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INFORMATION MODEL FOR HEAT AND MASS TRANSFER PROCESSES EVALUATION

Information model is offered for evaluation of interconnected and interdependent heat and mass transfer process. Information model is based on the design structure of heat and mass transfer process and the object-oriented design. An example of using the proposed information technology is given.

1. Introduction

The task of analysis of the heat and mass transfer process is very relevant, as heat and mass transfer is observed in a variety of systems of different functional design and various purposes, and the work efficiency of the relevant systems depends on the organization of this process. The heat and mass transfer process itself is a complex system, since it is interconnected and interdependent, although in each element, as a rule, has its typical features [1]. To analyze such a process we can not do without a computational experiment using mathematical modeling based on modern information technology. This work is dedicated to the development of appropriate specialized information technology.

2. Using

The developed information technology can be used to evaluate the heat and mass transfer process in complex systems, in which the characteristic feature is the thermal process through a multilayered structure due to heat conduction and (or) radiation, taking into account and without convective heat transfer.

3. Analysis of literary sources and resolving problems

The analysis of the models, methods and information technologies used to evaluate heat and mass transfer in specific subject areas shows that, despite the wide variety of approaches, currently there are no models considering interconnected heat and mass transfer processes in the entire corresponding complex system. Processes are considered either in individual elements of the system, or in the simplest formulation. Often in practice, when examining the thermal regimes of typical residential or non-residential premises, especially during the heating period, purely empirical approaches [2] are used, and modern tools for efficiently obtaining qualitative indicators of heat and mass transfer processes in buildings and other closed spaces are not available at this time. In the work [3] a simplified two-phase model is proposed heat transfer to a room that is tightly loaded with food, in order to predict the cooling air temperature and the actual product. Such a model is suitable for the evaluation of the effects of various heat and mass transfer parameters during the design of refrigeration facilities. In work [4] a simulation model for heat transfer in a building design was conducted to determine the efficiency of the heating system. In work [5] a numerical computer simulation of processes of heat and mass transfer of ventilation air is proposed on the basis of analysis of temperature distribution, pressure and velocity of the inflow air in the poultry house for the system of tunnel ventilation in the summer period of time. In this case ANSYS Fluent software was used to obtain the fields of velocity, temperature and pressure indoors, but this does not provide a comprehensive assessment of the quality of the heat and mass transfer process in the room.

4. Purpose and tasks of the investigation

The purpose of this work is to develop an information model for the evaluation of interconnected and interdepended heat and mass transfer process. To achieve this purpose you need to solve the following tasks:

- to choose models and methods for estimating the thermal conductivity through a multi-layer solid structure;
- to choose models and choose methods for estimating convective heat transfer in the space of the steam-air mixture;
- to choose models and methods for evaluation of radiation heat transfer;
- to choose a structural scheme of interconnected and interdepended heat and mass transfer process;
- to build a scheme of the implementation of information technology for evaluation of heat and mass transfer process and implement its program implementation.

5. Presentation of the main research material

The construction of information model in this work is based on the design structure of heat and mass transfer process and object-oriented design.

The heat-mass transfer process is presented in the form of a hierarchical structure, the lowest level of which is the elementary block. Elementary unit is the homogeneous thermalphysic and structural parameters, that is, a block in which there is a homogeneous heat and mass transfer process (heat conduction, convective heat exchange or radiation). Such a structure allows us to consider from a single position any heat-mass-exchange process, since it allows a complex interconnected and interdepended heat and mass transfer process to be reduced to a process in elementary blocks, coordinating them with the corresponding boundary conditions [6].

For the evaluation of thermal conductivity through a multilayer solid structure, in the presence of internal sources and heat waste, selected models and the method proposed in the work [7] for the estimation of convective heat transfer are the models and methods proposed in the work [8].

Between two solids with different temperatures there is a mutual exchange of heat with the help of radiation. The heat flowing from the more heated body to the less heated by radiation is determined from the Stefan-Boltzmann equation.

There are many systems of different nature, in which there are complex interrelated and interconnected different in nature heat and mass transfer processes. Linking these processes, that is, setting boundary conditions, is not an easy task.

To solve this problem it is proposed using a model of heat and mass interaction, which refers to a set of boundary conditions given in the simplest form, and non-stationary point, surface and bulk sources and mass flows, impulses and energies adjoining a certain boundary or scattered in the explored space. This allows you to specify the boundary conditions in the simplest form, and the real interactions of real processes to submit sources and sinks of the substance.

The determination of the intensity of sources and effluents of energy, mass and momentum, which are components of the model of heat-mass interaction, is based on the physical essence of a particular heat-mass transfer.

Sources (drains) of energy are supplied by heat from solar radiation, artificial light, heat from people and heating systems. Finding the intensity of the source (drain) of energy in this case is performed according to generally accepted methods.

The indicated methods require some experimental data (materials of fencing constructions, their thermalphysic characteristics, type of heating device, surface area of the device's heating, type of the lamp of illumination, angle of inclination of glazing to the horizontal plane, and so on). Required experimental data is designed in the form of special tables and is an integral part of the developed information technology.

The state of each elementary block of the structure of the heat and mass transfer system is determined by the internal processes represented in the submodel, and the influence on it with other elementary blocks.

The generalized information on the presence of influence for each elementary block is provided by a matrix of intracellular influences. This matrix is used to construct interfaces of functions that describe the state and behavior of elementary system blocks.

In accordance with the ideology of object-oriented modeling, all elementary blocks are typed, that is, they belong to a certain class and each block is represented by the object of the corresponding class. In this case, the structure, properties and behavior of the object of this class are uniquely determined by the description of this class. The class defines the information structure of the block and contains a set of functions (methods) that determine the evolution of its state. In this case, the structure of the intercellular interactions determined by the matrix of micronutrient influences is given in the corresponding classes in the form of lists of arguments of functions - members of the class.

To represent a functional model in the framework of object-oriented modeling, which reflects the structure and functions of the evaluation of the heat-mass transfer system, as well as the information flows that bind these functions, the IDEF0 methodology is used (Figure 1).

An object model of the heat and mass transfer process within the object-oriented modeling is provided by the UML diagram (Figure 2).

Information model for evaluation of the heat and mass transfer process is realized in the form of an information technology, which consists of three main parts: a preprocessor, a solver and a

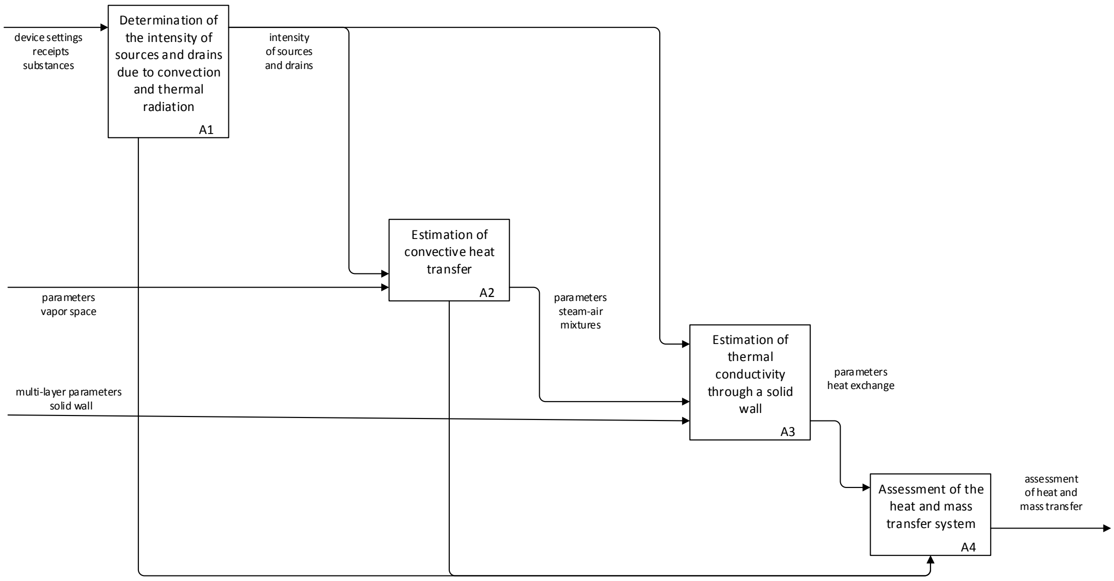

Fig. 1. IDEF0-diagram of information model for evaluation of heat and mass transfer

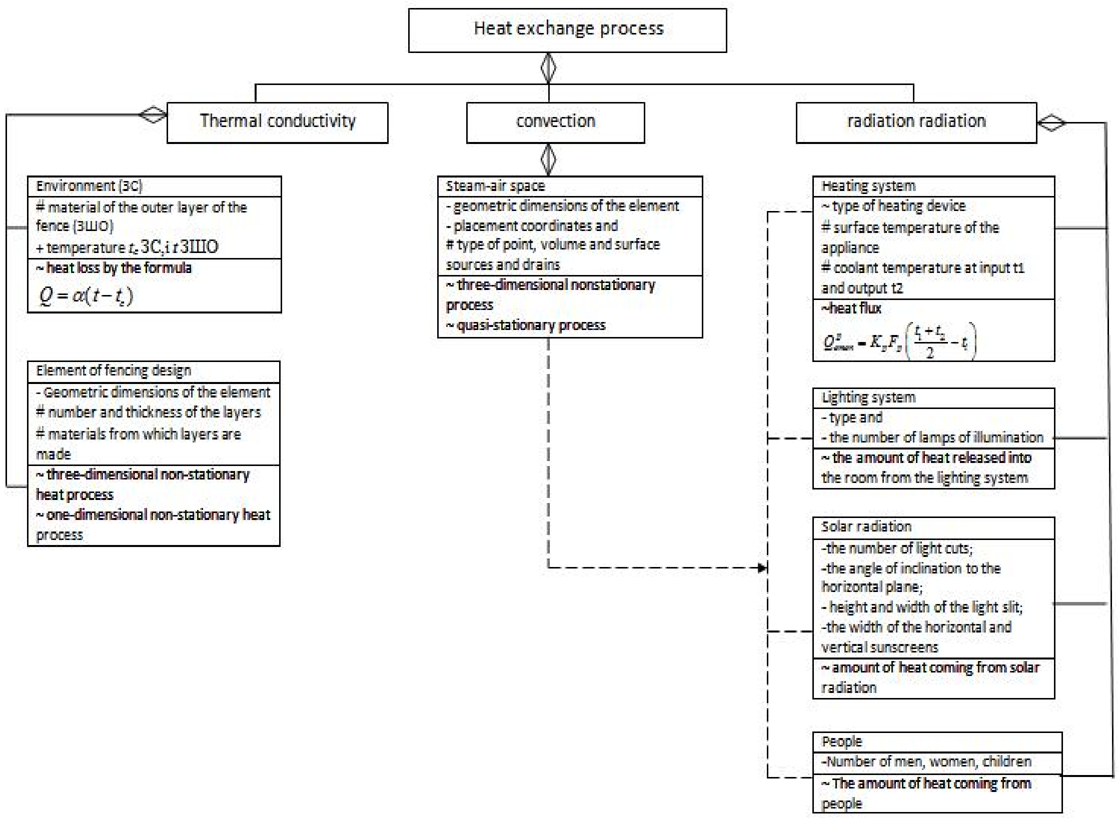

Fig. 2. UML-diagram of the model of heat and mass transfer process

postprocessor [9]. Each of these parts is independent and can be used as a separate program. Communication between programs is carried out using standardized data streams (files) [10].

The preprocessor is designed for reliable visual input and editing of information as geometric and thermalphysic, as well as determining the heat and mass transfer process. The preprocessor shell is constructed in the form of a hierarchical structure based on the tree of directories.

The solver based on the initial data obtained from the preprocessor, based on the functional model of the domain using modules that make up the information base of the medium, forms a program in the form of a sequence of classes and their objects for solving a specific task for the assessment of heat and mass transfer process and performs appropriate calculations.

The developed postprocessor provides the ability to visualize the fields of speed, temperature and pressure.

6. Example studying the heat mode of a typical two-room apartment

Let's consider a typical two-room apartment, located on the 9th floor of a 9-storey brick building [2] (fig. 3).

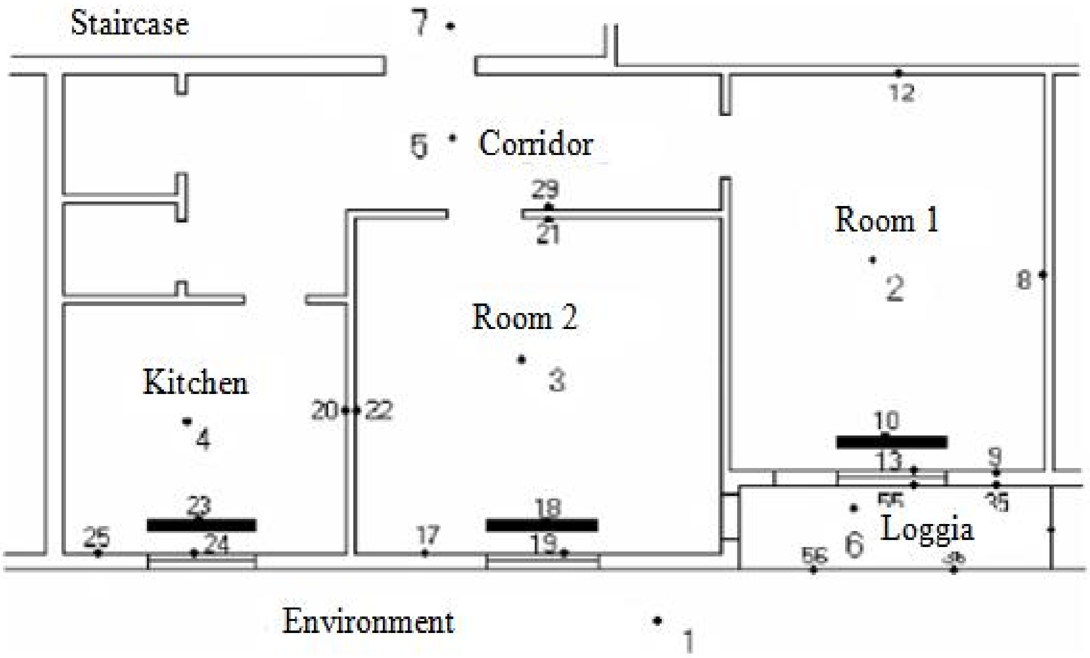

Fig. 3. The plan of the study two-room apartment. The numbers marked the points where the temperature was measured

The dimensions of the rooms are: room 1 - 3x5 m, room 2 - 4,1x4 m, kitchen - 2,7x2,3 m. The height of the floor - 2,5 m. Loggia is glazed. Heating devices of the centralized heating system - cast-iron radiators of type M-140-AO with the number of sections in the room 1- 6 pcs., in room 2 - 9 pcs., in kitchen - 5 pcs. The surface area of each section is 0.299 m^2.

The temperature of the external air was measured at a distance of 0,25 m from the building at the height of the floor. The characteristics of the enclosing structures are as follows: the outer wall is made of silicate bricks (thickness δ=0,52 m, density ρ=1700 kg /m^3, coefficient of thermal conductivity λ=0,829 W/m^{0}C, heat capacity C=800 J/kg^{0}C); internal walls - gypsum (thickness δ=0.25 m, density ρ=600 kg/m^3, coefficient of thermal conductivity =0.24 W/м^{0}C, heat capacity C=795 J/kg^{0}C); ceiling - reinforced concrete slab (thickness δ=0.22 m, density ρ=1000 kg /m^3, coefficient of thermal conductivity λ=0.507 W/м^{0}C, heat capacity C=800 J/kg^{0}C); floor - reinforced concrete slab (thickness δ=0.22 m, density ρ=1229 kg/m^3, coefficient of thermal conductivity λ=1.28 W/м^{0}C, heat capacity C=800 J/kg^{0}C); window - double glazing in wooden weaving (thickness δ=0,13 m, density ρ=101,5 kg/m^3, coefficient of thermal conductivity λ=0,606 W/м^{0}C, heat capacity C=1012,6 J/kg^{0}C).

In fig. 4 the main results of evaluation of temperatures in separate points of the apartment are submitted.

It is worth noting that due to the accident of the heating system in the adjoining apartment at the time of 17 hours, in room 1, the heating was switched off for 12 hours, which did not lead to a significant decrease in the air temperature in the room. The resulting computational experiment data with the help of the proposed information technology are in good agreement with the experimental data given in the work [2].

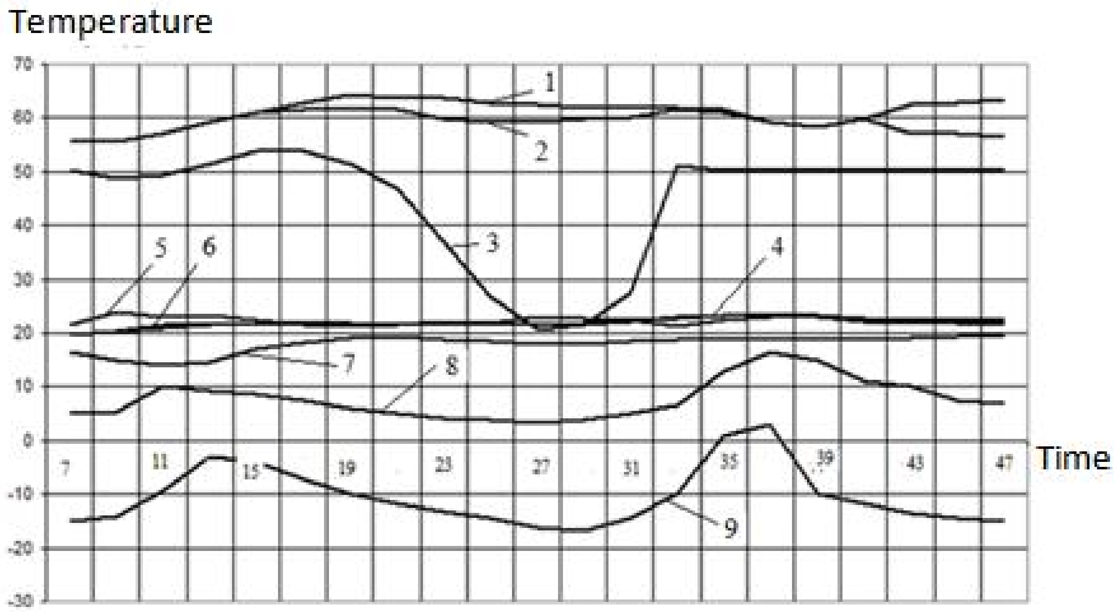

Fig. 4. Temperature changes in time. Curve 1 - radiator in room 1 (experimental data), curve 2 - radiator in the kitchen (experimental data), curve 3 - radiator in room 2 (experimental data), curve 4 - air in room 1 (calculation result), curve 5 - air in room 2 (result of calculations), curve 6 - air in the kitchen (result of calculations), curve 7 - air in the corridor (result of calculations), curve 8 - temperature in the loggia (result of calculations), curve 9 - temperature in the environment (experimental data)

7. Conclusions

In this article, the problem of choosing a model and method for estimating thermal conductivity, convective and radiation heat exchange was solved. A structural diagram of an interconnected and interdependent process of heat and mass transfer is chosen. This task is applicable can be applied to boiler installations, heating networks, foundry, which use liquid or gaseous means.

Calculation of heat and mass transfer processes allows determining the distribution of temperatures, concentrations of mixture components, as well as heat fluxes and mass of the medium as a function of coordinates and time.

As a result, information model for evaluation of interconnected heat and mass transfer process and its program implementation is implemented.

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МАТЕМАТИЧЕСКАЯ МОДЕЛЬ ПРОЦЕССА ОПРЕДЕЛЕНИЯ АДАПТАЦИОННЫХ ВОЗМОЖНОСТЕЙ РЕБЕНКА С АТОПИЧЕСКИМ ДЕРМАТИТОМ

В статье представлена математическая модель проточного хемостата для определения относительной результативности адаптивного процесса, позволяющая количественно выразить и определить состояние ребенка с атопическим дерматитом. Результаты анализа позволяют получить картину сравнительных характеристик изменения состояния больного.

1. Вступ

Атопический дерматит (АД) является одним из распространенных заболеваний современного человека. Согласно данным исследования The International Study of Asthma and Allergies in Childhood (ISAAC), которое активно выявляло пациентов методом анкетирования, в мире АД страдает до 22,5% детей в возрасте 6-7 лет и до 24,6% детей 13-14 лет. Была также отмечена тенденция к глобальному увеличению распространенности АД в среднем на 2 % ежегодно [1]. По данным публикации [2], АД отмечается у 25 % детей школьного возраста и 10 % взрослых. В Украине распространенность АД среди детей составила 5,05% [3].

Данное заболевание оказывает существенное влияние на качество жизни больного и его семьи, нарушая в большей степени психическую сферу, и может быть причиной детской инвалидности [4]. АД - это не только заболевание кожи, но и начало грозного "атопического марша", так как у многих больных развиваются респираторные аллергические болезни - аллергический ринит и бронхиальная астма [5, 6]. От того, насколько рано и правильно будет диагностирован АД и насколько адекватной будет его терапия, зависит и дальнейший прогноз аллергии.

Постоянно продолжается поиск новых патогенетических механизмов, методов лечения АД, но, к сожалению, и на сегодняшний день лечение больного с аллергическим заболеванием не приводит к полному выздоровлению [7, 8]. А существующие выводы, полученные при проведении прямых эмпирических исследований особенности формирования и протекания АД, не позволяют объективизировать изменения функционального состояния больных с различной степенью тяжести АД без применения соответствующего математического обеспечения.