Enhancing the Performance of Photovoltaic Panel by Nano-Fluid

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ABSTRACT:- Researchers are continually striving to improve the efficiency of photovoltaic panels which contain solar cells that convert light energy to electrical energy. The objective is to improve photovoltaic (PV) efficiency by maintaining it below maximum allowable temperature. Accordingly, the excess in heat must be dissipated efficiently in order to avoid excessive high temperatures, which have an adverse effect on the electrical performance of the cell. Therefore, in this paper a simulation work on Ansys software has been done to enhance the performance of photovoltaic cell using Al_2O_3 as a nano-fluid.

Keywords:- Photovoltaic (PV), ANSYS Software, Nano-fluid, Al_2O_3

I. INTRODUCTION

Energy holds significant economic importance for any country, as it is not only crucial for industries, but also for meeting the domestic needs of society. This energy can take various forms, such as electricity, chemicals, heat, and others. Traditionally, fossil fuels have been used to fulfill these energy demands, but they are finite resources that cannot be easily replenished. The rate at which humans consume fossil fuels far exceeds the rate at which they are naturally substituted [1]. Therefore, finding sustainable alternatives to fossil fuels is essential for meeting our long-term energy needs. Sustainable energy is a pivotal issue that has the potential to bring about positive change in the present situation [2, 3]. Fossil fuels not only contribute to environmental pollution, but also face the challenge of depletion. So, to decrease the environmental impact of such sources, the request for renewable energy is increasing to meet the growing energy needs. As the cost of solar energy drops below that of fossil fuels, the demand for fossil fuels tends to decrease. Solar energy can be harnessed through various systems, including Photovoltaic Thermal (PVT) units for producing both heat and electricity from solar energy.

PV units are applied to convert incident radiation into electricity and only 20% of the whole energy of sunlight can be converted and remaining is wasted. However, elevated operating temperatures can lead to a reduction in the conversion rate and this temperature increase can result in damage to the structural integrity of the solar panels [4, 5]. Efforts to augment the electrical performance (η_{el}) of PV panels involve reducing their operating temperature, which can be reached through the employ of a thermal absorber unit. Researchers have explored a method called PVT unit, to lower cell temperature6. The PVT system enables simultaneous generation of electricity and heat [6, 7].

It investigated a research to optimize the dimensions of a heat sink for improving cooling performance of solar panels. Their findings identified a duct with optimal design points then they employed in a 3D model to assess the effectiveness of a PVT. The greatest electricity performance achieved was 17.45%, which demonstrated a significant improvement of nearly 40% compared to a typical CPV/T system. They have presented a computational methodology for designing a high-performance composite material to be used as the backside of a concentrated PV (CPV) unit. The proposed composite shows promising potential and results in a 4.3% enhancement in electrical output and improved module durability. He presented a novel and versatile approach for cooling photovoltaic panels. They found that performance of PV enhances about 19% with employing the proposed system [8, 9].

Through ongoing research on fluid properties, water can be modified to enhance its heat removal capabilities for photovoltaic (PV) cells. This can be achieved by incorporating nanoparticles into water to increase its thermal conductivity. Nanofluid, which is a type of heat transfer medium composed of nanometer-sized engineering materials mixed with a base fluid, has garnered significant attention from researchers due to its performance in various usages [10]. Nanofluids have gained attention as promising cooling techniques for PVT. Researchers have experimented with different nanofluids in different structures of PVT systems to optimize their efficiency and establish an effective system with improved overall performance. A research managed examined the efficiency of a hybrid PVT in existence of micro fins and turbulator. The reported η_{el} of the unit was 10.8% and the maximum thermal performance of the unit was 83.3%. The optimal operating conditions for a PVT system with CuO nanofluid were scrutinized [13]. The outputs showed that increasing the nanofluid fraction resulted in a 1.11% and 3.3% increase in electrical and thermal performances.

II. RESEARCH METHODOLOGY

Drawing the geometry is the first step in the simulation process. Figure 1 shows a schematic view of the geometry model that was used in this simulation.

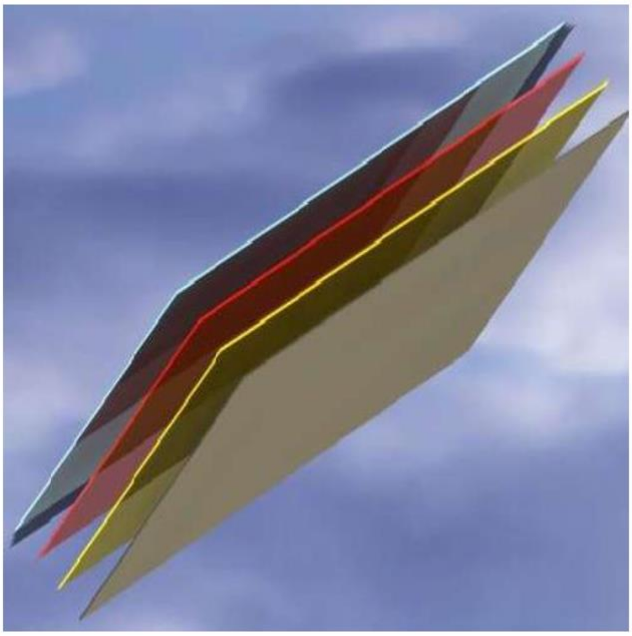

Figure 1: Different layer of photo voltaic cell

Table 1: Components description

Sr. no	Components	Dimensions
1.	Glass	1200×500×3 mm
2.	Eva	1200×500×0.8 mm
3	PV cell	1200×500×0.3 mm
4	Duct	1200×500×8 mm
5	Tedlar	1200×500×0.5 mm

The model of pv panel with and without cooling system is created in CATIA V5 software and then imported to spaceclaim in ANSYS workbench.

Assumptions used in simulation

The following assumptions are made in the numerical simulation model:

- The cooling fluid is considered as incompressible.
- The fluid flow is steady-state and uniform.
- As water and nanoparticles are in thermal equilibrium, the calculations assume no phase change of nanofluid. The flow regime is taken laminar.

Mesh generation

Mesh generation detail without duct.

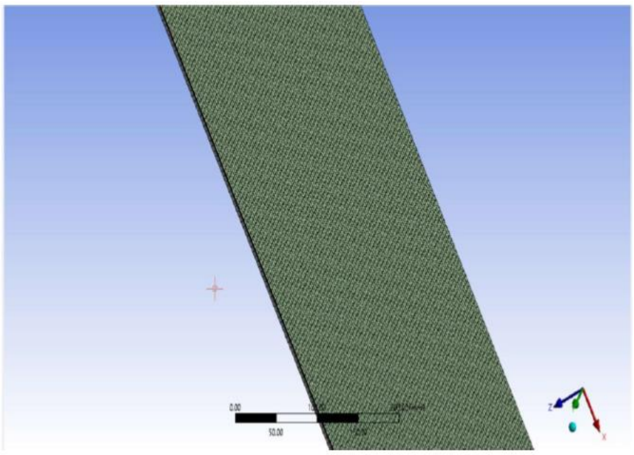

Figure 2: Mesh generation detail without duct

- Total number of node-194728
- Total number of element-96000
- Mesh size-5mm
- Mesh matrix- skewness

Meshing generation detail with duct

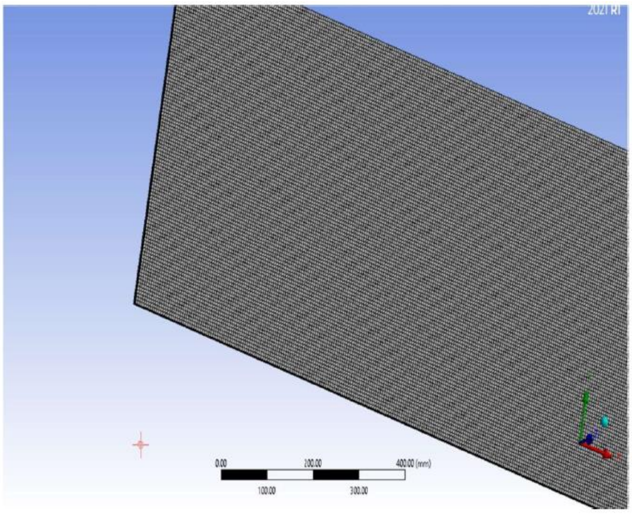

Figure 3: Meshing generation detail with duct

- Total number of node-267751
- Total number of element-144000
- Mesh size-5mm
- Mesh matrix- skewness.

Boundary condition
- Solar radiation-1000 W/$m2$
- Convective heat transfer-5 W/$m2k$
- Energy of the model is ON
- Flow is laminar.

Table 2: Thermo physical properties of material used in simulation

S. No.	Material	Specific heat (J/Kg K)	Thermal conductivity (w/m K)	Density (kg/m^3)
1	Glass	780	1.7	2500
2	Eva	3135	0.23498	920
3	Silicon	710	148	2328
4	Tedlar	1098	0.1583	1400

Table 3: Thermophysical properties of nano-fluid used in simulation

Particle concentration	Specific heat (J/Kg K)	Thermal conductivity (w/m K)	Density (kg/m^3)	Viscosity (kg/m s)
1%	4154.7	0.765	1000.7	0.000618
2%	4120.2	0.782	1033.6	0.000714
3%	4052	0.798	1059.8	0.000795
4%	4017.8	0.812	1086	0.00089

III. RESULTS AND DISCUSSION

Variation of PV cell temperature with solar radiation
After taking consideration of heat flux on the glass cover, the variation in the temperature of PV module was observed.

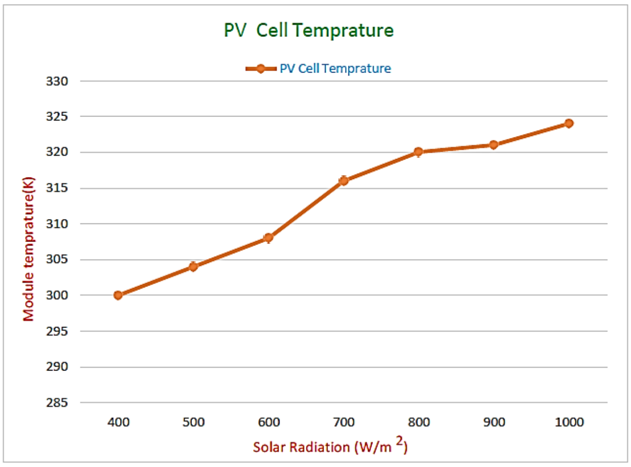

Figure 4: Variation of module temperature vs solar radiation

From above graph it can be inferred that as solar radiation temperature increases there is increase in photo-voltaic module temperature.

Variation of PV cell temperature with and without cooling
The variation of PV module temperature was observed with and without cooling effect. The variations in the surface temperature was observed to see the effectiveness of the cooling with the nano-fluid.

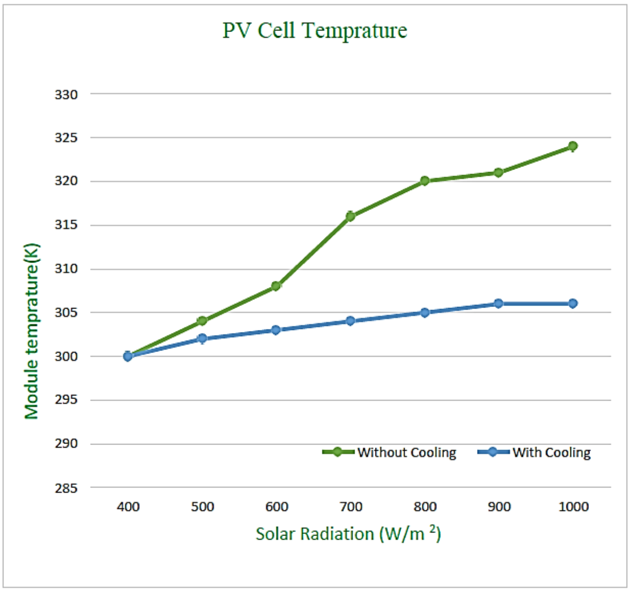

Figure 5: Variation of module temperature with and without cooling

Above graph was plotted between module temperature and cooling methods applied to the photo-voltaic module. From the above graph it can be concluded that module temperature decreases as cooling fluid passes through the duct at the base of the photo-voltaic module.

Variation of PV cell temperature with fluid velocity

The variation of PV module temperature was observed with varying fluid velocity. The variations in the surface temperature was observed to see the effectiveness of the cooling with the nano-fluid.

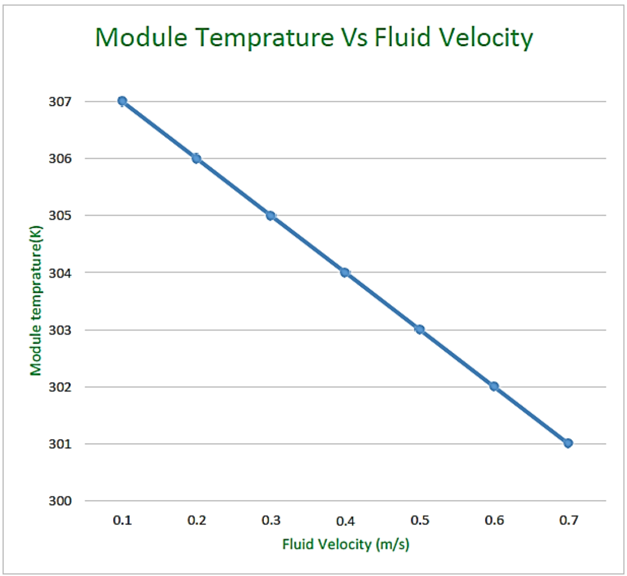

Figure 6: Variation of module temperature with fluid velocity

From above graph it can be seen that the effect of cooling goes on increasing when we increases the fluid velocity.

Variation of PV cell temperature with flow rate

The variation of PV module temperature was observed with varying mass flow rate. The variations in the surface temperature was observed to see the effectiveness of the cooling with the nano-fluid with respect to water.

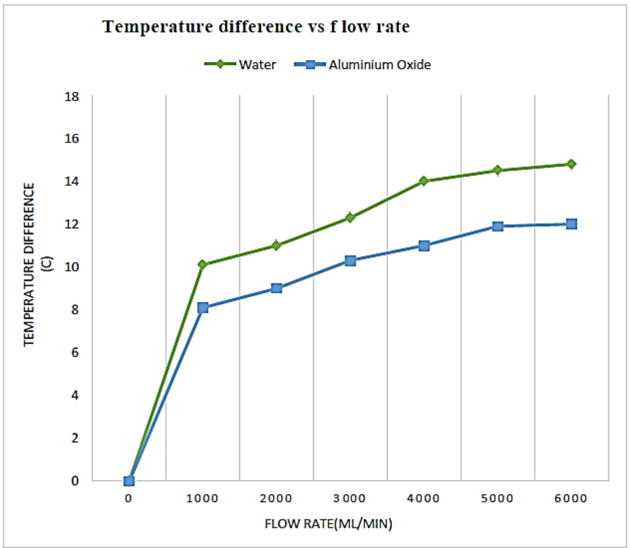

Figure 7: Variation of module temperature with mass flow rate

From above graph it can be seen that aluminium oxide has better cooling effect than water. So it can be inferred from the above graph that using nano-fluid as cooling agent improves conversion efficiencies of the solar PV module.

IV. CONCLUSION

1. The temperature of PV panel gets decreases by 18°C when nano-fluid (Al_2O_3) of concentration ratio 5% passed over it. The conversion efficiency of the photo- voltaic panel increased by 9%.
2. As the concentration of nanofluid increases the temperature reduction also gets increase.
3. As the velocity of the fluid increases heat transfer also gets increases.
4. The temperature of photovoltaic panel decreases as the mass flow rate increases.

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