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Study Of The Performances Of A Supply-Air Window For Air Renewal Pre-Heating

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Abstract

The principle of a supply-air window is based on the air renewal circulation between the glazings of a window before entering home. We study in this work the Paziaud® window composed of three glazings forming a U-shaped channel. The air warms up by recovering some part of the heat losses from the building and also by solar radiation absorbed through the glasses. This system generally works in forced convection by association with an air extraction system. This type of component is not embedded in usual dynamic tools for building thermal simulation. A major reason of this lack is that the heat transfers through the walls and the air exchange are treated separately. Moreover, this particular system is characterized by different heat fluxes if we consider the inner or the outer surface of the component. Our contribution is based on an original and appropriate representation of convective heat transfer in asymmetrically heated air layers. We offer a "simplified" model that can be easily implemented in dynamic simulation tools. This model is compared CFD simulations. From this model, parametric studies are performed to look for the parameters influencing the performance of the Paziaud® window: we show here that boundary conditions in temperatures, the thickness of the cavities, low emissivity coatings and the glazing area have significant effects on the performance criteria. We perform the parametric study on the basis of indicators specifically defined for the supply-air window.

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1. Introduction

The principle of a supply air window is to make the air renewal of the building circulating between the panes of glass of the window before entering into the building. A recent article [1] gives a complete study (literature review,

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numerical simulations and experimental work) on typical functioning of a supply-air window. We study here the window named Paziaud®. It is constituted of three panes of glass that delimit a U-shaped channel in which the air circulates [2]. The supply air warms-up by the heat loss of the dwelling and also by the solar radiation absorbed by the glass. Generally, the air circulates in this window by forced convection (with low velocity) associated with the extraction system of the building [3]. Two numerical models are used to carry out parametric studies in order to understand the influent factors on the thermal performance of a Paziaud® window: air flow rate in the window, temperature on both sides of the window, cavity thickness, low emissivity coatings, dimensions of the glazed surface. This parametric study, based on specific indicators defined for a supply air window [2–4] in paragraph 3, allows to show key points that will allow its future optimization.

2. Problem formulation

A laminar air flow is studied numerically entering through the upper section of a U-shaped ventilated window (Fig. 1) at the external temperature of 0°C. The air, being driven in forced convection, recovers a part of the thermal heat losses from the house (indoor temperature by default set at 20°C), and enters the room at an unknown temperature. The heat flux through the glazing « i » is Φ_i. The frame is not modelled in this study and the horizontal walls are supposed to be adiabatic.

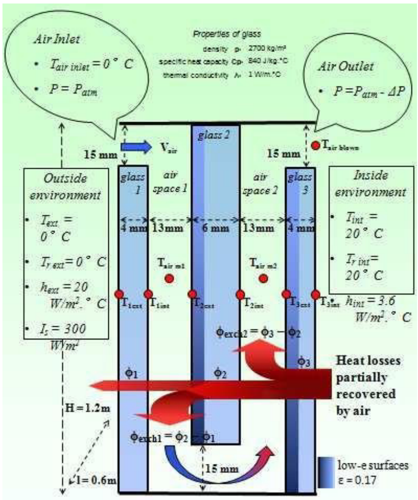

Fig. 1: Data and boundary conditions

Steady 2D numerical simulations are performed with the code Fluent® [3, 5]. Thermophysical properties of air are supposed to vary with temperature and the correlations used to determine them are taken from the standard EN 15099 [5]. A non-uniform structured mesh composed of 79 216 cells refined close to the glasses and close to the inlet and outlet of the channel is found to be sufficient for this study. Spatial discretization of the governing equations is achieved by means of the finite volume method using the pressure-based solver. The equations discretization was carried out using second order schemes for pressure and momentum (upwind scheme) and first order upwind schemes for energy and radiation. Momentum and pressure-based continuity equations are solved simultaneously with the coupled algorithm. To solve the long wave radiative transfer we use the Discrete Ordinates radiation model (DO). Convergence criteria were set at 10^{-6} for continuity, 10^{-7} for energy and 10^{-8} velocity and radiation. Concerning the boundary conditions for the external glazed surfaces (Fig. 1), two heat transfer coefficients are defined, h_{int} and h_{ext} corresponding to the indoor and outdoor environments. Radiative temperatures $T_{r\ int}$ and $T_{r\ ext}$ are defined at these side walls. The values of these parameters are defined in accordance with the ISO standard [5].

By default, glazings are 1.2 m high and 0.6 m width. The thickness of both air gaps is 13 mm. A low emissivity coating on glazings 2 and 3 is deposited towards the external part of the panes. The air change rate is set at 10 $m^3.h^{-1}$