Heat Transfer Analysis of Fin Tube

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1. Introduction

Cooling system in a nuclear power plant can be divided into two categories; 1) active pump driven system powered by alternating current and 2) passive cooling system drived by natural circulation phenomena. After the accident in Hukushima Nuclear Power Plants, the importance of the passive cooling system that can provide a long-term cooling of reactor decay heat during station blackout condition is emphasized [1]. However, the effectiveness of passive cooling system based on cooling water is limited by the capacity of water storage tank. To overcome the limit due to the exhaustion of the cooling water, an natural convection air cooling system is proposed. As the air operated cooling system utilizes natural circulation phenomena of air, it does not require cooling water. However, the heat transfer area of the air operated cooling system should be increased much as the heat removal capacity per unit area is much lower than that of water cooling system.

The air-water combined cooling system can resolve this excess increase of the heat transfer area in the air operated cooling system [2]. This air-water cooling system can be also used in the passive containment cooling system. This paper describes a preliminary numerical analysis of fin tube used for a heat exchanger of the air-water cooling system. The internal flow in a fin tube is steam and the external of the fin is cooled by air. The effect of design parameters such as fin tube arrangement, the fin height, and pitch has been analyzed and the chimney effect on the simulation of heat transfer in a heat exchanger is evaluated.

2. Analytic Model

The fin tube is made of SUS304, and the external diameter, thickness, and distance between fins are 33.4 mm, 1.65 mm, 5.8 mm, respectively. In this study, the fin height that has the highest heat removal rate has been derived from 1/4D, 3/8D, 1/2D, 5/8D height fin geometry by considering 80~90 % fin efficiency. Then, using the most effective fin height geometry, internal flow patter in a heat exchanger both for natural circulation flow condition and chimney condition has been compared.

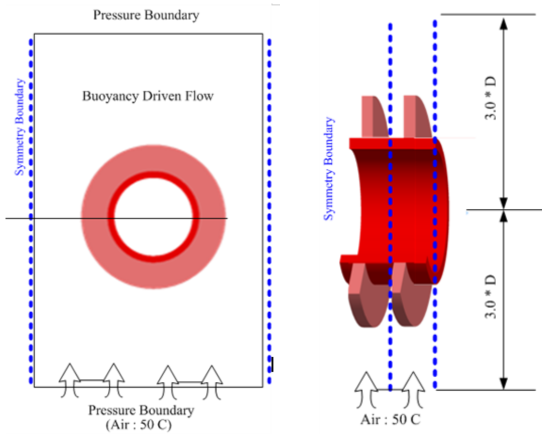

Fig. 1 Fin Shape and Boundary Conditions

The internal flow is analyzed using a CFX computer code. Figure 1 shows the shape of the fin tube used for the analysis. The inlet air temperature was assumed to be 50 oC and the exit was set to be pressure boundary. The shape of the fin tube array is shown in Figure 2.

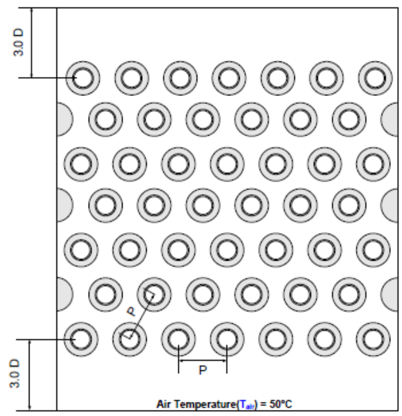

Fig. 2 Fin Tube Array

To conserve the shape of flow and wall effect, half circles were added to the side walls. Tube array was triangular. The internal pressure of the heat exchanger was atmospheric pressure and air flew in it.

3. Results

To evaluate the internal flows for natural circulation flow conditions and chimney condition, analysis was performed, and chimney condition was simulated by the suction velocity at the upper exit. Figure 3 shows the air velocity contours for the natural circulation flow condition (a) and for the chimney condition (b). In the analysis, the flow rates at the exit for two conditions were assumed to be the same. The velocity fields at the two test conditions are almost same for the lower first row to sixth row fin tubes. This results shows that the increase of the exit velocity does not result in the difference of thermal heat flux distribution at the lower fin tube rows. In other words, there is no big difference in the distribution of the velocity due to the heating effect (Fig. 4).

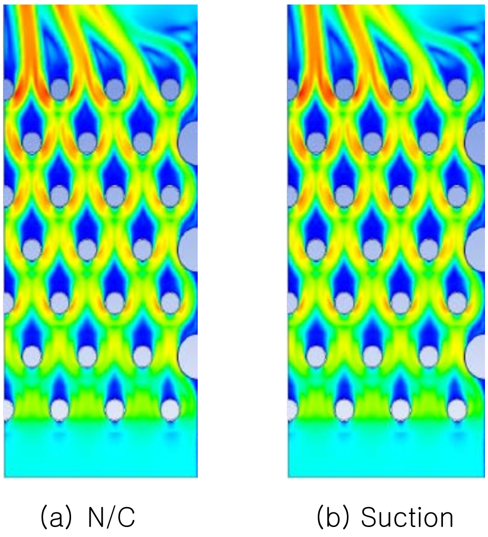

Fig. 3 Velocity Contour

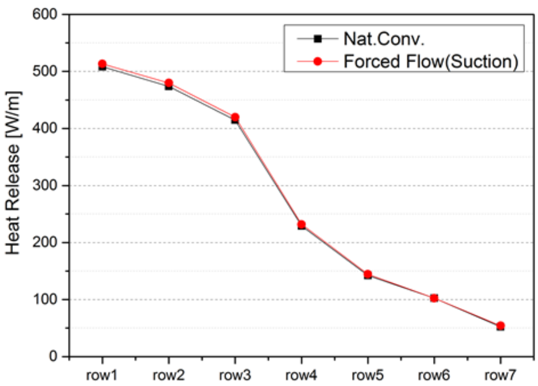

Fig. 4 Heat Release

4. Conclusions

The internal flows in a fin tube heat exchanger for natural circulation flow condition and forced convection (suction) condition were investigated. The results show that the heat transfer test with a chimney can be safely performed without invoking distortion on heat transfer or air velocity distribution between tubes due to the increase of exit suction velocity.

ACKNOWLEDGEMENT

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