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Numerical Analysis on the Thermal and Fluid in Air Conditioning Duct for Marine Offshore

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해양 구조물용 공조덕트 열유동에 관한 수치해석

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ABSTRACT

This study is about distributions of heat transfer in air conditioning duct used for marine and oil drilling ship. As the convective heat transfer coefficient increased, heat transfer was conducted dynamically to inside as it exited to the outlet of duct. So, it was checked that the amount of heat transfer generated at duct increased as the convective heat transfer coefficient increased. In case the convective heat transfer coefficient was low, the temperature of duct showed the relatively high temperature distribution due to the temperature influence of internal fluid as the heat transfer between the outside and inside of the duct. In case of temperature distribution generated the volume of the duct along the change of the convective heat transfer coefficient, it was found out that the temperature descended as heat transfer was promoted and the convective heat transfer coefficient increased.

Key Words : Drilling Ship(시추선), Air Conditioning Duct(공조덕트), CFD(전산유체역학)

1. Introduction

Among offshore plants, the submersible semi-drilling rig has air ducts for ventilation in columns and pontoons, which correspond to bridges.

The air duct generally used in submersible semi-drilling rigs is a lightweight, watertight air duct, which is installed as a module inside the column. It has a corrugation part on the surface in the longitudinal direction, which is designed to increase strength and reduce weight.

As the strength of the lightweight, watertight air duct is increased by the corrugation part, the air duct can be made thinner and the total weight can be reduced, allowing for more efficient air duct use in submersible drilling rigs. Thus, major oil companies in Europe and other regions generally try to reduce the weight of newly constructed drilling rigs.[1-4]

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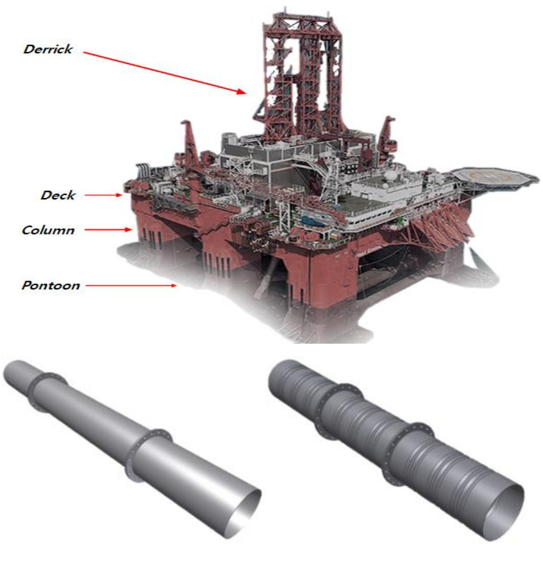


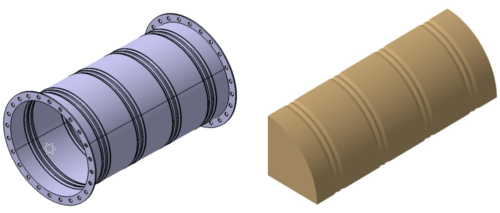
(a) Present **(b) Development**

Fig. 1 Air conditioning duct for marine offshore

As shown in Fig. 1, for the air ducts installed in the column of drilling rigs, the duct is produced simply with flat-surface steel plates and the ends are connected by welding. Therefore, this study analyzes the heat and flow inside the air duct through numerical analysis.

2. Heat Flow Analysis Method

This study investigated an air duct with a diameter of 550 mm, as shown in Fig. 2. First, the effects of the corrugations inside the duct on the flow field and heat transfer were examined.



(a) 3D modeling **(b) CFD modeling**

Fig. 2 Analysis model

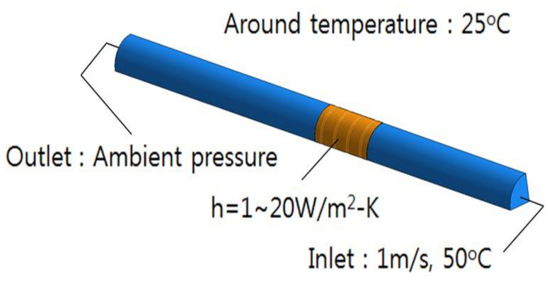


Fig. 3 Control volume shape for CFD analysis

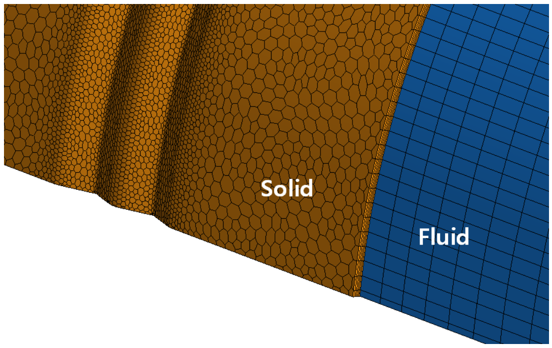


Fig. 4 Control volume for fluid and solid

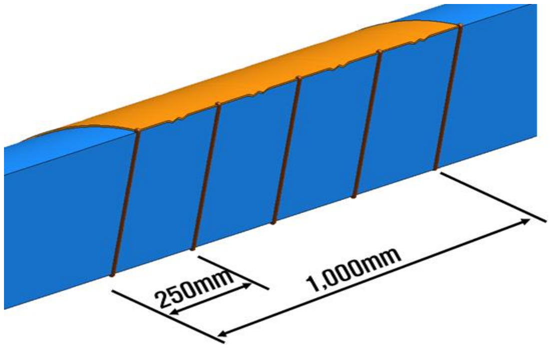


Fig. 5 Sensing positions at length and radial direction

Fig. 3 shows the boundary conditions for the heat flow analysis of the air duct. To ensure flow stability, the inlet and outlet were created by extruding them by five times and seven times the hydraulic radius.

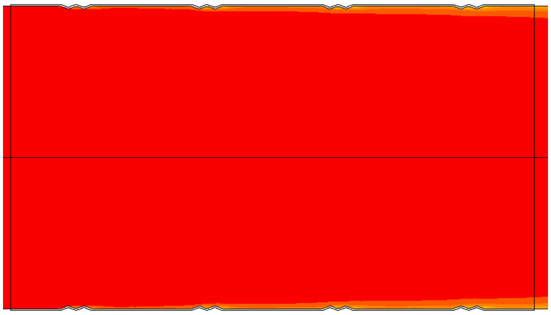
As shown in the figure, the convective heat transfer coefficient for the outside of the lightweight watertight duct was set as a variable. The ambient temperature in the atmosphere was assumed to be 25℃. In addition, it was assumed that air flowed into the inlet at 1 m/s and passed through the duct at a temperature of 50℃. The air at the outlet was assumed to have the atmospheric pressure.[5-7]

Fig. 4 shows the control volume for heat flow analysis. The thickness of the duct, which was a solid area, was 3 mm and consisted of five mesh layers.

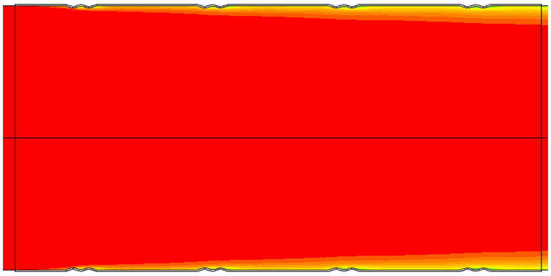
Fig. 5 shows the radial inner temperature distribution along the length of the lightweight watertight duct. The temperature was checked with virtual sensors at five points in 250-mm intervals from the duct inlet. The 250-mm point was the middle position between the corrugated tubes.

3. Results of Heat Flow Analysis

Fig. 6 shows the temperature distribution inside the duct according to the change in the convective heat transfer coefficient on the external surface of the lightweight watertight duct. As shown in this figure, heat transfer occurred on the duct surface and heat exchange with the outside occurred when the fluid flows through the duct. As a result, the inside of the duct cooled slowly.



(a) h=1W/m2-K



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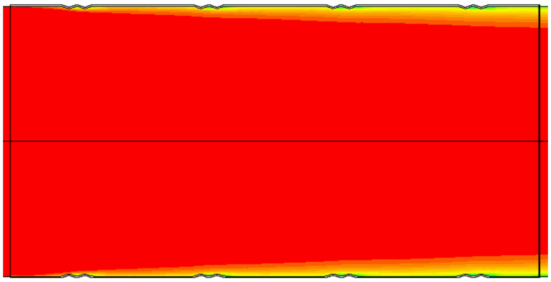
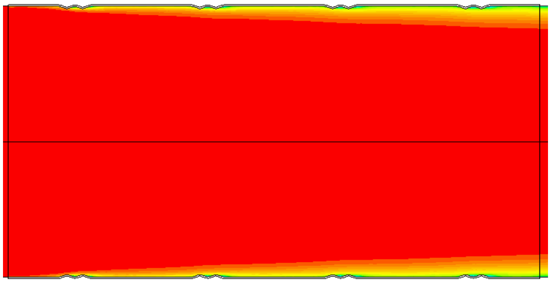


(c) h=10W/m2-K



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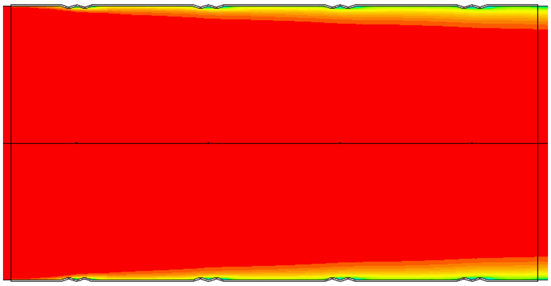

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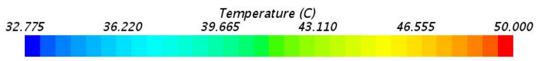
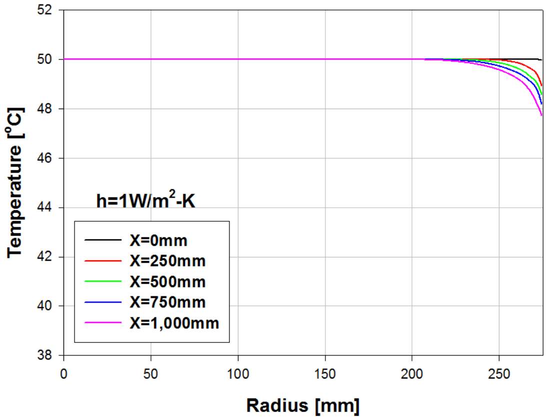
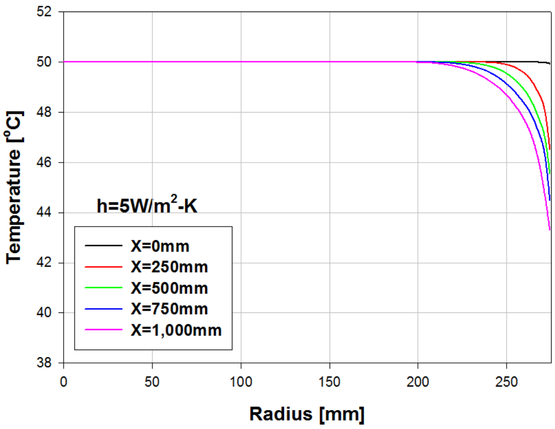


Fig. 6 Result of temperature distributions in Fluid region



(a) h=1W/m2-K



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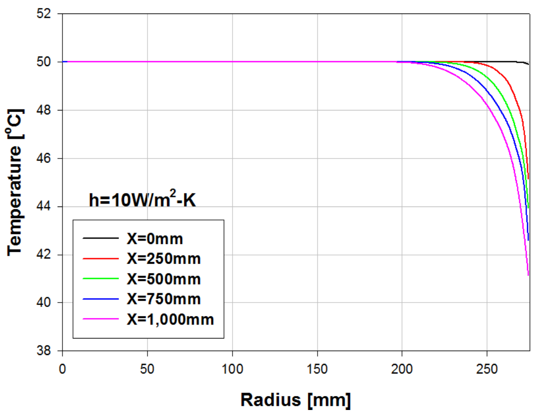

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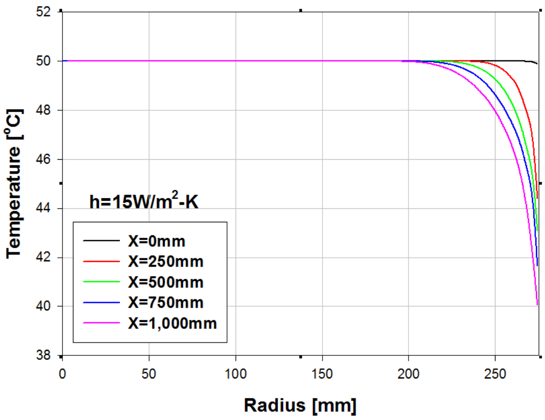

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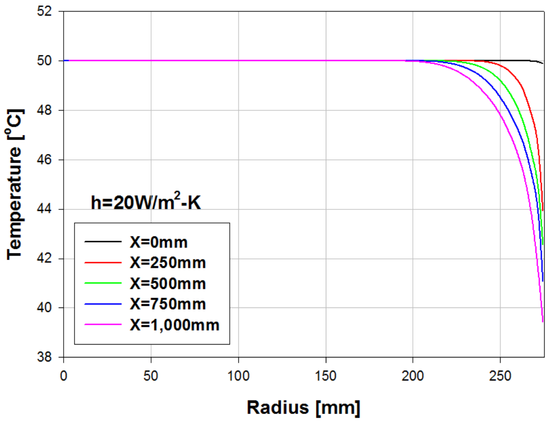


(e) h=20W/m2-K

Fig. 7 Comparison of temperature distributions at positions

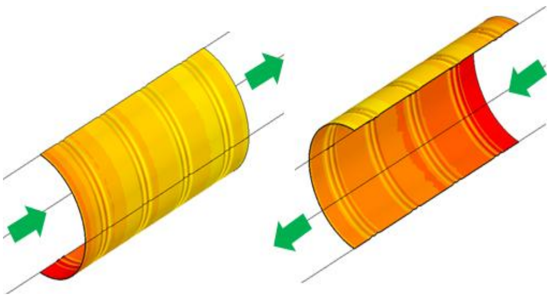
As the convective heat transfer coefficient increased, there was active heat transfer to the inside as the fluid flowed out through the duct outlet.

Fig. 7 shows the temperature distribution at each point according to the change in convective heat transfer. Here, the zero point of the X-axis indicates the center of the duct. In general, as the fluid passed through the duct, heat transfer to the outside of the duct occurred. Thus, the inside of the duct cooled more when it was closer to the outlet.

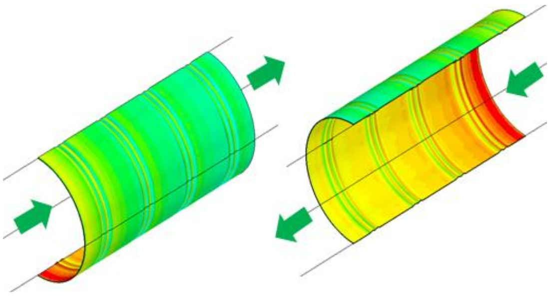
It was observed that as the convective heat transfer coefficient increased, heat transfer accelerated and the heat was transfered deeper into the duct.

Fig. 8 shows the temperature distribution for the solid duct region. As shown in this figure, when the convective heat transfer coefficient was low, the heat transfer between the outside and inside of the duct slowed and the duct temperature increased due to the effect of the internal fluid temperature. In contrast, as the convective heat transfer coefficient increased, heat transfer was accelerated and the duct surface temperature decreased.

An examination of the temperature distribution on the inner and outer surfaces of the duct confirmed that the inner surface had a higher temperature distribution because the temperature of the working fluid was high. In contrast, the outer surface had a lower temperature distribution due to the convective heat transfer with the outside.



(a) h=1W/m2-K



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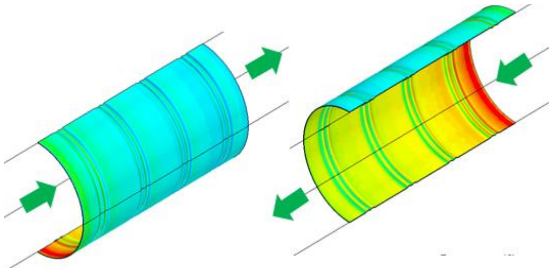

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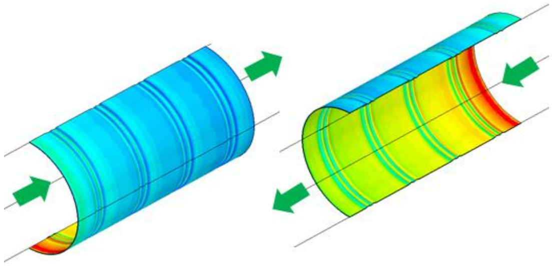
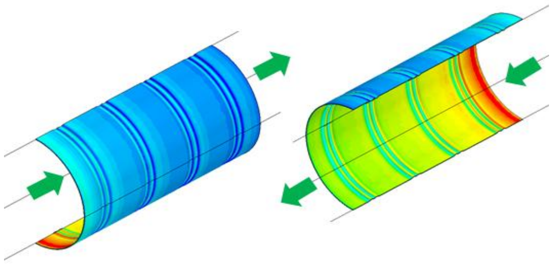


(d) h=15W/m2-K



(e) h=20W/m2-K

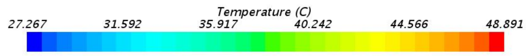


Fig. 8 Result of temperature distributions at solid region

Depending on the moving direction of the working fluid inside the duct, when the fluid passed through the outlet, heat transfer accelerated and the temperature distribution decreased.

Fig. 9 shows the heat transfer in the duct. As the convective heat transfer coefficient increased, the heat transfer in the duct increased. This is because as the convective heat transfer coefficient on the outer surface of the duct increased, the heat transfer with the working fluid flowing inside the duct was accelerated.

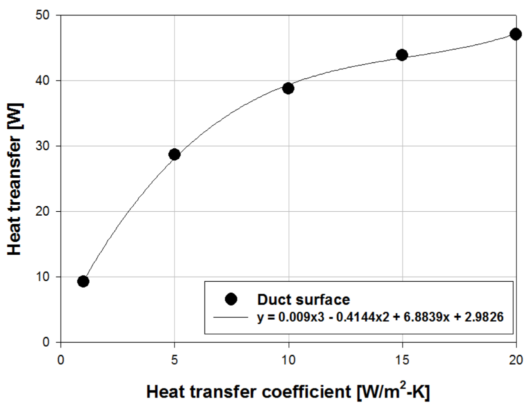


Fig. 9 Result of heat transfer distribution at duct surface

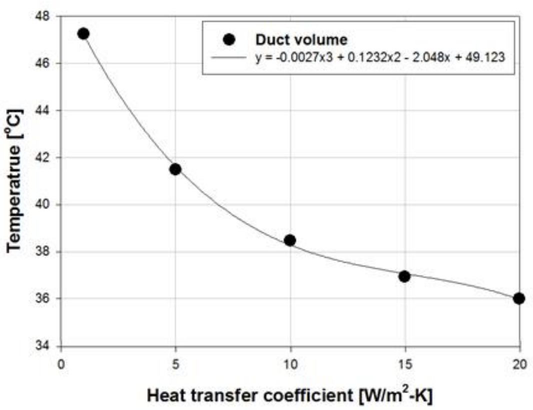


Fig. 10 Result of temperature distribution at duct

Fig. 10 shows the temperature distribution inside the duct according to the change in the convective heat transfer coefficient. It can be seen that as the convective heat transfer coefficient increased, heat transfer accelerated and the temperature decreased.

4. Conclusions

As a result of the heat transfer analysis of the air duct applied to offshore structures, the following conclusions were reached.

(1) As the convective heat transfer coefficient increased, the fluid flowed out through the duct outlet and active heat transfer occurred. Therefore, it was observed that the heat transfer in the duct increased as the convective heat transfer coefficient increased.

(2) When the convective heat transfer coefficient was low, the heat transfer between the outside and inside of the duct slowed and the duct temperature increased due to the effect of the internal fluid temperature.

(3) For the temperature distribution in the duct volume according to the change in the convective heat transfer coefficient, it was observed that as the convective heat transfer coefficient increased, the heat transfer accelerated and the temperature decreased.

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