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Performance assessment of façade integrated glazed air solar thermal collectors

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Abstract

Present trends on solar thermal systems for building integration define the need of integrated solar technologies for façades. The integration of solar systems in façades allows for the direct connection of solar systems to heated spaces, and automated air solar collectors based on the trombe-mitchell provide a suitable technology for its adoption in multi-rise buildings with decentralized-individual HVAC systems in Central-European and Mediterranean heating dominated climates.
This paper reviews the main principles of such building envelope components, and the construction and design considerations of two air-based solar thermal collectors. Full scale preliminary prototypes of these systems were tested at the KUBIK by Tecnalia test facility in an Oceanic Climate (Koppen Geiger Cfb zone). The observed thermal performance is analyzed, and the process of a full scale installation in a real building envelope retrofitting process of a building in Spain is reviewed.

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1. Introduction

With energy efficiency and an ultimate need to reduce primary energy consumption of buildings towards sustainability, energy systems are increasing its presence in building envelopes. Solar energy systems such as solar thermal and photovoltaic systems are being implemented in buildings, boosted by energy procurement policies and user/owner will to reduce the overall energy costs in buildings.

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Solar thermal systems are commonly used as a heat source for Heating Ventilation and Air Conditioning (HVAC) systems in buildings, in such a way that the need for electricity or fossil fuels in the building is reduced. Also, a large fraction of solar energy is commonly used for Domestic Hot Water (DHW) heating. These systems can be classified as indirect systems, as solar energy flows to the building use across the HVAC/DHW system.

In direct systems, solar heat is directly used in the building, without the need for its connection to HVAC networks in the building. These systems are commonly air-driven systems, where indoor air is circulated across the collector and introduced back into the building with a certain heat gain. Depending on various possible air loops, other circulations are possible, such as heating of outdoor ventilation air prior to its introduction to the building.

In [1], a Passive solar collector module for building envelope is proposed, which provides a flexible air circulation in the collector, with up to 4 different circulation schemes (trombe wall, parieto-dynamic wall, solar chimney, ventilated façade). In this paper, two engineered solutions of this concept are detailed and their performance assessed.

Due to increased requirements in the use of solar energy in buildings, an evenly increasing building envelope surface is required. This implies that the impact of solar thermal technologies in the overall aesthetics of the building also increases. For this reason, solar systems in buildings are evolving from “technical kits” to building envelope systems. The seamless integration of these technologies in buildings is required to ensure that building owners accept their integration in their property.

The presented solution integrates the solar thermal system within a curtain wall scheme, suitable for retrofit or new-constructed buildings, which also facilitates dimensional adaptation to construction projects.

2. Air solar collectors

Air solar collectors are relatively easy constructions where solar energy is absorbed and transferred to an air stream. Depending on the particular type of collector, the air stream is forced by a fan, or created by the thermal buoyancy of the air as it is heated.

Most commonly referred solar collectors are glazed constructions, where a glass cover is used to generate a channel over the absorber. The glazing serves the dual purpose of allowing solar radiation into the collector, and insulating the collector and the heated air from outdoor conditions.

In its most simple configuration, air solar collectors are created with the erection of a glazed pane in front of a brick wall, and the perforation of venting holes on the upper and lower edges of the wall. This constructions, when installed in irradiated façades (South façades in the Northern hemisphere), will serve to heat the building. However, the performance of this system would be substantially increased with some control of the otherwise completely natural and uncontrolled ventilation. Airflow control by means of operable ventilation grilles will avoid overheating of the served building, and also cooling phenomena in cold, non-irradiated periods (e.g. winter nights).

Although the concept is relatively simple, a modern implementation of such a system should incorporate a set of properties to ensure the proper formal integration of the system in buildings, a seamless and confortable operation, and reduced user disturbance when it is installed in retrofit projects.

3. The Tecnalia passive air solar collector system

In European Patent [1], a modular passive solar collector system is presented which presents a suitable root for the development of several air solar thermal collector systems. This concept is underpinned on a high quality curtain wall Aluminum frame, where the collector is housed.