PARAMETRIC STUDY RESULTS OF SOLAR PANEL COOLING SYSTEM OF HYBRID POWER PLANT BASED ON PHOTO AND HYDRO ENERGY

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Abstract
Today, the development and use of hybrid energy devices that complement each other is an urgent task of our time. In the article, using the methods of analytical analysis and mathematical modeling, the design of a combined hybrid solar photohydroelectric installation with a counter-rotor hydraulic unit and the main parameters of its organizational parts are studied.

Keywords: nozzle, micro HPP, jet hydro turbine, hydropower, hybrid devices, counter rotor.

1. INTRODUCTION

It is known that at this time, in order to obtain continuous energy from renewable sources, active applied research is being conducted on the creation of hybrid energy plants such as: “Solar-photovoltaic-hydraulic” [1], “Solar-photovoltaic wind”, “Solar-wind” [2], "Solar-photovoltaic-thermal", and "Hydraulic-hydrogen"

Despite the above-mentioned varieties of hybrid energy devices, it is considered more promising for sunny Uzbekistan to develop energy plants using solar radiation and the potential of low-pressure hydraulic sources.

Although there are hydraulic turbines that operate at such low pressures, their efficiency is low. To effectively use such low pressures, it is advisable to use a counter-rotor hydraulic unit with a nozzle jet hydraulic turbine, which has high speed.

2. Materials and methods

In work [3,4], the increase in the coefficient of water energy utilization is carried out due to the fact that the water coming from the first guide vane onto the first turbine hits and causes it to rotate. Next, the water reflected from the working blades enters the second guide blade and leads to rotation of the second turbine. In these hydraulic units, water loses most of its energy during the transition from the guide device to the second impeller due to the appearance of upward pressure, which, as a result, reduces the efficiency of the upper impeller and at pressures of 2-10 m the complex does not give the desired result.

In [5], a jet hydraulic turbine with a nozzle was developed, the efficiency of which was recorded at 76% for 200 liters of water at a water pressure of 2 meters. The absolute speed of the water jet at the exit from the nozzle of this jet hydraulic turbine is 4 m/s and is not used. An active impeller with an additional coaxial shaft was installed on this hydraulic turbine and a counter-rotor hydraulic unit was developed [6]. Using a counter-rotor hydraulic unit, a hybrid system based on solar and hydraulic energy was developed, consisting of a counter-rotor hydraulic unit, a solar panel, an automatic control system, a solar panel cooling device and a consumer [7].

The possibility of using water heated as a result of cooling the solar panel with water in the developed hybrid system was studied on the basis of mathematical modeling. In this case, water was passed through the channels of the cooling chamber made of Aluminum and Polycarbonate materials at different speeds. The temperature change of solar panel surface and water in heat exchange was simulated for laminar flow in Comsol multiphysics 6.1 software environment. The water flow channels are rectangular in size 10x10 mm, and the results were obtained for the time interval from 10:00 to 20:00 at the values of the flow velocity of 0.002-0.004 mm/s.

The ASHRAE meteorological database dated 01.07.2021 for the city of Karshi was used in the modeling of the daily variation of solar radiation.

The following energy balance and solar radiation intensity equations, the Stefan-Boltzmann equation and functions were calculated that give the ambient temperature as a result of the sum of all solar radiation wavelengths, taking into account the geographical width of the selected area. . The absorption coefficient of solar radiation for wavelengths of 2.5 mm was taken to be 0.9, and for wavelengths longer than 2.5 mm - 0.8. The following equations were solved by the finite element method:

$$G_j = G_{m,j} + G_{amb,j} + G_{ext,j}\ ;\ J_i = \varepsilon_i e_b(T) FEP_i(T) + \rho_{dj} G_i\ ; \quad (1)$$

$$G_{ambj} = F_{ambj}\varepsilon_{amb} e_b(T_{amb}) FEP_j(T_{amb}); \quad (2)$$

$$e_b(T) = n^2 \sigma \mathrm{T}^4\ ;$$

$$\varepsilon_j + \rho_{d,j} = 1; \quad (3)$$

$$FEP_j(T) = \frac{15}{\pi^4}\int_{c2/(\lambda_{j-1}-T)}^{c_2/(\lambda_j T)} \frac{x^3}{1-e^x} dx; \quad (4)$$

$$G_{extj} = q_{s,j}\ ;$$

$$q_{r,net,j} = \varepsilon_j (G_j - e_b(T) FEP_j(T)); \quad (5)$$

where, e_b – surface grayness; ρ_{dj} – reflection coefficient; ε_i – surface emissivity; FEP_i – seasonal radiation conditions of the area, $G_{ext,j}$ – mutual surface radiation (W/m^2); G_i – sirtning nurlanish intensivligi (W/m^2); $G_{m,j}$ – o'zaro sirt nurlanishi (W/m^2); $G_{amb,j}$ – surface radiation intensity (W/m^2); F_{ambj} – ambient radiation; n – refractive index; J_i –PV surface radiation intensity (W/m^2); λ_j – thermal conductivity (W/m^2); ε_{amb} – ambient emissivity; c_2 – heat capacity (J/(kg·°C)); $q_{r,net,J}$ – net radiant heat flow (W/m^2).

3. RESULTS AND DISCUSSIONS

The temperature of the panel surface increases almost linearly along the length of the channel. It can be seen in Figures 1-2 that the temperature of the panel surface differs by 3 K when the water velocity in the aluminum and polycarbonate channels is the same. From the calculations and the available literature, it was found that the increase in solar panel efficiency due to this difference is 0.15-0.2%.

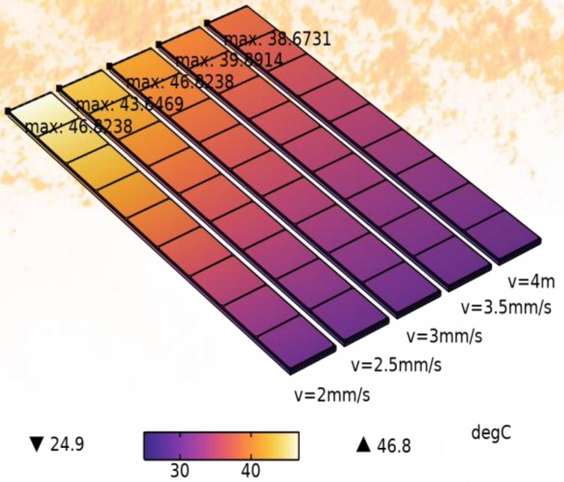

Fig. 1. Variation of solar panel surface temperature at different velocities of water flow in aluminum channel.

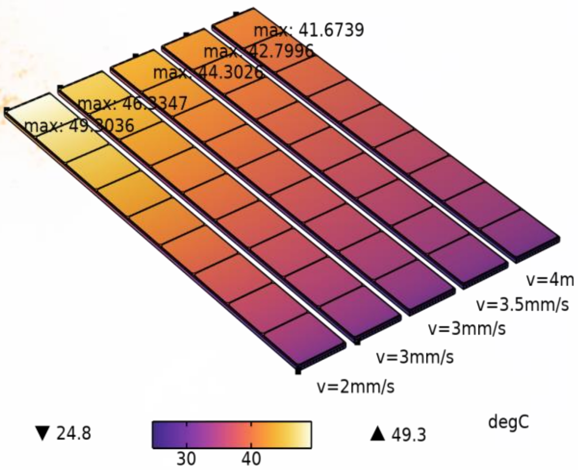

Fig. 2. Variation of solar panel surface temperature at different velocities of water flow in polycarbonate channel.

Figure 3-4 shows the change of water temperature along the length of the channel in the channels of the cooling system made of Aluminum and Polycarbonate material. In it, the temperature change of the water flow at a speed of 0.002mm/s is 470C in Aluminum and 42.50C in Polycarbonate. If the cooling system is used as a heat collector, the thermal efficiency is 67-70%.

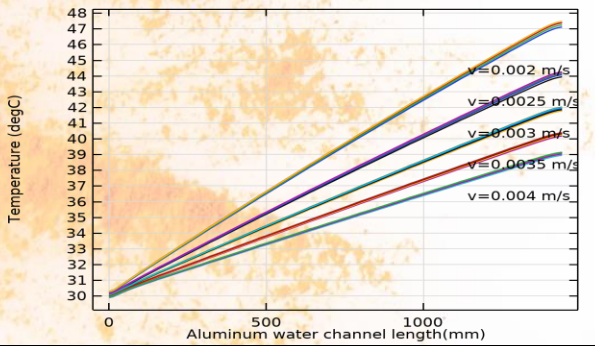

Fig. 3. Variation of water temperature in aluminum channels along the length of the channel.

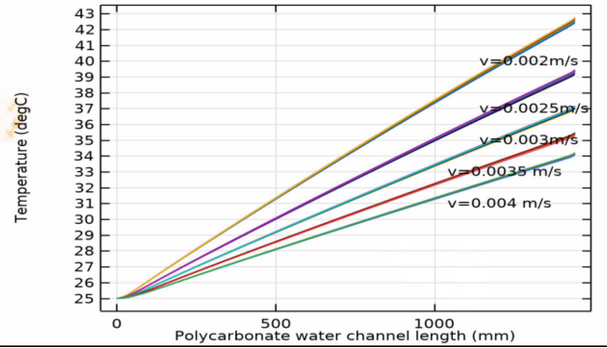

Fig. 4. Variation of water temperature in polycarbonate channels along the length of the channel.

4. CONCLUSION

Based on the above results, it is possible to use water to cool solar panels in hot climate regions. In this case, it is appropriate to use materials such as aluminum with a high heat transfer coefficient for the purpose of obtaining hot water. The temperature of the panel can be controlled by changing the number of solar cells placed along the length of the channel in the solar panel. This can be easily calculated from the temperature differences in the elements along the water flow.

It can be seen that the use of polycarbonate for water cooling and the use of hot water obtained as a result of cooling is economically more effective due to its light weight and low cost compared to the aluminum case.

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