Structural Design Concept Comparison for KALIEMR-600 and JSFR-1500

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1. Introduction

The comparison study is performed for the structural design concept of the pool type KALIMER-600 and the loop type JSFR-1500. Both are Gen-IV SFR candidate reactors proposed by Korea and Japan, respectively. The operating temperatures are 545°C and 550°C, respectively.

2. Description of KALIMER-600

The reactor vessel of KALIEMR-600 has overall dimensions of 18.0m in height, 11.41m in outer diameter, and 0.05m in thickness. The reactor vessel made of SS316L is attached to the reactor head and supports the reactor internals, the reactor core, and primary sodium. The reactor core diameter is 5.34m. The total reactor weight is about 2880tons. The containment structure is composed of a lower containment vessel for containing reactor vessel leaks and an upper concrete containment structure with a steel liner.

The reactor head is the top closure of both the reactor and containment vessels. It provides mechanical supports for the IHXs, primary pumps, two rotatable plugs and IVTM (in-vessel fuel transfer machine). The reactor head is 50cm in thickness. It is designed to operate at under 150°C. The temperature is attained by an inclusion of 5 horizontal layers of stainless steel insulation and shield plates, the top one of which is installed 45cm below the bottom of the reactor head.

The reactor internal structures are composed of the core support structure, inlet plenum, support barrel, reactor baffle and the reactor baffle sopport. The reactor internal structures provide the core support, primary coolant flow path and the component support.

The upper internal structure (UIS) is attached to a rotatable plug installed on the reactor head and cantilevered downward into the reactor hot pool. The total length is 10.2m and the two outer cylinders with porosity are 1.5m and 3.1m in diameters. The principal functions are the lateral support of the control rod drivelines(CRDLs), the protection of the drivelines from a sodium flow induced vibration, and the support of the above core instrumentation drywells.

The IHTS piping system connects the IHX, steam generator and the secondary EMP. The hot leg piping is 60cm in outer diameter and 0.9cm in thickness, while the cold leg piping is 82cm in outer diameter and 1.1cm in thickness. Each loop has two hot leg pipe lines and one cold leg pipe line. The total length of the IHTS piping is about 96.5m.

KALIMER-600 has four IHXs and two mechanical primary pumps. These components are supported by the reactor head in a vertical direction and by the reactor baffle support in a horizontal direction.

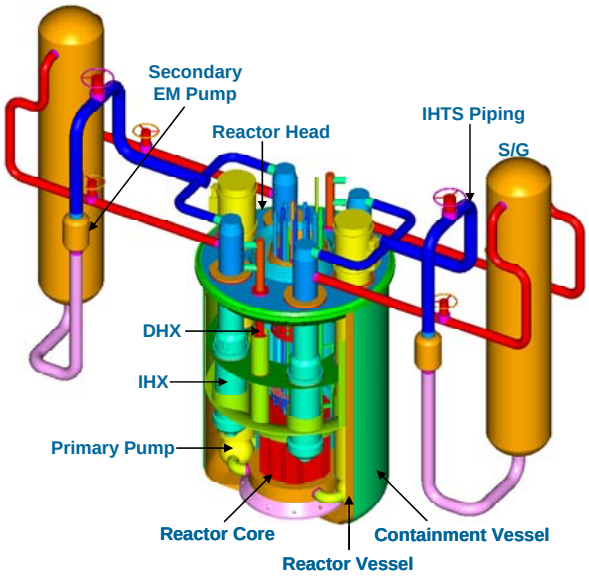

Figure 1. KALIMER-600 NSSS Concept

3. Description of JSFR-1500

The reactor vessel of JSFR-1500 has overall dimensions of 18.2m in height, 9.7m in outer diameter, and 0.03m in thickness. The reactor vessel is attached to the reactor head and supports the reactor internals, and the reactor core. The reactor vessel and internals are mostly made of SS316FR. The containment structure is a concrete containment structure with a steel liner.

The upper internals structure (UIS) is composed of many CRDLs and instrument pipes. There is a slit for accessing a inner fuel space by the in-vessel fuel transfer machine with a flexible arm, but no outer shell structure to reduce the structure weight. The principal functions are the same as the KALIMER-600.

The PHTS piping system connects the reactor vessel, IHX and the primary pump. The dimension of the primary heat transport piping is 127cm in outer diameter and 1.59cm in thickness. The total length of the PHTS piping is about 40m, but the IHTS piping is over 130m, which is relatively long in length.

The JSFR-1500 has two IHXs and two primary pumps, which are integrated as one component. Each loop has one integrated IHX/primary pump, one secondary pump and one SG. So the primary and secondary component size is huge.

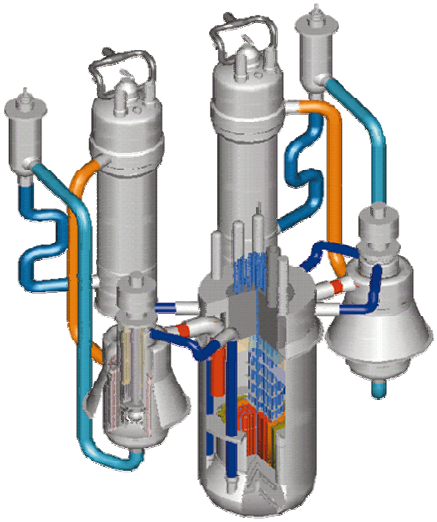

Figure 2. JSFR-1500 NSSS Concept

4. Comparison for Both Reactor Systems

The summary of the comparison items for the KALIMER-600 and JSFR-1500 structural design features is presented in Table 1.

JSFR-1500 has an economic benefit through the shortened length for the primary and secondary piping lines using 12Cr based material, but KALIMER-600 has only IHTS piping using Mod.9Cr-1Mo without a primary piping. The total main piping length of KALIMER-600 is much short compared with the JSFR-1500, and also the fabrication of the large diameter piping over 110cm with a small thickness can be an obstacle for JSFR-1500.

The reactor vessel size of KALIMER-600 is larger by 17% than the JSFR's one even through the electric capacity is smaller by 2.5 times. The reactor vessel for KALIMER-600 contacts with the cold sodium of 390°C, while the JSFR-1500 vessel directly contacts with the hot sodium of 550°C. So the reactor vessel structural integrity for KALIMER-600 has an advantage for a 60 years design life time.

The refueling systems for both reactors have merits and demerits because the two rotating plug system of KALIMER-600 has a reliability in a refueling operation, but is expensive when compared to the one rotating plug system of JSFR-1500.

As for the reactor head, KALIMER-600 has one piece of a welded steel plate of 50cm in thickness, but JSFR-1500 has a box type steel structure with a 2m deep thickness.

The number of primary and secondary components is minimized for both reactors. The volumes of the reactor building and containment of KALIMER-600 are smaller than the JSFR-1500 by about 30% for each. So the economics per capacity (MWe) of JSFR-1500 are better than KALIMER-600 for a reactor building construction.

5. Conclusion

The KALIMER-600 of pool type is a medium size SFR compared with the JSFR-1500 of loop type. The reactor building per the capacity (MWe) is relatively larger than the JSFR-1500. The economics for both reactors are comparable by the simplified design and reduced equipments and building size, and by the minimization of the structural material amount and the primary and secondary piping length.

Acknowledgement

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REFERENCES

[1] Lee, Jae-Han, et al, Summary of Structural Concept Design and High Temperature Structural Integrity Evaluation Technology for KALIMER-600 Liquid Metal Reactor, KAERI/TR-2938/2005, 2005.

[2] Nakajima, Ichiro, Feasibility Study for Commercialization of FBR Cycle Systems and International Collaborations, JNC, September 6, 2004.

Table 1 Summary of KALIMER-600 and JSFR-1500

Items	JSFR-1500	KALIMER -600
Capacity (MWe)	1500	600
RV diameter (m)	9.70	11.41
RV height (m)	18.2	18.5
RV material	316FR	316L
Loop no.(EA)	2	2
Piping diameter(cm)	127/86/112	82/60
Piping thickness(mm)	15 - 50	9.5-12.5
Piping Length (PHTS/IHTS)	~ (50 / 160) m	(0 /96.5) m
Piping material	12Cr	Mod. 9Cr-1Mo
Refueling system	1 RP/ Flexible Arm	2 RP/ Fixed Arm
IHX (EA)	2	4
Primary pump (EA)	2	2
SG dia. x length(m^2)	4.8 x 21	4.1 x 20.6
CV volume (m^3)	20,000	15,000
Building volume (m^3)	130,000	100,000
Seismic isolation system	Horizontal & Vertical (3D)	Horizontal only (2D)
Design life time (yrs)	60	60