Structural Design Concept for a SFR Demonstration Reactor of 600MWe Capacity

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1. Introduction

The demonstration reactor which has been developed by KAERI is a 600MWe pool-type SFR(Sodium-cooled Fast Reactor). Its design studies have been developed based upon the design concepts of KALIMER-600[1] and a 1200MWe commercial plant[2]. It has pursued the design concept achieving Generation IV technology goal. The main object of this study is to develop the structural design concepts for the demonstration reactor.

2. Structural Design Concept

2.1 General Description

The demonstration reactor is a pool-type primary system. The inlet and outlet temperatures of its reactor core are 510℃ and 365℃, respectively and net plant efficiency is 38.8%[3]. It has following structural features.

- Hot and cold volume without buffer zone in RV
- 2-loop intermediate heat transport system(IHTS)
- Active & passive types decay heat removal system
- DHXs submerged into hot pool
- Mechanical pump for primary and IHTS
- Top support concept for reactor vessel
- Single-walled helical tube type steam generator
- Two-rotating plugs

The structural design in this study just focuses on the PHTS(Primary Heat Transport System), IHTS and decay heat removal system. The sizing and arrangement concept of the structure and components was made by considering the core design and fluid system requirement.

2.2 Primary Heat Transport System(PHTS)

Since the demonstration reactor adopts the poo-type reactor concept, the main components such as IHX, primary pump, and DHX are located in the reactor vessel. There are 4-IHXs, 4-DHXs and 2-primary pump in the reactor vessel and all of them are supported by the reactor head. The primary pump is a mechanical type with long shaft driving impeller. While the IHX and DHX are submerged into hot pool volume, the pump contacts with cold pool sodium and cover gas. The reactor head is jointed with the reactor vessel upper flange by bolts and the jointed part is placed on the top flange of the skirt-type reactor support structure. The baffle plate which composed the annulus volume in KALIMER-600 to mitigate the large thermal gradients generated between hot and cold sodium boundaries is removed. The resultant outer diameter of a reactor vessel is 12.0m and its height is 16.5m. The internal structures including the reactor vessel are made of a Type 316 stainless steel. Figure 1 shows the structural design concept and the elevations of the primary regions.

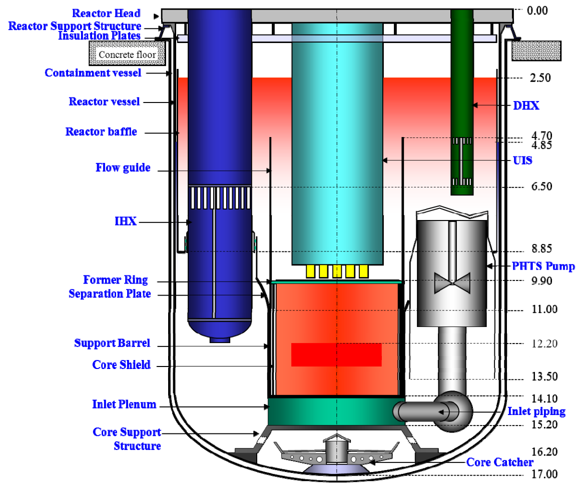

Fig. 1. Schematic front view drawing of the structural design concept, component arrangement and vertical elevation for PHTS.

2.3 Intermediate Heat Transport System(IHTS)

In the demonstration reactor, the IHTS is composed of two completely independent loops and each loop mainly consists of two IHXs, one pump, a steam generator(SG) and the piping connecting these components to each as well as the IHX. The SG concept is a single-walled helical tube, shell-and-tube type heat exchanger. The outer diameter of a SG is 4.3m and its height is 20.1m. The IHTS circulation pump is a mechanical type to apply the technically proven component. The IHTS pump is located at the vertical position of which free surface level is identical to the SG free surface level.

The IHTS piping material is a Modified 9Cr-1Mo steel and it can shorten the piping length compared to stainless steel due to its low thermal expansion and a high strength. The piping diameters for hot leg and cold leg are 0.6m and 0.82m, respectively. The sodium temperatures for hot and cold piping in IHTS are 502℃ and 305℃, respectively. The IHTS component arrangement is performed by considering the design requirements for the vertical elevation difference proposed by fluid system design. The hot leg piping layout is designed to ensure the sufficient structural integrity against seismic load and thus the overall piping length is about 144m for each IHTS loop. Figure 2 shows the IHTS arrangement configuration.

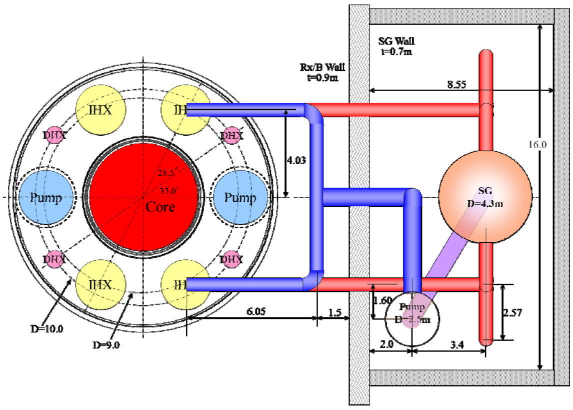

Fig. 2.Schematic drawing of the horizontal arrangement concept for a demonstration reactor PHTS and IHTS

2.4 Decay Heat Removal System

The residual heat removal in the demonstration reactor is accomplished by using a condenser cooling with a SG feed water system and decay heat removal system. It has employed two kinds of emergency decay heat removal system, which are active decay heat removal circuit(ADRC) and passive decay heat removal circuit(PDRC). The ADRC is comprised of two independent loops with DHX and FDHX located in upper region of the reactor building. The PDRC is also composed of two independent loops with DHX and AHX[3]. Figure 3 shows the conceptual arrangement of the demonstration reactor composed of PHTS, IHTS and decay heat removal system.

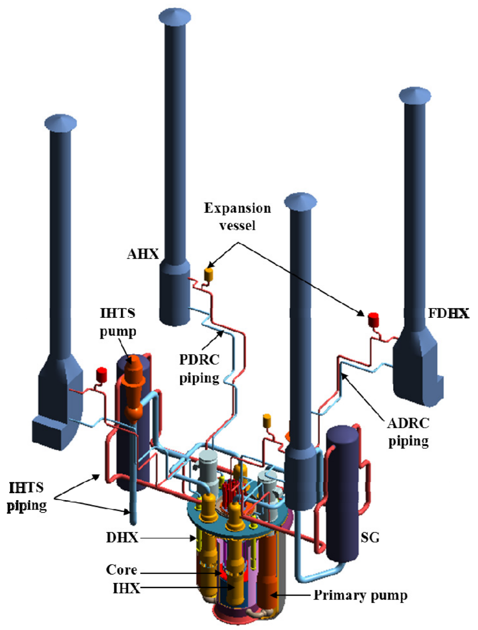

Fig. 3. Conceptual drawing of SFR demonstration reactor of 600MWe capacity

Table 1 shows the design features of demonstration reactor comparing with KALIMER-600. As shown in the Table, the demonstration reactor employs more number of DHX and thus it causes larger reactor vessel diameter. The demonstration reactor has larger upper internal structure diameter because of the control rod location in core layout nevertheless smaller core size.

Table 1. Structural design features of the demonstration reactor comparing with KALIMER-600

	KALIMER-600	Demonstration reactor
RV	D=11.4m	D=12m
Main components	4-IHX, 2-Pump, 2-DHX	4-IHX, 2-Pump, 4-DHX
DHX (normal condition)	Isolated from hot pool	Submerged into hot pool
Buffer zone	Closed volume	Open volume
Core	D=5.24m (in-mid-out)	D=4.84m (in-out)
Pump	PHTS: mechanical IHTS: electromagnetic	PHTS: mechanical IHTS: mechanical
UIS	D=3.1m	D=3.28m
SG tube	Single-walled helical type	Single-walled helical type
Piping	113m	144m
Reactor head	Integrated with reactor support	Bolting joint with RV flange
Reactor support	Extended reactor head	Skirt type support

3. Conclusions

The structural design and component arrangement for the SFR demonstration reactor with 600MWe electric capacity are conceptually proposed. The demonstration reactor is a pool-type and the structural sizing and component arrangement are conducted by considering the core design and fluid system requirement. It is composed of two independent loops of IHTS. The demonstration reactor employs the 2- loop PDRC and 2-loop ADRC for the emergency residual heat removal. The arrangement concept of the components and piping comprising IHTS, PDRC and ADRC are proposed with satisfying the arrangement functional requirements. These concepts shall be confirmed on the structural integrity through the further study.

ACKNOWLEDGEMENTS

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