EXPERIMENTAL STUDY OF HEAT TRANSFER IN THE SOLAR AIR COLLECTORS TRANSPIRATION TYPE

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For solar air heating collectors promising transpiration, ie radiation-convection heat exchangers in which organized air filtration through a porous absorber. Such an absorber may be made, e.g., of a nonwoven textile material web which is spanned inside the housing and on one side is heated by solar radiation. The absorbed heat is transported deep into the porous layer of thermally conductive frame (fiber matrix) and transmitted it to the moving air. Since the contact area of the air flow with the developed surface microchannels absorber is usually not defined, the heat transfer rate in the pores are usually described by means of volumetric heat transfer coefficient, which has the dimension W / m3gr. Find also this factor can only be experimentally.

The purpose of research - development of methods and experimental determination of the coefficients of volume heat transfer and hydraulic resistance in the movement of air in porous absorber transpiration solar collector, depending on the air velocity and the intensity of the radiation heat flux.

Materials and methods of research. Fig. 1 shows a diagram of the experimental setup for studying the volumetric heat transfer layer in the planar non-woven absorber at a filtration air therethrough.

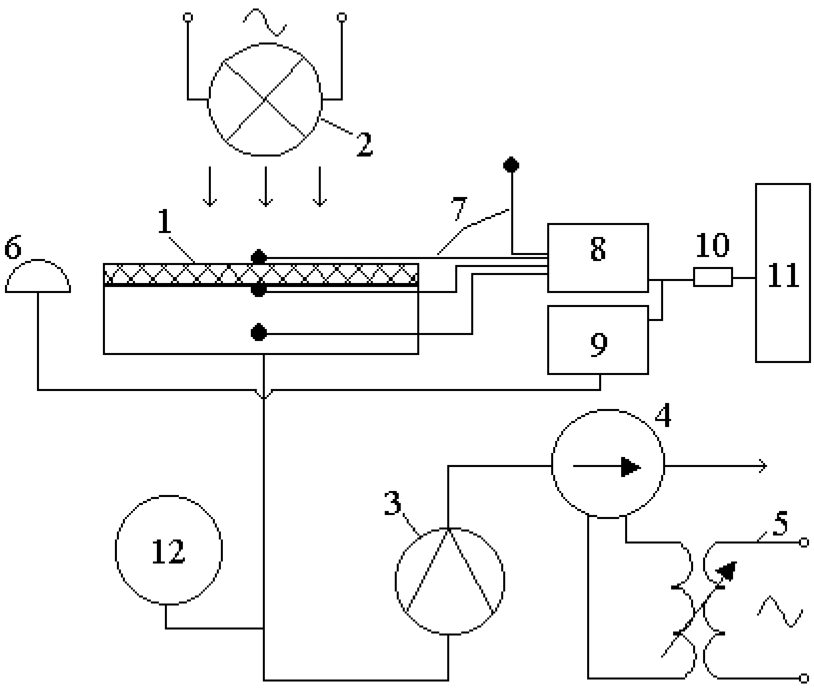

Fig. 1. Schematic of the experimental setup

Installing operating portion 1 is made of thin sheet metal and has a cylindrical shape with a diameter of 190 mm and a height of 60 mm. In its upper part there is a grid, which is fixed on a sample of the nonwoven material and the bottom of the cylinder is mounted to the air outlet pipe. Radiative heat flux created infrared lamp 2 mounted on the bracket. Air filtration provided an exhaust fan 4 turnovers regulated autotransformer 5. Airflow was measured rotameter 3, and the pressure drop across the sample was using micromanometer inclined tube 12 series MCM-2400. To measure the temperature on the surface of the sample, and the air temperature before and after the porous layer used Chromel-Copel thermocouple 7. The density of the radiant flux was determined pyranometer 6 grade M-80. Signals from thermocouples and pyranometer arrived on industrial controllers 8 and 9 type TPM 138 and 201. These controllers TPM through the interface converter AC3 10-M-220 were connected to a personal computer 11. Such measurements allow the automated system to receive and archive large amounts of experimental data with predetermined time step.

$$\lambda_1 \frac{d^2 t_1}{dx^2} - \alpha_v (t_1 - t_2) = 0$$
$$\rho_2 c_{p2} w \frac{dt_2}{dx} = \lambda_2 \frac{d^2 t_2}{dx^2} + \alpha_v (t_1 - t_2) \qquad (1)$$

where λ - coefficient of thermal conductivity, W / (mK); ρ - density, kg / m^3; α_v - volumetric heat transfer coefficient, W / (m^3K); Wed - isobaric heat capacity, J / (kgK); t - temperature, K; w - the average air velocity in microchannels, m / s; x - coordinate across the nonwoven layer. The subscripts 1 and 2 refer to the matrix and gas, respectively.

In these equations, the expression can be regarded as a source term; it has the dimension W / m3 and describes heat sink from the die to the gas by heat exchange therebetween. The average speed of the air in microchannels related to the rate of filtration wf expression, where P - porosity.

The system of differential equations (1) was solved numerically finite difference method on a uniform grid. In the alternative calculations of the radiant flux density entering the sample inlet air temperature and thermal parameters of the medium are assumed known, and the heat transfer coefficient of volume was chosen so that the calculated values of the temperature on the surface of the nonwoven material coincide with the experimental ones.

The results of research. Obtained using this technique for heat transfer coefficients of bulk samples of different thickness are shown in Fig. 2 depending on the speed of the air filtration.

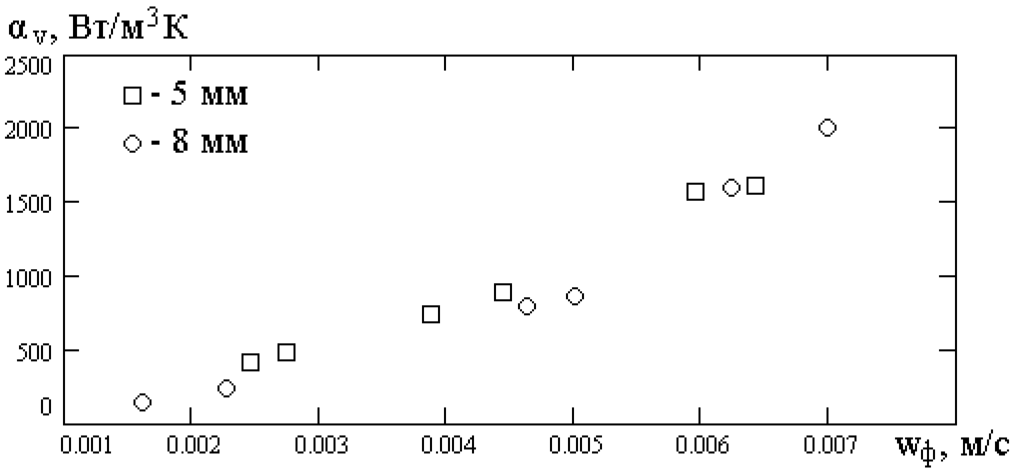

Fig. 2. The coefficient of volumetric heat transfer in the nonwoven fabric

Processing of the data shown in this figure, in dimensionless form yielded the following dimensionless equation

$$\overline{Nu_d} = 0{,}085\,\mathrm{Re}_d^{1{,}67}\,, \tag{2}$$

Where in the Nusselt number and the Reynolds number defined by the average diameter d of the fibers of the porous medium, i.e.

$$\overline{Nu_d} = \frac{\alpha_v d^2}{\lambda_в}; \quad \mathrm{Re}_d = \frac{w\ d}{\nu_в}\ . \tag{3}$$

Thus, equation (2) was obtained for the conditions of the external heat transfer in a porous body when viewed outside air flow through its filaments.

Fig. 3 shows the temperature ($t_п$) on the outside (the exposed) surface of the nonwoven absorber thickness of 5 mm and a temperature of air passing therethrough ($t_в$) depending on the filtration velocity; Data are shown for two values of the intensity of the radiant heat flux. The temperature of the air entering the absorber was 23 ° C. Fig. 4 shows experimental data on the hydraulic resistance of the absorber thickness of 5 mm for different flow velocities.

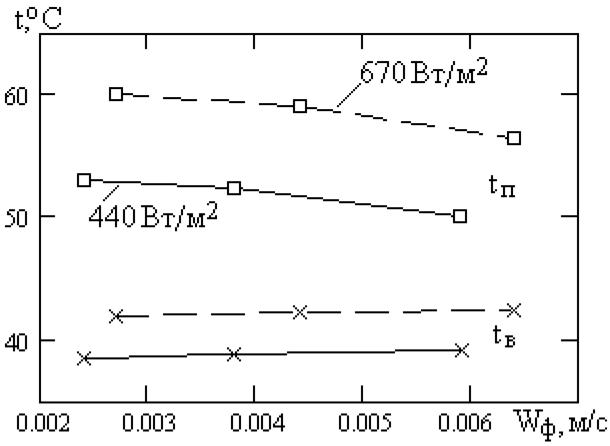

Fig. 3. The temperature of the irradiated surface of the absorber and heated air

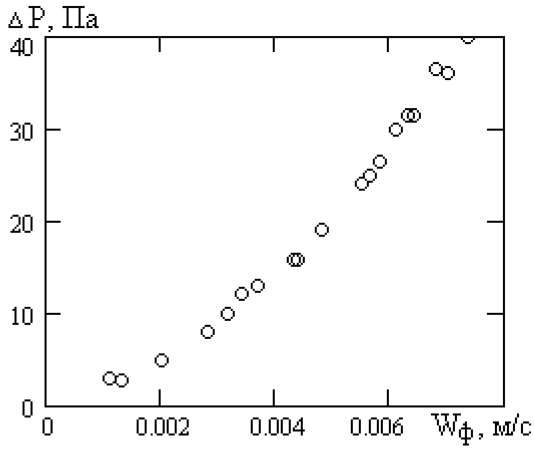

Fig. 4. Hydraulic resistance non-woven absorber

Simple calculations show that in the experiments described above laboratory setup conversion efficiency of radiative heat flux in the heat was low and did not exceed 25%. This caused significant heat losses, since body work area had no insulation, no clear coat on the absorber. In situ samples transpiration air collectors, these shortcomings will be addressed, which will significantly enhance their thermo perfection.

Conclusions

An experimental study of heat transfer in solar air collector transpiration type absorber with a porous non-woven material. The temperatures on the surface of the absorber and the air temperature at various speeds and its filtering radiative flux densities; measured as the hydraulic resistance of the absorber. Inverse method of the theory of heat transfer coefficients found in the nonwoven volumetric heat absorber of the solar collector.