New Technique for Treatment of the dust accumulation from PV solar panels surface

Naseer. K. Kasim*, Abbas.J. Al-Wattar, Khansaa. K. Abbas****

[*]Ministry of Science and Technology, Baghdad, Iraq.
[**] Baghdad University, College of Science, Physics Department, Baghdad, Iraq.

Abstract

One of the most important problems facing the world today is the energy problem. The solution was in finding renewable energy sources such as solar energy. The solar energy applications in Iraq is facing many problems . One of the most important problems is the accumulation of dust on the solar panels surface which causes decreasing its performance sharply. In the present work, a new technique was presented by using two-axis solar tracking system to reduce the accumulated dust on the solar panel surface and compared it with the fixed solar panels which installed at tilt angles 30° and 45°. The results indicated that the maximum losses of the output power due to accumulation of dust on the fixed solar panels is about 31.4% and 23.1% respectively for 34 days period of accumulation(from 18-2-2010 to 25-3-2010), while the maximum losses of output power for the solar panel with two-axis tracking system is about 8.5% for the same period of accumulation.

Keywords
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تقنية جديدة لمعالجة تراكم الغبار من سطح الالواح الشمسية

[*] نصير كريم قاسم , [**] عباس جاسم الوتار , [**]خنساء خضر عباس
[*] وزارة العلوم والتكنولوجيا , [**] جامعة بغداد – كلية العلوم – قسم الفيزياء

مستخلص

واحدة من المشاكل التي تواجه العالم اليوم هي مشكلة الطاقة. والحل هو ايجاد مصادر الطاقة المتجددة مثل الطاقة الشمسية. ان تطبيقات الطاقة الشمسية في العراق تواجه العديد من المشاكل. احدى أهم هذه المشاكل هي تراكم الغبار على سطح الالواح الشمسية التي تسبب انخفاض أدائها بشكل حاد. في العمل الحالي , قدمت تقنية جديدة لتقليل مقدارالغبار المتراكم على سطح الالواح الشمسية باستخدام منظومة التتبع الشمسي بمحورين ومقارنتها مع تراكم الغبار على سطح الالواح الشمسية الثابتة التي تم نصبها بزوايا ميل (30 $^{\circ}$),(45 $^{\circ}$) مع الافق. حيث أشارت النتائج أقصى قيمة لخسائر القدرة الخارجة للالواح الشمسية المائلة بالزوايا (30 $^{\circ}$), (45 $^{\circ}$) وصلت لحوالي 31.4% و 23.1% على التوالي لمدة 34 يوم من التراكم, بينما وصلت لحوالي بالنسبة للوح الشمسي المتحرك باستخدام منظومة التتبع الشمسي بمحورين 8.5% لنفس مدة التراكم.

Introduction

The problem that facing the world during recent years in the field of the solar energy is settling of atmospheric dust onto the surface of the solar panels. This atmospheric dust have several effects on the use of photovoltaic power systems, including decreasing of the amount of sunlight reaching the surface and the accumulation of dust on solar panel surface which reduces the transmission of solar radiation that reaches the solar cells; this leads to the decrease of the performance efficiency[1]. Ala'a in (2009) studied the effect of natural deposition of dust on solar panels under Baghdad environment, it was noted that the transmittance during one month, as an average decreased to, approximately, 50%. This result refers to the accumulation period as a strong effective parameter that causes a large decreasing in transmittance. This is due to the increasing of accumulated dust thickness with time. Hence the increase of the tilt angle of the PV panel leads to reducing the losses, due to decreasing of accumulated dust [2].

For long-term operation of arrays, it will be necessary to develop techniques to remove the deposited dust on the solar panel surface. The previous removal methods are the natural dust removal. The only significant category of natural dust removal methods are rainfall and wind clearing and then are made possible by simply choosing an array orientation other than horizontal[1].

The other method of dust removal is the electrostatic removal. If the array surface is charged, the array will attract particles of opposite charge, and repel particles of the same charge[3]. In this paper, new Iraqi technique was utilized by using movable platform attached to two-axis solar tracking system with photovoltaic's panels to reduce the amount of accumulated dust on solar panel daily which comes from the effect of gravitational forces on dust particles especially in Iraq that witnesses high activity of dust storm from time to time which continued in some times more than one week. During the daily working mechanism of the tracking system and at the sunsets, the direction of the solar panel is changed from west to east for the horizontal axis(Azimuth) with the change of tilt angle of the solar panel to become more than 90° (about 95°) for the vertical axis(Altitude). This process is subjectivity and daily at sunset and to take advantage of this movement, vibration will help to displace the deposited dust particles on solar panel surface. While the change in tilt angle will make the center of mass of the dust particles outside the solar panel any discarded entirely from the influence of gravitational force.

Experimental procedure

In the present work two-axis solar tracking system was used to study the amount of dust that removed from the solar panel surface which leads to increase the transmission of solar radiation to the solar panel to increase its performance. In addition, this procedure causes an increase of the output power of solar panel by making the solar angle of incidence between the beam of the solar radiation and the normal to the surface of the solar panel equal to zero (the geometrical losses become zero). The output power of the tracking system is compared with that of the fixed system to see the effect on the accumulation of dust on the performance of solar panels. The tracking system consist of four photodiodes that act as a two axis position sensor connected to an electronic card. This sensor discriminates the sun position and send an electrical signals proportional to the error in positions of the two axis to the controller which actuate the motor to track the sun. Two motors of power (6w) are employed: the first motor is responsible for the horizontal motion of the system from east to west to track the sun horizontal motion(Azimuth motion); the second motor is responsible for the vertical

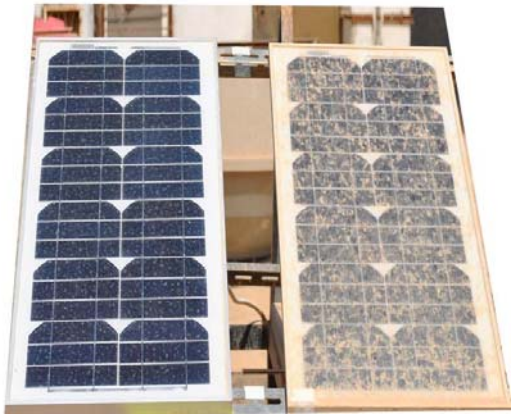
motion of system to track the vertical motion of the sun(Altitude). Two solar panels of power 20W(dimensions=$660\times306\times18mm$) are placed on the metal frame and fixed on the solar tracking system. The first panel is cleaned daily and considered as a reference to other panel which is covered with dust(dusty panel).

Fig.(1) Two solar panels(reference and dusty panel under test) with two-axis solar tracking system used in the experimental measurements.

While in the fixed system, two different tilt angles were selected. The first angle was 30° with the horizon as it is assumed to be the appropriate angle in Baghdad for annual applications in good match with latitude of Baghdad(L=33°), According to the information data of NASA and other research result[4]. The second angle was selected of 45° with the horizon as it is assumed the appropriate angle for winter applications. The fixed solar system consists of two panels with 20W power are mounted on the metal frame as shown in the figure(2). The first are being cleaned daily, and used as a reference panel(dust free) for the other solar panel (dusty). The output power of the solar panels are measured at solar noon using digital multimeter (FLUKE, 0.3% basic accuracy) to make a comparison between them. And the losses are calculated from the following relation:

$$\text{Relative Performance}=\frac{\text{output power of dusty panel}}{\text{output power of cleaned panel(reference)}}\times 100\%$$

Losses(%)=100 - Relative Performance



(a)

(b)

Fig.(2) The fixed solar system with different two tilt angles at(a) (30°) and (b) (45°) which is used in experimental measurements

Results and Discussions

The following table shows the losses resulting from all mentioned cases (fixed 30°, fixed 45°, tracking) with the description of weather conditions affecting on their performance.

Table(1)
The percentage losses for the fixed panel (at 30° and 45°) and movable systems at various weather conditions.ble

Date	Accumulation Period(days)	Losses% (Fixed 30°)	Losses% (Fixed 45°)	Losses% (Tracking)	Status
18/02/2010	0	0	0	0	Starting of work
21/02/2010	3	3.7	1	0.9	Dust accumulation
22/02/2010	4	4.4	1.8	1.3	Dust accumulation
23/02/2010	5	12.1	8.5	4	Heavy dust storm
24/02/2010	6	8.9	6	2.4	High winds
25/02/2010	7	9.2	6.6	2.4	Dust accumulation
28/02/2010	10	2.5	1	0.4	Heavy rainfall
01/03/2010	11	1.3	0.6	0.1	Heavy rainfall
02/03/2010	12	2.1	1.2	0.2	Dust accumulation
03/03/2010	13	3.3	2	0.4	Dust accumulation
10/03/2010	20	21.4	18.2	4.9	Heavy dust storm
14/03/2010	24	24.6	18.8	6	Dust accumulation
15/03/2010	25	28.7	20.2	7.5	Dust accumulation
17/03/2010	26	29.5	21	7.8	Dust accumulation
18/03/2010	27	31.4	22.8	7.7	Dust accumulation
22/03/2010	31	28.7	21.5	6.2	Winds
23/03/2010	32	30.3	23.1	8.5	Dust accumulation
24/03/2010	33	24.2	20.1	8	Rain showers
25/03/2010	34	18.2	16.7	7.7	Rain showers

Figure (3) shows the relation between the output power losses as a function of the accumulation period for fixed solar panel at tilt angle (30°) facing the south. The perturbation in the curve are due to the effect of weather conditions which occurred during the test period such as rainfall,wind (which affect the natural cleaning) and dust storm. From this figure it can be seen that the point (0) for accumulation period represents the start of work after cleaning the two panels and then a clear increase in losses is observed after 5 days from a heavy dust storm. But the apparent decrease in the losses after 6 days is due to effect of high wind speed, that reduced the losses from 12.1% to 8.9%. Then it was followed by increasing of the losses with increasing of accumulation period. After 11 days the panels was exposed to all the environmental effects causing a significant reducing in the losses from 9.2% to 1.3% because of heavy rainfall which cleaned the solar panels under test. With increasing of accumulation period the losses were increased too. But after 23-33 days it was observed decreasing in the curve because of rainfall effect. Consequently the maximum output power losses reach about 31.4% for fixed solar panel at tilt angle(30°).

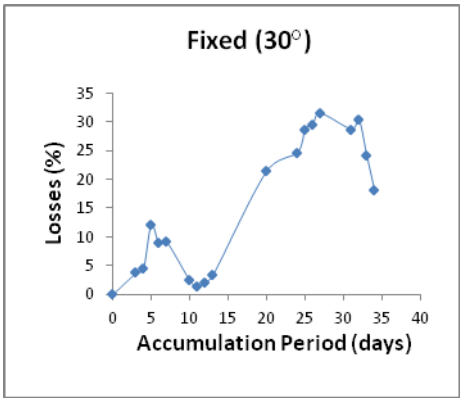


Fig. (3) The losses of o/p power for fixed panel at tilt angle 30° versus accumulation period

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While in the case of fixed solar panel at tilt angle (45°) facing the south, it can be seen that the losses in the output power of solar panel for 34 days is less than that of solar panel at tilt angle (30°). This is because that the increasing of the tilt angle leads to reduce the deposited dust on the solar panel surface due to the small impact of the gravitational force for dust particles. Therefore, leads to decrease the losses which resulting from the accumulation of dust. This is shown in figure (4).

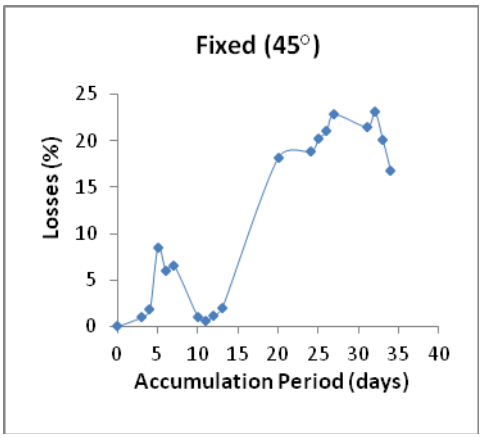


Fig. (4) The losses of o/p power for fixed panel at tilt angle ([45] °) versus accumulation period.

From this figure it can be seen that the maximum losses for 34 days of accumulation time is about 23.1% .
Whereas two-axis solar tracking system used to reduce the accumulated dust on the solar panel surface indicated the better performance compared with the two cases above (fixed 30°, fixed 45°) because the center of mass of the dust particles becomes outside the surface of the solar panel by change the tilt angle of the solar panel to become more than 90°(about 95°) and displace the deposited dust on the solar panel surface by vibration, which was caused by movement of the panel from west to east at evening. Figure(5) shows the relation between the losses and the accumulation period which indicated that the maximum losses for 34 days of accumulation time is about 8.5% .

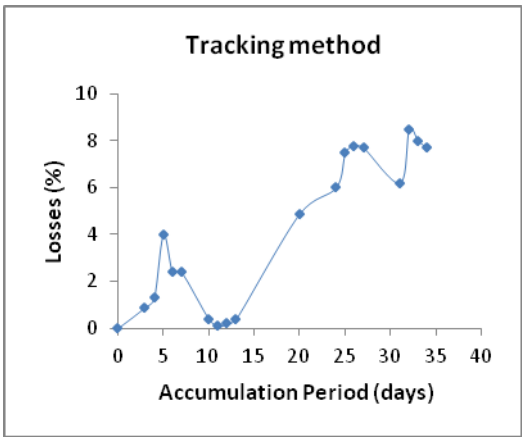


Fig. (5) The losses of o/p power for movable panel versus accumulation period.

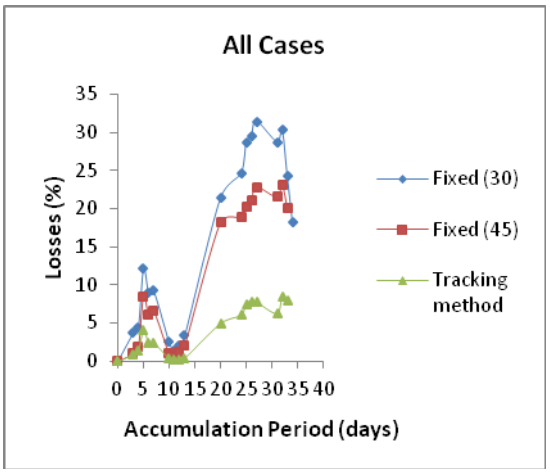
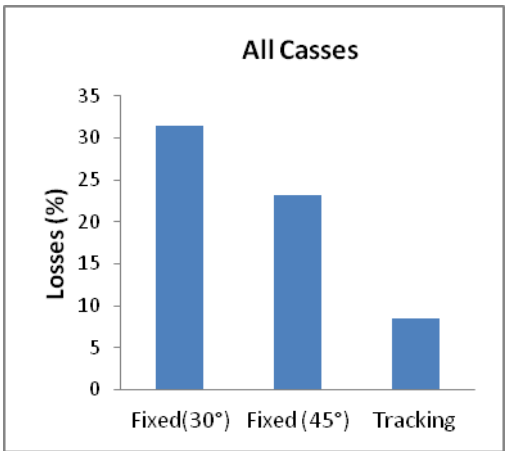


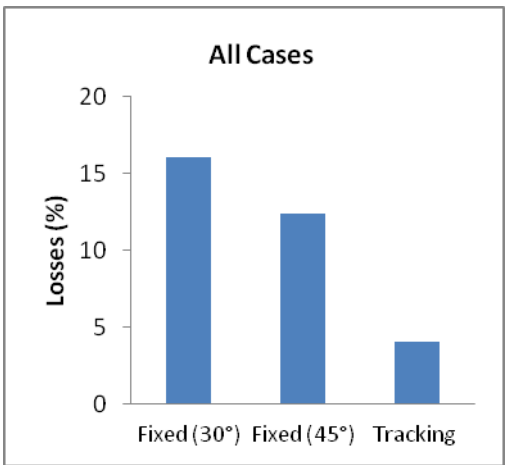
Fig.(6) The losses of o/p power versus accumulation period for all cases

Figure(6) shows that the percentage of o/p losses of the fixed solar panel at tilt angle 30° is greater than of the movable panel about four times and that of the panel installed at an angle 45° is greater than that of the movable panel about three times. It is note worthy that during the test period of 34 days from 18-2-2010 to 25-3-2010 Iraqi weather witnessed great changes of the rain more than once, heavy dust storm and wind with high speeds. And the results will be most important in the summer months, which are characterized by a very large dusty weather and no rainfall, to clean the panels as shown in the figure (6) for accumulation period reach to 10 days. As

well as for accumulation period 6 days which have experienced a clear leap in the behavior for all cases**.** The monthly average and maximum output power losses due to the dust accumulation was shown in the figure(7):



(a)



(b)

Fig.(7) Show (a) maximum losses (b) monthly average losses for 34 days due to dust in Baghdad of (fixed 30°, fixed 45°, tracking)

Conclusion

This work have described the treatment of accumulated dust on the solar panel surfaces by using two-axis solar tracking system as compared with the fixed solar panels which have installed at tilt angles of 30° and 45°. The results indicate that the maximum losses in the output power is about 31.4% and 23.1% for fixed solar panels at tilt angle 30° and 45° respectively for 34 days of accumulation period while the losses in the output power for the solar panel with two-axis tracking system is about 8.5%. One can therefore conclude that this method is very effective for reducing the accumulation of deposited dust on the solar panel surface dramatically and effectively. In addition to other big interest resulting from the use of a solar tracking system to reduce the geometrical losses to almost zero.

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