Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 30-31, 2008

Investigation into the Thermal-hydraulic Behavior in the KALIMER-600 Pool in a Transient State

Ji-Woong Han, Jae-Hyuk Eoh, Tae-ho Lee and Seong-O Kim
Korea Atomic Energy Research Institute, #150, DeokjinDong, YuseongGu, Daejeon, Korea, 305-353
jwhan@kaeri.re.kr

1. Introduction

During the design of nuclear reactors, securing a reliable decay heat removal system and evaluating its capability are important safety criterion. Especially various studies are necessary in order to assess the major parameters affecting the transient decay heat removal performances. The numerical approaches based on a multi-dimensional analysis can be utilized as a useful tool to investigate overall transient behaviors within a pool. In this research the COMMIX-1AR/P code[1] is utilized as a transient analysis tool in KALIMER-600 after a shut down.

Since the modeling approaches in a steady state were described in a previous study[2], the necessary information and related results were only introduced briefly for the analysis of the thermal-hydraulic behavior of KALIMER-600 in a transient state.

This study will provide the basic design information for modeling KALIMER-600 and the thermal-hydraulic behavior of it in a transient state condition.

2. Methods and Results

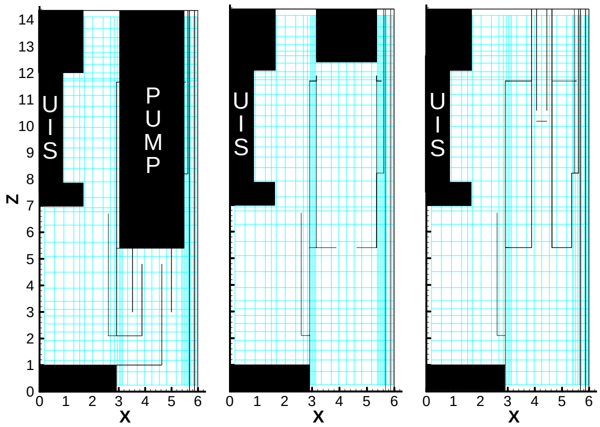
In this research the COMMIX-1AR/P code is utilized for analyzing three dimensional phenomena such as the single-phase fluid flow and heat transfer in KALIMER-600.

The necessary information for the transient analysis are as follows ; decay heat variation, PHTS pump coastdown flow variation, related boundary condition, and etc. In this calculation the decay heat variation profile is based on reference[3]. The coastdown flow is calculated based on reference[4]. Those data and the transient thermal-hydraulic behavior are introduced from now on.

2.1 Geometry and Grid

Figure 1 represents the grid system at XZ plane where Pump, IHX, and DHX is located respectively. In the present calculation a quarter of the reactor geometry was modeled in a cylindrical coordinate system, which includes a quarter of a reactor core and a UIS, half of a DHX and a pump and a full IHX. The lower concave region under the reactor core is simplified to be a flat one. Number of grid in each direction is as follows.

- NXxNYxNZ=33x14x39



(a) Pump(J=1) (b) IHX(J=8) (c) DHX(J=14)

Figure 1. KALIMER-600 grid system in XZ plane

2.2 Decay Heat

Figure 2 shows the transient decay heat ratio variation during 600 seconds. The scale on the Y-axis is presented as a decay heat divided by the heat at the normal operation condition. The ratio of decay heat amounts to the value of 0.03 at around 150 seconds and is reduced gradually after that.

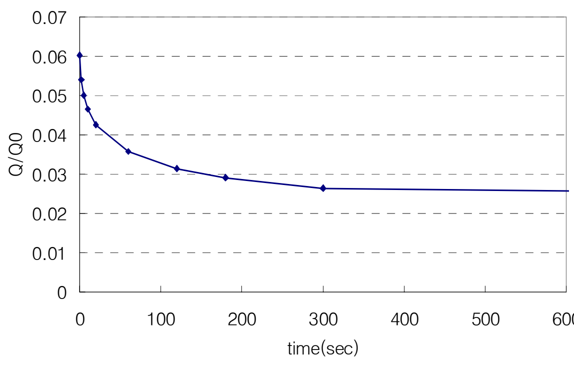


Figure 2. Decay heat ratio variation in KALIMER-600

2.3 PHTS Pump Coastdown

Four types of PHTS pump models are provided in COMMIX-1AR/P. Those include the homologous with full range operation, homologous with reverse rotation precluded, specified speed, and specified pressure increase. In this calculation specified pressure increase

option is selected for the transient analysis. In order to adopt the specified pressure increase model the profiles of PHTS pump pressure variation with time is necessary.
That information is calculated based on reference[4]. Figure 3 shows the pressure ratio variation during 50 seconds. Solid and dotted line represents the ratio of the head and coastdown flow variation respectively. In this analysis the coastdown flow time(CDT) is assumed as 50 seconds. In that case the flow becomes a half at 3.69 seconds.

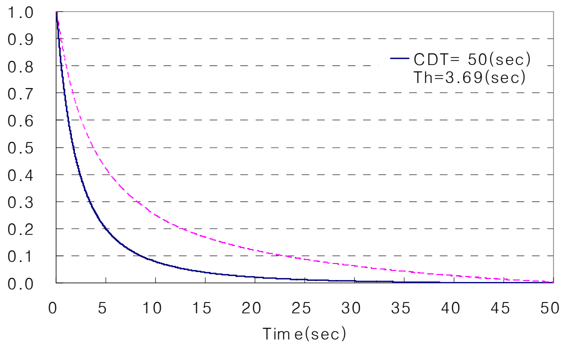
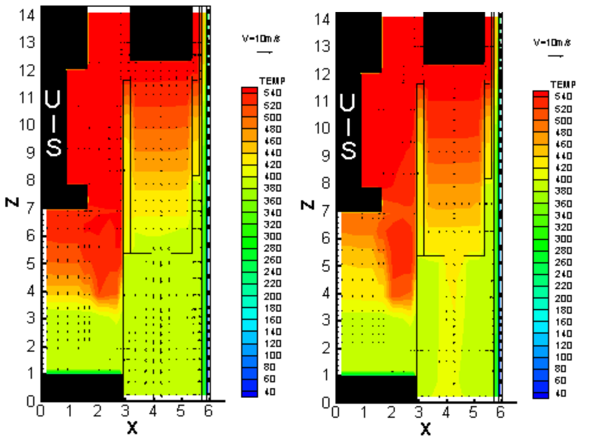
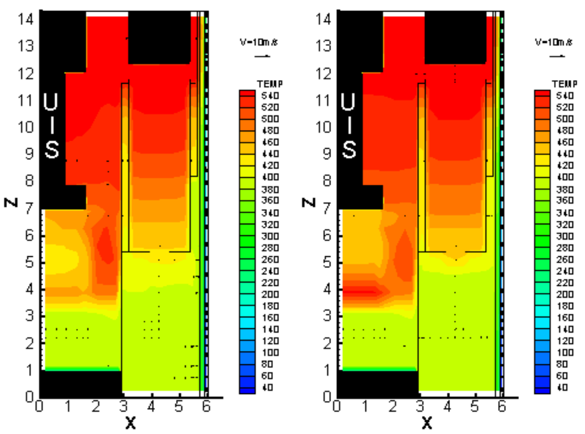


Figure 3. Ratio of PHTS pump head and flow variation

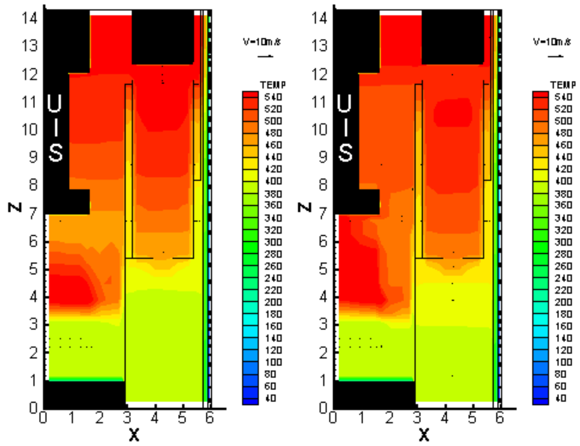
2.4 Thermal-Hydraulic Behavior in Reactor Pool



(a) 5 sec (b) 20 sec



(c) 50 sec (d) 100 sec



(e) 200 sec (f) 400 sec

Figure 4. Thermal-hydraulic behavior in KALIMER-600 at CDT=50

Figure 4 represents the temperature and velocity distribution at 5, 20, 50, 100, 200, and 400 seconds after a reactor shut down. The sodium flow velocity vector cased by the PHTS pump coastdown almost disappeared at 50 seconds. The core exit temperature becomes lower until the coastdown flow is supplied(Fig 4(a)~(c)). However it becomes higher since the coastdown flow supply has been stopped(Fig 4(d)~(f)). Those temperature variations are caused by an overcooling of the core during a coastdown flow supply. The present phenomena are also in accord with the results described in reference[5].

3. Conclusion

In this study thermal-hydraulic behavior in a transient state condition was analyzed using COMMIX-1AR/P. The overcooling of the core is attributed to the supply of a coastdown flow.

REFERENCES

[1] P. L. Garner, R. N. Blomquist, and E. M. Gelbard, COMMIX-1AR/P : A Three-dimensional Transient Single-phase Computer Program for Thermal Hydraulic Analysis of Single and Multicomponent Systems , Volume 2:User's Guide, Argonne National Lagoratory, ANL92-33, 1992.

[2] J. W. Han, T. H. Lee, J. H. Eoh, and S. O. Kim, Investigation into Thermal-hydraulic behavior in the KALIMER-600 Pool in a steady state, Transaction of Korean Nuclear Society Spring Meeting, pp.61-62, 2008.

[3] B. Y. Choi, Thermal-hydraulic analysis in core catcher LMR/FS100-AR-02-Rev.0/07, 2007.

[4] S. K. Choi, Improvement on methodology for setting moment of inertia and coastdown flow in PHTS pump of KALIMER-600, LMR/FS200-ER-03-Rev.0/05, 2005.

[5] Y. S. Sim, Introduction of IDINHX, a new heat exchanger for passive decay heat removal, Nuclear Technology, Vol. 161, Mar. 2008.