Structural Design Comparison of Sodium-cooled Fast Reactors Developed in KAERI

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1. Introduction

In the last 10 years the conceptual design studies for a SFR (Sodium-cooled Fast Reactor) were focused on the fulfillment of the Gen-IV technical targets in many countries. In Korea also, the conceptual designs of a SFR and several basic key technological developments were promoted through the Korea national long term R&D projects.

This paper lists several design items consisting of the primary system and the intermediate heat transport system (IHTS) of the KALIMER-150, the KALIMER-600, and a 1200MWe commercial reactor. These items have been taken into account from a construction economic point of view. The developed conceptual design results were described for each item.

With regards to the BOP (balance of plant) field, the conceptual design features of the containment boundary, the reactor building size and seismic isolation, and the refueling and storage building are described.

2. Reactor primary system design options

There are several design items in the structure and component selection of a primary system of a pool type sodium-cooled fast reactor.

The first one of these was the sizing of the reactor vessel and head supporting the primary equipment. The others are a type of refueling machine, an in-service inspection sensor type for reactor internals in hot liquid sodium environment, a primary sodium circulation pump and IHX types, a decay heat removal system such as RVACS (Reactor Vessel Auxiliary Cooling System) and PDRC (Passive Decay Heat Removal Circuit), and an upper internal structural concept holding I&C sensors and many control rod drive mechanisms. The relative importance of these items is represented in Fig.1 from an economical point of view even if it's very subjective.

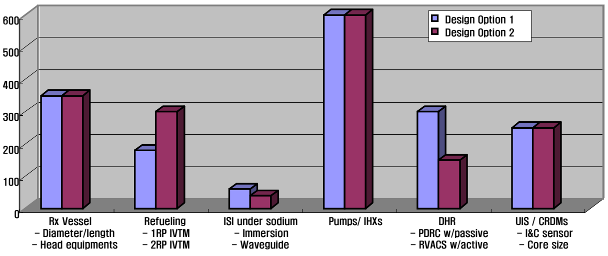


Fig. 1 Primary system design options

The conceptual designs of the NSSS of the three reactors developed in KAERI are represented in Fig.2~Fig.4. These reactors were designed with a two-loop of an intermediate heat transport system, but the number and type of the primary components are different according to the reactor capacities.

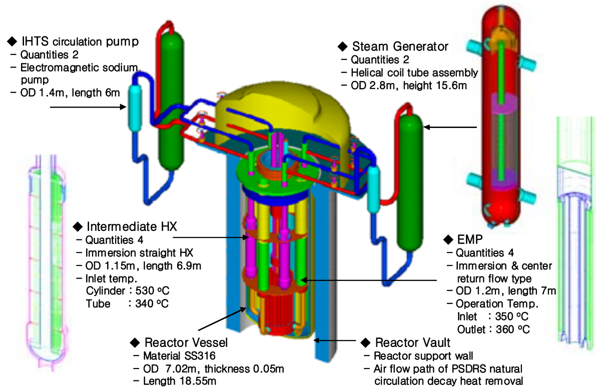


Fig. 2 NSSS layout of KALIMER-150

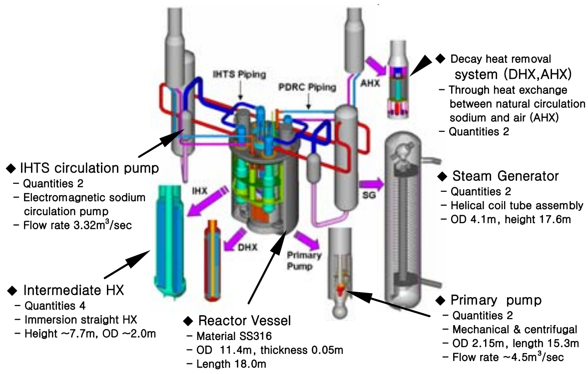


Fig. 3 NSSS layout of KALIMER-600

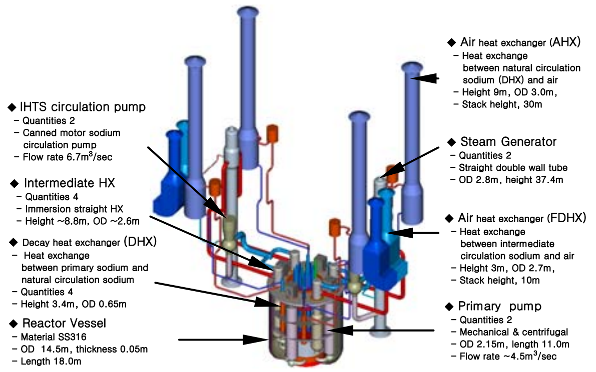


Fig. 4 NSSS layout of a 1200MWe commercial reactor

3. Intermediate heat transport system design options

The design items in structure and component of the IHTS design are: the piping layout, an intermediate sodium circulation pump, a protection method of a piping break such as a leak before break, an adoption of isolation valves in large diameter piping, a safety system connected to the IHTS for removing core decay heat, and a type of SG tube such as single and double walls. The relative importance of each item is represented in Fig.5 like as the primary system from an economical point of view.

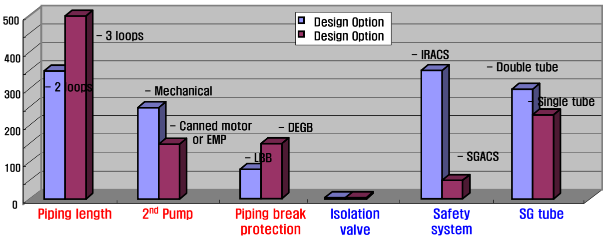
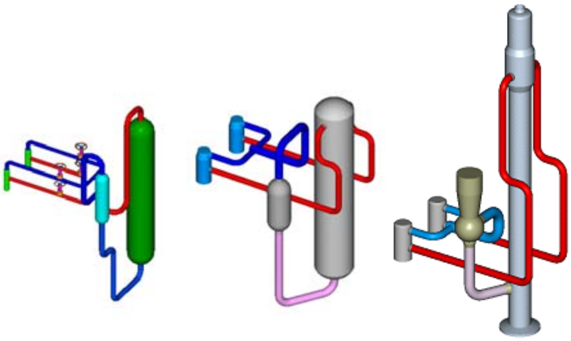


Fig. 5 Intermediate heat transport system design options

As for the IHTS system, the shortening of the piping length, and the type and locations of the circulation pump and SG are a major concern in design strategy. Fig.6 shows the intermediate heat transport loop layouts of the three reactors.



(KALIMER-150) (KALIMER-600) (1200MWe Reactor)

Fig. 6 IHTS layout with SG and pump locations

Since the KALIMER-600, the piping length was shortened by adopting the pipe material of a Mod.9Cr-1Mo, which has high mechanical strength and low thermal expansion properties.

4. Building and seismic isolation designs

The two-loop system has an advantage in realizing a compact building size because the number of components is minimized. The building efficiency becomes higher as the reactor capacity increases. As shown in Fig.7, the building size of a 1200MWe reactor is not a twice that of the KALIMER-600.

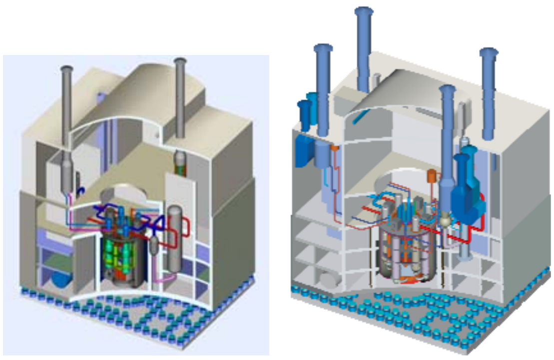


Fig. 7 Building arrangement of KALIMER-600 & 1200MWe commercial reactors

Table 1 represents the system requirements and the design features of IHTS system and reactor building of the three reactors.

Table 1. Design comparison of IHTS and building

System reqt's	KALIMER - 150	KALIMER - 600	1200MWe commercial reactor	
Center difference of SG /IHX	7 m	7 m	20 m	
Min. level difference of hot/cold legs	7 m	7 m	SG single tube	SG double wall tube
			21 m	non
System design				
IHTS piping length (m)	96.5	120	165	130
Isolation valves	4 (hot/ cold legs)	1 (IRACS)	1 (IRACS)	
Pump type	EMP	EMP	Canned Motor Pump	
SG tube	Helical single tube	Helical single tube	Straight double wall tube	
Building size (M3)	52 x 39 x 55	49 x 36 x 58	52.5 x 42.3 x 58.8	
No. of seismic isolators	174	164	188	
Containment volume, m3 (lower/upper)	66.9 / 1050	102.4/ 15000	181/ 18000	

5. Conclusions

The conceptual designs of the KALIMER-150, the KALIMER-600 and a 1200MWe commercial reactor have been performed. The key design options governing of the primary and intermediate systems were compared with each other.

The design features of the containment boundary, the reactor building and seismic isolation were also summarized.

ACKNOWLEDGEMENT

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