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Influence of windows geometrical parameters on calculations of the heat conduction coefficient

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Abstract

The relationship between the geometrical and thermodynamic variables of windows, of several types, sizes and materials, is presented in this paper. The heat conduction coefficients were calculated, for all the presented windows' types. Results that are presented provide for the possibility to select the optimal construction solution of the window, as well as for the material of the frame and type of the filling, with respect to the best heat conduction coefficient. That, in turn, ensures the optimal energy efficiency of the window structure.

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*Keywords:*heat conduction coefficient; window; frame; filling; energy efficiency

1. Introduction

Reducing the energy consumption and carbon-dioxide emission is one of the most important tasks in the areas of design and civil engineering. The key point for reducing the carbon-dioxide emission is increasing of the thermal characteristics of the buildings' envelope. That can be achieved in several ways, for instance by adding insulations to existing or new buildings. Considering the fact that about 30 to 50% of the heat conduction is lost through the windows, improvement of the thermal characteristics of windows can significantly contribute to savings of energy.

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Nomenclature

A_{cg}	area of the glass center, [mm^2]
A_{eg}	area of the glass edges, [mm^2]
A_f	area of the frame (opaque), [mm^2]
A_g	area of the glass (transparent), [mm^2]
A_t	total area of the window, [mm^2]
A_{pf}	area of the opening for the window reduced for the mounting clearance, [mm^2]
E_t	total incoming radiation, [W/m^2]
F_f	solar heat loss coefficient of the frame,[-]
F_g	solar heat loss coefficient of the glass, [-]
T_{in}	interior air temperature, [K]
T_{out}	outside air temperature, [K]
U_{cg}	heat conductivity coefficient of the glass center, [W/m^{2}K]
U_{eg}	heat conductivity coefficient of the glass edges, [W/m^{2}K]
U_f	heat conductivity coefficients, [W/m^{2}K]
U_w	heat conductivity coefficientsof the window, [W/m^{2}K]
b	the window frame width [mm]
d	the window frame thickness [mm]

The great attention is thus paid to reducing the heat conductivity or the U-value of windows, Jelle et al. [1].

The windows represent a component which affects the most the energy needs of the building. They consist of the opaque and transparent elements, which all together should provide for the high thermal characteristics, in order to reduce the heat losses. Thus, the design of each of the window's components (frame, glass, blinds and mosquito blinds) becomes important in realizing the energy savings. For example, aluminum has a very low heat resistance, but the thermal characteristics of the frame can be improved by applying the heat breaks and introduction of air fillings. They are characterized by the complex mechanisms of the heat exchange that were investigated by various procedures. Gustavsen et al. [2] have analyzed the profiles of the air fillings in the rectangular geometry.

There are several papers where the researchers were dealing with influence of windows on thermal and energy characteristics of buildings. Tsikaloudaki et al. [3] have analyzed how the windows influence energy characteristics of a building in conditions of the warm Mediterranean climate. In work by Thalfeldt et al. [4] an optimal model of a window for the case of an object in Estonia, in cold climate conditions and several months of need for heating, is presented. Cardinale et al. [5] have performed numerical and experimental analysis of six different types of the window frames and four different models of blinds in order to establish the optimalsolution.In paper by Asdrubali et al. [6], the influence of the openings geometry in frames on thermal performances of aluminum window frames was analyzed. Van Den Bergh et al. [7] have conducted a survey of commercial spacers and seals for windows and analyzed their influence on windows thermal characteristics.

Considering that improvement of the windows thermal characteristics is potentially a big source of energy savings, it is necessary to perform a calculation, which would include as large as possible data base on materials, which are used for manufacturing the windows frames and glasses, data on inert gases, which are used for filling the chambers in the windows profiles, data on standard windows dimensions, etc. From such a data base one would be able to choosethose materials that would satisfy required construction and energy requirements for the particular application.

The objective of this work was to create a way for calculation of the heat conduction coefficient, based on the given characteristics of the window frame, which would provide for the best insight in the construction solution of a window, frame material and type of the gas, which should be used to obtain the most energy efficient windows.The intention was to show the mutual dependence of geometrical parameters and thermodynamic variables for several types of windows, made of different materials; namely to model the construction of the window, based on the required material selection, type of window and given heat conduction coefficient. The calculations are done by the programming package Autodesk Inventor Professional 2010, which draws necessary data from the Microsoft Office Excel package.

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