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# DEVELOPMENT OF LOW-COST AIR COOLER USING DIRECT EVAPORATIVE COOLING TECHNOLOGY

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## ABSTRACT

Evaporative cooling is a heat and mass transfer process, that uses water evaporation for air cooling, in which large amount of heat is transferred from air to water, and consequently the air temperature decreases. The project deals with the design and development of low cost mud pot air coolers, which is a type of Active direct evaporative cooling system, with good efficiency. The aim is to achieve better Cooling and make the product easily available to different sections of society at lower cost, as the materials used in the product are mud pots, aspen wood wool or coconut fiber made evaporative cooling pads. A theoretical model was developed on python to simulate the results related to the effectiveness of the design. The product is very low cost as compared to the conventional room coolers, because of use of mud pot and cost of manufacturing of mud pot is low at the same time, if this product is made available on large scale can create lot of job opportunities for regions like rural India.

**Keywords:** Evaporative Cooling, Mud Pot Air Cooler, Low-Cost Cooling System, Cooling Efficiency, Rural Technology.

## I. INTRODUCTION

Energy demand worldwide for buildings cooling has increased sharply in the last few decades, which has raised concerns over depletion of energy resources and contributing to global warming. Current energy demand estimates stand at between 40 and 50% of total primary power consumption. In hot climate countries, the highest share of building energy use is mainly due to space air conditioning using traditional HVAC systems. For example, in the Middle East, it accounts for 70% of building energy consumption and approximately 30% of total consumption. Currently, mechanical vapor compression coolers (MVC) are commercially dominant despite their intensive energy use and low performance in hot climate. In contrast, evaporative cooling systems are more environmentally friendly as they consume less energy and their performance improves as air temperature increases and humidity decreases. Evaporative cooling is a heat and mass transfer process. That uses water evaporation for air cooling, in which large amount of heat is transferred from air to water, and consequently the air temperature decreases.

The air cooler may be define as the type of heat exchanger, which lower the temperature of the surrounding up to the certain cooling there is no humidity control and no air purification system like in air conditioners .since from the older time man has been trying to find out some convenient way to get the rid of the hot summer seasons

So the invention made the man invented the air cooler in the form of hand fan cooler, the wetted grass mat where employed In the evaporative process to cool the air ,since then evaporative process has been machined and various device has been developed and manufactured to utilized the evaporation in a heat exchanger process .

The current Research deals with the design and development of low cost, Easy to manufacture mud pot air coolers which is a direct evaporative cooling technology. Direct evaporative cooling technology is the oldest and

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the simplest type of evaporative cooling in which the outdoor air is brought into direct contact with water, i.e. cooling the air by converting sensible heat to latent heat. Ingenious techniques were used thousands of years ago by ancient civilizations in variety of configurations, some of it by using earthenware jar water contained, wetted pads/canvas located in the passages of the air. Direct Evaporative Cooling systems (DEC) could be divided into: Active DECs which are electrically powered to operate and Passive DECs that are naturally operated systems with zero power consumption. DEC is only suitable for dry and hot climates. In moist conditions, the relative humidity can reach as high as 80%, such a high humidity is not suitable for direct supply into rooms as it may cause uncomfortable environment. A typical direct evaporative cooler comprises of evaporative media (wet table and porous Pads), fan blows air through the wetted medium, water tank, recirculation pump and water distribution system

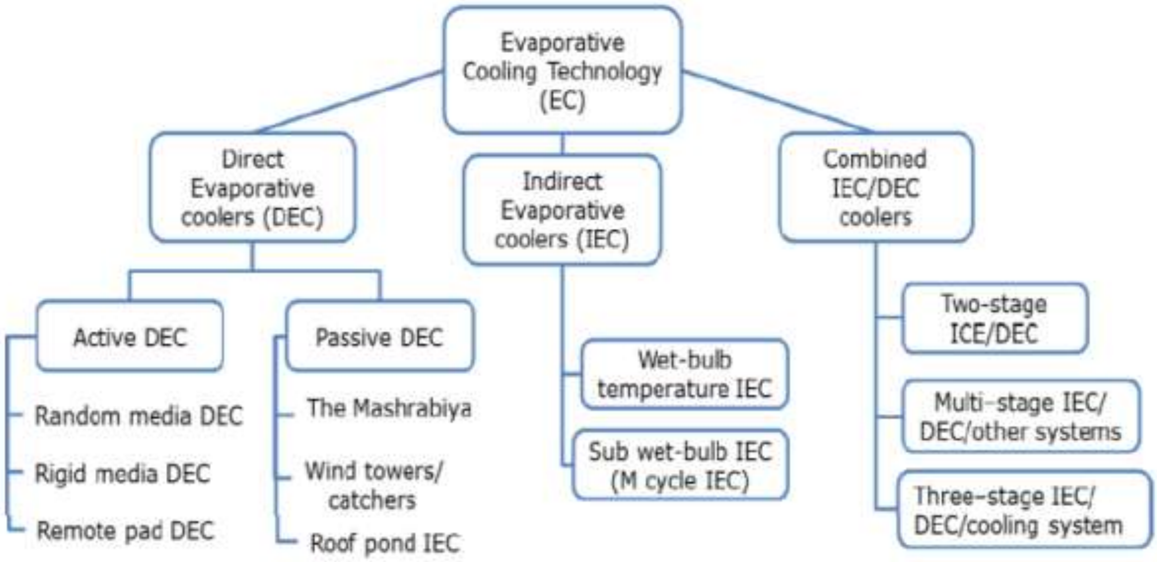


**Fig 1.1:** Classification of Evaporative cooling technology

The direct evaporative cooling is an adiabatic cooling process, i.e. the total enthalpy of the air is constant throughout the process the water absorbs the sensible heat from the supply air and The conventional DEC uses electricity to run, fan, and pump and also there is a need of good water distribution system for effective cooling of air. Evaporative coolers find its vast use in various places such as data center's, office buildings, ware houses, hospitals, laboratories and residential houses. Locations such as data centres house hundreds of computers and servers in addition to complex network systems, all of this generate heat, the evaporative coolers are essential to keep data centres cool, maintaining a proper humidity. Office environments, can be very difficult to keep cool and comfortable without proper humidity control. Using an evaporative cooler can assist with keeping temperatures in check while also cycling in fresh outside air, which is essential to employee wellness and productivity. Some goods, such as woods and musical instruments, can suffer from warping and damage in hot conditions. The installation of evaporative cooler can help to mitigate this risk. Airborne infection control is of critical importance to any healthcare environment, as in minimizing the risk of cross contamination, this can't be achieved without controlling the amount of air moisture content, which is influenced by current temperature, here evaporative coolers can be beneficial. Other applications of evaporative coolers are, commercial kitchens, large factories, retail centers,

The main purpose of the project is to use waste materials and eco-friendly technology which is need of the hour. The design in itself is unique and the product is quite efficient in cooling in hot regions, especially in summer season which is very much dry. This product if manufactured on large scale can be used by various segments of society including the poor people. There is a need of using ecofriendly solutions to reduce cost of production, to create jobs for traditional Indian workers, to reduce the energy input, to reduce overall maintenance cost. In conventional DEC when warm, dry (unsaturated) air is pulled through a water soaked pad, water is evaporated and is absorbed as water vapor into the air. The air is cooled in the process and the humidity is increased. We have tried to change the design of the conventional model hence eliminating the use of water soaked pads, pumps, pipes. The current modified model is quite simple and easy to study. This model consists of an AC fan which is installed on the top unlike the conventional models. In the design of the model various factors were considered which are both scientific and economic such as humidity, wet bulb temperature, dry bulb temperature, Air flow, porosity of material containing water etc. The study involve in analysis of these factors is psychometric. Psychometric consists of the interactions between Heat, moisture and air. It is basically the study of air-water mixtures and is an essential foundation for understanding, how to change air from one condition to another

## II. METHODOLOGY

**1.** Design

- To design an eco-friendly air cooler using mud/clay for evaporative cooling.
- Integrate a water storage tank for potable water that remains cool due to evaporative effect.
- Sketch the layout showing airflow channels, mud-coated surface area, water circulation system, and drinking water tank location.

**2.** Material Selection

- Jute or cotton cloth (for enhancing evaporation)
- Bamboo or metal frame (for structural support)
- Water pump (low power)
- Exhaust fan or blower
- PVC pipes (for water circulation)
- Stainless steel or food-grade plastic container (for drinking water)
- Mesh screen or filters (for dust and insect protection)
- Natural clay/mud (locally sourced)

**3.** Construction of the Cooling Unit

- Build a double-walled chamber with space between the walls.
- Coat the outer wall with mud mixed with natural binding agents (like hay, cow dung, or cement for strength).
- Attach jute or cotton cloth on the outside to enhance the wicking of water for continuous evaporation.
- Install a small pump that circulates water over the cloth/mud surface.
- Add a drainage and recirculation system to reuse the water effectively.

**4.** Drinking Water Storage Tank

- Place a separate stainless steel or food-grade plastic tank within or adjacent to the mud wall structure.
- The tank should be thermally insulated from external heat but exposed to the cooling side of the mud structure to benefit from evaporative cooling.
- Ensure hygienic access to drinking water via a tap and lid.

**5.** Assembly and Testing

- Fix the blower/fan at the rear to draw air through the moist, mud-coated surface.
- Ensure tight sealing to avoid water leakage.
- Measure air temperature before and after cooling.
- Check drinking water temperature over time.
- Monitor water consumption and refill frequency.

**6.** Performance Evaluation

- Compare the output temperature with standard coolers.
- Evaluate drinking water quality and temperature consistency.
- Analyze power consumption and sustainability aspects.

**7.** Maintenance

- Regular mud reapplication (every few months depending on use).
- Cleaning water tank and pipes.

Ensuring the cloth remains wet during use for efficient cooling,

## III. DESIGN AND DEVLOPMENT

**1.** Main Components

- Frame: Rectangular metal or wooden body supporting the structure.
- Cooling Mechanism: Evaporative cooling through mud-coated panels.
- Fan with Wire Mesh: A protective wire mesh covers the cooling fan.
- Water Storage Tank: Placed at the bottom with taps for drinking water.
- Water Tubes: Circulate water for cooling and drinking.
- Electrical Components: Wires connected to power the fan.

**3.** Fabrication Process

Step 1: Frame Construction- Use metal, wood, or plastic to build the outer frame. Ensure proper ventilation **for** airflow.

Step 2: Mud Coating Application-Prepare mud mix (clay + hay + sand for better *adhesion) and* Coat the side walls and allow drying for evaporative cooling.

Step 3: Fan and Wire Mesh Installation-Secure the fan in the front with **a** wire mesh for *protection. Connect* the electrical wiring for power.

Step 4: Water Storage Tank and Tubes Setup-Place the tank at the bottom for drinking *water. Connect* tubes from the tank for water distribution. Install taps for easy access to drinking water.

Step 5: Water Circulation System -Attach drip tubes to keep mud walls moist. Use **a** low-power pump to recirculate water.

**3.** Working Mechanism

- Water flows through tubes and keeps the mud-coated walls wet.
- Fan pulls air through the moist mud, cooling it via evaporation.
- The drinking water tank stays cool due to its placement inside the structure.
- Taps provide access to naturally cooled drinking water.

**4.** Advantages

- Eco-friendly – Uses mud for passive cooling.
- Energy-efficient – Low power consumption.
- Dual-purpose – Cools air & provides drinking water.
- Sustainable design – Reuses water efficiently.

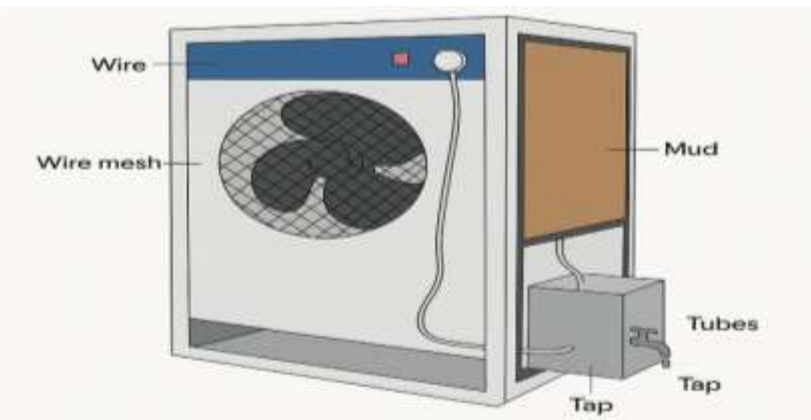


**Fig 3.1:** 3D view of Proposed Model

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## IV. WORKING

Inspired by the beehive structure, the mud pot air cooler consists of numerous mud tubes are that have been compactly packed and arranged in a rectangle form (rectangle cross tube). The cooling system consists of inner and outer surfaces embedded on a metal framework. The modified air cooler operates on the principle of evaporative cooling, where water evaporation from the mud-coated walls lowers the surrounding air temperature.

Fan or blower draws in warm air from the environment, passing it through the wet mud layer, which absorbs heat and cools the air before releasing it into the room. To maintain continuous cooling, a water distribution system consisting of tubes and a small pump keeps the mud surface damp by slowly dripping water over it. This ensures that evaporation continues, sustaining the cooling effect. Simultaneously, a drinking water storage tank is placed inside or adjacent to the mud-coated surface, benefiting from the evaporative cooling process. Since the surrounding mud remains wet and cool, the water inside the tank stays at a lower temperature compared to ambient conditions, providing naturally chilled drinking water without requiring refrigeration. The tank is fitted with taps for easy access to clean, cool water. Additionally, excess water from the cooling system can be collected and reused to minimize wastage, making the design sustainable and water-efficient. This dual-purpose system provides an eco-friendly and energy-efficient solution, particularly in hot and dry climates, where evaporative cooling is highly effective. Water passes through the mud pot waste, facilitating evaporative cooling. Air is cooled when it passes through the mud pot waste and coconut waste and comes out and stays cool like water in an earthen mud pot waste. This installation also gives a beautiful cascade effect when drenched in water. The humid clay traps some heat the air and the surrounding air gets cooled down to around 6-10$^0$ C due to the process of evaporative cooling. In this project low-tech terracotta air cooling system underwent advanced computational analysis and modern calibration techniques before being implemented. The bee-hive structure noted for its efficient geometry was also chosen as a result of the advanced computational analysis. During the trials, the air was around 122$^0$ F was relatively cooled down to a temperature of 96.8$^0$ F after being passed through the mud pot wastes

## V. ADVANTAGES AND DISADVANTAGES

**Advantages**

- Dual Purpose Utility – Provides both air cooling and drinking water storage, maximizing efficiency.
- Energy Efficient – Uses evaporative cooling, which consumes less power compared to conventional air conditioning.
- Eco-Friendly – Reduces electricity consumption and utilizes natural cooling methods.
- Cost-Effective – Lower operational and maintenance costs compared to traditional cooling systems.
- Water Conservation – The water used for cooling can be stored and repurposed for drinking or other applications.
- Better Cooling Efficiency – Mud storage further enhances cooling due to its high thermal mass and insulation properties.
- Simplicity in Design – Easy to fabricate, maintain, and repair using locally available materials.

**Disadvantages**

- Limited Cooling Capacity – Works effectively in dry climates but may not be efficient in humid areas.
- Water Quality Concerns – Requires proper filtration to ensure stored water is safe for drinking.
- Space Requirement – The additional storage tank may require extra space.
- Periodic Maintenance – Needs frequent cleaning to prevent contamination and clogging.
- Dependency on Water Supply – Requires continuous availability of water for proper functioning.

Applications

1. Households – Provides cooling and drinking water storage, especially in rural areas.
2. Offices & Small Businesses – Can be used in small commercial spaces where air conditioning is not feasible.
3. Agricultural – Can be used for storage of water for livestock and cooling farmhouses.

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4. Schools & Public Places – Provides drinking water along with cooling in community areas.
5. Remote Areas – Useful in areas with limited electricity supply, as it is energy efficient.
6. Construction – Offers cooling and drinking water supply for workers in hot environments.

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