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TESTING OF SOLAR COLLECTOR BASE MODEL FOR PV/T SYSTEM

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The paper proposes a framework of general model of the thermal exchange of the solar collector and review the most important parameters for the heat-transfer processes, such as the coefficient of thermal convection of the water, the water flow rate and water flow power, which mainly are determined by system parameters and fluid flow rates, and based on experimental studies systems.

Keywords: *solar collector, PV/T system, power withdrawn, water flow rate, temperature gradient, heat transfer.*

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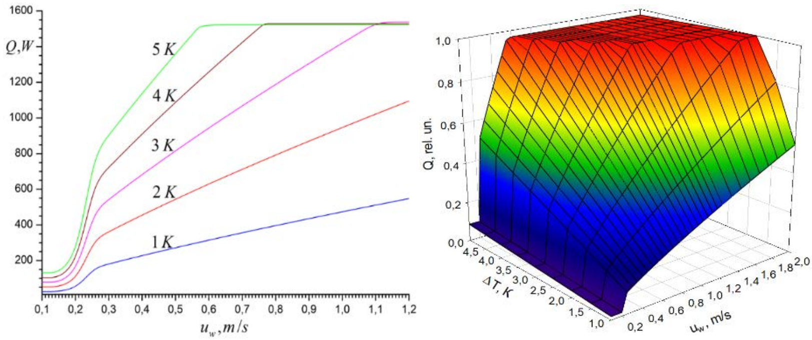
The generation of thermal energy from solar is of great interest among researchers. The electrical efficiency of solar cells is low, so most of the incident sunlight is lost in the form of heat. The temperature of the solar cell increases due to this heat, which leads to a decrease η of the photovoltaic system. Therefore, the removal of thermal energy arising and associated with the solar cell is necessary to achieve maximum efficiency. Creating combined photovoltaic–thermal system (PV/T), which converts incident radiation into electricity and heat at the same time, is gaining popularity. PV surface cooling with water as coolant, the system can be significantly improved [4]:

$$\eta = \eta_0 \lfloor 1 - \beta_0 (T_c - T_0) \rfloor, \tag{1}$$

where η_o – solar efficiency at standard test conditions (STC), β_o – temperature coefficient of efficiency (1/K), T_c and T_o – solar cell and coolant temperatures (K), respectively. The coolant in the PV/T system is then used to heat the water in the secondary circuit and its further use in domestic needs. Modern humanity are accustomed to the presence of hot water in the home and PV/T cooling system satisfies the need for electricity and hot water simultaneously.

Further research considering the disparate experimental results and described them as a private physical model not working in general. Therefore, previously we suggested the basis of a general model of heat exchange of the solar collector [1], which allows us to take into account all the necessary parameters, including parameters for the development of PV/T systems.

For values water flow rate u_w up to 0.2 m/s the regime of fluid motion is laminar and the amount of heat given off to the fluid is too small, and the coolant passes through the pipes practically without heating. With an increase water flow rate u_w, a sharp jump in the amount of heat of the transmitted liquid and, consequently, its heating is observed in the future. At water flow rate u_w of the order of 0.6 m/s amount of heat, which the water takes off reaches the maximum value, that is, the value of the effective energy that the system under consideration can provide with the given parameters for heating the water flow on 5 K in one pass through the pipes of this solar collector (Fig. 1).



a) b)

Fig. 1. The dependence of the amount of heat *Q*, which is diverted from the system when coolant flows through it at *T* = 293 K, by water flow rate u_w for different temperature gradients ΔT = 1,2,3,4,5 K

Thus, we can conclude that the obtained physical model $Q(u_w, \Delta T)$ is applicable to classical solutions of thermal collectors in a general form. However, under real operating conditions, depending on the various design features of the collector, the determination of optimal parameters should be carried out taking into account the design parameters. To test the model, laboratory studies of the collector were carried out, according to its classical connection diagram (Fig. 2).

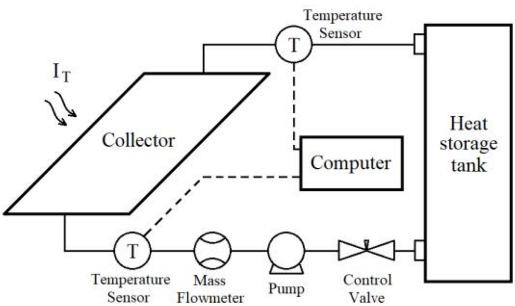


Fig. 2. Scheme of the measuring stand

Studies have allowed a comparison of simulation results with field values. A different temperature difference to match the simulation was achieved due to the forcedly changing light intensity. From the above dependences a fairly exact coincidence of the results of laboratory tests with the proposed model; during the tests, a characteristic small power take–off is also observed with a laminar flow at coolant flow rates up to 0.2 m/s, as well as reaching the maximum value at coolant velocities of more than 0.8 m/s and temperature gradient more 3-4 K, characteristic limit power withdrawn. The aforementioned confirms the correspondence of the model to the physical mechanism of the collector's operation and will allow further modeling of real systems, in particular PV/T systems, where there are additional thermal interfaces influencing the heat flows.

In practice, for a real system with a constant intensity of the light flux, the temperature gradient is directly related to the flow rate of the coolant through the design parameters of the collector. For example, the analytical dependence $\Delta T\,(u_w)$ or the laboratory test performed in the work has the following form:

$$\Delta T = \begin{cases} 4,3 \;\; at \;\; u_w < 0,2 \\ 5,31 \cdot e^{-1,05 u_w} \;\; at \;\; u_w \geq 0,2 \end{cases} \tag{2}$$

power taken by the collector on the flow rate of the coolant and the temperature gradient between the input and output.

Literarute:

1. Minakova K.A., Zaitsev R.V. Improving the Solar Collector Base Model for PVT System // Journal of nano- and electronic physics. – 2020. – Vol. 12. – No 4. – P. 04028-1 – 04028-5.