Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22, 2009

Structural Economic-Improvement Design of a Large Pool Type SFR of 1200MWe

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1. Introduction

An economic improvement is a hot issue as one of the Gen IV nuclear plant goals[1]. To secure economic competitiveness of a SFR compared to a pressurized water reactor, several structural design concepts are adapted in without loosing the reactor safety level.

One is the increase of the plant capacity with the minimum number of component and loop, which leads the reduction of the plant maintenance, repair, and construction costs by a large-size scale effect.

Another is the simple system arrangement, compact reactor size for only two loop system for a 1200MWe capacity of a pool type SFR, and the minimization of IHTS piping length through the properly locating the SG and secondary pump.

Several researches are also studied to attain the economic improvement target of the NSSS in structural point of view; for example, an integrated concept of a refueling machine and inspection device with a long waveguide sensor for reactor internals, a high temperature LBB (leak before break) technology application, which can minimize the large protection facility against a large sodium leak like as a guillotine pipe break.

2. Component Arrangements

Table 1. SFR structural design and fabrication issues

Design goals	**Design Issues**	**Design Approach**
Capacity 1,200MWe	Number of loop	Large components (SG, pump, piping)
Core exit temperature 545°C	60 years design life	Improvement of the design and evaluation technologies
Economic improvement	- Safety - Simple - LBB - Inspection & repair	- Proper safety target level - Integrated components - LBB application for RV & IHTS piping - Innovative ISI, minimizing welds, allocating access root
Fabrication w/ Mod.9Cr-1Mo	**Fabrication Issues**	**Fabrication Availability**
IHX,SG Shells	thickness above 50mm	to 300mm
IHTS Piping & Elbow	OD 1.1m, thick 12.7mm	OD 1.5m, thickness 250mm w/ forged or seamless piping
	Type IV cracking	Reducible with welding & heat treatment

Two-loop system of a large pool type SFR was developed based on the design concept of KALIMER-600, and the structural design approaches of Table 1.

2.1 Primary system

Fig.1 shows the reactor internals and components arrangement in reactor vessel. The outer diameter of the reactor vessel is 14.5m, which is very compact size compared to other designs, and 0.05m in thickness. It can accommodate the maximum core size of 7.9m. With the internal arrangement, the refueling availability of core assemblies was confirmed, and 36 control rods are supported and guided by upper internal structures[2]. The material of reactor vessel and internal structure is a Type 316 stainless steel.

The primary system consists of 4 sets of primary pump, IHX, and DHX in reactor vessel. The component size is not much larger than the KALIMER-600 design because the numbers of components was increased.

The reactor vessel's diameter is relatively so small that the minimum space between the components is 55cm, which may not be enough for equipment maintenance.

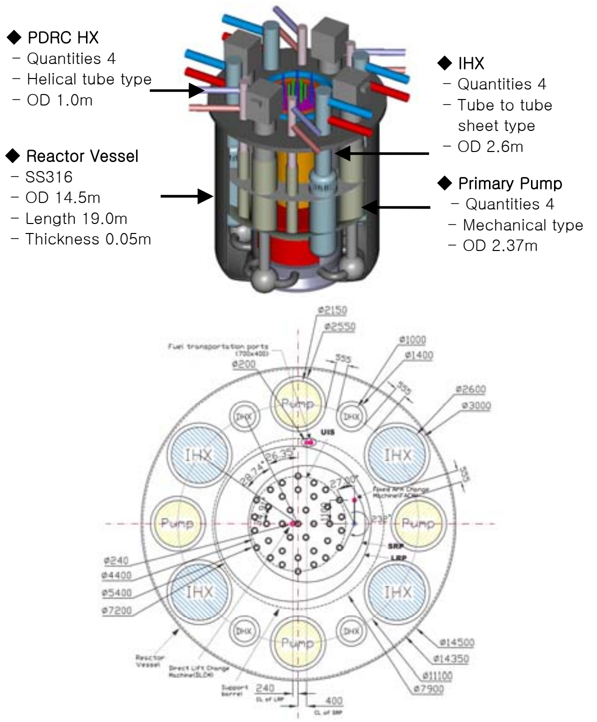


Fig. 1. Component arrangement in reactor vessel for two-loop system of a pool type SFR of 1200MWe.

2.2 Two loop intermediate heat exchange system

The NSSS has two intermediate heat transport loops as shown in Fig.2. The each of IHTS loops outside of the reactor vessel has 2 mechanical type pumps and 2 SGs[3].

The fabricability of the piping and elbows of the large piping diameter was investigated for realizing this system. The piping diameters for the hot and cold legs of 80 cm and 110cm respectively are within the feasible fabrication range through the both ways of forged pipe and seamless pipe.

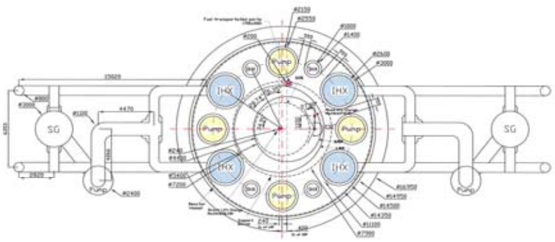


Fig. 2. NSSS arrangement of two-loop system of a pool type SFR of 1200MWe.

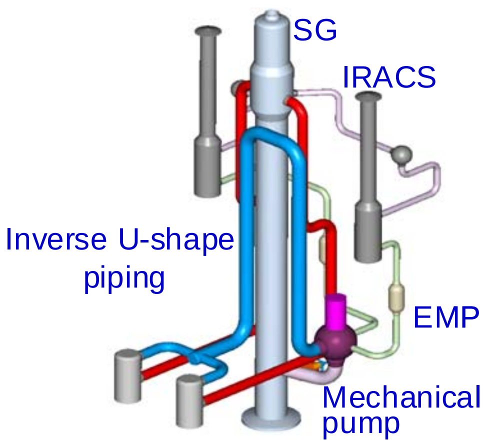
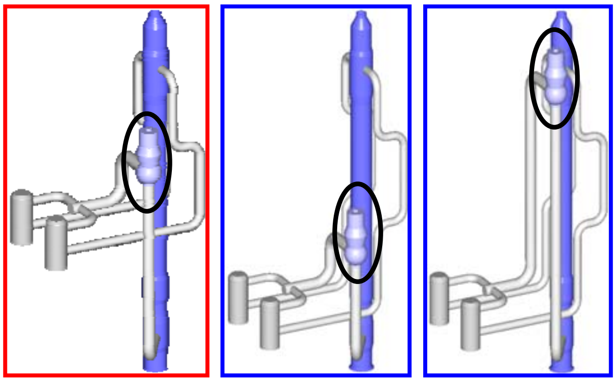


Fig. 3. IHTS and IRACS arrangement of two loop system

As shown in Fig.3, the piping length of each loop is relatively long about 180m because of the inverse U shape piping layout adapted to the preventing the pressure propagation to the reactor vessel when a sodium-water reaction accident occurs in SG upper tube. Since this long piping layout increases the maintenance cost, the shortening of the piping total length would be necessary like as Fig.4(a) by properly sacrificing over-excessive safety design level.

The pipe material of a Mod.9Cr-1Mo can shorten the piping length about 60m compared to stainless steel, which has also a higher mechanical strength and a low thermal expansion. This has an advantage for obtaining a simple layout of IHTS piping subjected to a high temperature environment. The two-loop system is also advantageous to a compact building size because the numbers of components can be minimized, and the total piping length could be shortened.

The height of the SG is about 37.4 m. The SG tube is a double-wall straight type to reduce the possibility of the water injection to the sodium side.



(a) (b) (c)

Fig. 4. IHTS layout according to SG and pump locations[2]

2.3 Advanced design features

Two new design strategies are adapted for the economic improvement of the NSSS in structural point of view. One is an integrated component of a refueling machine and an in-service inspection (ISI) tool with a long life waveguide sensor for reactor internals. This concept will shorten the overall period of about 2 days through the reduction of in-service inspection time of Rx internals.

The other is a LBB technology application for IHTS piping and RV, which will reduce the construction cost because of the unnecessary of a large scale protection facilities against to sodium leak accidents.

3. Conclusions

The component arrangement and reactor structural sizing for two loop systems for a 1200MWe capacity of a SFR are suggested with several structural design improved concepts to attain an economic improvement of a large size pool type SFR.

These concepts will be confirmed on the structural integrity for the operating and design loads, and optimized to a unified conceptual design through some trade-off studies.

ACKNOWLEDGEMENT

This study was supported by the Korean Ministry of Education, Science & Technology through its National Nuclear Technology Program.

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