Establishment of the Small Reactor Concept and Development of Related Innovative Technology

Background

Research and development on a small reactor designed for high safety (a 4S reactor: Super-Safe, Small and Simple Reactor, Fig.1) has been conducted by CRIEPI since 1988. In addition, research and development on the reflector-controlled core adopted for 4S reactor, such as the core neutronics, the thermal-hydraulics of fuel sub-assembly, the irradiation characteristics of the structural materials, the reflector driving mechanism, and so forth, has been entrusted to CRIEPI by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) since 2002.

The 4S reactor is a sodium-cooled small metallic fuel fast reactor with the advantages of high safety, high proliferation resistance, and a long period between refuelings. It is also expected to be a multi-purpose energy sources to provide electricity and drinking and agricultural water to improve the standard of living in developing areas. In addition to the research and the development for the 4S reactor, preparations for initiating the licensing procedure for it in US are now underway.

Objectives

The objectives of this study are to develop the fundamental technology and to produce detailed designs for reactor systems with electrical outputs of 10 MW and 50 MW to be licensed based on the developed technologies.

Principal Results

1. Concept of the small reactor

Two 4S reactor systems have been designed, one with an electrical output of 10 MW and a 30-years non-refueling core, and one with an electrical output of 50 MW with a 10-years-between-refuelings core (Table 1). For both designs, a high degree of safety has been determined by plant dynamic analyses. That is, there is little possibility of a reactor core damage accident and the reactor can be cooled passively in the event of a failure of the active decay heat removal system.

2. Development of fundamental technology

(1) In order to establish the evaluation technology for the neutronics of the reflector-controlled core, a series of critical experiments has been conducted at the fast critical facility (FCA) of the Japan Atomic Energy Research Institute - Tokai, and the results are analyzed to evaluate and improve the predictive accuracy of conventional calculation methods. Initial criticality of the reference core, Fig.2, was achieved in July 2004. Experimental data essential for the establishment of evaluation technology for the neutronics have been obtained, such as the effect of neutron leakage from the core.

(2) A full bundle mock-up water test with a reactor-size sub-assembly has been conducted (Fig.3). The target pressure loss of less than 0.2 MPa has been met. It is confirmed that this long-life core with its high fuel volume fraction has sufficient natural circulation in case of an accident.

In the present study, the "Development of fundamental technology" is the result of the "Development of Advanced Controlling System for Non-Refueling Reactor Core" in fiscal years 2003 and 2004 entrusted by Ministry of Education, Culture, Sports, Science and Technology (MEXT) to CRIEPI.

Future Developments

CRIEPI will apply for a pre-application review by the US Nuclear Regulatory Commission in cooperation with TOSHIBA in Japanese fiscal year 2005. Therefore, based on the technical data, the application documents are being prepared.

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Reference

Reports titled "Development of Advanced Controlling System for Non-Refueling Reactor Core", performed as a part of the Innovative Nuclear Energy System Technology Development of the Ministry of Education, Culture, Sports, Science and Technology in Japanese fiscal year of 2003 and 2004 (in Japanese)

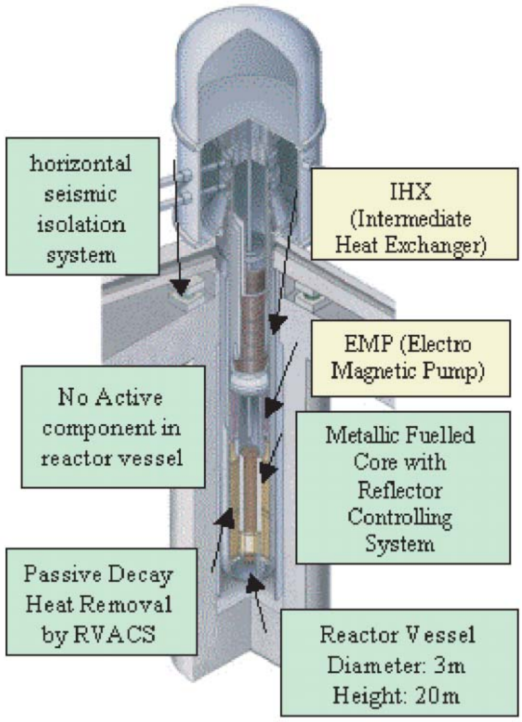

Fig.1 Reactor structure

Table 1 Main specifications of 4S reactor

Electric Output	50MWe	10MWe
Thermal Output	135MW	30MW
Primary Temp. Secondary Temp. Steam Condition	355/510°C 310/475°C 453°C/107ata	
Core life time Plant life time	10 years 30 years	30 years 30 years
Effective core dia. Core height Reflector thickness	1.2m 1.0m/1.5m 300mm	0.68m 2.0m 200mm
Fuel	U-Pu-Zr Alloy	
Ave. Burn-up	70GWD/ton	76 GWD/ton
Pu Enrichment	17.5w%HM(Inner) 20.0w%HM(Outer)	24.0w%HM(Inner) 24.0w%HM(Outer)
Max. linear heat rate	250W/cm	110 W/cm
Conversion ratio	0.7	0.6
Primary Pump	Series arrangement of two EMPs	
IHX	Shell & tube type: 1 unit	
Secondary Pump	EMP: 1 unit	
SG	Double tube wall helical coil type: 1 unit	

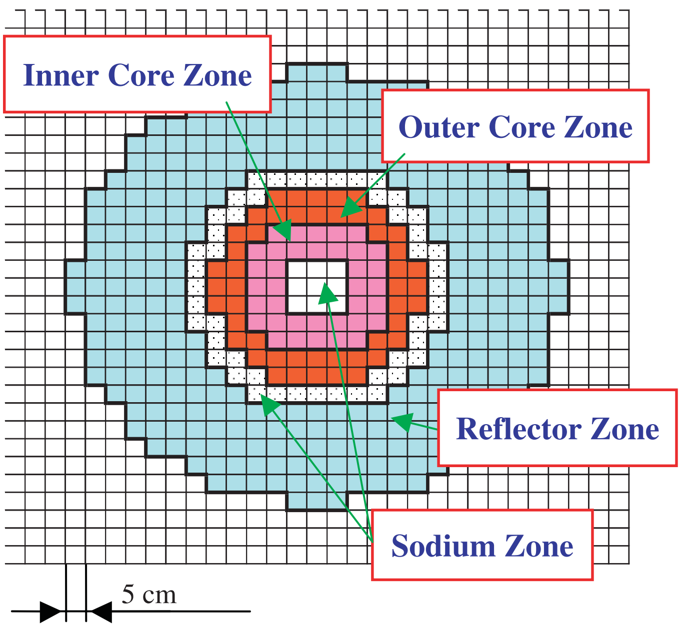

Fig.2 Core configuration of JAERI fast critical facility, FCA

Fig.3 Testsection of full mock-up fuel sub-assembly water test
(Length of sub-assembly: 5.0m)