COOLING OF SOLAR CELLS BY CHIMNEY -INDUCED NATURAL DRAFT OF AIR

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ABSTRACT

Low efficiency of the solar panels is one of the main concerns in the promotion of solar photovoltaic technology. An important factor affecting solar cell efficiency is its operating temperature. The solar cell voltage decreases close to linearly with increase of the cell operating temperature. The operating surface temperature of a PV panel is typically 20-30 ℃ higher than the ambient temperature. On the basis of these considerations, the efficiency the solar panel can be improved by maintaining their operating temperature as low as possible. Because of the inherent low efficiency of the panels, use of an acting cooling system such as forced cooling and water cooling is not a sustainable option. The experimental arrangement centers on a SOLAR COOLING CHIMNEY (SCC) designed and constructed. The SCC is in the form of a rectangular chimney, which converts the back of the panel and extends one meter above the panel top. The SCC has an inclined surface painted black to increase its solar thermal absorptivity. The absorber surface faces the sun in order to capture maximum solar radiation. Solar radiation passes through the transparent sheet and increases the temperature of the absorber surface of the SCC. The hot surface transfer heat to the air in the rectangular chamber. Because of the difference in density of the air inside the absorber area and the exterior of the chimney the air convects upwards and provides the desired cooling flow for the solar cell. Result of a theoretical analysis and preliminary experimental investigations have helped to validate the concept. The proposed SCC can provide a sustainable and passive method for cooling solar photovoltaic in solar power plants.

Keywords: air cooling, natural convection, solar cell cooling, solar chimney, solar photovoltaic

INTRODUCTION

A solar cooling chimney is an innovative device that works on the principle of buoyancy. In a solar chimney the thermal energy is collected from solar radiation to heat up the air at the bottom of the chimney. This heated air with lower density moves upward creating a natural draft. Prof. J. Schlaich of Stuttgart (Dos S. Bernardes, 2003) introduced the concept of solar chimney in late 1970. Much research has been done on the use of solar chimneys for power generation. Since then the solar chimney has undergone large technological advances. In some of the previous literature (Tonui and Tripanagnostopoulos, 2008) different ways have been suggested for cooling of PV panels. This research will study and suggest the way of using the natural convection for cooling of PV panel for solar power plants.

Conventionally chimneys have been used in industry for extraction of exhaust gases from boilers and furnaces. Usually exhaust gases are at higher temperature than atmospheric temperature. This difference in temperature leads to difference in density of the inside air and outside air. Tall concrete constructions of conventional chimneys increase the buoyancy effect caused by the density difference. In turn there is a natural flow of hot gases from the exhaust to the atmosphere, avoiding need for any active system to remove the exhaust gases. In some applications a conventional chimney is combined with active systems that provide forced draft to assist the natural buoyancy effect for extraction of exhaust gases.

Solar photovoltaic cell: A photovoltaic cell is a device made from a semiconductor material, which generates electricity when exposed to solar radiation. In earlier day photovoltaic were promoted, as a power decentralization system that can satisfy the small power needs in the remote areas where grid installation cost are high. More recently, solar energy has developed its importance as the only renewable source that can sustainably replace current fossil fuel power generation systems. PV installations can have long lives with little or no maintenance. Except for the initial capital cost the operating costs of PV plants are very low when compared to those of existing fossil fuel power plants.

Polycrystalline and multi-crystalline photovoltaic cells are widely used for existing commercial solar power generation. Efficiency of a PV panel is normally included in the manufacturer's specification. This efficiency could only be achieved under conditions specified by the manufacturer. It has been observed that if the surface temperature of a PV panel exceeds the manufacturer's specification, its efficiency decreases almost linearly (Akbarzadeh, 1992). The surface temperature of a photovoltaic panel is typically 15-20 °C higher than the atmospheric temperature. The expected surface temperature of the Photovoltaic panel is 40ºC to 45ºC. In this

scenario the efficiency of a PV panel can be drastically lowered.

This phenomenon of decrease in efficiency with rise in working temperature of the PV panel invites consideration of the options for it is cooling. External cooling system can help maintaining the working temperature of the PV panel with in the working range and thereby enhance the efficiency. Passive cooling system using the natural draft of air has been previously suggested by (Tonui and Tripanagnostopoulos, 2007; Tonui and Tripanagnostopoulos, 2008).

MATERIALS AND METHODS

Experimental setup: Considering the limited power output from a single PV panel, it is not practical to implement an active (externally powered) system to maintain the working temperature of the PV panel in the working range. This paper suggests the innovative option of using a Solar Cooling Chimney for cooling of PV panel for large-scale solar power plants. Passive cooling can provide a means to improve the efficiency of a photovoltaic cell without utilizing the energy produced by the PV panel itself. As shown in the figure 1 a SCC has a very simple design. This chimney is divided into three sections namely, top section, absorber section and PV section. The top section is a vertical rectangular chamber above the absorber section. This part of chimney assists in creating the natural draft. The middle section is known as the absorber section. The inner surface of the middle section (absorber section) is painted with non-shiny black paint. Painting this surface with black color increases the surface absorption of solar radiation, and in turn rises it's the surface temperature.

Figure.1.Experimental setup for solar chimney cooling

Formula used

Equation (1) Power output

$$P = V \times I \qquad (1)$$

Equation (2) Efficiency of the panel

$$\eta = \frac{\text{POWER OUTPUT}}{\text{SOLAR INCIDENT RADIATION} \times \text{AREA}} \qquad (2)$$

$$\eta = \frac{P}{G \times A}$$

P=power output (watts)
V=voltage (volt)
I=current (amps)
G=solar incident radiation (w/m²)
A=area (m²)

Result & Graph: From the method "cooling of solar cells by chimney-induced natural draft of air" i had plotted several graphs to compare the variation of several parameters.

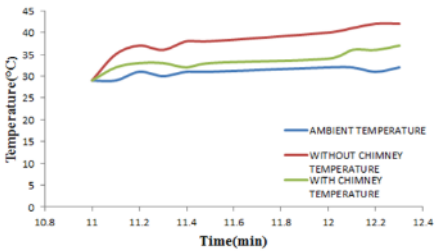

Figure.2.comparison between temperature and time

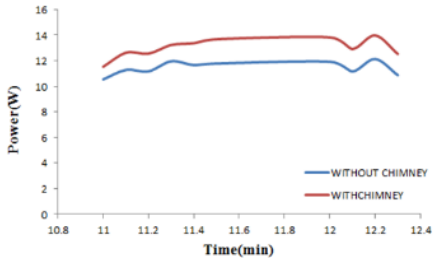

Figure.3.comparison between power and time

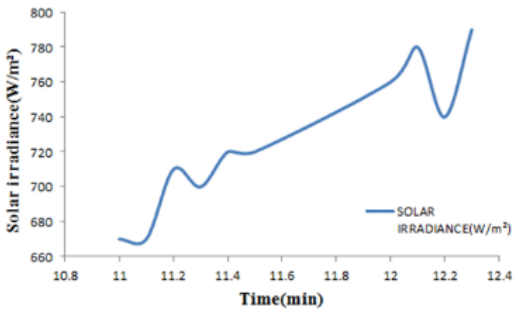

Figure.4.comparison between solar irradiance and time

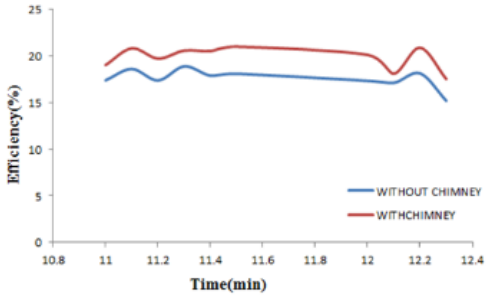

Figure.5.comparison between efficiency and time

CONCLUSIONS

Due to the chimney provided at the top of the PV panel the require power output has been increased. The temperature of panel plays a vital role in the efficiency of Photovoltaic module. From the above results, the following conclusion is made. Compared to without cooled panel, the with cooled panel temperature was maintained around 5℃ lesser, and also getting maximum power output 13.83 watts with reduced temperature 5°C.

Temperature variation:

- Observed temperature of panel without chimney cooling at peak hour is 42°C
- Observed temperature of panel with chimney cooling at peak hour is 37 °C
- Observed decrease in panel temperature due to cooling is 5°C

Power variation:

- Increase in maximum power due to cooling is 1.91watts
- Power of the panel without chimney cooling at peak hour is 11.92watts
- Power of the panel with chimney cooling at peak hour is 13.83watts

Efficiency variation:

- Increase in maximum efficiency due to cooling is 2.11%
- Efficiency of the panel without chimney cooling at peak hour is 18.87%
- Efficiency of the panel with chimney cooling at peak hour is 20.98%

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