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Efficiency Improvement of PV Panel Using Nanofluids

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ABSTRACT

Operating temperature is the main variable impacting the PV panel's efficiency. When light rays hit the PV pane plate, a specific region of this spectrum is converted into electrical power, while the remainder of the spectrum increases the temperature of the cell. The temperature of the cell rises by about 75 to 80 percent of the light that strikes the screen. The cell temperature has been lowered by using a variety of approaches. The use of various nanofluids to cool PV panels by circulating inside the tubes fastened to the panel's back is highlighted in this research. The numerical model for nanofluid heat transfer was used to simulate the outcomes for the temperature of the PV Panel as a result of using various nanofluids. Water, Al2O3, CuO, TiO2, and ethylene glycol are the nanofluids used to lower the temperature.

Keywords: *Simulation; Nanofluid; Light; Power; Temperature.*

1.0 Introduction

Primitive people required more food to support their welfare when men first appeared on the planet a few million years ago. That came from the food he had harvested while hunting for plants or animals [1]. He next looked at fire and how much energy it needed when we started using wood and other resources for cooking and maintaining heat over time. The man started cultivating land for farming. He brought a new facet to energy usage by teaching animals to labor for him [2]. People have started using the wind for sailing ships, wind generators, and the intensity of waterfalls as a result of increased energy demand.

It has been widely accepted that humans exclusively use renewable energy sources, and that the Sun provides all of their direct and indirect energy demands. The invention of the steam engine triggers the start of the industrial revolution, which brought about a number of changes and led to the widespread adoption of a new energy source [3]. After the development of combustion engines, the initial mistake of using fossil fuels—oil and natural gas—was utilized by biofuels, oil, and natural gas, and electricity was decentralized [4].

Extreme human mobility has changed how heat is produced and how fossil fuel engines operate. For the first time, man has the ability to control a machine and is no longer constrained to locations like a quickly moving steam for a portable generator or a mountain for using a wind turbine [5]. The development of electricity and the construction of central plants employing fossil fuels and water have increased mobility. Nuclear energy was a brand-new energy source.

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The sole substantial nuclear power plant was constructed more than 60 years ago, and several nations have already met a small but considerable amount of their energy needs [6]. Today, every nation relies on a range of sources to meet its energy needs. We can be broadly characterized as for-profit and commercial outlets. A developed nation like America gets the majority of its energy from commercial sources, and emerging nations like India use almost as much energy from corporate and nonprofit sources. [7].

In recent years, the loss in fossil fuels has been reduced progressively as they are rapidly running out [8]. In fact, it has come to light. As a result, it is important to first examine the rate of extraction of the various energy sources and to identify the available stocks [9]. This is especially true of gas and oil. The time frame for the fully available sources will be estimated with the help of the figure thus retrieved, obviating the necessity for renewable energy and briefly detailing these options [10]. Men have enhanced their way of life as a result of the widespread usage of commercial fuel. The adverse impact on the environment is perhaps most important.

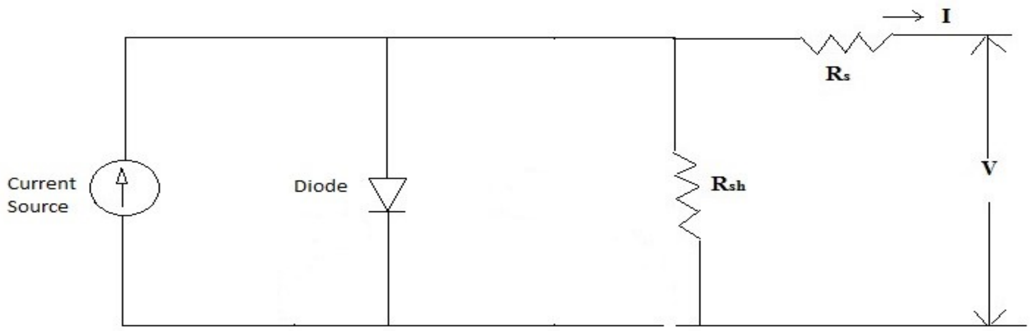
$$V_{OC} = \frac{kT}{q} \ln\left\{\frac{I_L}{I_0} + 1\right\} \quad \ldots(1)$$

$$I_{Total} = I_0\left\{e^{\frac{qV}{kT}} - 1\right\} - I_L \quad \ldots(2)$$

$$F.F = \frac{V_M I_M}{V_{OC} I_{SC}} \quad \ldots(3)$$

$$\eta = \frac{V_{OC}\, I_{SC}\, F.F}{P_{Rad}} \quad \ldots(4)$$

Figure 1: P-N Junction Solar Cell Equivalent Circuit



2.0 Nanofluids Cooling

Recently, it has been recognized that nanofluids are crucial for applications that demand low-cost and consistent temperature distribution, such as industrial processes, microchip cooling, microscopic hydrodynamic systems, etc. [11]. Additionally, nanofluids do not transparently absorb and disseminate the passing of solar radiance to the sun radiant energies, in contrast to standard heat transfer media like water, ethylene glycol, and mold salts. Solar panels use a black-surface absorber to capture solar thermal energy and transfer it to a fluid that circulates inside.

A number of mechanisms that in turn depend on the effectiveness of heat transfer processes control how well a solar thermal system performs [12]. The solar panel is in fact the main component that needs to be improved, however higher solar conversion efficiency is also a possibility. The ideal solar panel absorbs all photons, converts them into heat, and transfers that heat to a fluid medium. Increased power cycle energy conversion results from higher fluid thermal transfer, higher output temperatures, and higher temperatures [13].

$$m_{pv}c_{pv}\frac{dT_{pv}}{dt} = \alpha_{pv}G + A_{pv,env}h_{ray,pv\rightarrow env}\left(T_{sky} - T_{pv}\right) + A_{pv,amb}h_{wi}\left(T_{amb} - T_{pv}\right) - E_{elec} + A_{pv,pab}h_{cond,pv\rightarrow pab}\left(T_{pab-}T_{pv}\right) + A_{pv}k_{pv}\left(\frac{\partial^2 T_{pv}(x,y)}{\partial x^2} + \frac{\partial^2 T_{pv}(x,y)}{\partial y^2}\right) \quad \ldots(5)$$

$$A_{pab,i} = A\left(\frac{w - D_o}{w}\right) \quad \ldots(6)$$

$$A_{tv,i} = D_o L\left(\frac{\pi}{2} + 1\right) \quad \ldots(7)$$

$$T_{sky} = 0.0522 \times T_{amb}^{1.5} \quad \ldots(8)$$

$$h_{cond,m\rightarrow n} = \frac{1}{\frac{\delta_m}{k_m} + \frac{\delta_n}{k_n}} \quad \ldots(9)$$

$$h_{cond,pv\rightarrow pab} = \frac{K_{ad}}{\delta_{ad}} \quad \ldots(10)$$

According to the IPCC's 2013 report, the average global warming rate from 1951 to 2012 was 0.11 degrees Celsius each decade. However, the report also notes that for the previous 15 years, from 1998 to 2012, the trend was only 0.04 degrees Celsius per year; the IPCC referred to this reduction in global warming as a pause [14].

We have witnessed the quick depletion of fossil fuels and the slow end to their use in recent years [15]. In general, it is beneficial to assess the rates of utilization of the various renewable energy sources and to offer some evidence of the remaining stocks for oil and natural gas.

While males use commercial resources more extensively, which has helped to improve their quality of life, my problems have also surfaced. The negative consequences on the environment are perhaps the worst of them. The entire word will be analyzed first, and only then will the specific one be determined [16]. This number will aid in estimating the period of time during which existing energy sources totally replace the requirement for sustainable energy, and this option will be briefly discussed. The influence of nanofluids on cell temperature can be observed by solving the aforementioned equations (5), and we'll be able to do so with the aid of its SIMULINK model in MATLAB.

Table 1: PV Panel Specification

Sr. No.	Variable	Value
1	Cells used	70
2	P_{max}	240 W
3	V_{Pmax}	27 V
4	I_{Pmax}	8 A
5	V_{OC}	29.8 V
6	I_{SC}	9.2 A
7	Temperature Coeff. Of Voc	-027 % / °C
8	Temperature Coeff. Of Isc	0.112 % / °C

3.0 Results and Discussion

Table 2: Characteristics of the Panel's Performance Following the Use of a Cooling Technique

Sr.No.	I_R	T_P	V_{pmax}	I_{pmax}	P_{max}	V_{oc}	I_{sc}	F. F	η
1	1200	25	26.24 V	7.85 A	212.68 W	37.45 V	7.76 A	0.76	0.21
2	840	55	27.45 V	6.89 A	157.63 W	39.57 V	6.42 A	0.75	0.199
3	840	46.7	25.46 V	6.54 A	165.87 W	38.56 V	6.578 A	0.77	0.187
4	820	40.2	31.5 V	7.15 A	169.71 W	29.6 V	6.245 A	0.78	0.256
5	856	41	32.55 V	8.21 A	162.58 W	41.05 V	7.657 A	0.69	0.255

Table 3: Temperature Change Following the Use of a Cooling Technology

Sr. No.	I_R	T_{PV} (Before Cooling)	T_{PV} (After Cooling)	P_{max} (Before Cooling)	P_{max} (After Cooling)
1	1200	25	25	212.68 W	215.68
2	840	55	51	156.2 W	168.66
3	840	46.7	42.7	171.05 W	178.98
4	820	40.2	37.8	162.38 W	172.71
5	856	41	40.76	167.33 W	176.58

Here, temperature fluctuations between 71°C and 53°C and 65°C and 43°C are observable after cooling techniques have been used, but the level of irradiance for that condition has not changed. Temperature drops of about 23oC are seen after cooling technologies. When cooling nanofluid, we can deduce that a considerable temperature drop of around 23 oC is accomplished, and performance improvement and fill factor are seen in this temperature decline. The filling factor and efficiency are about 76 and 19 percent for 57°C, respectively.

4.0 Conclusion

As the temperature rises, the open circuit voltage falls. As can be observed from the tests above, the current increases gradually as the plate temperature rises and the output tension decreases linearly. We reduced the working temperature of PV panels using nanofluids as a refrigeration technology, achieving a variation of about 23 °C and a 2.3 % improvement in efficiency and fill factor, respectively. When compared to the power generated prior to cell cooling, we may increase power by more than 15 W using a cooling method known as nanofluid.

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