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TESTING OF DIFFERENT MATERIAL TYPE PHOTOELECTRIC BATTERY AND PHOTOTHERMAL BATTERIES COMPOSED

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In the world, over the years, the use of hydrocarbon resources is decreasing, and their place is being replaced by ecologically clean alternative and renewable energy sources. Therefore, the world is paying a lot of attention to improved devices based on photoelectric batteries. Conducting targeted scientific research in this direction is one of the urgent issues of the present time. This article presents the results of comparing the electrical parameters of photovoltaic and photothermal batteries based on them in natural conditions. The experiments were carried out on three traditional photoelectric batteries with different materials and constructions, as well as photothermal batteries made on their basis. All batteries are installed in a mobile structure, and two planes (reflectors) that reflect sunlight are installed along the long side of the device connecting the batteries. In the same conditions, the intensity of solar radiation is increased with the help of reflectors that return light to photoelectric and photothermal batteries. On the front surface of the photovoltaic batteries, a vertical (90°) fall of the sun's rays is provided. As a result, their electrical parameters changed to different values depending on the type of material and construction. Compared to traditional photoelectric batteries, photothermal batteries produced 1.3-1.4 times more electricity depending on the type of material. In the results of the experiment, data were obtained on the open circuit voltage, short circuit current and power of photoelectric and photothermal batteries in hot climate conditions. According to results, the high indicators in terms of electrical parameters are monocrystalline photoelectric and photothermal batteries based on them.

Keywords: monocrystal, polycrystal, photothermal, mobile device, heat collector, cellular polycarbonate, open circuit voltage, short circuit current.

Introduction

While increasing demand to the electric energy the many producing photovoltaic (PV) companies for the deserving place in the world technologies market are rivaling. However, in each concrete PV types there are advantages and drawbacks, which in the real working test regime of external climate conditions are revealing. The factors of the solar radiation, temperature, humidity, dust and air speed are the suchlike samples. As results we shell have the possibility for revealing the suitable PV which can work effective in the regional conditions after testing PV in the open environmental conditions. Unlike of the countries producing the electric energy based on PV Uzbekistan has the continental climate features that are the south regions have the wide temperature ranges, there are many fogs in winter, increasing the summer temperature up to 50 °C and the high dusting degree are such samples.

The different PV types have the different features to such climate conditions and that is influences to the working regime of the PV. In order to increase the efficiency of using conventional PV, several options of different types of heat collectors from different materials, black and colour metals, polymers [1-6], including cellular polycarbonate have been developed and studied [6]. The efficiency of eight PV in the Kuwait climate conditions in paper had been analyzed [7]. The selected PV in these experiments mono crystal (m-Si), poly crystal (p-Si), PV consisting thin mono crystal Si covered by thin amorphous Si layer (HIT), CdTe, copper indium gallium selenide (CIGS) and amorphous Si had been used. The collected data in period of 12 months had been observed systematically. As results showed that m-Si, p-Si and HIT batteries worked better than other ones in high radiation degrees at the same time, and at lower irradiance levels, it decreased rapidly. However, CIGS PV worked effectively in the low radiation degree. In order to select PV for the desert climate in Xelvan city of Egypt the parameters for mono, poly and amorphous PV in the different climate conditions in period of the several seasons had been measured and analyzed [8]. As experiments results showed, the amorphous Si PV has the maximal sensitivity in the visible part of the spectrum wave length (λ=522nm) and at the same time the maximal working range of the polycrystal Si PV corresponds to the infrared region (λ=922nm).

In the highest solar energy radiation of Europe country, Turkey (Düzce region) the experiments with PV had been carried out too [9]. There experiments in period of total year working regime of PV in the external climate conditions had been lasted. In these experiments monocrystal, polycrystal and amorphous Si had been used. As the experimental results showed the working efficiency for the amorphous, polycrystal and monocrystal Si PV were 4.79%, 11.36% and 13.26%, correspondingly.

The estimations of the working regime of the PV system connected to circuit having power 5.94 kilowatts on the roof of Safi practical sciences school of Morocco (NSASS) on the heat semi dry climate conditions had been carried out [10]. These investigations from June 2018 up to May 2019 had been carried out in which the yearly measuring data collected from batteries based on Si mono crystal, poly crystal and amorphous PV had been analyzed. As results showed that for this region the best battery is the based m-Si PV. The measurements with PV as polycrystal and monocrystal, Cu-In-Ga-Se, Cd-Te and Cu-In-Se batteries both in snow winter and heat summer days had been carried out [11]. It had been revealed in these experiments that the poly crystal PV has the best working regime, as the thinnest film PV was CIGS and CdTe PV has the stable effectiveness. In paper [12] the investigations with the heat and electric characteristics using PV and PVT in the Cameroun climate conditions had been carried out. In these experiments the mono crystal PV and PVT produced by "Trina Solar" and "Felicity Solar" companies had been compared between themselves. As the investigations results showed the PVT of "Trina Solar" company, having maximal power of 305W, produces the average daily energy to 42W (12.3%) more than ones usual battery. At the same time the "Felicity Solar" company PVT, having maximal power of 250W, has the average daily energy to 26.5W (11.1%) more than its usual variant. It should be noted that in climate conditions of Morocco PVT with power 200W constructed by "Solarex MSX-240" company using polycrystal Si collector that based on the water and usual PV electric parameters had been investigated and compared [13]. The heat and electric parameters of the module for six climate zones with the different climate conditions had been measured. In these zones in order to estimation working PVT, it with usual PV in the identical climate conditions the production of energy for month and year had been compared. As results showed that almost in all climate conditions PVT is able produce the energy for month more than PV. As to the reached year degrees of PVT energy, it varied from 15.5% up to 19% in dependence of the climate zones. In paper [14] results of studying PVT parameters when solar radiation intensity is controlling by attracting plates had been presented. It has been revealed there the electric energy production in the south regions is 1.5-1.6 times more than others and in winter period this battery is able obtain the heat water with temperature higher than 50 ^{o}C.

The investigations for the warm and humidity tropical climate zone in Ghana had been carried out [15] too. The main aim of these investigations was comparison of electric energy production with both PVT and usual PV in the open environment conditions. For this purpose the experimental equipment consisting the monocrystal PVT collector that water based and usual monocrystal PV had been installed to the roof of "Kvame Nkrumah" science and technology University of Kumasi in 2019. As results showed the temperature of the PVT having the active cooling system had been decreased essentially and the electrical efficiency of the PV had been increased to 9%. The electric efficiency of the usual PV in 11.00 o'clock was 15.8% and at the same time for the cooled PVT its value was 18%. The electrical energy growing for the total solar day with the active cooling system was 9%, at the same time the power for the without cooled module was 185W and for cooled one equaled to 211W.

As to our investigations in which unlike mentioned above equipment there are the several distinctions:

- the types and power of the selected PV for PVT;
- the collectors constructed on the parallel channel polycarbonate;
- the collector channels have a rectangle shape;
- there are attracting solar radiation plates on the frontal side;
- there are turning on two axes abutting construction;
- the device is mobile.

These factors of the PVT are providing the concrete advantages in comparison of mentioned above alternative batteries. In order to compare the devices parameters in the present paper we present the last measurement results obtained for the PV and PVT. The last years in collaboration with scientists of physical-technical institute by "Solar Physics" scientific production union in order to increase the PV efficiency in the warm climate conditions we have installed to the back side the heat collectors (HC) and attracting plates (reflectors) that is one has constructed the mobile photovoltaic device for testing PV. In the base structure of the device, six of the three types of PVs with a power of 50 W directed at the sun are installed at the same angle. The positions of three PV and three PVT on the year seasons dependence to the optimal directing angle with concrete instruments can be controlled. To the sides of construction installed three usual PV and PVT we have fixed two modernized reflectors.

We have two main purposes from these experiments. The first, revealing PV type with 50W power and having high working efficiency in the warm climate conditions when the solar radiation intensity is growing by reflectors. The second, observation the different PV based PVT electric efficiency variations on the cooling process in the same conditions and comparison them with usual PV. In the experiments we have obtained the results for the electric parameters variations of the special processed polycrystal, monocrystal PV and PVT back side which has white and black colors.

1. Materials and methods

Scientific research was carried out using PVs with the help of a multifunctional mobile photoelectric device (MMPD) mounted on a two-axle trailer. The prop size is 1300x800 mm and able raise up to 700 kilograms. The number of each installed solar elements (SE) are 36, the power equals 50W, used Si differs on the type and color of the backside. Unlike from the earlier developed devices in our one there are two modernized reflectors attracting the solar light on the long side of connecting PV and PVT device. Value of the attracting coefficient for reflector surface $R \sim 0.5$ and the total area equals to PV total one. These reflectors except working time, that is, in night for protection of PV surface from dusts can be used (see, Figure 1). Movement of the MMPD from one place to other one manually or using mechanical adapter tractor can be realized. List of the consisting parts of the device on Table 1 has been presented. The adapted tractor construction allows us turn the PV around the horizontal or vertical axis manually too.

Fig.1. Measurement of PV and PVT parameters in the natural conditions.

Table 1. List of the consisting parts of the photovoltaic device

No.	Battery type	Quantity	Type	Mechanical parameters	Electric parameters
1	PV	1	Polycrystal Poly-Si: 50W	The protected glass has textured surface (3 mm)	2.99 A, 21.6 V
2	PV	1	Monocrystal Au-FSM-50Bт	The protected glass has textured surface (3 mm)	2.92 A, 21.8 V
3	PV	1	Monocrystal PMS50-Si: 50W	The protected glass has textured surface (3 mm)	3.01 A, 21.5 V
4	PVT	1	Polycrystal Poly-Si: 50W	The protected glass has textured surface (3 mm)	2.99 A, 21.6 V
5	PVT	1	Monocrystal Au-FSM-50Bт	The protected glass has textured surface (3 mm)	2.92 A, 21.8 V
6	PVT	1	Monocrystal PMS50-Si: 50W	The protected glass has textured surface (3 mm)	3.01 A, 21.5 V

The PV electric parameters in the Tashkent climate conditions have been measured. There is possibility directing the PV and PVT to solar manually any time of the day. In order to provide direction of the incident beam perpendicularly to the PV frontal area operator directs PV to solar on each 15-20 minutes.

2. Results and discussion

The research in daily period of 9.00 a.m. up to 16.00 p.m. according to the regimes mentioned above have been carried out. The installed to MMPD PV electric parameters on 14 and 15 April, 2022 by air temperature 19-27°C and air speed 0.2-1.6 m/s have been measured. Figure 2 shows the intensity of solar radiation falling on the surface of PVs on this date depending on the time of day. The intensity of solar radiation was determined by measuring the short circuit current of the standard SE made on the basis of crystalline silicon.

The solar radiation intensity beginning from sunrise up to noon is growing and reaches its maximal value, after that up to sunset is decreasing. Dust and clouds in the atmosphere also cause a decrease in the intensity of light radiation. This situation influences to electric parameters of the PV. As we can see from Figure 2, at 11.00 a.m. the intensity is growing sharply because of the reflectors to an optimal angle have been installed. The dependence of solar radiation intensity on the time we divided to three parts. The first part begins from sunrise up to 11.00 a.m. in moment when the incident angle and intensity are increasing. The second part is the period when the solar radiation intensity on the PV area is growing sharply because of the reflectors to the optimal angles are installed. The finishing third part is the time when after noon the solar radiation intensity is decreasing. It should be noted in the measurements after reflectors to an optimal angle has been installed the solar radiation intensity has been increased for 1.3-1.5 times (see, Figure 2).

We studied the dependences of the open circuit voltage, solar radiation density, short circuit current and electric power on the time. The dependence of open circuit voltage on the time on Figure 3 has been presented. As we see from this Figure that in period from 9.00 a.m. up to 11.00 a.m. the open circuit voltage values have been decreased, namely for monocrystal to ~1.4V, polycrystal to ~1.8V, monocrystal with black color back surface ~2V. The differences of these values for PVT are higher than PV, namely for monocrystal ~1.65V, polycrystal ~2.4V, monocrystal with black color back surface ~2.65V. In this working regime we can see the PVT open circuit voltage is decreasing more than PV. This fact, in our opinion, can be explained that PVT is not able distribute collected heat directly to atmosphere because of to the PVT back surface collector is installed. This tendency up to water transferring via collectors is continuing. In the moments when reflectors begin working (from 11.00 a.m. up to 12.00 a.m.) the open circuit voltages values of usual PV for monocrystal to ~0.8V, polycrystal to ~0.85V, monocrystal with black color back surface ~0.9V are decreased accordingly. As to the PVT these values are for monocrystal to ~0.55V, polycrystal to ~0.9V, monocrystal with black color back surface ~1.1 V are decreased. This difference deals with the heating SE constructed with crystal Si, which is known with the even great differences of this parameter for having great power PV [8].

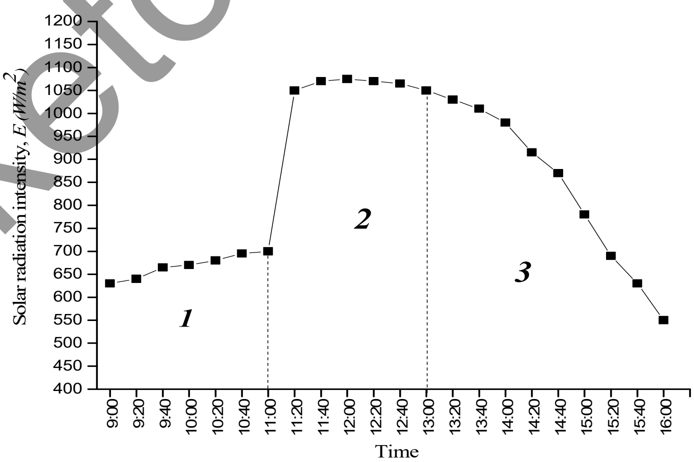
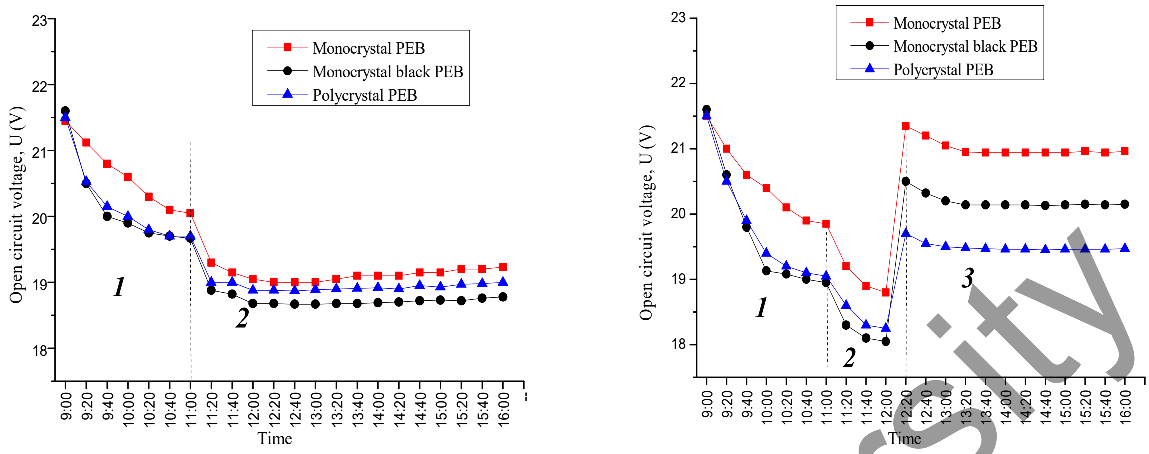


Fig.2. Time dependence of solar radiation intensity

In 12.00 o'clock, water with a temperature of 16-18°C was connected to the heat collector. Because of the temperature dropped on the back surface of PV the open circuit voltage on the PVT for monocrystal to ~2.55V, polycrystal to ~1.45 V, black color back surface monocrystal to ~2.45 V has been increased. In result this effect leads to growing the electric power. After that when solar noon (on 12.40 a.m.) finished the voltage has been decreased because of the solar radiation intensity changed in range of 0.2-0.35 V on dependence of panel types.



a) Simple PV b) Cooled PV (PVT)

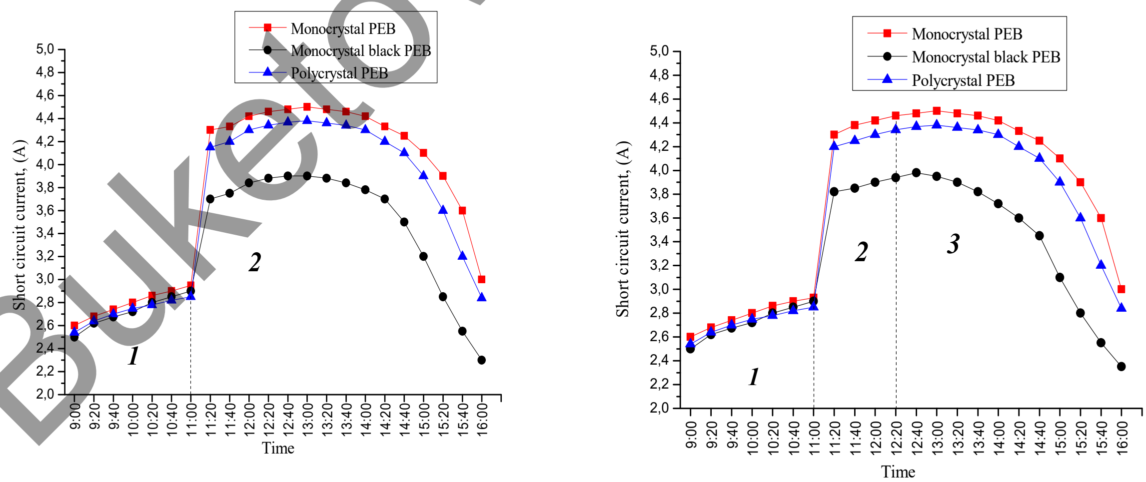
Fig.3. Time dependence of open circuit voltage of PV and PVT during the day.

The dependence of short circuit current on the time on Figure 4 has been presented. As seen from the comparative analysis of results for PV and PVT the short circuit current depends on the solar radiation intensity and panels types. Therefore, after that water opened to the collector in order to cooling the PV back area the future changes of the dependence of short circuit current on the time is defining with environment and atmosphere states.

The PVT electric power according this representation is defined:

$$P = FF \cdot I_{sc} U_{oc}$$

Here I_{sc} is the short circuit current, U_{oc} is the open circuit voltage, FF is the PV fill factor.

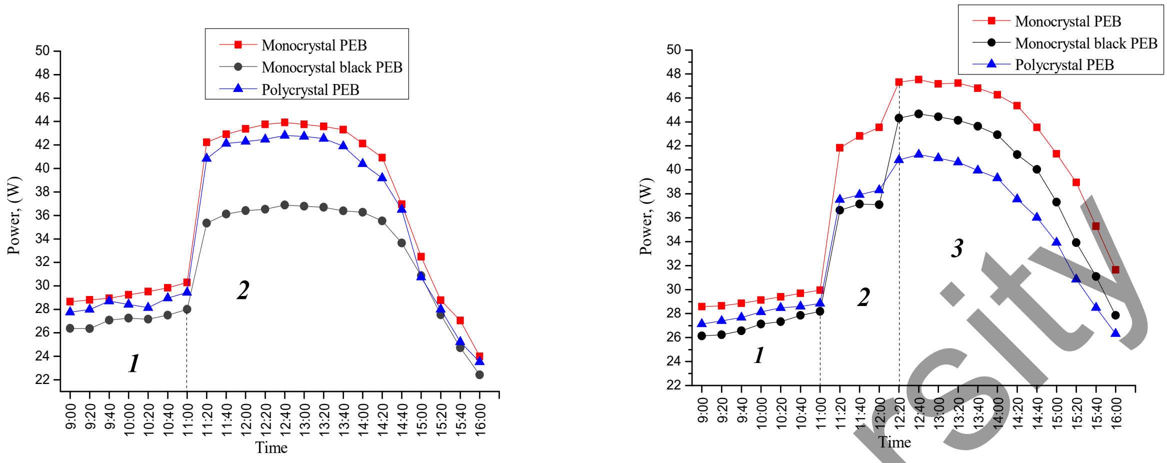


a) Simple PV b) Cooled PV (PVT)

Fig.4. The dependence of short circuit current of PV and PVT on the time.

In this case the PV fill factor is about 0.71-0.72. The dependence of the PV and PVT electric power on the time obtained using mentioned above data on Figure 5 has been presented. As Figures 2, 3 and 4 showed that the process of the dependence of electric power on the time deals with two factors, namely, the solar radiation intensity dropped to PV surface and open circuit voltage depend on the temperature. When PVT is working in second regime it leads to, the first, increasing electric power because of the forcing solar radiation and after, decreasing the open circuit voltage – a bit power stabilization.

When the sun passes noon then the power is decreasing on the solar radiation intensity. As we see from the Figure 5 the electric power maximal values in the usual PV regime equaled to: for monocrystal ~43 watts, polycrystal ~42 watts, black color back surface monocrystal ~36W, and PVT in the cooled regime for monocrystal ~48W, polycrystal ~43W, black color back surface monocrystal ~45W.



a) Simple PV b) Cooled PV (PVT)

Fig.5. The dependence of electrical power of PV and PVT.

Besides PVT produces additionally the heated water 6-10 litters/hour on temperature 55°C. The creation and use of a power plant based on PV is effective for areas with a shortage of centralized electricity supply and hot water.

Conclusion

Considering that different regions of the republic have unique climatic conditions the developed portable photoelectric device allows to determine in advance the efficiency of PVs planned to be used in this area before building large capacity photoelectric plants. Because of the MMPD is able to moving and controlling easily in small fields we can use one for revealing effective working regime of the different photovoltaic devices long away from the centralized energy sources of the different year seasons in our Republic. The proposing ourselves device can help for revealing energy losses in the different PV and decreasing possibility the losses after analyzing. The basic reasons of the energy losses are the temperature growing, atmosphere pollution and changing positions of PV relatively to sun. This device and developed test method helps us optimize these processes. In experiments we used the polycarbonate collector with new type parallel channel for cooling PV.

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