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Studying the effect of light intensity and the dust on efficiency of Silicon Solar cell

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ABSTRACT

In this paper, Two main effected parameters on the efficiency of solar cell has studied: the increasing in the amount of intensity of incident solar irradiance on the surface of silicon solar cell and–accumulation of dust on the front face of solar cell. The parameters of silicon solar cell (I_{sc}, V_{oc}, p_{max}, η) have been studied under various quantities of solar irradiations (G= 100, 172,252 and 606W/m^2) at a constant temperature (T_C=25±2)°C. The results showed an increasing in the value of conversion efficiency(fromη=7.1% to η=10%) with the increasing of intensity of solar flux. But the dust had a reverse effect on the value of conversion efficiency , thus after one week there was noticeable of(ΔI_{sc}= 5%) degradation at value of short circuit that lead to decrease of conversion efficiency.

1- Introduction

In spite of the Fossil fuel provides most of industrial demands of energy todays , but it is limited resources and decreasing day after day, also the increasing of environmental problems lead to many of climate changes, like global warming which is consider the most dangerous problem that facing the mankind today, [1-3]. therefore it became necessary to depend more and more on the advantages of renewable energies like: solar energy, wind energy, hydro energy, geothermal energy and biomass energy[4]. The photovoltaic systems had a noticeable improvement since 1979, which it have given supports to the global industry to produce more electric Gigawatts(GW)[5]. Although the advantages of clean energy that have produced by solar cells , but there are some difficult challenges face this energy field that lead to reduce the obtained conversion efficiency, like high temperature, low solar irradiance and the dust and clouds which has a negative effect on the performance of solar cell or solar panels. Generally, the heaping of dust on the surface of solar panels is the main reason of decreasing the amount of incoming solar irradiation to the photovoltaic modules[6] . In the last decades, many of researchers have been studied and explained the losses of efficiency that caused from dust and clouds. Generally the degradation per week is 7% and sometimes, the losses reached 15% or 40% [7-9] .

This work is focusing on the general effects of amount of solar irradiation at a constant temperature (25±2)°C and the rate of dust on the conversion efficiency of solar cells , thus the solar flux specifying factor for studying solar energy which is one of renewable energy resources. The obtained data were indoor.

2- Experimental part

The incidents flux of solar irradiance from Sun simulator (supplied by Philips company) on surface of solar cell was measured with solar meter supplied by (Instrument Haennimessy rate) fig (1) was used for this purpose[10]. It consists of: a mono crystalline silicon solar cell Connecting in series with ammeter and rheostat, and then Connects in parallel between the poles of a voltmeter.

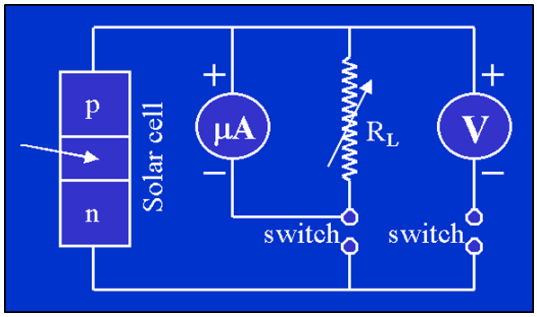

Fig. 1 : I-V characteristic circuit of solar cell [10]

The value of conversion efficiency (η) was calculated by using the equation[11]:

$$\eta = \frac{p_{max}}{p_{in}.a} x100\%$$

η:the conversion efficiency, p_{max}: maximum value of produced power, p_{in}: the incident irradiation, a: the area of solar cell.

The flux of sun simulator had been concentrated by using different Fresnel lenses having grooves density (0.1 , 5, 2) grooves/mm respectively. After that measuring had been took place again at dusty indoor conditions with Standard test conditions (T=25℃, G= 100W/m^2, Air mass=1.5). the amount of dust filled room was measured by dustmeter supplied from (Temtop PMD 331 , china). The measurement also included the calculations of fill factor (F.F) under same conditions of this work , it has been calculated by using equation[11]:

$$\boldsymbol{F.F} = \frac{\boldsymbol{P_{max}}}{\boldsymbol{V_{oc} I_{sc}}}$$

F.F: fill factor, p_{max}: maximum power, V_{oc}: open circuit voltage, I_{sc}: short circuit current.

3-Result and Discussion

3-1 The effect of Solar irradiance

The figure (2) shows the effect of increasing the intensity of the incident light (at constant temperature) on the solar cell using Fresnel lenses, which increases the number of incident photons on the surface of the cell and by interacting these photons with the cell material, a pair of electron-hole will be generated. which plays a major role in generating the photo current which appears at table (1). Also figure(3) explains the direct proportionality between short circuit current and the solar irradiance intensity. This results agree with results of [12].

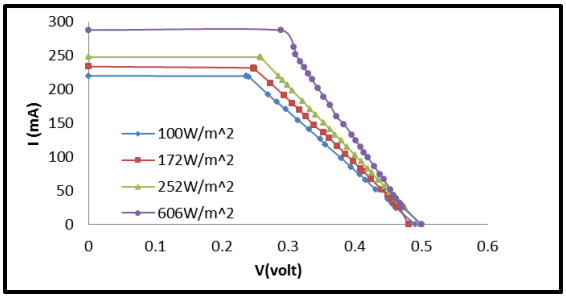

Fig. 2: effect of increasing the intensity of the incident light (at constant temperature) onthe solar cell

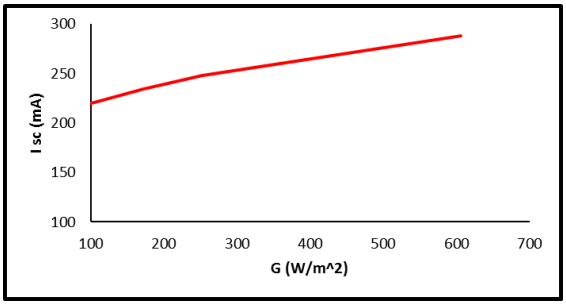

Fig. 3: direct proportionality between short circuit current and the solar irradiance intensity at constant temperature

Table 1: the parameters f solar cell under various solar flux

Parameters of solar cell	G=100 W/m^2	G=172 W/m^2	G=252 W/m^2	G=606 W/m^2
Isc(mA)	220.2	234	248	288
Voc(Volt)	0.491	0.4812	0.4995	0.5005
P (watt)	52	57.51	63.9	83.20
η%	7.1	7.3	8.1	10
F.F	0.40	0.50	0.51	0.577

We can also notice the change in the value of power produced by the solar cell under different values of incident solar irradiance intensity.

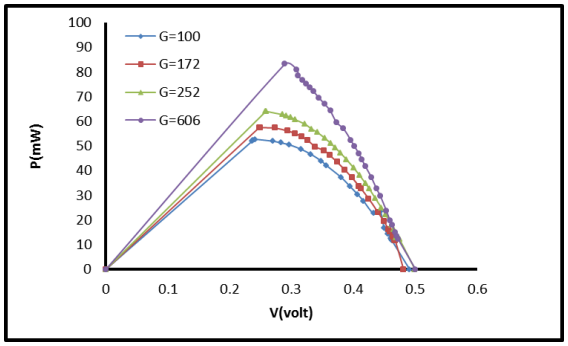

Fig.4: the output power as a function of output voltage

3-2 The effect of dust :

In spite of limited studies that deal with dust effect on efficiency of solar cell, but we tried at this paper to explain its negative effect (fig5) when the solar cell was exposed to dust for a week at a laboratory . The dust would reduce the incoming solar flux and then reduced the produced photocurrent because of dust effect on producing the charge carriers(electron-hole)pairs. It has also been noted that the open circuit voltage is rather maintained at its value. The conversion efficiency of solar energy to electrical energy was decreased from η=6.7% to η=6.03%. the relationship between current and conversion efficiency is appeared clearly at fig(6), it's clear there is decreasing in efficiency value with decreasing the short circuit current values.

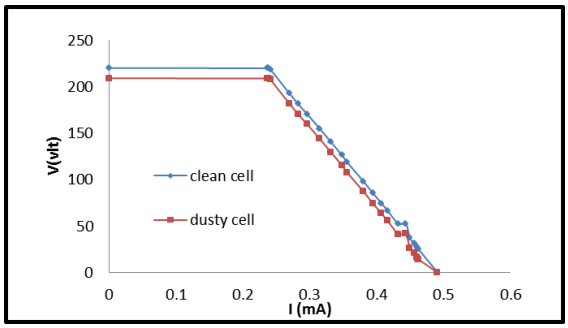

Fig 5: Degradation of conversion efficiency after exposed to dust for one week

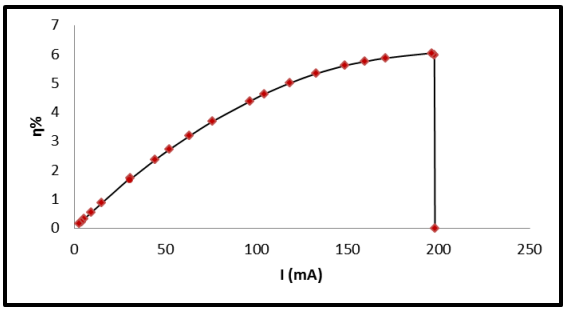

Fig. 6: the short circuit current as a function for conversion efficiency

4- Conclusion

Many factors overall- include: dust, smoke, position of the sun seasons ,cloud, fog , pollution, and shadow may reduce solar irradiance, and then decreased the produced energy of photovoltaic system. There was decreasing in the value of produced photocurrent, and it was noticed the short circuit current decreased 5% (ΔIsc=5%), this decreasing causeds a degradation in conversion efficiency(η) of solar cell from η=6.7% to η=6.03%. In other hand, the increasing of incident solar flux on surface of solar cell at constant temperature (T_{cell}=25±2)°C achieved a good increasing in conversion efficiency from η=6.7% to 10% under G= 606W/m^2.

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دراسةُ تأثيرِ شدّة الضّوء وكمية الغبار على كفاءة الخليّة الشّمسيّة السّليكونية

كوكب داود سالم

قسم الفيزياء ، كلية التّربية للعلوم الصّرفة ، جامعة تكريت ، تكريت ، العراق

الملخص

في هذا البحث تمت دراسة عاملينِ رئيسيين ومؤثرين جدّا على كفاءة الخلايا الشمسية ،وهما : زيادة كمية شدة الإشعاع الشّمسي السّاقط على سطح الخليّة السّيليكونية الشمسية ، وتراكم الغبار على الوجه الأمامي للخلية الشّمسيّة. كما وتمّت دراسة معلمات الخليّة الشّمسية مثل (I_{sc}، V_{oc}، p_{max}) تحت كميات مختلفة من الإشعاع الشّمسي (G= 100, 172, 252, 606 W/m^2) وعند درجة حرارة ثابتة (T=25±2°C). أظهرت النّتائج زيادةً في قيمة كفاءة التّحويل مع زيادة شدة التدفق الشّمسي. لكن الغبار كان له تأثيرًا عكسيًا على قيمة كفاءة التّحويل فبعد أسبوع واحد لوحظ حصول نقصان ملحوظ في قيمة تيار الدّائرة القصيرة (Δ5 = Isc٪) مما أدى إلى انخفاض قيمة كفاءة التحويل الفوتوفولطائي.