The Sodium Cooled Small Sealed Fast Reactor (4S) with Non-refueling

Background

CRIEPI has been developing the small fast reactor (4S) with high safety since 1988. The core of the 4S doesn't receive severe damage under ATWS (Anticipated Transient Without Scram) accidents because of it's negative reactivity coefficients (passive reactor shutdown). The core can be cooled with the decay heat removal system (DHRS) using the natural circulation force under the PLOHS (Protected Loss Of Heat removal System) event (passive heat removing).

It is thought that this small fast reactor can contribute to a multipurpose utilization of nuclear power like the power supply, heat supply, and desalting of seawater, etc. in regions like islands where the power transmission infrastructure cannot be maintained enough, and can become a powerful option of regional symbiosis energy in the future.

High proliferation resistance, a tenability as the energy source and a considerable decrease of the core damage frequency are requested as the Generation-IV reactors proposed by United States Department of Energy (DOE) in 2000.

If the core lifetime is extended while maintaining safety features such as passive shutdown and passive heat removal of 4S, and the sealed reactor concept of non-refueling can be constructed, construction of the nuclear reactor concept meeting the above-mentioned demand requirement can be expected.

When the core lifetime is extended maintaining the safety characteristics, the shortage of the worth of the reflector in comparison with burn-up reactivity loss is a large problem. Additionally, it is necessary to overcome the scale disadvantage that is a common problem to small reactors, and to suppress the construction cost.

Objectives

To extend the core lifetime to 30 years from 10 years while maintaining the excellent characteristics of 4S. To construct a new 4S concept without refueling.

Principal Results

(1) Core

Hexagonal core barrel was adopted and the reflectors were arranged at the position near the fuel assembly, as a result, a relative increase in the reflector worth was achieved(Fig.1). Additionally, the required reflector worth was decreased by adopting a fixed absorber. A core concept of the electric output 10MW was constructed from the design study by the neutron transportation calculation code based on the Monte Carlo method under the following conditions; "30-year core lifetime", "the temperature reactivity coefficients including the void reactivity coefficient are negative during core lifetime".

(2) Cooling system and building

Loop type cooling system was adopted for the miniaturization of the reactor vessel and the physical superiority reduction of the nuclear reactor system (Fig.2). The cooling system was designed by one loop, and composed of the integrated equipment that included the primary and secondary electromagnetic pumps (EMPs), intermediate heat exchanger (IHX) and steam generator (SG). The DHRS was designed as the combination of RVACS [*1] and SGACS [*3], as a result, the simplification of equipment could be expected compared with the combination of RAVCS and PRACS [*2] adopted in conventional 4S.

It was confirmed that new 4S has the characteristics of passive shutdown and passive heat removal the same as a conventional 4S by the evaluations with the plant transient analysis code CERES.

Air cooler of the PRACS, which gives a large impact to the reactor building size, was eliminated. Reactor vessel and the integrated equipment were arranged at same elevation. As a result, the reactor building became compact(22m x 16m、Height 11m、Fig.3).

The concept of a sealed small fast reactor of 10MW with 30-year core lifetime and non-refueling was constructed by these studies(Table.1).

Future Developments

Evaluation of comparison with the tank type system and the evaluation concerning the merchantability will be performed.

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Reference

Y. Nishi, et al., 2004, "The Sodium Cooled Small sealed Fast Reactor (4S) with non-refueling", CRIEPI Report T03058 (in Japanese)

Y. Nishi, et al., 2004, "A New Concept of the 4S Reactor and Thermal Hydraulic Characteristics", Proc. of the ICONE12, ICONE12-49257

＊1：Reactor Vessel Auxiliary Cooling System
＊2：Primary Reactor Auxiliary Cooling System
＊3：SG vessel Auxiliary Cooling System

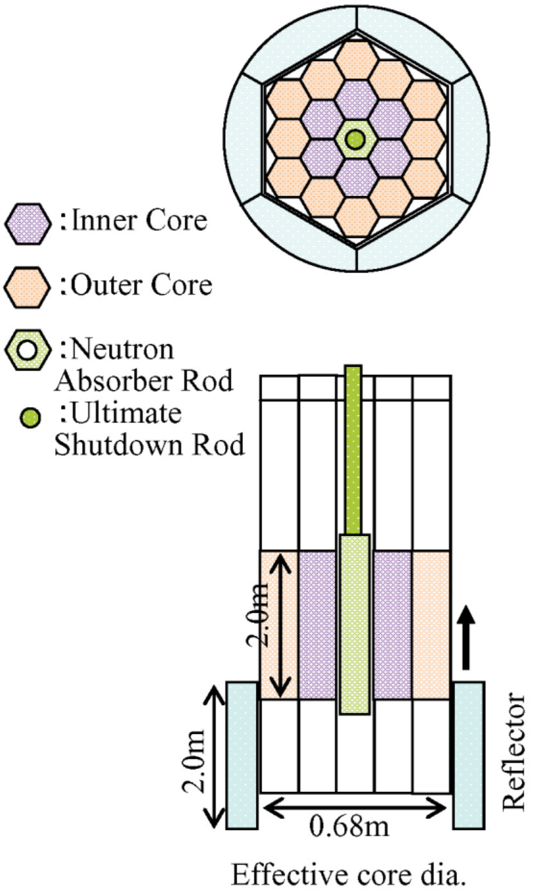

Fig.1 Core Concept

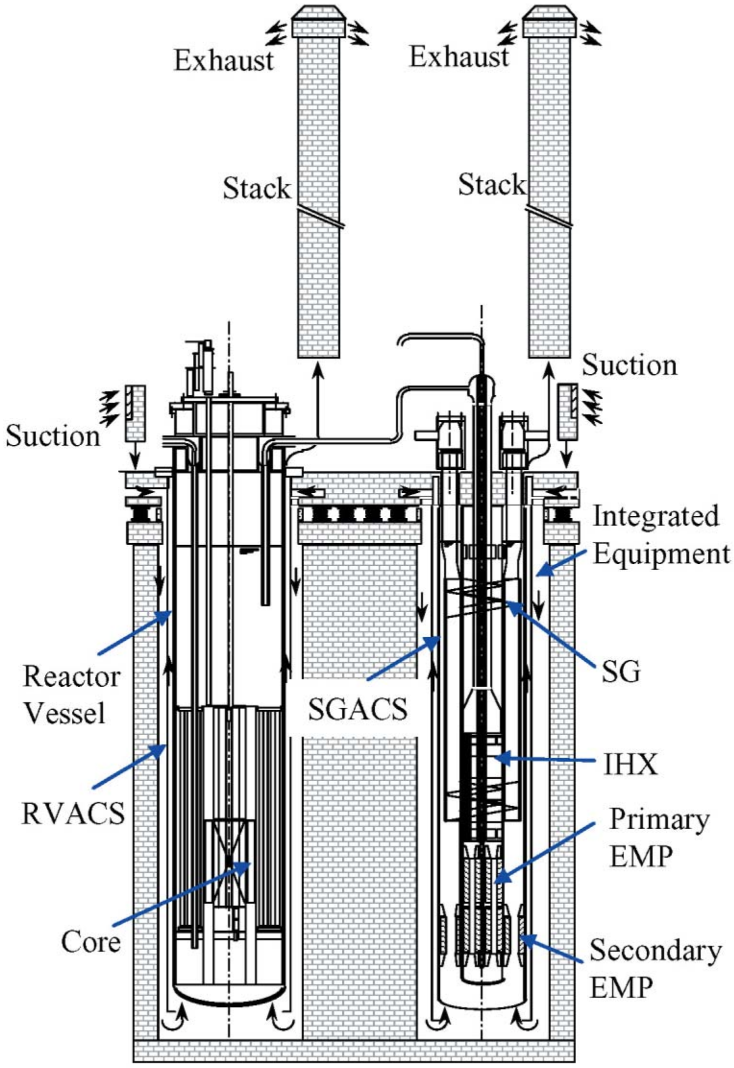

Fig.2 Concept of the Reactor System

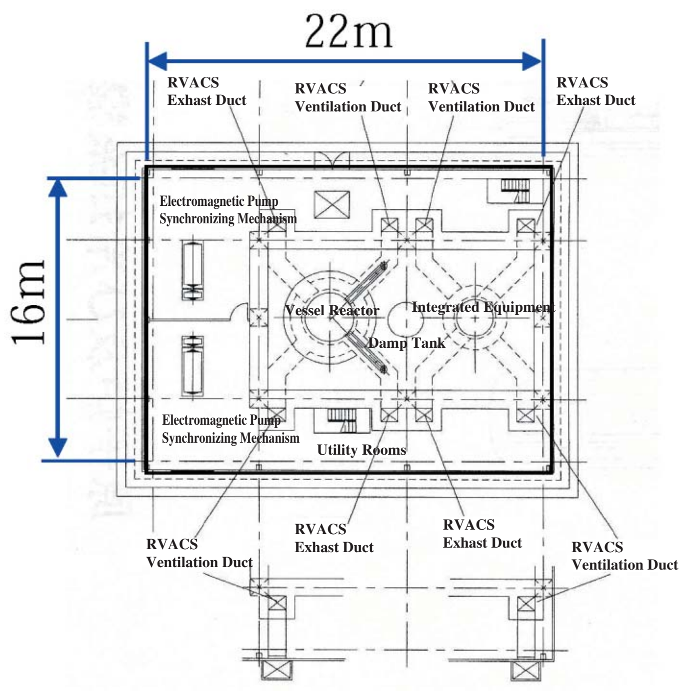

Fig.3 Plot Plan

Table 1 Main Specifications

Electrical Output	10MW
Thermal Output	30MW
Core Lifetime	30-year
Fuel	Metal U-24Pu-10Zr
Primary EMP	2 (Serial)
Secondary EMP	4 (Parallel)
IHX Heat transfer tube length	2.6 m
SG Type	Once-through, Double-wall tube, helically coil
DHRS	RVACS、SG ACS
Seismic Isol ation	Horizontal