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Solar Panel Efficiency Enhancement Using Water Filter

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A B S T R A C T

Efficiency reduction of photovoltaic cells caused by increasing temperature, is an important issue that restricts their use in the middle of the day especially in summer. A new cost-effective method to increase the solar cell efficiency is presented to alleviate the problem. A combination of 40 fiberglass small cells are used in the form of a panel to perform the experimental tests. Water is used as absorbent of heat to reduce high temperature effects on the panel and the test results show that the panel efficiency is increased using the suggested method by amount of at least 16.8%. A 300W halogen lamp is regarded as the light source throughout the experiments.

Keywords: solar cell, efficiency, solar panel, photovoltaic cell

1. Introduction

Solar energy is a free and pure energy source available on earth surface and is become popular in recent years because of its advantages like ease of use and maintenance, environment friendly characteristics, and ability of installation in almost everywhere. [1,2]

Solar cells can convert solar energy from sun light to electric power. Usually an array of series/parallel cells are connected to each other to form an area to receive acceptable amount of energy. These modules can be used in many applications from large sizes to establish a photovoltaic solar power-station, to small sizes to design a pocket-size solar power bank.

The main problem of solar cells is their low efficiency. Many studies are done to characterize and propose methods to increase the efficiency of panels [3,4,5,6].

Solar panels are sensitive to temperature and their efficiency decreases as temperature goes high. During production, solar panels are tested mainly in 27 °C under normal test conditions, but they are used in the day light where the sunlight may cause the temperature go very upper. Of course, the more the sunlight, the more electric power produced, but also the less the efficiency because of the rising temperature.

Common methods to prevent efficiency drop is to install panels above the ground surface to make the air circulation better, or to use heat sinks behind the panel to cool it down [3], or to use temperature compensated panels which are more expensive. Here a new and cost-effective method is presented to alleviate the high temperature problem in the sunny days and increase the panel efficiency.

As is known, water is an absorber of heat, so the idea is to use water to absorb the thermal energy of the sunlight, while letting its light to radiate on the panel surface. A

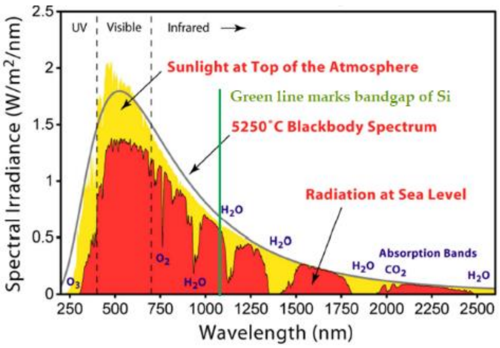

Figure 1. solar radiation spectrum

volume of water in front of the panel can be regarded as a thermodynamic filter.

Another issue of testing solar panel is the light source. Here a halogen lamp is used to simulate the solar light for all different test conditions.

Properties of the utilized lamp is described in the next section, and then the panel configuration and test results are brought. The experimental results of the panel with the proposed water filter are explained later which show the better efficiency in the presence of the filter.

2. Materials and Methods

2.1. Halogen lamp

Providing a light source for testing a photovoltaic cell is an important issue since the source must retain its illumination power throughout the experiments. For this reason, the sunlight itself is not suitable because of its variable characteristic throughout the day and also from day to day. However, the used artificial source must be as similar as possible to sunlight. First of all, the nature of the sunlight should be studied. Fig 1 shows the sunlight electromagnetic spectrum [4,9]. To test the panel a source with similar spectrum can be used.

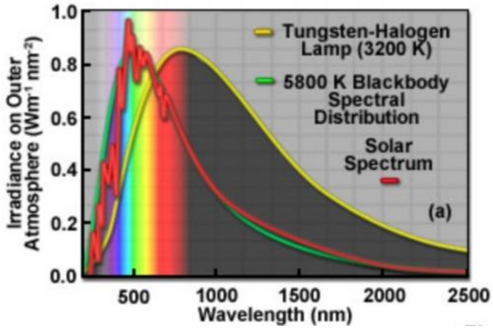

Figure 2. Tungsten Halogen lamp spectral distribution

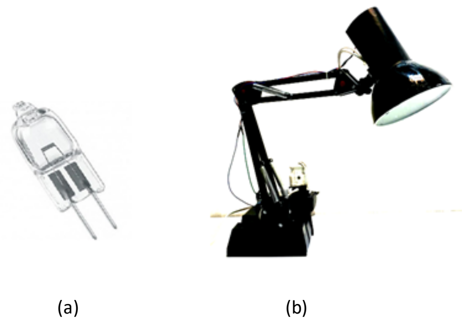

Figure 3. a) 300W OSRAM Halogen lamp, b) light source setup

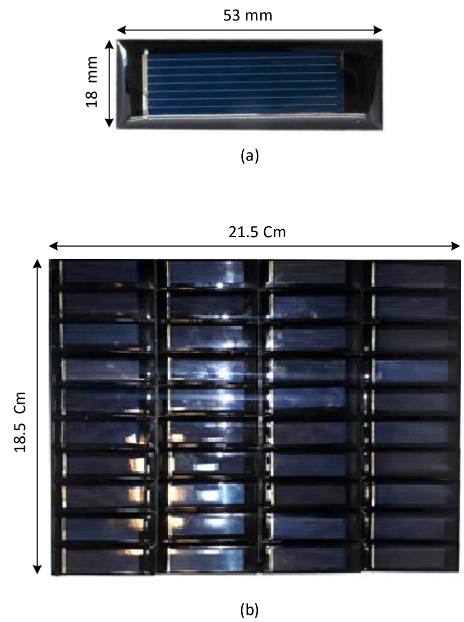

Figure 4. a) photovoltaic cell b) panel

There are several ways to simulate the sunlight indoor, such as using the Sun 2000 Solar Simulator

Class A machine. But there are also other inexpensive ways like using a halogen lamp [5], which its spectrum is shown in Fig 2, and as it can be seen it has an acceptable spectrum distribution coverage with sunlight [6].

In this research, a 300W halogen tungsten lamp (Fig. 3-a) is used to simulate the sunlight and all experimental tests are done with that. High power halogen lamps are very sensitive to fingerprints and easily burn out, so a robust light setup is needed like what is in the form of Fig. 3-b, to project the light to the panel.

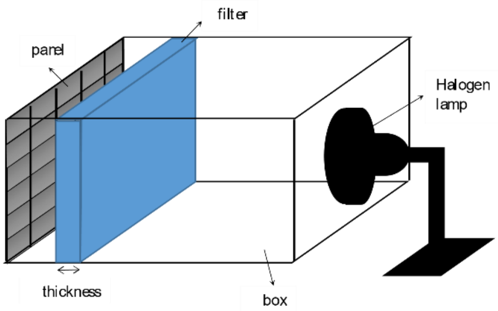

Figure 5. graphical view of the test setup

2.2. Panel configuration and test setup

Fig 4-a shows the photovoltaic cells used in this research which produce 0.5v, and 130mA electric energy. These cells are connected ten by ten in series to reach the average voltage of 5 v, and then four arrays of them are connected in parallel to form the panel shown in Fig 4-b, and produce average current of 520mA.

Panel size is 18.5×21.5 cm, so a cardboard box with the dimensions of 18×20×23 cm is used as test setup. In the box, the panel is placed close to one side and the halogen lamp is projected from a hole on the opposite side in the distance of 18 cm from the panel, while the whole box is covered to prevent any other light source effect.

To reduce the temperature effect, a water filter is used in the form of an aquarium with different thicknesses. The idea is to place the filter in front of the panel, and let the lamp to project to their combination (Fig 5). Of course, it should be mentioned that the water container is of glass, and since glass absorbs the UV light, using this filter will cancel out the UV spectrum as well.

Fig 5 depicts the graphical view of the test setup.

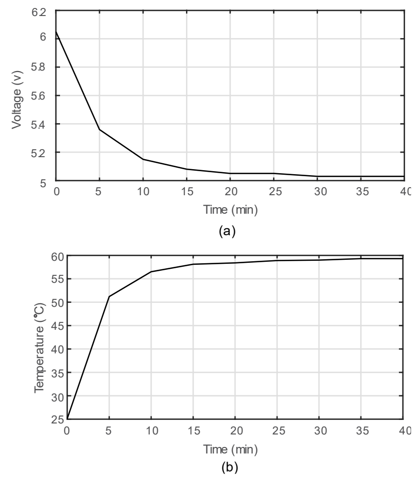

Figure 6. panel with no filter a) open loop voltage, b) surface temperature

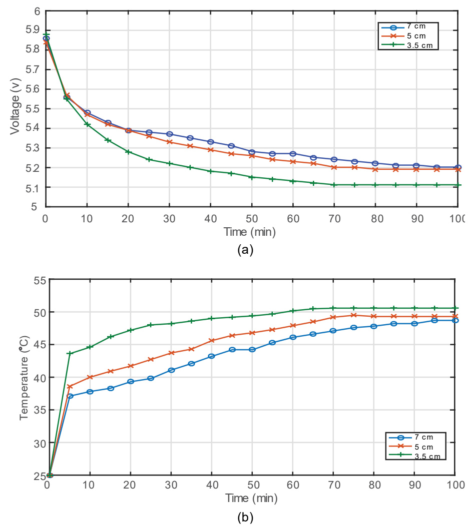

Figure 7. panel test with three different filters a) open loop voltage, b) surface temperature

3. Experimental Tests Results

The temperature of the panel surface is continuously measured using a digital thermometer with the accuracy of 0.1°C. Generated open circuit voltage of the panel along with its surface temperature is measured every 5 minutes as the results. All tests are done under this condition.

Fig 6, shows the open loop voltage, and the surface temperature of the panel under explained test conditions when there is no filter, which decreases from 6.05 to 5.03V as the temperature increases from 25 to 59.3°C and saturates after 35 minutes.

Different filter thicknesses are tested to see the effect of the water amount on the panel efficiency. Fig. 7 shows the result of experimental tests for 100 minutes and for 3 different filters. Increasing the filter thickness from 3.5cm to 5cm will improve the efficiency, but the improvement will stop for wider filters. So, the results of improvement are reported for a filter of 5cm thickness. For this filter the panel output open loop voltage drops from 5.84 to 5.19V, while temperature increases from 25-49.3°C, and the saturation time is about 80 minutes.

Figure 8 shows the temperature reduction of the panel surface in two cases: when there is no filter, and with a 5-Cm thickness filter. The temperature increment is reduced with the filter by an amount of 10°C, equal to 16.8%, considering the saturated condition for both tests. But if the saturation time of the panel with no filter is to be the basic factor, the improvement will be of amount 23%.

It should be mentioned that after finishing the panel test for one filter, a time space is considered to let the panel cool down to 25°C and be ready for the next one.

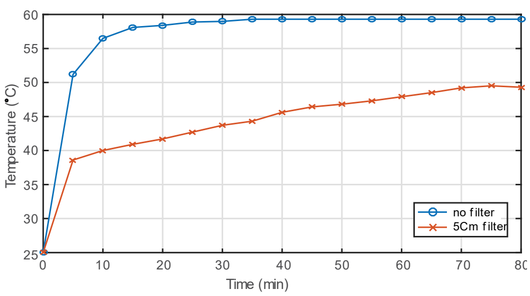

Figure 8. suggested filter effect on the panel surface temperature

4. Conclusions

A novel method is suggested for improving the efficiency of the solar panels. The idea is to add water filter in front of the panel which its effect is reduction of the heat on the panel surface. The reduction is about 16.8% comparing the saturated temperature values of the test without filter and the test with 5cm filter thickness, and it becomes higher up to 23% comparing the temperature values of the two tests after 40 minutes.

Water filter can be used to increase efficiency of panels with different sizes, circulation of the water inside the filter might provide more efficiency because of more heat reduction which can be studied in the future works.

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