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The effect of evaporative cooling on the efficiency of solar cell

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Abstract

There are many difficulties facing of using solar cell in generating electric Power, Such as high initial cost of system and low efficiency of generating of power due to high ambient temperature. Many studies was done to reduce the effecting of this difficulties, in this project we made a practical study to know the effect of cooling of solar cell by using a cold air produce from evaporative cooling system on the performance of the Solar cell. The results of experiments for many days was indicated an improvement in output power and efficiency of solar cell from 10% to 20% in Comparison of not using Cooling.

Introduction

The most important energy supplier of earth is the sun. It provides light and heat and thereby enables life on earth. In addition to that, the sun is the most environmentally friendly and continuous source of energy. Available solar energy is 1.5×10^{18} kWh per, which is more than 10000 times current energy

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demand of the world [1] Solar PV panels are, in particular, becoming widely used to produce electrical energy with almost negligible operating costs and less environmental impacts than the conventional power generation plants that use fossil fuels. their initial costs are still

higher than that of conventional energy power plants. However, the price of the PV panels is decreasing sharply and could be -in the seen future – competitive [2]. The efficiency of PV panels is generally low due to converting of major part of incident solar energy to heat. Furthermore, this low efficiency is affected by the increase of the operating temperature of PV panels due to the generated heat. It is reported in the literature that every 1 °C rise in operating temperature of PV panels results in a decrease of 0.5% in efficiency [2]. Important portion of the solar energy is converted into heat and lost by radiation and convection to the surrounding. Fig (1-1) shows a schematic Figure on the energy flows in a PV panel. Therefore, cooling PV panels using a suitable cooling method helps to partially tackle this problem.

Many methods were proposed to cool PV panels. These include cooling by natural air, forced air, water, phase change materials (PCM), thermoelectric cooling, transparent coating and evaporation cooling. In this work we used evaporative cooling because this method offer the following advantages:

(1)It is easy to implement.

(2)Its total cost is relatively low.

(3)Its an effective method in dry climates.

The aim of this work is to now the effect of this type of cooling on the performance of pv panel in the climate of Baghdad city.

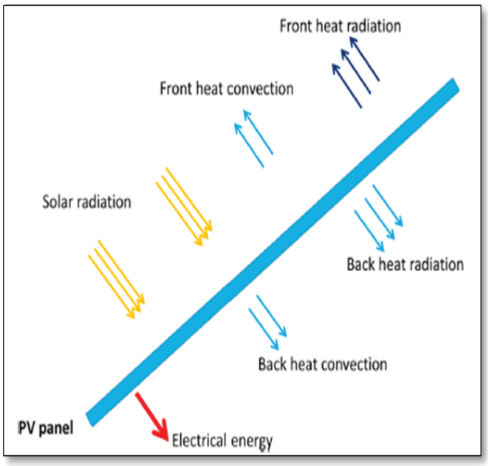


Fig. 1-1: Energy flow in PV panels

Theoretical Review

2-1 The output power of the solar cell is calculated by the equation:

P_{max} = Imax* Vmax *FF …………………(1)

The input power of solar cell is calculated by the equation:

Pin=E*A………..(2)

The efficiency of solar cell is calculated by the equation:

Efficiency =(Pmax / Pin) * 100%

Efficiency=(I_{max}*V_{max}*FF/E*A)*100% ………(3)

Where :

Pmax: maximum output power of solar cell in (Watt).

Imax: maximum current of solar cell in full load in (A).

E : the input solar radiation per m2.

A:the area of solar cell in m2.

FF:

Practical work

The apparatus of the study is shown in the fig (2) and composed from the following componants:

3-1-1 Solar Cell

specification:

Solar Module Type	Apm-p 110-12
Peak power	w 110
Maximum Power Voltage	V 17.2
Maximum Power Current	A 6.40
Open – Circuit Voltage	V 21.6
Short – Circuit Current	A 7.0
Weight	Kg 10.5
Dimension	mm 35*680*1300
Maximum System Voltage	700V
Operating Temperature	°-40c° To 90c
Wind Resistance	pa 2400

3-1-2 Cooling Pad

Specification:

*Type :cellulose pad.

*Dimension: (80*35*20) cm

3-1-3 Cooling Water Basin

*Specification:

*The basin made of galvanized steel.

*Dimension: (80*35*20) cm.

3-1-4 Water Pump

*Type : submersible

*Input power: 25 w , 220 v, 50HZ .

*Discharge: 1000L/H.

*Head: 1.8 m, H_2O.

3-1-5 Battery

*Model: - RM12-120

*Type: Rechargeable Valve Regulated

*Maximum Voltage: 12 V

*Maximum Current:120A.H.

3-1-6 *Solar Charge Controller (PWM)*

Solar Charge Controller is an electronic device that manages the power going into the battery bank from the solar array. It ensures that the deep cycle batteries are not overcharged during the day and that the power doesn't run back to the solar panels overnight and drain the batteries.

3-1-*8 Control Box:*

The control box contain the following components :

(a) Control switch, No.(6)

(b)Digital voltage and current meter.

(c)Tungsten lamp (10)watt,(12)V,No.(6).as a load on the cell.

3.1.9 *Axial flow fan:*

a-Axial fan, diameter (10) cm, (12) V DC, (0.18) A, NO. (5) as a load on the cell.

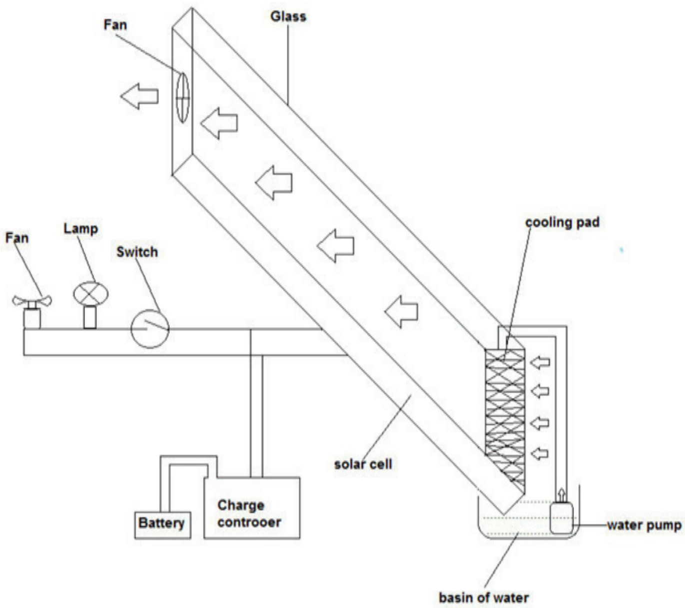
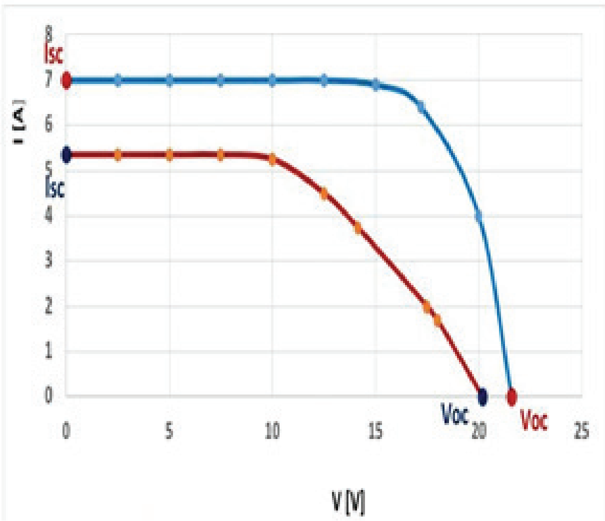


Fig. (2) Schematic drawing of apparatus.



Reading and Results:

4-2 Reading:

The Solar Cell was tested in two Condition Cooling and without cooling in the months April and May, table (4-1&4-2&4-3&4-4)

Show the performance of cell.

10/ April							
Time	Solar radiation energy (E) w/m2	Output power (W)no cooling	Output Power (W) Cooling	Efficiency no cooling (%)	Efficiency Cooling (%)	Δ power (%)	Δ η (%)
10:30	808	47.54736	56.13408	5.884574	6.947287	18.0593	18.0593
11:00	938.5	47.1528	55.4364	5.024273	5.906915	17.56757	17.56757
11:30	951.5	46.89792	55.56384	4.928841	5.839605	18.47826	18.47826
12:00	916.5	45.97776	53.11872	5.016668	5.795823	15.53134	15.53134
12:30	965.5	45.47664	54.87264	4.710165	5.683339	20.66116	20.66116
13:00	763.5	45.85248	51.9912	6.005564	6.809587	13.38798	13.38798

Table (4-1) performance of cell at 10 April

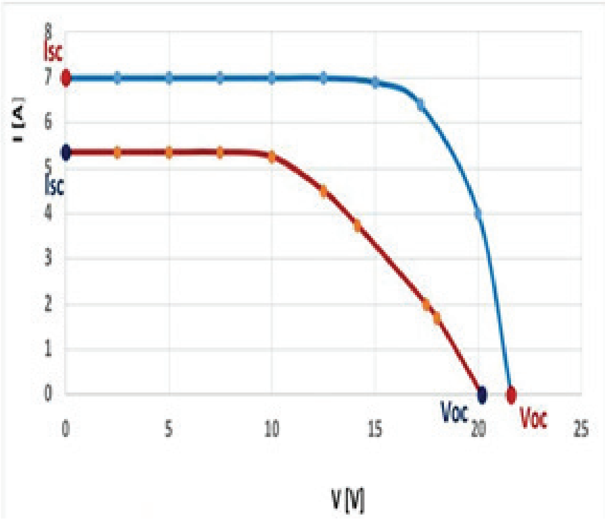


Fig (4-2) I-V curve performance of cell at 10 April

The current Isc decreased by 1.652 A due to the decrease in solar radiation by 236 w/m^2 .

The voltage decreased by 0.935 V as a result of an increase in temperature by 7 degrees Celsius

13/ April							
Time	Solar radiation (W/m2)	Output Power (W)no cooling	Output Power (W) Cooling	Efficiency (%) no cooling	Efficiency (%) cooling	Δ power (%)	Δ η (%)
9:30	937.5	22.63248	28.65888	2.414131	3.056947	26.62722	26.62722
10:00	688	38.47392	39.528	5.59214	5.745349	2.739726	2.739726
10:30	887.5	48.60504	54.7344	5.476624	6.167256	12.61054	12.61054
11:00	904	47.0448	55.08	5.204071	6.09292	17.07989	17.07989
11:30	907	46.5156	54.162	5.128512	5.971555	16.43836	16.43836
12:00	880.5	45.87264	52.71552	5.20984	5.986998	14.91713	14.91713
12:30	901.5	45.738	53.046	5.073544	5.884193	15.97796	15.97796
13:00	895	43.46496	45.99936	4.85642	5.139593	5.830904	5.830904

Table (4-2) performance of cell at 13 April

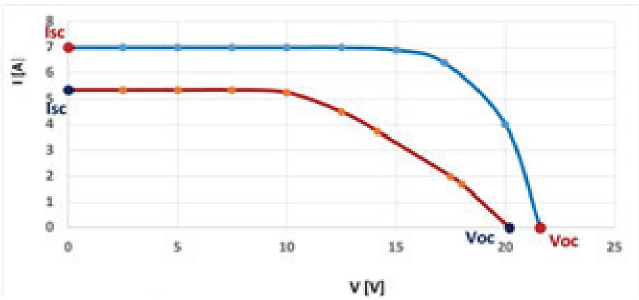


Fig (4-3) I-V curve performance of cell at 13 April

The current Isc decreased by 0.7 A due to the decrease in solar radiation by 99 w/m^2

The voltage decreased by 0.93 V as a result of an increase in temperature by 3 degrees Celsius

27/April							
Time	solar radiation E(W/m2)	Output Power (W)no cooling	Output Power (W) Cooling	Efficiency (%)no cooling	Efficiency(%) Cooling	Δ power (%)	Δη (%)
10:00	767.5	38.52576	41.9328	5.019643	5.463557	8.843537	8.843537
10:30	805	46.39392	50.23872	5.76322	6.240835	8.287293	8.28729
11:00	812.5	45.738	52.542	5.629292	6.466708	14.87603	14.8760
11:30	829	46.116	52.038	5.562847	6.277201	12.84153	12.8415
12:00	823.5	45.7272	58.8816	5.552787	7.150164	28.76712	28.7671
12:30	810	45.738	56.7	5.646667	7	23.96694	23.9669
13:00	836.5	46.12608	51.9552	5.514176	6.211022	12.63736	12.6373

Table (4-3) performance of cell at 27 April

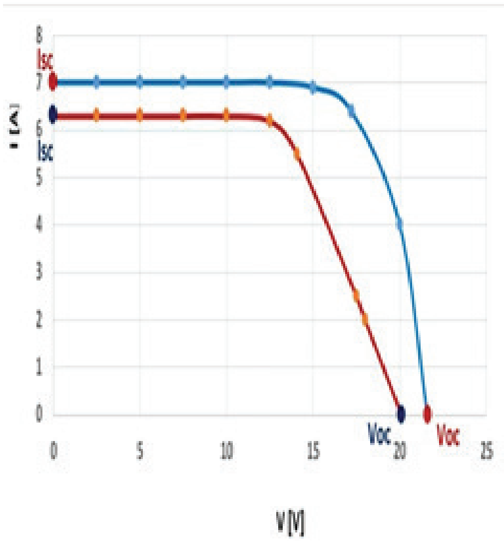


Fig (4-4) I-V carve performance of cell at 27 April

The current Isc decreased by 1.2 A due to the decrease in solar radiation by 146 w/m^2

The voltage decreased by 0.921 V as a result of an increase in temperature by 8 degrees Celsius

14/ May							
Time	solar radiation(W/m2)	Output Power (W)no cooling	Output Power (W) Cooling	Efficiency (%)no cooling	Efficiency (%) cooling	Δ power (%)	Δ η (%)
9:30	984.5	27.12528	31.18752	2.755234	3.167854	14.97585	14.97585
10:00	984	33.8256	44.85024	3.437561	4.557951	32.59259	32.59259
10:30	970.5	45.49464	47.0412	4.687753	4.84711	3.399433	3.399433
11:00	930.5	45.7524	49.23216	4.916969	5.290936	7.605634	7.605634
11:30	969.5	44.85888	47.28024	4.627012	4.876765	5.397727	5.397727
12:00	984.5	42.84	44.1	4.351447	4.479431	2.941176	2.941176
12:30	947.5	39.25152	40.7808	4.142641	4.304042	3.896104	3.896104
13:00	950.5	41.0112	42.2928	4.314698	4.449532	3.125	3.125

Table (4-4) performance of cell at 14 May

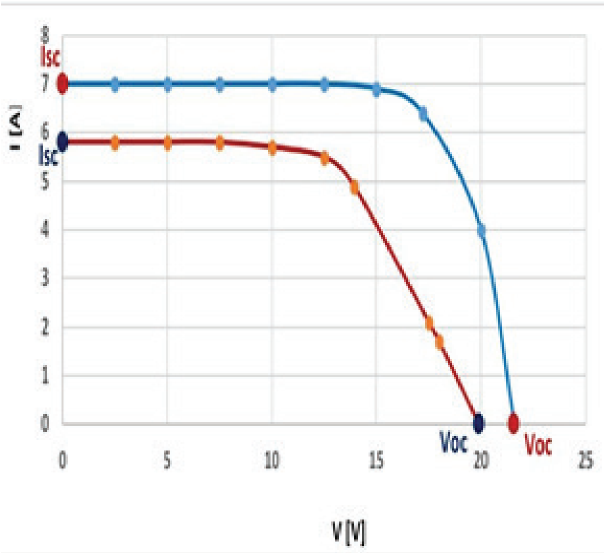


Fig (4-5) I-V carve performance of cell at 8 May

The current Isc decreased by 0.1 A due to the decrease in solar radiation by 16 w/m^2

The voltage decreased by 0.926 V as a result of an increase in temperature by 7 degrees Celsius

Results:

The following figures (4-6)&(4-7)&(4-8)&(4-9)&(4-10) shows the Relationship of output power and efficiency against time of Solar cell in two conditions, cooling and without Cooling.

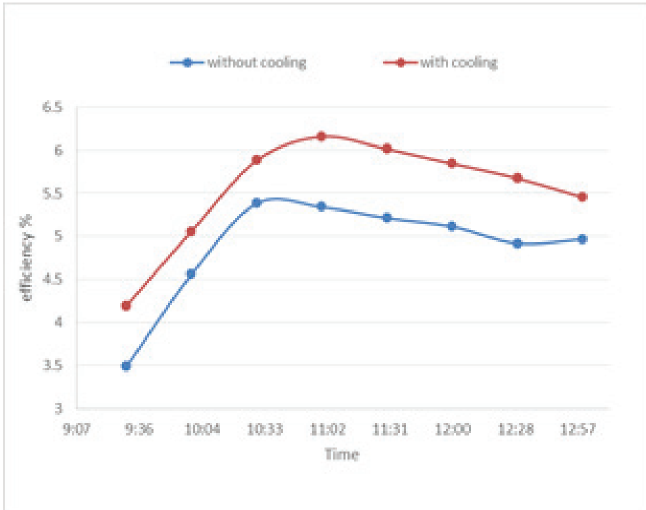


fig (4-6) Relationship between efficiency of PV panel and time

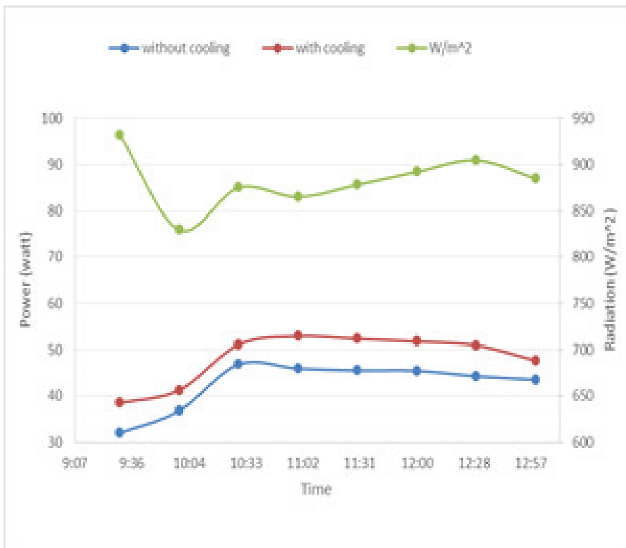


fig (4-7) Relationship between radiation, output power of PV panel and time

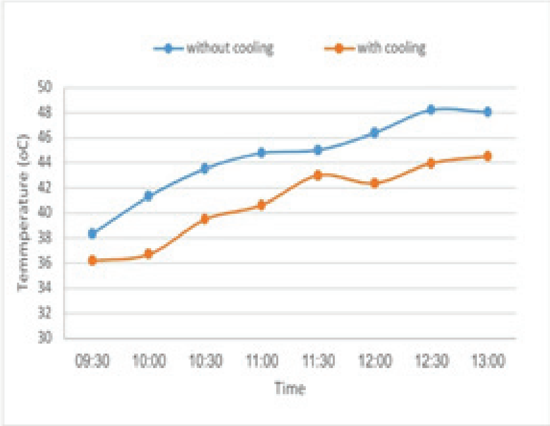


fig (4-8) Relationship between temperature of PV panel and time

fig (4-9) Relationship between the percentage of efficiency variation and time

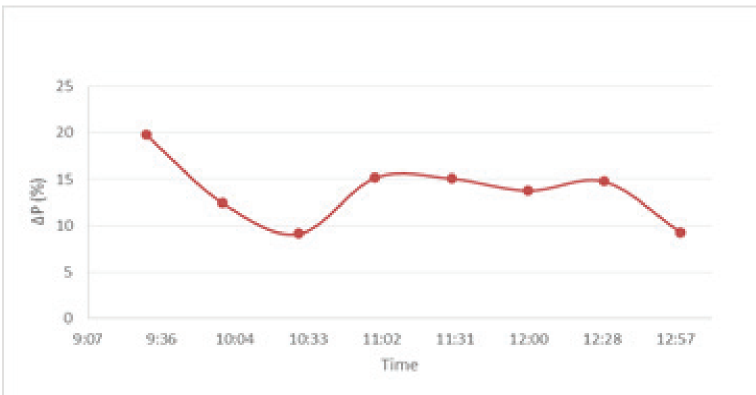


Fig (4-10) Relationship between the percentage of variation of output power and time

4-4 Discussions:

1. Fig (4-6) show the graphical relationship between The efficiency of pv panel and time in two conditions Cooling and without cooling, the Percentage of improvement Are from 10% to 20% for a short period from (6) April to (14) May, we believe these percentage is low because the Condition of weather is not stable and the sky was cloudy and dusty effecting on the intensity of Solar Radiation.

2. Fig (4-7) show the graphical relationship between the output Power of pv panel and time in two conditions cooling and without cooking, the Percentage of increasing of power are from 10% to 20% for the same period mentioned above and for the same previous reasons.

3. Fig (4-8) show the graphical relationship between the Temperature of pv-panel and time in two Condition Mentioned above, the temperature reduce from 2°c to 6°C. In general, also the temperature and relative humidity for this period are from 20°C,RH 20% and 34°C,RH 46%, so that The rate of water evaporation from cellulose pad was low and that is effecting on cooling process of air which used in cooling of p v-panel.

4. The glass plate covering the solar cell maybe was effected on the incident solar radiation, and Finally reducing the efficiency of the Cell.

5-1 Conclusions:

From this work we conclude the following: -

1. Evaporative Cooling of PV- panel improve the output power of p v-panel from 10% to 20%.

2. Evaporative cooling of PV- panel improve the efficiency of PV -panel from 10 %to 20%.

3. Evaporative cooling reduce the temperature difference of the PV -panel are from 20 C to 6 C .

5-2 Recommendations:

For future work we recommend the following:

1. Studying the Performance of solar cell using this method of Cooling in months June, July, august.

2. Using another Cooling method to cool the solar cell.

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