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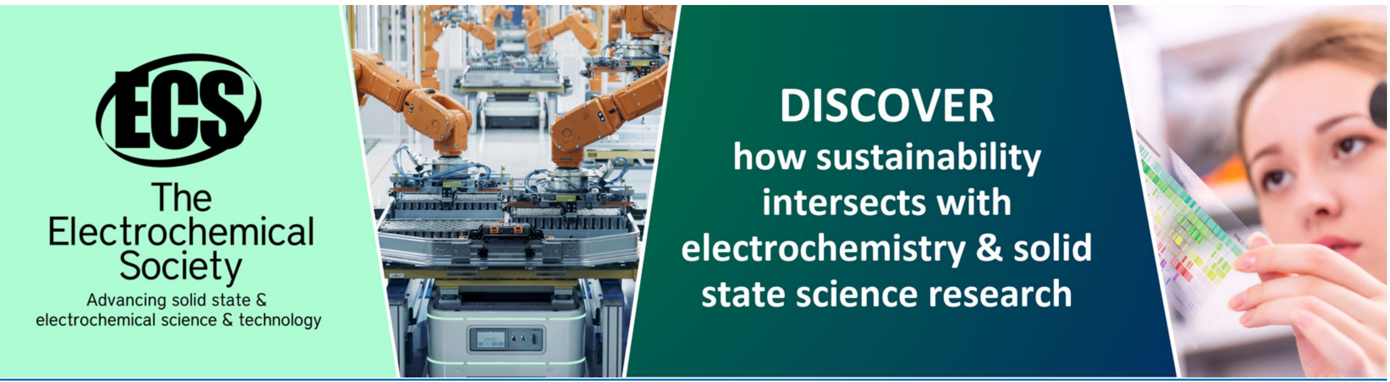

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The development and test of the PV concentrator system with electrical and thermal output

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Abstract. The article presents the control system of the PV concentrator system cooled by a heat sink. The installation is a hybrid system that generates heat and electrical energy from sunlight. The installation consists of a concentrator, photovoltaic modules and their cooling systems. It is necessary to control each part of the System to make it work effectively and get the highest amount of energy from it. The control system consists of subsystems, which control the sun tracking, cooling and the photovoltaic modules with accumulators.

1. Introduction

It is not urgently necessary to use everywhere an alternative energy systems in Russia, because Russia has a large amount and infrastructure for traditional energy resources: oil, coal, gas, hydro and nuclear. Therefore the authors see a prospect for alternative energy usage for small villages and private houses in distant and remote terrain (example, villages in a taiga, and houses of forestry officers in national parks).

The installation is a hybrid system that converts solar energy into electricity and heat. The sunlight falling silicon photovoltaic modules are converted into electricity. Production of heat occurs at the expense the cooling of photovoltaic modules.

The low concentrator is added to the system to increase energy production. The concentrator is a parabolic reflector.

Coming radiation flux falls on the concentrator and is reflected on the photovoltaic module. The plane of the solar module is located perpendicular to the flow of the reflected radiation. Direct light is not incident on the photovoltaic module.

For the effective operation work in the cold season it is possible to use the additional cover (transparent to the direct sun rays and impervious to reflected radiation within the system), which would protect the concentrator and photovoltaic modules from precipitation and reduce the outflow of heat into the environment.

To increase the power the tracking system can be used

2. Describe of system

The PV Concentration system shows on the figure 1.

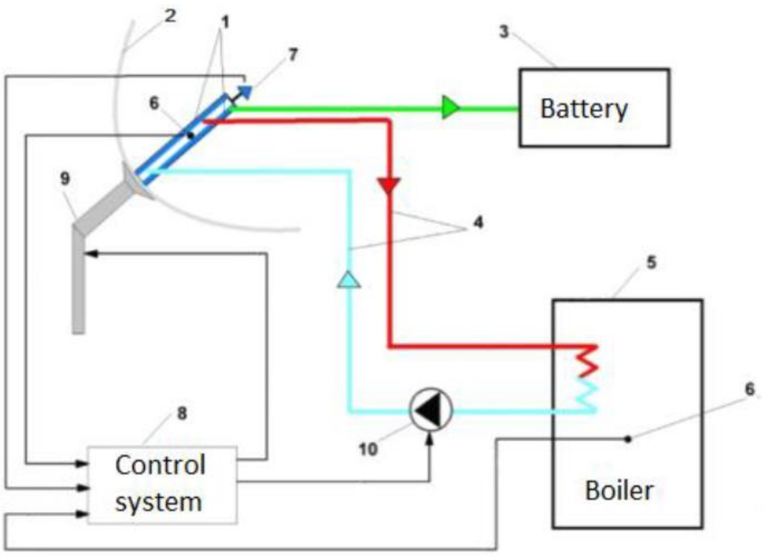

Figure 1. PV concentrator system with a heat sink: 1 is PV module, 2 is Concentrator, 3 is Accumulator Battery, 4 is Copper Tubes, 5 is Boiler, 6 is Temperature Sensors, 7 is Sensor of Tracking System, 8 is Control System, 9 is Rotating device, 10 is Pump.

The photovoltaic module consists of the two panels arranged in parallel to each other. . The area between the photovoltaic modules is filled with the liquid. The photovoltaic modules are cooled by the liquid flow at the same time the liquid is heating.

The concentrator consists of two parabolic reflecting surfaces. The concentrator can be made of any material that meets the economic and operational tasks, such as metal or plastic with a reflective coating.

The mathematical model takes into account the influence of the concentrator as a multiplier for solar radiation.

The cooling system is a typical thermal solar system. As the coolant can be applied any coolant with a high value of specific heat capacity. The Coolant is glycol, mineral oil or water. Water is pumped from the bottom and moved upward by the pump. A configuration of cooling system is coil.

The control system consists of the several subsystems that control individual units. Harmonization of all subsystems is based on a microcomputer BeagleBon. Power for BeagleBon will be provided directly by PV modules as well as other sensors. The microcomputer will form a database of system and save it. That will optimize the system.

Management of PV: Battery control will be based on the MPPT-controller.

The system orientation to the sun is realized on the basis of the active tracking system [1].

This system based on the photoelectric sensor. The Photoelectric sensor can be used in the tracking system. In our system we use three photovoltaic inverters A, B and C [2].

At the heart of the gauge: two obverse of elements A and B define the position of the Sun, the third rear element (C) accepts influence of scattered radiation. The signal of the received element C is subtracted from signals of the elements A and B. The device compares the signals and then generates a control signal to the motor (whether positive or negative), which directs the solar battery.

Control cooling system. The subsystem monitors the temperature of the coolant at the inlet and outlet of the solar panel [3, 4].

If the temperature difference at the inlet and outlet is less than the minimal value (approximately 5°), the pump power is decreased; if greater than the maximum value, it is increased (approximately 20°).

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3. The mathematical model

Numerical modeling of a PV concentrator system is designed with the help of MATLAB. MATLAB is a mathematical package of great potential. MATLAB works with matrix data and enables to create a custom calculated program. Simulink can be used together with the MATLAB and other toolboxes, as well as individually. Simulink implements the principle of visual programming: the user uses the library to construct the model, configures the solver and calculation step.

4. Field test

The field experiment was conducted. The experimental results have shown efficiency of the installation. A great influence on the electrical output has a minimal deviation from the direction of the sun. The prototype shows on the figure 2.

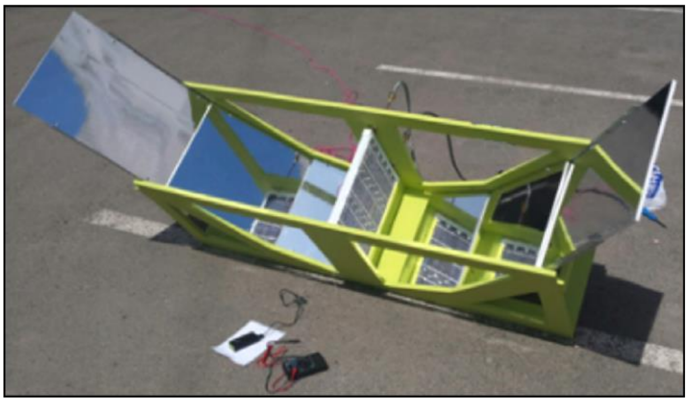
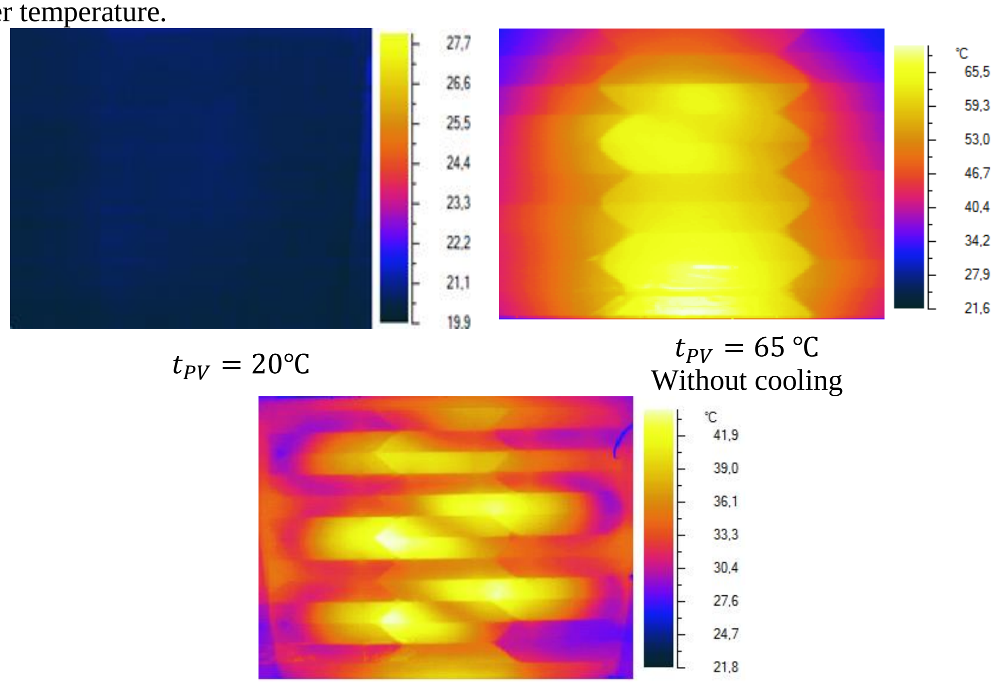


Figure 2. The prototype.

The experimental date shows on the figure 3. The data are the thermograms of the surface of PV and water temperature.



$t_{PV} = 20$°C

$t_{PV} = 65$ °C
Without cooling

$t_{PVmax} = 42$ °C
$t_{PV} = 32$ °C
With cooling

Figure 3. Experimental date.

When the temperature setting to 60 ° C, power generation decreased by 8.2% and at a temperature of 90 ° C decline in power output is 18%. The water temperature is increase 20°C.

5. Summary

The aim of the article is to provide the reader with some information about a design of hybrid system. Hybrid system represents a concentrator photovoltaic solar energy system with electrical and thermal output. This system allows more effective using of photovoltaic modules in region with some solar radiance. Low concentrator adds to a beam solar flow, and cooling system reduces a risk of overheating and premature degradation of photovoltaic modules. Removing heat will be used on water heating in boiler or heat accumulator.

The computer modeling is applied for design of some system elements. Parameters of coil pipe of cooling system are developed. The concentrator optimization is providing more uniformly illumination of photovoltaic module surface.

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