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Experimental thermal study of a solar wall of composite type

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Abstract

The use of solar energy for the heating of buildings, via storage walls, has been extensively studied and several components have been developed since the Trombe works. The standard Trombe wall has two main drawbacks. During cold and cloudy winter days, it causes important heat losses and thus discomfort to the occupants. In summer it creates important and undesired inputs. These drawbacks can be eliminated by a more complex design such as the composite Trombe wall. In connection with architects such as J. Michel, we designed a massive solar wall, with an insulating panel located just behind it. A ventilated air layer exists between this panel and the wall. Vents located at the top and the bottom of the insulating panel allow air circulation and thus energy inputs to the building. A prototype was built into a test cell at Cadarache and was tested for 2 years. This allowed various climatic conditions and operation modes to be examined. We used tangential gradient type heat fluxmeters to determine the thermophysical properties of the massive wall and we quantified the heat transfers in the ventilated layer and to the building. The data obtained are now being used as input for a software to assess the performance of this improved component.

Keywords: Thermal study; Solar wall

1. Introduction

b The use of solar energy for the heating of buildings, through storage walls, has been the object of many studies since the works of Trombe [1–3]. The standard Trombe wall suffers large thermal losses during cold and less sunny periods as well as undesirable energy transfers in the summer. With the help of architects and particularly J. Michel, we have designed a solar wall of composite type which includes an insulating panel located at the back of the storage wall which eliminates the previously mentioned drawbacks. Energy is transferred from the outside to the inside by conduction through the massive wall and then by convection, using the phenomenon of thermocirculation of air between the wall and the insulating partition. This wall was built into a test cell of Genec at Cadarache (in southeastern France), and was tested under realistic operating conditions.

We have instrumented and worked with it for more than one year in order to study its operation during the heating period and during the summer. The main originality of this work is the use of heat thermal fluxmeters. These sensors are particularly interesting as their slight thickness (≈ 0.2 mm) and their metallic nature (of a printed circuit type) do not interfere when conducting measurements. Their time constant of 1 s makes them a perfectly adapted instrument for the study of heat transfer under variable operating conditions [4,5].

In this article, we present how, by using the signal treatment methods and by playing on the emissivity of the sensors, we can obtain very precise information about the thermal–physical characteristics of the massive wall and the heat exchanges (conductive, radiative and convective) which have a great effect on the energy performance of the solar component.

2. Experimental set-up

The experiment was performed in a rural environment in southeastern France at Cadarache (latitude: 43° 39′ 18″ N; longitude: 5° 46′ 21″ E; altitude: 268 m).

The test cell consists of a single room. The underfloor space and the attic are subjected to natural ventilation. The dimensions of the cell are shown in Figs. 1 and 2. The south façade consists of a Trombe wall of composite type.

The storage wall is made up of solid concrete blocks. An insulating panel was placed around the sides of the storage wall to reduce lateral heat losses. The insulating wall limiting the ventilated air layer is placed on a wooden frame and can

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