The University of Sydney
Integrated Sustainability Analysis ™

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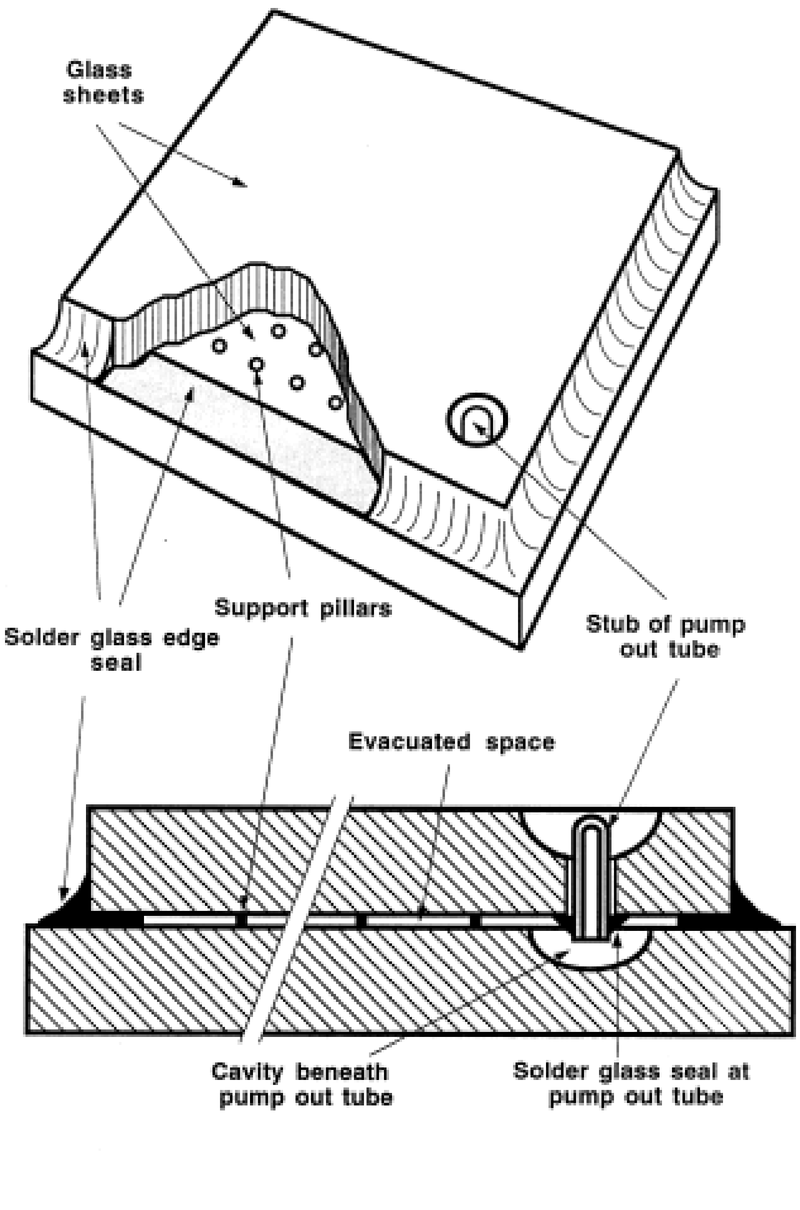
Student topic

A life-cycle assessment of vacuum glazing

1. Brief rationale

1.1 Vacuum glazing – a new type of transparent insulation

Vacuum glazing is new a type of transparent thermal insulation, which can be applied in windows for energy-efficient buildings. It consists of two soda-lime glass sheets separated by a narrow evacuated space (see Figure below). The internal vacuum eliminates conductive and convective heat flow due to gas, and low emittance coatings on one or both internal glass surfaces reduce the radiative heat flow to a low level. The separation of the glass sheets under the influence of atmospheric pressure is maintained by an array of high-strength support pillars (typically 0.1 - 0.2 mm high, 0.25 - 0.5 mm diameter, 20 - 25 mm spacing). The design, construction, manufacture and operating performance of vacuum glazing have been described in detail elsewhere.



1.2 Manufacture of vacuum glazing

Fabricating vacuum glazing requires forming a leak-free seal around its perimeter. This is accomplished by fusing the two sheets together with solder glass. The latter is essentially soda-lime glass, but with the lime replaced by lead oxide, which acts as a fluxing agent, and lowers the melting point. The fusing procedure is carried out at atmospheric pressure, while the glazing is heated up to 460°C in an oven. This temperature is above the melting point of solder glass, but below that of the glass sheets, so that the solder glass is able to wet the surfaces of the sheets, and form a fused seal of about 5 mm width around the edges of the glazing. A similar seal is simultaneously made between the upper sheet and a short glass pumpout tube, which is connected to the internal space. After the edge seal formation and subsequent cooldown of the assembly, a diffusion-pumped vacuum system is connected to the glazing via a pumpout cup involving an O-ring seal onto the upper sheet around the pumpout tube. During evacuation the assembly is heated again to temperatures between 130°C and 220°C in order to outgas the internal glazing surfaces. After cooling to room temperature, the external end of the pumpout tube is melted and closed by means of radiative heat transfer from either a tungsten coil within the pumpout cup, or through a fused quartz window by an infrared lamp located outside the cup. This tip-off operation typically takes only a few seconds. The time required for completing the edge seal formation and the bakeout is mainly limited by the rate at which the temperature of the glass sheets can be changed. While the sample can be baked out and cooled in two to four hours, the edge seal takes about eight hours to form.

1.3 Net energy considerations

Vacuum glazing requires energy to be expended during its construction. In particular, the outgassing and edge seal formation processes are energy-intensive. On the other hand, vacuum glazing can bring about considerable energy savings during its life time. Net energy is a concept that deals with the relative magnitude of energy requirements and energy production/savings of devices.

1.4 Challenge

The aim of this project is to carry out a life-cycle assessment of vacuum glazing, initially in terms of (net) energy. If time and data allow, this assessment can be expanded towards a full Triple Bottom Line analysis, including economic indicators such as profits, and social indicators such as employment.

2. Knowledge, tasks and skills

- Life-Cycle Assessment
- Heat transfer through building components
- Manufacture of glass
- Net energy requirements

3. Supervisors

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4. Literature

Overviews:
Robinson and Collins 1989; Collins *et al.* 1991a; Collins and Robinson 1991; Collins 1992; Collins *et al.* 1992b; Collins *et al.* 1993c; Collins *et al.* 1995; Collins and Simko 1998

On production and production cost:
Collins *et al.* 1993b; Garrison and Collins 1995

On particular aspects and elements of vacuum glazing:
Collins and Fischer-Cripps 1991; Collins *et al.* 1991b; Collins *et al.* 1992a; Fischer-Cripps and Collins 1992; Collins *et al.* 1993a; Clugston and Collins 1994; Turner *et al.* 1994a; Turner *et al.* 1994b; Fischer-Cripps and Collins 1995; Fischer-Cripps *et al.* 1995; Turner and Collins 1996; Ng and Collins 2000; Ng *et al.* 2003

On outdoor performance:
Lenzen and Collins 1997; Lenzen *et al.* 1999; Ng 2000

On net energy:
Leach 1975; Rotty *et al.* 1975; Bullard 1976; Huettner 1976; Icerman 1976; Bowen 1977; Marland 1977; Perry *et al.* 1977a; Perry *et al.* 1977b; Perry *et al.* 1977c; Treat 1977; Bain 1978; Bullard *et al.* 1978; Frantz and Bulent Cambel 1981; Gilliland *et al.* 1981; Haack 1981; Bailey 1982b; a; Lund and Kangas 1983; Herendeen 1988; International Atomic Energy Agency 1994; Crawford *et al.* 2002

On life-cycle assessment:
Pilati 1976; International Organisation for Standardisation 1998a; b; 2000; Treloar 2000a; b; Treloar *et al.* 2000a; Treloar *et al.* 2000b; Guinée *et al.* 2001; Lenzen 2001; Heijungs and Suh 2002; Heijungs *et al.* 2003; Lenzen and Treloar 2003; Suh *et al.* 2004

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