# A Review on Photovoltaic Panel Cooling Using Heat Pipe

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***Abstract*— various solar energy technologies exist and they have different application techniques in the generation of electrical power. The widespread use of photovoltaic (PV) modules in such technologies has been relatively high costs and low efficiencies. The efficiency of PV panel decreases as the operating temperature increases. This is due to reflection from the top surface, absorption of heat by the parts other than the cell, absorption of heat from the other portion of the spectrum. For that the temperature should be maintained in prescribed limit. In this work cooling system is used for maintain the temperature. Heat pipe is used for cooling of solar panel.**

***Index Terms*—photovoltaic panel, heat pipe, heat transfer**

## I. INTRODUCTION

Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. A photovoltaic (in short PV) module is a packaged, connected assembly of typically 6×10 solar cells. Solar Photovoltaic panels constitute the solar array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions, and typically ranges from 100 to 365 watts. There are a few solar panels available that are exceeding 19% efficiency. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, a solar inverter, and sometimes a battery and/or solar tracker and interconnection wiring.

Solar modules use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most solar modules are rigid, but semi-flexible ones are available, based on thin-film cells. These early solar modules were first used in space in 1958.

## II. NEED FOR COOLING OF PHOTOVOLTAIC PANEL

High temperature can severely reduce the solar panel's production of power. Higher temperature increases the conductivity of the semi conductor charges become balanced within the material, reducing the magnitude of the electric field, inhibiting the charge separation, which lowers the voltage across the cell. Depending on the location, heat can reduce the output by 10% to 25%.

In the built environment, there are a couple of ways to deal with high temperature. Install solar panels on a mounting system a few inches off the roof this will help cool them by allowing air circulation. Use photovoltaic panels that are designed to be more efficient in hotter climates. Ensure that panels are constructed with light-colour materials, to reduce heat absorption. Inverters and combiners can be moved into the shaded area behind the array.

## III. INTRODUCTION OF HEAT PIPE

Heat pipes were developed especially for space applications during the early 60´ by the NASA. One main problem in space applications was to transport the temperature from the inside to the outside, because the heat conduction in a vacuum is very limited. Hence there was a necessity to develop a fast and effective way to transport heat, without having the effect of gravity force. The idea behind is to create a flow field which transports heat energy from one spot to another by means of convection, because convective heat transfer is much faster than heat transfer due to conduction.

Nowadays heat pipes are used in several applications, where one has limited space and the necessity of a high heat flux. Of course it is still in use in space applications, but it is also used in heat transfer systems, cooling of computers, cell phones and cooling of solar collectors.

Especially for micro applications there is micro heat pipes developed as for cooling the kernel of a cell phone down. Due to limited space in personal computers and the growing computational power it was necessary to find a new way to cool the processors down. By means of a heat pipe it is possible to connect the processor cooling unit to a bigger cooling unit fixed at the outside to cart of the energy. It is also used at the Alaska pipe line, where you use the low temperature of the ground to cool the transported fluid down.

**III. CONSTRUCTION OF HEAT PIPE**

A heat pipe is a container tube filled with the working fluid. One end of this tube (called evaporator section) is brought in thermal contact with a hot point to be cooled. The other end (called condenser section) is connected to the cold point where the heat can be dissipated. A portion of the tube between evaporator and condenser is called adiabatic section.

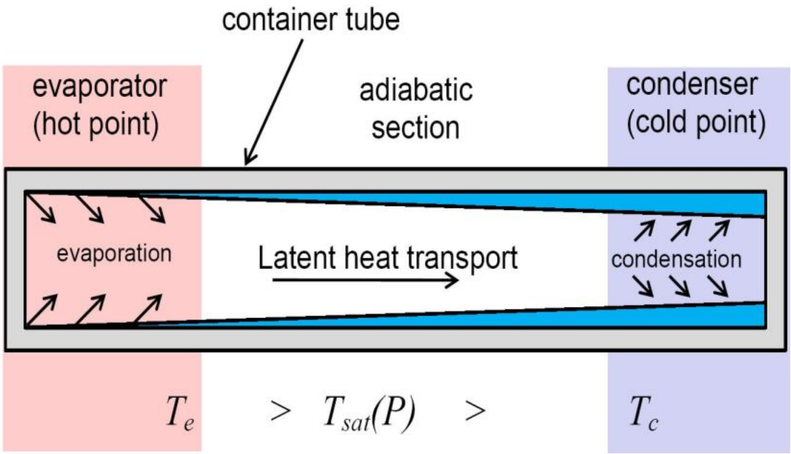


Figure 1.1 simple heat pipe

The working fluid and its pressure are chosen in such a way that the saturation temperature is between the evaporator temperature Te and condenser temperature Tc. The fluid is thus vapourized in the evaporator section. The created vapour is transported to the condenser section and condenses there. The liquid is transported back to the evaporator section. The heat is transferred mainly due to the latent heat absorption in the evaporator and its release in the condenser. Since the latent heat is large, the heat pipes are quite efficient. They are capable of evacuating up to 100-200 W/cm2. There are different kinds of heat pipes. They differ by their geometry and a mechanism of fluid transport inside the heat pipe.

**IV. LITERATURE REVIEW**

**Sayran A. Abdulgafar, et al**[1] has studied the water immersion method for improving the efficiency of solar panel. Cooling of the solar cells is a critical issue, especially when designing concentrating photovoltaic (PV) systems. In the present work, the cooling of a photovoltaic panel via Water immersion technique is investigated. The aim of this project is to optimize the efficiency of a solar panel by submerged it in distillates water at different depths. Experiment is done for polycrystalline silicon panel. An evident increase of efficiency is found with increasing the water depth.

**H.G. Teo, et al**[2] has studied the active cooling system for photovoltaic module. The electrical efficiency of photovoltaic (PV) cell is adversely affected by the significant increase of cell operating temperature during absorption of solar radiation. A hybrid photovoltaic/thermal (PV/T) solar system was designed, fabricated and experimentally investigated. To actively cool the PV cells, a parallel array of ducts with inlet/outlet manifold designed for uniform airflow distribution was attached to the back of the PV panel. Experiments were performed with and without active cooling. A linear trend between the efficiency and temperature was found. Without active cooling, the temperature of the module was high and solar cells can only achieve an efficiency of 8–9%. However, when the module was operated under active cooling condition, the temperature dropped significantly leading to an increase in efficiency of solar cells to between 12% and 14%.

**A. Benuel Sathish Raj, et al**[3] has studied the Experimental Study on the Performance of Concentrated Photovoltaic System with Cooling System for Domestic Applications. As the Concentrated Solar radiation reaches the PV panel system, the temperature increases rapidly and because of this increase in temperature, the output efficiency will be decreased. In order to reduce the temperature and to increase the output efficiency, the Cooling System is used.

It has been found that the electrical output of the water cooled CPV is 4.7 to 5.2 times more than the PV module (without concentration and cooling). The cooling system has a heat pipe filled with Acetone.

**J.K. Tonui, et al**[5] has studied the PV/T solar collectors with heat extraction by forced or natural air circulation. The photovoltaic (PV) cells suffer efficiency drop as their operating temperature increases especially under high isolation levels and cooling is beneficial. Air-cooling, either by forced or natural flow, presents a non-expensive and simple method of PV cooling and the solar preheated air could be utilized in built, industrial and agricultural sectors. However, systems with heat extraction by air circulation are limited in their thermal performance due to the low density, the small volumetric heat capacity and the small thermal conductivity of air and measures for heat transfer augmentation is necessary. This paper presents the use of a suspended thin flat metallic sheet at the middle or fins at the back wall of an air duct as heat transfer augmentations in an air-cooled photovoltaic/thermal (PV/T) solar collector to improve its overall performance.

**Morteza Ebrahimi, et al**[6] has studied the experimental study on using natural vaporization for cooling of a photovoltaic solar cell. This study attempts to investigate a new way for cooling PV cell using natural vapour as coolant. The performance of solar cell was examined on simulated sunlight. The natural vapour encountered backside of PV cell vertically in various distribution and different mass flow rates. Also, the effect of natural vapour temperature in cooling performance was analyzed.

**K.A. Moharram, et al** [7] has studied the enhancing the performance of photovoltaic panels by water cooling. The objective of the research is to minimize the amount of water and electrical energy needed for cooling of the solar panels, especially in hot arid regions, e.g., desert areas in Egypt. A cooling system has been developed based on water spraying of PV panels. A mathematical model has been used to determine when to start cooling of the PV panels as the temperature of the panels reaches the maximum allowable temperature (MAT). A cooling model has been developed to determine how long it takes to cool down the PV panels to its normal operating temperature, i.e., 35 0C, based on the proposed cooling system. Both models, the heating rate model and the cooling rate model, are validated experimentally.

**Shwin-Chung Wong, et al**[8] has studied Visualization experiments for groove-wicked flat-plate heat pipes with various working fluids and powder-groove evaporator. This work experimentally compares the evaporation characteristics of three working fluids: water, methanol and acetone, in groove-wicked flat-plate heat pipes. In addition, the performance enhancement by filling copper powders in the evaporation section is investigated.

**Kyu Hyung Do, et al**[9] has studied a mathematical model for analyzing the thermal characteristics of a flat micro heat pipe with a grooved wick. A mathematical model is developed for predicting the thermal performance of a flat micro heat pipe with a rectangular grooved wick structure. The effects of the liquid–vapour interfacial shear stress, the contact angle, and the amount of liquid charge are accounted for in the present model. As the amount of liquid charge increases, Qmax increases modestly due to a decrease in the effective heat pipe length, but the thermal resistance increases much more rapidly. Finally, the grooved wick structure is optimized using the proposed model for maximum heat transport rate with respect to the width and the height of the groove.

## V. CONCLUSION

Based on the above literature survey, Parameter to be considered are orientation of heat pipe, number of turns, type of working fluid, length of adiabatic section, evaporator section and condensation section, effect of filling ratio, effect of inclination angle etc.Thermal performance of heat pipe is completely independent of the orientation but some researcher suggests that the vertical operation is good compare to horizontal operation.

The number of turns increases the level of perturbations inside the device. If the number of turns is less than a critical value, then there is a possibility of a stop-over phenomenon to occur. In such a condition, all the evaporator U-sections has a vapour bubble and the rest of the het pipe has liquid. This condition essentially leads to a dry out and small perturbations cannot amplify to make the system operate self-sustained.From literature, it is essential to maintain the temperature of solar cell under the limit. For that cooling system is required. The different cooling systems are available. From that cooling with the help of heat pipe gives the good performance.

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