RESULT 228

CADDET IEA OECD energy efficiency

AIVC 12,388

Solar collector system for heating ventilation air

Summary

The Conserval Perforated Plate Solarwall is a metal solar collector designed to provide preheated ventilation (make-up) air for buildings. The system is intended primarily for industrial applications, but also has potential for commercial and multi-residential buildings with large south-facing walls.

In 1991, a 420 m² Solarwall was erected at the General Motors of Canada Battery Plant in Oshawa, Ontario. This installation reduced energy costs in several ways: by capturing solar energy, by reducing heat loss through the south-facing wall of the building, and by destratifying indoor air.

The cost-effectiveness of the Solarwall measured relative to the available alternative make-up air systems gave a payback period of one year.

Highlights

- Highly efficient solar air heating system
- Performs better than glazed walls, yet costs less
- Short payback compared to alternative systems

Solarwall at GM Battery Plant.

Aim of the Project

The Conserval Perforated Plate Solarwall is an aesthetically pleasing solar collector designed to provide preheated ventilation (make-up) air. It can be retrofitted to an existing wall without the use of expensive glazing. The project aimed to show that the Solarwall could operate effectively and economically at the General Motors plant.

The Principle

In the past, industrial solar air heating systems have often involved the addition of large, glazed facades on the exterior of south-facing walls. Unfortunately, these glazed walls raised fire concerns, were expensive, and were sometimes unsightly. Moreover, some incoming solar energy was lost due to reflection from the glazed surface.

The Solarwall is a solar air heating system that addresses these problems. The complete system consists of four main components: a perforated metal collector (the Solarwall), a canopy overhanging the Solarwall, fans, and ducting inside the building for air distribution.

The Solarwall is an unglazed aluminium surface perforated by small holes. This aluminium surface is mounted on the south-facing exterior of a building, separated from the main building wall by an air space. To maximize the absorption of solar energy, the aluminium surface is painted black (although any dark colour can be used). As outside air is drawn through the perforations and into the air space, the absorbed solar heat is transferred from the metal to the air.

In the air space behind the aluminium surface, the warmed air rises, partly by convection and partly due to the action of the fans. At the top of the wall, the air enters the canopy, which extends horizontally across the top of the wall. Inside the canopy, the air moves towards the intake openings, where it is drawn into the building.

Like the metal wall, the canopy face is perforated. In addition, the underside of the canopy, which overhangs the wall below, is perforated to collect heated air rising up the outside face of the Solarwall.

Inside the building, the fan system is coupled to perforated fabric ducts that direct the make-up air to those areas of the building that require ventilation. A set of dampers controls the mixture of fresh solar-heated outside air with recirculated plant air.

To assist in destratification of the indoor air, the ducts are located at ceiling level. Because the air supplied by the system is cooler than the air at the ceiling, the delivered air settles towards the floor, causing mixing of the building air.

Solarwall showing perforaled hole construction and canopy.

The Situation

In the summer of 1991, a Solarwall was erected at the General Motors of Canada Battery Plant in Oshawa, Ontario. The Solarwall has a total area of 420 m^2, including 365 m^2 of vertical perforated plate. The metal is perforated with a regular pattern of small holes 1.6 mm in diameter. In total, the holes make up about 2% of the wall surface. The Solarwall is separated from the existing wall by an air space of about 150 mm.

The canopy has a cross-sectional area of 1.6 m^2. It projects outwards beyond the surface of the wall below by 900 mm. The face and underside of the canopy are perforated, with the openings making up 1% of the surface area.

Air is drawn through the wall perforations into the air space by two high efficiency vane-axial fans. The maximum design flow rate is 74,700 m^3 per hour, delivered to the plant via 122 m of perforated fabric ducting. Actual airflow rates are approximately 68,000 m^3 per hour.

The temperature of the delivered air is controlled by mixing solar heated air with recirculated indoor air: the lower the temperature of the air from the collector, the greater the proportion of recirculated air. The desired air delivery temperature is preset and controlled automatically. Selecting the lowest comfortable temperature maximizes the active solar performance of the system.

When the outside temperature is above 18°C, the system is designed to bypass the Solarwall completely. Automatic dampers in the canopy allow air to be drawn directly from the building exterior.

The Solarwall is nearly maintenance-free, and the fans, motors, and dampers require only a few hours of maintenance each year. The ducts have a life expectancy of 20 years and the Solarwall itself has a near indefinite life (since it is constructed of aluminium).

Based on 1993-94 monitoring results, the GM Solarwall is delivering 455 kWh/m^2 of solar energy per year, at an average solar collection efficiency of 72%. In addition, the Solarwall system reduces heat transmission through the south-facing building wall, recovers lost heat in the incoming air and destratifies the indoor air. The most recent monitoring results show that these savings amount to 300 kWh/m^2 annually. Thus, the GM Solarwall is contributing an estimated annual total of 755 kWh m^2 of collector area (based on an eight month heating season).

The Company

Conserval Engineering Inc. of Toronto, Canada has been designing solar air preheating systems since 1982. Conserval initially developed glazed and unperforated Solarwall systems, then refined their approach with the development of perforated systems. This technology served as Canada's official contribution to the International Energy Agency's Solar Heating and Cooling programme, Annex 14: Advanced Active Solar Energy Systems.

Economics

The total cost of supplying and installing the Perforated Plate Solarwall system at the General Motors plant was about CAD 92,000, or roughly CAD 220 m^2. Costs per square metre can be expected to be lower for larger systems and for

Table 1: Cost-effectiveness of the GM Perforated Plate Solarwall.

	Compared to a steam-operated fan coil unit	**Compared to a direct-fired natural gas unit**
Incremental capital cost to install the Solarwall	CAD 15,500	CAD 23,200
Annual energy cost savings provided by the Solarwall	CAD 12,200	CAD 4,700
Simple payback period (incremental capital cost - annual energy savings)	1.3 years	4.9 years

The energy cost savings are based on steam costs of CAD 9.27 per 453kg (1000 pounds), and gas costs averaging CAD 0.15/m^3. For steam-operated units, total cost savings include an estimated CAD 1990 in reduced electricity costs for fan operation. (No savings in fan operation would be expected relative to the gas-fired units.)

new construction (as opposed to a retrofit like the GM plant).

The cost-effectiveness of the Solarwall must be measured relative to the available alternative make-up air systems. For the GM plant, the available alternatives were a low pressure steam-operated fan coil unit, or a direct-fired natural gas unit. As shown in table 1, capital costs for either system are lower than for the Solarwall system. However, the substantial energy cost savings generated by the Solarwall offset this initial cost premium.

Host Organisation

General Motors of Canada
1908 Colonel Sam Drive
Central Plant Engineering
Oshawa, Ontario
L1H 8P7 Canada
Tel.: +1-(905)-644-5970
Fax: +1-(905)-644-5887
Contact: Mr L. Whitney

Main Contractor

Conserval Engineering Inc.
200 Wildcat Road
Downsview, Ontario
M3J 2N5 Canada
Tel.: +1-(416)-661-7057
Fax: +1-(416)-661-7146
Contact: Mr J. Hollick

Monitoring Agent

Enermodal Engineering Inc.
368 Phillip Street, Unit 2
Waterloo, Ontario
N2L 5J1 Canada
Tel.: +1-(519)-884-6421
Fax: +1 (519)-884-0103
Contact: Mr J. Kokko

Information organisation

Energy Technology Branch
Natural Resources Canada
580 Booth Street
Ottawa, Ontario
K1A 0E4 Canada
Tel.: +1-(613)-996-6078
Fax: +1-(613)-996-9416
Contact:
Mr D. McClenahan

Please write to the address below if you require more information.

CADDET energy efficiency IEA * OECD

Swentiboldstraat 21,
6137 AE Sittard,
P.O. Box 17, 6130 AA Sittard,
The Netherlands,
Telephone: +31-46-459-5224,
(As of April 10 1996: +31-46-420-2224)
Telefax: +31-46-451-0389,
E-mail: nlnovcce@ibmmail.com
Internet: http://www.caddet-ee.org

* IEA: International Energy Agency
OECD: Organisation for Economic Co-operation and Development

IEA

The IEA was established in 1974 within the framework of the OECD to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among the 23 IEA Participating Countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology, and research and development (R&D).

This is achieved, in part, through a programme of energy technology and R&D collaboration currently within the framework of 35 Implementing Agreements, containing a total of more than 60 separate collaboration projects.

The Scheme

CADDET functions as the IEA Centre for Analysis and Dissemination of Demonstrated Energy Technologies. Currently, the Energy Efficiency programme is active in 15 member countries.

This project can now be repeated in CADDET Energy Efficiency member countries. Parties interested in adopting this process can contact their National Team or CADDET Energy Efficiency.

Demonstrations are a vital link between R&D or pilot studies and the end-use market. Projects are published as a CADDET Energy Efficiency 'Demo' or 'Result' respectively, for on-going and finalised projects.