

IOT Based Human Detecting Air Cooler

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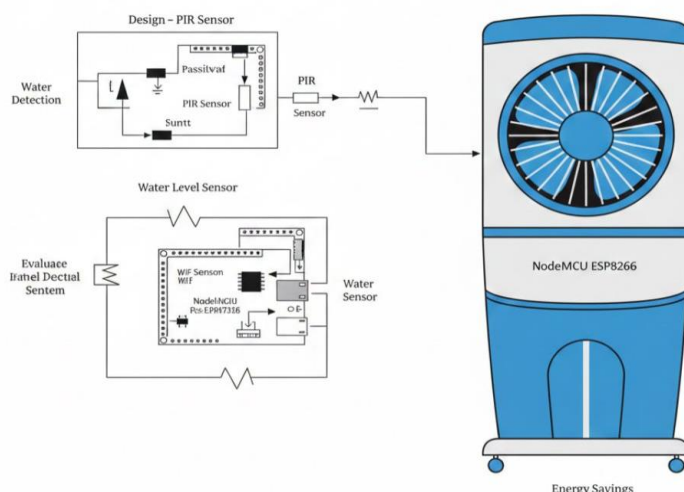
ABSTRACT

The paper discusses the design and implementation of an IoT-based human detecting air cooler aimed at enhancing energy efficiency and adapting to user needs. It addresses the inefficiencies of conventional air coolers, such as excessive power consumption and bulkiness, by integrating a PIR sensor for occupancy detection and automating cooling operation. The system activates based on detected motion and conserves energy by shutting off when no presence is sensed. A NodeMCU ESP8266 microcontroller enables IoT connectivity, allowing users to monitor and control the cooler via smartphone. The compact design includes a vertical layout and detachable reservoir to fit confined spaces. Experimental results show a 35-40% energy consumption reduction compared to traditional coolers, with accurate human detection within 5-6 meters and stable remote command execution, indicating suitability for smart home environments. This project represents a convergence of IoT technology, automation, and ergonomic design principles to produce an innovative, eco-friendly, and intelligent air-cooling solution.

Keywords: IOT, Air Cooler, Human Detection

CHAPTER NO: 1

1.1 Introduction to IoT Based Human Detecting Air Cooler



The Internet of Things (IoT) has enabled a new era of intelligent automation in household appliances by integrating sensors, connectivity, and data-driven decision making. An IoT-based human detecting air cooler represents a smart solution that not only provides cooling comfort but also optimizes energy usage by responding to human presence and real-time environmental conditions. Traditional air coolers operate continuously once turned on, regardless of occupancy or ambient temperature, leading to unnecessary power consumption and wear of mechanical components. By integrating IoT technology, the system can monitor user presence, control cooling cycles, and operate only when needed.

The human detecting feature is achieved using a Passive Infrared (PIR) sensor, which identifies human

motion and sends signals to the microcontroller. When a human is detected, the cooler activates automatically, and if no motion is detected for a predefined duration, the device shuts down to conserve energy. In addition to occupancy detection, the system employs a DHT11 sensor to measure temperature and humidity, enabling adaptive cooling control based on environmental conditions. This ensures that cooling is provided when necessary and at optimal levels, improving comfort and efficiency.

The IoT architecture is centered around the NodeMCU ESP8266 microcontroller, which processes sensor data, executes control logic, and facilitates remote monitoring through Wi-Fi connectivity. The system can be integrated with a smartphone app or cloud dashboard that allows users to monitor temperature, humidity, water level, and cooler status from anywhere. A water level sensor acts as a protective mechanism by preventing the pump from running dry, ensuring safety and improving the reliability of the system. A 5V relay module serves as the switching interface between low-power control electronics and high-power electromechanical components such as the fan and water pump.

This IoT-based system not only enhances user comfort but also offers significant energy savings by eliminating unnecessary operation when the user is absent. The automation makes the cooler self-regulated, reducing manual intervention and improving user experience. The use of low-cost sensors and open-source hardware ensures affordability and scalability, making it suitable for domestic and commercial applications.

Overall, the IoT-based human detecting air cooler represents a step toward sustainable and intelligent cooling solutions. By combining sensor feedback, wireless communication, and decision-based control, the system delivers improved performance, safety, and efficiency.

1.2 History

The evolution of air cooling spans centuries, with early civilizations using natural evaporation techniques to create a comfortable indoor environment. Ancient Egyptians and Persians hung wet fabrics or used water channels to promote evaporative cooling within buildings. This primitive yet effective method laid the foundation for the modern principle of cooling through water evaporation.

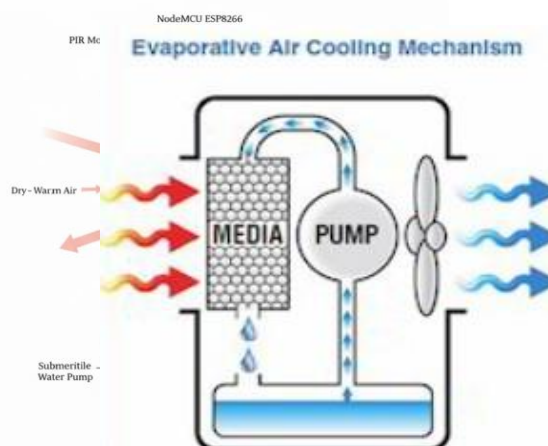
With the advent of industrialization in the late 19th and early 20th centuries, mechanical fans were introduced to enhance airflow and improve cooling efficiency. Early air cooler designs were simple, consisting of a fan, water reservoir, and basic evaporation medium. As electricity became widely available, electric motor-driven fans replaced manual systems, making air cooling more accessible to households.

The development of modern evaporative coolers gained momentum in the mid-20th century, particularly in dry and semi-arid regions where humidity was low. Manufacturers began experimenting with new materials, including sheet metal, cellulose pads, and plastic components, resulting in improved performance and durability. Water circulation pumps were introduced, enabling continuous moisturization of cooling pads, which enhanced the overall evaporation rate.

In recent decades, technological advancements have paved the way for automation, energy optimization, and smart monitoring. The integration of microcontrollers, sensors, and wireless networks has transformed traditional air coolers into intelligent systems. Modern IoT-based coolers now incorporate motion detection, climate monitoring, and remote control to provide user-centric comfort with minimized energy consumption.

1.3 Physical Principle

The operation of an air cooler is based on the fundamental physical principles of heat transfer and evaporative cooling. When air comes in contact with a wet surface, water absorbs heat energy from the



surrounding air and undergoes a phase change from liquid to vapor. This process lowers the air temperature, resulting in cooler and more comfortable airflow. The rate of evaporation depends on factors such as air temperature, humidity, surface area, and air velocity.

The evaporative cooling effect can be explained using the concept of latent heat of vaporization. Water requires a significant amount of energy to change its state from liquid to vapor. This energy is taken from the air in the form of heat, causing a noticeable drop in air temperature. The phenomenon is most effective in dry climates, where relative humidity is low, allowing faster evaporation and greater cooling efficiency.

Airflow plays a crucial role in enhancing heat transfer. A fan increases the velocity of air passing through the wet cooling pad, improving evaporation rate and heat removal. As fresh air continuously circulates through the system, the cooling process is sustained, providing a steady supply of cold air. The porous structure of cooling pads further increases surface area, allowing more contact between air and water molecules. Modern air coolers may incorporate sensors to regulate cooling based on environmental conditions. For example, a temperature and humidity sensor can determine whether cooling is effective or requires adjustment. This adaptive operation improves comfort, reduces energy consumption, and prolongs system longevity.

CHAPTER No :- 2

2.1 DESIGN CONSIDERATIONS

The design of an air cooler requires careful consideration of several mechanical, electrical, and environmental factors to ensure optimal cooling performance, reliability, and energy efficiency. Key design considerations include airflow rate, heat load, material selection, water circulation, power consumption, and overall system durability. In IoT-based systems, additional attention is given to sensor placement, control logic, and connectivity.

Airflow capacity is one of the most critical parameters, as it determines the volume of air that can be cooled and distributed. The choice of fan type, size, and speed directly influences cooling efficiency and noise levels. Similarly, the heat load of the environment must be evaluated to determine the required cooling capacity and operating conditions.

Material selection affects durability, corrosion resistance, and cost. Sheet metal, plastic components, and cooling pads must withstand exposure to moisture, dust, and continuous airflow. Water circulation design is also essential, requiring an efficient pump and proper piping layout to maintain uniform wetness across cooling pads and prevent dry spots that reduce performance.

Energy efficiency is another important factor, especially in automated systems. Efficient motors, low-power electronics, and intelligent control strategies help reduce power consumption. IoT integration introduces sensors and microcontrollers that monitor environmental conditions, occupancy, and water levels, enabling adaptive control of fan speed and pump operation.

Safety and maintenance considerations are also crucial. Electrical components must be properly insulated to prevent hazards, while mechanical parts should be easily accessible for cleaning and servicing. Water level monitoring prevents pump damage and ensures long-term reliability.

Overall, effective air cooler design requires a balanced approach between mechanical performance, energy efficiency, safety, and smart automation features.

2.2 Types of Air Cooling Methods

- Direct evaporative cooling
- Indirect evaporative cooling
- Hybrid cooling systems

CHAPTER NO:-3

3.1 NODEMCU ESP8266 MICROCONTROLLER

NodeMCU ESP8266 is a low-cost, Wi-Fi-enabled microcontroller platform widely used in Internet of Things (IoT) applications. It is built around the **ESP8266EX SoC (System on Chip)** developed by Espressif Systems, which integrates a **32-bit Tensilica processor**, onboard SRAM, and a full Wi-Fi transceiver. The primary advantage of NodeMCU is that it enables IoT functionality with minimal hardware, making it an ideal solution for smart appliances, automation, and wireless sensor networks.

1. Architecture and Hardware Features

The ESP8266 microcontroller operates at a frequency of **80–160 MHz**, providing sufficient processing capability for real-time sensing and control. It includes approximately **64 KB instruction RAM**, **96 KB data RAM**, and **external flash memory** for program storage. NodeMCU exposes **GPIO pins** that can interface with sensors, actuators, relays, and other peripherals required in automation systems.

A major benefit of the board is its **integrated Wi-Fi module**, eliminating the need for additional communication hardware. It supports both **Access Point (AP)** and **Station (STA)** modes, allowing devices to connect either directly to it or via a router.



2. Programming and Software Ecosystem

NodeMCU is compatible with **Arduino IDE**, **MicroPython**, and **Lua**, making it easy to program and prototype. It includes a built-in **USB to UART converter (CH340/CP2102)**, allowing direct programming and debugging from a PC without any external interface. Libraries for sensor reading, MQTT communication, HTTP requests, and cloud integration are widely available, reducing development time.

3. Networking and IoT Capabilities

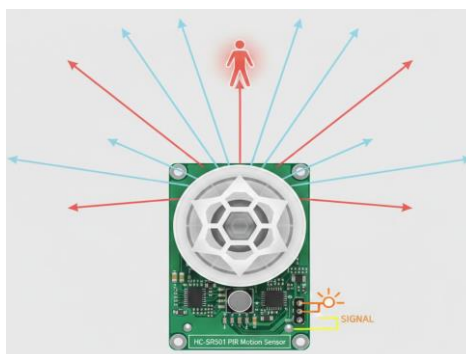
One of the core strengths of NodeMCU ESP8266 is its **native TCP/IP stack**, enabling wireless communication through Wi-Fi. It supports REST APIs, MQTT protocols, cloud platforms, and mobile app interfaces. This makes it possible to send sensor data to remote servers, receive control commands, and enable **bidirectional communication** between user and device.

Power Efficiency and Performance

NodeMCU is optimized for low-power IoT applications and supports various sleep modes such as **deep sleep** and **light sleep**, which significantly reduce power consumption when the system is idle. This feature makes it suitable for battery-operated as well as continuous-power systems.

3.2 PIR MOTION SENSOR

A Passive Infrared (PIR) motion sensor is an electronic device used to detect human presence by sensing variations in infrared radiation emitted from the human body. Unlike active sensors, PIR sensors do not transmit signals; instead, they passively monitor the infrared energy in their surroundings. This makes them **energy-efficient**, **reliable**, and **widely used** in



automation and security systems.

1. Principle of Operation

The PIR sensor detects motion based on changes in infrared (IR) radiation. All warm-blooded living beings emit infrared energy in the wavelength of approximately **8–14 micrometers**. The sensor consists of two **pyroelectric elements** placed side by side. When a person moves across its field of view, the infrared energy striking these elements changes, generating a small electrical signal. This signal is then processed by onboard amplifiers and comparators to produce a **digital output**, typically HIGH when motion is detected and LOW when the environment is static.

2. Detection Characteristics

Typical characteristics of PIR sensors include:

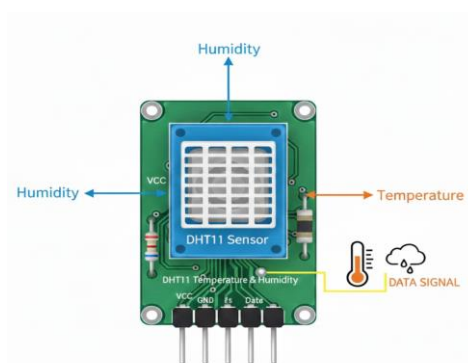
- **Detection range:** 5 to 7 meters
- **Detection angle:** 90°–120°
- **Output type:** 3.3V or 5V digital signal
- **Power consumption:** Very low
- PIR sensors detect **motion only**, not static presence. Continuous movement is required to maintain frequent triggering.

3. Role in IoT-Based Air Cooler

In an IoT-based human detecting air cooler, the PIR sensor serves as a **human presence detection module**. The sensor detects when a user enters the room and sends a signal to the microcontroller (NodeMCU ESP8266). Based on this input, the cooler is switched ON automatically using a relay module.

3.3 DHT11 TEMPERATURE AND HUMIDITY SENSOR

The DHT11 is a low-cost digital sensor used for measuring **ambient temperature and relative humidity**. It is widely employed in environmental monitoring, smart appliances, and IoT systems due to its simplicity, low power consumption, and reliable performance. The sensor integrates a temperature sensing element, a humidity sensing component, and an onboard signal conditioning circuit, providing **calibrated digital output** to microcontrollers.



1. Principle of Operation Humidity Measurement

The DHT11 measures humidity using a **capacitive humidity sensor** electrodes with a moisture-absorbent dielectric material between them. The dielectric's capacitance changes, causing variation in the sensor's electrical characteristics. This capacitance value is converted into a **digital humidity reading** through internal analog-to-digital conversion.

Temperature Measurement

Temperature is measured using an **NTC thermistor**, where electrical resistance varies with temperature. The built-in ADC converts the analog signal into a **10-bit digital temperature value**, which is processed by the internal microcontroller.

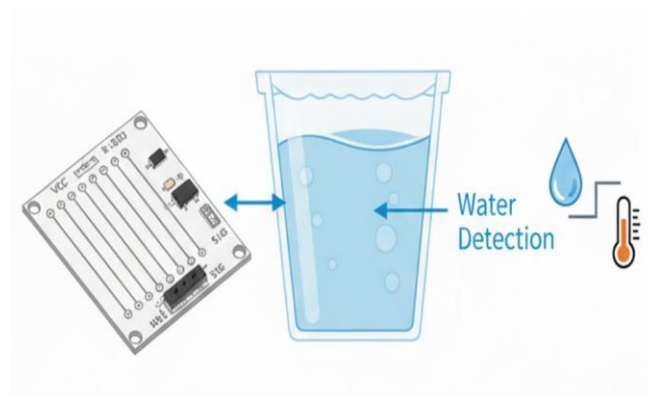
2. Performance Characteristics

Typical specifications of the DHT11 include:

Parameter	Value
Temperature Range	0°C to 50°C
Temperature Accuracy	±2°C
Humidity Range	20% to 90% RH
Humidity Accuracy	±5% RH
Operating Voltage	3.3V – 5V
Sampling Rate	1 Hz (1 reading/second)

3.4 WATER LEVEL SENSOR

A **Water Level Sensor** is an electronic device used to detect, monitor, and measure the level of water present inside a tank or reservoir. In IoT-based air cooler systems, the water level sensor plays a vital role in determining whether sufficient water is available for cooling and in preventing dry running of the water pump. By continuously monitoring the water status, it enables automatic control and provides safety to the system.



1 Working Principle

The working of a water level sensor is based on detecting the presence or absence of water at specific points. Most commonly used sensors in air coolers are **float-type** or **conductive-type (probe)** sensors.

- In **float sensors**, a mechanical float moves up or down with the water level. When the water level changes, the float activates a switch, which changes the electrical output state.
- In **conductive sensors**, metal probes are placed at different heights inside the tank. When water touches a probe, it completes a circuit because water conducts electricity. This allows the system to determine whether the tank is full, half, or empty.
- The output from the sensor is sent to a microcontroller, such as NodeMCU ESP8266, which interprets the signal and performs control actions accordingly.

2 Electrical Output Characteristics

Water level sensors generally provide a **digital output**, represented as:

HIGH (1) when water is present

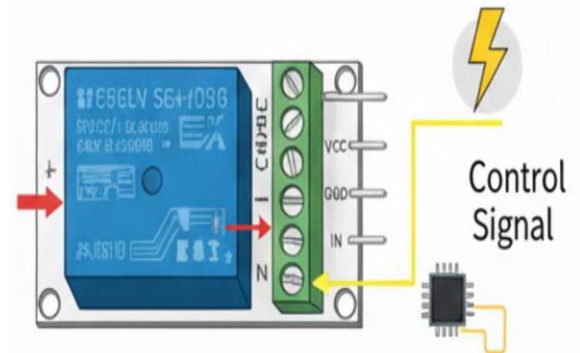
LOW (0) when water is not detected

In some advanced sensors, an **analog output** may be provided, which represents the water level continuously in the form of varying voltage.

This output is read by the microcontroller through its input pins.

3.5 5V RELAY MODULE

A **5V Relay Module** is an electromechanical switching device used to control high-voltage or high-current loads using low-power electrical signals. In microcontroller-based systems, such as IoT air coolers, the relay module provides an interface between the low-voltage controller (3.3V/5V) and the high-voltage electrical components like motors, pumps, and fans. It acts as an electrically isolated switch that can turn devices ON or OFF based on the control signals received from the microcontroller.



1 Construction and Principle of Operation

A relay module consists of:

- **Electromagnetic coil**
- **Armature**
- **Spring mechanism**
- **Switching contacts (COM, NO, NC)**
- **Indicator LED**
- **Optocoupler (in some modules)**

When the relay coil is energized by a **5V supply**, it generates a magnetic field that pulls the armature, causing the switch to change its position. This mechanical movement opens or closes the circuit connected to the relay.

The contacts are:

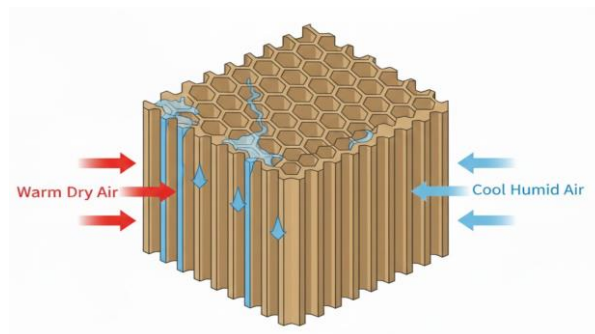
- **NO (Normally Open):** Circuit is open when relay is OFF, closes when ON
- **NC (Normally Closed):** Circuit is closed when relay is OFF, opens when ON
- By selecting NO or NC contacts, loads can be controlled in different ways.

Working with Microcontroller

The relay module is controlled by a **digital control signal**, typically from a microcontroller like NodeMCU ESP8266 or Arduino. When the microcontroller outputs a HIGH or LOW signal (depending on relay type), it drives the relay coil through a **transistor-based driver circuit**.

3.6 Cooling pads

Cooling pads are essential components of an air cooler, designed to increase the efficiency of heat removal from the incoming air. They act as **evaporative media**, allowing water to spread evenly over their surface and evaporate into the passing air stream. The evaporation process extracts heat from the air and thereby reduces its temperature, resulting in cool, humidified air output.



Cooling pads play a vital role in determining the overall cooling performance, airflow quality, and

energy efficiency of the system.

1 Construction and Materials Cooling pads are commonly made from:

- **Cellulose fiber (honeycomb pads)**
- **Aspen/Wood wool**
- **Synthetic polymer materials**
- Higher surface area for evaporation
- Better water retention
- Long-lasting durability

The structure of these pads consists of **cross-corrugated layers** of cellulose treated with anti-fungal and anti-rot chemicals to improve durability and hygiene.

Working Principle

1. The working of cooling pads is based on **evaporative cooling**.
2. Water is distributed over the pad surface by a pump.
3. The porous pad absorbs and retains water.
4. When hot and dry air passes through the wet pad:
5. Water absorbs heat from air
6. Water molecules evaporate
7. Air temperature decreases
8. Humidity increases

This process is often referred to as **adiabatic cooling**, as the reduction in air temperature occurs due to evaporation without external refrigeration.

3.7 AIR COOLER FRONT GRILL

The **front grill of an air cooler** is a structural and protective component located at the outlet side of the cooler through which the conditioned air is distributed into the surrounding environment. It functions as a **safety barrier, airflow regulator, and design feature**, ensuring efficient delivery of cool air while maintaining user safety and aesthetic appearance.

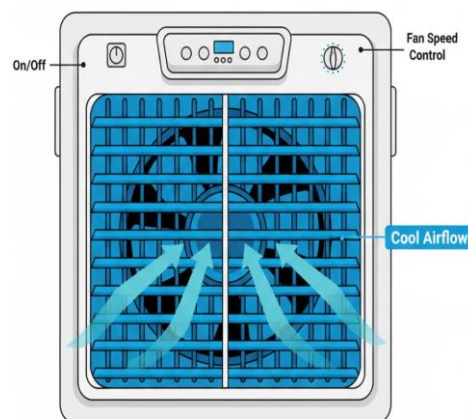
The grill is typically made from **plastic, metal, or fiber-reinforced material**, designed with openings or louvers to guide air flow in a controlled direction.

1 Design and Structure

The grill features a series of **horizontal or vertical slats** (louvers) arranged in a grid pattern. These slats are designed to:

- Allow maximum airflow
- Stop large particles or foreign objects
- Prevent accidental contact with internal components
- Reduce noise and turbulence

Many grills include **adjustable louvers** that allow the user to change the direction of airflow.



Types of Front Grills

1. Fixed Grill

- Slats are stationary
- Simple and low-cost

2. Adjustable Grill

- Louvers can be moved manually • Controls airflow direction

3. Swing Grill

- Motorized oscillation • Wide air distribution
- Used in high-end coolers

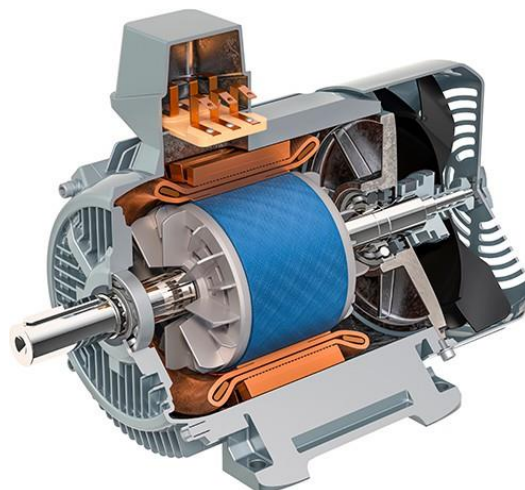
4. Mesh Grill

- Fine metal/plastic mesh
- Used in industrial units for safety.

3.8 AIR COOLER MOTOR

1. Introduction

The motor used in an air cooler is a key electromechanical component responsible for driving the cooling fan, ensuring continuous airflow across the cooling pads. Efficient air circulation enhances the evaporative cooling process and directly influences the overall performance of the air cooler. The motor shown in the system is a **single-phase induction motor**, designed for reliable operation under varying environmental conditions.



2. Specifications of the Motor

Based on the label visible in the image, the motor exhibits the following specifications:

- **Type:** Single Phase AC Induction Motor
- **Output Power:** 60W
- **Voltage Rating:** 230V AC
- **Frequency:** 50Hz
- **Speed:** 2500 RPM
- **Current Rating:** 1.8A (Approx.)
- **Insulation Class:** Class B / F
- **Manufacturer:** Angel Electrical Co., New Delhi, India.

These specifications indicate that the motor is optimized for **low power consumption, stable speed, and reliable performance** in household cooling applications.

3. Advantages

The motor offers several benefits:

- **Low power consumption (60W)**
- **High reliability** in continuous operation
- **Low noise and vibration** • Easy maintenance
- **Economically viable**
- Suitable for **domestic and industrial delivery fans**

Its **2500 RPM speed** makes it efficient in generating sufficient airflow for cooling.

4 Safety and Maintenance Considerations

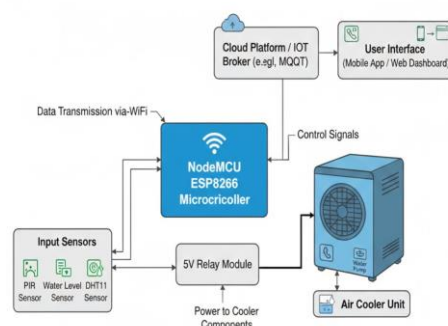
To ensure long operational life, the following guidelines are recommended:

- Avoid overloading or obstructing fan blades
- Ensure proper **ventilation and cooling**
- Prevent **water ingress** into windings
- Periodically lubricate bearings (if serviceable)
- Inspect wiring for **damage or loose connections**.

CHAPTER NO:- 4

4.1 Design and Construction of IoT Based Human Detecting Air Cooler

The design and construction of an IoT based human detecting air cooler involve the integration of conventional evaporative cooling mechanisms with intelligent sensing, control, and communication technologies. The primary objective of this system is to automatically detect the presence of humans and regulate the operation of the cooling unit to reduce energy consumption, enhance user comfort, and provide real-time monitoring through an IoT platform. By combining mechanical cooling components with electronic sensors and microcontroller-based automation, the system delivers improved efficiency, safety, and user convenience compared to traditional air coolers.



Mechanical Design

The mechanical structure consists of a rectangular cooler body made from corrosion-resistant plastic or galvanized sheet metal. The housing accommodates components such as the fan motor, water pump, water tank, cooling pads, and air outlet grill. Honeycomb cooling pads are arranged on three sides of the cooler for maximum evaporative surface area, whereas a submersible pump circulates water from the tank to keep the pads wet. A front grill with adjustable louvers ensures directional airflow, and a centrifugal or axial fan is used to deliver cool air into the room. The fan motor and pump are sized based on required airflow rate, tank capacity, and cooling performance.

Electronic Design

The electronic control unit is built around a **NodeMCU ESP8266 microcontroller**, which serves as the central processing and communication module. The system interfaces with multiple sensors, including a **PIR (Passive Infrared) motion sensor** for human detection, **DHT11 temperature and humidity sensor** for environmental monitoring, and **water level sensor** for tank status detection. A **5V relay module** is used to switch high-voltage loads such as the fan and pump, while maintaining electrical isolation between low-power electronics and AC devices.

The PIR sensor continuously scans its surroundings to detect human motion within its sensing range. When a human presence is detected, the microcontroller activates the cooling system by turning ON the fan and water pump. In the absence of motion, the system automatically switches OFF after a preset delay to conserve electricity and water. The DHT11 sensor provides continuous feedback on temperature and humidity, enabling environmental monitoring and data logging. The water level sensor prevents dry running of the pump by shutting down the system and sending alerts when water is low.

IoT Architecture and Communication

The IoT functionality of the system is implemented using Wi-Fi connectivity supported by the ESP8266 module. The cooler is connected to a cloud platform or mobile IoT application, allowing users to remotely monitor and control the system. Parameters such as fan status, temperature, humidity, and water level are transmitted to the user interface in real time. The user can control operating modes, set schedules, or turn the system ON/OFF via smartphone. This communication framework makes the system highly interactive and enhances overall user convenience.

Control Logic and Automation

The control algorithm is programmed using embedded C/C++ in the Arduino IDE. The logic includes three major functions: human detection-based automatic control, environmental data acquisition, and safety monitoring. When motion is detected, the controller activates the relay to start the fan and pump. If no motion is detected for a defined time period, the system shuts down to avoid unnecessary power usage. Simultaneously, the system checks water level and prevents pump activation during low water conditions. Temperature and humidity data may also be used to adjust fan speed or operational mode in advanced designs.

Power Supply and Safety

The system operates using a standard AC supply, which powers the fan motor and pump through the relay module. The electronic circuit is powered using a regulated 5V/3.3V power supply. Electrical isolation, fuse protection, and proper insulation are incorporated to ensure safe operation, especially in humid conditions. Additional safety features such as overcurrent protection and automatic shutdown are considered during design.

Energy Efficiency and Performance

This air cooler significantly improves energy efficiency by operating only when occupants are present. Traditional coolers run continuously, resulting in unnecessary power and water wastage. The detection-based control reduces operational time, minimizes resource usage, and prevents motor damage. Monitoring of environmental parameters also ensures optimal cooling performance and user comfort.

4.2 Working Principle of IoT Based Human Detecting Air Cooler

The working principle of an IoT based human detecting air cooler is based on the integration of **evaporative cooling**, **human presence detection**, and **IoT-based monitoring and control**. The system intelligently operates the cooling mechanism only when a human is detected, thereby reducing energy consumption and water wastage. The main components involved in its operation include a **PIR motion sensor**, **NodeMCU ESP8266 microcontroller**, **DHT11 sensor**, **water level sensor**, **relay module**, **fan motor**, and **water pump**.



1. Human Presence Detection

The system continuously monitors the surroundings using a PIR motion sensor, which detects infrared radiation emitted by human bodies.

- When motion is detected, the sensor sends a **signal to the microcontroller**.
- If no human movement is detected, the system remains in standby mode or switches off after a delay. • This ensures that the cooler runs **only when needed**, improving efficiency.

2. Control and Decision-Making

The **NodeMCU ESP8266** acts as the central control unit. It receives signals from the PIR sensor and decides when to activate or deactivate the cooler.

Control logic:

- **Presence detected** → **Turn ON fan and pump via relay** ● **No presence for a set time** → **Turn OFF fan and pump** ● **Water low** → **Stop pump and notify user**
- **Remote command via app** → **override automatic mode**
- The microcontroller ensures **automatic, safe, and optimized operation**.

3. Evaporative Cooling Process

When the fan and pump are activated:

1. The pump circulates water from the tank to the **cooling pads**.
2. The pads absorb the water and become wet.
3. Hot air is drawn through the wet cooling pads by the fan.
4. Water evaporates and absorbs heat from the air.
5. The air temperature drops and **cool, humid air** is blown into the room.

This process is called **evaporative cooling**, which provides low-cost, eco-friendly cooling.

4. Environmental Monitoring

The **DHT11 temperature and humidity sensor** continuously measures: ● Ambient temperature

- Relative humidity

The readings are sent to the microcontroller and displayed on the IoT platform.

This allows:

- Performance evaluation
- User monitoring
- Adaptive control (in advanced models)

5. Water Level Monitoring and Safety

A **water level sensor** monitors the water tank. If water is too low:

- The system **stops the pump** to prevent dry running ● **A notification is sent to the user**
- The fan may continue to operate depending on design ● This protects the pump and improves reliability.

6. IoT Communication and User Control

The system uses Wi-Fi communication via ESP8266 to connect with an IoT platform or mobile app.

Users can:

- Monitor temperature, humidity, and water level ● Turn ON/OFF the cooler remotely
- Receive alerts and notifications ● Set schedules or modes
- Thus, the system provides **remote access and smart automation**.

7. Power Switching and Actuation

A **5V relay module** acts as an electronic switch between:

- Low-voltage control (microcontroller) ● High-voltage loads (fan and pump)
- When triggered by the controller, it safely switches the electrical devices ON or OFF.

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