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Increasing the Efficiency of Solar Panel through Cooling by using Various Materials

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***Abstract*—**Electric power performs a very indispensable role in our daily life.For economic growth of countries continuous sprinting of industries is an essential part. For nonstop running of these industries, ceaseless availability of electric power is an essential requirement. To cop the power outages in the world, solar energy is getting enormous attention for the last few years because of its renewable nature, cleanliness and instant power. The only limiting factor is the efficiency of the solar system. Because on STP the PV panel gives maximum output power at 25^0 C. The electrical efficiency of PV cell is adversely affected by the significant increase of cell OPT during absorption of solar radiation. To overcome the temperature increase of the panel we can use different cooling agents like water, air, oil, gases and liquids but here air and water has been used as cooling agents. Due to higher heat absorption capacity of water as compared to air, output power of the panel was found higher than air. Finally, computational models were made in MATLAB to obtain results that were compared with the experimental and analytical results.

***Keywords*—**Standard temperaturepressure, Photovoltaic, Operating temperature.

I. Introduction

In recent years, renewable energy is widely advocated by many countries. PV cell is one of the most popular renewable energyproducts. It can directly convert the solar radiation into electricitywhich can be utilized to power household appliances.However, during the operation of the PV cell, only around 15% of solar radiationis converted to electricity with the rest converted to heat. Theelectrical efficiency will decrease when the operating temperatureof the PV module increases. Therefore, decreasing the temperature of PV module can boost the electrical efficiency. Generally, some techniques, like aircooling and water cooling, areutilized to cool the PV module tomaintain lower operating temperature. Many numerical experimental studies have been conducted to find out the mostefficient and low cost hybrid PV/T system. Sometimes, the thermal energy extracted from the PV module can also be utilized for low temperature applications e.g. water and air heating. In a number of studies, attention is focused on modifying the configuration of PV panel. By changing the structure of the panel, the variation of performance of the system can be observed. According to Weng et al [1], the increase in temperature by 1K corresponds to the reduction of the photoelectric conversion efficiency of 0.2% to 0.5%. Hendrie [2], in his experiment used water and air as the cooling medium for reduction of temperature. Agarwal and Garg [3] also experimented on water and air cooled PV solar system. Performance comparison of mirror reflected solar panel with tracking and cooling was performed. Modeling and analysis of water cooled PV cells was done by Efstratios and Chaniotakis[4]. They presented two different types of solar cells and analyzed air and water cooled. The water cooled PV panels uses water for cooling purpose while air cooled panels use air as a coolant. Air and water cooled panels provide higher efficiency compared to the conservative ones.Stefan Krauter [5] studied the increased of electrical efficiency throughwater flow over the front of PV panels.H. Bahaidarah and Abdul Subhan [6] performance evaluation of a PV module by back surface water cooling for hot climateconditions. Water spray cooling technique applied on a PV panel by S. Nizetic, D. Cook and Yadao [7]. The results showed satisfactory cooling effect on the panel. In October 2016, A. Elango and S. Tharves Mohideen [8] worked on the “Performance Enhancement of Solar PV cells using effective cooling methods”. They reported that Photovoltaic solar cells are sensitive to temperature changes to overwhelm this outcome. They use different techniques for the purpose of cooling the solar panel and to get maximum output power and to find the efficiency

versus temperature. Water cooling arrangement were done on upper and lower side of the solar panel and uses this warm water for other domestic purpose and fruitful result is obtained by utilizing different techniques for cooling the solar panel.

II. Research Methodology

The geometry of the model, was realized using MATLAB Design Modeler. Two ways of cooling the photovoltaic module will be presented in MATLAB Simulink, one in the presence of water and second one in the presence of air.Theoretical algorithm is applied in MATLAB Simulink Blocks to get our final results. Simulink is a block map platform for multitask simulation and Model-Based Design. It supports simulation,

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programmed code generation, and continuous trial and verification of fixed systems. Simulink is basically a technique which is used to solve problems. Simulink is combine with MATLAB.Simulink blocks are present in MATLAB Simulink library. Blocks are the main Elements uses to build models in Simulink.

A. *Matlab Simulink Blocks*

PID Controller, Solar Cell, Thermal sensor, Scope, Simulink PS Converter, Voltage and Current Sensor.

B. *Water Matlab Simulink Blocks*

One way of cooling the Solar panel glass is using water. Water is used to absorb the heat from the solar panel and cool the panel according to our set value temperature. The output heat which is absorbed by the water can be utilize for different indoor and outdoor purpose. In Water MATLAB Simulink blocks it consists of five subsystems i.e. subsystem 0,1,2,3 and 4. Each subsystem further consists of six solar cells which are connected in parallel, Connection 2 is connected to the current sensor and connection 3 is connected to the Voltage sensor from one port. I get short circuit current and from the other get open circuit voltage. By the multiplication of the above two quantities we get watts of the solar panel.

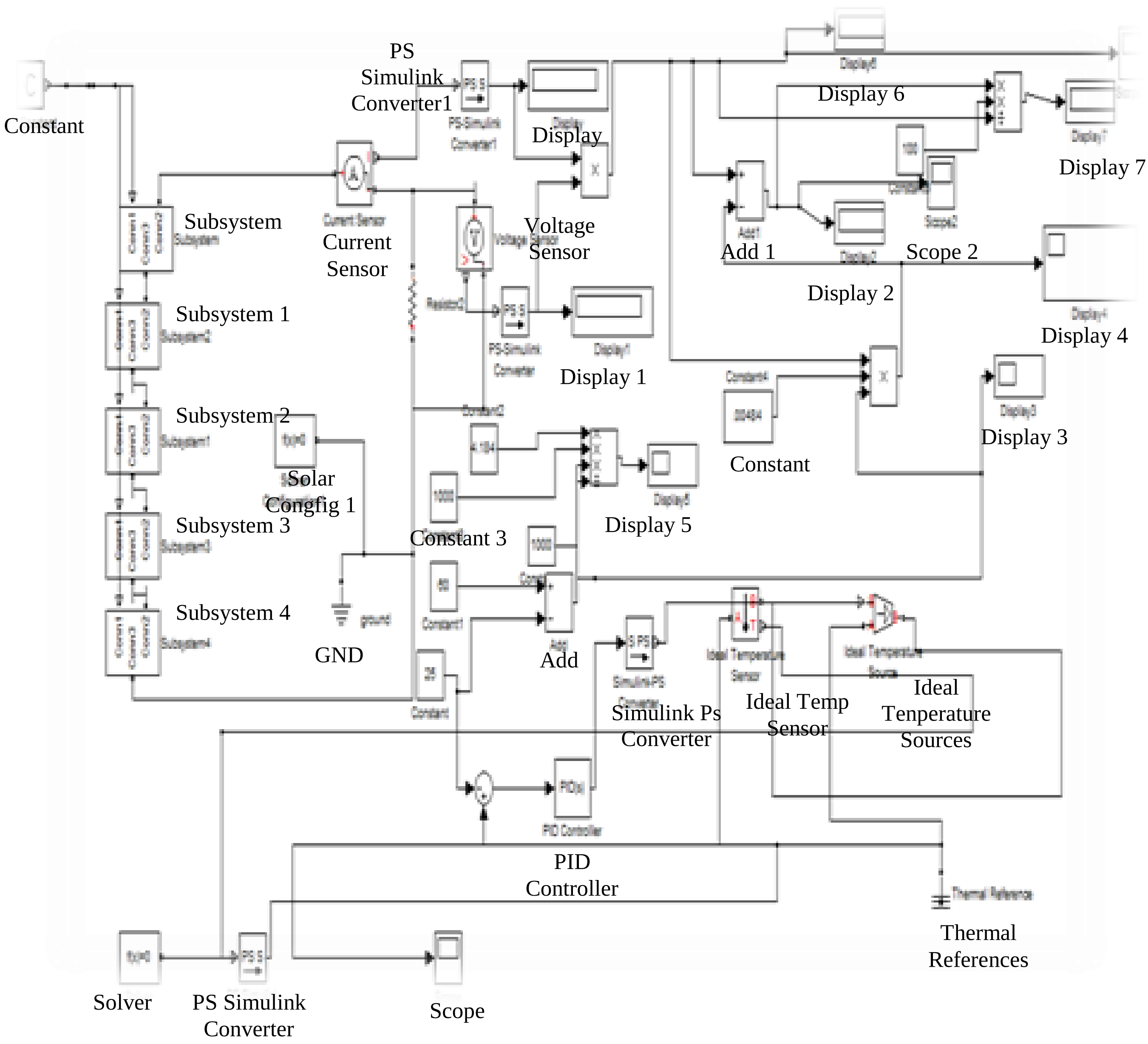

Figure 1. Water Matlab Simulink Blocks

C. *Air Matlab Simulink Blocks*

One way of cooling the photovoltaic Panel is by using air. Of course in this precise case air is used to engross the heat from the Panel and accordingly to cool it. The heat absorbed by the air can be used for different purpose according to the demand and accessibility. i.e. for indoor and outdoor requirement.

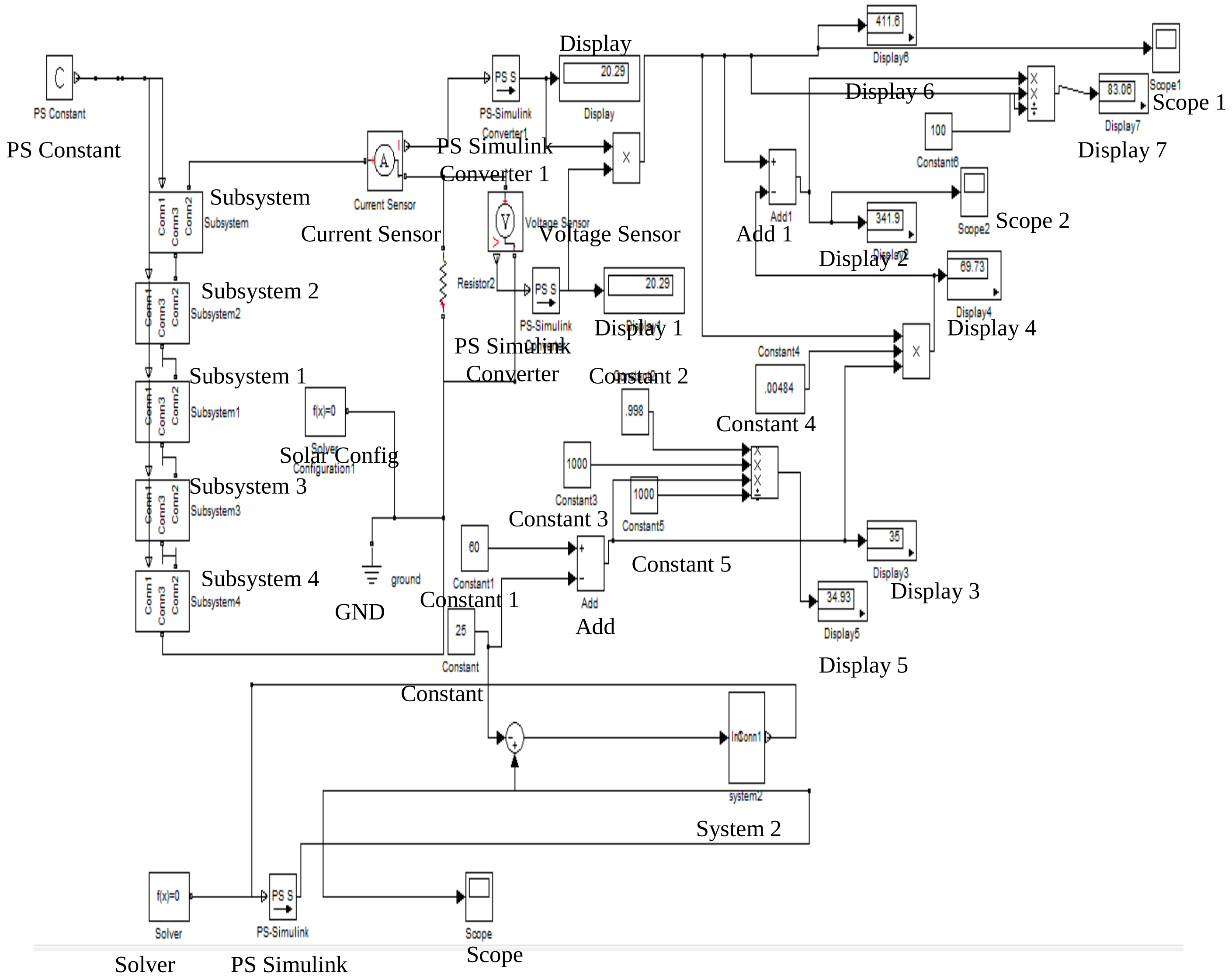

Figure 2. Air Matlab Simulink Blocks

D. *Simulink Blocks Water and Air*

Display 0: Shows Short circuit current of solar panel.

Display1: Shows Open circuit voltage of solar panel.

Display2: Shows Power reduction of solar panel due to the increase oftemperature

Display3: Shows the temperature difference between initial temperatureand Final temperature or it shows the temperature difference between iteration.

Display6: Shows the rated power of solar panel i.e. multiplication of display 0 and display 1 gives valued power of solar panel.

III. RESULTS AND DISCUSSION

Results of simulations consist of the photovoltaic panel temperature variation depending on the heat Figuresexported from the MATLAB software present temperature versus Efficiency.

Tabulation of Solar Panel Efficiency in the Presence of water:

Note: (Civic solar panel $\eta_{max=}$100% at 25 C^0)

. TABLE 1

S. No	Temperature	Efficiency	No. of calories
1	60 C^0	83.06 %	146.44 J
2	55 C^0	85.48 %	125.52 J
3	50C^0	87.9%	104.6 J
4	45 C^0	90.32%	83.68 J
5	40 C^0	92.74%	62.76 J
6	35 C^0	95.16 %	41.84 J
7	30 C^0	97.58 %	20.92 J
8	25 C^0	100 %	0 J

MATLAB GRAPHICAL VIEW (WATER):

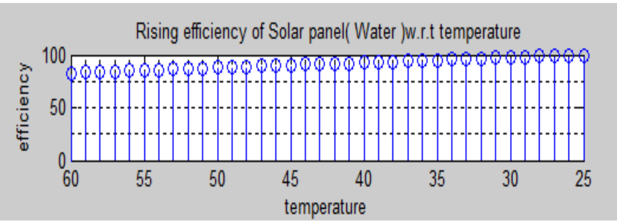

Figure 3. Temperature vs Efficiency Enhancement (Water)

Figure shows the relationship between Temperature versus Efficiency. The temperature of solar panel is going to decrease because of the induction of water on the surface of solar panel as result the efficiency of the panel is going to increase, temperature and efficiency has inverse relationship.

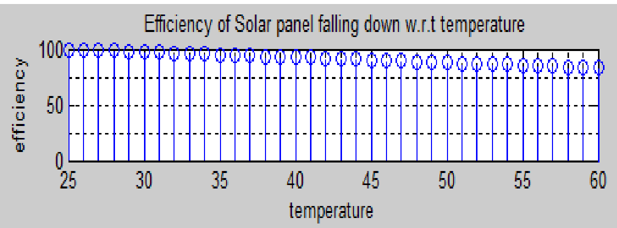

Figure 4. Efficiency vs Temperature in the absence of Water

Figure shows the relationship between Temperature versus Efficiency. Thetemperature of solar panel is increase as a result the efficiency of the panel is going to decrease.

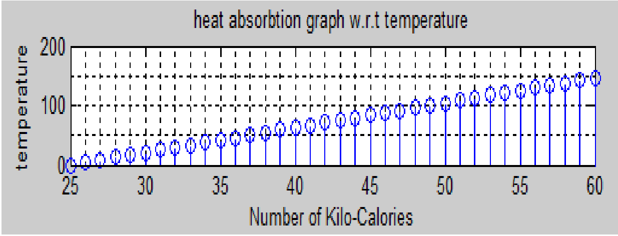

Figure 5. Temperature vs number of Kilocalories

Figure indicates direct relation between temperature and water absorbing capacity. (No. of calories). when the temperature is increasing the No. of calories absorb by the water is increasing or vice versa. Water has high absorbing capacity because of their high specific heat constant.

Tabulation of Solar Panel Efficiency in the Presence of Air**:**

Note: (Civic solar panel) $\eta_{max=}$100% at 25 C^0)

TABLE 2

S. No	Temperature	Efficiency	No. of calories
1	60 C^0	64.50%	35.69 J
2	55 C^0	69.50 %	30.59J
3	50 C^0	74.50 %	25.49J
4	45 C^0	79.60 %	20.39J
5	40 C^0	84.70%	15.29J
6	35 C^0	89.50 %	10.90 J
7	30 C^0	94.90 %	5.09 J
8	25 C^0	100 %	0 J

MATLAB GRAPHICAL VIEW (AIR):

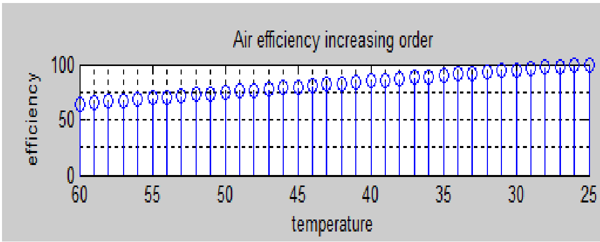

Figure 6. Temperature vs Efficiency Enhancement (Air)

Figure indications the relationship between temperature versus efficiency. The temperature of solar panel isdecrease because of the induction of Air on the panel as result the efficiency of the panel is going to increase.

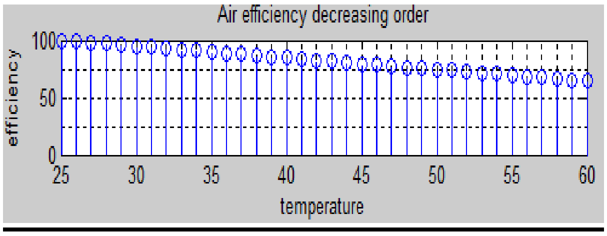

Figure 7. Efficiency vs Temperature in the absence of (Air)

Figure shows the relationship between Temperature versus Efficiency. Temperature of solar panel is increase as a result the efficiency of the panel is going to decrease. Air is used as cooling agent to cool the solar panel and to enhance the efficiency. When there is no cooling agent i.e. Air so the efficiency and temperature has inverse relationship as the graph clearly indicates that when the temperature is slowly and gradually increasing the efficiency of solar panel is going to decrease in reverse order.

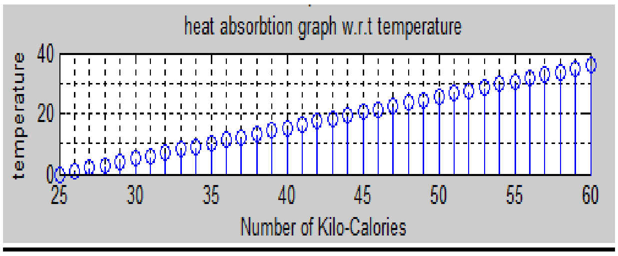

Figure 8. Temperature vs number of Kilocalories

Figureshows the relationship between Temperatures versus No. of kilocalories. This graph indicates direct relation between temperature and Air absorbing capacity. (No. of calories). When the temperature is increasing the No. of calories absorb by the air is increasing or vice versa. Air has less absorbing capacity because of their low specific heat constant as compare to water. Air is able to absorb heat. Without increasing much in heat better than many substances. This is because for air to increase in temperature air molecules must be made to move faster.The real cooling comes from a phase change.

Temperature versus Output Power

Note: Rated Output Power of Solar Panel = 411.6 watts

TABLE 3

S. No	Temperature	Output Power
1	25 C^0	411.6
2	30 C^0	401.6
3	35 C^0	391.7
4	40 C^0	381.7
5	45 C^0	371.8

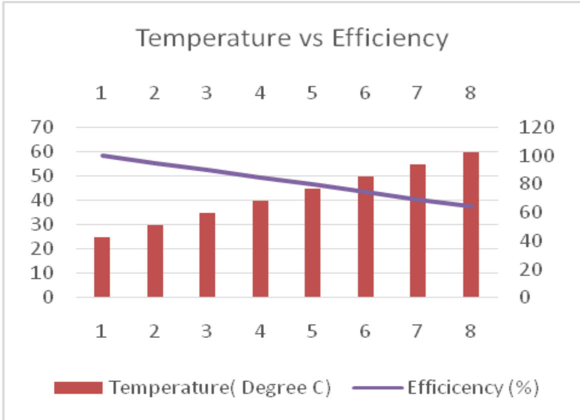

Figure 9. Temputure vs Efficiency

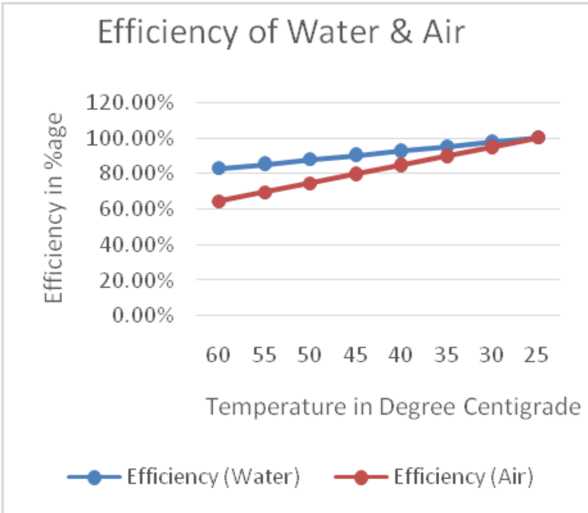

Figure 10. Efficency of Water and Air

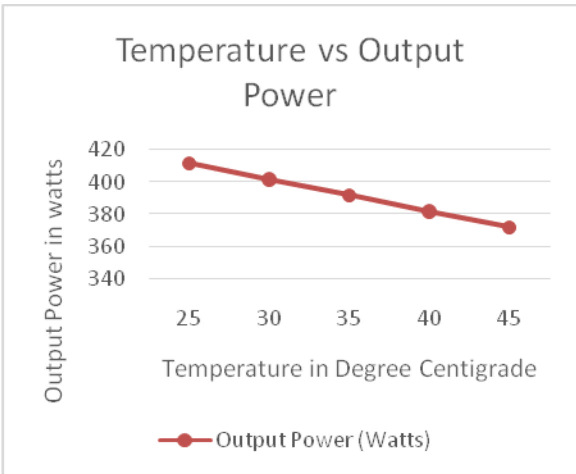

Figure 11. Temputure vs Output Power

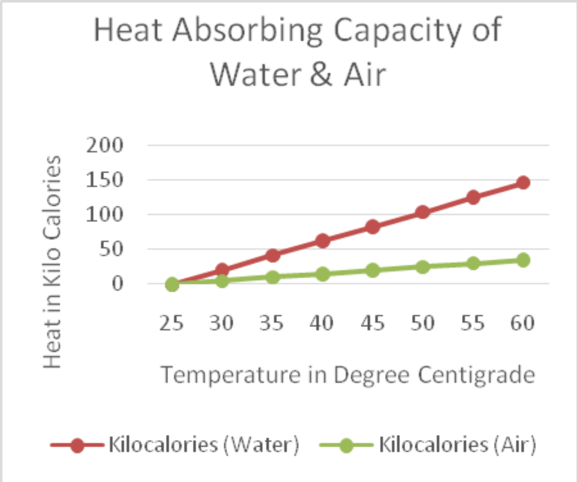

Figure 12. Heat Absorbing Capacity of Water & Air

CONCLUSION

From the analysis of test system, the efficiency of the PV panel is inversely related to the environmental temperature. PV panel gave maximum efficiency when the temperature was low and vice versa. With the introduction of cooling agents like air and water enormously changed the output of the panel. Without the cooling agent the efficiency of the panel was decreasing with increase in temperature. But as the cooling agents were introduced, it blew away the rising temperature which resulted in cooling of the solar panel. It has also been shown that with water the output power of the solar panel was high as compared to the air. It is because water has the higher heat absorption capacity compared to the air. Although water gives higher output power yet it has some discrepancy as compared to air as a cooling agent. For water cooling system, we need to install cooling fins or radiator on the back of the panel, where the rotating water will dissipate the absorbed heat, which costs extra money on the system. However, such kind of system is not required in the air cooling system. Looking at the results above we can say that if more output power of the panel is requirement then we will go for water cooling system, but if money is the limiting factor then we will go for air as a cooling technique.

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