Design and fabrication of solar Based air cooler

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***Abstract*—This paper presents the design and development of a solar-powered air cooler aimed at providing an energy-efficient and eco-friendly alternative to conventional cooling systems. The system operates using solar energy to power a DC fan and water pump, enabling evaporative cooling. It is designed to be cost-effective, portable, and suitable for areas with limited access to electricity. Initial testing shows a noticeable drop in ambient temperature, highlighting the potential of solar cooling technology for sustainable applications.**

1.INTRODUCTION

The global rise in energy demand, coupled with the depletion of fossil fuels and environmental concerns, has led to a significant focus on renewable and sustainable energy sources. One of the major energy consumers in the residential and commercial sectors is air conditioning and refrigeration systems. Conventional air conditioning units not only consume a large amount of electricity but also contribute to environmental degradation due to the use of refrigerants and fossil-fuel-based power sources. In regions where electricity supply is limited or unreliable, there is a pressing need for alternative cooling solutions that are both energy-efficient and environmentally sustainable. Solar energy, being abundant, clean, and renewable, is an ideal source to power such systems. The use of solar photovoltaic (PV) panels to operate small appliances has gained popularity in recent years due to advancements in solar technology and reductions in cost. This project explores the integration of solar energy with a simple evaporative air-cooling system to design a standalone, solar-based air cooler suitable for rural and off-grid applications. Evaporative cooling is a natural process that uses the principle of heat absorption by water evaporation. When air passes through wet cooling pads, it loses heat and the temperature drops, producing a cooling effect. By combining this principle with solar-powered components such as a DC water pump and DC fan, the system can function without relying on grid electricity. The main objective of this work is to design and fabricate a cost-effective, energy-efficient, and eco-friendly air-cooling system powered entirely by solar energy. The project also aims to demonstrate the feasibility of using solar power in small-scale cooling applications and to provide a sustainable solution for areas facing extreme heat and unreliable electricity access. In recent decades, the global rise in temperatures and the increasing frequency of heatwaves have intensified the need for efficient and accessible cooling technologies. Traditional air conditioning systems, while effective, are energy-intensive and costly to operate.

They rely heavily on electricity generated from fossil fuels, which contributes significantly to greenhouse gas emissions and environmental degradation. Moreover, the use of refrigerants in conventional cooling systems poses additional risks to the ozone layer and overall environmental health. In regions where electricity supply is either limited, unreliable, or expensive, the use of such systems becomes impractical, especially for rural or low-income households. In response to these challenges, renewable energy technologies have gained significant attention. Among them, solar energy stands out as one of the most promising alternatives due to its abundance, availability, and environmental friendliness. Solar photovoltaic (PV) systems convert sunlight directly into electricity and have been increasingly used in various standalone and grid-connected applications. When combined with low-power devices, solar energy systems can offer sustainable solutions to meet basic energy needs, including cooling.

Figure 1: Solar Panel

2. SOLAR PANEL

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells must be connected electrically in series, one to another. Externally, most of photovoltaic modules use MC4 connector's type to facilitate easy weatherproof connections to the rest of the system.

Module electrical connections are made in series to achieve a desired output voltage or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

Solar panels also use metal frames consisting of racking components, brackets, reflector shapes, and troughs to better support the panel structure.

2.1 PERFORMANCE OF SOLAR

Module performance is generally rated under standard test conditions (STC): irradiance of 1,000 W/m2, solar spectrum of AM 1.5 and module temperature at 25°C. Electrical characteristics include nominal power (PMAX, measured in W), open circuit voltage (VOC), short circuit current (ISC, measured in amperes), maximum power voltage (VMPP), maximum power current (IMPP), peak power, (watt-peak, Wp), and module efficiency (%).

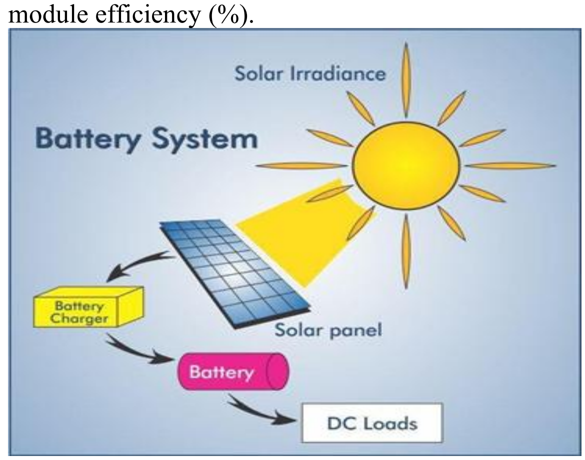

Figure 2: Solar panel

Nominal voltage refers to the voltage of the battery that the module is best suited to charge; this is a leftover term from the days when solar modules were only used to charge batteries. The actual voltage output of the module changes as lighting, temperature and load conditions change, so there is never one specific voltage at which the module operates. Nominal voltage allows users, at a glance, to make sure the module is compatible with a given system. Open circuit voltage or VOC is the maximum voltage that the module can produce when not connected to an electrical circuit or system.

2.2 DC PUMP

A pump is a device used to move gases, liquids or slurries. A pump moves liquids or gases from lower pressure to higher pressure, and overcomes this difference in pressure by adding energy to the system such as a water system. A gas pump is generally called a compressor, except in very low pressure-rise applications, such as in heating, ventilating, and air-conditioning, where the operative equipment consists of fans or blowers. Pumps work by using mechanical forces to push the material, either by physically lifting, or by the force of compression. Hand-operated, reciprocating, positive displacement, water pump. A positive displacement pump causes a liquid or gas to move by trapping a fixed amount of fluid or gas and then forcing displacing that trapped volume into the discharge pipe. They are relatively inexpensive, and are used extensively for pumping water out of bunds, or pumping low volumes of reactants out of storage drums. Conversion of added energy to increase in kinetic energy increase in velocity. Conversion of increased velocity to increase in pressure. Conversion of Kinetic head to Pressure Head. Meet all heads like Kinetic, Potential, and Pressure. Periodic energy addition. Added energy forces displacement of fluid in an enclosed volume. Fluid displacement results in direct increase in pressure. One sort of pump once common worldwide was a hand-powered water pump over a water well where people could work it to extract water, before most houses had individual water supplies.

2.3 BATTERY

In our project we are using secondary type battery. It is rechargeable type. A battery is one or more electrochemical cells, which store chemical energy and make it available as electric current. There are two types of batteries, primary (disposable) and secondary (rechargeable), both of which convert chemical energy to electrical energy. Primary batteries can only be used once because they use up their chemicals in an irreversible reaction. Secondary batteries can be recharged because the chemical reactions they use are reversible; they are recharged by running a charging current through the battery, but in the opposite direction of the discharge current. Secondary, also called rechargeable batteries can be charged and discharged many times before wearing out. After wearing out some batteries can be recycled.Batteries have gained popularity as they became portable and useful for many purposes. The use of batteries has created many environmental concerns, such as toxic metal pollution. A battery is a device that converts chemical energy directly to electrical energy it consists of one or more voltaic cells. Each voltaic cell consists of two half cells connected in series by a conductive electrolyte.One half-cell is the positive electrode, and the other is the negative electrode. The electrodes do not touch each other but are electrically connected by the electrolyte, which can be either solid or liquid. A battery can be simply modelled as a perfect voltage source which has its own resistance, the resulting voltage across the load depends on the ratio of the battery's internal resistance to the resistance of the load.When the battery is fresh, its internal resistance is low, so the voltage across the load is almost equal to that of the battery's internal voltage source. As the battery runs down and its internal resistance increases, the voltage drop across its internal resistance increases, so the voltage at its terminals decreases, and the battery's ability to deliver power to the load decreases.

3. METHODOLOGY

The design and fabrication of the solar-based air cooler followed a systematic approach, beginning with the selection of an efficient and low-cost evaporative cooling method compatible with solar power. Key components such as a 10W solar panel, 12V DC fan, 12V submersible pump, wood wool cooling pads, and a rechargeable battery were selected based on power requirements and availability. The outer casing was built using lightweight thermocol for insulation and portability. The pump circulates water from a small tank to the top of the cooling pads, while the fan draws ambient air through the moistened pads to produce a cooling effect via evaporation. The entire system is powered by the solar panel, with the battery providing backup during low sunlight. After assembly, the system was tested under natural sunlight to measure cooling efficiency and power performance.

4. CONCLUSION

The solar-based air cooler designed and fabricated in this project offers a sustainable, cost-effective, and eco-friendly alternative to conventional cooling systems, especially in rural and off-grid areas. By utilizing solar energy and the principle of evaporative cooling, the system operates efficiently without relying on grid electricity or harmful refrigerants. The use of locally available components and simple construction makes the cooler highly accessible and easy to maintain. Initial testing showed a significant reduction in ambient temperature, validating the system's effectiveness. This project demonstrates the potential

of renewable energy in addressing basic human needs like cooling, while also contributing to environmental conservation. Further improvements, such as adding a battery backup system and enhancing the design for higher airflow, can increase the system's performance and usability.

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