The Effects of Internal Components' Disposition on Thermal-Hydraulic Behaviors in Sodium Cooled Fast Reactor

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1. Introduction

Decay heat removal is very important in a nuclear power plant. The KALIMER-600, Korea Advanced Liquid MEtal Reactor, employs the PDRC(Passive Decay heat Removal Circuit) to remove the decay heat. However the cooling performance before the activation of DHX greatly depends on the natural circulation flow within the reactor pool.

In the previous studies[1,2] the effect of various design parameters such as coastdown flow, IHX(Intermediate Heat eXchanger) elevation and heat transfer via CCS (Cavity Cooling System) on the initial cooling performance has been analyzed. In the case of IHX elevation analysis the increase of IHX elevation was shown to enhance the initial cooling performance. However, the elevating the IHX is accompanied by the variation of hot or cold pool volume, the previous calculation was resulted from the combination of those effects.

In order to analyze those effects qualitatively supplementary calculation conditions were prepared and related analyses have been done in this study. In those analyses the ratio between hot and cold pool volumes has been varied without elevating the IHX by changing the vertical position of separation plate and baffle plate.

The COMMIX-1AR/P code[3] is utilized as a tool to investigate overall transient behaviors within a pool. This study is expected to provide the basic information for the decision of internal components' layout in the sodium cooled fast reactor.

2. Methods and Results

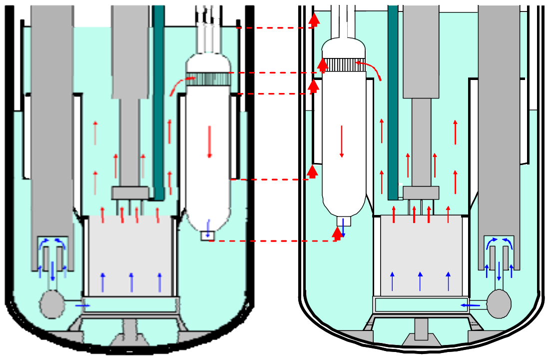
In this research the COMMIX-1AR/P code is utilized to assess the effect of internal components' disposition on thermal-hydraulic behaviors in sodium cooled fast reactor.

The basic information adopted in modeling approaches such as grid construction, initial and boundary conditions, decay heat variation[4], PHTS pump coastdown flow variation[5] and etc. are omitted in this paper since they are well described in the previous researches[1,2].

2.1 Geometry change

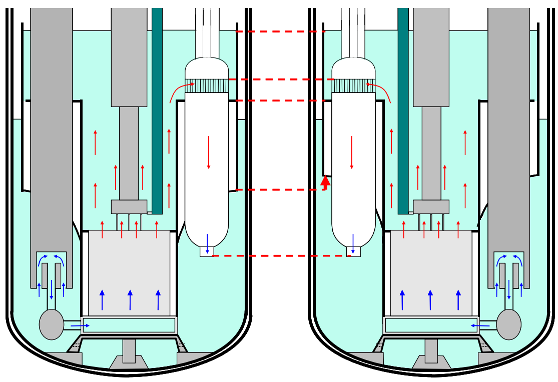
In this calculation various geometries have been considered to assess the effect of internal components' disposition on thermal-hydraulic behaviors.

Fig. 1 shows the geometry change due to the increase of the IHX elevation, which has been applied in the previous study[2]. In order to increase the IHX elevation the position of the related geometry such as the separation plate, IHX inlet window, top of support barrel, etc. were changed altogether in comparison with the reference geometry. The sodium free surface was also increased in order to maintain the depth of the IHX inlet window from sodium free surface.



(a) Reference (b) IHX elevation change
Fig. 1 Geometry change due to the increase of IHX elevation

Fig. 2 shows the geometry change without elevating the IHX. In this case only the vertical disposition of separation plate, positioned on the bottom of buffer region is elevated and the others' dispositions were not moved.



(a) Reference (b) Pool volume change
Fig. 2 Geometry change without the increase of IHX elevation

As shown in Fig. 1 change of pool volume is indispensible in elevating the IHX. This geometrical change effect could be separated by the displacement of separation plate without elevating the IHX as shown in Fig. 2. In this case only the cold pool volume increases and the ratio between hot and cold pool volume is varied.

In this way the effects of internal components' disposition on thermal-hydraulic behaviors were evaluated.

2.2 Evaluation of thermal-hydraulic behaviors

Fig. 3 shows the effects of IHX elevation on the maximum core temperature and $RmfQ$. The maximum temperature of coolant at the core is evaluated by the highest one among the averaged temperatures in the circumferential direction at every axial grid of the core region. The parameter, $RmfQ$, represents how fast the flow rate decreases relative to the decrease of the core heat generation rate.

$$RmfQ \equiv \frac{\dot{m}(t)/\dot{m}_0}{\dot{Q}(t)/\dot{Q}_0} \qquad (1)$$

The core can be considered to be overcooled for $RmfQ$ larger than 1 and to be undercooled for $RmfQ$ smaller than 1.

The symbol represents the maximum temperature and $RmfQ$ at core in reference reactor. Solid line and dashed-dotted line represent those of different IHX elevation condition. In the reference case the first peak appears at the beginning of reactor trip. This peak is caused by the unbalance between the coolant flow rate and the core power. The unbalance and the maximum temperature increase with lowering IHX and decrease with elevating IHX.

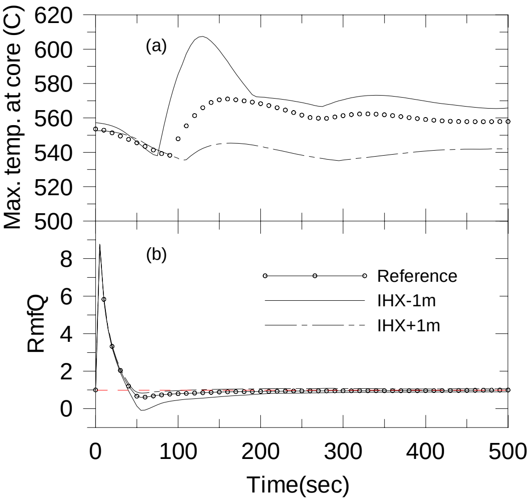


Fig. 3 Effect of IHX elevation on thermal-hydraulic behaviors

Fig. 4 shows the effect of pool volume variation on thermal-hydraulic behaviors. The dashed-dotted line represents the case of lowered IHX elevation with the increased cold pool volume. It could be accomplished by decreasing the volume of buffer region with elevating separation plate.

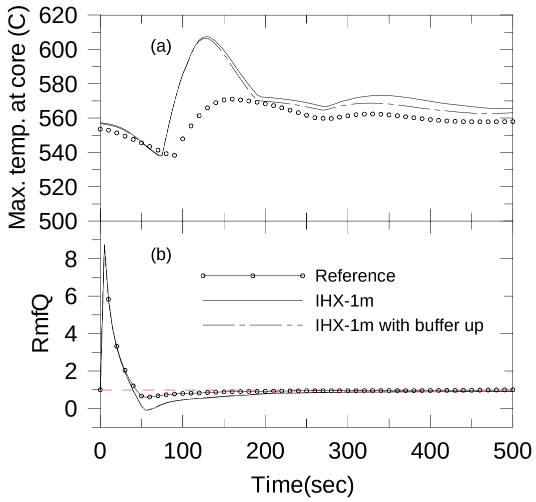


Fig. 4 Effect of pool volume variation on thermal-hydraulic behaviors

As shown in Fig. 4 there's little differences between solid and dashed-dotted line. Therefore it could be concluded that the thermal-hydraulic behaviors depends a lot on IHX elevation and the contribution of pool volume variation on them is very small.

3. Conclusion

In this study the effects of internal components' disposition on thermal-hydraulic behaviors were analyzed using COMMIX-1AR/P. The IHX elevation was proven to have a major effect on thermal-hydraulic behaviors and contribution of pool volume variation was shown to have a little effect on them.

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