INTERNATIONAL JOURNAL OF
ENERGY AND ENVIRONMENT

*Imam Al-Kadhum College (IKC) Conference on Applications of Engineering Techniques in Renewable Energy and Environment (AETREE), Najaf, Iraq, 5th May 2019.*

*Journal homepage: www.IJEE.IEEFoundation.org*

# Study the effect of dust on performance of PV panel and design cleaning system

**H. Gh. Hameed, D. M. Hachim, AbdulRasool S. Al-Hilo, Ameer Mazen, Labran Ali, Narjes Maqdad, Zahraa Farhan**

Power Mechanical Department, Engineering Technical College, Al-Furat Al-Awsat Technical University, Najaf, Iraq

**Abstract**
The abundant availability of solar energy in the nature is due to emitted energy by the sun at an extremely large rate. When all solar energy can be converted into usable forms, it become enough to supply the world's energy demand. However, this is not possible because of the environmental conditions such as effect of temperature, clouds and dust. Thus that through solar panel, solar energy can be converted to more usable energy forms. In a country like Iraq, efficiency of the solar panel is affected by accumulation of dust, where the permeability of its surface is reduced, which impedes the absorption of falling photons and thus reduces its ability to generate electricity. In the present study, a pre-programmed moveable cleaning system is used and the results showed that the output power of solar panel with cleaning increased by 45% as compared with that one without cleaning.


**Keywords:** Solar panel; Cleaning system; Dusty solar cell; Performance of PV panels.

## 1. Introduction

Currently, solar energy is one of the most renewable and clean source, and since Iraq is located within the middle east, which is characterized by high intensity of solar energy, thus many applications are used. The most important of which is used in the field of heating, desalination and power generation. When the photon collides with the upper surface of the solar panel the electrons will be attracted to the cell due-face. This causes the electrical voltage between the upper and lower layers of the cell. When the electrical circuits are formed at the top and bottom of the cell, electrical equipment is operating. photovoltaic cells, solar panels, are grouped and linked together (parallel and series) to obtain special specification and number of cells and how they bind. The generation of solar energy in dusty areas is a challenge because the spread of dust in the atmosphere and its accumulation on the surface of the solar cell generates a barrier on it, reducing its ability to absorb photons falling on it. Thus, the efficiency of the solar cell is reduced by a certain percentage, leading to loss of solar energy. Also, the accumulation of dust and its properties play an important role in reducing the efficiency of the board. The accumulation of 4 grams per square meter reduces the conversion efficiency of solar energy by 4%, [1].
Therefore, most companies and individuals working in the field of solar energy trying to find solutions to the problem of dust and dirt attached to the panels and try to keep the panels as clean as possible. As a

result, there are many ways to clean the solar panels appeared, perhaps the simplest manual method where a person cleans it manually. Because the manual method is tiring and consumes more time, there are more ways to clean the plates, such as putting a device or a moveable base with scanners and spraying the water on it for cleaning and other uses compressed air for cleaning (Waterless, especially in the desert). Other techniques based on the self-cleaning mechanism (based on Piezoceramic Actuation) or install sensors on the panels to sense the amount of dust on the panels and cleaning is done automatically, [2]. Cleaning system operates by spraying an amount of water on the PV panel surface and then actuating the wiper using a DC motor is proposed by U. Hasanuddin and U. Bosowa [3]. Two limit switches are used to sense the wiper position at the edge of the PV panel. In the experimental test, an amount of dust is deployed on the PV panel surface to test the control power performance.
K. Tsamaase et al. [4] presented a cleaning system was designed by writing it with a C program and compiled with Arduino IDE to read voltage and sense current from the PV and calculate power output. Simulation results show that the system was able to detector power loss due to dust accumulation on module surface and as a results the motor drive for the cleaning mechanism responded accordingly to operate cleaning mechanism. Cleaning system has been designed by Abdul Bari and Pavan [5] cleans the solar panel module by controlling the Arduino programming. To remove the dust in the PV modules to improving the power efficiency.
Power measurements of PV modules in test laboratories and industry are usually performed with solar simulators. Dust is the lesser acknowledged factor that significantly influences the performance of the PV installations. Many researches for performance of PV system and the effects of the deposition of dust is limited due to the fact that powder is a complex phenomenon that is influenced by different environmental and weather conditions. Rajput and Sudhakar [6] presented a brief schematic representation of the factors that determines the settling of dust on the PV panels is shown in setup of experiment. A detailed analysis of the influence of dust on the PV modules performance is proposed in them work. Based on all this information the effects of the dust on the PV panels electrical performances have been highlighted. During the study of the performance of solar PV panel with and without dust, then the following factors considered:
1. Solar Radiation v/s Time characteristics.
2. Ambient Temperature v/s Time characteristics.
3. Panel efficiency v/s Time analysis with dust.
4. Panel efficiency v/s Time analysis without dust.
Study the impact of dust accumulation on photovoltaic solar modules in Baghdad city in Iraq is investigated experimentally by Saidan et al. [7]. The study has been conducted to quantify losses caused by the accumulation of dust on the surface of three identical photovoltaic solar modules. The modules have been installed with direct exposure to weather conditions, in a well-controlled experimental setup. Subsequently, measurements of dust accumulation on modules have been taken on daily, weekly and monthly basis. The dust density and size distribution of aerosol particles and fibers have been also investigated and measured by a highly sensitive aerosols measuring system.
The dusted module and another similar clean module have been then exposed to constant radiation and constant temperature using a solar simulator as light source. The deposition of the dust on the surface of the photovoltaic solar modules showed a reduction in both the short circuit current (Isc) and the output power compared to the same parameters of the clean module. The average degradation rate of the efficiencies of the solar modules exposed to dust are; 6.24%, 11.8% and 18.74% calculated for exposure periods of one day, one week and one month. The experimental results are well compared with the calculations obtained by a theoretical model recently developed by the authors.
In the present study, the effect of dust on performance of PV panel, and designed and constructed a simple cleaning system, is investigated experimentally under the conditions of Najaf city in Iraq.

## 2. Experimental methodology

The experiment is conducted by using the four 300-watt solar panel mounted on a frame, as shown in Figure 1. The electrical parameters like voltage and current have been measured to study the effect of dust. The net effect of dust on the power reduction was evaluated and analyzed. The effect of dust can be quantified by comparing the efficiency of panel exposed to dust and without dust. In this work, the system of measurements is consisting of a polycrystalline solar panel of area 1.94 $m^2$, see Table 1. for specifications, a dc voltmeter for measurement of generating voltage, a dc ammeter for measurement of producing current, and also a suitable load resistance as shown in Figure 2.

 

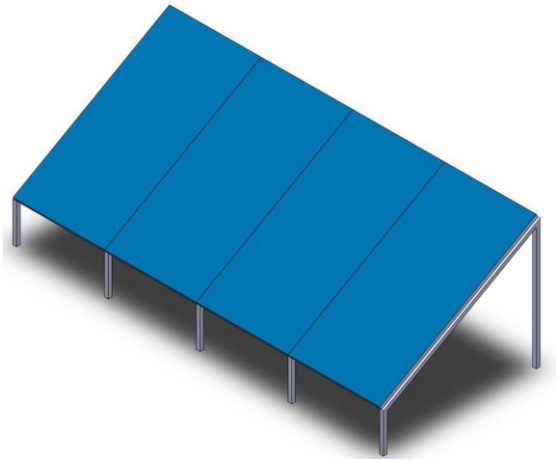

Figure 1. Schematic diagram of solar panels.

Table 1. Solar panel specifications.

| Parameter | Specification |
|---|---|
| Cell Type | Polycrystalline Solar Cell |
| Rated Max. Power | 300 W |
| Tolerance | 0~+3% |
| Voltage at Pmax | 37.08 V |
| Current at $P_{max}$ | 8.10 A |
| Open-Circuit current | 44.35 A |
| Short--Circuit current | 8.865 A |
| Max. System Voltage | 1000 VDC |
| Max. Series Fuse Raring | 15 A |
| Operation Temp. | -40 C to 85 C |
| Dimensions (mm) | 1956*992*40 |
| Standard test conditions | AM=1.5, E=1000W/$m^2$, Tc=25 °C |
| Manufacture Date | Feb 2018 |

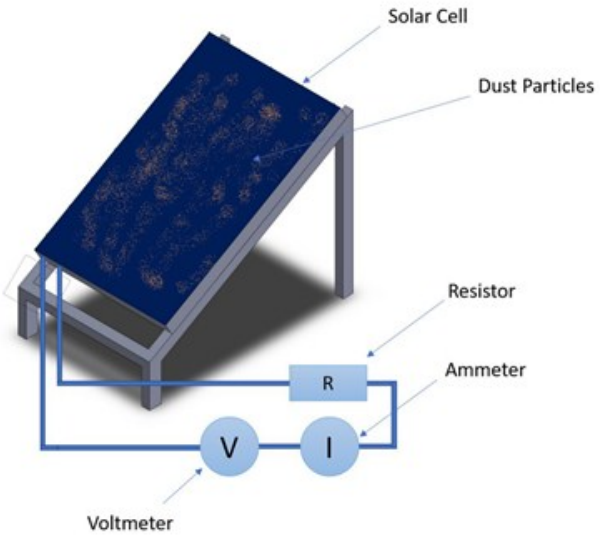


Figure 2. Schematic diagram of solar panel in case of power measuring.

All experiments of this work are carried out in April 2019 at the roof of the communication department building in the Engineering Technical College, Najaf, Iraq. The latitude and longitude of the location are 32o 03 N and 44o 19 E. The ambient temperature fluctuates in the range of 6 to 52 ºC during a year in

 

Najaf. The solar photovoltaic panel was tested and the parameters like Voc, Isc, solar irradiance, and ambient temperature etc. needed for the evaluation of the systems were measured at interval of one hour between 9.00 and 15.00. The ambient temperature and the incident solar radiation intensity was obtained by Davis weather station, which is installed at 10 m above the ground in the Engineering Technical College / Najaf [8]. This station measures the solar radiation in (W/m$^2$) with range from 0 to 1800 W/m$^2$ and accuracy of ±0.3%. The output power (Po in watt) and efficiency (η) of the solar panels are calculated from the following formula [6]:

$$P_o = V_{OC} \times I_{SC} \times F.F \tag{1}$$

$$\eta = \frac{V_{OC} \times I_{SC} \times F.F}{A \times I} \tag{2}$$

Where,
$V_{oc}$: Voltage of electricity produced (volts), $I_{sc}$: Electrical current produced by the solar PV panel (Ampere), F.F: fill factor, A: Area of solar panel (cross-section of panel), I: Intensity of Solar Radiation (W/m$^2$), the power improvement of solar panel can be obtained as follows:

$$improvement(\%) = \frac{P_{without\_dust} - P_{With\_dust}}{P_{without\_dust}} \times 100\% \tag{3}$$

**3. Cleaning system description**

An AC variable speed electric motor with four pulleys, rope and movable base are installed on a frame which connected to the upper side of the solar panel frame as shown in Figure 3. The electric motor is connected to an electrical control circuit, shown in Figure 4, to specify the rotation of motor right or left. Motor rotation is inversed depending on proximity switches fixed at frame ends. The motor pulls out a moveable base by pulleys and rope. The moveable base mounted on a four small wheels fixed on a track or rail and moves left and right depending on the proximity switch when touch it will send a signal to the control circuit to reverse the motor rotation direction. A water sprinkler and wipers connected to arm connect to the movable base to cleaning the solar panel. The cleaning system started with known time, by adjusting the timers in the control circuit, by press the start button and stopped after finished the time interval.

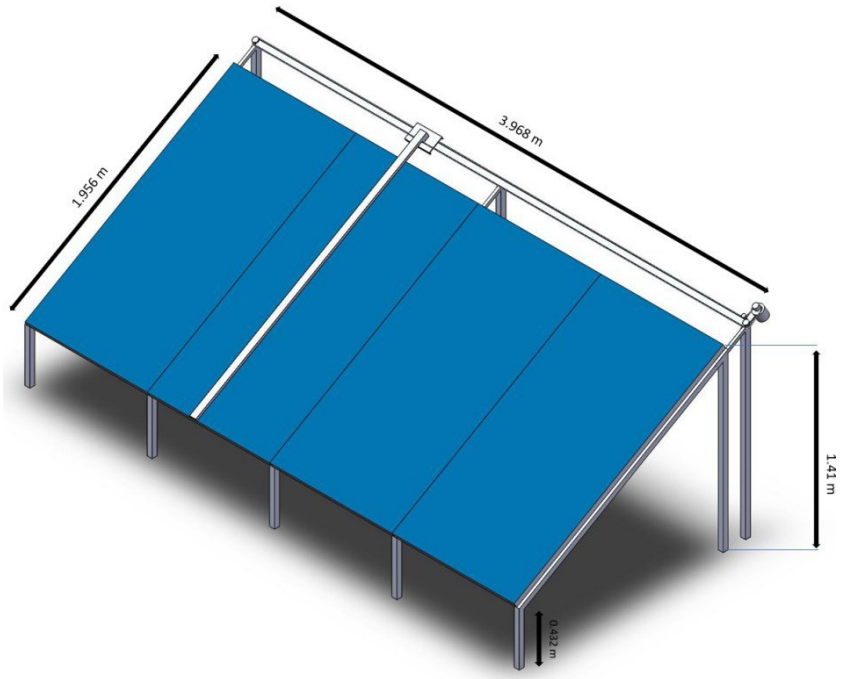


Figure 3. Schematic diagram of solar panels and cleaning system.

 

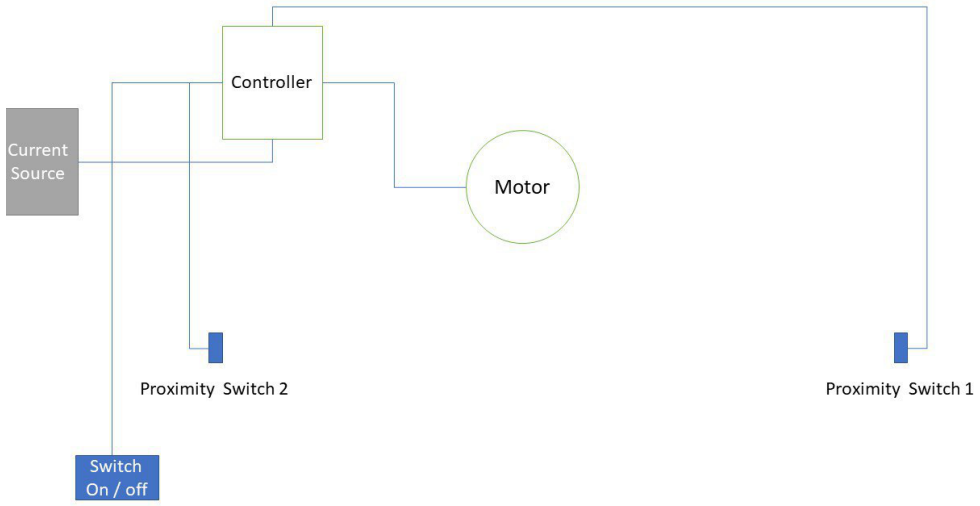


Figure 4. Sketch control circuit for cleaning system.

## 4. Results and discussion

The experiments are carried out for four solar panels. One leaves without any cleaning along the interval of measurements and two others; one with dry clean and the other with wet clean (i. e using water and wiper). While the fourth panel cleaned hourly with wet cleaning during the time of experiment. Figure 5 to Figure 7 show the variation of voltage, current and power with time of measurements during one day for dusty, dry cleaning and wet cleaning of solar panel. From the figures its appear that the values of voltage, current and power augmented with panel module cleaning and more with wet cleaning because it works as cooling method for the panel.

Figures 8 and 9 show the values of voltage, current and power during the day time for hourly wet cleaning of panel. The wet cleaning gives the best results and from these figures appear that the values of voltage and current with small fluctuation due to decreasing the panel temperature during cleaning.

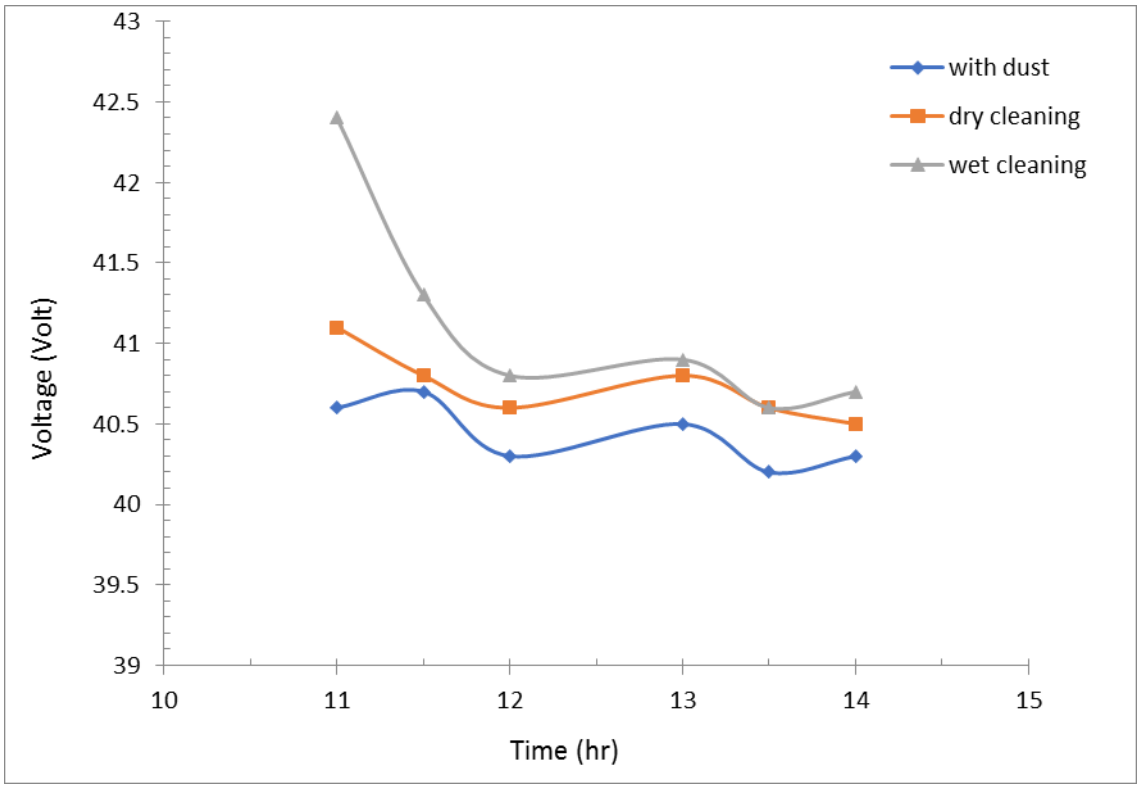


Figure 5. Variation of voltage with time during one day.

 

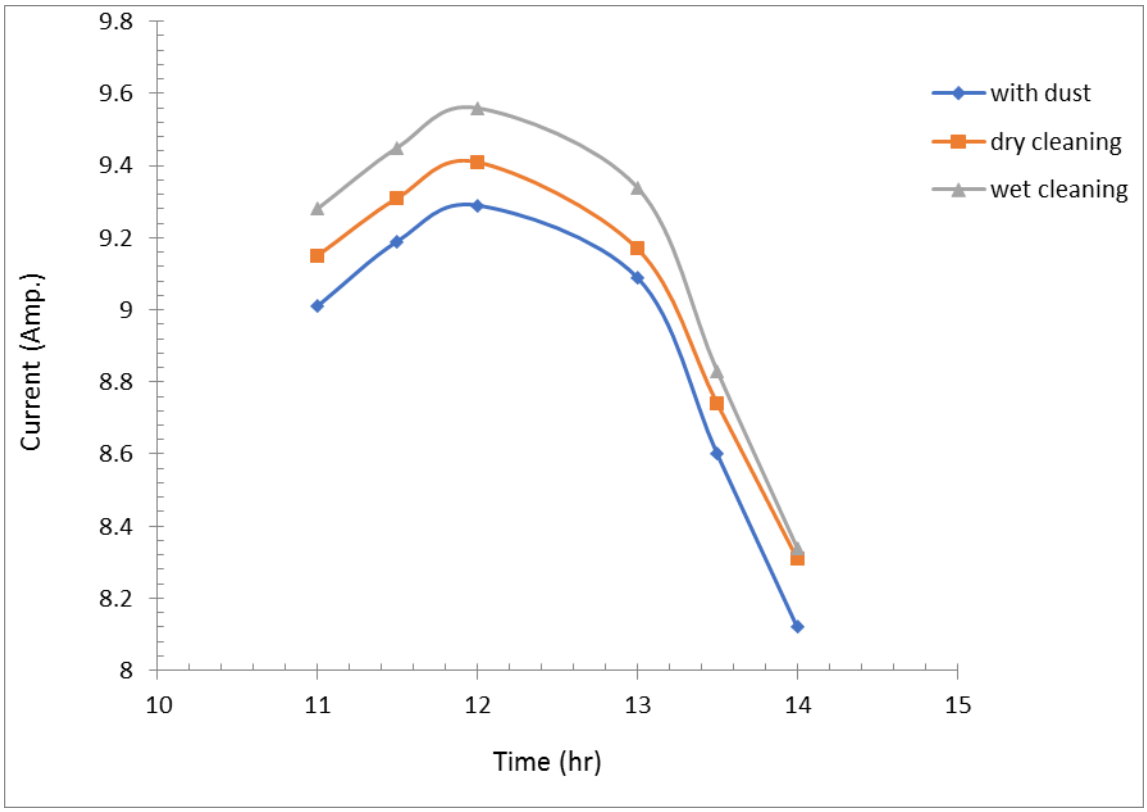


Figure 6. Variation of current with time during one day.

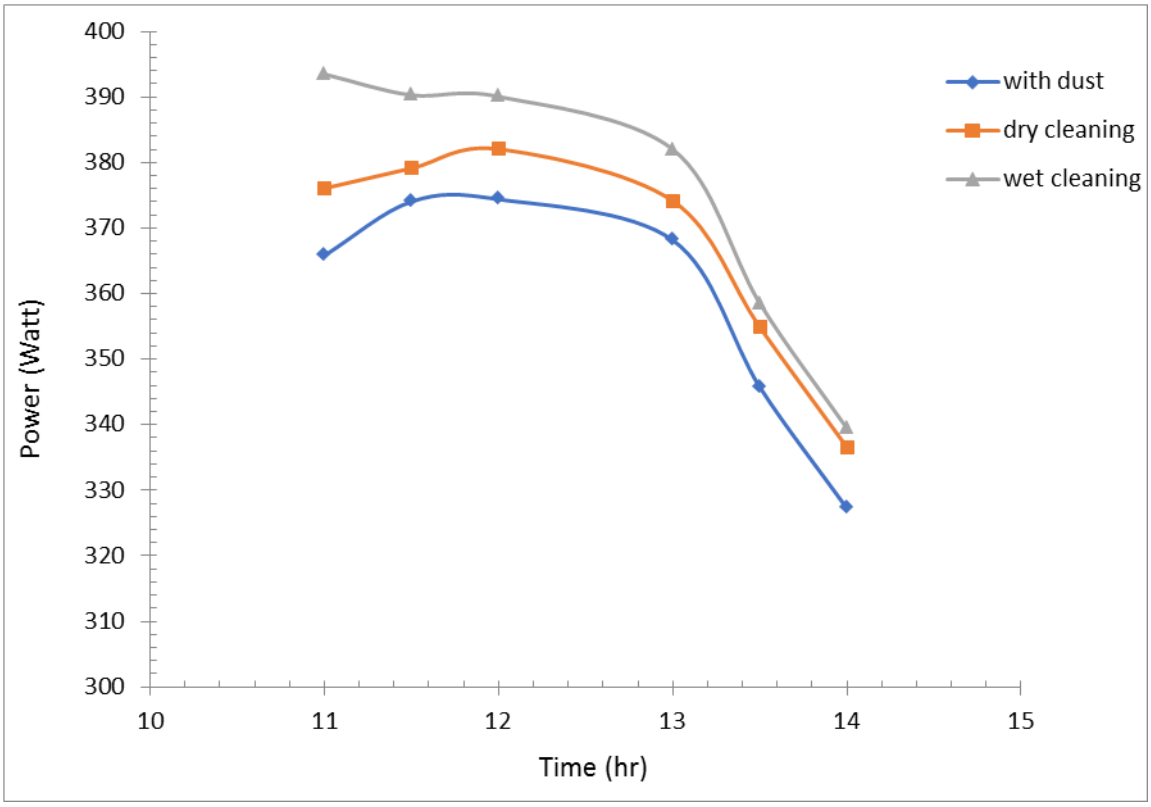


Figure 7. Variation of power with time during one day

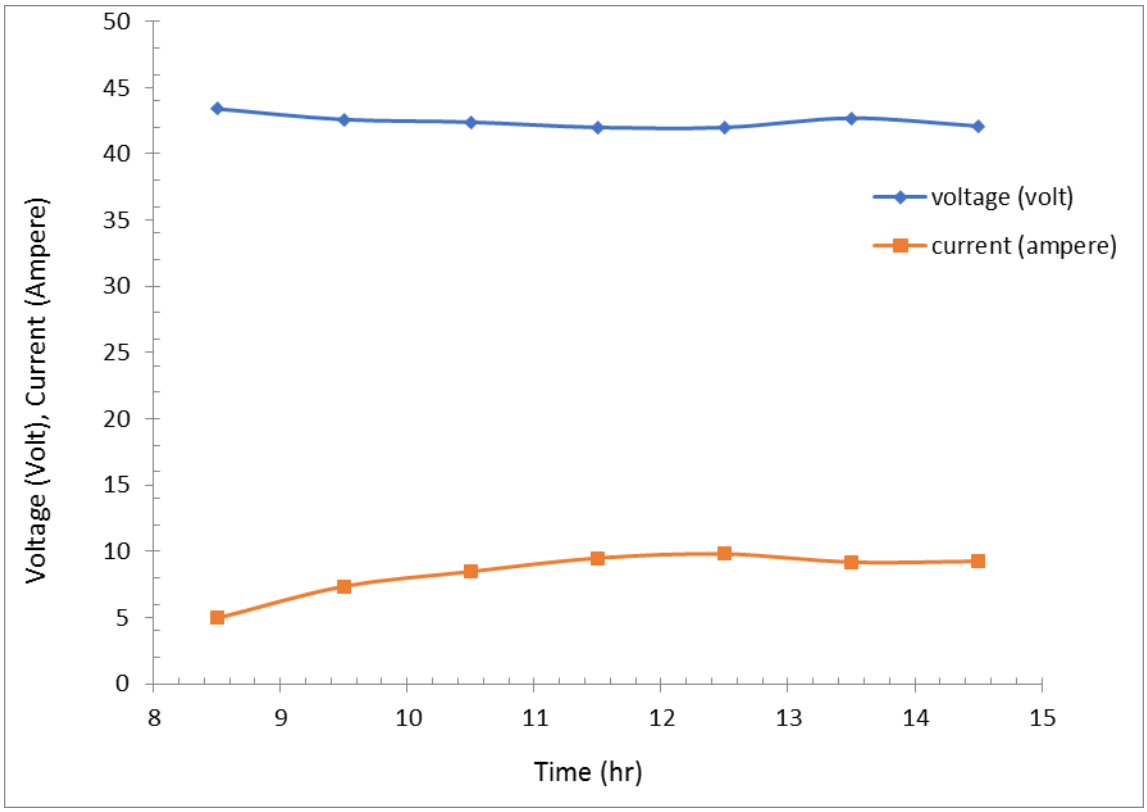


Figure 8. Variation of voltage and current with time during one day for hourly cleaning.

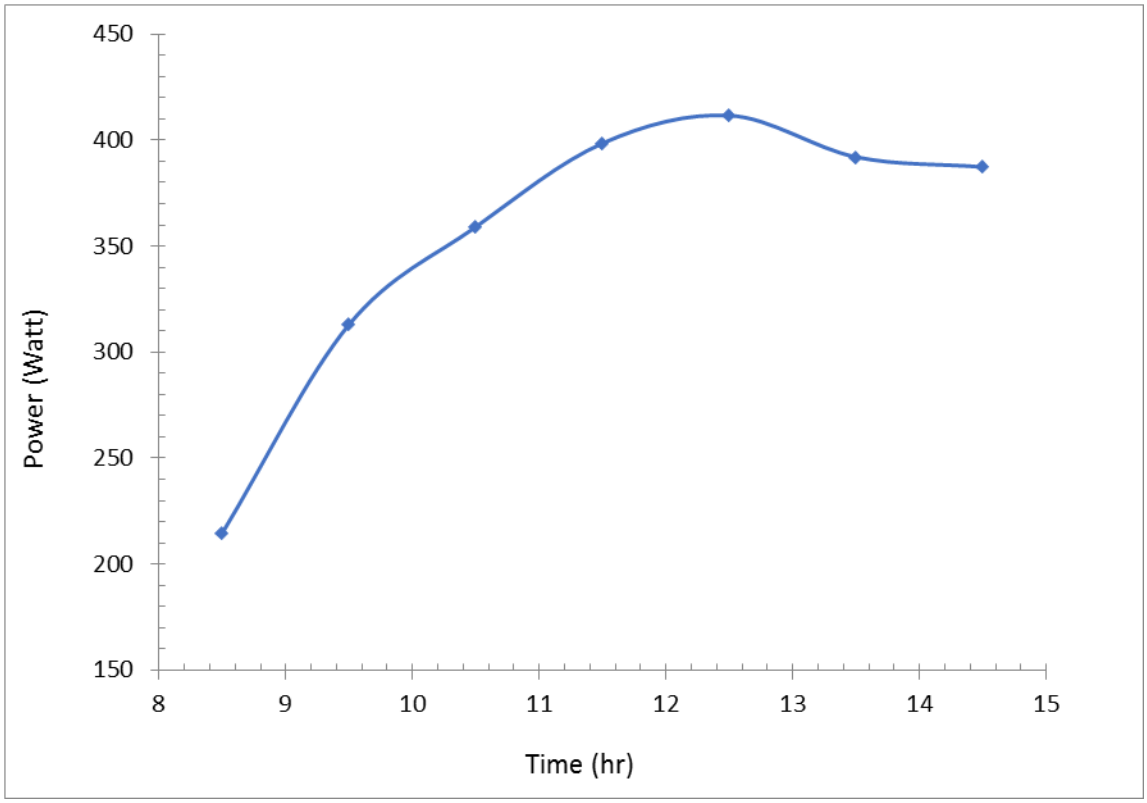


Figure 9. Variation of power with time during one day for hourly wet cleaning.

## 5. Conclusion

From experiments it can be conclude the accumulation of dust on the solar panel surface have essential effect on the panels output, whereas with increasing the amount of dust the output power of panel decrease. So that the cleaning system very important to keep the PV panel work efficient, special in Iraqi weather conditions. Also, the experiments show that wet cleaning is more efficient than dry cleaning and the improvement in output power due to using dry cleaning reaches up to 2.84% and 7.03% for wet cleaning.

## References

[1] Nicoletta Ferretti "PV Module Cleaning -Market Overview and Basics", PI Photovoltaic-Institute Berlin AG, 2016.

[2] S. Das, "An Integrated Design of an Auto Clean and Cooling Smart PV Panel," vol. 4, no. 1, pp. 80-88.

[3] U. Hasanuddin and U. Bosowa, "Design of automatic control for surface cleaning systems of photovoltaic panel," vol. 8, no. 11, pp. 1457–1464, 2017.

[4] K. Tsamaase, T. Ramasesane, I. Zibani, E. Matlotse, and K. Motshidisi, "Automated dust detection and cleaning system of PV module," vol. 12, no. 6, pp. 93–98, 2017.

[5] Manju B Abdul Bari and Pavan C M "Automatic Solar Panel Cleaning System" International Journal of Advances in Scientific Research and Engineering. Volume 4, Issue 7 July – 2018.

[6] Dayal Singh Rajput and K. Sudhakar "Effect of Dust On the Performance of Solar PV Panel" International Journal of ChemTech Research, Vol.5, No.2, pp 1083-1086, April-June 2013.

[7] Motasem Saidan, Abdul Ghani Albaali, Emil Alasis and John K. Kaldellis, "Experimental study on the effect of dust deposition on solar photovoltaic panels in desert environment" Renewable Energy 92 (2016) 499-505.

[8] Hassanain Gh. Hameed, Ahmed H. Ali and Zaid M. Al-Dulaimi "Experimental Investigation of the Enhancement Parameters on the Performance of Single-Slope Solar Still" International Journal of Latest Trends in Engineering and Technology Vol.10, Issue3, pp.139-145, 2018.