Solar Based Air Cooler Using BLDC Motor

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Abstract - With the intensifying global demand for thermal comfort, traditional cooling systems are contributing significantly to high electricity consumption and environmental strain. This research proposes an innovative solution by developing an evaporative air cooler powered by solar photovoltaic (PV) energy and driven by a Brushless Direct Current (BLDC) motor. Unlike standard coolers that use AC induction motors, the integration of BLDC technology offers superior efficiency, reduced thermal loss, and enhanced longevity. The system utilizes a dedicated charge controller to manage energy harvested from solar panels, storing it in a battery unit for consistent operation during non-sunny periods. Experimental observations indicate that this system provides a cost-effective and sustainable cooling alternative, particularly effective for off-grid applications or regions facing frequent power instability.

Key Words: Photovoltaic Energy, BLDC Motor, Sustainable Cooling, Energy Storage, Evaporative Technology.

1.INTRODUCTION

The escalation of global temperatures has made air cooling a necessity rather than a luxury. However, the reliance on grid-connected AC cooling systems poses economic and environmental challenges, especially in developing regions where electricity is either expensive or unavailable. To mitigate these issues, transitioning toward renewable energy sources like solar power is essential.

This project focuses on the synergy between solar harvesting and high-efficiency motor control. By replacing conventional motors with BLDC variants, the system minimizes energy conversion losses. Since solar panels generate DC power, using a DC-native BLDC motor eliminates the need for complex inverters, thereby simplifying the architecture and boosting overall system performance. This paper explores the design, hardware configuration, and functional efficiency of such a solar-driven cooling unit.

Body of Paper

2.1 Methodology

The developmental process was centered on optimizing the energy flow from the sun to the cooling fan. The methodology involved calculating the required solar wattage to support the BLDC motor's load and selecting a battery capacity that ensures at least 4-6 hours of backup. The physical design prioritizes air-flow dynamics to maximize the cooling effect through evaporative pads.

2.2 Principle of Operation

The system functions through a multi-stage energy conversion process:

1. **Energy Harvesting:** Solar PV panels capture solar radiation and convert it into low-voltage DC electricity.
2. **Power Management:** A smart charge controller regulates this power, ensuring the battery is charged safely without over-voltage risks.
3. **Storage & Distribution:** The battery acts as a buffer, providing a steady current to the BLDC motor regardless of fluctuating sunlight intensity.
4. **Mechanical Cooling:** The BLDC motor drives the fan blades, drawing air through moisture-saturated pads, which lowers the ambient temperature via the latent heat of evaporation.

2.3 Component Specifications

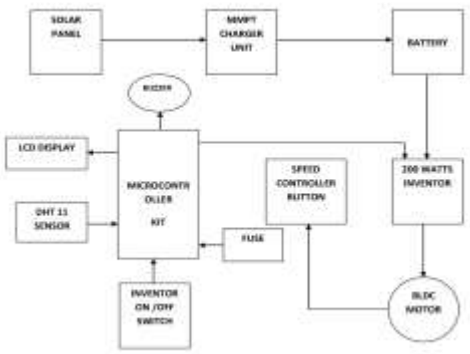
Photovoltaic Module: High-efficiency polycrystalline/monocrystalline panel for DC generation.

BLDC Motor: High-torque, low-noise motor capable of operating directly on DC supply.

Battery Unit: Deep-cycle rechargeable battery for energy retention.

Charge Controller: PWM or MPPT based regulator to optimize charging efficiency.

BLOCK DIAGRAM OF THE SYSTEM:



WORKING PRINCIPLE

The working principle of the **solar-based air cooler using BLDC motor** is based on converting solar energy into electrical energy and using it to operate a highly efficient BLDC motor, which drives the air-cooling mechanism. The system combines **solar power generation**, **battery storage**, and **evaporative cooling** to deliver continuous and eco-friendly cooling.

1. Solar energy conversion

- The solar panel absorbs sunlight and converts it into **dc electrical power** using photovoltaic cells.
- This energy acts as the primary power source for the entire system.

2. Power regulation (charge controller)

- The dc power from the solar panel is passed through a **charge controller**, which regulates the voltage and current.
- It prevents:
    - Overcharging of the battery
    - Deep discharge
    - Voltage fluctuations
- The charge controller ensures safe and efficient charging of the battery.

3. Energy storage in battery

- The regulated dc power is stored in a **rechargeable battery**.
- The battery provides backup power during:
    - Cloudy weather
    - Low sunlight
    - Nighttime
- This ensures continuous operation of the cooler even when sunlight is not available.

4. Operation of BLDC motor

- The BLDC (Brushless dc) motor receives dc power from the battery or directly from the solar system.
- Properties like high torque, low noise, and reduced power consumption make it ideal for cooling applications.
- The BLDC motor drives the fan blades, producing strong airflow efficiently.

5. Evaporative cooling process

- The fan pulls surrounding hot air through **wet cooling pads**.
- As air passes through these pads, **water evaporates**, reducing the air temperature.
- This produces cool and refreshing airflow.

6. Delivery of cool air

- The cooled air is blown into the room or area, providing effective cooling without grid electricity.
- The entire system consumes very low power, making it ideal for solar operation.

PROJECT MODEL OUTPUT

DISCUSSION & ANALASIS RESULT:

1. Solar panel performance

- The 20w/40w solar panel generated sufficient dc power during peak sunlight hours.
- Output voltage remained stable between **12v – 18v**, depending on sunlight intensity.
- Charging of the battery began immediately under sunlight, indicating good efficiency.

2. Battery backup

- The 12v battery stored enough energy to operate the cooler for **2–4 hours** depending on motor speed.
- The charge controller protected the battery from overcharging and deep discharge.

3. BLDC motor efficiency

- The BLDC motor delivered **high airflow**, low noise, and smooth operation.
- Power consumption was significantly lower than traditional ac motors.
- Motor speed remained stable even during voltage fluctuations.

4. Cooling effectiveness

- Temperature drop of **4°c – 8°c** was observed depending on humidity and room size.
- Cooling pads absorbed water uniformly, enhancing evaporative cooling.
- Airflow from the fan was strong and evenly distributed.

5. System operation

- Complete system worked purely on solar energy during daytime.
- Transition from solar to battery mode was smooth with no interruption.
- The cooler operated safely with no overheating or electrical issues.

ADVANTAGES:

1. High efficiency with BLDC motor

The use of a BLDC motor substantially improved airflow while reducing power consumption. Its low noise and high torque performance made the system more reliable compared to conventional induction motors.

2. Dependence on solar conditions

The system performs best during sunny hours. The battery helps maintain performance when sunlight is low, but longer backup time requires a bigger battery.

3. Environment-friendly operation

Since the cooler uses solar energy, it produces **zero carbon emissions**, making it suitable for rural and urban areas facing environmental challenges and high electricity costs.

4. Cost-effectiveness

Operating cost is almost zero after installation. The system reduces electricity bills and provides long-term savings, especially in areas with high cooling needs.

5. Practical usability

The cooler is portable, easy to maintain, and ideal for:

- Homes
- Small shops
- Rural areas
- Outdoor use
- Emergency cooling during power cuts

APPLICATIONS:

- Solar cells can also be applied to other electronics devices to make it self-power sustainable in the sun. There are solar cell phone chargers, solar bike light and solar camping lanterns that people can adopt for daily use.

- Solar power plants can face high installation costs, although this has been decreasing due to the learning curve. Developing countries have started to build solar power plants, replacing other sources of energy generation.
- In 2008, solar power supplied 0.02% of the world's total energy supply. Use has been doubling every two, or fewer, years. If it continued at that rate, solar power would become the dominant energy source within a few decades.
- Since solar radiation is intermittent, solar power generation is combined either with storage or other energy sources to provide continuous power, although for small distributed producer/consumers, net metering makes this transparent to the consumer.

3. RESULTS AND CONCLUSION

The implementation of the solar-based BLDC air cooler demonstrates a viable path toward reducing the carbon footprint of domestic appliances. The results show that the BLDC motor consumes significantly less power for the same RPM compared to traditional AC motors, making the solar investment more cost-effective. This system successfully addresses the dual challenges of energy scarcity and rising utility costs. It stands as a robust solution for sustainable rural electrification and eco-friendly urban living.

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