Solar Water Cooler cum Room Cooling System

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Abstract - The increasing demand for thermal comfort and potable cold water has resulted in higher electricity consumption, leading to environmental degradation and increased operational costs. This research presents the design, development, and performance evaluation of a **solar water cooler cum room cooling system**, which utilizes renewable solar energy to provide both chilled drinking water and indoor air cooling simultaneously. The system integrates a solar photovoltaic panel, DC water pump, evaporative cooling chamber, water storage tank, and air circulation fan. During operation, solar energy powers the pump to circulate water through cooling pads, thereby reducing room temperature while simultaneously cooling stored water through evaporative heat transfer. Experimental analysis shows that the system can reduce room temperature by 6–10°C and lower water temperature by 8–12°C under typical Indian climatic conditions. The proposed system is eco-friendly, cost-effective, and suitable for rural and semi-urban areas with limited electricity access.

Key Words: Solar energy, evaporative cooling, water cooler, room cooling, renewable energy, energy conservation.

1. INTRODUCTION

Energy consumption for cooling applications has increased significantly due to population growth and rising ambient temperatures. Conventional air conditioners and electric water coolers consume large amounts of electrical power and contribute to greenhouse gas emissions. In developing countries like India, there is an urgent need for low-cost and sustainable cooling solutions.

Solar energy is one of the most abundant and clean renewable energy sources available. Utilizing solar energy for combined applications can significantly improve system efficiency and reduce dependency on grid electricity. The **solar water cooler cum room cooling system** is designed to provide dual functionality using a single energy source. This system is especially useful in rural areas, schools, small offices, and homes where electricity availability is unreliable.

2. METHODOLOGY

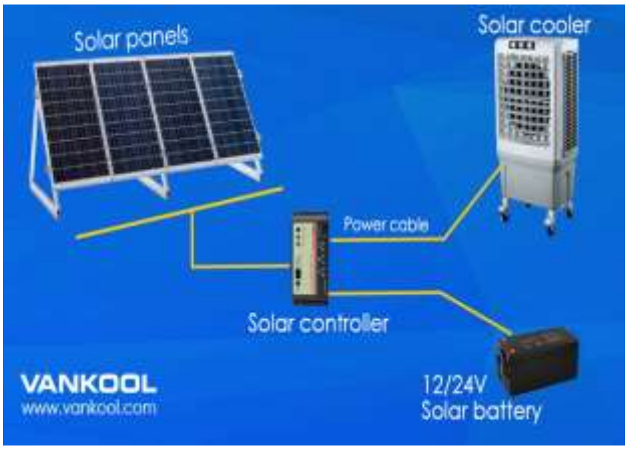
2.1 System Components

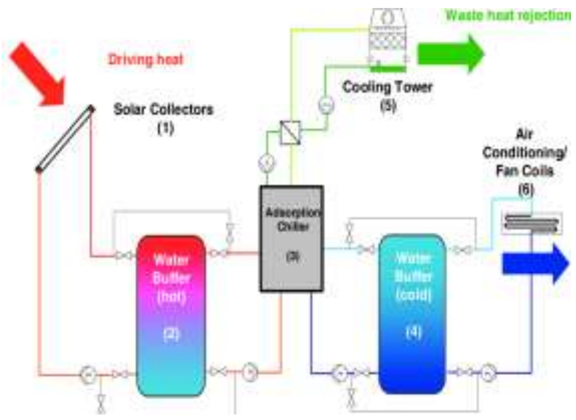
The major components of the proposed system are:

- Solar photovoltaic (PV) panel
- DC water pump
- Water storage tank
- Cooling pads (evaporative type)
- Axial or DC fan
- Air duct and casing
- Piping and control valves

2.2 Working Principle

The system operates on the principle of **evaporative cooling** powered by solar energy. Solar radiation is converted into electrical energy using a PV panel. This electricity drives a DC pump that circulates water from the tank to the cooling pads. When hot air passes through the wet cooling pads, water evaporates by absorbing latent heat from the air, resulting in a reduction in air temperature. The cooled air is then supplied into the room using a fan. Simultaneously, the continuous circulation of water inside the system leads to a reduction in water temperature, providing cool drinking water.





2.3 Design Considerations

Solar Panel Capacity: Selected based on pump and fan power requirements

Cooling Pad Area: Affects air-cooling effectiveness

Water Flow Rate: Optimized for maximum heat transfer

Material Selection: Corrosion-resistant materials improve durability

2.4 Performance Analysis

Experimental testing was carried out under outdoor conditions. Key observations include:

- Ambient temperature: 35–42°C
- Room temperature reduction: 6–10°C
- Water temperature reduction: 8–12°C
- Power consumption: Zero grid electricity

Table – 1: Performance Parameters

Parameter	Observed Value
Solar panel rating	100–150 W
Air temperature drop	6–10 °C
Water temperature drop	8–12 °C
Water flow rate	2–4 L/min
Electricity consumption	Nil (solar powered)

2.5 Advantages

- Uses renewable solar energy
- Zero electricity cost
- Environment-friendly system
- Low maintenance
- Suitable for remote location

2.6 Applications

- Rural households
- Schools and colleges
- Offices and waiting rooms
- Construction sites
- Small shops

4. MATHEMATICAL DESIGN CALCULATIONS

This section presents the theoretical design calculations used for sizing the solar panel, water pump, air flow rate, and cooling performance of the solar water cooler cum room cooling system.

4.1 Cooling Load Estimation (Room Cooling)

Assume:

- Room size = 4 m × 3 m × 3 m
- Room volume,

V=4×3×3=36 m3V = 4 \times 3 \times 3 = 36, m^3V=4×3×3=36m3

Air density,

ρ=1.2 kg/m3\rho = 1.2 \, kg/m^3ρ=1.2kg/m3

Mass of air,

m= ρ×V =1.2×36=43.2 kgm = \rho \times V = 1.2 \times 36 = 43.2 \, kgm=ρ×V=1.2×36=43.2kg

Specific heat of air,

Cp=1.005 kJ/kg·KC_p = 1.005 \, kJ/kg·KCp =1.005kJ/kg·K

Temperature reduction,

ΔT=8∘C\Delta T = 8^\circ CΔT=8∘C

Cooling load,

Q= m×Cp×ΔTQ = m \times Cp \times \Delta TQ=m×Cp ×ΔT Q=43.2×1.005×8=347.3 kJQ = 43.2 \times 1.005 \times 8 = 347.3 \, kJQ=43.2×1.005×8=347.3kJ

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This cooling load is achieved using evaporative cooling without conventional refrigeration.

4.2 Water Cooling Capacity Calculation

Assume:

- Water quantity = 20 liters
- Density of water = 1 kg/L

Mass of water,

m=20 kgm = 20 \, kgm=20kg

Specific heat of water,

Cp=4.186 kJ/kg·KC_p = 4.186 \, kJ/kg·KCp =4.186kJ/kg·K

Temperature drop,

ΔT=10∘C\Delta T = 10^\circ CΔT=10∘C

Heat removed from water,

Q=m×Cp×ΔTQ = m \times C_p \times \Delta TQ=m×Cp×ΔT Q=20×4.186×10=837.2 kJQ = 20 \times 4.186 \times 10 = 837.2 \, kJQ=20×4.186×10=837.2kJ

4.3 Fan Power Requirement

Assume: 1.Air flow rate = 800 m³/hr

2. Convert to m³/s:

Q=8003600=0.22 m3/sQ = \frac{800}{3600} = 0.22 \, m^3/sQ=3600800=0.22m3/s

Fan power required (approximate):

P=Q×ΔPηP = \frac{Q \times \Delta P}{\eta}P=ηQ×ΔP

Assuming: 1. Pressure difference, ΔP = 60 Pa

2. Fan efficiency, η = 0.6

P=0.22×600.6=22 WP = \frac{0.22 \times 60}{0.6} = 22 \, WP=0.60.22×60=22W

4.4 Solar Panel Sizing

Total electrical load: 1. DC pump = 18 W

2. Fan = 22 W

P total=40 WP_{total} = 40 \, WP total=40W

Considering losses and cloudy conditions (×1.5 factor):

P panel=40×1.5=60 WP_{panel} = 40 \times 1.5 = 60 \, WP panel=40×1.5=60W

Selected solar panel rating = 100 W (for safe and continuous operation).

3. CONCLUSIONS

The solar water cooler cum room cooling system successfully demonstrates an energy-efficient and eco-friendly solution for meeting cooling and drinking water needs. The system performs effectively under Indian climatic conditions and significantly reduces dependency on conventional electrical appliances. Due to its simple design, low operating cost, and dual functionality, the proposed system has high potential for widespread adoption in rural and semi-urban areas. Future work may include thermal energy storage integration and performance optimization.

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