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FABRICATION OF AIR COOLER USING COPPER TUBES AND REFRIGERANT GAS

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ABSTRACT
The growing demand for affordable and eco-friendly cooling systems has encouraged the development of hybrid technologies. This study presents the design and fabrication of an air cooler that integrates vapor compression refrigeration (VCR) principles with copper tubing and refrigerant gas (R134a). The system enhances heat exchange using high-thermal-conductivity copper coils and optimizes air cooling with a fan-assisted mechanism. Results indicate improved cooling efficiency and reduced electricity consumption, making it a viable alternative to traditional air conditioning, especially in resource-constrained settings.

Keywords:
Air cooling, Copper tubes, Refrigerant gas R134a, VCR system, Energy efficiency, Thermal management

INTRODUCTION
The increasing global temperatures, rapid urbanization, and rising energy demands have made indoor cooling a critical necessity. Conventional air conditioning (AC) systems, while effective, are often associated with high operational costs, significant energy consumption, and environmental concerns due to refrigerant emissions and water usage. To address these challenges, this work presents the design and fabrication of a cost-effective, energy-efficient air cooling system based on the vapor compression refrigeration (VCR) cycle. The system uses R134a refrigerant, a widely accepted, ozone-friendly hydro fluorocarbon (HFC), in conjunction with copper tubes for efficient thermal exchange. Unlike traditional evaporative coolers, which rely heavily on water and are less effective in humid climates, the proposed hybrid design combines forced convection with refrigeration principles for superior cooling performance. Key system components include a motor-driven fan for airflow, copper coils acting as the evaporator, and a compact compressor or air pump to drive the refrigerant through the cycle. The refrigerant absorbs heat as it circulates through the coiled copper tubing, and the cooled air is delivered into the surrounding environment. This method enhances both energy efficiency and portability, making it suitable for use in locations with limited resources or infrastructure.

Fig.1 Flow of Refrigerant

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OBJECTIVES

To design and fabricate a portable air cooler using copper tubes and refrigerant. To study the working principles of vapor compression refrigeration. To improve heat transfer efficiency using copper as the primary conductor. To provide a sustainable and low-cost cooling solution. To reduce electricity consumption compared to conventional air conditioning systems.

Steps Involved In VCRS System:

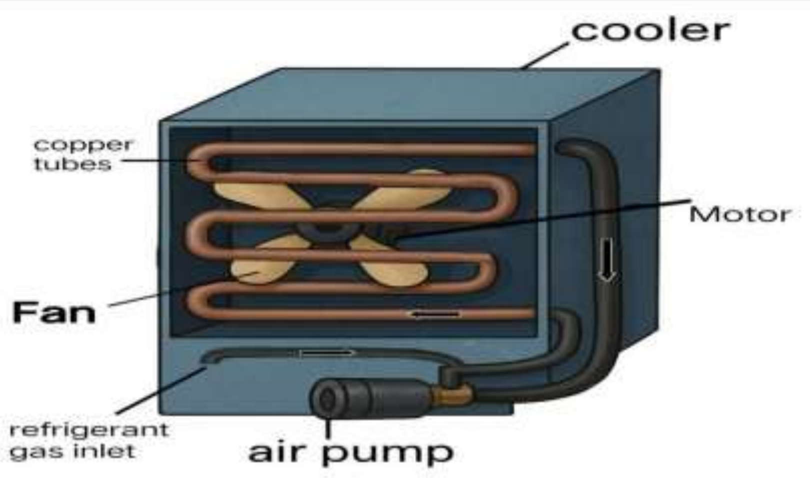
1. 1-2 compression of vapour refrigerant is done in the compressor.
2. 2-3 condensation of high pressure and temperature vapour refrigerant is condensed by the condenser. After condensation, the refrigerant changes in liquid form at same pressure and low temperature. There is a loss of temperature in the form of latent heat.
3. 3-4 now, this low temperature liquid refrigerant enters the throttling valve which changes the phase of liquid into Mixture of liquid and vapour refrigerant.
4. 4-1 now the mixture of liquid and vapour refrigerant enters the evaporator evaporates and achieve low temperature & low pressure due to gain of latent heat. A. Simple Vapour Compression Refrigeration Cycle It is shown on T-S and P-H diagram below, at point 1, let T1, P1, and s1 be the properties of vapour refrigerant and the four processes of the cycle are as follows.

Working Principle:

The air cooler operates on the vapor compression refrigeration cycle, which includes a compressor, condenser, expansion valve, and evaporator. The copper tubes are used for better heat exchange due to their high thermal conductivity. The refrigerant circulates through the copper coils and absorbs heat from the surrounding air, thus cooling the air before it is blown out into the room.

1. Compression (Air Pump): The air pump/compressor compresses the low-pressure refrigerant vapor (R134a) from the evaporator (copper coil).Compression raises the pressure and temperature of the refrigerant gas. This high-pressure, high-temperature gas flows to the condenser coil.
2. Condensation (Condenser Coil): In the condenser, heat from the refrigerant is transferred to the outside air. The fan may also blow over the condenser to help remove heat. The refrigerant condenses into a high-pressure liquid after losing its heat.
3. Expansion (Capillary Tube/Expansion Valve): The liquid refrigerant passes through an expansion device (capillary tube or expansion valve).This sudden pressure drop reduces the temperature of the refrigerant drastically. The refrigerant becomes a low-pressure, low-temperature liquid-vapor mixture.
4. Evaporation and Cooling (Copper Tubes as Evaporator): The cold refrigerant enters the copper coil (evaporator) placed inside the air cooler. A fan, driven by an electric motor, blows warm room air over the cold copper tubes. As the air passes over the tubes, heat is absorbed by the refrigerant inside. This process cools the air and causes the refrigerant to evaporate back into a gas.
5. Repeat of Cycle: The evaporated refrigerant gas is once again sent back to the compressors.

Fig.2 working of air cooler



METHODOLOGY:

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To design and fabricate a portable air cooler using copper tubes and refrigerant. To study the working principles of vapor compression refrigeration. To improve heat transfer efficiency using copper as the primary conductor. To provide a sustainable and low-cost cooling solution. To reduce electricity consumption compared to conventional air conditioning systems. The fan circulates room air across the cold copper tubes filled with refrigerant. The copper tubes, due to their high thermal conductivity, quickly absorb heat from the air. This causes the air to cool down, and the cooled air is then released into the room.

Supporting Functions:
Copper tubes: Act as an efficient heat exchanger (evaporator).
Refrigerant (R134a): Circulates heat through the system.
Compressor (Air Pump): Pressurizes and moves the refrigerant through the cycle.
Fan + Motor: Move warm air over the cold tubes and distribute cool air into the room.

Components Used:
Compressor – To compress the refrigerant and circulate it through the system.
Condenser Coil (Copper Tube) – Dissipates heat from the refrigerant to the surroundings. Expansion Valve – Reduces the pressure and temperature of the refrigerant.
Evaporator Coil (Copper Tube) – Absorbs heat from the incoming air. Refrigerant (e.g., R134a or R22) – Acts as the cooling medium.
Cooling Fan – To blow cooled air into the room.
Mild Steel Frame/Body – Structural support for the entire setup. Power Supply – Electrical energy to run the compressor and fan.

Fabrication Process:
Frame Construction – Build a frame using mild steel to support all components. Mounting the Compressor – Secure the compressor to the base. Copper Tubing Arrangement – Coil the copper tubes for the condenser and evaporator sections. Connecting Components – Join the compressor, condenser, expansion valve, and evaporator in a closed loop. Charging the System – Fill the refrigerant after vacuuming the system. Fan Installation – Fit the fan near the evaporator section to blow cool air. Insulation and Testing – Insulate pipes if needed, then test for leaks and performance.

Performance Evaluation:
The system was tested in a closed room environment. Cooling efficiency was compared with a traditional desert cooler. The fabricated system consumed less power and provided better cooling efficiency.

RESULTS AND DISCUSSION

Observation and Calculation:
Observation:

Table 1: Observation of Temperature, Pressure, And Enthalpy

T1	T2	T3	T4	P1	P2	H1	H2	H4
130C	56.10 C	33.50 C	0.30C	3bar	10.34 bar	410	443	245

Here,
T1= Temperature at the inlet of Compressor
T 2 = Temperature at the outlet of Compressor
T 3 = Temperature at the outlet of Condenser T 4 = Temperature at the inlet of Evaporator P 1 = Pressure at the inlet of Compressor
P 2 = Pressure at the outlet of Compressor h1=Enthalpy at the inlet of compressor h2=Enthalpy at the outlet of compressor h4= Enthalpy at the inlet of Evaporator
The Table represents the observations for Relative Humidity

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Table 2: Observation for Relative Humidity

Td	Tw
180C	12.50C

Here, Td = Dry Bulb Temperature of air (D.B.T.) Tw = Wet Bulb Temperature of air (W.B.T.)

Calculation:
Hence the coefficient of performance is calculated as below: COP=Refrigerating Effect/Work Done.
= (h1 –h4) ÷ (h2 – h1)= (410-245) ÷ (443-410), COP = 5
Power Consumption
Cooler electricity consumption: In this system three parts have consumed electricity, these are
Compressor: Inside motor (for evaporator fan) Outside motor (for condenser fan) Compressor =300 Watts
Inside motor =10 Watts
Outside motor =5 Watts
Overall consumption = compressor + inside motor + outside motor
= 300+10+5= 315Watts, 315 Watts = 1 hours = 315 W-hr.
1000 Watts consume 8rupees Therefore, 315 x 3.15 unit =992.25 watts
3 hr. 15 min. it consumes 8 units = 8 Rupees, 6hr. 30 min. it consumes 16 units= 16 Rupees
This cooler consumes power 1984.5 watts after each day when we used 6.30 hr. in a month.
Monthly Bill of Cooler: Monthly electricity consumes in terms of rupees = 30(day) x16 (unit) = 480 Rupees.
Air Conditioner Electricity Consumption: As compare to air conditioner electricity consumption is 5 times more than a cooler. Monthly Bill of Air Conditioner: Monthly electricity consumes in term of rupees = 480 x 5 = 2400 Rupees.

Result:
Hence from the above calculations the coefficient of performance comes out to be 5.Higher compatibility and portability is achieved which is more efficient than other cooling units.

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CONCLUSION

This project is very cheap and effective as compared with the conventional cooler and air conditioner system as it based on VCRs system. It has very low power consumption which ultimately increases the cop of the system which increases the cooling effect (refrigeration effect) of the system. It is portable. It has very low effect on environment as it saves electricity and water. One-time Installation procedure.
The concept is very cost effective as compared to AC and very Energy Effective system.

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