International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 02 | Feb 2023 www.irjet.net p-ISSN: 2395-0072

Design of The Cooling System for Optimizing the Performance of Solar Panel

Abdul Qayyum [1], Shilpa Mondkar[2],

[1] Student, Dept. of Mechanical Engineering, Pillai College of Engineering, Maharashtra, India
[2] Professor, Dept. of Mechanical Engineering, Pillai College of Engineering, Maharashtra, India

***

Abstract - *There is a persistent need for further development and implementation of renewable energy sources, such as wind and solar. Due to the increase in global population, the disappearance of fossil fuels, and the reality of climate change, renewable power is needed now more than ever. These modules work via silicon cells which are as semiconductors, outputting electrical energy when incident with solar radiation. This is done by separating electrons and protons within the cell. Additionally, the lifespan of a PV system is significantly reduced as a result of cell degradation due to excess thermal stress. For this project, I have modeled, prototyped, and tested three cooling systems for PV modules. Two of the cooling systems are passive, non-power consuming. One simply consisting of a large Acrylic tank centered on the backside of the module, and the other consisting of a combination of copper heat pipes and the same aluminum heat sink. The third system consisted of a water-cooling method where water was pumped over the working surface of the module from a reservoir, being evenly spread across the working surface through a perforated tube.*

1. INTRODUCTION

This document is template. The growing acceptance of climate change as a real and present danger all life on Earth. All of these factors have caused a huge increase in the investment of renewable power options. Solar PV, photovoltaic, is just one of numerous promising renewable power generations methods. Unfortunately, PV cell technology performance is sensitive to operating temperature. Since power is generated via silicon cells which is semiconductor material, outputting electric power when incident with solar radiation. Like all semiconductors as the operating temperature increase s, the output voltage drastically decreases despite a slight increase in the output current resulting in an overall significant reduction in power production and module efficiency. Photovoltaics global potential, as a primary power source, is dependent upon designing more efficient PV systems. Creating immense interest within the scientific community in possible PV cooling over the last 40 year

1.1 Operating Principle

Photovoltaics directly convert solar radiation into electricity. Each cell is comprised of layers of a semiconducting material, p and n-Type. When incident with light, the cell enacts an electric field between layers, resulting in an output voltage and current. The cells are either polycrystalline, made up of pieces from numerous silicon crystals, or monocrystalline, which are cut from a single large crystal. That process of conversion take place with addition of heat which increases the PV cell temperature, which later transferred into the water through copper plate. As the temperature of PV cell increases the water temperature increases. As the water surface which is in contact with plate getting warmer and warmer it starts to moving through copper pipe which is submerged in a water in enclosed earthen pot.

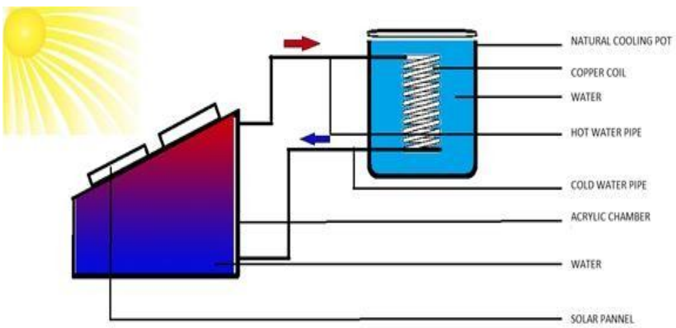

Fig – 1: Illustration of Solar Cooling System

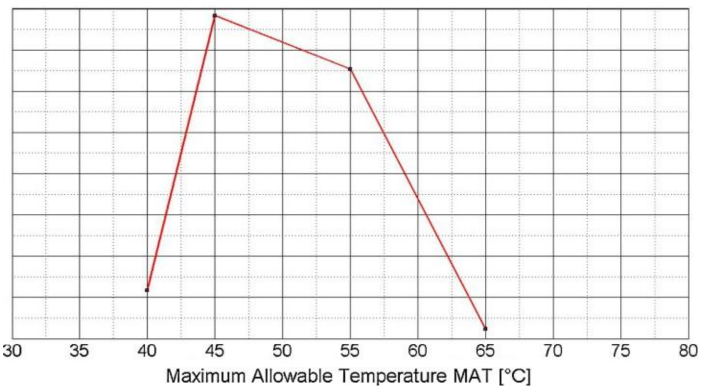

Chart – 1: Temperature vs output graph

Ref: K.A. Moharram, M.S. Abd-Elhady, H.A. Kandil,

Experimental Readings (Without cooling system) (Avg. Value)			
Date	Solar Plate (·c)	Current (A)	POWER (W)
28/10/22	70.33	0.84	5.06

Table -1: experimental readings

2. LITREATURE REVIEW

Many academics have recently started looking at solarpanels and techniques to harvest thermal energy from them. Numerous research using the front and back sides of thecells for cooling has been explored in a number of studies. Several attempts have been documented to control the temperature of PV panels using air, water, piezoelectric materials, and other methods. Solar panels' efficiency degrades as a resultof absorbed heat; hence solar panel cooling is critical.

1. Mohsin Jamil et al. In 2014 presented the possibility of extraction of thermal energy from the panels using water. Their research shows The results of the experiment for improving efficiency of solar panel using mirrors and cooling were come out to be highly encouraging. Using mirrors plus cooling is better than the other two as efficiency is approximately 52%

2. K.A. Moharram, et al. In 2013 reported performance enhancement by cooling of photovoltaic panels. System for cooling was designed and developed using water as coolant. The cooling system was combined through solar photovoltaic panels to form hybrid system. Cooling agent for cooling the solar panels i.e. water, was continually circulated in the region of the PV panels. The high temperature water generated from the system can be used for variety of household applications.

3. Fahad Al-Amri, et al. In 2020 reported performance enhancement by cooling of photovoltaic panels. System for cooling was designed and developed using passive cooling. The cooling system was combined through solar photovoltaic panels to form hybrid system. The system used for cooling the solar panels i.e. heat sink in addition with PCM material.

4. Barbara Swatowska, et al. In 2011 designed and developed a hybrid type Silicon cell solar system. He investigated That reflection coefficient can be reduced by covering the top of the solar panel surface by antireflective coatings and also discuss the effect of thickness of ARC on solar

5. A. Ibrahim et al. In 2011 presented comprehensive simulation studies. In their research they have studied the relation of solar panel efficiency and operating temperature in outdoor atmosphere. Cold temperatures produce more efficient photo conversion for single-crystal solar panels. The efficiency for single-crystal solar panel decreases as the operating temperature of cells increases. It is reported in the literature that the decrease in the efficiency is approximately 0.06 in absolute value per ˚C increase

6. F.M. Gaitho et al. In 2009 reported that the efficiency of single crystal silicon solar panel very much depends on the thermal system of the entire cell, the main factor being thermal conductivity, which is greatly seen to vary with temperature. The efficiency of this cell is optimum when its output is at its highest value at a nominal operating cell temperature of 312 K.

7. Y M Irwan, et al. In 2015 compared air and water cooling methods and found out that water as cooling agent is much better compared to air. For constant air movement they used fan and water pump was used to maintain circulation of coolant on the reverse side and front side of PV module respectively. Temperature detection of PV Temperature was carried by sensors which were installed on the PVmodule. To automatically switch ON or OFF fan and water pump was connected to PIC microcontroller.

8. Manel Hammami, et al. In 2017 reported despite the cooling air gap, there is a remarkable PV cell temperature increase introduced by the back side batteries, estimated at 20–25 °C for the PV cells on the battery area.

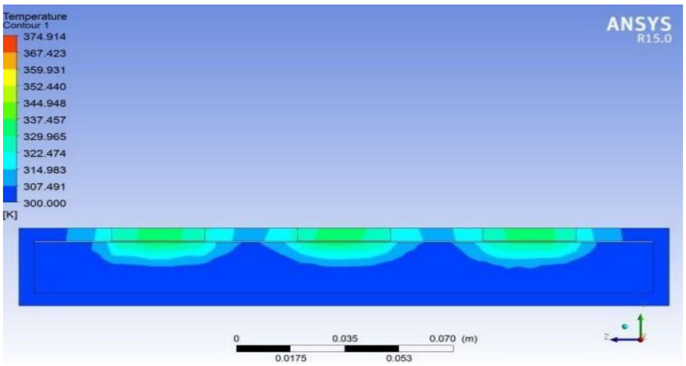

Fig -2: Thermal Analysis of solar plate by Ref: Manel Hammami

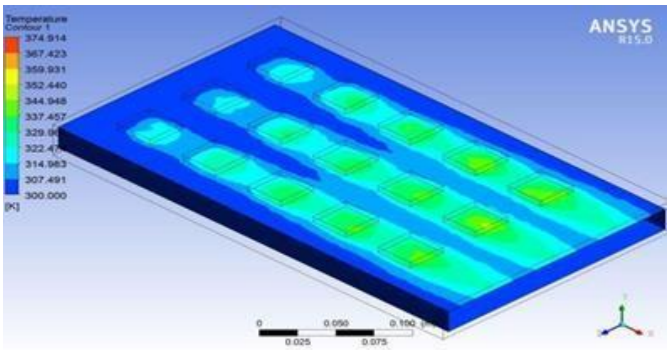

Fig -3: Thermal Analysis of solar plate by Ref: Manel Hammami

3. CAD Modelling and Material selection

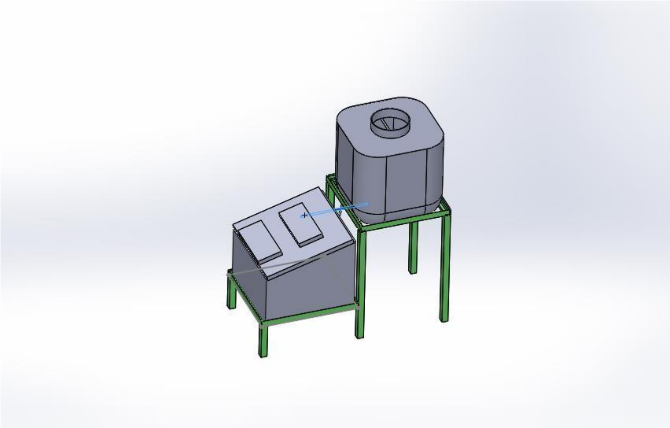

Fig -4: CAD model of The Cooling System

To prepare any machine part, the type of material should be properly selected by considering design, safety andfollowing points:

The selection of material for engineering application isgiven by the following
Factors: -

1) Suitability of the material for the required components.
2) Suitability of the material for the desired conditions.
3) Availability of materials.
4) Cost of the materials.

3.1 Coolant

The coolant which we selected for this experiment is Water.

Thermal conductivity (W/mk)	0.61
Density	997
Dynamic Viscosity	0.89
Heat Capacity	4.2

Table 3.1.1: Thermophysical Property of Liquid Used

3.2 Cooling Chamber

Cooling chamber used here is made of mud and POP as it has porous surface and can perform capillary action and keeps the water cool which is stored inside.

Fig -5: Cooling Chamber

3.3 Tank

Tank is made of Acrylic, as Acrylic is much economical compared to any other metal and also put good resistance to outside heat

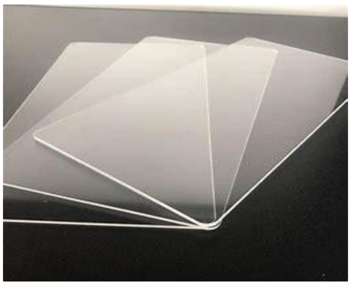

Fig -6: Acrylic

3.4 Pipes

Pipes which is used here are of copper as it is a good thermal conductor.

Fig -7: Copper Pipe

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 02 | Feb 2023 www.irjet.net p-ISSN: 2395-0072

3.5 Prototype

Fig -8: Prototype

4. Experimental Observation

From October/28/2022, until November/4/2022, we conducted an experiment to obtain the most accurate reading possible. The results are highly encouraging, and the reading we obtained during this experiment is listed below.

Location	Navi Mumbai, Panvel
Range of temperature in day	28 C to 36 C
Atmospheric pressure	1 Bar
Local time of conducting the experiment	12.00 PM IST

Table -4.1: Geographical Condition of area

DATE	TIME	Plate Temp (C)	water temp (C)	Current (A)	Voltage (V)	Power(W)	outside temp (C)
28-Oct-22	12:00	54	0	0.87	6	5.2	30
28-Oct-22	12:30	61	0	0.87	6	5.2	32
28-Oct-22	01:00	68	0	0.85	6	5.1	33
28-Oct-22	01:30	73	0	0.87	6	5.2	33
28-Oct-22	02:00	76	0	0.85	6	5.1	34
28-Oct-22	02:30	77	0	0.80	6	4.8	34
28-Oct-22	03:00	75	0	0.83	6	5	32
28-Oct-22	03:30	75	0	0.83	6	5	31
28-Oct-22	04:00	74	0	0.83	6	5	30
	AVG.	70.33333333	0	0.84		! .066666667	32.11111111

Table -4.2: experimental readings (Without Water)

Date	TIME	Plate Temp (C)	water temp (C)	Current (A)	Voltage (V)	Power (W)	outside temp (C)
29-Oct-22	12:00	50	26	0.87	6	5.2	31
29-Oct-22	12:30	58	31	0.87	6	5.2	31
29-Oct-22	01:00	65	36	0.88	6	5.3	34
29-Oct-22	01:30	67	37	0.90	6	5.4	34
29-Oct-22	02:00	66	40	0.90	6	5.4	33
29-Oct-22	02:30	65	42	0.92	6	5.5	32
29-Oct-22	03:00	68	42	0.88	6	5.3	32
29-Oct-22	03:30	67	40	0.87	6	5.2	31
29-Oct-22	04:00	67	38	0.87	6	5.2	30
	AVG.	63.66666667	36.88888889	0.88		5.3	32

Table -43.: experimental readings (Without Water)

Date	TIME	Plate Temp (C)	water temp (C)	Current (A)	Voltage (V)	Power (P)	outside temp (C)
30-Oct-22	12:00	52	26	0.88	6	5.3	29
30-Oct-22	12:30	55	29	0.88	6	5.3	29
30-Oct-22	01:00	60	33	0.88	6	5.3	34
30-Oct-22	01:30	66	37	0.88	6	5.3	34
30-Oct-22	02:00	67	40	0.90	6	5.4	35
30-Oct-22	02:30	67	43	0.90	6	5.4	34
30-Oct-22	03:00	65	44	0.88	6	5.3	32
30-Oct-22	03:30	64	40	0.87	6	5.2	30
30-Oct-22	04:00	61	39	0.87	6	5.2	30
	AVG.	61.88888889	36.77777778	0.88		5.3	31.88888889

Table -4.4: experimental readings (Without Water)

Date	Time	Plate Tempe (C)	Water Temp (C)	Current (A)	Voltage (V)	Power (W)	outside temp (C)
31-10-2022	12:00	50	28	0.88	6	5.3	30
31-10-2022	12:30	56	30	0.88	6	5.3	31
31-10-2022	01:00	58	31	0.90	6	5.4	33
31-10-2022	01:30	62	35	0.90	6	5.4	34
31-10-2022	02:00	64	41	0.90	6	5.4	36
31-10-2022	02:30	65	43	0.88	6	5.3	34
31-10-2022	03:00	63	38	0.87	6	5.2	34
31-10-2022	03:30	63	37	0.87	6	5.2	33
31-10-2022	04:00	60	34	0.87	6	5.2	31
	AVG.	60.11111111	35.22222222	0.88		5.3	32.88888889

Table -4.5: experimental readings (With Water)

Date	TIME	outside temp (C)	water temp (C)	Current (A)	Voltage (V)	Power (W)	outside temp (C)
01-Nov-2022	12:00	49	28	0.90	6	5.4	30
01-Nov-2022	12:30	56	32	0.87	6	5.2	30
01-Nov-2022	01:00	61	35	0.88	6	5.3	34
01-Nov-2022	01:30	65	39	0.92	6	5.5	34
01-Nov-2022	02:00	68	43	0.92	6	5.5	33
01-Nov-2022	02:30	67	42	0.90	6	5.4	32
01-Nov-2022	03:00	64	42	0.88	6	5.3	31
01-Nov-2022	03:30	60	41	0.87	6	5.2	31
01-Nov-2022	04:00	56	37	0.85	6	5.1	30
	AVG.	60.66666667	37.66666667	0.89		5.3	31.67

Table -4.6: experimental readings (With Water)

Date	Time	Plate Tempe (C)	Water Temp (C)	Current (A)	Voltage (V)	Power (W)	outside temp (C)
02-Nov-22	12:00	50	30	0.90	6	5.4	32
02-Nov-22	12:30	53	32	0.88	6	5.3	33
02-Nov-22	01:00	59	36	0.87	6	5.2	33
02-Nov-22	01:30	67	36	0.88	6	5.3	35
02-Nov-22	02:00	76	41	0.90	6	5.4	35
02-Nov-22	02:30	77	45	0.92	6	5.5	34
02-Nov-22	03:00	75	45	0.90	6	5.4	32
02-Nov-22	03:30	73	41	0.90	6	5.4	31
02-Nov-22	04:00	70	39	0.90	6	5.4	31
	AVG.	66.66666667	38.33333333	0.89		5.366666667	32.88888889

Table -4.7: experimental readings (With Water)

Date	Time	Plate Tempe (C)	Water Temp (C)	Current (A)	Voltage (V)	Power (W)	outside temp (C)
03-Nov-22	12:00	53	30	0.87	6	5.2	30
03-Nov-22	12:30	56	34	0.90	6	5.4	34
03-Nov-22	01:00	63	38	0.90	6	5.4	36
03-Nov-22	01:30	67	40	0.90	6	5.4	36
03-Nov-22	02:00	71	43	0.88	6	5.3	35
03-Nov-22	02:30	68	45	0.88	6	5.3	35
03-Nov-22	03:00	66	44	0.88	6	5.3	33
03-Nov-22	03:30	62	40	0.87	6	5.2	33
03-Nov-22	04:00	60	37	0.87	6	5.2	33
	AVG.	62.88888889	39	0.88		5.3	33.88888889

Table -4.8: experimental readings (With Water)

Date	Time	Plate Tempe (C)	Water Temp (C)	Current (A)	Voltage (V)	Power (W)	outside temp (C)
05-Nov-22	12:00	53	32	0.87	6	5.2	33
05-Nov-22	12:30	56	32	0.90	6	5.4	34
05-Nov-22	01:00	63	38	0.90	6	5.4	36
05-Nov-22	01:30	67	46	0.88	6	5.3	37
05-Nov-22	02:00	71	49	0.87	6	5.2	36
05-Nov-22	02:30	70	45	0.88	6	5.3	35
05-Nov-22	03:00	68	45	0.88	6	5.3	34
05-Nov-22	03:30	62	43	0.88	6	5.3	33
05-Nov-22	04:00	60	41	0.87	6	5.2	31
		63.33333333	41.22222222	0.88		5.288888889	34.33333333

Table -4.9: experimental readings (With Water)

Date	Time	Plate Tempe (C)	Water Temp (C)	Current (A)	Voltage (V)	Power (W)	outside temp (C)
	12:00	53	29	0.87	6	5.2	32
04-Nov-22	12:30	56	32	0.90	6	5.4	34
04-Nov-22	01:00	63	38	0.90	6	5.4	36
04-Nov-22	01:30	67	44	0.92	6	5.5	36
04-Nov-22	02:00	71	49	0.88	6	5.3	36
04-Nov-22	02:30	70	45	0.87	6	5.2	35
04-Nov-22	03:00	68	45	0.88	6	5.3	34
04-Nov-22	03:30	62	43	0.87	6	5.2	33
	AVG.	63.33333333	40.66666667	0.88		5.3	34.22222222

Table -4.10: experimental readings (With Water)

Date	Time	Plate Tempe (C)	Water Temp (C)	Current (A)	Voltage (V)	Power (W)	outside temp (C)
06-Nov-22	12:00	53	32	0.87	6	5.2	33
06-Nov-22	12:30	56	32	0.90	6	5.4	34
06-Nov-22	01:00	63	38	0.90	6	5.4	36
06-Nov-22	01:30	67	46	0.88	6	5.3	37
06-Nov-22	02:00	71	49	0.90	6	5.4	36
06-Nov-22	02:30	70	45	0.88	6	5.3	35
06-Nov-22	03:00	68	45	0.88	6	5.3	34
06-Nov-22	03:30	62	43	0.88	6	5.3	33

Table -4.11: experimental readings (With Water)

4. Summary of conclusion

1. From the above experiment we can safely conclude that when there is no active cooling system involve the maximum average power output is 5.06 W (Ref. Table 4.1).
2. But When we start using the cooling system the average output increases to 5.3W also the average current output is also increased to 0.9 (Ref. Table 4.2 to Table 4.10).
3. Apart from that the average maximum temperature attained by the solar plate is 71 ^{0}C while with activated cooling system the average temperature lies between the range of 60 ^{0}C-63 ^{0}C.
4. After completion of the experiment the average power output increases by 7%.
5. Average Maximum temperature decreases by 8 ^{0}C which can prevent cell degradation and increases the life expectancy of solar plate.
6. The above mention are short term advantages that we have seen during the experiment, for more accurate outcomes we have to expand the duration of course.

5.ACKNOWLEDGEMENT (Optional)

The authors sincerely appreciate the technical assistance offered by the Prof. Shilpa Mondkar and Department of Mechanical Engineering, MES Pillai College of Engineer

6.REFERENCES

[1] Fahad Al-Amri, Taher S. Maatallah, Omar F. Al-Amri Sajid Ali, Sadaqat Ali, Ijlal Shahrukh Ateeq, Richu Zachariah, Tarek S. Kayed Innovative technique for achieving uniform temperatures across solar panels using heat pipes and liquid immersion cooling in the harsh climate in the Kingdom of Saudi Arabia Alexandria Engineering Journal (2022) 61, 1413–1424

[2] K.A. Moharram, M.S. Abd-Elhady, H.A. Kandil, H. El-Sherif Enhancing the performance of photovoltaic panels bywater cooling, Ain Shams Engineering Journal (2013),
Ain Shams Engineering Journal (2013) 4, 869–877

[3] A. Ibrahim Analysis of Electrical Characteristics of Photovoltaic Single Crystal Silicon Solar Cells at Outdoor Measurements, Smart Grid and Renewable Energy, 2011, 2, 169-175

[4] Manel Hammami Simone Torretti, Francesco Grimaccia and Gabriele Grandi Thermal and Performance Analysis of a Photovoltaic Module with an Integrated Energy Storage System, IEEE Trans. Energy Convers. 2015, 30, 1386–1396

[5] Rizwan Arshad, Salman Tariq, Muhammad Umair Niaz, Mohsin Jamil Improvement in solar panel efficiency using solar concentration by simple mirrors and by cooling
2014 International Conference on Robotics and Emerging Allied Technologies in Engineering (iCREATE)

[6] E.M.G. Rodrigues, R. Melício, V.M.F. Mendes and J.P.S. Catalão Simulation of a Solar panel considering Single-Diode Equivalent Circuit Model, International
Conference on renewable energies and power quality, Vol.1, No.9, May 2011

[7] BARBARA SWATOWSKA, TOMASZ STAPINSKI, KAZIMIERZ DRABCZYK, PIOTR PANEK The Role of Antireflection Coatings in Silicon Solar Cells – The Influence on Their Electrical Parameters
Optica Applicata, Vol. XLI, No. 2, 2011

[8] F.M. Gait ho, F.G. Ndiritu, P.M. Muriithi, R.G. Ngumbu, J.K. Ngareh Effect of thermal conductivity on the efficiency of single crystal silicon solar cell coated with an
anti-reflective thin film Science direct Solar Energy 83(8):1290-1293

[9] Ankit S. Gujrathi, Sudhir U. Patil, Sachin P. Ingale Analysis of Solar Photovoltaic Thermal System with air cooling Special Issue – ICRTET-2018 ISSN: 2454-9150