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RESEARCH METHODS FOR PROTECTING THE SURFACE OF PHOTOVOLTAIC BATTERIES FROM POLLUTION

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Abstract: The paper considers the mechanisms of pollution and deposition on the surface of photovoltaic batteries in various conditions of the seasons and incidence angles from the degree of surface treatment of photovoltaic cells of the PVB and the size of the dust particles. Experimental results were obtained on the influence of the degree of pollution of the surface of the FEB from the time of day, and it is shown that closing the surface of the FEB at night before sunrise leads to a significant reduction in the surface pollution of photovoltaic batteries.

Keywords: FEB, PVB, batteries, photovoltaic.

Introduction. Central Asia is fenced off from cyclones and monsoons by mountain ranges. The air is characterized by great dryness, high temperature (up to +40 ° C and more) and strong dust. Deserts occupy a significant part of the territory of Kazakhstan, most of the territory of Uzbekistan and Turkmenistan. On the territory of Uzbekistan, the Kashkadarya region, the southeastern end of the Surkhandarya region, and the western part of the Ferghana region are most susceptible to wind erosion [1,2]. Wind erosion in an arid climate is the main reason for the high dust content of atmospheric air. The centers of the removal of dust and salts on the territory of the Republic are the dried part of the bottom of the Aral Sea, the surface of saline dump lakes and salt marshes [3]. Over the past years, at almost all observation points in Uzbekistan, a significant increase in the density of precipitation has occurred. In the summer, sand and dust drills occur in the central and southwestern regions of the republic. Under the influence of wind, a saline soil flow settles on the surface of a photovoltaic battery (FEB), forming a thin layer, the thickness of which increases over time.

Researchers from the Indian Institute of Technology Gandinagar (IITGN), University of Wisconsin in Madison, Duke University scientists have found that the accumulation of pollution really affects the final output of solar energy. They measured the reduction in energy from IITGN solar panels. Each time the panels were cleaned every few weeks, the researchers noted a 50 percent increase in efficiency. China, India and the Arabian Peninsula are the most “dusty” in the world. Even if their panels are cleaned monthly, they can still lose 17 to 25 percent of solar energy production. And if cleaning occurs every two months, the losses are 25 or even 35 percent [4].

In all works on the use of photovoltaic installations (PMTs) in a dry, hot climate, little attention is paid to such an environmental parameter as air dust. It has been established that the main reason for the decrease in power output for the southern and steppe regions of the republic is, along with the influence of high temperature, also pollution of the surface of the photovoltaic cell, the degree of which depends on the environment [5-6]. As protection against atmospheric influences on the front side of the FEB, tempered glass with a polished or corrugated surface with a

thickness of 4-6 mm is used. The fixation of contaminants in the form of a dust particle on the surface of the FEB depends on the degree of processing of the glass surface, on the speed and direction of the wind, and the value of atmospheric humidity. So, as the listed conditions for the regions of Uzbekistan vary significantly, the degree of dust and their impact on the parameters of the FEB will also be different. Thus, a certain correlation should be observed between the influence of the degree of contamination of the surface of the FEB and the conditions of rural regions of the republic.

From the point of view of the design features of the FEB, the fixing of contaminants in the form of a dust particle depends on the angle of incidence of the particles on the surface of the flat glass of the battery. With a relief surface of the glass, the fixing of particles depends on the shape of the relief. It has been established that when the FEB is in a vertical position to the horizon, surface contamination will be minimal, since at an angle of incidence of particles that are close to zero, contaminants will not be likely to adhere to the glass surface. Deviation of the position of the FEB from the vertical leads to the appearance of dust on the surface of the FEB, first in places with defects, for example, on scratches. From the conducted experiments in the photomultiplier, located by deviations from the vertical by 7-10 ° C for 20-40 days, the influence of dust on the short-circuit current leads to a decrease in the fabric of 3-5%. An increase in the deviation of the angle of incidence from the vertical position of the FEB leads to an increase in the fixation of dust particles on the surface of the photovoltaic battery [5-6].

It was previously established that in rural areas of Uzbekistan in winter and early spring, the coefficient of performance (COP) is reduced by 8-15%, because the concentration of dust in the air is negligible and the surface of the FEB is cleaned by rain and snow [3]. Dust concentration increases sharply in the second half of May and does not decrease until the end of November. In Tashkent (geographic latitude is ~ 400), the decrease in the parameters of the FEB oriented by the latitude of the area per month is 25-35%. Moreover, the maximum values are observed in the September-October months (up to 40%), and the minimum pollution values are December-January months (up to 15%) .The reason for the increase in dust concentration in the air in the summer and autumn months is not only constantly blowing winds from the Aral Sea and saline lakes, but also agricultural work that begins in spring and ends in late autumn. During this period of time, the surface of the FEB should be cleaned more often than in late autumn or winter. Long-term observations are required to make final forecasts and give practical recommendations. Therefore, the results obtained should be considered as preliminary. At angles of deviation from the vertical of more than 450, a decrease in the effect of pollution on the parameters of photovoltaic batteries is observed.

With a horizontal arrangement of the FEB, the number of particles that remain on the surface will be maximum, almost all particles are fixed. In addition, in this case, the degradation of the surface of the glass (corrosion of the glass) occurs with time when atmospheric precipitation interacts with the glass. Corrosion of glass is a chemical leaching reaction [7], from the surface layer of Na + ions and hydroxyl groups (OH) -. The destruction of the surface extends to a depth of several micrometers and the surface becomes dull. The thickness of the corrosion layer depends on the composition of the glass and the physical properties of the surface: roughness, mechanical stress, damage (cracks, scratches), etc. Sections of glass subjected to corrosion have properties different from the bulk of the glass: a lower refractive index and coefficient of thermal expansion. The glass surface is well wetted with water, i.e. it is hydrophilic. The water film remains on the surface for a long time, even if the glass is installed vertically. After the water has dried, traces remain, and the surface of the glass, dried in air, is always contaminated. This type of pollution is called wet pollution [8]. In the absence of wetting with water, foreign substances from the environment usually settle evenly on the outer surfaces of the glass. This pollution is called dry pollution.

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In the conditions of Uzbekistan, when each piece of land must be used for the benefit of the national economy, there is a need to place FES in the territories of unsuitable or unsuitable for economic activities. In the case of rural areas, this is uncultivated land for one reason or another, in most cases due to lack of water. In this regard, there should be a need to find ways to reduce the surface contamination of photovoltaic modules, without any additional processing or coating that shades the surface.

Dust particles in the atmosphere have a wide range of sizes, since they include particles consisting of several molecules (clusters) having a diameter of the order of 1 nm and a diameter of several tens of microns. The sedimentation rate of various particles depends on their size [8]:

- large particles - more than 100 microns, sedimentation rates> 0.5 m / s, quickly fall;
- medium particles - from 1 to 100 microns, sedimentation velocity> 0.2 m / s, slowly settle;
- small particles - less than 1 micron, slowly fall, in a calm atmosphere, the process can take from days to years to settle. In a disturbed atmosphere, they can never settle, they can be washed with water or rain.

The authors of [9–10] studied the dependence of the air flow rate that cleans the surface of the FEB on the distance to the surface of the FEB. It is shown that to remove large particles with a small electric charge, a lower air flow rate is required. The main pollution factor for the surface of the FEB is particles with a small radius of the cross section.

We conducted a study of the degree of contamination of the surface of the FEB from the time of day. We proceeded from the position that the arid climate corresponding to the conditions of Tashkent, when the temperature of night and day in the summer - autumn season, differs almost 2 times. Assuming that practically the weight range of particles with different sizes in the daytime is in motion due to the absorption of solar radiation and wind, it is assumed that dust deposition mainly occurs at night. To verify this assumption, two PV modules made of crystalline silicon-based solar cells were selected that have the same values of short circuit current and open circuit voltage within 1%. The experiment was conducted in an open area in the conditions of Termez, the choice is justified by the fact that the region is extremely polluted [1.11], and there are no large plants that emit exhaust gaseous substances, unlike Tashkent. In fig. 1 shows photos of the FEB.

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Fig. 1 Photovoltaic batteries selected for the experiment: 1- FEB with a closed surface, 2 - FEB with an open surface.

Photovoltaic batteries were placed horizontally to ensure maximum pollution. The second FEB was all the time with an open surface during the time of day. The first FEB, unlike the second, was in the daytime with a closed surface. Then, from 8 p.m. until sunrise (6 a.m.), the surface of the FEB was open. The measurements of the parameters of the FEB were carried out daily, when the Sun reached the Zenith point. In this case, the amount of solar radiation incident on the surface of the FEB in a clear sky practically coincides and the measurement errors are minimal. The following parameters were measured: open circuit voltage, short circuit current, solar radiation density, temperature and air humidity, wind speed. The measurements were carried out on sunny days when changes in wind speed and air humidity were minimal. In fig. Figures 2 and 3 show the results of the study for August and September 2019, the relative values of the short-circuit current for the days of the month of August and September for two PVs. As can be seen from Fig. 2 for the month of August, the dependence of the degree of pollution on the number of days is saturating with increasing thickness

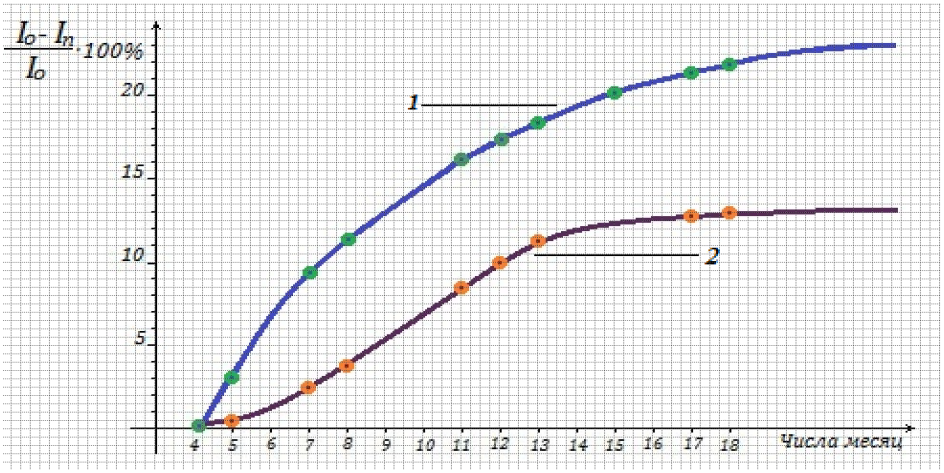

Fig. 2. The dependence of the degree of surface contamination in the month of August 2019 1- FEB with an open surface. 2 - FEB with an open surface only at night.

pollution. In addition, there is also an increase in the difference in the two graphs, starting from August 12, which is explained by a change (decrease) in the difference between night and day temperatures. In general, during studies for an open-surface FEB, the degree of contamination is ~ 21%, and for an open-surface FEB only at night, ~ 14%.

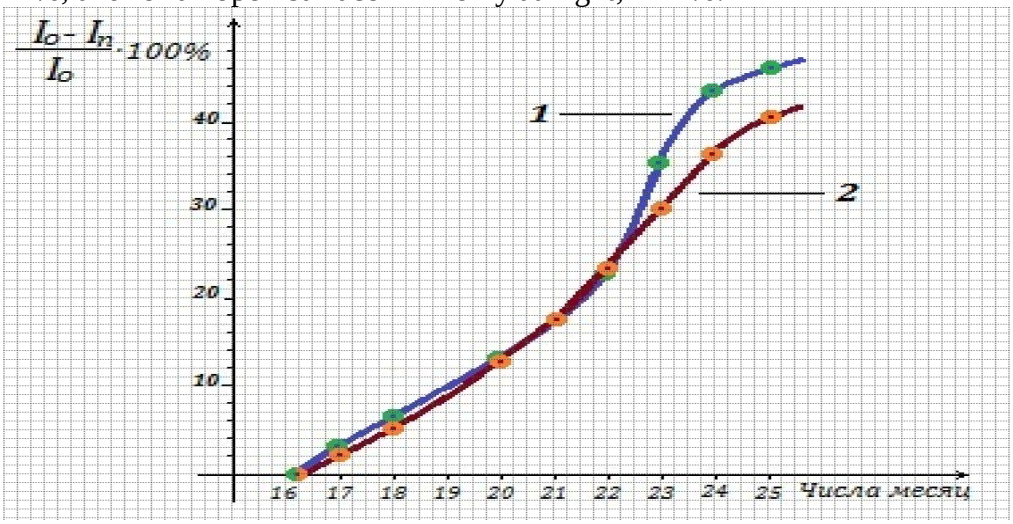

Fig. 3. The dependence of the degree of surface contamination in the month of September 2019. 1- FEB with an open surface. 2 - FEB with an open surface only at night.

Figure 3 shows the results of studies of the degree of pollution of the surface of the FEB for September 2019. In this case, the measurements were carried out without taking into account changes in wind speed. The difference in the degree of surface contamination for the two cases of the arrangement of the FEB before September 22 practically coincides. Further, the wind speed increased by 1.5-1.7 (from 10-11 meters / sec to 17-19 m sec) due to the appearance of wind from the south of the republic. The south wind operated from the evening of September 22 to the evening of September 23. An increase in wind speed led to an increase in the difference in the degree of precipitation of pollution up to 4% (see Fig. 3) .Taking into account the change in weather parameters in the following days (according to the weather forecast), it is assumed that the further difference will increase to 5-6%.

Conclusions. In general, we can conclude that closing the surface of the solar cell at night before sunrise leads to a significant reduction in surface contamination of photovoltaic batteries. In the future, thus, it is possible to reduce the effect of pollution on the parameters of photovoltaic plants based on crystalline silicon photovoltaic batteries [12]. Apparently, similar studies should be carried out in all regions of the republic for a more accurate forecast of a decrease in the effect of pollution on the parameters of photovoltaic batteries.

References

[1] https://ru.wikipedia.org/wiki/ 14.04.2015.
[2]www.krugosvet.ru/Earth_sciences/geografiya/PUSTINI.html
[3] Shardakova L.Yu., Kovalevskaya Yu.I., Vereshchagina N.G. “The effects of climate change: soil erosion and how to deal with it” (NIGMI Uzhydromet), “Adaptation to climate change: examples from Uzbekistan and Kazakhstan.” Tashkent 2012. P. 5-6.
[4] - https://habr.com/ru/post/370605
[5] M.N. Tursunov, V.G.Dyskin, I.A. Yuldashev Criterion for the contamination of the glass surface of a photovoltaic battery, Solar technology. 2015, No. 2, p. 82-84
[6].V.G. Dyskin, M.N. Tursunov, Abdullaev E.T. Mobile measuring probe for monitoring the degree of contamination of glass // Problems of energy and resource conservation, 2016, No. 1-2, p.
[7] M. Mazumder, M. N. Horenstein, J. W. Stark, P. Girouard, R. Sumner, B. Henderson, O. Sadder, I. Hidetaka, A. S. Biris, R. Sharma//IEEE transactions on industry applications. 2013. v. 49. № 4, P 1793 – 1800.
[8] A. Felts Amorphous and glassy inorganic solids. M: Mir, 1986. -556 P.
[9] V.F. Gremenyuk, M.S. Tivanov, V.B. Zalessky Solar cells based on semiconductor materials // Alternative Energy and Ecology. 2009, No 1 (69), P 59-123.
[10] M. Mani, R. Pillai//Renewable and Sustainable Energy Reviews. 2010., v. 14, P 3124–3131.
[11] M.N. Tursunov, V.G. Dyskin, I.A Yuldashev, Kh. Sabirov, Park Jeong Hwoan “A Creterion of Contamination of the Glass Surface of Photovoltaic Batteries”// Applied Solar Energy, 2015 Vol. 51.No.2, pp 163-164
[12] Proceedings of the International Conference “Fundamental and Applied Problems of Physics”, Section 3: Renewable energy sources and solar materials science, their applied aspects, Tashkent 2016, Tursunov MN, Dyskin VG, Sabirov H., Abdullaev ET, Komolov IM, Study of the influence of atmospheric effects on the parameters of photovoltaic batteries, p.122-124.