooled cores compared to LMFBRs also allows the potential for loading greater quantities of minor actinide isotopes. Loading large quantities of minor actinide isotopes into sodium cooled cores has been shown to lead to unacceptably large positive coolant void effects. An additional attractive feature of gas-cooling over sodium cooling, in terms of minor actinide incineration, is the harder neutron spectrum of gas-cooled cores.

Drawing on the extensive UK experience gained in the successful design and operation of the Advanced Gas Reactors (AGRs) coupled with the experience gained from the design of the liquid metal fast reactors and earlier UK designs of gas-cooled fast reactors, a number of different gas-cooled fast reactor systems ranging from a conventional, plutonium burning, design based on existing technology to a dedicated minor actinide burning system have been investigated. The potential of a gas-cooled fast breeder reactor has also been demonstrated.

This paper reviews the main, representative, core designs considered to date concentrating on the core physics and safety aspects particularly in terms of plutonium and minor actinide management. In this context the advantages of gas-cooling over sodium cooling are highlighted. Three basic designs are considered in some detail.

i) A conventional core design which has been optimised for plutonium burning and utilises conventional MOX fuel pellets. The steel diluent sub-assemblies in the inner core region for this concept allow scope for balancing the enrichment levels in the inner and outer core regions which is advantageous in increasing the overall plutonium burning, whilst also producing a relatively flat power profile across the core.

ii) A dedicated minor actinide burning concept, fuelled mainly with minor actinides and only sufficient plutonium to obtain criticality. This concept utilises nitride fuel coupled with a zirconium hydride moderator.

iii) A core design optimised for plutonium breeding. This concept is based on conventional MOX fuelled pins and incorporates both axial and radial breeder blankets.

All the designs considered are for commercial sizes reactors with a thermal power output of 3600 MW, comparable to the European Fast Reactor (EFR).

The studies have considered core design, core performance, safety parameters, and preliminary transient studies and have demonstrated the significant flexibility of gas-cooled fast reactors towards fuel and fuel cycle utilisation.