Numerical Solution of an inverse diffusion problem for the moisture transfer coefficient in porous materials

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Content

Introduction

Porous materials:-

- Materials with different pore sizes (from nanometer to millimeter).
- porous materials are organic materials, polymeric foams and inorganic porous materials.
- Contain pores (cavities, channels, interstices) which are different in accessibility and shape.

Porosity

- Measured by Vp / Va
- Range from 30 – 98 %

Chemical and physical properties of porous materials:

- High Bulk density
- Energy adsorption
- Low thermal conductivity
- Air and water permeability

Moisture transfer

- described by moisture transfer coefficient which depend on moisture content.
- Moisture transfer causes changes of physical and chemical properties into building materials.

Formulation of the problem

$$D(\omega) = P_1 + P_2\omega + \ldots + P_n\omega^{n-1}$$

$$\frac{\partial \omega}{\partial t} = \frac{\partial}{\partial x}\left[D(\omega, t)\frac{\partial \omega}{\partial x}\right], t > 0, 0 < x < 1$$

$D(\omega)$ Moisture transfer coefficient

$D(\omega, t)$ coefficient of Moisture transfer in time, width of Sample

$W_0(x)$ Moisture distribution

$$\frac{\partial \omega}{\partial \mathrm{t}} = \frac{\partial}{\partial x}\left[D(\omega, t)\frac{\partial \omega}{\partial x}\right], t > 0, 0 < x < 1$$

$$D(\omega, t) = P_1 \omega^{P(t)} + Ae^{-\mu(\omega - v_o)}$$

$$P(t) = P_2 + P_3(1 - \mathrm{t})^{P_4}$$

$$\omega(x,0) = \omega_0(x), \qquad 0 < x < 1$$

$$\frac{\partial \omega}{\partial x}(0,t) = 0, \qquad -D(\omega(1,t),t)\frac{\partial \omega}{\partial x}(1,t) = B(\omega(1,t) - v_\circ)\,, t > 0$$

$$S(P) = \sum_{k=2}^{M} \int_0^1 [\omega(x,t_k) - \omega_e(x,t_k)]^2 dx$$

$$\int_0^1 [\omega(x,T_1) - \omega(x,T_2)]dx = -\int_{T_1}^{T_2} D\big(\omega(1,t)\big)\frac{\partial \omega}{\partial x}(1,t)dt$$

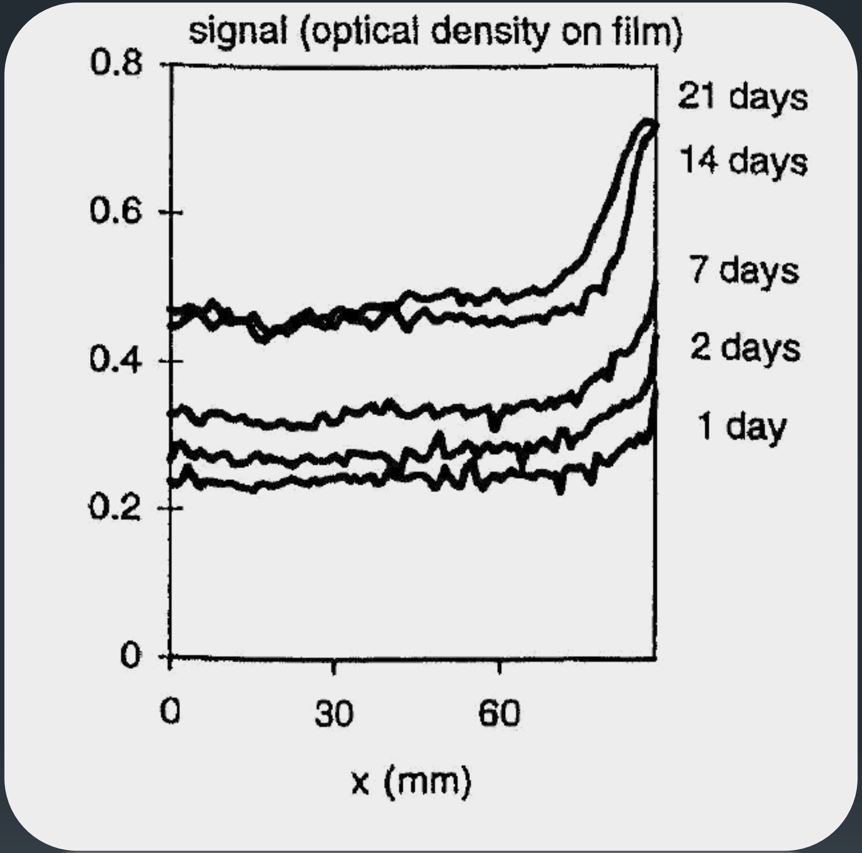
Method of numerical solution

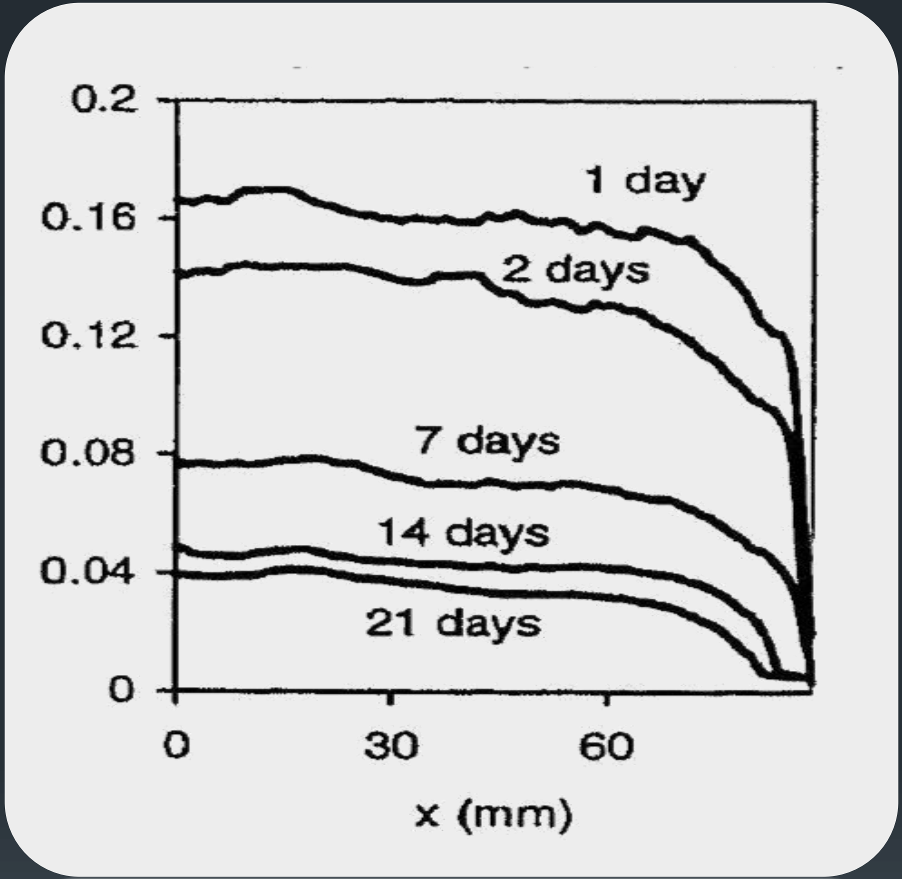
- We use Gauses elimination (decrease coefficient and ordering equation)
- Then use Newton method to minimize functional parameters

$$\boldsymbol{max}\left|\omega_i^{J+1(\mathrm{g}+1)} - \omega_i^{J+1(\mathrm{g})}\right| < \varepsilon, i = 0,1, \dots, m,$$

$\boldsymbol{where}\ \boldsymbol{\varepsilon} > \boldsymbol{0} - is\ a\ positive\ small\ number$

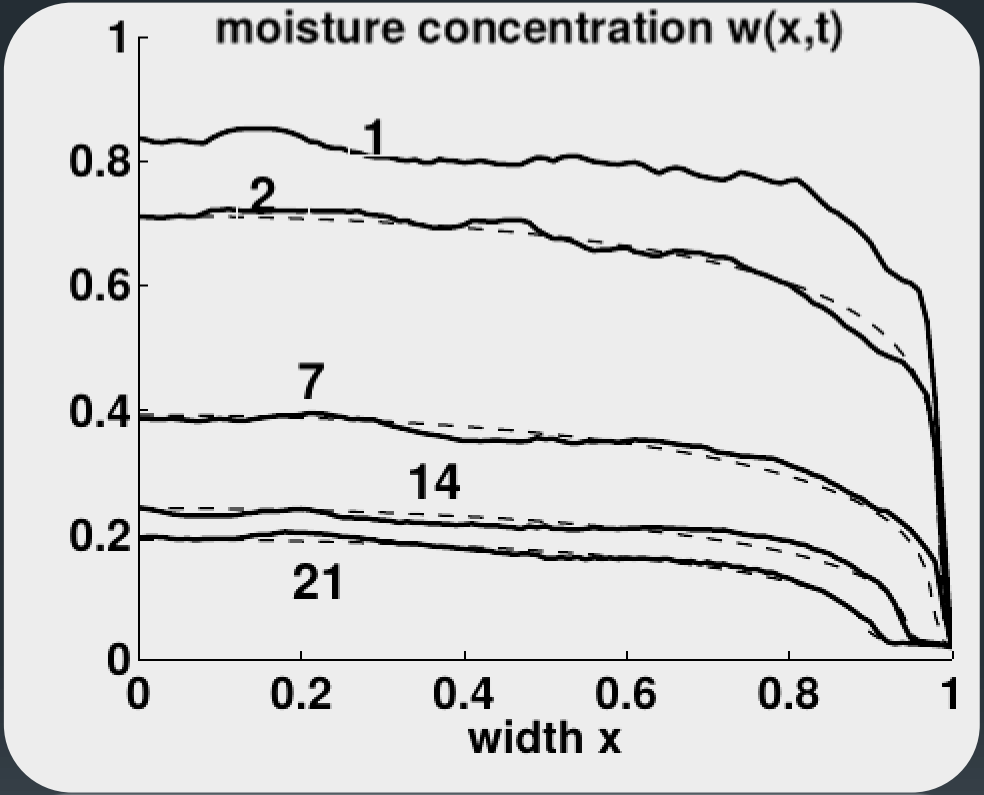
Experimental Results

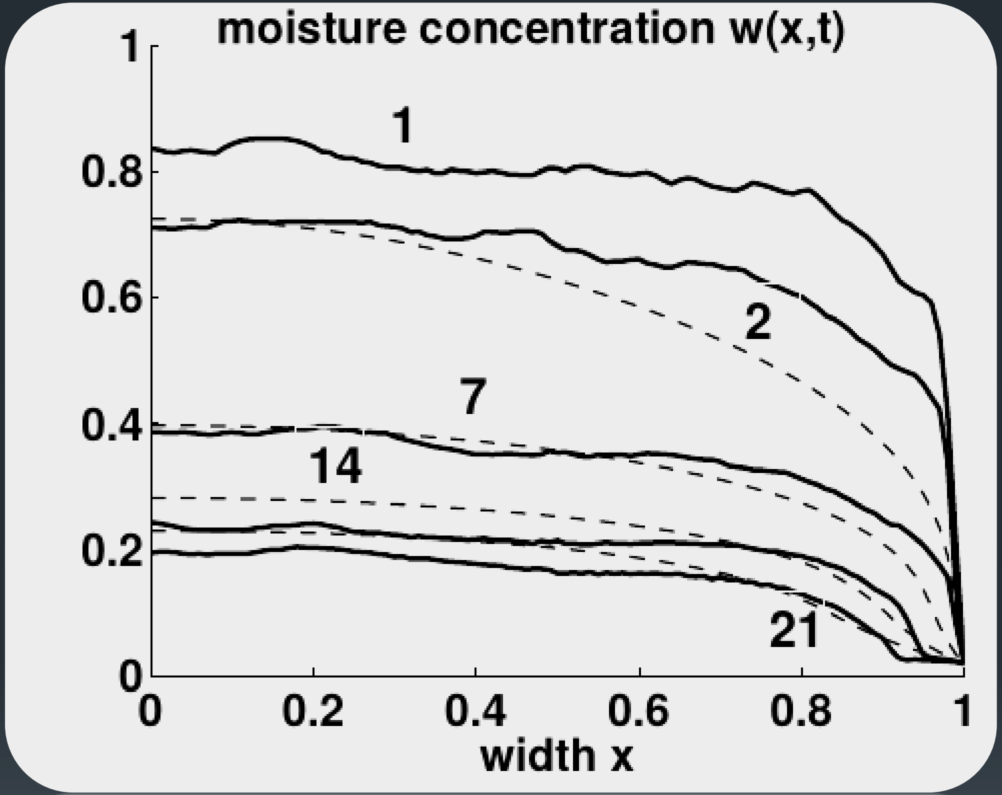




Distribution of moisture construction Obtained by signal transformation analysis

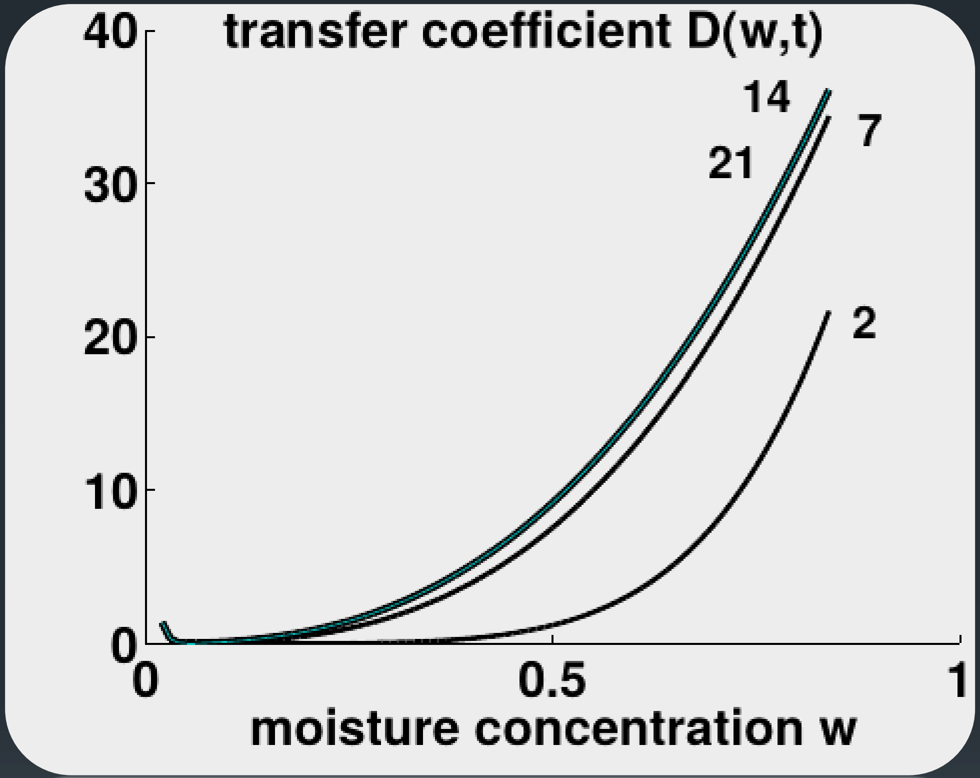
Computational Results:

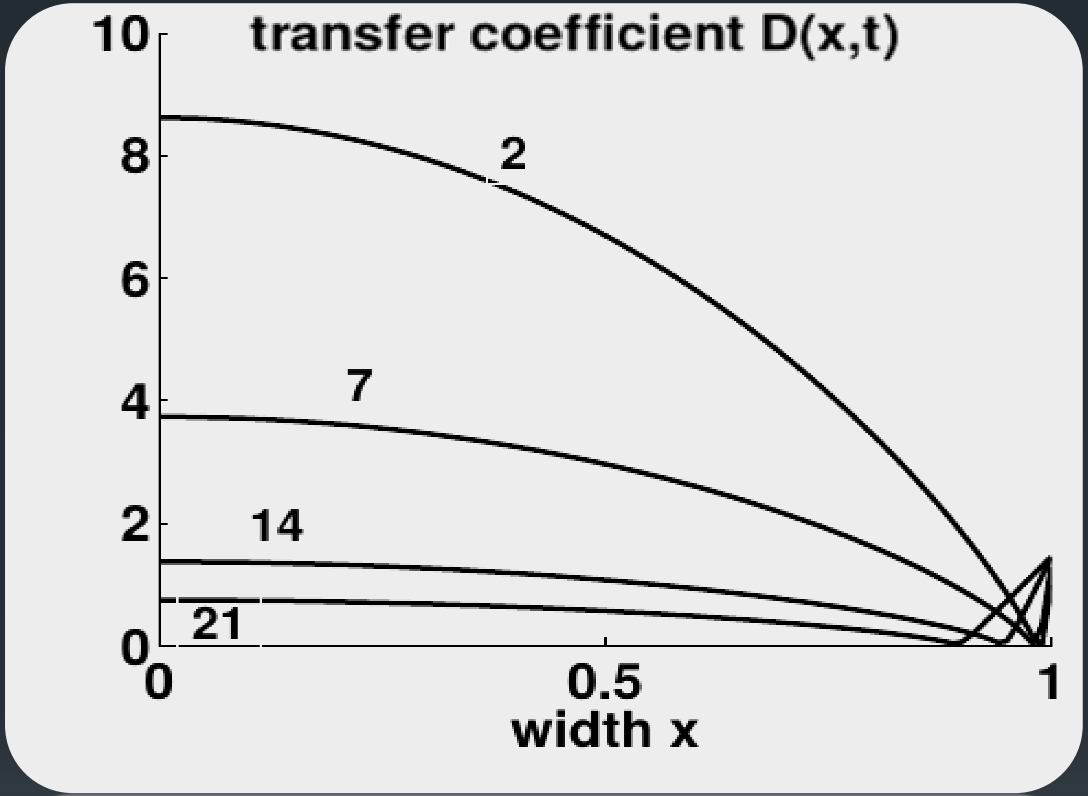




Moisture concentration before and after minimization

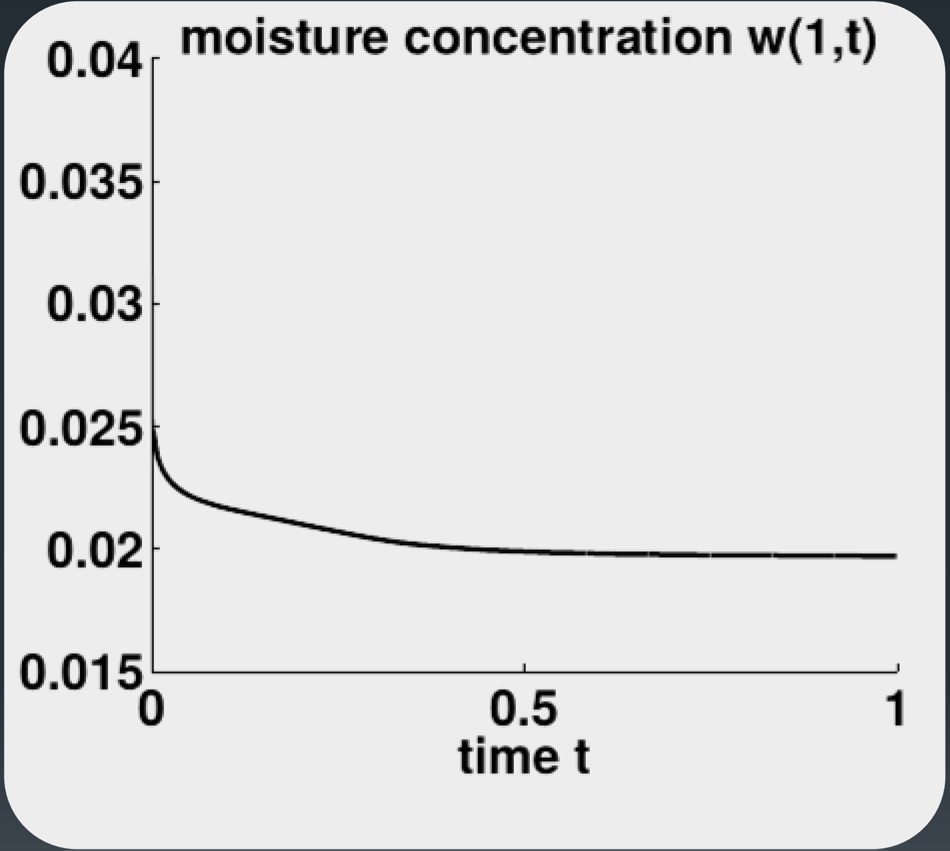
Computational Results:

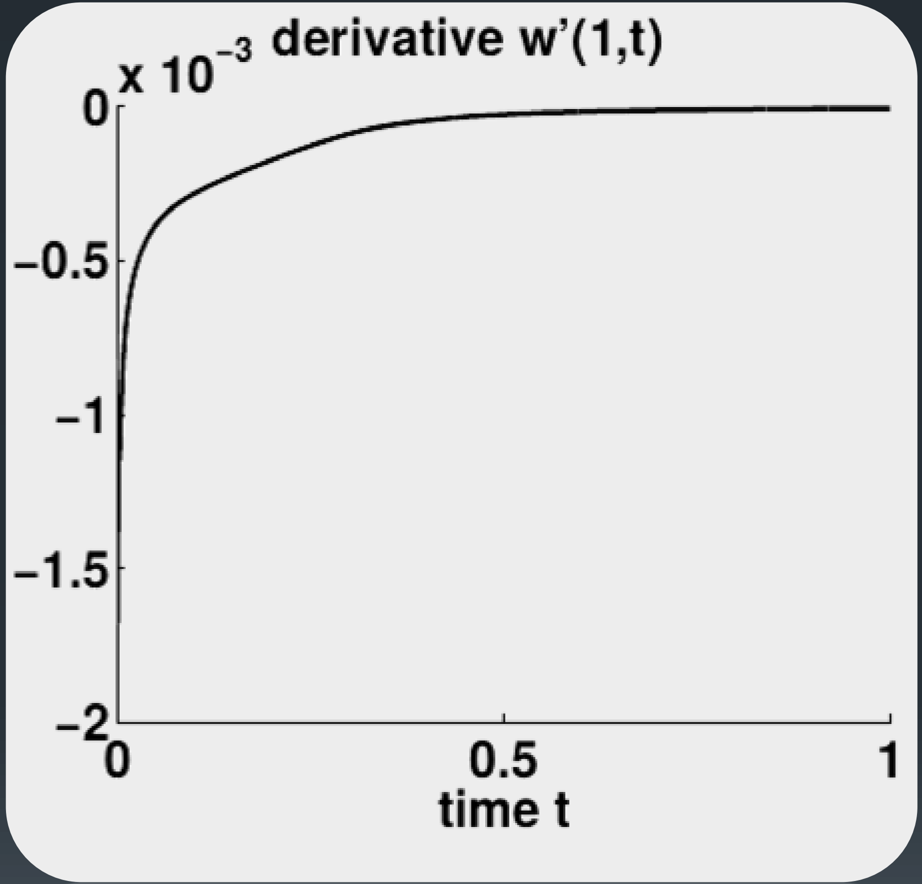




Dynamic change of moisture transfer coefficient

Computational Results:





Moisture concentration dependence on time

Thank

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