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Hybrid Model of Solar panel With High Efficiency

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Abstract: The light obtained from the Sun is a renewable source of energy which is free from environmental pollution and noise. It can easily replace the energy drawn from the non-renewable sources of energy such as fossil fuels and petroleum deposits inside the earth. In this paper a hybrid model of concentrated photovoltaic (CPV) technology based solar panel is proposed. This hybrid model is integrated with automatic dual axis solar tracking system, nano-fluid cooling and automatic dust cleaning system for improving its efficiency. Efficiency of solar panel can be improved by using solar tracker with CPV panel which continuously tracks sunlight throughout the day to get maximum solar energy. Second method to improve the efficiency is dust cleaning. Dust is barrier between sunlight and solar panel. Third method is cooling technique. As panel temperature increases output voltage of solar panel decreases so cooling of panel is necessary for improvement of efficiency.

Keywords: Concentrated photovoltaic (CPV) technology**,** automatic solar tracking system, nano-fluid cooling and automatic dust cleaning system.

I. Introduction

Due to the constraints and consequences posed by nonrenewable energy sources, renewable energy sources ought to be given preference over those sources of energy that do not replenish themselves. Developing nations are forced to investigate new solutions because of factors such as global warming, emissions of greenhouse gases, changing oil costs, and an increase in the need for power [1]. Solar energy, in general, offers a greater number of benefits than fossil fuels like coal and oil in terms of lowering carbon emissions, improving air quality, and having a greater availability [2]. In the current state of affairs around the globe, there has been a rise in the amount of power that is consumed. Therefore, researchers have concentrated their attention on creating solar energy technologies in order to get highly effective CPV panels while simultaneously minimising their financial investment and their impact on the environment [3].

In this article, a hybrid model of a solar panel that is based on the technology of concentrated photovoltaics, or CPV, is suggested. For the purpose of increasing its overall efficacy, this hybrid design has an integrated automatic dual-axis sun tracking system, nano-fluid cooling, and an automatic dust cleaning system. Utilising a solar tracker with a CPV panel, which continually follows the sun throughout the day in order to collect the greatest amount of solar energy, is one way to enhance the efficiency of solar panels. In order to maximise the utilisation of solar power, the installation of concentrated photovoltaic, or CPV, systems is essential. Sun cells are able to function at increasing efficiencies when exposed to higher solar concentrations. Replacing solar cells with optical devices that catch light is an efficient means of reducing the cost of a system without sacrificing the quantity of solar energy that is absorbed. The elimination of dust is the second way for enhancing productivity. Dust is barrier between sunlight and solar panel. The method of cooling is the third approach. It is vital to cool solar panels in order to enhance their efficiency since the output voltage of solar panels falls as the temperature of the panels increases.

II. CONCENTRATED PHOTOVOLTAIC (CPV) TECHNOLOGY IN SOLAR CELLS:

In the past, various kinds of semiconductor materials and technologies are devised to design solar cells with low cost as well as high conversion efficiency. Traditional solar panels made from silicon crystalline wafer modules are heavier which makes the transportation difficult. These are generally the large sized solar panels covered with glass sheets.

Third generation cells are the new promising technologies. Most of the developed 3rd generation solar cell types are [4]:

1) Nano crystal based solar cells.
2) Polymer based solar cells.
3) Dye sensitised solar cells.
4) Concentrated solar cells.

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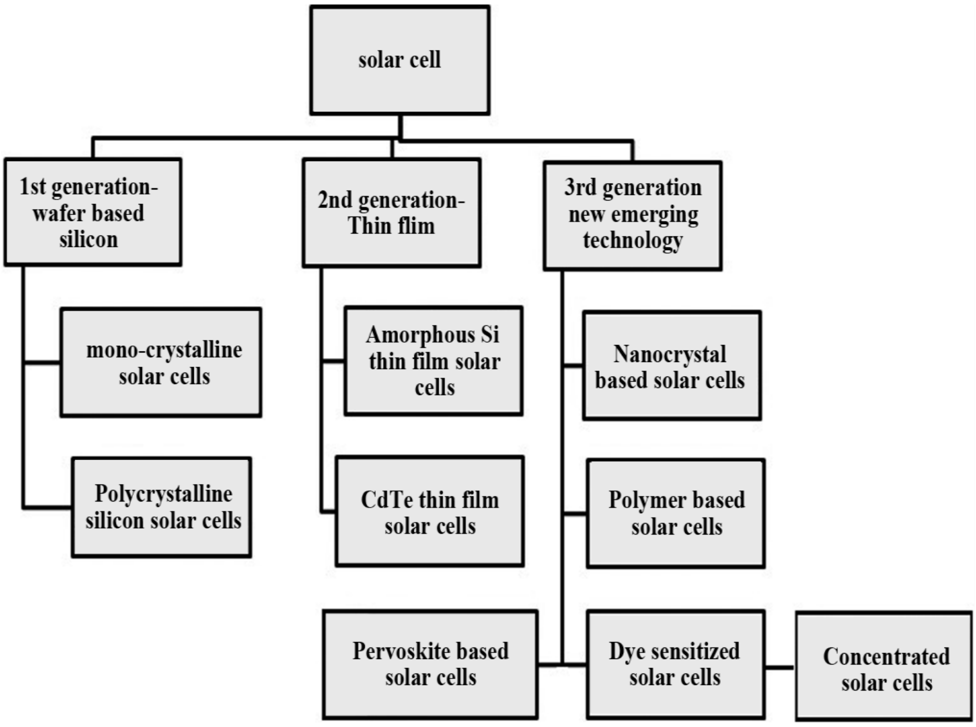

Figure1. Various types of solar energy cells and latest trends[4]

Concentrated Solar Cells

Concentrating photovoltaic, often known as CPV, has been around since the 1970s [5, 6], [7]. It is the most recent innovation in the field of research and development for solar cells. As can be seen in Figure 2, the fundamental idea behind concentrated cells is to focus a significant quantity of the sun's rays into a relatively small area just above the PV solar cell. This method is predicated on the use of optics, namely the arrangement of huge mirrors and lenses, in order to concentrate the beams of sunlight onto a particular section of the solar cell [8]. As a result, a significant quantity of thermal potential energy is generated when the radiations of sunlight converge. This heat energy is then used to drive a heat engine, which is in turn controlled by a power generator that includes integrated components. CPVs have demonstrated their potential for success in the solar industry [4, 5]. Depending on the strength of the lens systems, it is possible to divide it into three distinct categories: low, medium, and high concentrated solar cells [7]. The benefits of concentrating photovoltaic technology include solar cell efficiencies of greater than 40%, the absence of any moving parts, high thermal stability, a lower cost than regular silicon cells, a quicker reaction time, and the flexibility to scale to a variety of sizes.

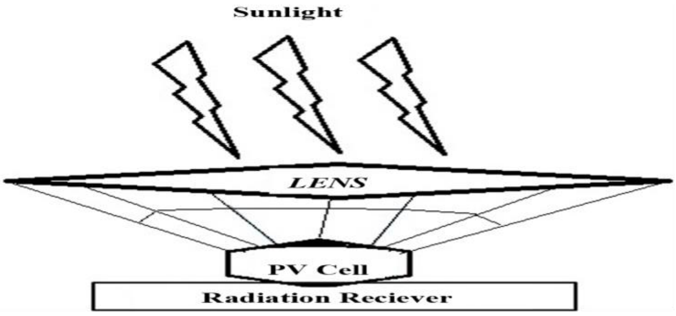

Figure 2. Schematic of concentrated solar cell.

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III. LOW COST AND ROBUST SOLAR TRACKING SYSTEM BASED ON DATA OF DAILY AND SEASONAL VARIATION IN SUN POSITION REGARD TO SPECIFIC LOCATION ON EARTH

Solar panel arrays can be positioned to take use of the sun's rays more efficiently by using a dual-axis tracking system, which has just been proposed [9]. The rotation around one axis is automated and occurs daily in order to monitor the sun, while the rotation around the other axis is done manually in order to account for seasonal changes in the route the sun takes. There is a database that can be accessed online that shows the position of the sun at any given point in time and from any location on earth. Because it utilises an optimised database of yearly sun position for a given area on earth to follow the sun, the system is able to function normally even when the sky is overcast. This is due to the system's distinguishing characteristic, which tracks the sun. If light detector sensors were to be utilised, however, this would necessitate cleaning the sensors, and there would be no protection against malfunctioning in overcast conditions. The positioning of the solar panels is done with the use of a low-cost closed loop control system.

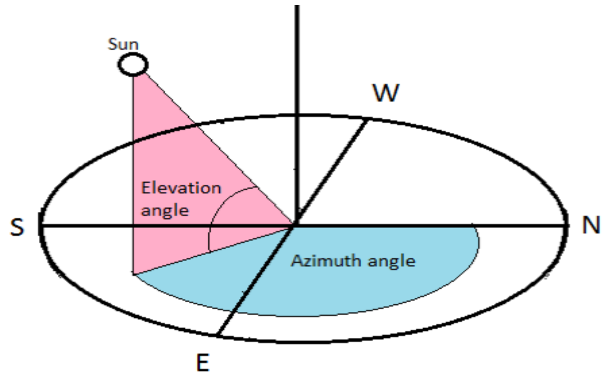

Figure 3. Elevation and azimuth angle [9]

Figure 4 provides a visual representation of the tracking system. PWM IGBT-based motor driver is in charge of controlling the motor [10]. A microcontroller is responsible for the generation of control signals in response to a given programme. After sunset, the panels are equipped with a battery that has a capacity of 12 volts and 36 ampere-hours so that they may be readjusted to face east for the following day's tracking. In order to obtain input on the actual angle, a rotary potentiometer with 270 degrees of precision has been added. The date and time are often shown on LCD. Along with being able to change the date and time, the push buttons on the interface also allow access to other system status

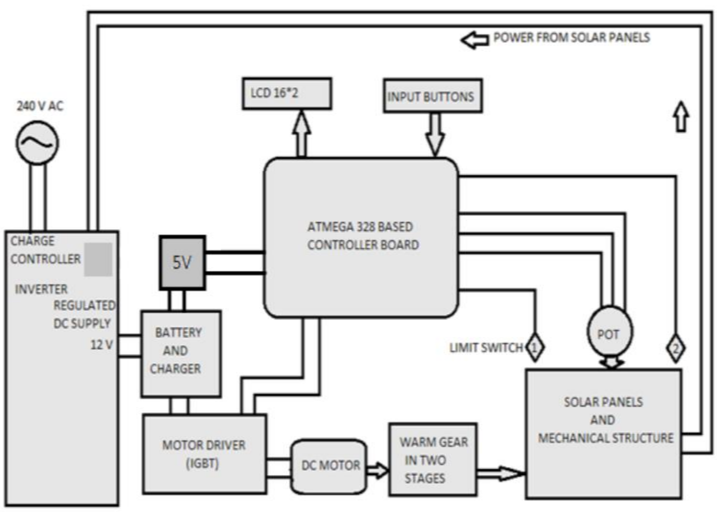

Figure 4. System architecture [9]

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information. The inverter as well as the charge controller were bought in accordance with our setup. After the sun rises, tracking begins once the elevation angle is more than 5 degrees. The dual axis tracker that is implemented has human tilting adjustment but automated rotation around one of the axes.
The panels, which have a total power output of 1000W and are installed on the frames as indicated in Figure 5, are rotated by a DC motor through a heated gearbox. As can be seen in Figure 5, there are two limit switches installed at both ends of the panels in order to safeguard them from any potential malfunctions in the system.

Figure 5. Mechanical structure [9]

IV. SELF CLEANING TECHNIQUE

The primary purpose of self-cleaning technology was to be utilised in rovers and other machines that were to be sent on space missions to the moon and to Mars. The approach calls for the deposition of an electrically sensitive substance that is transparent either on glass or on a layer of transparent plastic that covers the panels [11]. The dust levels on the panel's surface are monitored by sensors, which activate the material when the dust concentration reaches an unacceptable threshold. The electric charge causes a wave that is repellent to dust to cascade over the surface of the material, which then removes the dust and transports it away from the screen's borders. Within two minutes, the technique cleans a solar panel of around 90 percent of the dust that was on it. According to the reports, the mechanism just needs a little quantity of the power that is produced by the panel in order for it to function properly. Solar cells may have their efficiency increased and their maintenance costs reduced by applying a coating to their surface [12], which is especially beneficial for large-scale installations. Solar panels with built-in cleaning mechanisms would be particularly useful in large-scale installations. Dust storms and low levels of precipitation are common challenges that the panels face in the arid areas where many of solar installations are located. At this time, just around 4 percent of the world's deserts are utilised in the process of collecting solar energy. The traditional ways of cleaning solar panels typically entail using a significant quantity of water, which is both expensive and difficult to come by in such arid regions.

V. NANO-FLUID COOLING OPTIMISATION OF HIGH CONCENTRATION PHOTOVOLTAIC PANELS

A rise in temperature of a solar CPV cell results in a considerable reduction in performance. The effectiveness of a CPV system can be increased by the introduction of an appropriate thermal management or cooling system [13]. There are a variety of methods [14-15] that have been developed to prevent the deterioration of solar cells, to maintain them within a temperature range that is suitable for them, and to reach an acceptable level of system efficiency. There has been a significant amount of research conducted on the cooling system. There is both a passive and an active approach to do it. This latter method is utilised in the job that we do. Several methods of cooling have been discussed, including the Heat pipe, which is straightforward, dependable, uniform, free of charge, does not require an air fan, pump, or energy

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consumption, and is appropriate for HCPV [16]. Micro-channels that have a low thermal resistance, a low power need, and the capability to remove a high quantity of heat from a small area [17, 18]. When compared to water, the efficiency of forced air is lower, and it generates more parasitic power [19]. When coupled with the suitable attachment, porous exhibits substantial temperature reduction [20]. [21] An impinging jet is responsible for providing the coolant to the hybrid system.

Due to their outstanding heat transfer capabilities, nano-fluids are an excellent choice for use as a coolant in the vast majority of applications. A nano-fluid is a fluid that contains nanoparticles, which are particles with dimensions of nanometers or less. These fluids are designed suspensions of nanoparticles in colloidal form that are suspended in a base fluid. Nanoparticles, which are commonly used in nano-fluids, can be made from a wide variety of materials. These materials include oxide ceramics (Al2O3,CuO), nitride ceramics (AlN,SiN), carbide ceramics (SiC,TiC), metals (Cu,Ag,Au), semiconductors (TiO2,SiC), carbon nanotubes; and composite materials such as alloyed nanoparticles. However Because of their one-of-a-kind thermo-physical characteristics and the manner in which they conduct heat transfer [13], nano-fluids have been the focus of a lot of attention over the past ten years. Experiments have demonstrated that the use of nano-fluids may increase thermal conductivity and convective heat transfer by significant margins [14, 15], and critical heat flow by up to 300%f[17, 18]. Additionally, nano-fluids improved the pool boiling heat transmission in several different circumstances [19]. The primary objective of this research is to identify the most effective cooling solution that can be utilised for a solar panel when it is being subjected to high levels of concentration.

The cooling system of a solar panel is depicted in Figure 6 below. This particular solar panel has 12 horizontal solar cells and 8 vertical solar cells, which together represent three different scenarios of selected physical models. It is a hollow that is rectangular in shape, measuring L in length and H in width, and it contains a variety of nano-fluids, including Cu, Al2O3, and TiO2 in water. It is believed that the nano-fluids have Newtonian, isotropic, and homogenous properties. The table below provides a summary of the boundary requirements for each of the cases. The flow is turbulence, which is stationary, which is incompressible, and which is un two dimensions. It is assumed that the nano-fluid will maintain its thermo-physical characteristics throughout time. Both the fluid phase and the phase containing the nanoparticles are in a condition of thermal equilibrium, and both phases are moving at the same speed. In order to account for the fluctuating density of the nano-fluid, the Boussinesq approximation has been chosen as the appropriate model to use.

Three different cooling cases are selected for this purpose. In the first scenario, there is a vertical chamber of 0.15 metres in length that is rectangular in shape and includes eight solar cells. In the second scenario, it is expected that the rectangular cavity would be horizontal. It will have a length of 0.2 metres and will contain 12 solar cells. The last scenario involves a cross-cavity that contains twenty solar cells and is characterised by the intersection that occurs between the first vertical cell and the last horizontal cell. A finite element approach was utilised in order to find solutions for the continuity, momentum, and energy equations (FEM). The present analysis takes into consideration three distinct kinds of nanoparticles: Al2O3, Cu, and TiO2. These nanoparticles have volume fraction values between 4% and 8% for the nano-fluids, and their Reylonds numbers fall anywhere between 3000 and 30000. The walls that surround the solar cells are kept at a high temperature in order to protect them. The numerical results suggest that an increase in both the Reynolds number and the volume percentage of nanoparticles would lead to a rise in the Average Nusselt number. In addition, the temperature of the cross cell drops as the arc length increases.

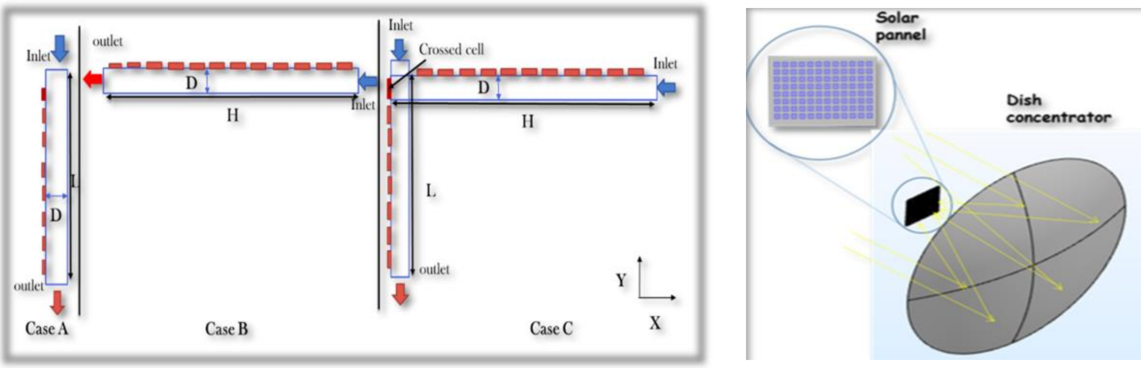

Figure 6. Physical model of the CPV receiver and the three cooling system cases.

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Optimal cooling of solar panels is crossed geometry [13] due to the ideal position of the intersection cell, which is cooling with the passage of the nano fluid at the same time, which confirms the dominance of the convection phenomenon, and consequently a good cooling.

VI. PROPOSED HYBRID MODEL

This is the Hybrid solar panel model proposed by us which integrates all the features shown in figure 7. to increase efficiency. This hybrid design incorporates an integrated automated dual-axis sun tracking system, nano-fluid cooling, and an automatic dust cleaning system to increase its overall efficiency. One method to increase the effectiveness of solar panels is to use a solar tracker with a CPV panel, which continuously tracks the sun throughout the day to capture the maximum amount of solar energy. The second strategy for increasing productivity is dust removal. Solar panel and sunlight are separated by dust. The third strategy is the cooling technique. Since the output voltage of solar panels decreases as their temperature rises, cooling is essential to maximising their efficiency.

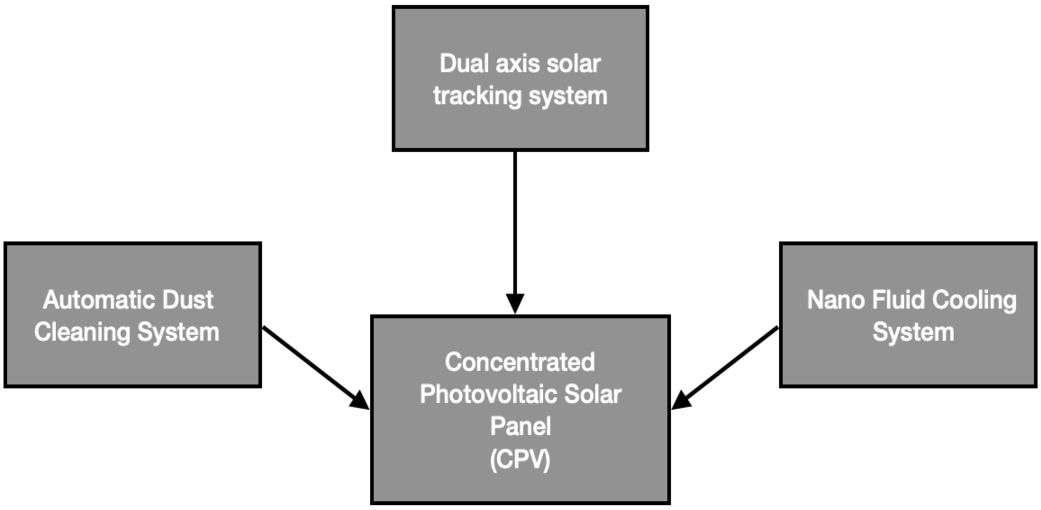

Figure 7. Proposed Hybrid Solar Panel Model

VII. CONCLUSION

One of the most demanding renewable sources of electricity is solar power generation. Compared to other energy sources like fossil fuels and petroleum resources, it has a number of benefits. It is a steady and promising alternative to address the rising demand for energy. Although there are easy ways to use solar energy, there is still a need for an effective and long-lasting solar material. The rational and effective use of solar energy is a key avenue for dealing with the current global energy issue. Photovoltaic (PV) cell that transforms sunlight to electrical current with no mechanical or thermal interconnection. As a result, research into enhancing the efficiency of solar panels is critical. We presented numerous strategies to enhance the efficiency of solar panels (using Concentrated photovoltaic (CPV) technology**,** automatic solar tracking system, nano-fluid cooling and automatic dust cleaning system). The adoption of these technologies has proven to successfully enhance the efficiency of solar power generation in practise. This industry has a number of difficulties, such as cutting manufacturing costs, raising public awareness, and having the greatest infrastructure. Today's world needs solar energy, and research into solar cells has a bright future.

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