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PV Panel Efficiency Improvement Using Nanofluids

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ABSTRACT

The primary factor affecting the efficiency of the PV panel is operating temperature. A portion of this spectrum is converted into electrical power when light rays strike the PV pane plate, while the remainder of the spectrum raises the temperature of the cell. About 75 to 80 percent of the light that reaches the screen increases the temperature of the cell. A number of methods have been used to lower the cell temperature. This research emphasizes the use of different nanofluids to cool PV panels by circulating inside the tubes attached to the panel's back. The temperature of the PV Panel as a result of using different nanofluids was simulated using the numerical model for nanofluid heat transfer. The nanofluids used to lower the temperature are water, Al2O3, CuO, TiO2, and ethylene glycol.

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

1.0 Introduction

When men first began to populate the planet a few million years ago, they needed more food to sustain their welfare. That was made up of food that he had captured while tracking down plants or animals [1]. He then turned his attention to fire and how much energy it required when we first started using wood and other resources for heating and cooking. The man began preparing the land for farming. By training animals to work for him, he added a new dimension to energy usage [2]. Due to the rise in energy demand, people have started using the wind for wind turbines, sailing ships, and to increase the intensity of waterfalls. It is widely acknowledged that all of humanity's energy needs, both direct and indirect, are met by the Sun and other renewable energy sources. The industrial revolution, which brought about a number of changes and resulted in the widespread adoption of a new energy source, was launched by the invention of the steam engine [3]. The initial error of using fossil fuels—oil and natural gas—was used by biofuels, oil, and natural gas after the development of combustion engines, and electricity was decentralized [4].

Extreme human mobility has altered the way fossil fuel engines work and how heat is generated. For the first time, man can operate a machine and is no longer restricted to specific locations, such as a mountain for using a wind turbine or a portable generator [5]. Mobility has increased as a result of the development of electricity and the establishment of central plants using fossil fuels and water. A new source of energy was nuclear power.

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More than 60 years have passed since the construction of the only sizable nuclear power plant, and several countries have already satisfied a sizable but modest portion of their energy needs [6]. Today, every country depends on a variety of sources to satiate its energy requirements. We can be broadly categorised as commercial and for-profit establishments. A developed country like the United States gets the majority of its energy from commercial sources, and emerging economies like India use business and nonprofit sources almost equally [7].

As fossil fuels are quickly running out, the loss has gradually decreased in recent years [8]. It has actually come to light. In order to determine the available stocks, it is crucial to first assess the rate of extraction of the various energy sources [9]. Gas and oil are particularly examples of this. The figure thus obtained will be used to estimate the time frame for the fully available sources, eliminating the need for renewable energy and briefly describing these alternatives [10]. Men's quality of life has improved due to the widespread use of commercial fuel. The negative effects on the environment are perhaps the most significant.

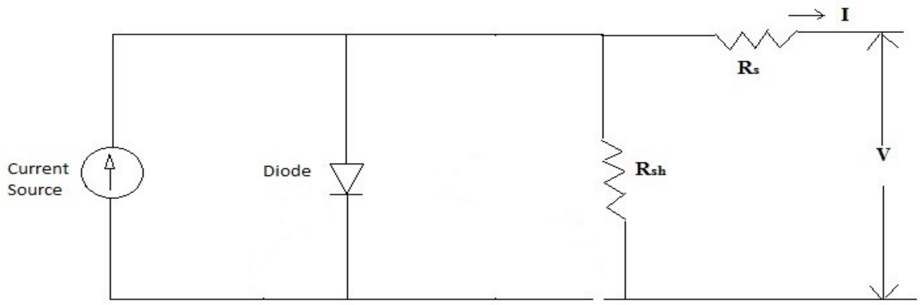
$$V_{OC} = \frac{kT}{q} \ln\left\{\frac{I_L}{I_0} + 1\right\} \quad \ldots (1)$$

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

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

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

Figure 1: P-N Junction Solar Cell Equivalent Circuit



2.0 Nanofluids Cooling

Nanofluids have recently come to be understood as being essential for applications like industrial processes, microchip cooling, microscopic hydrodynamic systems, etc. that call for low-cost and reliable temperature distribution [11]. Additionally, unlike conventional heat transfer media like water, ethylene glycol, and mould salts, nanofluids do not transparently absorb and dissipate the passing of solar radiance to the sun's radiant energies. A black-surface absorber is used in solar panels to absorb solar thermal energy and transmit it to a fluid that circulates inside.

The efficiency of a solar thermal system is governed by a number of mechanisms, which in turn depend on how well heat transfer processes work [12]. The solar panel itself needs to be improved, but there is also a chance of increasing solar conversion efficiency. All photons are absorbed by the ideal solar panel, which then transforms them into heat and transfers it to a fluid medium. Higher fluid thermal transfer, higher output temperatures, and higher temperatures lead to increased power cycle energy conversion [13].

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

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

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

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

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

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

The average global warming rate from 1951 to 2012 was 0.11 degrees Celsius per decade, according to the IPCC's 2013 report. The report also points out that the trend for the preceding 15 years, from 1998 to 2012, was only 0.04 degrees Celsius per year; the IPCC referred to this decrease in global warming as a pause [14].

In recent years, we have seen both the rapid exhaustion of fossil fuels and the gradual end to their use [15]. Generally speaking, it is advantageous to evaluate the rates of utilization of different renewable energy sources and provide some evidence of the remaining oil and natural gas stocks.

Males use commercial resources more frequently, which has improved their quality of life, but my issues have also become apparent. The adverse effects on the environment are arguably the worst. Prior to identifying the specific one, the entire word will be examined [16]. This figure will help in determining how long it will take for current energy sources to completely replace the need for sustainable energy, and this solution will be briefly discussed.

By resolving the aforementioned equations (5), we will be able to see how nanofluids affect cell temperature. We will be able to do this with the help 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

After cooling methods have been applied, temperature fluctuations between 71°C and 53°C and 65°C and 43°C are visible, but the amount of irradiance for that condition has not changed. Following the use of cooling technologies, temperature drops of about 23oC are observed. We infer that cooling nanofluid results in a significant temperature drop of about 23 oC, and we observe performance improvement and fill factor in this temperature decline. For 57oC, the filling factor and efficiency are approximately 76 and 19%, respectively.

4.0 Conclusion

The open circuit voltage decreases as the temperature increases. As the plate temperature rises and the output tension linearly decreases, as can be seen from the tests above, the current gradually increases. By using nanofluids as a refrigeration technology to lower the working temperature of PV panels, we were able to increase efficiency and fill factor by 2.3 percent and about 23 °C, respectively. Using a cooling technique known as nanofluid, we may be able to increase power by more than 15 W in comparison to the power generated prior to cell cooling.

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