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VAPOUR PERMEABILITY PREDICTION OF TEXTILE MATERIALS AND PACKS MADE OF THEM

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Method for prediction of vapor permeability of different textile materials with regard to corrosive medium - phenol being in form of aerosol with different concentration has been proposed.

Keywords: prediction, permeability, corrosive medium, textile materials.

Requirements to functional properties of textile materials and garments, their permeability with regard to corrosive media do not correspond to the current state of climatic and man-caused environment since they embrace not all types of technogenic pollutants; concentration, exposure time, real climatic factors, etc. are not being taken into consideration.

Analysis of existing methods and devices is testimony to the fact that tests of permeability of textile materials are to be carried out under dynamic conditions of technogenic and climatic environments. Research into textile materials intended for finished goods for various applications by means of complex evaluation seems to be optimum.

A device has been developed which enables to bring nearer the parameters of an experiment to real conditions of utilization of materials, with simultaneous manifestation of diffusion of air with different humidity, aerosol with different concentration, with different process duration and air speed within the temperature range from +1 to 100°C through material; it also makes possible to determine the quantity of pollutant absorbed and passed through the fibrous-porous material [1]. This device enables to investigate permeability of materials with regard to technogenic pollutants being in form of aerosol with different concentration in ambient air; it also makes possible to determine the sorption properties of materials by dynamic method under conditions which simulate real conditions of utilization with simultaneous change and manifestation of all factors.

Materials of different fibrous composition and structure have been selected as subjects of research (Table 1).

Table 1

# of sample	Name/article of fabric	Fibrous composition, %	Type of weave	Surface density g/m^2	Thikness, mm	Linear density, tex	
						T_o	T_y
1	Batiste	Cotton	Fabric	71,0	0,19	8,2	8,1
2	Apparel plain dyed fabric 3080/28A	Cotton	Serge	186,3	0,48	38,1	20,5
3	Apparel Premiere 180 81419	Cotton+Polyester 33%+67%	Serge	180,0	0,46	44,7	44,2
4	Cloth	Wool +viscose-lavsan rayon 30%+70%	Serge	384,0	0,94	100,2	92,5
5	Plaid	Wool	Fabric	190,0	0,38	44,3	44,3
6	Apparel plain dyed fabric 3080/26A	Wool	Serge	230,0	0,60	36,2	35,8
7	Suitings	Wool +viscose-lavsan rayon 60%+40%	Serge 2/2	276,3	0,72	42,2	41,6
8	Apparel plain dyed fabric	Cotton	Fabric	150	0,32	28,8	28,4

Phenol has been taken as a model-based man-caused environment. Factors which predetermine its usage in the experiment are the growing dynamics of atmospheric emissions, and high penetrability.

Investigation of vapor permeability has been carried out under given conditions: of time (τ, min), температуры (t, °C), speed of air flow (m/s) and concentration (s, g/ml) of substance in solution, on a laboratory-scale device. To determine dependence of vapor permeability from ambient environment factors, the following set (range) of conditions has been accepted whereby one parameter was changed, the other ones remained constant

a) C = var ; τ = 5 min.; W_1= 13.9 m/s; t = 23 °C

b) t = var; τ = 5 min. ; W_1= 13.9 m/s ; C = 12.7 g/l.

c) τ = var; W_1= 13.9 m/s ; C = 12.7 g/l ; t = 23 °C

d) W_1 = var; τ = 5 min.; t = 23 °C ; C = 12.7 g/l.

Parameter values had been chosen from a real range: of temperature from 1 to 40°C, speed of air flow – from 8.7 to 24.5 m/s, time from 1 to 30 min.

To obtain a model which enables to predict vapor permeability of textile material under influence of climatic and man-caused factors, similarity methods and dimensional analysis have been applied [2].

The research conducted in this scientific work demonstrated that both features of samples and characteristic of model-based environment have an effect on vapor permeability of fabrics with different composition and produced with different weave techniques.

The following below factors have been selected as major ones

$$B_v = f\,(B_1, W, \tau, C, T, d, \rho, t_o, t_y, R_o, R_y, T_o, T_y, V_o, V_y), \qquad (1)$$

where B_v - vapor permeability of textile material, g/(m^2·c); B_1 - vapor permeability of textile material at temperature 1°C, g/(m^2·s); d – area of sample, m^2; ρ – substance density, mg/mm^3; t_o – number of major overlappings in repeat of warp threads; t_o – number of major overlappings in repeat of weft threads; R_o – pattern repeat of warp cloth; R_o – pattern repeat of weft cloth; T_o – linear density of warp threads, tex; T_o – linear density of weft threads, tex; D_o – fabric's warp density, number of threads/10 cm; D_o – fabric's weft density, number of threads/10 cm; W – speed of air flow, m^2/s;

τ – impact time / experiment duration time, min; C – concentration of man-caused pollutant / model-based environment, g/vl; T – temperature, °C.

Using similarity theory and dimensional analysis, let us represent the dependence (1) in form of a set of non-dimensional indicators:

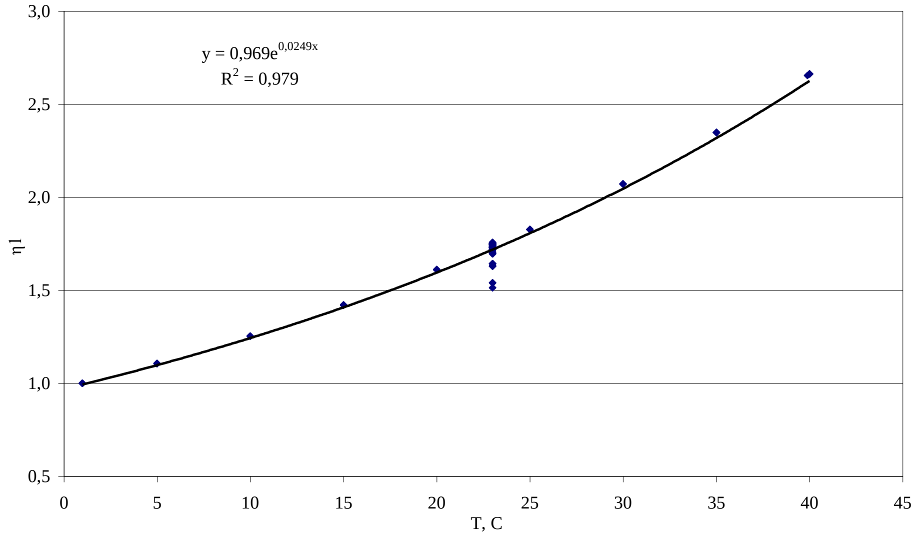
$$B_v/B_1 = f(\eta_1, \eta_2, \eta_3), \quad (2)$$

where η_1 – temperature complex; η_2 – complex characterizing structural characteristic of fabric; η_3 – parameters of environment.

Experimental results of vapor permeability of fabrics with different composition and produced with different weave techniques under impact of a number of ambient environment factors demonstrate that more pronounced (for given conditions) is the dependence of vapor permeability from ambient temperature.

Dependence of temperature complex for fabrics under investigation η_1 is defined with a high degree of fine precision by the function of the following form (3) and Picture1:

$$\eta_1 = f(T) = 0.969 \cdot e^{0.0249T}. \quad (3)$$



Picture 1

Dependency of the complex characterizing the structural charcteristic of fabric η_2 is determined by a function of the following form (4) and Picture 2:

$$\eta_2 = f\left(\frac{t_o t_y}{R_o R_y}\frac{T_y \Pi_y}{T_o \Pi_o}\right) = \frac{\frac{t_o t_y}{R_o R_y}\frac{T_y \Pi_y}{T_o \Pi_o}}{0,418 e^{2,101 \cdot \left(\frac{t_o t_y}{R_o R_y}\cdot\frac{T_y \Pi_y}{T_o \Pi_o}\right)}}. \quad (4)$$

Dependency of the ambient environment parameter η_3 is determined with a high degree of fine precision by the function of the following form (5) and Picture 3:

$$\eta_3 = f\left(\frac{WC\tau}{\rho d}\right) = \frac{\frac{WC\tau}{\rho d}}{242,950\frac{WC\tau}{\rho d} + 6,784}. \quad (5)$$

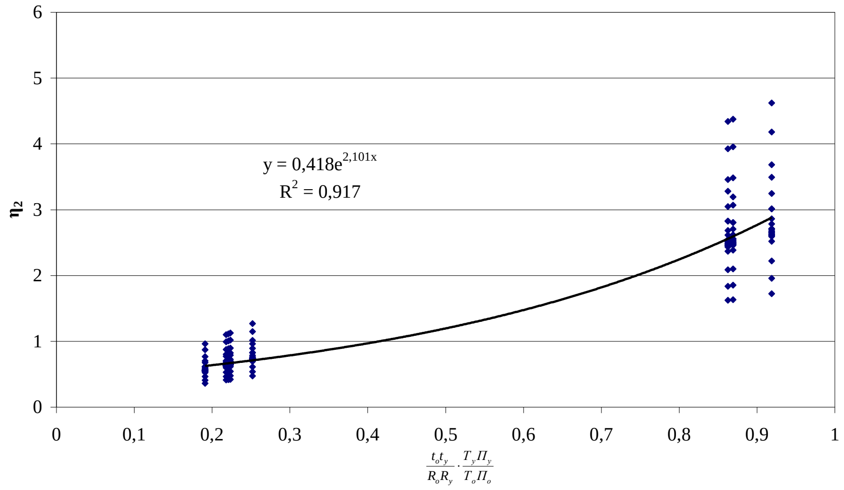
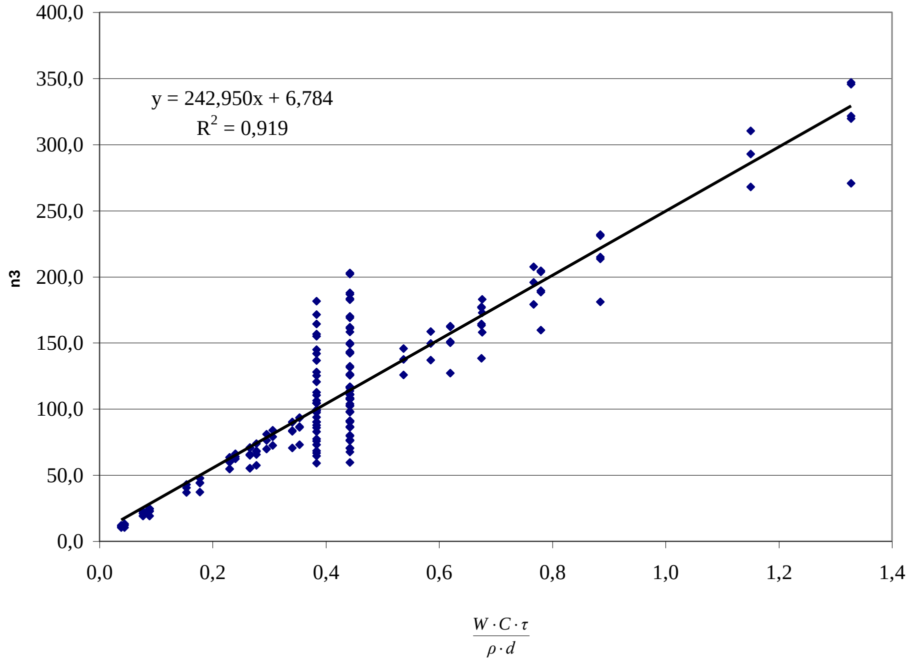


Fig.2



Picture3

Thus, general view of dependency can be represented in the following form (6):

$$B_{\Pi} = 782{,}35 \cdot B_1 \left(0{,}969 e^{0{,}0249 \cdot T}\right) \left(\frac{\dfrac{t_o t_y}{R_o R_y} \cdot \dfrac{T_y \Pi_y}{T_o \Pi_o}}{0{,}418 e^{2{,}101 \cdot \left(\frac{t_o t_y}{R_o R_y} \cdot \frac{T_y \Pi_y}{T_o \Pi_o}\right)}} \right) \left(\frac{\dfrac{WC\tau}{\rho d}}{242{,}95 \dfrac{WC\tau}{\rho d} + 6{,}784} \right).$$

Analysis of obtained data shows that deviation of experimental data from designed ones does not exceed 7%.

CONCLUSIONS

The obtained mathematical relation enables to predict vapor permeability of textile materials under impact of a number of climatic and man-caused factors with a high degree of precision.

B I B L I O G R A P H Y

1. "Device for investigation of penetrability of fibrous-porous materials and packs made of them": patent 2276345 Russian Federation.

2. *Yu.S. Shustov*Similarity Methods and Dimensional Analysis in the Textile Industry. M.: MSTU named after A.N. Kosygin, 2002.

Recommended by the editorial board. . Received 03.06.11.