Inflatable Glazing

Prototyping of a dynamic thin glass unit
with a switchable thermal insulation

P4 reflection

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Date: 09.05.2023

Aspect 1: The relationship between research and design.

This graduation project investigates a novel type of dynamic glazing that can adjust its insulation value on demand. The thesis's starting point was the use of thin glass, utilizing its bending properties to open or close a cavity within the unit. This movement influences the unit's thermal transmittance, resulting in either a low insulating or high conducting value.

A comprehensive literature review has been conducted to understand the fundamental physics of insulation, the composition of Insulated Glass Units (IGUs), the current market for similar products, and the properties of thin glass. Subsequently, the thesis adheres to the principles of research by design.

An extensive analysis of thermal performance, energy efficiency, and structural performance has been carried out. The insights from these analyses have been instrumental in enhancing the product's design. Several prototypes have been constructed throughout the thesis to demonstrate functionality and manufacturability. These prototypes were then used to determine the inflated geometry using a 3D scan precisely. Finally, the data from this scan has been integrated into the thermal and energy simulations to yield more realistic results.

The thesis concludes by showcasing the aesthetic quality of the product and illustrating how designers could incorporate this technology to reduce a building's energy demand.

Aspect 2: The relationship between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master program (MSc AUBS).

The Building Technology track encourages the use of a variety of tools to not only review data but also to create data. In Building Technology, knowledge in various fields (facade design, computational design, climate design, and structural design) is provided, which helps one to look at a real-life problem from different angles and be confident enough to tackle these.

Furthermore, the thesis project has not only been looked at from the perspective of an engineer but also as an architect. Finally, both worlds come together and create a fully integrated design aiming to lower a building's energy demand, while emphasizing visual quality, aesthetics, and user comfort. Moreover, the mentors aided in procuring the real materials and a professional assembly and testing, which enhanced the quality of the results immensely.

Aspect 3: Elaboration on research method and approach chosen by the student in relation to the graduation studio methodical line of inquiry, reflecting thereby upon the scientific relevance of the work.

This graduation project mainly followed the research method of research by design, which was highly encouraged by the mentors. Furthermore, the possibility of working with various industry professionals giving not only their feedback on the project but also offering components and materials to push the research in the field of thin glass, motivated me throughout the thesis. Thin glass research for architectural applications has a high output at the TU Delft, and previous work has shown that material experiments and product innovation provide promising solutions. However, these studies also pave the way for further research to use this material in the built environment eventually.

Aspect 4: Elaboration on the relationship between the graduation project and the wider social, professional and scientific framework, touching upon the transferability of the project results.

Inflatable glazing tackles societal issues by reducing a building's energy demand and enhancing the thermal comfort of its occupants. Unlike other smart glazing products, the technology allows occupants to maintain an unobstructed view. Furthermore, there is a high potential of reducing material usage and thus lowering the CO2 footprint of the facade. The product offers renovation possibilities due to its thickness, and with reduced weight, it also lowers labor intensity.

The thermal performance of dynamic IGUs with uneven surfaces has been evaluated, showing promising data. Additionally, the energy efficiency of switchable insulation technology has proven to be advantageous, leading to conclusions about its optimal use, locations, and energy reduction. The structural performance of thin glass panes under gas pressure has also been theoretically assessed using Finite Element Analysis and compared with simple laboratory tests. To understand the extent of double curvature and shape, the inflation geometry of thin glass panes has been evaluated using a high-resolution 3D scanner. Finally, the project has investigated the flexibility and durability of innovative edge seals under high shear forces due to pressure.

Aspect 5: Discuss the ethical issues and dilemmas you may have encountered in (i) doing the research, (ii, if applicable) elaborating the design and (iii) potential applications of the results in practice.

This master's thesis fulfilled my expectations completely, delivering valuable insights both in theory and practice. I am very content with the outcome of the thesis and the physical prototypes. However, ethical issues might arise considering the costs of the system. As for now, it is not fully disclosed how much thin glass would be priced for the building market. Therefore, this technology is in the more costly segment of the modern glazing market. It should be evaluated if the costs of the system would equal the energy savings over the product's lifetime. However, if the demand for thin glass increases, one can expect this material to be more affordable.