Transactions of the Korean Nuclear Society Autumn Meeting
Busan, Korea, October 27-28, 2005

Case Study for the Arrangement and Structural Evaluation of the KALIMER-600 IHTS Piping System

Chang-Gyu Park and Jae-Han Lee
KAERI, 150 Dukjin-dong, Yuseong-gu, Daejeon 305-353, Korea, chgpark@kaeri.re.kr

1. Introduction

KALIMER-600(Korea Advanced LIquid MEtal Reactor, 600MWe)[1] is a pool type sodium-cooled liquid metal reactor. The NSSS is composed of three heat transfer systems of a PHTS(Primary Heat Transfort System), a IHTS(Intermediate Heat Transport System) and a SGS(Steam Generation System).

This paper is on the case study for the arrangement and structural evaluation of the KALIMER-600 IHTS piping system. The arrangement of piping system was carried out by considering the piping length, the number of curved pipings and the sizes of the components. The stress and strain for the structural integrity evaluation were calculated for each case of the piping arrangement by considering the material of the piping system.

2. Arrangement of IHTS Piping System

2.1 Design Feature

The IHTS piping system is composed of a steam generator, EM pump and piping which can be classified into three types such as hot leg, cold leg and suction leg pipings. Hot leg is connecting the outlet of the IHX to the inlet of a SG and a cold leg is connecting the outlet of a SG to the EMP. SG and EMP are connected by a suction leg piping.

The pipings and components should be arranged properly in the SG room space according to their design specifications. The diameters of a large bored piping, small bored piping, SG and EMP were 60.0cm, 82.0cm, 4.1m, 1.7m, respectively. Large bored piping was applied to the cold leg, hot leg and suction leg but the small bored piping was applied to only the hot leg. The components and pipings were arranged to maintain a distance of 1.0m more from the SG room wall. The normal operating temperature of KAIMER-600 is 545°C and inlet and outlet temperature of a SG are 526°C, 320°C respectively.

In this study, following four cases of the IHTS piping system according to the hot leg arrangement were investigated.

- Case 1 : Large bored piping
- Case 2 : Large bored piping with vertically straight
- Case 3 : Small bored piping
- Case 4 : Small bored piping with vertically straight

2.2 Arrangement of Case 1

Fig.1 shows the schematic top view drawing of the IHTS piping arrangement appling the large bored hot leg piping. Two small bored pipings were merged into a large bored piping with a T-branch in the head upper wall space. The merged single hot leg was connected to the top of the SG to provide heated sodium into the SG. The elevated temperature of the hot leg can induce a severe thermal stress. To reduce the thermal stress due to the thermal expansion, a curved piping at a hot leg was used. In this case, the horizontal distance from the IHX to the SG was 14.05m, the total length of the piping was 115m and the number of curved piping used in a hot leg was 11.

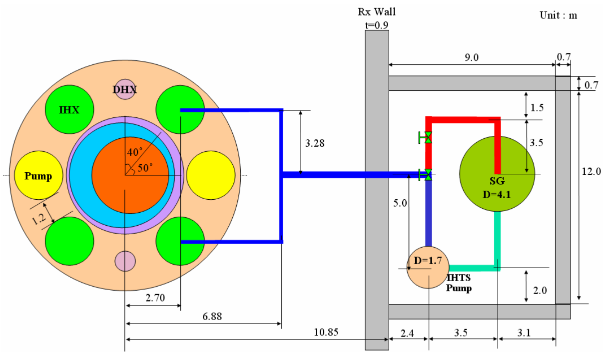


Figure 1. Schematic top view drawing of Case 1

2.3 Arrangement of Case 2

Case 2 was studied to assess the effect of the curved pipe in a large bored hot leg. The arrangement of the components, cold leg and suction leg was same as Case 1, but the vertical curved piping to reduce the thermal expansion was not adapted at the hot leg. Total length of the piping was 107m and the number of curved piping used in a hot leg was 7.

2.4 Arrangement of Case 3

Fig.2 shows the schematic top view drawing of the IHTS piping arrangement appling the small bored hot leg piping. The small bored piping connected to the side of the co-axial piping was extended to 16.15m horizontally and 8.6m vertically. Two small bored hot legs were connected to each side of the SG inlet as shown in Fig.2. Two curved pipings per one hot leg were used. In this case, total length of piping was 120m and the number of curved piping used in a hot leg was 8.

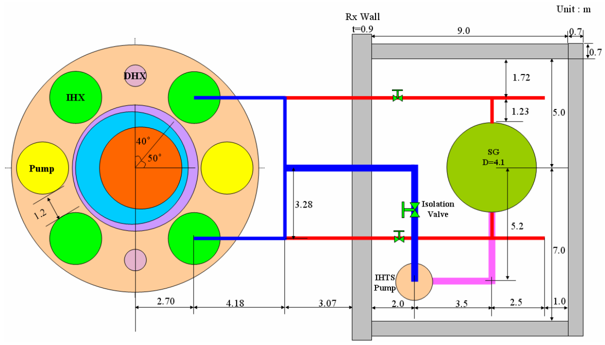


Figure 2. Schematic top view drawing of Case 3

2.5 Arrangement of Case 4

Case 4 was an arrangement replacing the curved piping with straight piping at the small bored hot leg vertical part. The arrangement of the components, cold leg and suction leg was same as Case 3, but each hot leg piping was shortened by 2.5m horizontally. Total length of the piping was 110m and the number of curved piping used in a hot leg was 4 EA.

3. Structural Evaluation

For the structural integrity evaluation of the IHTS piping system in this study, stress and strain values were calculated under the combined thermal gradient caused by a temperature distribution and a mechanical loading using the ANSYS[2] finite elelent analysis software. The mechanical loadings were composed of the structural dead weight, sodium weight and reaction force at supports. Stress analyes were carried out for four cases classified according to the hot leg arrangement with two kinds of IHTS piping material, Mod.9Cr-1Mo and 316 SS.

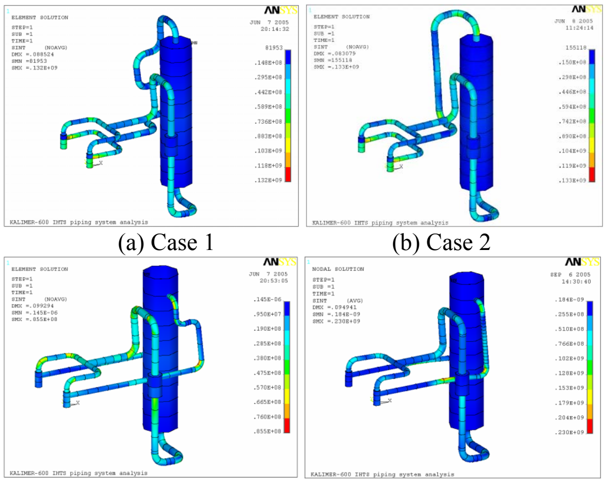
Table 1. Stress analysis results for each case

	Materials	Stress(MPa)		Strain(%)	
		Max.	Limit	Max.	Limit
Case 1	316 SS	221	285	0.18	5.0
	Mod.9Cr-1Mo	132	348	0.11	5.0
Case 2	316 SS	223	285	0.18	5.0
	Mod.9Cr-1Mo	133	348	0.11	5.0
Case 3	316 SS	142	285	0.11	5.0
	Mod.9Cr-1Mo	88.5	348	0.07	5.0
Case 4	316 SS	374	285	0.30	5.0
	Mod.9Cr-1Mo	230	348	0.19	5.0

Table 1 shows the stress analysis results for each case. From Table 1, Mod.9Cr-1Mo material when compared with the 316 SS material reduces the maximum stress by about 40%. There is little difference between Case 1 and Case 2 in the maximum stress value, because the maximum stress occurred at the co-axial piping not at the hot leg piping. But as for the hot leg piping, the maximum stress value of Case 1 was less by about 40% than that of Case 2.

In addition, Mod.9Cr-1Mo material reduces the strain by about 38% when compared with the cases of 316 SS.

Fig. 3 shows the maximum stress intensity for each case with the material of Mod.9Cr-1Mo. The maximum stress region for Case 1 and Case 2 was at the junction of the co-axial piping with a hot leg piping. But for Case 3 and Case 4, the maximum stress intensity occurred at a hot leg piping.



(a) Case 1 (b) Case 2

(c) Case 3 (d) Case 4

Figure 3. Stress intensity results (Mod.9Cr-1Mo)

4. Conclusion

In this paper, the case study for the arrangement and stress assessment of the KALIMER-600 IHTS piping system was carried out.

The case study was investigated for four cases according to the hot leg arrangement. In addition, two kinds of piping material were considered. Though all the cases except Case 4 applying the 316 SS material satisfied the stress and strain limit, Case 3 was the most advantageous. The total length of the piping was similar to each other. In view of the number of the curved piping, Case 4 was the most advantageous.

From these results, the IHTS hot leg with the small bored piping made of Mod.9Cr-1Mo is more favorable in spite of a little increased piping length.

A future study will be concentrated on the reduction of the IHTS piping length and a structural integrity evaluation including the creep-fatigue damage evaluation.

ACKNOWLEDGMENTS

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

REFERENCES

[1] D. Hahn, et al., "Design Features of Advanced Sodium-Cooled Fast Reactor KALIMER-600," Proceeding of ICAPP'04, Pittsburgh, USA, 2004.
[2] ANSYS User Manual for Version 9.0, Swanson Analysis System, Inc.