RESOLVE OF INVERSE PROBLEM IN THE ONE-DIMENSIONAL CASE BASED ON THE ONE COMPONENT LINEAR DIFFUSION MODEL BY EXAMPLE OF CONCRETE COMPOSITE CERAMIC

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Abstract. Investigation of concrete ceramic is very important for understanding of humidity migration into the porous media according to classical behavior of sorption isotherms or retention and drainage curves. It is good known [1] that behavior of sorption curve according to experimental data [2] is reminds the well known Type IV sorption isotherms described by [4]. Also it was demonstrated in work [1] how the structural parameters of porous body can be obtained according to drainage or retention curves. The main purpose of this work refers to calculation of diffusion properties of water vapor component of gas mixture in the porous sample of concrete like composite ceramic under condition that results [2,3] for distribution of water saturation corresponding to the pore saturation by liquid at isothermal condition is known from experimental or computer simulation data. This method, refers to inverse mathematical problem, is first defined by the works of Liu and Simpson [5-7] and classified as ill-posed problem that is, their solution does not satisfy the general requirements of existence, uniqueness and stability under small changes of the input data [8]. The inverse method has been used with success to determine the thermal conductivity in heat conduction problem by Chen [9] or Yeung and Lan [10]. Since the governing equations for heat conduction and moisture diffusion are similar, it is only natural to use the same procedure to investigate the diffusion coefficients in the moisture resorption or desorption process of the alveolar concrete ceramic.

Key Words: porous media, inverse problem, diffusion, computer simulation and modeling.

We are considering porous body as three component media which consist of porous skeleton as solid phase, non adsorbed free water and two component gas mixture of water vapor and dry air into porous space of hard skeleton. According to local averaging method [13] at this assumption we can review [11,12] the concentration of water vapor in porous media as function of liquid pore saturation by liquid via relation

$$C_v = \phi(1 - \eta_W)\rho_v^G, \tag{1}$$

where $\rho_v^G = p_v M_v / RT$ and $p_v = \varphi p_{vs}(T)$ are the density and partial pressure of water vapor into the gas phase, here $p_{vs}(T)$ is the saturated water vapor pressure as function only thermodynamic temperature and φ is the relative humidity of dry air in porous sample.

We assume that the pore saturation by liquid [12] $\eta_W = \eta_W(\varphi, T)$ is depends only from relative humidity and thermodynamic temperature. So in general we may represents of the water vapor concentration in the form of relation

$$C_v = C_v(\eta_W) = C_v(\varphi, T).$$

Under isothermal conditions we may collect necessary relation [5,6] for resolving of one dimensional inverse problem in the terms of water vapor concentration as component of gas mixture in the such way:

I. Diffusion equation

$$\frac{\partial C_v(z,t)}{\partial t} = \frac{\partial}{\partial z}\left(D(C_v;\phi,\tau)\frac{\partial C_v(z,t)}{\partial z}\right)\ (0 \leqslant z \leqslant h); \tag{2}$$

II. Boundary conditions

$$\frac{\partial C_v(z,t)}{\partial z} = 0\ (z = 0, t \geqslant 0); \tag{3}$$

$$D(C_v;\phi,\tau)\frac{\partial C_v(z,t)}{\partial z} = \alpha(C_v^{eqv} - C_v).\ (z = h, t \geqslant 0;$$

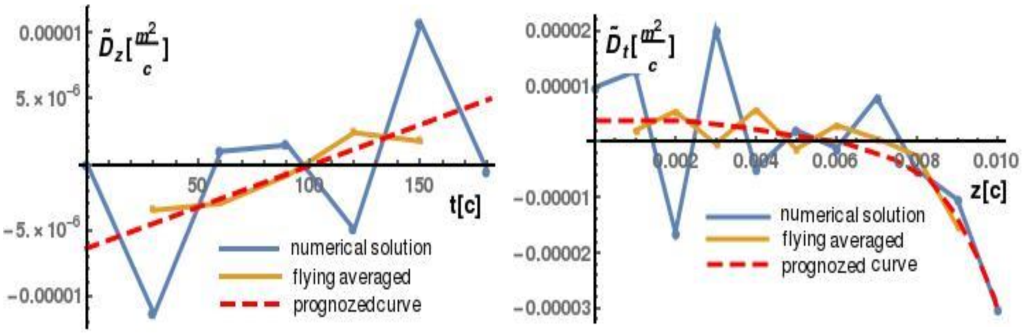
III. Initial conditions

$$C_v = C_v^0 \qquad (0 \leqslant z \leqslant h, t = 0). \qquad (4)$$

May be considered as far as possible two possibilities: 1. $C_v^{eqv} > C_v$ is the desorption case; 2. $C_v^{eqv} < C_v$ is the sorption case, whereC_v^{eqv} is the concentration of water vapor into ambient environment, $C_v^0$is the corresponding to initial concentration at the zero time moment. The desorption case is considered in this work.

.The main idea in the introduced by the works [5-7] inverse method is into searching or reproduction of diffusion coefficient into equations (2-4) and consist of in the resolution of differential equation (2) numerically by the usage of finite difference method. The experimental data was obtained form the works [3] for the classical building material as alveolar concrete ceramic. The experimental or numerical results have been determined in the porous cylindrical sample of height $h = 0.01[m]$with averaged porosity $\phi = 0.70$ and tortuosity factor$\tau = 4$under averaged constant temperature $T = 301.5(K)$. The external environment outside sample was supported through constants room temperature $T_{amb} = 320.15[K]$ and normal ambient $P_G = 101325[Pa]$atmospheric pressure. For numerical simulation in the work [3] on the upper surface it was suggested to put the constant mass $\alpha = 0.015[m/c]$ and heat ($\beta = 15[W/(m^2K)]$) transfer coefficients by the mentioned numbers under ideal ($\varphi = 0|z \to \infty$) drying conditions, where z is the vertical abscissa coordinate.

The numerical resolving of inverse diffusion model (2-4) due to computer simulation data [3] is depicted on the Fig.1 below.



A. Averaging over time

B. Averaging over coordinate

Fig.1.Averaged over time or coordinate diffusion coefficients into porous sample. Here $\bar{D}_z$and $\bar{D}_t$ is averaged over time and coordinate diffusion coefficients into porous cylindrical sample.

Conclusions. Only averaged macroscopic quantities of diffusion coefficients have meaning into macroscopic (2-4) diffusion equations. There is also interesting effect into limitation of diffusion coefficient value near small values of liquid saturation which corresponds to existing of the lover limit of humidity into pores due to starting of adsorption process or existing residual saturation [1] in form of adsorbed water. The change of sign is not fully justified into averaged quantities of diffusion coefficients but may corresponds to opposite action of suction and gravity effects.

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ТЕХНІЧНІ АСПЕКТИ ЗАСТОСУВАННЯ ТЕОРІЇ КОНДЕНСОВАНИХ СЕРЕДОВИЩ ДЛЯ ФУНКЦІОНАЛЬНИХ СИСТЕМ

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Для розвитку функціональних систем, таких як сенсори, акустичні та оптичні пристрої, використовуються матеріали з оптимізованими динамічними властивостями [1]. Теорія конденсованих середовищ допомагає визначити, як матеріал буде вести себе в умовах високих частот або швидких коливань, що важливо для забезпечення надійності і ефективності роботи таких систем.

Теорія конденсованих середовищ (ТКС) є важливим інструментом для розуміння та моделювання фізичних властивостей матеріалів, що використовуються в різноманітних функціональних системах. Вона дозволяє детально вивчати взаємодію матеріалів із зовнішнім середовищем, зокрема, їхню реакцію на зміни температури, механічні навантаження, електричні та магнітні поля. Це особливо актуально для розробки матеріалів для технічних систем, де точність прогнозування їхньої поведінки при різних зовнішніх впливах є ключовою для забезпечення ефективності та надійності таких систем [2].

Завдяки ТКС можна створювати математичні моделі, які допомагають передбачити, як матеріали будуть реагувати на зміни навколишнього середовища, що дозволяє оптимізувати їхні характеристики для конкретних застосувань. Наприклад, для п'єзоелектричних або магнітоелектричних матеріалів важливо мати точне уявлення про їхню поведінку при впливі зовнішніх полів, що дозволяє розробляти більш чутливі та ефективні сенсори або виконавчі механізми. Вивчення цих властивостей є важливим для створення матеріалів, які можуть змінювати свої характеристики залежно від зовнішніх змін, наприклад, матеріалів для сенсорних технологій, що реагують на механічні коливання, зміни температури чи електричні впливи.