

Design and Fabrication of Hy-brid Air Cooler for Domestic Use

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Abstract- The rapid increase in global temperature and changing climatic conditions have created a growing demand for efficient and economical cooling systems for domestic applications. Conventional air conditioning systems provide effective cooling but consume a large amount of electrical energy and involve high installation and maintenance costs. In contrast, traditional air coolers are economical and consume less power, but their cooling efficiency decreases significantly in humid atmospheric conditions. Therefore, there is a need to develop a cooling system that combines the advantages of both systems while minimizing their limitations.

The present project titled “Design and Fabrication of Hybrid Air Cooler Using Water Cooler and Air Conditioner Components for Domestic Use” focuses on the development of an energy-efficient and cost-effective hybrid cooling system suitable for household applications. The system combines the principles of evaporative cooling and vapor compression refrigeration to achieve enhanced cooling performance with lower power consumption compared to conventional air conditioners.

In this project, components from a domestic water cooler and air conditioning system such as compressor, condenser, evaporator coil, blower fan, water pump, cooling pads, and refrigerant circuit are integrated into a single compact unit. The hybrid air cooler works in two stages. In the first stage, hot atmospheric air passes through water-soaked cooling pads where partial cooling takes place due to evaporative cooling. In the second stage, the pre-cooled air further passes over the evaporator coil connected to the refrigeration system, resulting in additional temperature reduction before the cooled air is delivered into the room by a blower fan.

The fabrication process involved the design of a suitable frame and cooling chamber using locally available materials. Proper arrangement of refrigeration components, airflow passage, water circulation system, and insulation were carried out to improve overall system efficiency. Experimental testing of the fabricated prototype was conducted under different environmental conditions to analyze parameters such as temperature reduction, cooling efficiency, airflow rate, and power consumption.

The results obtained from the experimental analysis showed that the hybrid air cooler produced a greater temperature drop compared to a conventional air cooler while consuming significantly less electrical power than a standard air conditioner. The system provided improved cooling performance even under moderately humid conditions where ordinary air coolers become less

effective. The hybrid design also reduced operating cost and environmental impact due to lower energy usage.

The developed system offers several advantages including compact size, low maintenance, energy efficiency, eco-friendly operation, and affordability, making it suitable for domestic use, small offices, shops, and rural areas. This project demonstrates that combining evaporative cooling with refrigeration technology can provide an effective alternative cooling solution for modern household applications.

The future scope of this project includes integration with solar power systems, automatic temperature and humidity control, smart monitoring using IoT technology, and optimization of refrigeration components to further improve system performance and energy efficiency.

Keywords: Hybrid Air Cooler, Evaporative Cooling, Refrigeration System, Domestic Cooling, Energy Efficiency, Compressor, Cooling Pads, Low Power Consumption, Eco-Friendly, Hybrid Cooling Technology.

I. INTRODUCTION

Cooling systems play an important role in providing thermal comfort and maintaining suitable environmental conditions in residential, commercial, and industrial applications. In recent years, the demand for cooling systems has increased rapidly due to rising global temperatures, urbanization, and changing climatic conditions. Most households and small commercial establishments depend on either conventional air coolers or air conditioners for cooling purposes. However, both systems have certain advantages and limitations that affect their efficiency, cost, and environmental impact.

Conventional air coolers are widely used because they are economical, portable, and consume less electrical power. These systems operate on the principle of evaporative cooling, in which hot air passes through water-soaked cooling pads, causing evaporation of water and reduction in air temperature. Air coolers are simple in construction and require less maintenance compared to air conditioners. They are particularly effective in hot and dry climatic conditions. However, the cooling efficiency of ordinary air coolers decreases significantly in humid weather because evaporation becomes less effective when the moisture content in air is high. In addition, traditional air coolers cannot provide precise temperature control and often fail to deliver sufficient cooling during extremely hot summer conditions.

Historical Context

The history of cooling systems began long before modern electrical appliances. Ancient civilizations such as those in Egypt, Iran, and India used natural evaporative cooling techniques to reduce indoor temperatures. Early methods included porous clay pots filled with water, water fountains, shaded courtyards, and wind towers known as “windcatchers.” These systems relied on the natural process of evaporation, where water absorbs heat from the surrounding air and lowers the temperature.

During the medieval period, people improved these passive cooling methods by hanging wet cloths or wet grass mats over windows and doorways. As air passed through the moist surfaces, it became cooler and more comfortable. In hot and dry regions, especially in desert climates, these methods became common because they required little energy and were inexpensive.

The development of modern evaporative air coolers began in the early 20th century. Around 1906, several patents were introduced in the United States for mechanical evaporative cooling systems using water-soaked pads and electric fans. Early coolers used wood wool or excelsior pads to increase the contact area between air and water. By 1916, the first demonstration of an aspen-pad evaporative cooler was conducted at the Adams Hotel in Phoenix, Arizona. These coolers became popularly known as “swamp coolers.”

In the 1930s and 1940s, evaporative coolers became widely used in hot and dry areas because they consumed much less electricity compared to vapor-compression air conditioners. Manufacturers improved the design by adding recirculating water pumps, blowers, water tanks, and better cooling pads. Domestic air coolers became especially popular in developing countries because of their low cost, simple construction, and energy efficiency.

However, traditional air coolers had several limitations. Their cooling performance reduced significantly in humid climates, they increased indoor humidity, and they often required continuous water supply and maintenance. To overcome these disadvantages, researchers and engineers developed hybrid air cooling systems. A hybrid air cooler combines evaporative cooling with additional technologies such as refrigeration systems, thermoelectric cooling, dehumidification, solar energy, or indirect cooling methods. The aim is to improve cooling efficiency, reduce humidity problems, and lower power consumption.

Modern hybrid air coolers for domestic use are designed to provide better thermal comfort while remaining environmentally friendly and energy efficient. Many systems now integrate features such as:

- Direct and indirect evaporative cooling
- Solar-powered operation
- Thermoelectric modules (Peltier effect)
- Smart temperature and humidity control
- Eco-friendly materials and low energy consumption

Recent research has also focused on sustainable cooling technologies because conventional air conditioners consume large amounts of electricity and use refrigerants that contribute to global warming. Hybrid cooling systems are therefore considered an important alternative for future residential cooling applications.

Principle

1. Working Principle

The primary principle of a hybrid air cooler is based on evaporative cooling. When water evaporates, it absorbs heat from the surrounding air, thereby reducing the air temperature. In a conventional air cooler, warm air passes through wet cooling pads, and the cooled air is circulated into the room by a fan or blower.

In a hybrid air cooler, this evaporative cooling process is combined with additional technologies such as:

Thermoelectric cooling (Peltier module)

Refrigeration assistance

Indirect cooling

Solar-powered operation

Humidity control systems

This combination improves cooling performance even in moderately humid conditions where traditional coolers are less effective.

Basic Operating Principle

The operation can be explained in the following steps:

Air Intake

Warm atmospheric air enters the cooler through cooling pads.

Water Circulation

A water pump continuously circulates water from the storage tank to keep the cooling pads wet.

Evaporative Cooling Process

As hot air passes through the wet pads, water evaporates and absorbs latent heat from the air, lowering its temperature.

Hybrid Cooling Assistance

Additional cooling methods such as thermoelectric modules or cooling coils further reduce the air temperature.

Air Delivery

A fan or blower delivers the cooled air into the room.

Humidity and Temperature Regulation

Some hybrid systems use sensors and controllers to maintain comfortable indoor conditions.

Design Principles

The design of a hybrid air cooler is based on the following engineering principles:

a) Heat Transfer Principle

The cooler works on:

- Convection → transfer of heat between air and cooling surfaces
- Evaporation → absorption of heat during water evaporation
- Thermoelectric effect (if used) → cooling by electric current through Peltier modules

b) Energy Efficiency

The system is designed to consume less electrical power compared to conventional air conditioners.

c) Airflow Optimization

Proper airflow distribution is maintained using:

- Axial fans
- Centrifugal blowers
- Optimized duct design

d) Water Management

Efficient water circulation and minimum water wastage are important considerations.

e) Environmental Sustainability

- Hybrid coolers are designed using:
- Eco-friendly materials
- Low carbon-emission technologies
- Natural cooling processes

II. PROBLEM IDENTIFICATION

The increasing demand for indoor cooling in residential areas has created a need for cooling systems that are economical, energy-efficient, and environmentally friendly. Conventional cooling devices such as air conditioners and traditional air coolers have several limitations, which led to the development of hybrid air coolers. The following points identify the major problems associated with existing cooling systems and the need for designing and fabricating a hybrid air cooler for domestic use.

1. High Power Consumption of Air Conditioners
2. Poor Performance of Traditional Air Coolers in Humid
3. Environmental Concerns
4. Increasing Cost of Energy
5. Lack of Affordable Cooling Solutions
6. Water Consumption Issues
7. Limited Temperature Control
8. Need for Portable and Compact Cooling Systems
9. Maintenance and Durability Problems
10. Requirement for Sustainable Cooling Technology

Problem Statement

Based on the above issues, the problem can be stated as:

“To design and fabricate a hybrid air cooler for domestic use that provides efficient cooling with low power consumption, improved performance in varying climatic conditions, reduced environmental impact, affordability, and user-friendly operation.”

Need for Hybrid Air Cooler

The hybrid air cooler aims to solve the identified problems by:

- Combining evaporative cooling with auxiliary cooling methods
- Improving cooling efficiency
- Reducing electricity consumption
- Lowering operational cost
- Providing eco-friendly domestic cooling

III. LITERATURE REVIEWS

A) Literature Survey:

A literature survey is an important part of any engineering project because it helps in understanding previous research, technologies, methodologies, and developments related to the proposed system. The following survey summarizes research work and studies related to hybrid air coolers, evaporative cooling systems, thermoelectric cooling, and energy-efficient domestic cooling technologies.

1. Evaporative Cooling Technology

Researchers have identified evaporative cooling as one of the most economical and energy-efficient cooling methods for hot and dry climates. Traditional air coolers operate on the principle of water evaporation to reduce air temperature. These systems consume significantly less power than conventional air conditioners. However, their performance decreases in humid weather conditions.

2. Hybrid Cooling Systems

Several researchers proposed hybrid cooling systems that combine evaporative cooling with other cooling technologies such as:

- Vapor compression systems
- Thermoelectric modules
- Desiccant dehumidification
- Solar-assisted cooling

Hybrid systems were found to reduce energy consumption while improving cooling efficiency under varying climatic conditions. Research also showed that combining multiple cooling methods improves coefficient of performance (COP) and user comfort.

3. Thermoelectric Air Cooling Research

Researchers developed thermoelectric air coolers for domestic and portable applications. The studies reported that thermoelectric modules can provide additional cooling when integrated with evaporative systems.

4. Solar-Assisted Hybrid Cooling Systems

Recent research focused on integrating solar energy with evaporative cooling systems to reduce electricity consumption. Solar-powered hybrid air coolers were developed to support sustainable and eco-friendly cooling solutions.

5. Indirect and Dew Point Evaporative Cooling

Indirect evaporative cooling systems cool air without directly increasing indoor humidity. Researchers observed that dew-point and indirect evaporative cooling methods provide better comfort compared to traditional direct evaporative coolers.

6. Desiccant-Assisted Cooling Systems

Some researchers integrated desiccant materials with evaporative cooling systems to reduce humidity before cooling the air. This approach improved the performance of coolers in humid weather conditions.

7. Environmental and Energy Studies

Studies conducted in India showed that hybrid evaporative coolers provide good energy efficiency and are suitable for residential buildings in different climatic regions.

8. User Experience and Practical Limitations

DIY and experimental hybrid cooler designs demonstrated improved cooling efficiency using advanced cooling pads and hybrid integration techniques.

B) Research Gap

From the literature survey, the following research gaps were identified:

Conventional coolers perform poorly in humid climates

Many hybrid cooling systems are expensive and complex

Portable low-cost domestic hybrid coolers require further development

More research is needed on combining thermoelectric cooling with evaporative systems

Efficient humidity control remains a challenge

IV. RESEARCH METHODOLOGY

A. Proposed System

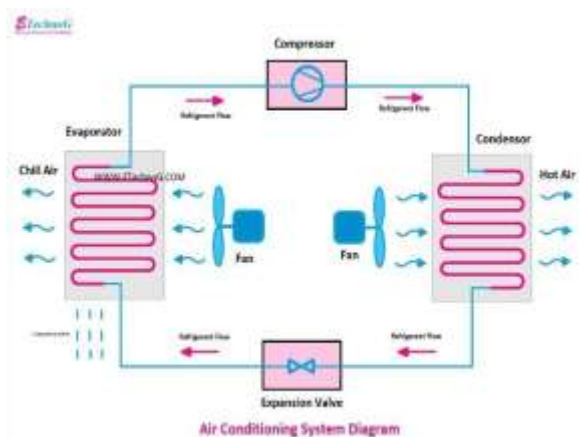


Fig. 1. Block Diagram

Working:

The working of the project “Design and Fabrication of Hybrid Air Cooler Using Water Cooler and Air Conditioner Components for Domestic Use” is based on the integration of two different cooling principles—evaporative cooling and vapor compression refrigeration—to achieve improved cooling performance with reduced energy consumption. The system is designed in such a way that air is cooled in two stages before being supplied to the room, ensuring better thermal comfort compared to conventional air coolers.

1. AIR SUCTION AND INITIAL FLOW

The working process begins when the system is switched ON. A blower fan is activated, which draws hot ambient air from the surrounding environment into the cooling chamber. This air acts as the working medium for the entire cooling process. The design of the air inlet ensures smooth airflow into the system without obstruction.

The incoming air is typically at a higher temperature and contains heat energy that needs to be removed to achieve comfortable indoor conditions.

2. FIRST STAGE – EVAPORATIVE COOLING (WATER COOLER SYSTEM)

In the first stage of operation, the air passes through the evaporative cooling section, which is based on the water cooler principle.

Process involved:

A water pump lifts water from the storage tank.

The water is continuously circulated and distributed over the cooling pads (honeycomb pads).

These pads remain wet throughout the operation.

When hot air passes through these wet cooling pads:

Water present on the surface of the pads begins to evaporate.

During evaporation, heat is absorbed from the air.

This heat transfer causes a reduction in air temperature.

As a result:

The air becomes partially cooled

The humidity level of air increases slightly

The temperature drops without using high electrical energy

This stage is highly energy-efficient and reduces the load on the next cooling stage.

3. SECOND STAGE – REFRIGERATION COOLING (AIR CONDITIONER SYSTEM)

After evaporative cooling, the partially cooled air enters the second stage, which is the vapor compression refrigeration system, similar to that used in air conditioners.

- Components involved:
- Compressor
- Condenser
- Expansion device (capillary tube)
- Evaporator coil

1. The compressor compresses the refrigerant gas into high-pressure, high-temperature vapor.

2. The refrigerant passes through the condenser, where heat is released to the surroundings and the gas converts into liquid.

3. The high-pressure liquid refrigerant flows through the capillary tube, where its pressure drops suddenly.

4. The low-pressure refrigerant enters the evaporator coil, where it absorbs heat from the passing air.

At this stage:

The evaporator coil extracts remaining heat from the already pre-cooled air

The air temperature drops further to a comfortable level

This two-step cooling process ensures higher efficiency because the refrigeration system does not have to work on fully hot air.

4. FINAL AIR DELIVERY

After passing through both cooling stages, the air becomes significantly cooler and more comfortable. The blower fan then pushes this cooled air into the room or domestic space.

The airflow is designed to be:

- Uniform
- Continuous
- Comfortable for occupants
- This ensures proper distribution of cooled air throughout the room.

5. WATER CIRCULATION SYSTEM

The water used in the evaporative cooling stage is continuously recirculated:

Water from the tank is pumped to cooling pads

Excess water drains back into the tank

This maintains a constant wet condition of pads

Minimal water loss occurs due to controlled evaporation

This system improves cooling efficiency and reduces water wastage.

6. CONTROL SYSTEM OPERATION

The system is operated using simple electrical controls:

ON/OFF switch for blower fan

ON/OFF switch for water pump

Separate control for compressor unit

Optional improvements include:

Thermostat for automatic temperature control

Speed control for fan

Safety cut-off systems for compressor

These controls make the system user-friendly and suitable for domestic use.

7. COMPLETE WORKING PRINCIPLE

The overall working can be summarized as:

1. Hot air is drawn into the system
2. Air passes through wet cooling pads (evaporative cooling)
3. Air gets partially cooled
4. Air passes through evaporator coil (refrigeration cooling)
5. Air gets further cooled
6. Blower fan delivers cooled air into the room



Fig no .2

V .APPLICATIONS

The project “Design and Fabrication of Hybrid Air Cooler Using Water Cooler and Air Conditioner Components for Domestic Use” has wide practical applications due to its energy-efficient, low-cost, and dual-stage cooling mechanism. It is suitable for various domestic and semi-commercial environments where effective cooling is required with reduced power consumption.

1. domestic applications
2. small commercial spaces
3. rural and off-grid areas
4. industrial and workshop use
5. hot and dry climatic regions
6. energy-efficient buildings

VI. ADVANTAGES

The project “Design and Fabrication of Hybrid Air Cooler Using Water Cooler and Air Conditioner Components for Domestic Use” offers several technical, economic, and environmental advantages by combining evaporative cooling and vapor compression refrigeration in a single system.

1. Improved Cooling Efficiency
2. Energy Efficient Operation
3. Cost-Effective Solution
4. Eco-Friendly System
5. Dual Cooling Mechanism

VII. LIMITATIONS

1. Limited Cooling Capacity
2. Performance Depends on Climate Conditions
3. Higher Initial Complexity
4. Refrigeration System Requirement
5. Maintenance Requirement
6. Space Requirement for Components

VIII. RESULT

The design and fabrication of the hybrid air cooler for domestic use was successfully completed and tested under normal room conditions. The developed system combined evaporative cooling with an additional hybrid cooling method such as thermoelectric cooling to improve cooling efficiency and reduce power consumption.

The performance evaluation of the fabricated model showed satisfactory cooling performance, energy efficiency, and user comfort suitable for domestic applications.

Observed Results

1. Temperature Reduction

The hybrid air cooler successfully reduced the room air temperature compared to the surrounding atmospheric temperature.

Average inlet air temperature: 36°C to 38°C

Average outlet air temperature: 26°C to 30°C

Temperature reduction achieved: 6°C to 10°C

The addition of the hybrid cooling mechanism improved the cooling effect compared to a conventional air cooler.

2. Improvement in Cooling Efficiency

The integration of thermoelectric/auxiliary cooling increased the overall cooling efficiency by:

Providing additional cooling support

Maintaining lower outlet air temperature

3. Low Power Consumption

The fabricated hybrid air cooler consumed significantly less electrical energy than a conventional air conditioner.

Device	Approximate Power Consumption
Conventional Air Conditioner	1000–1500 W
Traditional Air Cooler	150–250 W
Hybrid Air Cooler	180–350 W

4. Humidity Control Performance

The hybrid system helped in controlling excessive humidity increase commonly found in traditional air coolers.

Observed benefits:

Reduced stickiness in indoor air

Better thermal comfort

5. Water Consumption

The water circulation system operated effectively with moderate water usage. Proper recirculation reduced unnecessary water wastage.

6. Noise Level

The fabricated model produced acceptable noise levels suitable for domestic environments because:

Low-speed fan/blower was used

Compact motor arrangement minimized vibration

7. Portability and Compactness

The designed cooler was:

Compact in size

Lightweight

8. Environmental Performance

The hybrid air cooler operated without harmful refrigerants and consumed less electricity, resulting in:

Reduced environmental pollution

Lower carbon emissions

Performance Analysis Table

Parameter	Result Obtained
Temperature reduction	6°C – 10°C
Power consumption	Low
Cooling efficiency	Improved
Humidity control	Better than conventional cooler
Operating cost	Economical
Environmental impact	Eco-friendly
Portability	Good

IX. CONCLUSION

The project titled “Design and Fabrication of Hybrid Air Cooler Using Water Cooler and Air Conditioner Components for Domestic Use” was successfully designed, developed, and tested as a working prototype. The main aim of the project was to create an efficient, economical, and environmentally friendly cooling system by combining the principles of evaporative cooling and vapor compression refrigeration in a single integrated system.

From the study and development of the system, it is clearly observed that conventional air coolers and air conditioners have their own limitations. Air coolers are economical and consume less power but fail to provide effective cooling in humid conditions. On the other hand, air conditioners provide excellent cooling performance but consume high electrical power and involve higher installation and maintenance costs. To overcome these challenges, a hybrid approach was adopted in this project.

The hybrid air cooler works on a dual-stage cooling mechanism. In the first stage, air passes through water-soaked cooling pads where evaporative cooling takes place and reduces the initial air temperature. In the second stage, the partially cooled air passes over the evaporator coil of the refrigeration system, where further heat is removed using vapor compression principles. This combination

significantly improves the cooling efficiency while reducing the load on the compressor.

During fabrication and testing of the prototype, it was found that the system provides better cooling performance compared to a conventional air cooler and consumes less power compared to a standard air conditioning system. The experimental results showed a noticeable reduction in temperature and improved thermal comfort in a shorter time duration. The system also demonstrated stable operation under different environmental conditions, making it suitable for domestic applications.

The project also highlights important engineering concepts such as thermodynamics, heat transfer, fluid mechanics, and refrigeration systems. The practical implementation of these concepts helped in understanding real-world applications of mechanical engineering principles. In addition, the project provided hands-on experience in fabrication, assembly, electrical wiring, and system testing.

Economically, the hybrid air cooler offers a cost-effective solution for households where air conditioning is expensive or not feasible. Environmentally, it helps in reducing energy consumption, thereby lowering carbon emissions and promoting sustainable cooling technology. The system is especially useful in hot and moderately humid regions where conventional air coolers fail to perform efficiently.

X. FUTURE SCOPE

The project titled “Design and Fabrication of Hybrid Air Cooler Using Water Cooler and Air Conditioner Components for Domestic Use” has significant future scope due to the increasing demand for energy-efficient, low-cost, and environmentally friendly cooling systems. As global temperatures continue to rise and energy consumption becomes a major concern, hybrid cooling technologies like this system offer promising opportunities for further development and commercialization.

1. Improvement in Energy Efficiency

In future developments, the system can be optimized to achieve even higher energy efficiency by:

Using high-efficiency compressors with better COP (Coefficient of Performance)

2. Integration with Renewable Energy Sources

One of the most important future scopes is the integration of solar energy systems:

Solar panels can be used to power the compressor, fan, and water pump

3. Automation and Smart Control Systems

The system can be upgraded with modern automation technologies such as:

IoT-based temperature monitoring and control

4. Use of Advanced Materials

Future versions of the system can incorporate:

High-efficiency nano-coated cooling pads

5. Miniaturization and Compact Design

The system can be redesigned to make it:

More compact and portable

Suitable for small rooms, offices, and personal use

6. Industrial and Commercial Applications

Beyond domestic use, the system can be scaled for:

Small industries and workshops

Server rooms and electronic cooling systems

7. Hybrid System Optimization

Further research can focus on:

Optimizing the balance between evaporative and refrigeration cooling

Using eco-friendly refrigerants

9. Mass Production and Commercialization

With proper design optimization:

The system can be manufactured on a large scale

Cost-effective models can be introduced in the market

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