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Design and Optimization of PV/T Solar Collector System Suitable for Local Climate Conditions in Türkiye - İran

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Abstract: This study implements this concept by using a new roof-mounted PV multi-reflection panel, which not only increases the power output of the PV panel, but most importantly, the aesthetic aspect is a major barrier to large-scale uptake of PV/T. We developed it by considering the production planning of the industrial, expecting our model to determine each optimum production level. This model is based on a mixed binary-continuous linear optimization problem. The flow variables are continuous and the decision variables can be sales and purchases in the markets and gas purchases. We extracted the extra earnings and generate by comparing the situations that interact with the electricity markets and those that do not. In this study, it is aimed to develop an alternative system to the inefficient conventional building energy production and space heating systems, which are widely used in Türkiye, and to ensure that the developed technology has wide usage areas. The reason of rapid development of photovoltaic/thermal (PV/T) solar collector technologies, which are not yet known in the world and not used in R&D industrial applications, is to provide solutions to the industrial and social difficulties in the field of energy with Türkiye and İran, which has a close climate, by providing commercial value. In this way, it contributes to the industrial and economic development of both countries by creating new employment opportunities. Thus, private investment in innovative research in the field of solar and other renewable energy systems contribute to the reduction of carbon emissions by the two neighbouring powerful states and to the solution of problems related to energy security, climate change and increased energy consumption. In the study, more heat than heated PV panels using the high thermal conductivity of the fluids, which achieved 14% improvement in electricity production with the withdrawal of Fe_2O_4 nanofluid. Since the amount of heat absorbed in the thermal system is high, there is an increase in the average 10.4% temperature (ΔT) hot fluid temperature compared to the base fluid water was obtained in Fe_2O_4 nanofluid. For this reason, it is to integrate a power-generating PV panel and a solar thermal heating panel within the same collection surface.

Keywords: PV/T Systems, Optimization, Climate change, Türkiye, İran.

1. INTRODUCTION

The most common systems used to convert solar energy into thermal energy, water has traditionally been used as liquid. In this study, we obtained nanofluids, a new thermal nanofluid with high basic temperature, using conventional water and doped nanoparticles to achieve better efficiency. Magnetic nanoparticles are formed when groups of magnetic nanoparticles with diameters ranging from 50 to 200 nanometers come together. Magnetic nanoparticle assemblies are made up of a collection of nanoparticles that have each been extracted and isolated independently by a team of researchers (Swese & Hançerlioğulları, 2022). These specific purposes are as follows; to perform the design, modeling/simulation and optimization of the proposed photovoltaic thermal (PV/T) solar collector system; to design, build and test the PV/ThermoGen prototype; building integration and system performance studies and testing in building/climatic contexts; to make economic, social, environmental and thermodynamic analyzes of the PV/ThermoGen system (Shahsavar et al., 2021). In this study, focusing on the electro-mechanical production industry of advanced PV/T solar panels, studies carried out on the development of new methodological methods for the efficiency of existing asset management practices of the infrastructure of this industry and the optimal improvement of new technological systems. For this reason, it is to

integrate a power-generating PV panel and a solar thermal heating panel within the same collection surface. In this research, it was implemented using a new roof-mounted PV multi-reflection panel, which not only increases the power output of the PV panel, but most importantly, the aesthetic aspect is a major barrier to large-scale uptake of PV/T of Türkiye-İran, Europe, some Asian countries, especially. Advanced innovation companies around the world have recently focused on both useful and ergonomic systems for renewable energy systems (Ghadiri et al., 2015). By applying a multi-reflective absorption concept and integrating it with solar and air source heat pump, the proposed technology provides a building integrated solar system with high efficiency and aesthetically appealing (Khanlari et al., 2019). For photovoltaic (PV) systems, simulation of some parameters carried out by engineering analysis and machine learning algorithm to improve deep neural network and maximum power point efficiency. Solar Photovoltaic (PV) systems are one of the most promising renewable energy sources that convert solar energy into electrical energy in an environmentally compatible manner. However, these systems have low efficiency and high relative costs. To overcome these disadvantages, the load requirement, there is a need for a grid-connected PV energy system to meet the requirements. In line with this information, I develop a new and efficient algorithm in PV/T Systems. The amount of electricity produced in Türkiye, which is one of the developing countries, does not meet the energy requirement. We need more than half of our energy needs in a state connected to neighbouring countries (Russia, Bulgaria, İran, etc.). Hard coal, lignite, oil and natural gas are the only important domestic energy sources. Approximately 97% of the grid electricity in Türkiye is produced from fossil fuels, which emit harmful CO_2 gases into the atmosphere.

2. MATERIALS AND METHODS

2.1. Preparation of the Hybrid Nanofluid

The Fe_2O_4 nanoparticle used in this study that is obtained from Nanography Nano Technology Science and Consultancy Ltd. Company. Physical parameters such as particle size, shape and purity of nanoparticles and pure water were listed in Table 1. The particle ratios Fe_2O_4 0.6% by weight, while the ratio of nanoparticles by weight in hybrid nanofluid is 1%. The nanoparticles first dispersed in pure water by mechanical mixing. Various techniques are used to prevent precipitation problems and to obtain a homogeneous fluid (Lämmle et al., 2017). In this study, 0.2% surfactant Triton X-100 added to the solution with nanoparticle concentration of 1%. For homogeneous distribution of Fe_2O_4 nanoparticle in the base fluid (pure water), the obtained hybrid nanofluid was kept in an ultrasonic bath for 5 hours.

Table 1. Thermo-physical properties of nanoparticles and pure water (40 °C).

Material	Particle Morphology	Colour	Purity (%)	Particle Size (nm)	Density (kg/m^3)	Specific Heat (J/Kg K)	Thermal Conductivity (W/m K)
Pure Water	/	/	/	/	995	4250	0.620
Fe_2O_4	Spherical	Black	97.45	17	5300	702.3	75

2.2. Measurement of the Thermophysical Properties

The relationships between base fluid and hybrid nanofluid for different thermal physical properties were calculated. The specific heat value of the hybrid nanofluid was calculated as follows;

$$Cp_{hna} = \frac{\rho_{Fe_2O_4} Cp_{Fe_2O_4} + (1-\Phi)\rho_{pure\ water} Cp_{pure\ water}}{\rho_{hna}} \quad (1)$$

where Cp_{hna} is the specific heat of the hybrid nanofluid, ρ_{Fe_32} is the density of Fe_2O_4 nanoparticles, $\rho_{Fe_2O_4}$ is the density of Fe_2O_4 nanoparticles, $\rho_{pure\ water}$ is the density of the base liquid, ρ_{hna} is the density of the hybrid nanofluid, $Cp_{Fe_2O_4}$ is the specific heat of. The calculated thermos-physical properties of the hybrid nanofluid are given in Table 2.

Table 2. Thermo-physical properties of hybrid nanofluid.

Hybrid Nanofluid	Density (kg/m^3)	Specific Heat (J/Kg K)	Thermal Conductivity (W/m K)
(Fe_2O_4)/Water	5.326	702.3	120.3

The necessary theoretical analysis was carried out using the data, recorded as experimental results. The heat production of PV/T panels can be expressed as follows:

$$\dot{Q}_{PVT} = \dot{m}_{PVT} c_p (T_{PVT,o} - T_{PVT,i}) \quad (2)$$

3. RESULTS AND DISCUSSION

We carried out in the climatic conditions average of Türkiye as experimental study. The maximum surface temperature difference is 14ºC. As a result of the experiments, it was observed that the cooling of the panel reached to a significant degree. In the PV/T system, the cooling amount increased by using different fluid, water, and hybrid nanofluid. In addition, 14% improvement in energy output was calculated in the hybrid state (Fe_2O_4+Water) compared to conventional water (Sandnes & Rekstad, 2002).

Figure 1 give to variation of inlet and outlet temperatures of serpentine with time, according to the type of fluid used in the cooling circuit (Sözen et al., 2020). Mains water primarily used as the cooling fluid in the experiments carried out according to the values measured at certain times of the day. Firstly, calculation of heat absorbed by cooling system have been made, and coolant able to remove maximum heat identified.

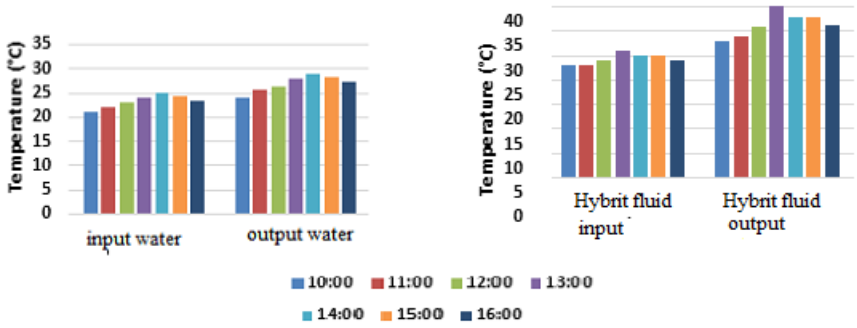

Figure 1. Input/output compare of temperature –time (water and hybrid fluid).

4. CONCLUSION

Considering the climatic conditions and energy needs of Türkiye and İran, successful development of the proposed system has significant economic impact and help global investment achieve the target of reducing emissions as required by both Turkish and Iranian governments (Michael & Iniyan, 2015). Hybrid PV modules with thermal units (PV/T) are heat-releasing systems that are installed together with a solar cell. The system also allows excess heat to be stored for other purposes, so that the benefits of solar energy are greatly harnessed (Maadi et al., 2017). In addition to increasing the electricity production performance of PV systems, the importance of PV/T systems is to obtain thermally hot fluid from the system. The importance of the PV/T system has also increased due to the wide application area of the produced hot fluid, which can be used as an energy source in heat pumps in industrial drying systems and for heating rooms/areas and green houses. In this study, it can be concluded that the hybrid nanofluid containing nanometer-sized Fe_2O_4 particles is aimed to replace pure water with properties such as high thermal conductivity and heat transfer coefficient. Therefore, weight, energy and production cost be reduced.

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