3D Analysis of Cooling Performance with Loss of Offsite Power Using GOTHIC Code

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1. Introduction

GOTHIC code enables to analyze one-dimensional or multi-dimensional problems for evaluating the cooling performance of loss of offsite power. The conventional GOTHIC code analysis performs heat transfer between plant containment and the outside of the fan cooler tubes by modeling each of fan cooler part model and component cooling water inside tube each to analyze boiling probability.

In this paper, we suggest a way which reduces the multi-procedure of the cooling performance with loss of offsite power or the heat transfer states with complex geometrical structure to a single-procedure and verify the applicability of the heat transfer differences from the containment atmosphere humidity changes by the multi-nodes which component cooling water of tube or air of Reactor Containment Fan Cooler in the containment, otherwise the component model uses only one node.

2. Methods and Results

2.1 Heat Transfer Model

Figure 1 shows heat transfer model of boiling analysis about containment fan cooler tubes at the design basis accidents (DBAs) accompanied by loss of offsite power.

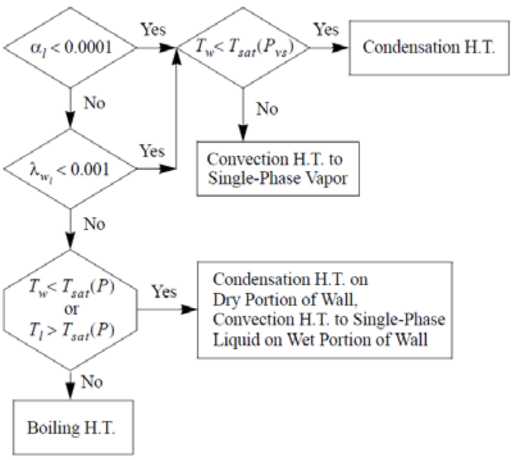

Figure 1. Thermal Conductor Film Heat Transfer Model

The high temperature air heat in containment is transferred to component cooling water through containment fan cooler tubes following a DBA. In this process, convection causes liquid film formation on the outside of tubes by condensation, and heat is transferred from outside of tubes to inside by conduction. Boiling at component cooling water in fan cooler tubes would be occurring by natural convection, pool boiling and forced convection due to the heat from outside.

2.2 Fan Cooler Heat Transfer Model Verification

Comparing heat transfer model with part model evaluate propriety of heat transfer rate as well as input data of fan cooler heat structure such as area, temperature etc. As basic verification steps of heat transfer model were used in boiling analysis, verification was conducted about input data of fan cooler part model and containment/atmospheric conditions as follows.

Figure 2 shows nodal to verify heat exchanger of part model included GOTHIC code. Component of nodal consists of two control volumes to describe containment, two boundary conditions to describe atmospheric conditions, and a flow path to connect two control volumes with boundary conditions. Heat exchanger is assigned on flow path (FP2) to describe fan cooler.

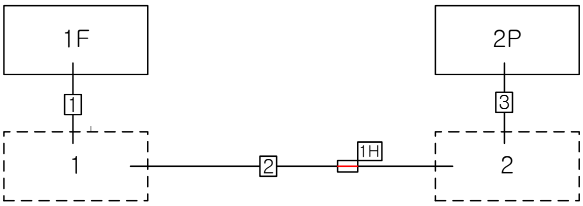

Figure 2. Part Model (GOTHIC)

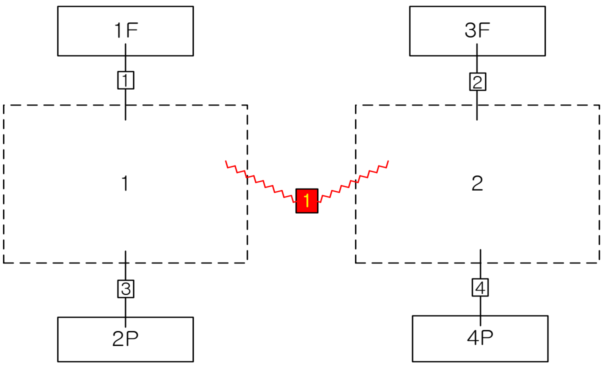

Figure 3. Heat Transfer Verification Model

Figure 3 is the model for verification in this paper. Volume 1s describes component cooling water, volume 2 describes atmosphere of containment.

Between volume 1s and volume 2, heat transfer is described by external conductor. Difference of surface area between component cooling water and atmosphere of containment is set to facilitate heat transfer of equal quantity by using function. Figure 4 is the analysis result of part model and heat transfer verification model. Looking at temperature on component cooling water of part model and heat transfer verification model, the difference decreases with the time. Through this perspective, heat transfer model which has been used in this study is capable of predicting heat transfer rate that is similar to transfer rate predicted by part model.

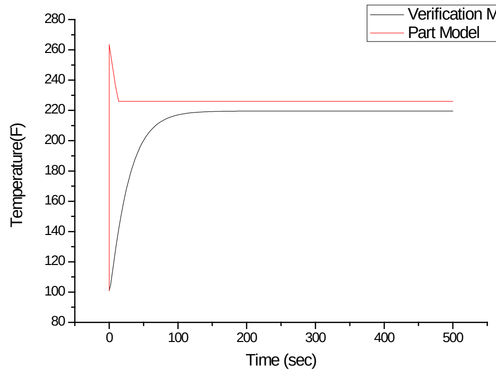

Figure 2. Part Model/Verification Model Temperature

2.3 Boiling Probability Analysis

Figure 5 represents GOTHIC Code 3D model for analysis of boiling probability. Boundary condition (1F, 2F, 3P, 4P) was used to set atmospheric condition of containment, control volume (2s, 3s, 4a, 5s) was used to describe component cooling water in fan cooler tube at stopping status.

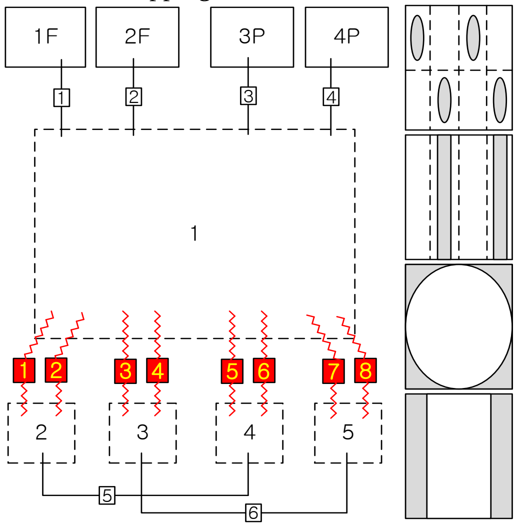

Figure 3. Boiling Probability Analysis Model (GOTHIC)

2.4 Boiling Probability Analysis Result

Figure 6 represents temperature of fan cooler tube according to the analysis of boiling condition of fan cooler. Through the analysis, boiling occurs in 22 seconds after accident. Maximum heat flux is found in the first component cooling water tube. Accordingly temperature is also higher as much as 2F.

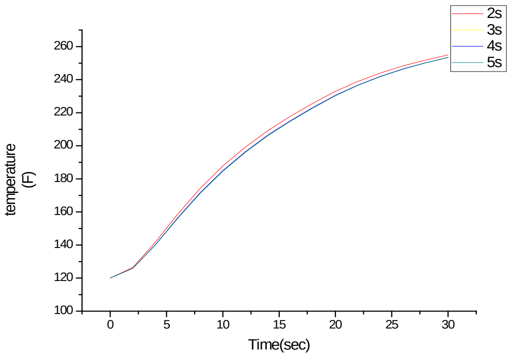

Figure 4. Component Cooling Water Temperature

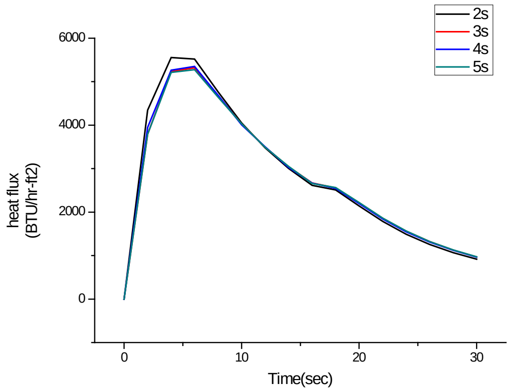

Figure 5. Component Cooling Water Heat Flux

3. Conclusions

As a result of boiling analysis about fan cooler tube of containment with loss of offsite power, there are differences of temperature and heat flux at each node. Although temperature difference doesn't affect the result of boiling analysis significantly, the suggested multi dimensional analysis is applicable to the actual phenomenon.

REFERENCES

[1] T.L. George et al, "GOTHIC Containment Analysis Package User Manual Version 7.2b", NAI 8901-02 Rev 18, Numerical applications, Inc., Washington, USA, March, 2009.

[2] T.L. George et al, "GOTHIC Containment Analysis Package Technical Manual Version 7.2b", NAI 8907-06 Rev 17, Numerical applications, Inc., Washington, USA, March, 2009.

[3] Yeonggwang #2 FSAR 9,2,2 Component Cooling Water System