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Analysis of Optimal Placement Proposal of HVAC System in Smart Greenhouse using CFD Simulation

Minji Baek[1]*, Hyunsang Cho[2], Doyoung Lee[3], Jeonghwan Seo[4], Jimin Kim[5], Hyounseung Jang[6]

[1] *Undergraduate Student, Architectural Engineering Program, School of Architecture, Seoul National University of Science and Technology, 232 Gongneung-ro, Gongneung-dong, Nowon-gu, Seoul 01881, Korea,* E-mail address: 02bmjyellow@seoultech.ac.kr
[2] *Graduate Student, Architectural Engineering Program, School of Architecture, Seoul National University of Science and Technology, 232 Gongneung-ro, Gongneung-dong, Nowon-gu, Seoul 01881, Korea,* E-mail address: honeyhs@seoultech.ac.kr
[3] *Undergraduate Student, Architectural Engineering Program, School of Architecture, Seoul National University of Science and Technology, 232 Gongneung-ro, Gongneung-dong, Nowon-gu, Seoul 01881, Korea,* E-mail address: ldy3318@seoultech.ac.kr
[4] *Undergraduate Student, Architectural Engineering Program, School of Architecture, Seoul National University of Science and Technology, 232 Gongneung-ro, Gongneung-dong, Nowon-gu, Seoul 01881, Korea,* E-mail address: tjwjdghks21@seoultech.ac.kr
[5] *Associate Professor, Architectural Engineering Program, School of Architecture, Seoul National University of Science and Technology, 232 Gongneung-ro, Gongneung-dong, Nowon-gu, Seoul 01881, Korea,* E-mail address: jang@seoultech.ac.kr
[6] *Professor, Architectural Engineering Program, School of Architecture, Seoul National University of Science and Technology, 232 Gongneung-ro, Gongneung-dong, Nowon-gu, Seoul 01881, Korea,* E-mail address: jmkim@seoultech.ac.kr

Abstract: Greenhouses require various control systems to create an optimal environment, and from an architectural engineering perspective, the uniformity of the internal environment is crucial for crop growth. However, greenhouses are structurally exposed to external weather conditions, leading to a high probability of variations in temperature, humidity, CO2 levels, lighting, etc., across different zones within the greenhouse. Such non-uniformity can impact the growth rate, quality, and yield of crops, highlighting the necessity of maintaining a consistent environment within the greenhouse. To address this, experiments utilizing Computational Fluid Dynamics (CFD) simulations were conducted targeting greenhouses in Pocheon, South Korea, focusing on the central heating and cooling systems to propose an optimal design considering the uniformity of internal temperatures. Subsequently, validation was performed using measurements from temperature and humidity sensors within the greenhouses. The heating and cooling systems operate based on indoor temperatures, activating cooling when indoor temperatures exceed the set cooling temperature in summer and heating when temperatures fall below the set heating temperature in winter. A standard greenhouse model was set as case 1, and experiments were conducted by adjusting the position and spacing of the fabric ducts of the heating and cooling systems, resulting in six categorized cases. Variations in temperature and humidity distribution were observed among the cases, and quantitative analysis provided optimal positions and spacing for the fabric ducts. The results of this study can serve as foundational data for developing environmental control solutions for agricultural facilities.

Key words: Greenhouse, Computational Fluid Dynamics (CFD), Uniformity, Heating & Cooling systems