International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Experimental Investigation of the Effect of Temperature Variation on Photovoltaic Cell and Efficiency Improvement by Water Cooling

Pawan Kumar Tiwari [1], P.B.L Chaurasia[2]

[1]M. Tech (Dual degree) Electrical + Energy Engineering,
Suresh Gyan Vihar University, Jaipur (Rajasthan), India

[2]Centre of Excellence, Solar Energy Research & Utilization,
Suresh Gyan Vihar University, Jaipur (Rajasthan), India

Abstract: ***In this paper we studied the effect of temperature variation on the performance of photovoltaic cell parameter and efficiency improvement .This paper show the solar cell efficiency and performance by varying open circuit voltage (v_{oc}), short circuit current (I_{sc}), and these parameter are responsible for solar cell performance changing. We investigated experimentally at different temperature range under constant radiation. Initially the short circuit current increase with temperature but as temperature increases then it decreases. The efficiency are directly related to open circuit voltage and open circuit current and show the photovoltaic cell performance. when we plot graph between temperature and efficiency then we saw initially temperature increases then efficiency increases but after at higher temperature it start decrease, so we need to improvement in efficiency at higher temperature range ,for this purpose we use a water cooling. it maintain the solar cell temperature and it improve efficiency of solar pv module.***

Keyword: Solar cell, temperature, opens circuit voltage, short circuit current, water sprinkle, efficiency

1. Introduction

Solar energy is highly existing sources at present day we are now looking for renewable energy in command to replace the current fossil fuel. One of the most probable renewable energy found is solar energy because it is non polluting. Solar cell is devices that use pn junction to convert directly sun light in to electricity and it show the relationship between voltage and current. The overall performance of solar energy depends on temperature and radiation, with the change in temperature the solar cell efficiency will change, not only temperature but also fill factor change. The lower insulation level shoe increase percentage of total power being generated. Too much insulation cause saturation of cell and number of free electron and mobility decreases. The sprinkle water cooling system is use to maintain the module temperature and improve the module efficiency because panel is need to low temperature for acquire higher efficiency. When temperature increases then efficiency of solar pv panel increases but at maximum temperature the efficiency start decreases, so for improvement in efficiency we used water sprinkle cooling .it maintain the temperature of module and improve the panel efficiency. Since efficiency decreases between temperature range $(36\text{-}40)^0$c then we use water sprinkle at 40^0c after 3-5 minute it maintain 36^0 c and improve the efficiency.

2. I-V Characteristics

In I-V characteristics we plot the curve between current and voltage and show the relationship between voltages and current. It shows the maximum power at different temperature level and it gives the inverse relationship between current and voltage when radiation 262.8W/M^2. The current and voltage change because due to temperature variation and due to change in voltage and current maximum power will also change.

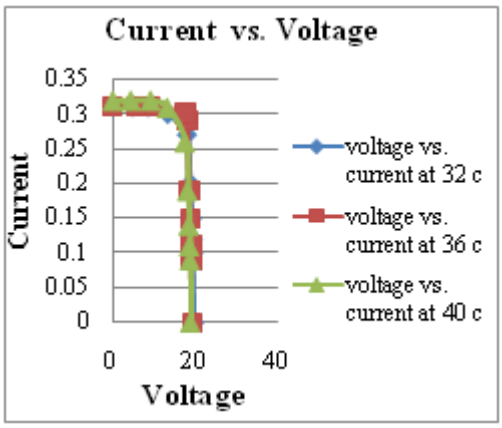

Figure 1: Graph I-V curve of solar cell at different temperature level

In this graph we can see the inverse relationship between current and voltage and maximum power can be obtained at 36^0 C.

3. P-V Characteristic

P-v characteristics show the curve between power and voltage .in power and voltage curve initially power increases but after at higher voltage level it start decreases. Here graph is shown different power and voltage curve at different temperature level.

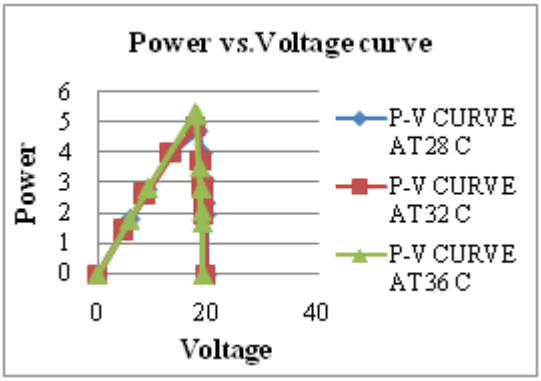

Figure 2: Graph p-v curve of solar cell at different temperature level.

From above graph we can see at different temperature level the variation in power is different and maximum power is obtained at 36^0 c.

4. Experimental Procedure

It describes the function of pv cell parameter with variation in temperature between them. Like open circuit voltage (v_{oc}), short circuit current (i_{sc}), power (p), efficiency, and give the graph between them like I-V and P-V

4.1 Module Specification

Table 1: Module specification

Rated maximum power (p_m)	40 W
open circuit voltage (v_{oc})	21.9 V
Short circuit current (i_{sc})	2.45 A
Rated current(I_{mpp})	2.30A
Rated voltage(V_{MPP})	17.40 V
Area	0.2 m^2
Halogen lamp	900watt
Module temperature	25^0C
Material	Polycrystalline

4.2 Specification for Water Cooling Behaviour

Table 2: Specification for water cooling

Water cooling temperature	28^0c
Height of water pipe	80 cm
Time teken to drop temperature from (40 to 36) ^{0}c	3-5 minute
Motor power rating	18 watt
Voltage	165-250 volt
Output	1200 lt/hr
module	Polycrystalline

We also use a different instrument during experiment like

1) Main controller: - It Show the reading of temperature, open circuit voltage, short circuit current, and it contain port meter by varying port meter we can take reading.
2) Resistance temperature detector (RTD):-Resistance temperature detector use to measure temperature variation of photovoltaic panel.
3) Solar power meter (Radiation measurement):-This instrument is use to measure radiation in w/m^2.

(A) Open Circuit Voltage

Open circuit voltage (v_{oc}) is the voltage across diode when total generate current flow through diode .the open circuit voltage depend on temperature for pn junction and insulation

Open circuit voltage (Voc) =kT/q ln[I_{ph}/I_s]`

Where k is Boltzmann constant, T is temperature, Iph is phase current and I_{SC} is short circuit current.

(B) Short circuit current(I_{sh})

The short circuit current is create to be dependent on temperature .It show that short circuit current initially increases with temperature but at higher temperature it start decreases

Short circuit current (I_{SC}) = I_{SC}[exp q*V_{oc}/KT -1]-I_{ph}

(C) Efficiency (η)

Efficiency show the ratio of output power to the input power we take cell power output as output power and take maximum power point and surface area of solar cell as a input power. It depends upon category of cell. For evaluating module efficiency the output power is divided by radiation and area

$$\text{Efficiency } (\eta) = V_m * I_m / P_{in}$$

Where P_{in}= radiation * panel area

5. Result

In this section we show the overall performance of temperature with respect to current, voltage, and efficiency of pv panel, when radiation is 262.8W/M^2 and we also discussed the water cooling and their efficiency improvement on solar pv panel.

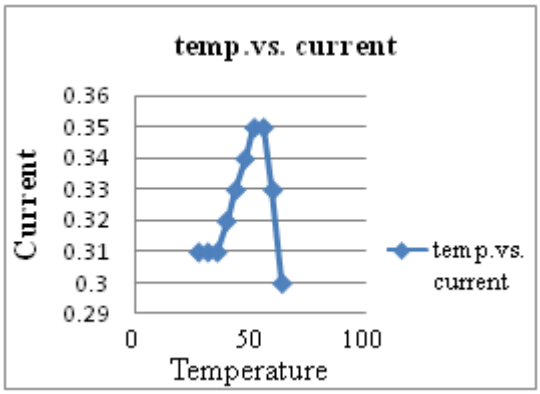

Figure 3: Graph between temperatures vs. current

From above graph we can see current Increases with temperature but at higher level of temperature it starts decreases.

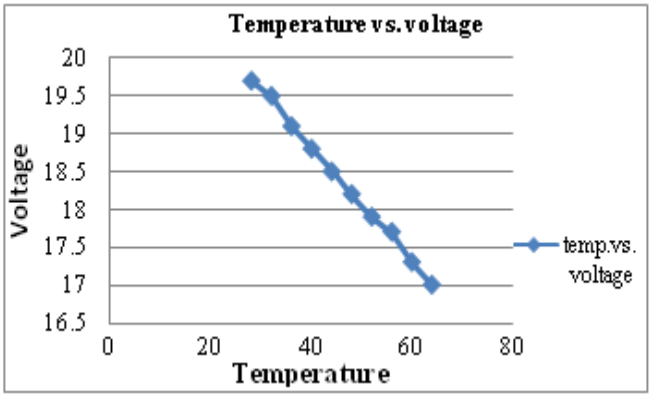

Figure 4: Graph between temperature (T^0C) and voltage (V_{OC})

From above graph the temperature increase then the open circuit voltage decrease. Due to decreases Voltage the maximum power point will change.

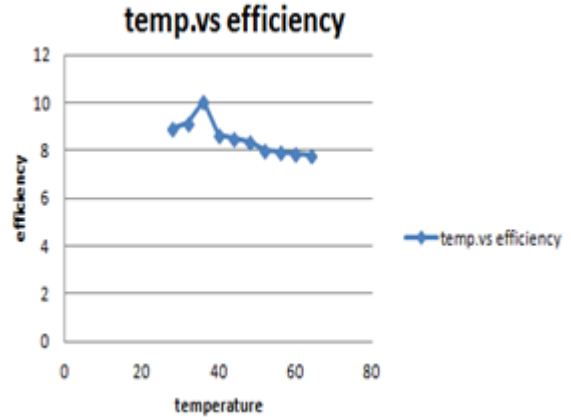

Figure 5: Graph between temperature and efficiency.

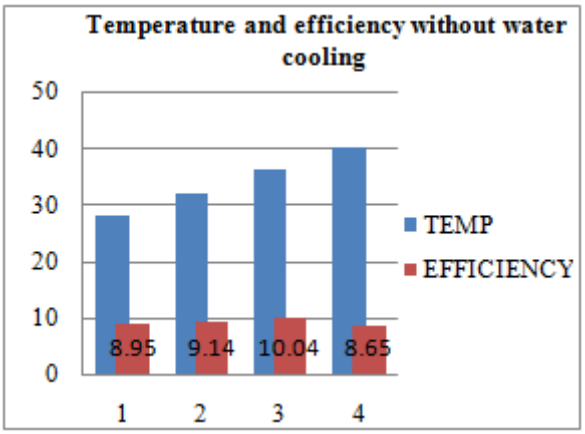

Figure 6: Graph chart between temperature and efficiency without water cooling

From above graph between temperature and efficiency we can see initially temperature increases then efficiency increase but at 36^0c temperature, the efficiency start decreasing.

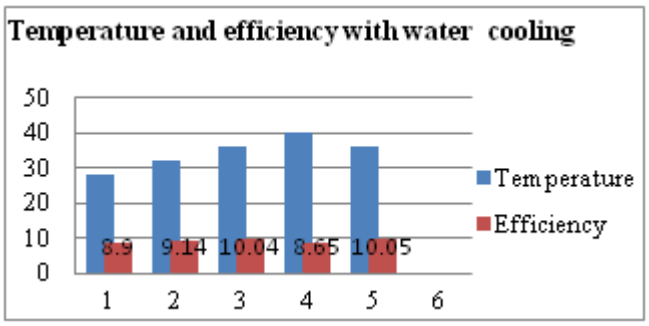

Figure 7: Graph chart between temperature and efficiency with water cooling

From above graph chart we can see initially temperature increases, at point it start decreases but when we use water sprinkle at maintain the temperature and maximum efficiency.

6. Conclusion

From the above study of graphs we found that the efficiency of crystalline silicon solar cell photo module depends on the temperature. The maximum open circuit voltage (voc) 19.7 at 280 c and maximum short circuit current 0.35 at 520c and then decreases at higher temperature. The efficiency initially increases due to increase temperature but at a higher temperature it start decrease and maximum efficiency is obtained at 10.04 %.at 360c .After maximum efficiency the efficiency start reduces that is it decreases (10.04-8.65)%.So our main purpose to maintain this temperature and improvement in efficiency we used water cooling sprinkle method ,water cooled the pv panel and it maintain the temperature and improve the efficiency of pv panel within 3-5 minute .if we compared graph chart 6 and 7 then we conclude following

(1) In graph chart 6, the temperature increases then the efficiency increases but at maximum certain temperature the efficiency started decreasing i.e. efficiency decreases from (10.04 to 8.65) % it means losses in efficiency is 1.39 %
(2) In graph chart 7,when we used a water sprinkle cooling by drop water on pv panel 3-5 minute, then it maintained the temperature from (40 to 36)^{0}c ,and improved the efficiency of solar pv panel i.e.1.40 % approx.

7. Future Scope

The future scope of solar solar energy has large potential, there are following-

(1) If we maintain temperature the efficiency of solar cell will be high and we can use as a many application purpose like, water spray, solar vehicle etc.
(2) Due to varying temperature, we can study the power performance and their efficiency of different types of pv panel.
(3) We can use waste water as a water sprinkle irrigation purpose because all plants need water for growing up

8. Acknowledgment

I would like to thank Mr. Hari Kumar Singh (Associate Professor of Suresh Gyan Vihar University) and my friend's

Shobhit Kumar, Pawan Kumar Pandit, Saurav Kumar for their valuable suggestion towards my paper.

References

[1] V.fthenakis,Third Generation photovoltaic pp.202, InTech publisher,Croatia 2002
[2] P.Mialhe,H.Toufik,M.Tachi,N.Toufik and W.Tazibt,"silicon for optoelectronic "journal of Electron devices,vol.6,pp.170-173,2008
[3] P.mialhe,H.Tanhchi,N.Toufic,and w.Tazibt for optoelectronic",jouranal of electronic devices,vol.6,pp.170-173,2008
[4] Qusay assim hanna al-Nases,Noorah MohammedAhmed Al-barghoothi,Noor Ahmed salman"IJEBEA,ISSN:2279-0020,PP108-112,2013
[5] Pradhan Arjyadara,Ali S.m,jena chitralekha,IJECT,VOL-2,P.P 214-220-2013
[6] Ike,C.U,International journal of Engineering and science,vol.3 p.p 10-14,2013
[7] Awachie,I.R.N and Okeke C.E,The Effect of Climatology Factor on total solar radiation .vol-4.p.p-53-58-1985.
[8] HaithamM.Bahaidarach,S.Raheman,P.Gandhiasan and Bilal Tanwer,"Experimental Evaluation of performance of photovoltaic panelwith water cooling" IEEE,978-1-4799-3/13-2013
[9] R.L Donovan and H.C Hunter, The Kilowatt Photovoltaic concentrating array.13th IEEE photovoltaic specialists conf.washington,DC,pp.1125-1130-1978

Author Profile

Pawan Kumar Tiwari was born in 1991 in India. He completed B.Tech first class in Electrical Engineering in 2013 and pursuing M. Tech in Energy Engineering from Suresh Gyan Vihar University, Jaipur India. His research interested on Experimental Investigation of the Effect of Temperature Variation on Photovoltaic Cell And Efficiency improvement by water cooling. He is at Suresh Gyan Vihar school of Engineering and Technology, Jaipur, India (Rajasthan)