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# Development of the interactive model between Component Cooling Water System and Containment Cooling System using GOTHIC

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## 1. Introduction

In a design point of view, component cooing water (CCW) system is not full-interactively designed with its heat loads. Heat loads are calculated from the CCW design flow and temperature condition which is determined with conservatism. Then the CCW heat exchanger is sized by using total maximized heat loads from above calculation. This approach does not give the optimized performance results and the exact trends of CCW system and the loads during transient. Therefore a combined model for performance analysis of containment and the component cooling water(CCW) system is developed by using GOTHIC software code. The model is verified by using the design parameters of component cooling water heat exchanger and the heat loads during the recirculation mode of loss of coolant accident scenario. This model may be used for calculating the realistic containment response and CCW performance, and increasing the ultimate heat sink temperature limits.

## 2. Model

GOTHIC as a containment analysis code involves the network model also for the analysis of a collection of rooms served by a heating, ventilating and cooling system. The network model simplifies the modeling of piping system. This analysis use this characteristics of GOTHIC for the interactive analysis between CCW system and the containment cooling system.

Figure 1 shows the interactive model. The upper part in the figure is the containment analysis module and the lower network is CCW performance analysis module. Two modules are connected by the containment heat exchanger ('CS Hx' in the figure) in CCW module and the containment spray pump in the containment analysis module ('Spray PP' in the figure). The containment temperature and the recirculation spray flow rate in the boundary condition 7F are used in the secondary inlet condition of the containment heat exchanger in CCW system. Then the secondary outlet temperature of the containment spray heat exchanger is used in the boundary condition 8F and it makes the recirculation spray flow condition.

In this evaluation, the heat load in the containment spray heat exchanger is calculated directly in the containment analysis module and the properties of spray water after spray heat exchanger are calculated in the CCW performance analysis module.

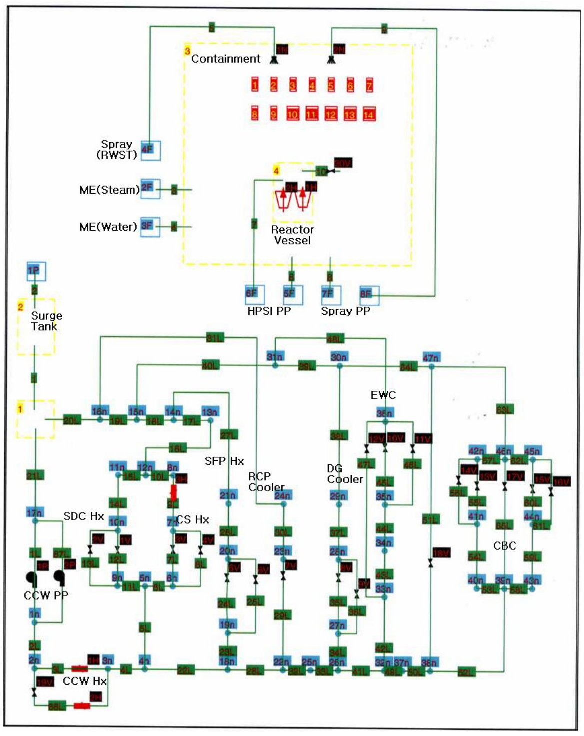

Figure 1 CCW/Containment Interactive Analysis Model

The CCW module is verified by the design parameters of CCW heat exchanger and the heat loads during recirculation stage in LOCA as shown in Table 1 and Table 2.

Table 1 Design Parameters for CCW Heat Exchanger

| Parameter | Shell Side | Tube Side |
|---|---|---|
| Fluid Type | Demi. Water | Sea Water |
| Flow Rate(gpm) | 16000 | 26000 |
| Inlet Temperature(F) | 141.6 | 86 |
| Outlet Temperature(F) | 110.0 | 104.8 |
| Overall HTC(BTU/hr-ft$^2$-F) | 265.4 (Service),<br>610.5(Clean) | |
| Surface Area(ft$^2$) | 37066(Gross),<br>36328(Effective) | |

Table 2 CCW Heat Load during LOCA Recirculation Operation

| Load | | Flow Rate (GPM) | Heat Load (MBTU/hr) |
|---|---|---|---|
| Safety | SDC Hx | 0.0 | 0.0 |
| | Spray Hx | 8000.0 | 200.0 |
| | DG Cooler | 1760.0 | 24.70 |
| | SFP Cooling Hx | 3500.0 | 15.00 |
| | Essential Chiller | 2000.0 | 9.30 |
| Non-Safety | RCP Cooler | 0.0 | 0.0 |
| | Containment Chiller | 0.0 | 0.0 |
| Total | | 15260.0 | 249.0 |

## 4. Results

Figure 2 shows the verification results. As seen in Figure 2 after 1550sec (start of the recirculation stage), GOTHIC calculates the fluid temperatures of heat exchanger which are similar to the design values in Table 1.

Figure 3 shows the CCW heat exchanger's parameters which are predicted by the combined model. The containment spray heat exchanger load is directly calculated in the containment module for the double ended break in the rector coolant pump suction with the maximum safety injection flow.

Figure 4 shows the containment pressure prediction. After the recirculation, the containment pressure is rapidly decreased for the combined model.

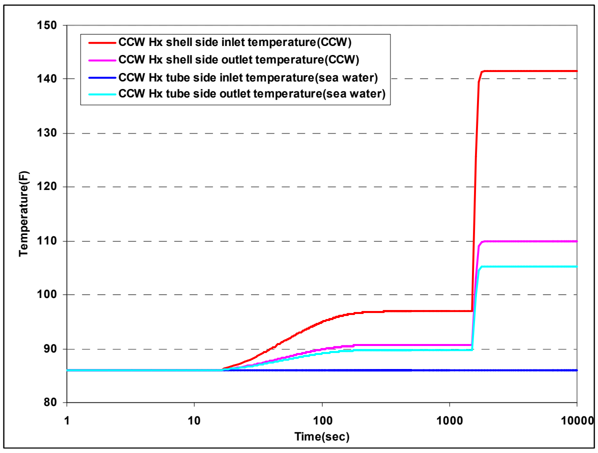

Figure 2 Inlet/Outlet Temperature for CCW Heat Exchanger using Design Parameter

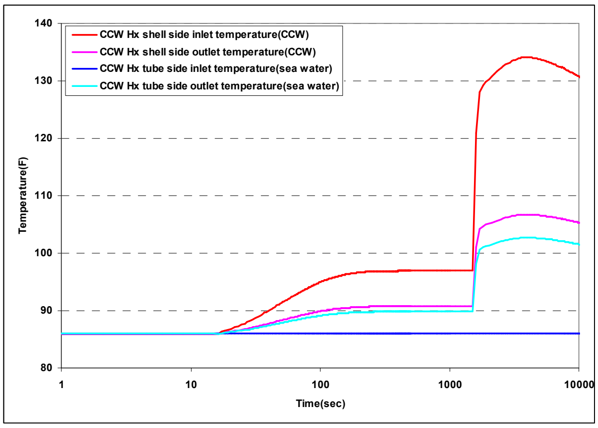

Figure 3 Temperatures of CCW Heat Exchanger from the Combined Model

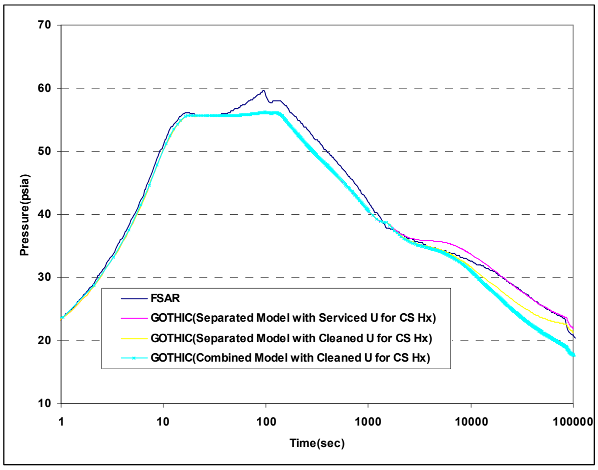

Figure 4 Containment Pressure Response

## 4. Summary and the future work

In this paper, the interactive model between the CCW system and the containment cooling system is constructed and is verified by using the design parameters such as CCW heat exchanger performance parameters and the design heat loads. This model need to be revised more realistically by using the loss coefficients in the CCW piping , exact component elevation and film coefficient in the heat exchanger tube and shell.

## REFERENCES

[1] T.L. George, et. al., "GOTHIC Containment Analysis Program, Version 7.2, Volume 1and 2", NAI 8907-02, Rev. 16, Numerical Applications, Inc, Sept. 2004.
[2] Final Safety Analysis Report, Uljin unit 3&4.