Preliminary Requirement for Internal Structure Configuration of 600 MWe SFR

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1. Introduction

Under the national mid- and long-term nuclear R&D program, the SFR basic key technologies development project is being conducted by the fast reactor development group at KAERI. The objective of fluid system design will be made on developing a conceptual design of heat transport system, engineered safety features, I&C system, power conversion system, and auxiliary system design for a demonstration reactor. Based on the KALIMER-600[1], Korea Advanced Liquid MEtal Reactor, and the detailed design concepts for demonstration reactor are under review. For the development of detailed design, the design description for system should be provided at first stage.

In this research the preliminary design requirements for configuration of Primary Heat Transport System (PHTS) were formulated prior to decision of internal structure arrangement. PHTS forms a barrier against the uncontrolled release of primary sodium and radioactive materials to the environment. PHTS provides sufficient cooling during all the plant operations and anticipated operational occurrences to preclude significant reactor core damage. PHTS transfers heat from the reactor core to the IHTS or other residual heat removal system for normal operations. Based on the prescribed PHTS function the overall procedure and preliminary elevation requirements for the decision of PHTS configuration were introduced.

2. Methods and Results

Based on the design basis of demonstration reactor[2] it is rated at 600MWe(1548MWt). The reactor vessel is composed of various major components such as four IHXs, four DHXs, two PHTS pumps, and a core. The preliminary layout of PHTS is shown in Fig. 1. Every elevation has been described by the relative distance from the active core.

2.1 IHX

The design of IHX layout should take into account of following descriptions.

- 4 IHXs shall be arranged axisymmetrically.
- Its inlet slot shall be placed deeply enough to prevent the intake of cover gas at rated and refueling operation mode.

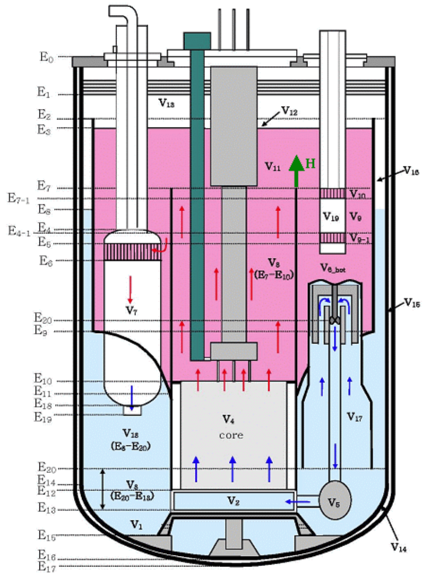

Fig. 1 Schematics of 600MWe demonstration reactor design[3]

- Its inlet slot shall be placed equally or lower comparing to the outlet slot of DHX.
- Its outlet nozzle shall be placed higher than active core region to prevent the radiation of intermediate loop sodium.
- The horizontal arrangement shall be decided to minimize the flow stagnation in cold pool.

Based on the prescribed design requirement the IHX outlet nozzle shall be located at the upper end of active core at least.

2.2 DHX

The design of DHX layout should take into account of following descriptions.

- A DHX shall be located between PHTS pump and IHX on the horizontal configuration and 4 DHXs shall be installed in total.
- Imaginary concentric ring going through the centers of DHXs shall be located outside of that going through the centers of PHTS pumps and IHXs on the horizontal configuration.
- Its inlet slot shall be placed deeply enough to maintain its function at reactor vessel break accident.

- Its inlet slot shall be placed equally or lower comparing to the top of reactor barrel to maintain the sodium flow from barrel inside to outer annulus region.
- DHX outlet slot shall be placed higher or equally comparing to IHX inlet slot.

Based on the prescribed design requirement the outlet slot of DHX shall be located at the upper end of IHX inlet slot at least. The relative elevation of DHX outlet slot from active core shall be 4.3m considering the length of IHX.

The relative elevation for DHX inlet slot could be estimated from the DHX length and its minimum elevation amounts to 6.6m from active core.

The free surface level from the inlet slot of DHX shall be decided to secure its function at the lowest free surface level condition such as reactor vessel break accident. The free surface level was set to be higher than DHX inlet slot by 0.3m and related sodium mass were estimated considering pool volume and density for the worst case. Finally estimated total sodium mass amounts to 1134ton.

Fig. 2 shows the expected free surface level relative to DHX inlet slot, which was evaluated based on total sodium mass, volume and density for the respective operation mode.

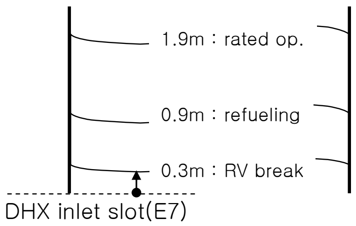

Fig. 2 Free surface level for various operation modes

2.3 Reactor barrel and reactor baffle

As prescribed in 2.2 top of the reactor barrel shall be located equally to the top of DHX inlet slot. In the case of reactor baffle top it shall be placed higher than sodium free surface at rated operation mode by 0.3m, which amounts to 8.8m from active core at least.

2.4 Insulation plate

Minimum elevation for insulation plate was estimated from the maximum free surface level of sodium which was evaluated by assuming the pool temperature as that for service level C. Based on temperature condition the expanded volume and the highest free surface level were evaluated and minimum elevation requirement for the lowest insulation plate was decided to be 9.6m.

2.5 Reactor head and PHTS pump

The position of reactor head and PHTS pump should be decided by considering cover gas pressure, limits for pump shaft length, free surface level and uncertainty. Table 1 shows the cover gas pressure for various reactors. The nominal value and uncertainty for cover gas was estimated to be 120 MPa and 5% respectively in demonstration reactor. The pump shaft length was limited to be 10m. Based on those assumptions available elevation range for reactor head and PHTS pump impeller were evaluated. The elevation for reactor head shall be ranged from 10.8m to 11.0m and that for PHTS pump impeller shall be 1.0m from active core.

Table. 1 Comparison of cover gas pressure[4]

Reactor	Cover gas pressure [kPa]		Range	
	at operation	nominal value	[kPa]	[%]
Demonstration Reactor	114.0-126.0	120.0	± 6	±5
Super-Phenix1	108.325-112.325	110.325	± 2	±2
PFBR	110-112	111.0	± 1	± 1
Monju	151.325	151.325	-	-
BN-600	137	137.0	-	-

3. Conclusion

In this study preliminary elevation requirements for IHX, DHX, reactor barrel and baffle, insulation plate, reactor head and PHTS pump were estimated. These data are expected to be utilized as the preliminary requirements for PHTS configuration of 600 MWe demonstration reactor.

REFERENCES

[1] Hanh, D. H. et al., KALIMER-600 Conceptual Design Report, KAERI/TR-3391/2007, 2007.
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[3] Park, C. K., "Draft for elevation and volume of demonstration reactor", Internal document, 2010.
[4] IAEA-TECDOC-1531, Fast reactor database 2006 update