

Performance of New Active Water flow double-pane windows for Energy management in buildings.



Engineering

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ABSTRACT

Buildings account for such a significant amount of the energy consumed in the World. While window glazing will be more and more extensively used in modern architecture, active water-flow window panels are being introduced in the market with a double objective: to reduce energy consumption and to manage solar energy striking on building façades. In order to reach a nearly-zero energy consumption new materials and constructive solutions are required. Disposing of the heat captured by the water can be achieved in different ways. In hot climates it can either be dissipated together with the building's other heat loads in whatever refrigeration system is provided, or it can be stored in a tank and cooled down by evaporative refrigeration or night dissipation at a very low energy cost. This article shows real data obtained by means of monitoring real buildings using water flow glass panes.

INTRODUCTION

Glass has always followed the great building technology evolutions, acquiring an increasingly larger role, until the point of becoming the whole envelope of a building. Although able to generate positive concepts such as luminosity, visual relation or apparent lightness, it has also generated important energy efficiency problems. These could be summarized in excessive energy losses in the winter, and exaggerated energy gains in the summer.

Buildings with low thermal inertia envelopes have large demand of energy in hot climates with high sun radiation, which leads to air conditioning installations that quite often have an unwanted influence in the occupant's comfort.

Certain layer coatings have been developed in order to reduce the emissivity of the glass, and to retain the heat inside. Hermanns, del Ama and Hernández (2012) demonstrated properties of low-emissivity glazing used in solving the problem of excessive heat loss in winter. Ismail and Salinas (2006) proved that acting in the air chamber can improve the insulation capacity in double-glazed windows, for instance by filling it with inert gas, or by it being a vacuum space. In summer conditions the problem consists of solving energy gains in the summer due to solar radiation. An effective approach to overcome this problem is to capture the largest possible solar fraction before it reaches the occupied areas, and dispose of it somewhere else. Chow, Li and Lin (2010) studied the effectiveness of water flow glazing especially in hot climates with no extreme exterior temperatures.

Description of Water flow windows.

An important first step toward a net zero energy building is to minimize the energy loads required. This can be accomplished through energy efficient HVAC design, passive solar design, increased insulation, high-efficiency building envelope, natural ventilation, high performance glazing, and high-performance appliances.

Windows are therefore offered the opportunity to be used as energy saving devices, reducing heating and cooling loads and eliminating internal-load dominated buildings.

Increasingly aware of energy consumption from the design phase, the technology in this sector faces the problems no longer in a passive way, but turning the glass into an active part of a more efficient management of energy resources.

Active Glass system features multiple glazing elements in the building's envelope with water circulating in closed loop between the glass layers. Based on the physical property of sunlight near infrared radiation (NIR) absorption by water, circulating water captures a significant portion of the incoming radiation

and carries it away from the occupied areas. The flow and the speed of circulating water depend on the cooling need in the specific place at a given moment. This chamber is connected to a circuit with supply and return pipes, and to a water pump controlling the flow. The main advantages of the Active Glazing system with circulating water chamber are: increased comfort in occupied spaces, energy savings in removal of heat excess, energy transfer from cooling demanding areas to heat demanding areas (in moderate climate regions) and architectural integration into any type of building due to its zero visual impact.

A large percentage of the absorbed energy can be easily evacuated in the water flow thanks to its high heat capacity (4.186 kJ/kg K) and can be stored in a buffer tank, providing sufficient thermal inertia to the system. Typical water storage volume is 100 liter per m² glazing.

Triple glazing features a third layer of glass within the same frame. Fluids filling each of the gaps are water and air, respectively. This arrangement is very adequate in moderate climates since it provides an increased insulating effect on top of the benefits of infrared absorption by water. Furthermore, cool night temperatures around 15-20 °C can provide a very adequate means for cooling when the water circulated during daytime is stored in a sufficiently large tank. Circulating the water (at controlled temperature) once more during the night would benefit from free-cooling effect. However, the use of triple glazing in hot climates should be carefully considered. First of all, the position of the filling fluids -starting from the outside- is important: air adds insulating capacity while water adds thermal inertia. Secondly, temperature increase in the air varies significantly depending on whether it gets direct sun's radiation (outer layer) or it provides insulation to occupied spaces (inner layer).

Experimental results.

The Faculty of Journalism of Castilla La Mancha University in Cuenca Campus is located in a new building with rectangular floor plan. A 16 m high lobby receives daylight through a west facing curtain wall. The lobby has a staircase along the west wall and two corridors in each floor leading to classrooms on both sides. HVAC system consists of radiant floors for cooling and heating and high efficiency air units for ventilation. Energy for the radiant floors is obtained from a ground source heat pump that uses the earth as a heat source (in the winter) or a heat sink (in the summer). This design takes advantage of the moderate temperatures in the ground to boost efficiency and reduce the operational costs of heating and cooling systems.

Solar radiation in the afternoon causes a major problem in the lobby since the west-bearing façade is a 160 m² curtain wall, made of extruded aluminum frame filled with 80 2x1 m transparent double glazing panels with different thicknesses of glass

incorporating a laminated layer of glass with a noise-reducing interlayer. Since radiant floor surface was not sufficient to provide cooling for the lobby space and the air-handling unit was dimensioned to eliminate only latent heat gains, an active curtain wall with Active Glazing systems was installed.

Figure 1 shows real data obtained from a summer day. The design water flow through windows is 1 liter/(min m²). Each row of five panels is connected to the secondary circuit of a plate heat exchanger. An in-line pump circulates the water from the glazing to the heat exchanger where the solar energy absorbed by the windows is transferred to the water circulating in the heat exchanger primary circuit. One in-line pump supplies the primary circuits of all sixteen heat exchangers with water from the radiant floors' return collector; return water from the primary circuits mixes with return water from the radiant floors before entering a buffer tank. Water in the tank is chilled by a geothermal heat pump. This system avoids radiation entering the interior space.

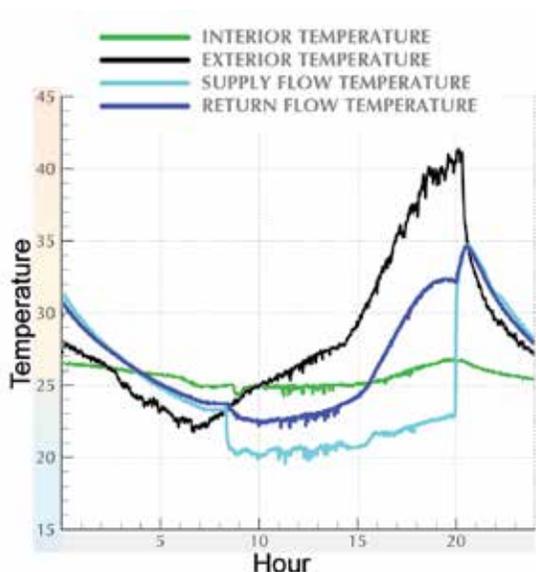


Figure 1: Experimental Temperatures.

Besides, the heat absorbed by water can be stored in buffer tanks so this solution can work as a pre-heating device for Domestic Hot Water.

CONCLUSIONS

The curtain wall presented in this article is a demonstration project showing Active Glazing possibilities but not limiting them. The creation of a thermal shield capturing solar radiation plus the conversion of double glazing panels into air conditioning final elements (if chilled water is circulated) may be a solution in buildings exposed to heavy solar radiation, thus reaching active glazing its full meaning. Solar radiation energy captured by water circulating between the glass layers is finally evacuated together with the rest of the building's heat gains in whatever water chilling device suits best each project. The water flow window system neither impose any constraint on the water chilling system to be used, nor any restriction in the architectural design of the building. In addition to energy savings in cooling these curtain walls can be used as preheating devices for domestic hot water.

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