Experimental Analysis of solar panel efficiency with different modes of cooling

*B.Koteswararao[1] K. Radha krishna[2] P.Vijay[3] N.Raja surya[4]
[*1]Assistant Professor, Department of Mechanical Engineering, K L University, Guntur, India-522502
[2]Assistant Professor, Department of Mechanical Engineering, K L University, Guntur, India-522502
[3]Assistant Professor, Department of Mechanical Engineering, K L University, Guntur, India-522502
[4]Assistant Professor, Department of Mechanical Engineering, K L University, Guntur, India-522502
*basam.koteswararao@gmail.com;+91-9394810064;9951045471

ABSTRACT - The new capital[2] area of andhrapradesh[1] having huge power demand. We can meet up to certain requirement throughout the year by using renewable energy[4] resources like solar[5] energy. Because this is the place where the sun intensity[3] available much more. Our paper gives better utilization[6] methods of sun energy through these methods. Even though we are having plenty amount of solar energy availability but we are unable to utilize solar energy effectively due to temperature variation from time to time. We can maintain constant power generation by the help of cooling .Our paper suggests the best cooling method for solar PVC panels among two cooling methods that is water and air. In water cooling cross flow and parallel flow used. Thermal sensor automatically switches on the motor after reaching panel over heat. The efficiency of the panel and Fill Factor measured in all the conditions.

Keywords: Andhrapradesh[1], capital[2], intensity[3], renewable energy[4], solar[5], utilization[6]

I. INTRODUCTION

A solar cell[1] is a device that straightly converts the energy from sunlight in to electrical energy through the process of photovoltaics. A typical PV module has an excellent conversion efficiency in the range of 31%. The remaining energy is converted into heat and this heat increases the operating temperature of PV system which affects the electrical power production of PV modules and this can also cause the structural damage of PV modules guide to shorting its life span and lowering conversion efficiency. The output power of PV module drops due to rise in temperature, if heat is not removed . One of the main obstacles that face the operation of photovoltaic[1,2] panels (PV) is overheating due to excessive solar radiation and high ambient temperatures. Overheating decreases the efficiency of the panels dramatically.The ideal P–V characteristics of a solar cell for a temperature variation between 0^0 C and 75^0 C , which is adopted from Rodrigues et al. The P–V characteristic is the relation between the electrical power output P of the solar cell and the output voltage, V, Relay is the electromagnetic switch and when temperature moves above 49^0C,relay operates and activate supply of cooling water continuously up to panel reach temperature 45^0C.

II. EXPERIMENT SETUP

The cooling system consist of

1. Motor

(a solar water pump enveloped has lifted the 2.4 m^3/h water to 10 meters height with the help of 12 V 17 AV battery)

Table: 1. Motor/Pump specifications

MOTOR SPECIFICATIONS	
Rated voltage	DC 12 V
Current	7 A
Speed	40 rpm
Noise	60 db
PUMP SPECIFICATIONS	
Type	Single acting recepocating
Diameter	80 mm
Stroke (L)	160 mm
Head	11 Meters
Mechanical efficiency	54%

2. Solar panel
3. Multi-Meter
4. Battery
5. Cooling panels-2 types
6. Thermal sensor
7. Distributor
8. Collecting tank.

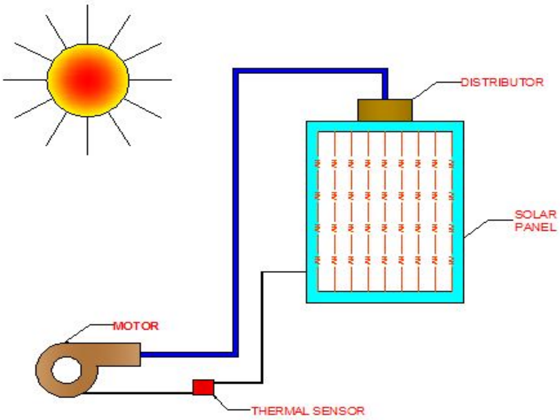

Figure: 1.Layout of Project (Experiment)

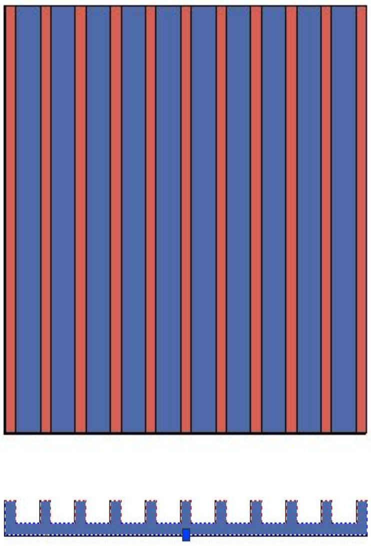

Figure: 2.Front view and top view of parallel flow cooling panel

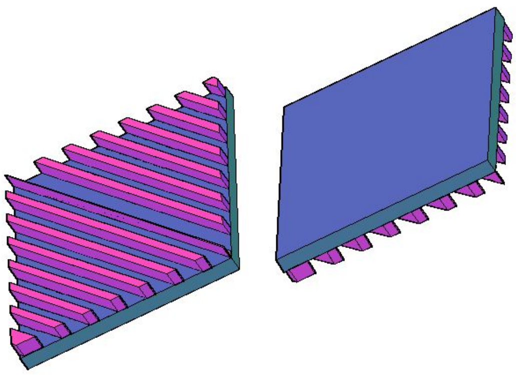

Figure: 3.cross flow type panel

River water taken with the help of motor and outlet of motor connected to distributor. Which is used to send the water to panel maintain equal flow. Then the water stored[6,7] in the bottom case and once more submitted to river. The power generation connected to battery and multimeter.

We took readings for few days on 50W panel.12V and 4.1ampheres.those reading are tabulated below and also for three modes separately. The best readings in each case out of nine readings are tabulated in table no.3.

II.I. Technical specifications of 50 W 12 V solar module panel:

Table:2 .panel specifications

Multi crystalline	50 w
Minimum power output	93 %
Voltage p_{max}	17 V
Maximum power	45 W
Current at P_{max}	2.9 A
Short circuit current	3.15 A
Open circuit voltage	20.9 V
Cell operating temperature	47+2 or 47-2 ^{0}C
Dimensions	770 L X510 W X 52 mm
Weight	6.5 Kg
Solar cells	72 cells in 4 X 18 matrix form connected in 2 parallel strings of 36 in series.

Using air as a coolant was found to reduce the solar cells temperature by 5.2 °C and increases the solar panel efficiency by 3.3%, while using water as a coolant in parallel flow[4] was found to decrease the solar cells temperature by 10 °C and the panel efficiency by 4.2%.Where as water as a coolant in counter flow was found to decrease the solar cells temperature by 12 °C and the panel efficiency by 4.8% when compare to standard efficiency. Therefore, cross flow cooling by water was found to be more effective than air cooling.

Table: 3 output results for 50W panel.

. TIME	CIRCUIT VOLTAGE (V)		
	WITH OUT COOLING(V)	PARALLEL COOLING(V)	CROSS FLOW(V)
8:00 AM	15.7	15.9	16
9:00 AM	15.9	16.0	16,3
10:00 AM	16.1	16.1	16,4
11:00 AM	16.4	16.3	16,6
12:00 PM	16.5	16.5	17
1:00 PM	16.7	16.8	17
2:00 PM	16.6	17	16.8
3:00 PM	16.2	16.9	16.7
4:00 PM	16.0	16.4	16.5
5:00 PM	15.9	16.1	16.3

A commercial polycrystalline solar panel with an area of 770 X 510 mm^2 was tested. PV panel specifications are shown in Table 2. The experimental setup is consists of 12W power rating solar panel, 12V battery 20 AH battery, volt meter, ammeter, solar lamp and cooling system. The photographic view of experimental set up is shown in Figure 1. the water. The solar panel is located on 3 feet mild steel stand with a tilt angle of 18°(Based on Vijayawada altitude and latitude). The solar panel is connected to the positive terminal and negative terminals of the battery through the voltmeter and ammeter. Battery is discharged with bulb load. Schematic diagram of output characteristics test system of solar panels is shown in Figure 2 Voltmeter and ammeter were used in range of 0-50 V and 1-10A respectively. 4W DC bulb was used as the load. A solarimeter[12] was used to measure the real-time solar radiation intensity (800 W/m^2). Temperatures of the solar panel, ambience and the water in the tank was monitored with digital thermometer. The water is supplied with the motor to the distributor. The flow rate of water is controlled by knob in the hose pipe line. The setup is placed towards south in the direct sunlight and the readings of ammeter and voltmeter are noted in hour by hour and the panel temperature was also noted using digital thermometer. Readings were recorded for every one hour on 4th June 2015 from 8.00 am to 17.00 pm without water cooling. The same procedure was repeated from 6-10th May 2015 with water cooling by varying the flow rate from 10 litre/hr up to 30 litre/hr in step of 1 litre/hr. Weather conditions on those days the air temperature was 35^0 C and the water temperature was between 23^0 C to 28^0C.Wind speed 1.3 m/s.

Following Fig4. shows the temperature distribution over the panel surface the heat transfer analysis of panel with cooling of solar pannel. Thermal Specification as Environment. Having atmospheric temperature of 39^0C. It is found that the temperature[9,10] attained by panel is 50^0C by considering solar load on top glass of the panel. Then the water flow will start due to activation of thermal sensor.

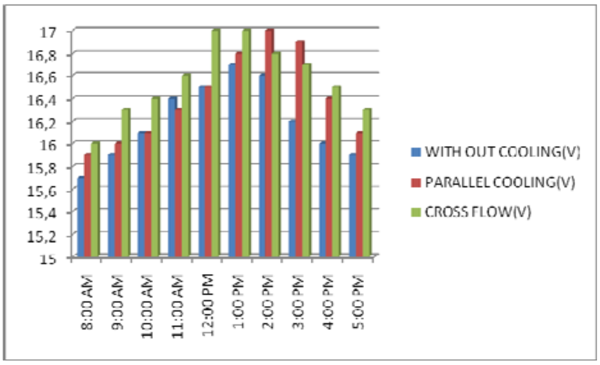

Figure: 4.Graph for three modes of cooling

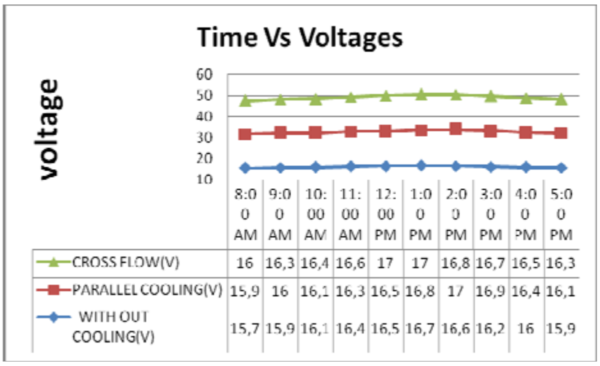

Figure:5.Time Vs voltage for three modes

III. RESULTS

The efficiency of the panel caluculated by following relation.

$\eta = (V_m . I_m / I.A)$

Where

V_m =Maximum voltage (V_{max})

I_m = Maximum current (I_{max})

I = Solar intensity on earth surface (W/M^2)

A – Effective area of the cell [m^2].

Fill factor of current – voltage characteristic of solar cells can be calculated by using the following relation:

$FF = Vm \cdot Im / Voc \cdot IsC$

Where:

Voc = pen circuit voltage [V],

Isc = short circuit current [A].

Table:4. characteristic of the solar panel with cross flow cooling

Time	Vm (V)	I m (A)	P max	I w/m^2	F F
8:00 AM	16	1,01	16,16	730	0,517
9:00 AM	16,3	1,05	17,115	780	0,547
10:00 AM	16,4	2,1	34,44	810	0,698
11:00 AM	16,6	2,2	36,52	835	0,741
12:00 PM	17	2,6	44,2	840	0,896
1:00 PM	17	2,5	42,5	850	0,862
2:00 PM	16,8	2,5	42	835	0,851
3:00 PM	16,7	2,4	40,08	820	0,812
4:00 PM	16,5	2,3	37,95	790	0,769
5:00 PM	16,2	2,3	37,26	740	0,755

From the above table it is observed that, the efficiency of the panel is reaches 21% in cross flow cooling from 16%. Average Fill Factor for cross flow 0.744, parallel flow 0.72 and without cooling condition 0.691.

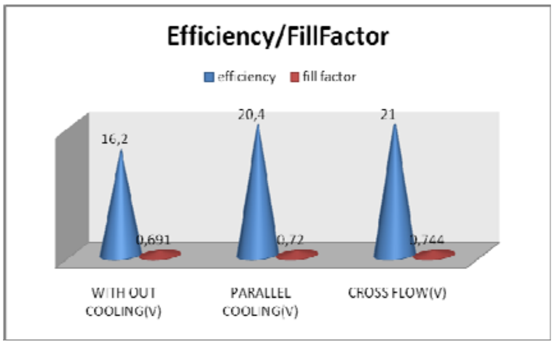

Figure:6. Results of the project

IV. CONCLUSION

We can improve the efficiency of the panel by cross flow. From the graphs it is clearly observed that due to cross flow cooling in particular time we can get 1.6 times output when compare to without cooling. Among tested three types cooling methods cross flow gives better power output and efficiency level reaches 21% from 16.2%. We can also improve some more by using optical filters. With less maintenance we improved much efficiency of the panel and also Fill Factor.

ACKNOWLEDGEMENT

We would like to express my sincere thanks and indebtedness to GOD almighty for his grace and bounteous blessings for successfully completing this project. I am highly thankful to my roommate for their cooperation to full fill this design and paper.

I express my heart full thanks to Ms. Bhanu Kiran for his support to complete this Design and assembly work. This acknowledgement would be incomplete without expressing our gratitude to our parents who act as a beacon light and inspired us unconditionally and to our friends who motivated us during the tenure of academic works.

REFERENCES

[1] Joshi AS, Tiwari A, Tiwari GN, Dincer I, Reddy BV (2009) Performance evaluation of a hybrid photovoltaic thermal (PV/T) (glass-to-glass) system. Int J Thermal Sci 48:154.
[2] Dubey S, Sandhu GS, Tiwari GN (2009) Analytical expression for electrical efficiency of PV/T hybrid air collector. Appl Energy 8: 697-705.
[3] Chowdary TT (2010) A review on photovoltaic/thermal hybrid solar technology. ApplEnergy 89: 365-9.
[4] Rott N (1991) Note on the history of the Reynolds number. Annual Review ofFluid Mechanics 22: 1–11.
[5] Gnielinski V (1996) New equations for heat and mass transfer in turbulent pipeand channel flow. Int Chem Engg 16: 359–368.
[6] Angist, S.W., 1970. Energy Conversion (All0yn and Bacon, Inc., Boston, Mc,)
[7] Field Rl. Photovoltaic / Thermoelectric Refrigerator for Medicine Storage for Developing Countries. Solar Energy 1981; 25(5):4356.
[8] Omegaa.(n.d.)The thermocouple. Retrieved September 11, 2011, from http:// www.omegaa.com/temperature/z/ pdf/z022-034.pdf
[9] International Journal of Solar Engineering (IJSE), Volume (4): Issue (III): 2012, Riffat SB. Xiaolima Thermo-Electric: A Review of Present and Potential Applications. Applied Thermal Engg. 2004:22:912– 36.

[10] Dai Yj, Wang Rz, Ni L. Expr. Investigation on A Thermo-Electric Refrigerator Driven By Solar Cells. Renew Energy 2003; 28:949–59.
[11] Tarak Salmi, Mounir Bouzguenda, Adel Gastli, Ahmed Masmoudi (2012) MATLAB/ Simulink modeling of solar photovoltaic cell',
[12] International journal of RENEWABLE ENERGY RESEARCH, Vol.2, No.2
[13] Tiwari .G. N., Swapnil Dubey, 'Fundamentals of Photovoltaic Modules and Their Applications oriented', Royal Society of Chemistry, may 2011 .

AUTHOR PROFILE

*B.KOTESWARARAO was born in yedlurupadu Village,Prakasam District, India, in 1990. He received the B.Tech in Mechanical Engineering from the JNT University Kakinada, India, in 2011, and M.Tech Degree in Thermal Engineering from the university college of Kakinada, India, in 2014. Currently he is working as Asst.Professor in KLuniversity , Vijayawada. From May 2011 to December 2012, he has been with the Department of Mechanical Engineering, RVR Institute of Engineering & Technology. Where he was an Assistant Professor. His current research interests include alternative fuels, automobile emission reduction, and power plant Optimization. He is a SENIOR MEMBER in INDIAN SOCIETY OF MECHANICAL ENGINEERS. He published more than 15 papers in various international journals and delivered presentations in various national and international conferences.

[2]K.RADHAKRISHNA was born in Vijayawada, India, in 1981. He received the B.Tech. Degree in Mechanical Engineering from the JNTU Technological University Hydrabad, India, in 2005, and the M.E. Degree in CAD/CAM from from Andhra university in 2011. Presently he is a Research Scholar in K.L university and also working as Assistant Professor.From May 2012. alternative fuels, automobile emission reduction , and power plant optimization.