Different methods used for improvisation of solar panel efficiency

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ABSTRACT

The solar energy is completely a natural and it is one of the renewable energy sources. Now a days the demand for the solar system i.e, PV system increases due to the major fact that they produce the electricity without harming the environment. Also there will be so many reasons to decrease the efficiency of solar panel. Viz., increase in the temperature of solar panel. So the study on improving the efficiency of solar panel is very important aspect. In this paper we have discussed different methods used for efficient working of solar panel. First method is removing the dust from the solar panel which acts as a barrier in between the sunlight and solar panel. Second method is cooling technique where the water is used as a coolant. And the third method is using of phase change material (PCM) and the fourth method is solar tracking system..

Keywords: *Dust Cleaning, Cooling Technique, Phase change material, efficiency, Solar panel.*

1. INTRODUCTION

One type of renewable energy source is the photovoltaic (PV) cell, which converts sunlight to electrical current, without any form for mechanical or thermal interlink. Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of cells containing a photovoltaic material. Because it is safe, renewable and pollution-free, PV has advanced considerably in recent years [1, 2]. PV cells are usually connected together to make PV modules, consisting of 72 PV cells, which generates a DC voltage between 23 Volt to 45 Volt and a typical maximum power of 160 Watt, depending on temperature and solar irradiation. Solar panel efficiency depends on various factor such as solar intensity (brighter the sunlight, the more there is for the solar cell to convert), temperature, dust which decreases the efficiency of panel etc. Following methods are used to improve efficiency of solar panel.

2. DIFFERENT METHODS

2.1 Dust cleaning method

Large-scale solar installations already exist in China, Europe, the Middle East, Australia, and USA. These installations usually are located in sun-drenched desert areas where dry weather and winds sweep dust into the air and deposit it onto the surface of solar panel. Just like grime on a household window, that dust reduces the amount of light that can enter the business part of the solar panel, decreasing the amount of electricity produced. Clean water tends to be scarce in these areas, making it expensive to clean the solar panels. It is reported that a dust layer of 4 gram per square meter decreases solar power conversion by 40 percent [3, 4]. For improving the efficiency of the PV and protecting the solar cell, the research of the cleaning method is vital. The cleaning method is summarized as natural means, mechanical means, self-cleaning, and electrostatic means.

2.1.1 Natural removal of dusts

The natural powers are employed to remove the dusts, such as wind power, gravitation and the scour of the rainwater. The effect of this method is not very well. Gaier J, Davis P and Marabito M [5, 6] reported that they had studied the validity of this method. It is viable that the solar cell array can be turned to vertical or oblique position to remove the dusts easily when early morning, late evening, night and a rainy day. However, the rotation of the large solar cell array is very difficult.

2.1.2 Mechanical removal of dusts

The mechanical methods remove the dusts by brushing, blowing, vibrating and ultrasonic driving. The brushing methods clean the solar cell with something like the broom or brush that were driven by the machine was designed just like windscreen-wiper. However, firstly, because of the small size and the strong adhesivity of the dusts, the cleaning method is inefficient. Secondly, the abominable working environment of the solar cell makes the maintenance of the machine difficult. Then, due to the large area of the solar cell array, the cleaning machine is powerful. Lastly, the surfaces of the solar cell maybe were damaged by the brush when wiping. The blowing method cleaning the solar cell with wind power is an effective cleaning one except the low efficiency, high energy-consumption and the unsatisfactory maintainability of the blower. Removing the dusts with vibrating and ultrasonic is also a valid mechanical cleaning method. The key of this strategy consist of the driving method, the frequency and the amplitude of the solar cell.

2.1.3 Self-cleaning method

The self-cleaning technology was developed by Boston University professor Malay K. Mazumder and his colleagues, in association with the National Aeronautics and Space Association, and was originally intended for use in rovers and other machines sent to space missions to the moon and to Mars. The technology involves the deposition of a transparent, electrically sensitive material on glass or on a transparent plastic sheet that cover the panels. Sensors monitor dust levels on the surface of the panel and energize the material when dust concentration reaches a critical level. The electric charge sends a dust-repelling wave cascading over the surface of the material, lifting away the dust and transporting it off of the screen's edges. Within two minutes, the process removes about 90 percent of dust on a solar panel. The mechanism reportedly requires only a small amount of the electricity generated by the panel for it to work.

Coating the surface of solar cells can increase their efficiency and reduce maintenance costs, especially for large-scale installations. Self cleaning solar panels would be especially effective in large installations. The desert environments where many of these installations reside often challenge the panels with dust storms and little rain. Currently, only about 4 percent of the world’s deserts are used in solar power harvesting. Conventional methods of cleaning solar panels usually involve large amounts of water which is costly and scarce in such dry areas.

2.2 Water cooling technique

Photovoltaic panels (PV) get overheated due to excessive solar radiation and high ambient temperatures. Overheating reduces the efficiency of the panels. The ideal P–V characteristics of a solar cell for a temperature variation between 0 °C and 75 °C are shown in Fig.1.The P–V characteristic is the relation between the electrical power output P of the solar cell and the output voltage, V, while the solar irradiance, E, and module temperature, Tm, are kept constant. The maximum power output from the solar cells decreases as the cell temperature increases, as can be seen in Fig.1. This indicates that heating of the PV panels can affect the output of the panels significantly.

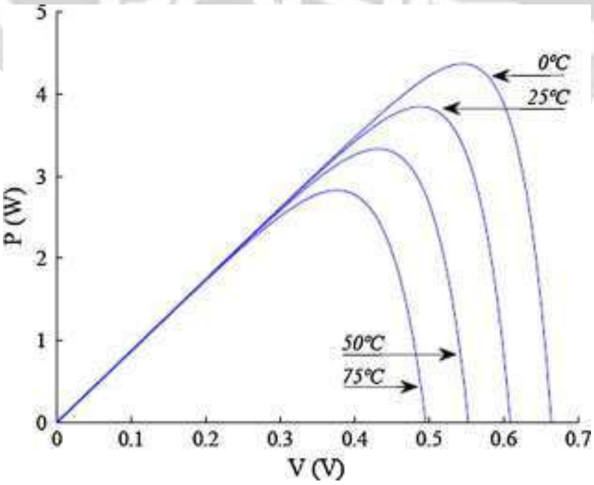

Fig -1: Influence of temperature on solar panel [23]

Hybrid Photovoltaic/Thermal (PV/T) solar system is one of the most popular methods for cooling the photovoltaic panels nowadays shown in fig 2 . The hybrid system consists of a solar photovoltaic panels combined with a cooling system. Water is circulated around the PV panels for cooling the solar cells, and the warm water leaving the panels pump back to water tank. Warm water mixed with cool water of tank.

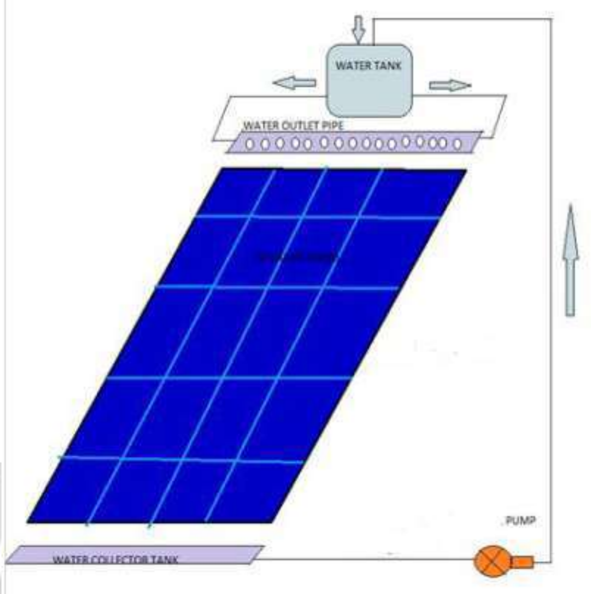

Fig -2: Cooling technique by using water [23]

It is concluded that the cooling system could solve the problem of overheating the PV panels due to excessive solar radiation and maintain the efficiency of the panels at an acceptable level by the least possible amount of water.

2.3 Using of phase change material

The efficiency of solar panels depends on three factors: the intensity of the solar radiation flux, the quality of the semi conductor in use, and the operating temperature of the semi conductor cell. The variations of solar radiation cannot be controlled. Therefore the ongoing research focuses either on new material like copper, indium diselenium, cadmium tellurium and chalcopyrites, or on maintaining low operating temperatures. For PV panels, high operating temperatures create a drop in the conversion rate of about 0.5% per Celsius degree over the nominal cell operating temperature of 25°C [7], as defined by the industry standard STC (Standard Test Conditions). In summer, panel's temperature typically ranges from 40 to 70°C which makes a 7.5 to 22.5% drop in the conversion rate. In the same way, the efficiency of solar thermal panels decreases mainly because of radiation losses when their operating temperature is above the ambient.

To lower the operating temperature, one can either improve the free cooling on the back of the panel thanks to natural or forced convection, or try to absorb the excess heat by modifying the panel's architecture. The latter solution includes the use of PCMs situated on the back of solar panels. PCMs are materials that undergo reversible transition of phase depending on their temperature. They absorb or reject heat in the process. Only a few studies have been specifically devoted to passive cooling of solar panels by SP/PCM architectures. The hypothesis driving the research is simple: when the panels' temperature rises, the excess heat must be absorbed until the PCM has completely melted. When the panel's temperature decreases, the solidification of the PCM should provide additional heat for the operating liquid in solar thermal panels, provide heat to the building or act as an insulation material. The SP/PCM solution is expected to be very useful for roof or facade integrated panels where space for ventilation is limited.

Huang et al. [8] studied the melting of PCMs in an aluminum container submitted to a solar radiation of 750 to 1000W/m². They used a finite volume model to resolve both the heat transfers diffusion and the Navier-Stokes equations. They later included cooling fins in the tank to improve the PCM bulk thermal conductivity [9] [10]. They found that the temperature rise in the system could be reduced by more than 30°C for 130 minutes. Cellura et al. [11] resolved the same architecture using a finite element PDE solver. However, they considered the PCM as pure, meaning that the PCM melting temperature is unique and does not change while the PCM is still melting. This property is not valid for most commercial PCMs which are generally mixtures of several different materials. By resolving only the heat transfers diffusion equation, they showed that a PCM with a melting temperature between 28°C and 32°C can improve the energy conversion efficiency by around 20% in summer time. Jay et al. [12] experimentally studied a layout where PCM were contained in a honeycomb grid to improve conduction in the container. They showed that after 6 hours and 30min of experiment under an artificial insulation of 800W/m² on real PV panels, the temperature of a PV/PCM system was still lower than that of a single panel, with a mean temperature difference of 24°C. They also found that the panel's temperature drop using a PCM with a melt temperature at 27°C was higher than using a PCM with a melt temperature at 45°C.

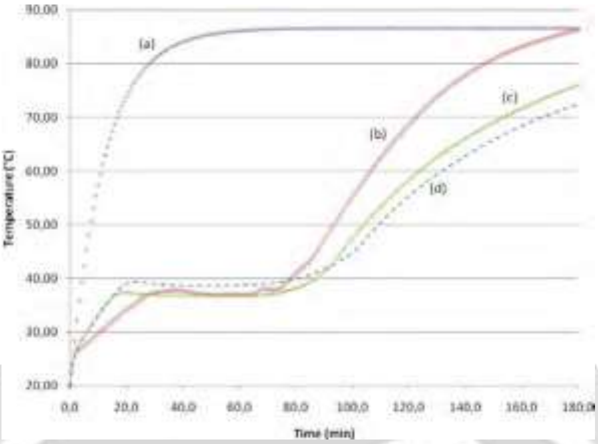

Fig -3: Impact of the SP/PCM size on the panel's operating temperature [25]

The parametric study also shows that the operating temperature drops proportionally to the increase of the PCM width: after 3600s, T = 34.9°C when L = 0.049m whereas T=37°C when L = 0.02m. Comparing curves (c) and (d) shows that the same trend is observed when the panel height is increased but only when the PCM has completely melted. In brief, it is better to increase the PCM width than its height to lower the panel's temperature. Adding cooling fins in the PCM tank provides a faster attenuation of the operating temperature because the PCM bulk conductivity is increased. But this layout accelerates the phase transition too. When the PCM has completely melted, the operating temperature rises faster than for all other SP/PCM architectures (Fig. 3). This fact moderates the idea that adding cooling fins makes SP/PCM systems more efficient [10]. To conclude, adding PCM on the back of solar panels is an efficient way of improving panels' performance. Their operating temperature can be substantially decreased using that technology.

2.4 Solar tracking system

Solar tracking is one of the various techniques used to increase the efficiency of solar panels. Light gathering by solar panelsis dependent on the angle of incidence of light rays to the solar cell's surface. If a flat solar panel is mounted on level ground, the sunlight will have an angle of incidence close to 90°in the morning as well as in the evening hours [13]-[15]. At such an angle, the light gathering ability of the cell is essentially zero, resulting in no output. As the day progresses to midday, the angle of incidence approaches 0°, causing a steady increase in power until the light incident on the panel is completely perpendicular, and maximum power is achieved [13].Further, as the day continues toward dusk, the reverse happens, and the increasing angle causes the power to decrease again toward minimum again. Hence, there is a need to maintain the maximum power output from the panel by maintaining an angle of incidence as close to 0° as possible[15]. The process of sensing and following the position of the sun is known as Solar Tracking[13].

2.4.1 Types of solar tracker

I. Passive solar tracker

In passive tracking system (as shown in Fig. 1) realizes the movement of the system by utilizing a low boiling point liquid. This liquid is vaporized by the added heat of sun and the center of mass is shifted leading to move the system to anew equilibrium position [14]. Sun's heat moves the liquid from side to side. This action allows gravity alone to turn the Track rack to follow the sun[16].Shipped partially assembled, it is easy to install and is module specific.

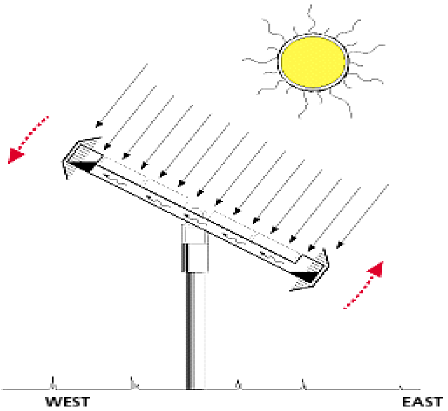

Fig -4: Passive solar tracker [14]

II. Active solar tracker

a. Triangular Solar Panel

In this panel, a simple triangular set-up uses two solar cells facing opposite directions as shown in Fig. 2. In its rest position, both the solar cells receive an equal amount of sunlight, as the angle of incidence, although not 90°, is equal in both cases [13]. As the sun moves in the sky, the angle of incidence of light to the reference panels will cause more light to fall on one cell than the other. This cause a voltage difference. It results in a detectable signal at each cell, which can be processed by a suitable circuit. The efficiency of triangular solar panel is 18% [13]-[19], i.e. higher than fixed solar panel.

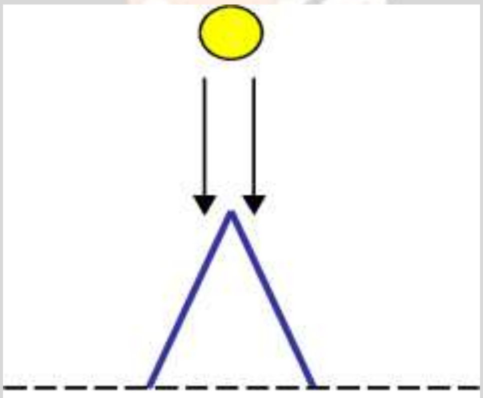

Fig -5: Triangular solar tracker [13]

b. Single Axis Tracking

Single axis tracking systems realizes the movement of either elevation or azimuth for a solar power system. A single-axis tracker can only pivot in one plane – either horizontally or vertically. This makes it less complicated and generally cheaper than a dual-axis tracker, but also less effective at harnessing the total solar energy available at a site. Trackers use motors and gear trains to direct the tracker (as commanded by a controller) towards maximum sunlight. Since the motors consume energy, one wants to use them only when necessary [21]. A horizontal-axis tracker (HSAT) consists of a long horizontal tube to which solar modules are attached. The tube aligned in a north-south direction, is supported on bearings mounted on pylons or frames, and rotates slowly on its axis to follow the sun's motion across the sky [22]. This kind of tracker is most effective at equatorial latitudes where the sun is more or less overhead at noon. For higher latitude, a vertical-axis tracker is better suited [15]. The efficiency of single axis tracking is 23% which is higher than the fixed panel & passive solar tracking [14].

c. Double Axis Tracker

Dual axis trackers have two degrees of freedom that act as axes of rotation (as shown in Fig.3). They can rotate simultaneously in horizontal and vertical directions, and so are able to point exactly at the sun at all times in any location. Dual axis tracking systems realize movement both along the elevation and azimuthally [19]. These tracking systems provide the best performance with efficiency is in the range of 27-40% [20]. Properties in a simple process and at relate the process involves conversion of monomers into a colloidal solution (sol) that acts as the precursor for an integrated network (or gel) of either discrete particles or network polymers. From fig2 a small sol-gel method of synthesis is shown.

3. CONCLUSION

As the Photovoltaic (PV) cell, converts sunlight into electrical current, without any form for mechanical or thermal interlink the study on improving the efficiency of solar panel is very important aspect. In this regard a thorough literature survey is made and the most common methods have been discussed for the effective utilization of solar panels in achieving the highest efficiency.

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