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INTENSITY AND POTENTIAL OF THE TRANSPORT PROCESS IN CHANNEL FLOWS

ІНТЕНСИВНІСТЬ ТА ПОТЕНЦІАЛ ПРОЦЕСУ ПЕРЕНЕСЕННЯ В РУСЛОВИХ ПОТОКАХ

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Abstract. *The main physical processes considered in channel flows are the processes of heat, moisture and air transfer occurring in channels and streams. Heat is one of the types of energy, and moisture and air are specific types of matter. The intensity of the process of momentum, heat and matter transfer in the laminar flow regime is determined by molecular exchange. In most real situations, the intensity of the transfer processes is low compared to the intensity of molecular mixing and molecular exchange processes.*

The potential for heat transfer is temperature, and the potential for the transfer of matter, in particular moisture and air, is appropriately considered to be energy per unit mass. The occurrence of heat and matter transfer processes in structures or the air environment is possible only with a difference in temperature or pressure in individual zones or sections of the analyzed material system. The mechanism of mass transfer of matter and, in particular, moisture or air is associated with the permeability and features of the porous structure of the material within which the transfer process occurs.

Given energy constraints, the natural course of physical processes is associated with the transfer of heat or matter from areas with higher transfer potentials to areas with lower values of these thermodynamic parameters. A system in which a constant distribution of temperature or pressure values is established enters a state of constant equilibrium exchange of heat or matter with the environment.

Keywords: *transport processes, channel flows, transport intensity, transport potential.*

Introduction.

The main physical processes considered in channel flows are the processes of heat, moisture, and air transfer that occur in channels and streams. Heat is one of the types of energy, and moisture and air are specific types of matter. The physical mechanism of energy and matter transfer is different. To quantitatively study the features that cause transfer from these differences, it is necessary to know the transfer constants, as well as external driving forces or thermodynamic parameters. These parameters, which determine the direction and intensity of heat and mass transfer processes, are called transfer potentials [1].

The main text

The intensity of the transfer process is characterized by the flow of the corresponding value. The intensity of the momentum, heat and mass transfer process in the laminar flow regime is known to be determined by molecular exchange. In a developed turbulent flow regime, the role of molecular exchange becomes extremely insignificant, molecular exchange is replaced by molar. The most complex mechanism of exchange in the intermediate section of the flow is the one where both types of transfer phenomena (molecular and molar) are commensurate in magnitude and interact in a non-additive, nonlinear manner [2]. This circumstance gives a specific character to the transfer patterns in the transition region of the flow, different from similar patterns for purely laminar or turbulent regimes. In most real situations, the intensity of transfer processes is low compared to the intensity of molecular mixing and molecular exchange processes [3].

The potential for heat transfer is temperature, and the potential for transfer of matter, in particular moisture and air, is appropriately considered to be energy per unit mass (Fig. 1). This energy is often expressed in terms of the corresponding type of pressure. For example, when studying molecular processes of moisture transfer, which diffuses mainly in the vapor phase, the partial pressure of water vapor is considered. And for molar transfer of liquid moisture or moist air, the total pressure caused by the corresponding causes (wind force, gravity, etc.) [4].

The occurrence of heat and matter transfer processes (for example, moisture) in structures or indoor air is possible only with a difference in temperature or pressure in individual zones or sections of the analyzed material system. However, since the physical mechanism of heat transfer in material media and, in particular, capillary-porous building materials is significantly different from the process of substance transfer, the specific conditions of occurrence, as well as the kinetics of these types of transfer are also different [5].

Since the vast majority of the most common capillary-porous building materials (concrete, brick, etc.) have limited electrical conductivity, the main importance for their thermal conductivity is the vibrations of atomic groups occurring in structural

lattices. In this regard, energy transfer occurs in both ideally dense materials and capillary-porous ones. This process is not related to the permeability of materials for substance flows. Heat transfer in solid materials occurs at any temperature difference Δt, and the amount of heat Q transferred is always proportional to the potential difference, regardless of whether this difference is large or small *(Q~Δt)* [5, 6].

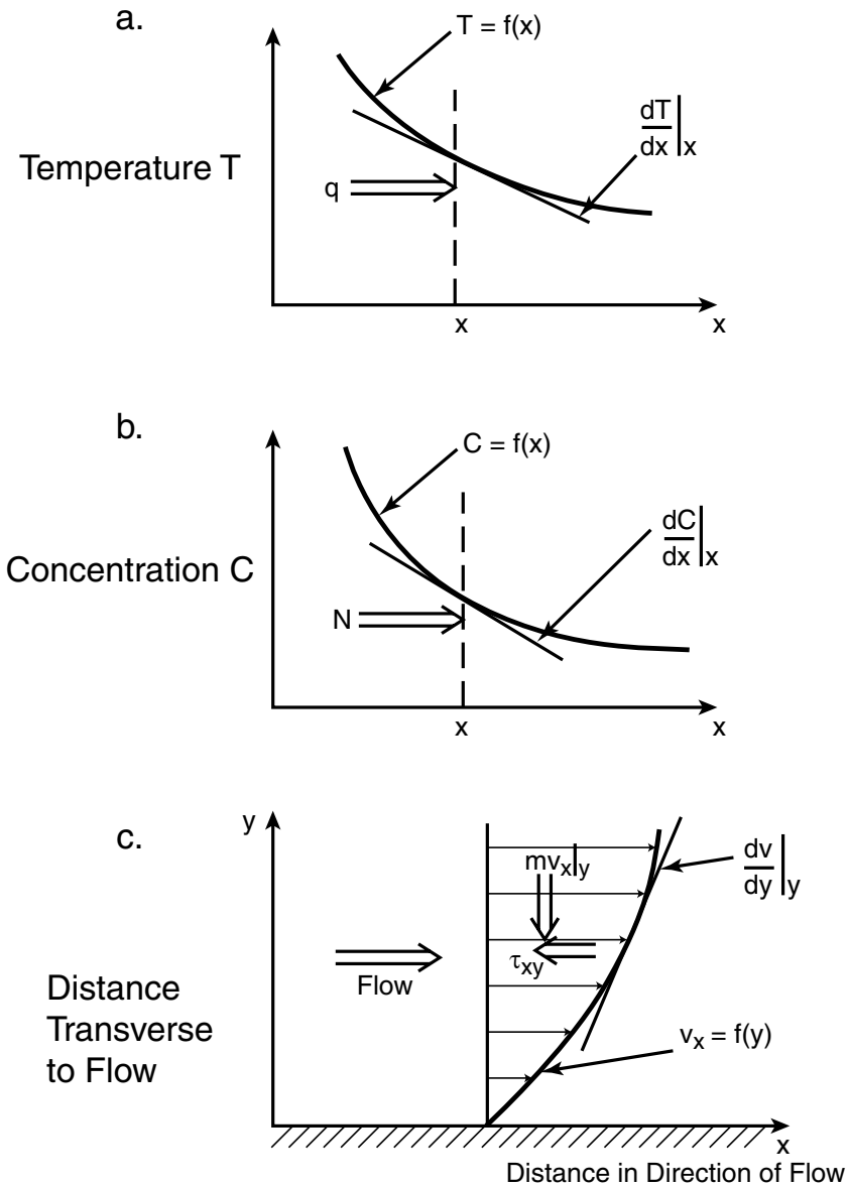

Figure 1 - Diffusion transfer: a) heat; b) mass; c) momentum [4]

The mechanism of mass transfer of matter and, in particular, moisture or air is associated with the permeability and features of the porous structure of the material within which the transfer process occurs. In absolutely dense materials or those that are characterized by ultrafine porosity, in the surface layer that is directly exposed to

external influences, resistances arise that limit the transfer of matter. These resistances, with a small difference in transfer potentials, can exceed the energy level of the latter and turn out to be insurmountable. Under these conditions, mass transfer through a sufficiently dense material does not occur, but such transfer can occur in the other direction, where the resistances will be smaller than the energy of the pressure difference. For example, a flow of cold air in the wind can flow around a building without penetrating inside, since the resistance to penetration of the dense finishing layer of the external walls is very significant. Only in the presence of cracks and leaks does this flow penetrate into the room.

Similar resistances to air flow occur in moist capillary-porous materials, in which water is held by the forces of moisture binding to the material, for example, by adhesion or capillary pressure [7]. The energy level required to overcome these resistances can be significant, and for a small difference in external potentials, the transfer will exceed the energy of this difference. In this case, the transfer of the mass of a substance (air, gas or water vapor) through the porous material will not occur, despite the presence of an external potential difference. The mass of the substance contained in the capillary-porous system will be in equilibrium.

Mass transfer, in particular moisture, will occur only at a pressure difference ΔP exceeding the pressure P_{cr}, which is equal to the energy level of the resistance to the transfer of matter on the surface or inside the material. The amount of transferred matter Q_M will be proportional to the difference between the energy levels of the external potential and the resistance to the transfer inside the system, i.e. $Q_m \sim (\Delta P - P_{cr})$. At a potential difference less than P_{cr}, the amount of matter that could be transferred in the direction that requires overcoming the corresponding resistance will be zero. In this case, building structures from systems that exchange energy and mass with the external environment, for example, heat and moisture (in thermodynamics such systems are called open), are transformed into limitedly closed systems, in which heat exchange processes occur at any temperature difference. And mass exchange processes at a limited pressure difference can be extinguished by resistance to the transfer of matter [4, 8].

Conclusion and findings.

Given these energy limitations, the natural course of physical processes is associated with the transfer of heat or matter from areas with higher transfer potentials to areas with lower values of these thermodynamic parameters. As a result of such a directionality of processes, it is possible (if there is a transfer resistance inside the structure or material environment) to stabilize the temperature or pressure values in individual areas of the system under consideration. A system in which a constant distribution of temperature or pressure values is established enters a state of constant equilibrium exchange of heat or matter with the environment. The process of such constant exchange is called stationary. If the quantitative expression of the exchange is zero, then the system is said to be in thermodynamic equilibrium with the environment.

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Анотація. *Основними фізичними процесами, що розглядають у руслових потоках, є процеси переносу тепла, вологи та повітря, що відбуваються у руслах та потоках. Тепло є одним із видів енергії, а волога та повітря — конкретними видами речовини. Інтенсивність процесу переносу імпульсу, тепла та речовини за ламінарного режиму течії визначають молекулярним обміном. У більшості реальних ситуацій інтенсивність процесів перенесення порівняно з інтенсивністю молекулярного перемішування та молекулярними обмінними процесами виявляється невисокою.*

Потенціалом перенесення тепла є температура, а потенціалом перенесення речовини, зокрема вологи та повітря, доречно вважати енергію, віднесену до одиниці маси. Виникнення процесів перенесення тепла і речовини у конструкціях чи повітряному середовищі можливе лише за різниці температур чи тисків у окремих зонах або ділянках аналізованої матеріальної системи. Механізм перенесення маси речовини і, зокрема, вологи або повітря пов'язаний із проникністю та особливостями пористої структури матеріалу, всередині якого відбувається процес перенесення.

З урахуванням енергетичних обмежень, природний перебіг фізичних процесів пов'язаний з перенесенням тепла або речовини від ділянок з більш високими потенціалами перенесення до ділянок з нижчими значеннями цих термодинамічних параметрів. Система, у якій встановлюється постійний розподіл значень температур чи тисків, входить у стан постійного рівноважного обміну теплом чи речовиною з довкіллям.

Ключові слова: *процеси переносу, руслові потоки, інтенсивність переносу, потенціал переносу.*

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