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Artificial Neural Network Based Window Ventilation System For Indoor Particulate Matter Reduction

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Abstract **-** The management of indoor air quality is regarded highly important to health of modern people because more than 85% of their daily time stay in the indoor. There are a number of pollutants that affect the indoor air quality. Among them, particulate matter is one of the serious threats to the health of occupants. A window type ventilation system refers to a system, in which windows and ventilation systems are integrated, without interfering with the function and performance of the window. The purpose of this study is to evaluate the performance of windows with Bernoulli principle through Computational fluid dynamics analysis. As a result of the study, it is expected that the ventilation rate will be maximized due to the formation of a jet stream in the window where the Bernoulli principle is applied.

Keywords**:** Particulate Matter, Window Type Ventilation System, Artificial Neural Network, Computational Fluid Dynamics.

1. Introduction

It is very important to maintain a comfortable indoor air quality because modern urban people live in the room more than 85% of their daily lives. When the contaminated room air is exposed to human body, there is a risk of diseases such as Sick building syndrome and multiple chemical sensitivity. The building syndrome is a symptom of a health symptom caused by indoor pollutants It is a term. Major symptoms include sensory deprivation, headache, respiratory illness, and even death. In order to maintain a pleasant indoor public quality, there are various methods such as suppressing the generation of pollutants and preventing inflow of the pollutants.[1]

However, the National Institute for Occupational Safety and Health [NIOSH; According to the National Institute for Occupational Safety and Health, the contribution of indoor air pollution is 52%, which means that the insufficient ventilation is the highest. Thus, ventilation is one of the most important factors in modern architecture.

Ventilation systems applicable to buildings vary greatly depending on the ventilation system and type. A window-type ventilation system, one of the ventilation systems, means a system in which windows and a ventilation system are integrally combined without interfering with the function and performance of the window. Advantages are that it is installed on the window frame and duct connection is unnecessary, so there is no fear of duct pollution, and it has an advantage in terms of energy saving because it incorporates the total heat exchange core.[2,3]

In this study, a window type ventilation system with increased ventilation efficiency by applying the Bernoulli principle and a performance comparison with the existing window type ventilation system through CFD (Computational Fluid Dynamics). We want to demonstrate the superior performance of the outdoor window in the application window.

1.1. Research Scope and Method

The purpose of this paper is to verify the performance of window type ventilation system using Bernoulli principle. In Chapter 2, we explain the principle, basic structure and detailed functions of window type ventilation system. In Chapter 3, comparison and analysis of ventilation and heat exchange performance were performed through CFD simulations of general windows and air glides windows. CFD analysis consisted of one control group and three comparison groups. The control group consisted of airglide windows and the comparative group consisted of two general ventilation systems (a. Lower ventilation window and b. Side ventilation window). Figure 1 below shows the method and scope of the study.

Trend research of the existing window type ventilation system outline and case study·technology

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Analysis of Air-glide window principle, basic structure and detailed functional

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Comparative analysis and performance verification of CFD simulation of general window and Air glide window

⇩

Conclusion

Fig. 1: Flow Chart of Research.

2. Theory Discussion

2.1. Window Ventilation System

In general, a ventilation method is divided into natural and mechanical ventilations. If stable ventilation and comfortable indoor environments inside the building cannot be ensured using only natural ventilation, mechanical ventilation is used (Figure. 2).[4]

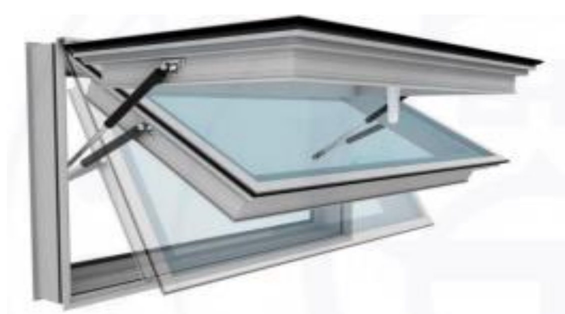


Fig. 2: Natural Ventilation with window.

2.2. Bernoulli's theorem

The Bernoulli Principle is one of the fundamental laws of fluid mechanics, published by D. Bernoulli in 1738 on the relationship between fluid flow and speed, pressure and height. The sum of the kinetic energy and the kinetic energy of the fluid is derived from the fact that the velocity of the fluid increases when flowing through a narrow passage and decreases when flowing through a wide passage. The window ventilation system developed in this study is a system that implements the above principle by constituting minute outlet in window frames. When a fluid (outside air) is inserted into a window frame and the pressure is increased, a strong airflow jet flow is formed by a fine air outlet, thereby increasing the outside air inflow rate.

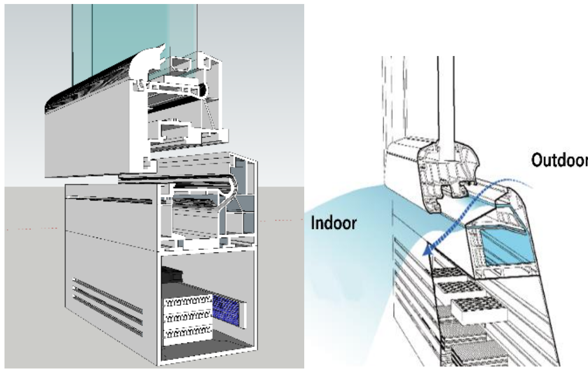


Fig. 3: Basic concept of window type ventilation.

3. Computational Fluid Dynamics (CFD)

In this study, computational fluid dynamics (CFD) analysis was performed to compare and verify the performance of windows. CFD simulation analysis has the advantage of analyzing various situations with comparatively little cost, and as the program technology is rapidly developed, more sophisticated simulation analysis becomes possible. In this study, the CFD simulation program used for the performance analysis of the window type ventilation system was using CD-Adapco's Star-CCM + (ver.9.06) and the standard K-epsilon model proposed by Launder and Spalding was used. For the efficient operation of the simulation considering the size of the target model, we set the mesh to 0.05m and set it as a polyhedral mesh which is the hexagonal lattice most effective for the 3D analysis.[5~7]

Table 1: Simulation environment setting.

Item	Settings
Space	Three Dimensional
Mesh	Polyhedral Mesh
Mesh Size	0.05m
Time	Steady
Material	Gas
Flow	Segregated Flow
Fluid state	Equilibrium Air
Viscosity	Turbulent
Reynolds-turbulent flow	k-ε Turbulence
Iteration	100

To compare ventilation and heat exchange performance of window type ventilation system, one control and three comparison groups were analyzed. The control group consisted of a ventilation system developed by the present research group and a comparative group consisting of a lower ventilation window and a side ventilation window. In order to verify the performance of the ventilation system according to the wind velocity of the ventilation system, the wind speed was varied at 2m / s, 4m / s and 6m / s. The area of the wind outside the wind speed, the area of the outlet, All conditions were set equal. The average wind speed was 1.5m / s and the wind direction was the main wind direction, using the data (30 years) of Seocho-gu in Seoul based on the data of the Korea Meteorological Administration.

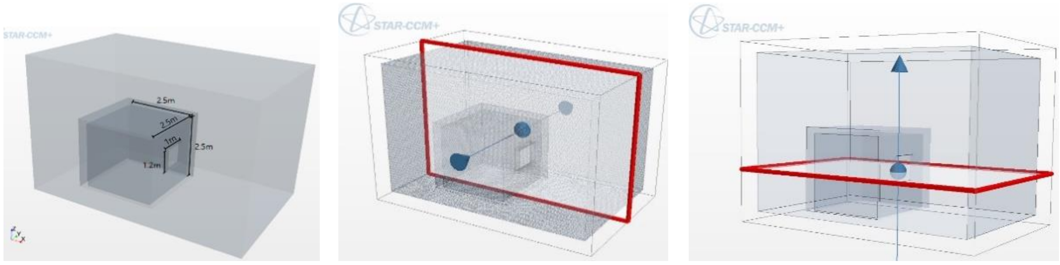
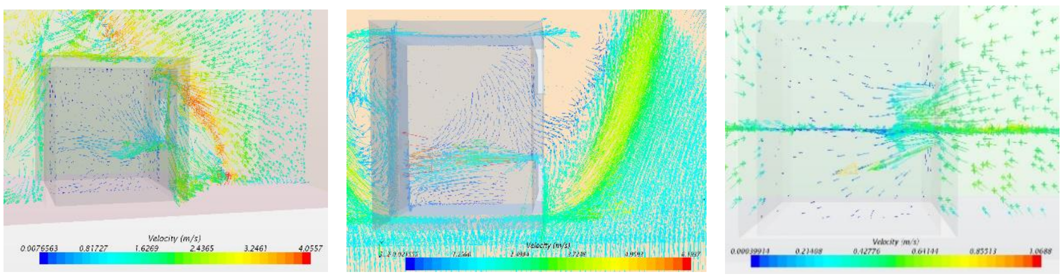


Fig. 4: CFD simulation modeling and method of vertical section and horizontal section.

4. Result



The simulation results of this study are as follows.

(1) The inflow of outside air through the opening was small in the lower and the side type, but the ventilation system confirmed that a large amount of outside air was introduced through the opening.

(2) It was confirmed that the bottom type and the side type ventilate the indoor air through the opening, but the ventilation system confirmed that the outdoor air continuously flows through the opening around the air outlet.

(3) It was confirmed that the outside air inflow rate of the air glide window was more efficient even in the same outlet area and wind speed.

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