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3상 GIS Busbar내 자연대류에 대한 수치해석적 연구

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A Numerical Study on Natural Convection in A Three-Phase GIS Busbar

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Keywords: *Heat release, Natural convection, GIS Busbar, Nusselt number*

Abstract

The temperature rise of GIS (Gas Insulated Switchgear) busbar system is a vital factor that affects its performance. In this paper, a two-dimensional model is presented by commercial code CFX11 for the evaluation of natural convection in the busbar system. In the model, SF6 (Sulfur Hexafluoride) is used to insulate the high voltage device and improves the heat transfer rate. The power losses of a busbar calculated by the magnetic field analysis are used as the input data to predict the temperature rise by the nature convection analysis. The heat-transfer coefficients on the boundaries are analytically calculated by applying the Nusselt number considering material property and model geometry for the natural convection. The temperatures of the tank and conductors from CFX simulation and the experiment were compared. The results show a good agreement. In the future, we will calculate the 3-D model and try to reduce the temperature by adjusting some dimensional parameters.

1. INTRODUCTION

Power transformer system is a device employing the principle of mutual induction to convert variations of alternating current in a primary circuit into variations of electrical parameters like voltage and current in a secondary circuit at the same frequency [1]. In the system, the electric current is very strong. So we can't use normal electric wire but a special wire busbar. The busbar is produced by using steel or aluminum [2], which is exposed to the currents and as a result, eddy current losses are induced inside. The joule heat cost by source currents leads to temperature rise of busbar [3]. Nowadays, busbar system has grown to become an integral part of electric power distribution system. For insulating the high voltage device and improving the heat release rate, some special additives are appended. For example, gas and some special oil are used. At this time, the busbar with gas is studied. The temperature rise of GIS (Gas Insulated Switchgear) busbar system is a vital factor that affects its performance [4]. In this paper, a two-dimensional model is presented by commercial code CFX11 for the evaluation of natural convection in the busbar system. In the model, SF6 (Sulfur Hexafluoride) is used to insulate the high voltage device and improves the heat release rate.

2. THEORY

The fluid in the busbar is governed by Navier-Stokes equations, which are shown in Equation 1.

$$\rho\left[\frac{\partial \vec{V}}{\partial t}+\vec{V}\cdot\nabla\vec{V}\right]=-\nabla p+\mu\nabla^2\vec{V} \tag{1}$$

The heat-transfer coefficients on the boundaries are analytically calculated by applying the Nusselt number considering material properties and model geometry for the natural convection. The equations we used are shown in Equation 2 and Equation 3. Equation 2 represents Nusselt number. The Equation 3 represents nature convection heat transfer coefficient.

$$Nu = 0.386\left(\frac{\Pr}{0.861+\Pr}\right)^{1/4}\left(Ra_c\right)^{1/4} \tag{2}$$

$$h=\frac{k}{L}Nu = 0.386\frac{k}{L}\left(\frac{\Pr}{0.861+\Pr}\right)^{1/4}\left(Ra_c\right)^{1/4} \tag{3}$$

The power losses of a busbar are calculated by the magnetic fi eld analysis. In this study, we use the result directly.

3. CALCULATION BUILD-UP

Figure 1 and Table 1 show the cross-sectional view and the dimension of 145kWV 40kA 3150A GIS busbar model, respectively.

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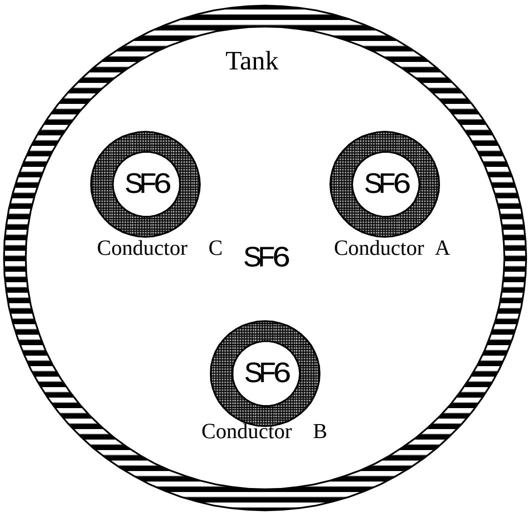

Fig.1 Cross-section of the busbar model

Table1 Dimension of the busbar model

Spec.	Material	Inner diameter [mm]	Outer diameter [mm]
Conductor	Aluminum	60	90
Tank	Aluminum	580	596

The power losses of a busbar calculated by the magnetic field analysis are used as the input data to predict the temperature rise for the nature convection analysis, shown in Table 2

Table2 The power losses of the busbar model

Spec	Conductor			Tank
	Phase A	Phase B	Phase C	
Power Losses[W/m]	133.686	113.685	113.686	133.75

And the governing equation is Navier-Stokes equations. The outside air temperature is 17 °C .

4. RESULT AND CONCLUSION

The temperature distribution of the CFX simulation's result is shown in Fig.2.

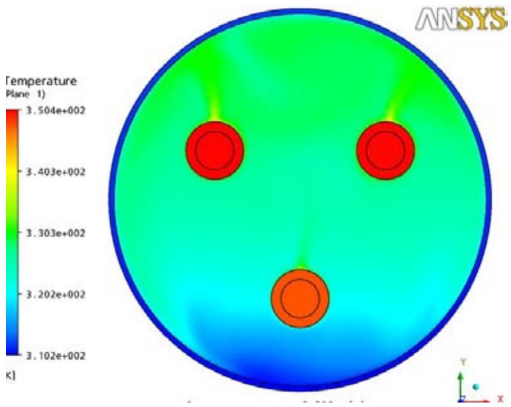

Fig. 2. Temperature distribution of CFX result

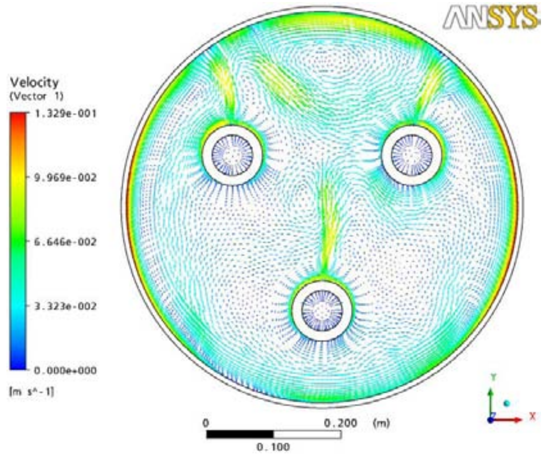

Fig. 3. Velocity distribution of CFX result

Fig.3 shows the velocity field of the busbar from CFX result. The temperatures of the tank and conductors from CFX simulation and the experiment were compared. The result is shown in Table. 3. We can see a good agreement. In the future, we will calculate the 3-D model and try to reduce the temperature by adjusting some dimensional parameters.

Table3. The comparison of conductor&tank's temperatures

Temperature(°C)	Conductor			Tank
	Phase A	Phase B	Phase C	
Measurement	74.5	70.6	75.2	36.7
CFX Result	77	74.7	77.2	37

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