Cavity controlled Double Glazed Glass with Transparent Solar Layer for Passive Cooling

Senior Design 412 - 232

Meet the team

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Abstract

The initiative is revolutionizing building architecture by integrating a transparent solar layer into double-glazed glass facades, which feature a cavity between them to utilize exhausted air from the building for window cooling. This innovation was proven in simulation to reduce gain by 30% and lowers temperatures by 17°C through rigorous modeling and analysis, consequently decreasing reliance on HVAC systems and enhancing energy efficiency. The model is undergoing real life testing to prove its function in real life. Beyond enhancing occupant comfort and sustainability, this strategy offers a practical pathway towards a greener built environment. Architects, developers, and legislators alike stand to greatly benefit from this revolutionary technology in meeting energy demands and addressing sustainability concerns.

Background & Objective

In response to the pressing challenges faced by skyscrapers, particularly under extreme hot weather conditions where maintaining a comfortable indoor environment heavily relies on traditional HVAC systems, there is a crucial need for innovative, sustainable, and energy-efficient solutions. Our objective is multifaceted: to reduce building heat gain by over 25%, significantly decrease carbon footprints, maintain the functionality of glass transparency, and preserve the aesthetic integrity of building designs. Achieving these goals requires a revolutionary solution that integrates airflow circulation within building facades, optimizing energy consumption and enhancing overall sustainability.

Constraints

We identified eight key constraints to guide our design development, aligning with:

Welfare
Facilitate the flow of fresh air while removing exhausted air

Privacy
Incorporating thoughtful shaded windows addressing culture preferences

Social
Raise awareness of sustainability products

Public Health
Reducing bacterial presence indoor

Economical
Achieving lower energy consumption and investment in reducing electricity bill

Environmental
Reduction of Carbon footprints

Safety
Implementing Robust Safety measures

Global
Incorporate ASHRAE standards for efficient HVAC systems

Target Specifications

We established the specifications by leveraging theoretical equations and engaging in detailed discussions with subject matter experts (SMEs). Some specifications were challenging to determine, requiring optimization through trial and error exercises.

Metric No.	Metric	Units	Target	**Results
1	Installation Time	Hours/Unit	1<	-
2	Cavity	cm	Optimal	1
3	Air Velocity	m/s	Optimal	1.3
4	Transparency	%	60	-
5	PV Glass Efficiency	%	> 25	-
6	Life Span	Years	>15	-

**Results after optimization

Design

The prototype features transparent solar panels affixed to its exterior, serving dual purposes: harvesting solar energy and utilizing an air-filled cavity to prevent solar heat penetration, thereby enhancing energy production and conservation. Beneath these panels lies a protective layer of glass, shielding the structure from the elements. To assess heat transfer efficiency, the design integrates insulation and cement board at strategic locations.

Transparent Solar Panels
Wall Insulation
Glass (Exterior Envelop)
Cement board
1 cm Cavity
Aluminum Frame
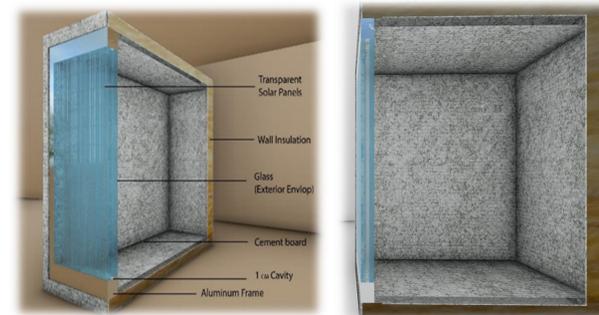
We translated our theoretical built model into a tangible physical prototype to validate our experiment through a real-life example.

Test & Results

Simulation: After SolidWorks testing under specified conditions (e.g., outside glass at 60°C, 1000 x 1000 x 40 mm glass, 1000 x 1000 x 10 mm cavity, inlet air temp 20°C, air velocity 0.5 m/s), we reduced temperature by 17°C, almost 30% better. Compared to Argon, it's a 100% improvement, validating our technique.

Setup Configuration: The same room model was used, simulating indoor conditions with an AC system and exposed to direct sunlight for the outdoor conditions.


Enhanced Instrumentation:

· **Thermocouples:** Utilized eight matched thermocouples to measure surface temperatures—four positioned on the exterior (warm side) and four on the interior (cold side) of the glass facade. This setup aims to capture a comprehensive thermal gradient across the facade.

· **Heat Flux Sensors:** Four heat flux sensors were installed in a facing arrangement—two on the inside paired directly opposite to two on the outside, ensuring precise alignment for accurate heat flux measurement.

Data Handling:

Temperature Difference and Heat Flux Calculation: The temperature difference (ΔT) and heat flux (Φ) were computed by averaging the readings from all four measurement points. This method reduces localized discrepancies and provides a robust data set reflecting the overall performance of the facade.

Thermal Resistance Calculation: The overall thermal resistance was calculated using the formula $R = \frac{\Delta T}{\Phi}$, where the averaged values of ΔT and Φ were used.
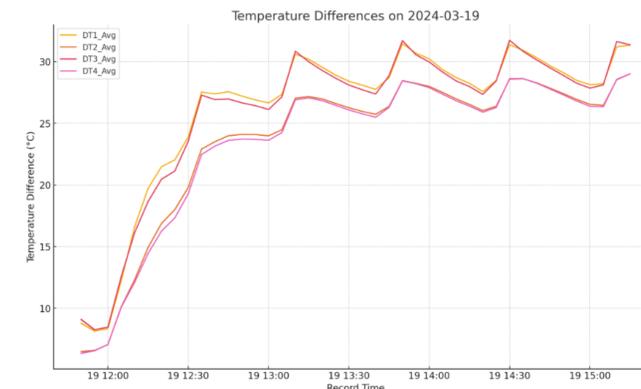
The graphs displayed above are sample visualizations representing the temperature differences measured on different days. These preliminary graphs serve as an example of the detailed analysis that will be conducted

Financial Analysis

Our product has demonstrated its ability to positively impact energy consumption costs, averaging monthly savings of 442 SAR with a payback period of just under one year.

Impact

Our building design integrates PV glass for on-site clean electricity, slashing energy costs and reliance on non-renewables. With an air cavity system enhancing cooling efficiency, it reduces the need for air conditioning. This technology offers unparalleled value in the green building sector, delivering economic savings, environmental benefits, and advanced heat management.

Conclusion

After reviewing all the steps we've taken and analyzing the results, it's clear that our product outperforms the competition. Let's build on this success and further enhance and extend our market leadership

Acknowledgment