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A Basic Study on the Application of Aircaps to Improve the Insulation Performance of Windows to Reduce Building Energy

Heangwoo Lee

College of Design, Sangmyung University, Cheonan-si, Chungcheongnam-do, South Korea
2hw@smu.ac.kr

Abstract

Recently, the amount of energy used in the building sector accounts for a high proportion of the total consumption of energy and various studies are being performed to resolve this problem. In particular, heat loss is the highest in the building envelope such as windows, so the demand for research to improve the insulation performance of windows is increasing. As a part of this research, various studies are being performed on the aircap, which has been recognized for its insulation performance. However, the inconvenient process of attaching and detaching aircaps and the spoiling of the view associated with their use have served to limit the growth of related markets. Therefore, the purpose of this study is to propose a design that improves the convenience of attaching and detaching aircaps. For this purpose, this study considered the concept of aircaps and previous technologies for improving the insulation performance of windows, and based on this, the study proposed a new concept of window aircap application. As a result, this study proposed a new concept of aircaps by applying the principle of curtains, and improved the problem of conventional aircaps by making them easy to apply to windows. However, this study only presented the application of aircaps to improve the insulation performance of windows without evaluating the performance, which will be addressed in further studies in the future.

Keywords: *Aircap, Window, Curtain, Performance evaluation*

1. Introduction

Recently, energy consumption in the building sector has been on the rise and the demand for research and technology development to address this problem is increasing. In particular, the consumption of cooling and heating energy in the building sector is high at 36% and 34%, respectively, in the United States and Korea [1][2][3], and therefore, various studies are being performed to reduce energy consumption. Among these studies, the building envelope such as the window has the highest heat loss, so various studies in relation to double skin façade and PCM are being performed to improve the insulation performance of windows. However, these systems are costly to construct and lack economic efficiency. On the other hand, aircaps, which were originally developed for packaging, are often used to improve insulation performance by attaching them to the glass surface of windows based on the perception that aircaps enhance insulation performance. However, in order to improve the insulation performance by applying aircaps to windows, the aircaps must be attached to the front of the window, so problems occur

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with regard to the inherent function of windows as the view or prospect right is damaged. This is negatively impacting the development of the insulation aircap market.

2. The concept of aircaps and consideration of previous studies related to improving the insulation performance

2.1. The concept of aircaps and consideration of previous studies

As shown in [Figure 1], aircaps were originally developed for the purpose of cushion packaging, in which two or more polyethylene films are superposed and filled with air [4][5][6]. However, recently, aircaps have been recognized for their insulation performance due to its material properties related to the air layer, and their application as insulation finishing materials for improving the insulation performance of windows has been increasing. However, the conventional aircap is an opaque material, which is difficult to attach and detach and also damages the view provided by windows. According to previous studies, water or vinyl type double-sided tapes are used to attach aircaps to windows, which causes further difficulties in the attaching and detaching process.

Figure 1. Concept of aircap

As shown in [Table 1], prior studies have focused on evaluating the performance based on the position and area of aircaps attached to windows, so there is a lack of research on the convenience of applying aircaps[6][7]. In addition, the hassle associated with using water or vinyl type double-sided tapes to attach aircaps to windows is deterring the development of the insulation aircap market. In this respect, the curtain type aircap module in this study can be significant.

Table 1. Research trends related to aircaps

Research title	Research purpose	Aircap attachment method	Ease of application considered
Thermal Performance Evaluation of the Window Systems with Air-bubble Sheets [7]	Analysis on the insulation performance according to the position and type of aircaps	Water (Glass surface of window)	Not considered
A Comparative Evaluation on the Thermal Insulation Performance of Windows according to the Temporary Improvement Method [8]	Analysis of insulation performance according to the position of aircaps on windows	Water or vinyl type double-sided tape (Window frame)	Not considered

2.2. Consideration of research to improve the insulation performance of windows

The windows of the building envelope exhibit the highest heat loss, so various studies are being performed to develop technologies to improve the insulation performance of windows as shown in [Table 2] [8][9][10][11][12][13][14][15]. Among these, the double skin façade is a structure that doubles the outer envelope of the building to improve the insulation performance, but increases the construction cost compared to a single skin façade structure. PCM is a material that accumulates heat or releases stored heat through a process of physical change, which reduces the energy consumption of buildings when applied to windows by releasing the heat accumulated during the day at night. However, this method also increases the price of windows and its application to buildings is not without difficulty. In addition, although the double skin façade and PCM can be applied to new buildings they are not suitable for conventional buildings that are already built.

On the other hand, aircaps are economical materials with excellent insulation performance, which can be easily applied to existing buildings to improve the efficiency of reducing building energy. This is why this study focuses on aircaps to reduce building energy.

Table 2. Research trends to improve the insulation performance of windows and building envelopes

Author	Research purpose Aircap attachment method	Ease of application considered
Yoon and Park [9]	Double skin facade	To investigate and compare the real-time static and dynamic control strategies of double skin façade systems
Park et al. [10]	Double skin facade	To develop a box-type double skin façade system suitable for the conditions and climate in Korea and to evaluate the thermal performance during cooling and heating periods
Shin et al. [11]	Double skin facade	To provide useful data for determining the cavity height of a multi-layered double skin façade by evaluating the thermal performance of a multi-layered double skin façade according to the cavity height
Choi et al. [12]	Double skin facade	To analyze the temperature and airflow of the cavity according to the position of blinds after developing an evaluation model according to the combination of factors affecting the thermal performance of the double skin façade
Choi et al. [13]	Double skin facade	To propose an optimal design method of a curtain wall building with a front-facing double skin façade system by comparing and reviewing the reduction of energy load due to installing a double skin façade system
Jeong et al. [14]	PCM	To verify the performance of a PCM Cool Roof system (PCM + Cool Roof combination) through a miniature model test to confirm the thermal performance
Lee et al. [15]	PCM	To conduct a performance evaluation of building energy reduction according to installing a thermal storage wall system using PCM
Lee et al. [16]	PCM	To analyze the energy saving effect according to thickness when PCM is applied to building roofs by energy simulation

3. Aircap module design proposal to improve window performance

This study applied the principle of curtains as shown in Figure 2 to improve the convenience of applying aircaps to windows. In other words, this enables the occupant to open or close the aircaps to improve the insulation performance of windows or to secure the view. For this purpose, the window aircap module of this study is composed of a guide frame, aircap sliding frame, aircap flexible fixing guide, and aircap as shown in Figure 3, and in particular, the aircap sliding frame is a rail which allows the aircap to move left and right. In addition, the aircap flexible fixing guide and aircap are connected with a clip, which is similar to the structure of curtains.

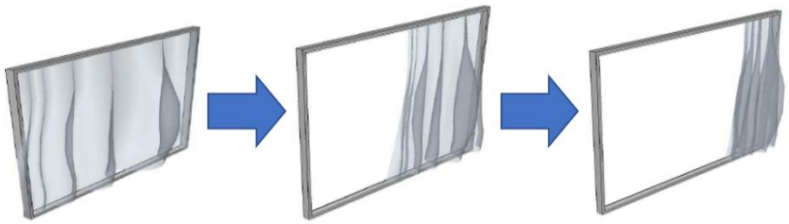

Figure 2. Concept of curtain-type aircap module attached to windows

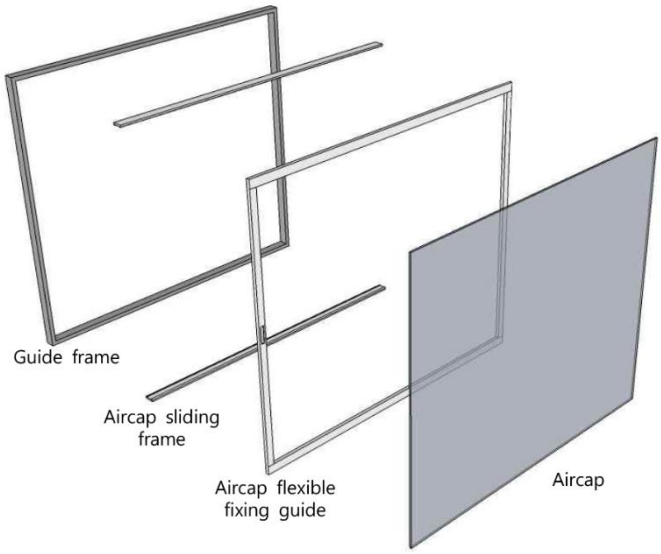

Figure 3. Configuration of curtain-type aircap module attached to windows

4. Conclusion

This study proposed an aircap module design to improve the insulation performance of windows in order to reduce building energy consumption and to create a comfortable indoor environment. First, aircaps can be applied to windows to improve the insulation performance of the building envelope - previous studies related to this did not consider the convenience of attaching and detaching aircaps. Second, this study applied the principle of curtains so that the occupants can secure their prospect right according to their needs by applying the concept of opening and closing the aircaps attached to the window. Third, the aircap window attachment module in this study uses a special frame designed to implement the principle of curtains, and is composed of a guide frame, aircap sliding frame, aircap flexible fixing guide, and aircap.

This study is meaningful in that it seeks to reduce building energy consumption and minimize the damage to the view, which is the inherent function of windows. However, there are some limitations with regard to this study as it does not include the performance and economic evaluation of the proposed system. Therefore, we plan to examine these aspects in further studies in the future.

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Authors

Heangwoo Lee
Sangmyung university, Assistant Professor