"PERFORMANCE MONITORING OF WATER COOLED SOLAR PANEL USING MICROCONTROLLER"

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ABSTRACT

Solar panels, or photovoltaic (PV) cells, generate electricity from sunlight, but their performance decreases as they get hotter. A major portion of solar energy absorbed by these cells is converted into heat, which negatively affects their electrical efficiency. This project addresses the thermal management of PV panels through the use of an automated water cooling system. The system activates when the panel temperature exceeds 25℃, spraying water to lower the temperature and maintain optimal operating conditions. It also includes a real-time temperature monitoring mechanism. To evaluate its effectiveness, tests were conducted comparing the power output of a PV panel with and without the cooling feature. A solar cell with a rated peak power of 5.0 watts was employed, along with supporting electronics for the cooling function. The outcome of the project demonstrated the potential of such a cooling technique to enhance the overall efficiency of solar energy conversion.

Keywords: Analysis, investigation, research.

I. INTRODUCTION

This project aims to monitor the performance of a water-cooled solar panel system using a microcontroller. As part of our research, we examined existing literature, design methodologies, component configurations, and previous implementations. Through this exploration, we identified various studies relevant to our topic, which helped highlight potential challenges that may arise during the system's development and deployment. One significant concern involves choosing the most appropriate components for our application and ensuring accurate processing of sensor data through the microcontroller.

The increasing reliance on solar power, owing to its renewable and eco-friendly characteristics, has led to widespread use of photovoltaic (PV) systems for converting sunlight into electricity. However, a major limitation of PV panels is the decline in efficiency caused by excessive heat due to strong solar exposure and high surrounding temperatures. This thermal buildup can severely impact energy production. Research findings suggest that integrating a water-cooling mechanism can mitigate this issue and boost energy output. Simulations using computational fluid dynamics (CFD) have shown that the layout and structure of the cooling system play a critical role in determining its effectiveness. Additionally, experiments involving photovoltaic/thermal (PV/T) systems that utilize air for cooling have compared natural versus forced convection. Results indicated that the addition of fins improved heat transfer and enhanced the system's thermal performance.

II. METHODOLOGY

Project Planning and Requirement Analysis

1. Objective Setting:

- The main aim of this project is to track and enhance the functionality of a solar panel system cooled by water, using a microcontroller for automated data acquisition and control operations.
- **Performance Benchmarks** include monitoring the panel's surface heat, water flow levels, voltage and current readings, and overall energy conversion efficiency.

2. Requirement Identification:

- **Core Functional Features:** The system must support real-time tracking of thermal conditions, fluid flow, and electrical parameters, while also enabling data storage and remote accessibility.
- **Supporting Non-Functional Features:** Priorities include stable performance, precise measurement capabilities, ease of operation, and the flexibility to scale for future enhancements.

3. System Framework:

A. Physical Setup (Hardware):

- **Solar Panel System:** Includes an active water-based cooling mechanism to manage heat buildup.
- **Sensor Setup:** Temperature, voltage, current, and flow sensors interface with the microcontroller for continuous data acquisition.
- **Display & Control Unit:** Features an interactive screen (OLED/LCD) along with physical buttons or a touch interface for user interaction and system navigation.

B. Software Architecture:

- **Embedded Code Development:** Custom firmware is developed to read sensor inputs, control operations, and execute data processing routines.
- **Data Processing & Storage:** Algorithms are used for interpreting sensor data, handling records, and possibly triggering control actions based on set thresholds.

4. System Implementation:

A. Hardware Integration Steps:

- **Sensor Wiring:** Electrical and thermal sensors are connected to the microcontroller in a structured layout.
- **Interface Installation:** The visual display is configured to show system status and live data.
- **Power Setup:** A reliable and regulated power source is connected to run the microcontroller and associated components.

B. Software/Firmware Tasks:

- **Sensor Configuration:** Routines are created to calibrate sensors, ensuring high measurement accuracy.
- **Data Collection Logic:** Code is written to fetch data from each sensor and compute necessary values.
- **Interface Interaction:** Programming is done to enable data visualization and user control through the interface.

II. MODELING

Model and Material which are used is presented in this section. Table and model should be in prescribed format.

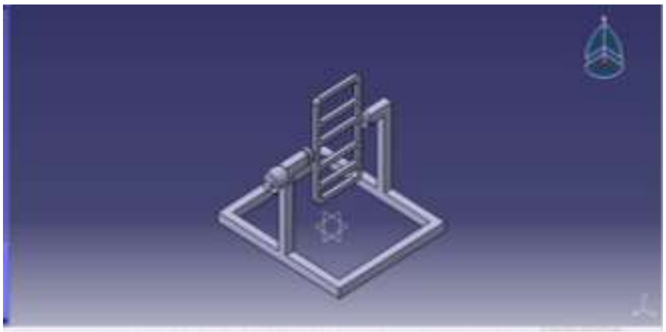

Figure 1: 3D view of Model

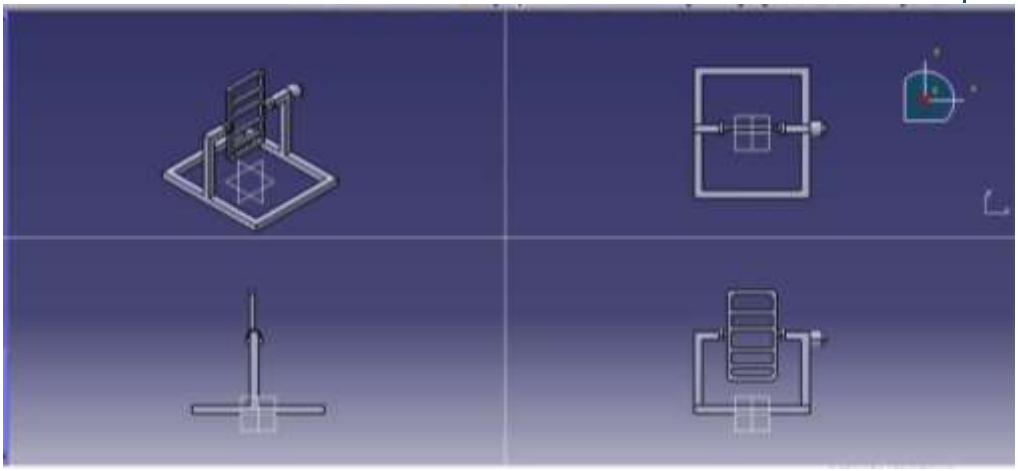

Figure 2: Drafting

Figure 3: Model Image

IV. RESULTS AND DISCUSSION

This study was carried out to improve the performance of photovoltaic (PV) panels by integrating an active cooling mechanism that utilizes water. To assess the effectiveness of the system, a comparative analysis was performed between PV panels with the cooling solution and those operating under standard conditions. The primary objective was to lower the temperature on the panel surface efficiently, while also aiming to limit the consumption of both water and electrical energy..

Table 1. Observation table (Before Cooling)

Time	Temperature ℃	Voltage V	Current A	Power W
10.30 AM	26	17.8	4.90	87.2
11.00 AM	28	17.5	4.85	84.8
11.30 AM	29	17.3	4.80	83.0
12.00 AM	31	17.0	4.75	80.7
12.30 AM	34	16.5	4.60	75.9
1.00 AM	35	16.3	4.55	74.1
1.30 AM	37	16	4.44	71.04

Table 2. Observation table (After Cooling)

Time	Temperature °C	Voltage V	Current A	Power W
10.30 AM	21	18.2	5.00	91.0
11.00 AM	23	18.0	4.95	89.1
11.30 AM	24	17.8	4.90	87.2
12.00 AM	26	17.5	4.85	84.8
12.30 AM	29	17.2	4.70	80.8
1.00 AM	30	17.0	4.60	78.2
1.30 AM	32	16.8	4.55	76.4

V. CONCLUSION

A gravity-fed, low-pressure water spray mechanism was designed to provide direct surface cooling to the solar panel. The prototype aimed to assess improvements in power generation and to study how effective temperature control could influence overall system efficiency. Although the current version lacks a feature for recycling water, future enhancements may include this capability to support better environmental performance and operational efficiency.

In its current setup, the system's energy usage was greater than the electrical output from the PV panel. However, this limitation is expected to be mitigated when the design is applied to larger solar arrays, where the efficiency improvements can outweigh energy costs.

The cooling setup utilized a 3V direct current (DC) pump capable of delivering water at a rate of 80 liters per hour. With cooling applied, the solar panel's efficiency rose from 5.29% to 6.37%, marking a 20.4% increase. The panel used had dimensions of 14 cm by 8 cm, yielding a surface area of 0.0112 square meters. Under an irradiance of 1000 W/m², it received a total solar energy input of 11.2 watts. When the pump was powered using an external source, the cooling system led to significant performance improvements. However, running the pump directly from the panel's output caused an overall energy deficit, suggesting that this approach may not be viable for small-scale photovoltaic systems.

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