Design and Fabrication of Vacuum Glazing Units using a New Low Temperature Hermetic Glass Edge Sealing Method

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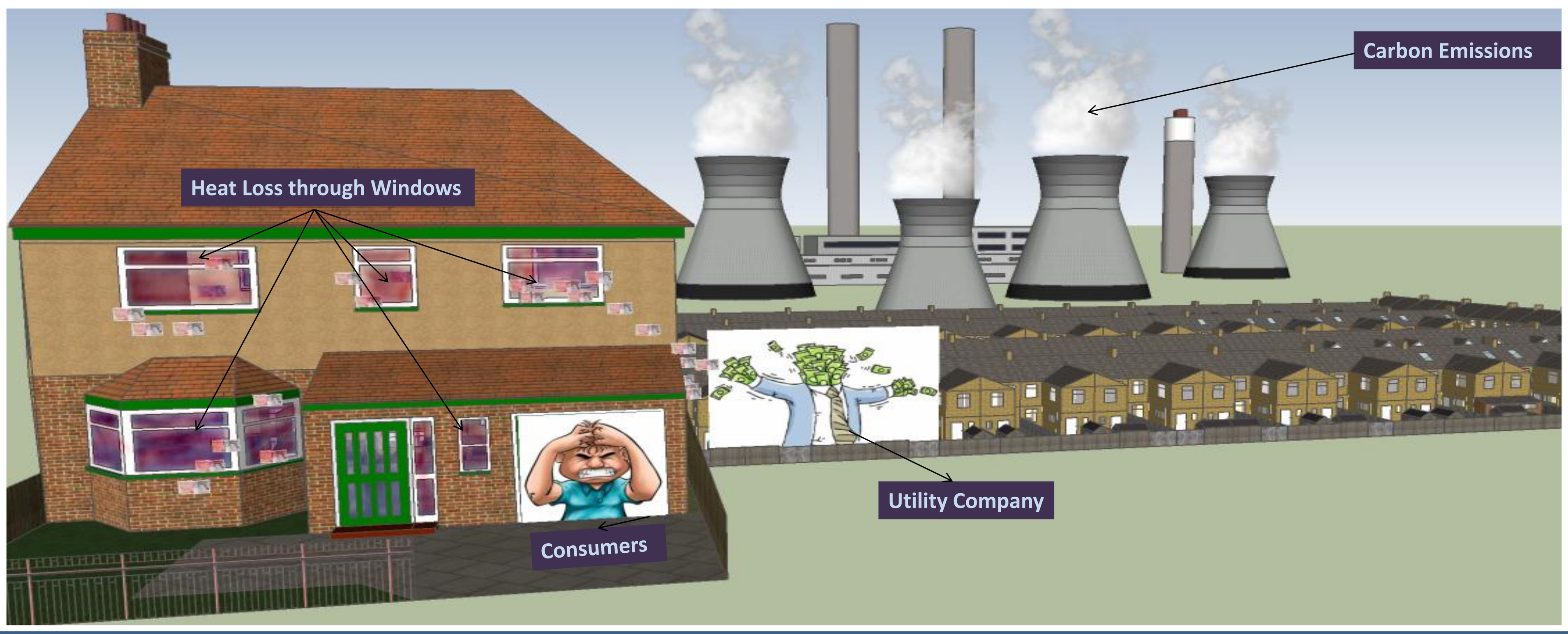
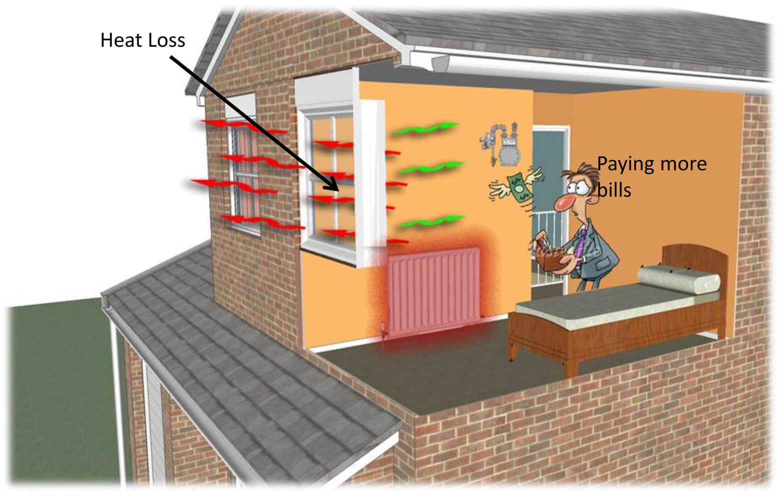
Overview of Research

A Big Picture

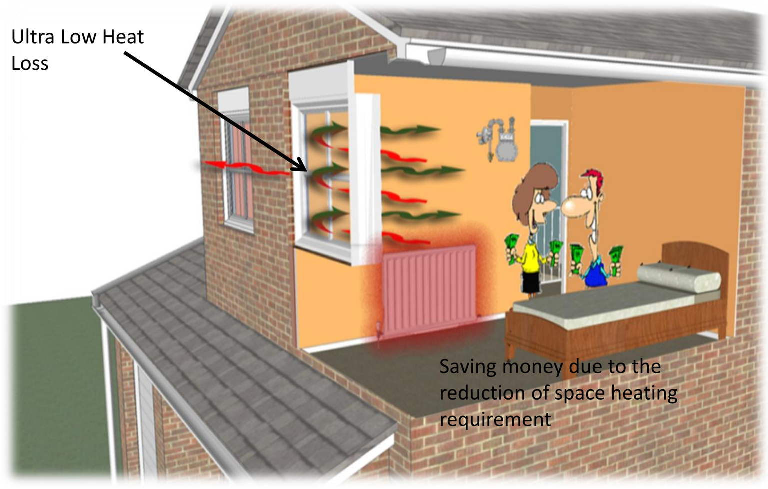


Problem



Heat loss through the windows of dwellings is a major concern due to the increase in use of natural gas in domestic boilers that not only increases the gas utility bills but also emits CO_2 that is a greenhouse gas.

Solution



Vacuum glazing can not only reduce gas bills and CO_2 emissions but allows an increase in the window to wall area ratio that permits an increase in day light transmittance and solar gains.

1. Abstract

This poster aims at presenting experimental investigations for the fabrication of vacuum glazing using a new low-temperature (less than 200°C) based hermetic edge sealing method, as shown in *Fig. 1*. To date two materials indium and solder glass have been used for sealing the edges of the glass sheets in a vacuum glazing. Indium is a low temperature sealing material, melts at 157°C, but is very expensive. Solder glass is a high temperature sealing material, melts at around 450°C, but has limitation of using low-e coatings and a tempered glass. One of the main hindrances to the manufacture of vacuum glazing at the industrial level is the cost. In this poster presentation, a vacuum glazing sample was fabricated at a laboratory scale using a modified evacuation pump-out sealing technique is presented. The vacuum pressure measurements are performed using a combined transducer consists of MicroPirani and miniaturised hot cathode ionisation gauge. The vacuum pressure of less than 0.046Pa in the cavity of the vacuum glazing samples was recorded. An experimental performance verification of samples can be executed in a hot box calorimeter to measure thermal transmittance performance of the samples.

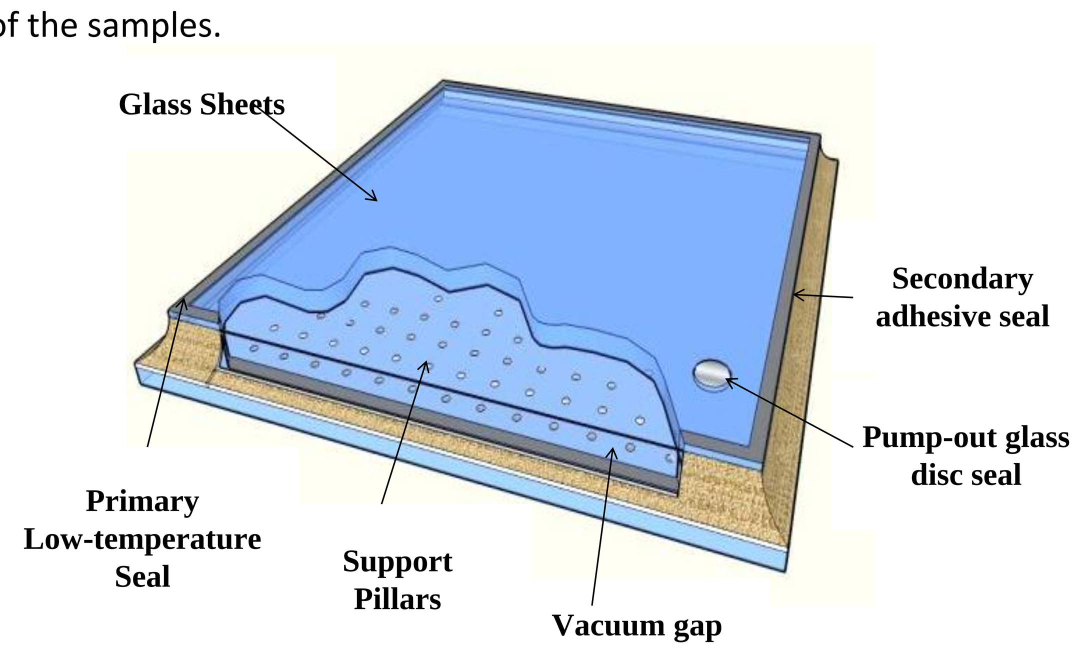


Figure 1: Graphical representation of the vacuum glazing using a dual edge sealing method.

2. Vacuum Glazing Production Facility

- A laboratory was established at CREST, Loughborough University, for the fabrication of vacuum glazing. The vacuum system has the capability to reach to a pressure of up to $1x10^{-5}$Pa.
- It includes a material testing/design, support pillar placing, glass sheet cleaning and the heating system for the fabrication of glazings using different edge sealing materials, as illustrated in *Fig. 2*.
- High and low temperature hermetic sealing materials were prepared and tested to understand the sealing properties and achievable cavity vacuum pressure.
- A new approach that includes the use of low cost sealing materials is under development.

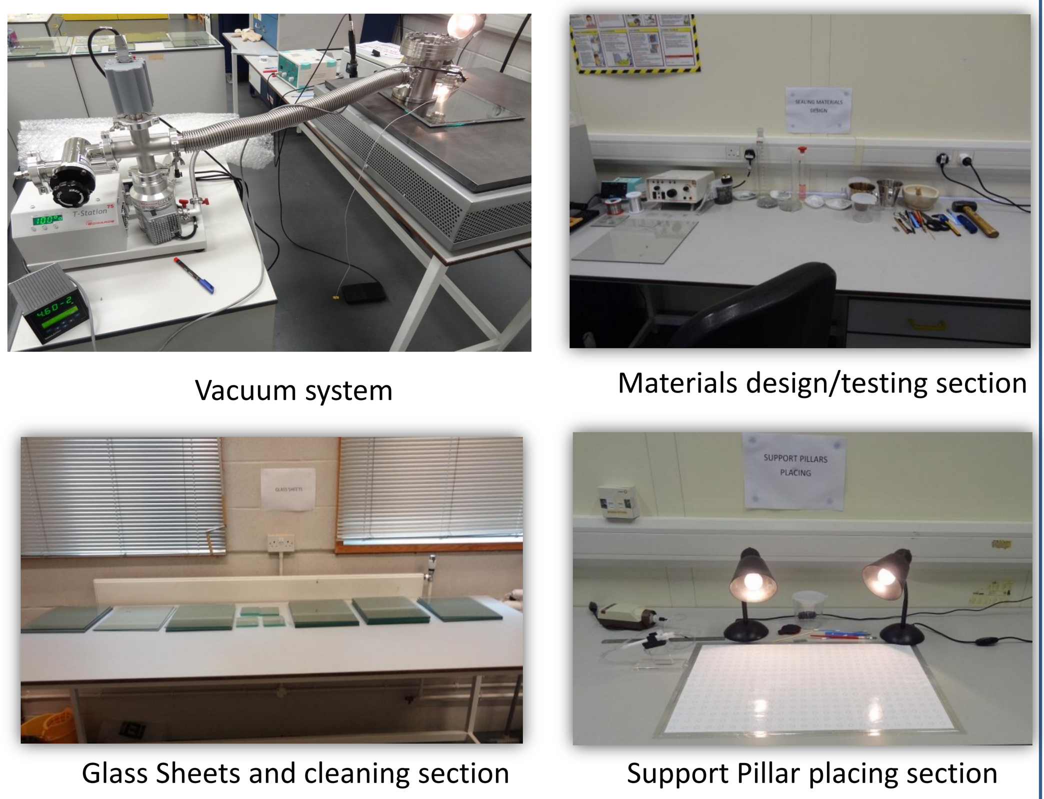


Figure 2: Vacuum glazing production facility illustrations

3. Evacuation Pump-out System

- A new vacuum cup was designed and constructed with dimensions of 100mm diameter and 150mm height ,as shown in *Fig. 3*. A pump-out sealing a square cover slip (around 10x10mm) pre-soldered with a novel sealing material to be placed over pump-out hole.
- The heating element, cartridge heater and thermocouple mounted a metallic rod controlled through a supporting Y shaped block provides up and down motion of up to 10mm.
- A K type thermocouple fixed to the heating block measures the approximate glass disc/square temperature. Heat transfer at high vacuum occurs through both radiation and conduction due to the contact of the heating block with the glass disc/square.
- The required temperature is approximately 40˚C more than the melting temperature of the pump-out sealing material to seal the pump-out hole.

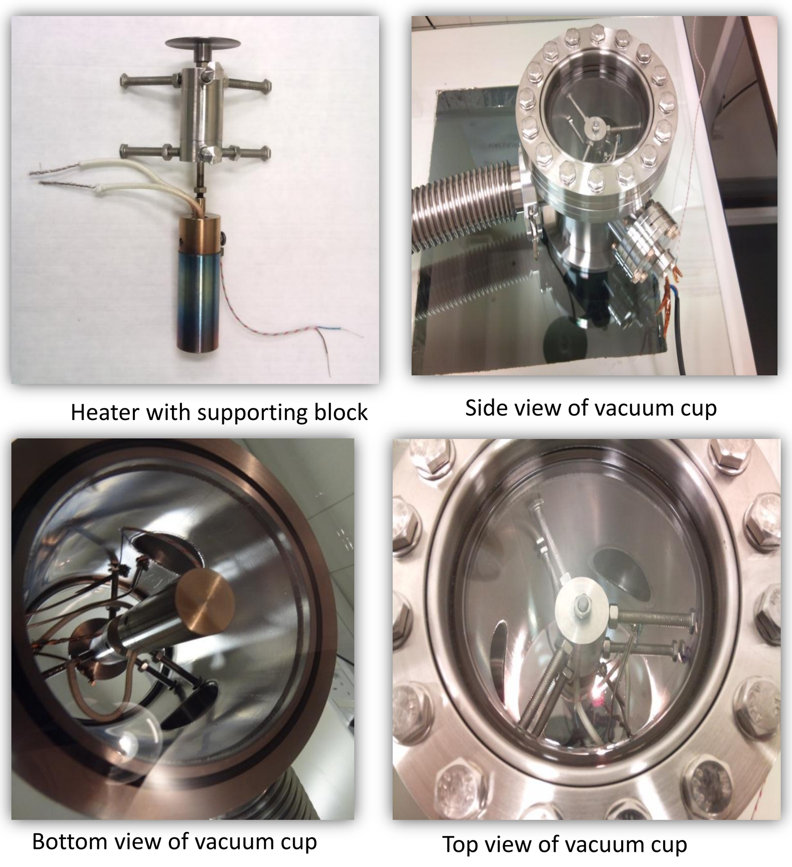


Figure 3: Modified Design of the Vacuum cup and pump-out sealing technique.

4. Dual Edge Seal Design

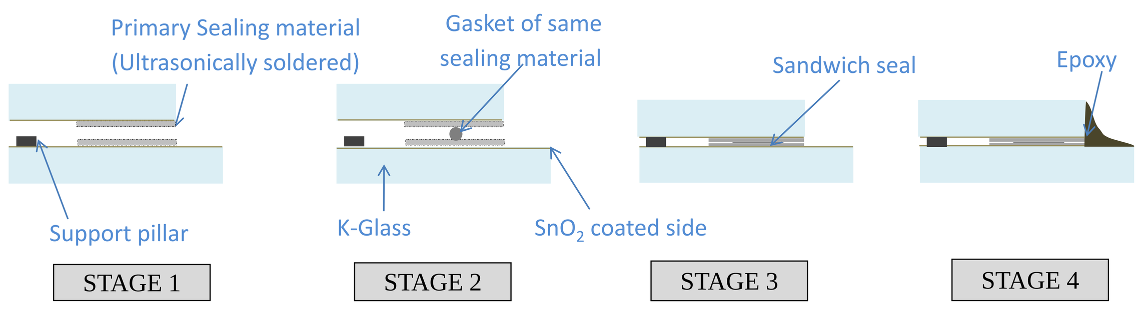


Figure 4. Four stage dual edge sealing design process for the fabrication of vacuum glazing.

5. Results & Discussion

A number of samples have been fabricated that could reduce the cost of vacuum glazing at an industrial production level. The two existing materials used by Ulster University and Sydney University groups for the fabrication of vacuum glazing; their edge seals are either too expensive, such as indium, or require high temperature for sealing, such as solder glass, that limits the use of low emittance coatings and tempered glass. This dual edge sealing method is a new step in the vacuum glazing technology. In this poster two samples are presented. sample A-170mmx170mm, shown in *Fig. 5a*, achieved a vacuum pressure less than 0.001Pa. Due to its small size, the level of stresses on the periphery of the sample was low. This experiment was repeated and it was found that similar vacuum pressure was achieved. Sample B-300mmx300mm, shown in *Fig. 5b*, achieved a vacuum pressure of up to 0.046 Pa and the level of stress patterns over pillars in between glass sheets were observed after pump-out sealing. A typical temperature/pressure graph of the sample B is presented in *Fig. 6*.

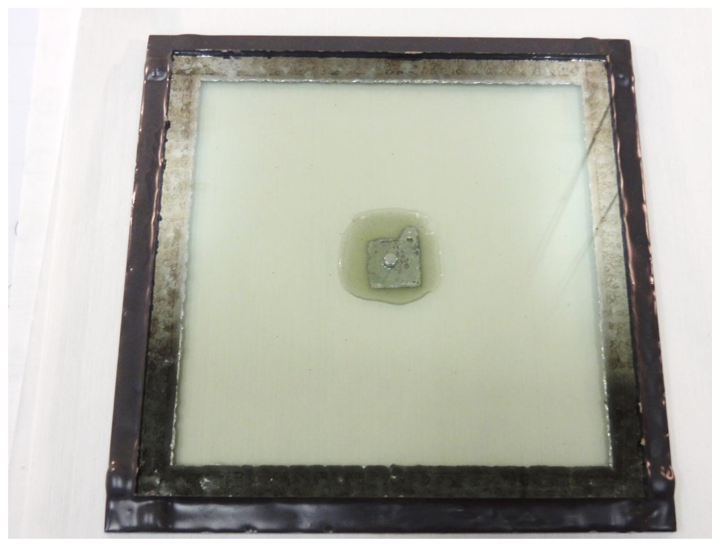


Figure 5a, Sample A, vacuum glazing 170mmx170mm achieved a pump-out pressure of less than 0.001 Pa.

Figure 5b, Sample B, vacuum glazing 300mmx300mm achieved a pump-out pressure of up to 0.046 Pa.

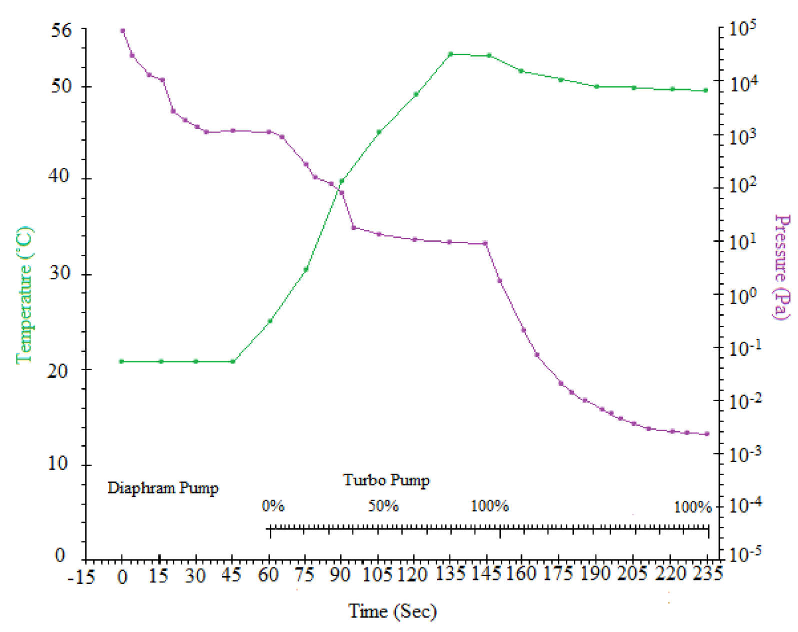


Figure 6: Typical temperature/pressure profiles for evacuation and heating of the Sample B.

6. Conclusions & Recommendations

- A vacuum glazing lab production facility was developed at Loughborough University for the fabrication of vacuum glazing units.
- A pump-out sealing system was designed that achieves good seals.
- Vacuum glazing samples were successfully fabricated that achieved an evacuated pressure down to 0.046 Pa.
- The samples were experimentally analysed by recording the pump-out vacuum pressure of the samples. An experimental thermal performance can be executed in a hot box calorimeter to measure thermal transmittance performance of the samples.

7. Acknowledgement

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