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Comparison Study of Automatic Room Humidifiers

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Abstract: Maintaining optimal indoor humidity is essential for ensuring comfort, health, and air quality. This project presents a comparative study of two automated room humidifiers integrated with NodeMCU-based smart control. The first model utilizes an ultrasonic humidifier to generate fine mist silently, while the second model employs a mechanically operated system using a BO motor and crank mechanism to disperse water into the air. Both systems incorporate a DHT11 humidity sensor to monitor ambient conditions and activate humidification when required. The study evaluates each model based on parameters such as cost, efficiency, noise level, maintenance, and complexity. Results indicate that while the ultrasonic humidifier offers quiet and efficient performance, the mechanical humidifier serves as a cost-effective and faster alternative for basic applications. The analysis aids in selecting an appropriate humidification method based on user needs and environmental conditions.
Keywords: Room Humidifier, Ultrasonic Humidifier, Mechanical Humidifier, NodeMCU, Smart Control, DHT11 Sensor, BO Motor, Humidity Monitoring, IoT, Automation, Crank Mechanism, Relay Module

I. INTRODUCTION

In recent years, maintaining a healthy indoor environment has become a priority, especially in urban areas where people spend a significant amount of time indoors, whether at home, offices, schools, or hospitals. One crucial factor that directly impacts indoor air quality and comfort is humidity. The ideal indoor relative humidity typically ranges between 40% and 60%. When humidity falls below this range, it can lead to health issues such as dry skin, irritated eyes, respiratory discomfort, and increased susceptibility to colds and infections. Furthermore, low humidity can also cause damage to wooden furniture, musical instruments, and sensitive electronic devices due to static buildup and material shrinkage. To address this issue, various types of room humidifiers are used to add moisture to the air. Traditionally, these devices function manually, requiring the user to switch them on or off based on perceived need. However, with the rise of smart technologies and IoT-based automation, there is a shift towards intelligent systems that can operate automatically by sensing environmental conditions. This project aims to design and compare two automated room humidifier models using NodeMCU, a Wi-Fi-enabled microcontroller, and DHT11, a digital humidity and temperature sensor. The main objective is to study the performance, efficiency, cost, noise level, and complexity of two different humidification mechanisms, both integrated with real-time smart control.

II. PROJECT OBJECTIVE

The primary objective of this mechatronics project is to design, develop, and compare two different automated room humidifier models integrated with smart control systems using the NodeMCU microcontroller. These models aim to maintain optimal indoor humidity levels automatically, based on real-time environmental data.

A. *Specific Objectives Include*

To develop an ultrasonic humidifier model with automated control using NodeMCU and DHT11 sensor, focusing on silent and efficient mist generation.

To develop a mechanically operated humidifier model using a BO motor and crank mechanism, controlled by NodeMCU, for a cost-effective and DIY approach to air moisture regulation.

To implement real-time feedback control in both models by monitoring ambient humidity using the DHT11 sensor and triggering appropriate actions through electronic control circuits.

To evaluate and compare the two models based on:

- Humidification performance and efficiency
- Operational cost and maintenance
- Ease of assembly and design complexity
- Noise levels during operation
- Suitability for different environmental or use-case scenarios

To demonstrate the application of IoT-based automation in home appliances, highlighting the potential of smart systems in enhancing comfort, energy efficiency, and indoor air quality.

To analyze the trade-offs between mechanical and ultrasonic methods of humidification in terms of reliability, adaptability, and user convenience.

III. METHODOLOGY

The methodology followed in this mechatronics project involved a systematic process of designing, building, and evaluating two different room humidifier models integrated with smart automation features. The project was divided into multiple phases, each focusing on specific objectives to ensure a comprehensive comparison between the two models.

A. Phase 1: Research and Component Selection

A literature review was conducted to understand different types of humidification techniques and their applications.

Based on performance, cost, and feasibility for automation, two humidifier types were selected:

1) Ultrasonic humidifier

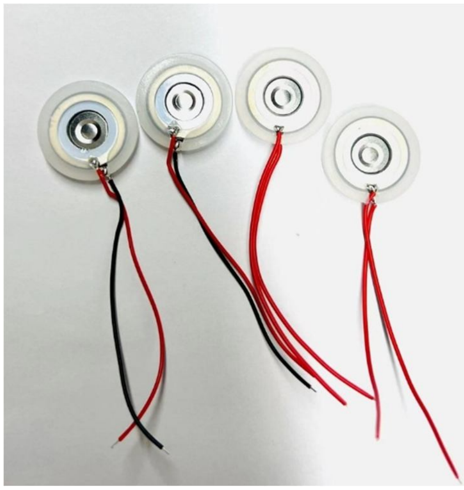

Figure 1 Ultrasonic Humidifier

2) Mechanically operated humidifier using BO motor

Figure 2: BO Motor

Components were selected to enable sensor-based automation using NodeMCU as the controller and DHT11 as the sensor.

B. Phase 2: Circuit Design and Control Logic

For Both Models:
DHT11 Sensor was used to continuously monitor ambient humidity.
NodeMCU (ESP8266) was programmed to process humidity data and make control decisions.
If humidity < threshold (e.g., 45%), the system activates the humidifier.
If humidity ≥ threshold, the humidifier remains OFF.
Model 1: Ultrasonic Humidifier
NodeMCU receives humidity data from DHT11.
When humidity drops, NodeMCU triggers a relay module to turn ON the ultrasonic humidifier, which generates a fine mist.
Once the required humidity is achieved, the relay turns OFF the humidifier.

Model 2: Mechanical Humidifier
NodeMCU, based on DHT11 data, activates a motor driver module connected to a BO motor.
The BO motor rotates a crank mechanism, converting rotary motion to oscillatory motion.
The oscillation moves a spray arm that splashes water, thereby humidifying the air.

C. Phase 3: Assembly and Prototyping

Model 1 involved simple wiring between NodeMCU, relay, DHT11, and the ultrasonic humidifier.
Model 2 required mechanical fabrication:
Crank-lever setup was designed and mounted.
BO motor was fixed and coupled with the mechanism.Proper water spray system was attached for effective operation.

D. Phase 4: Testing and Calibration

Both models were tested in a controlled environment. Humidity thresholds were calibrated using real-time data from the DHT11 sensor. Each model was operated under identical environmental conditions to record:

1) Time taken to reach the target humidity
2) Power consumption
3) Noise levels
4) Ease of operation
5) Responsiveness to humidity changes

E. Phase 5: Data Analysis and Comparison

Observations were tabulated to compare both systems based on:

- Efficiency and speed of humidification
- Component cost and availability
- System complexity and maintenance requirements
- Performance reliability and user-friendliness

The results were used to draw conclusions regarding the most suitable model for specific applications (e.g., silent operation vs. budget-friendly solutions).

1) Model 1: Ultrasonic Humidifier with NodeMCU

This model employs an ultrasonic humidifier module, which works on the principle of ultrasonic vibrations. A ceramic disc in the module vibrates at a high frequency, breaking the water particles into a fine mist. This mist is then released into the air, increasing humidity without using heat or mechanical spraying.
The operation is controlled using a NodeMCU (ESP8266**)** microcontroller, which constantly receives real-time humidity data from the DHT11 **sensor**. When the humidity falls below the preset threshold, the NodeMCU triggers a relay module, which powers the ultrasonic humidifier.

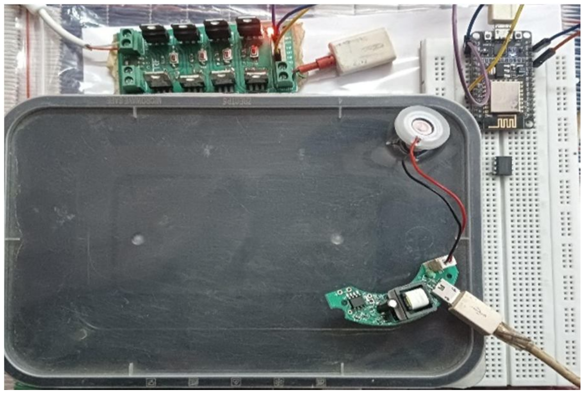

Figure 3: image of Model 1

Key Components Used:

- Ultrasonic Humidifier Module: Converts water into a fine mist using ultrasonic vibration.
- NodeMCU (ESP8266): A low-cost Wi-Fi-enabled microcontroller for automation and smart control.
- DHT11 Sensor: Measures humidity and temperature and sends data to the microcontroller.
- Relay Module: Acts as a switch to control high-power devices with low-power signals from NodeMCU.

This model is compact, silent, and aesthetically appealing, making it ideal for modern living spaces. However, it requires distilled water to avoid mineral buildup and periodic cleaning of the ultrasonic plate.

2) Model 2: Mechanical Humidifier with NodeMCU and BO Motor

This model features a mechanical approach to humidification. When the ambient humidity drops below the desired level, the NodeMCU, using feedback from the DHT11 sensor, activates a BO motor through a motor driver circuit. The motor rotates a crank mechanism, which converts rotary motion into oscillating motion.

The oscillating motion is used to move a spray arm, which splashes water droplets into the air, thereby increasing the humidity level. This setup mimics the action of a manual humidifier but is automated and controlled via electronics.

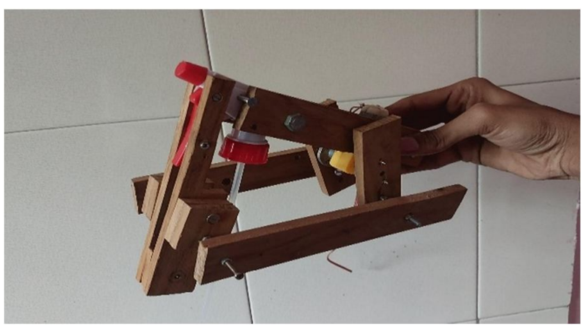

Figure 4: Image of Model 2

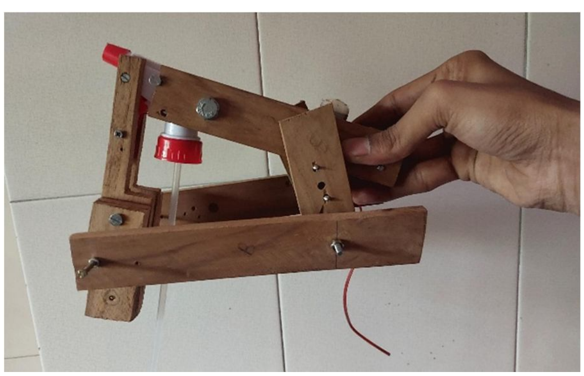

Figure 5 Image of Model 3

Key Components Used:

- BO Motor (Battery-Operated DC Motor): Provides rotary motion for the crank mechanism.
- Crank Mechanism: Converts rotary motion into oscillating/splashing movement.
- NodeMCU (ESP8266): Controls the system using real-time humidity data.
- DHT11 Sensor: Monitors the ambient humidity.
- Motor Driver Module (L298N or equivalent): Interfaces between the microcontroller and the DC motor.

This model is more cost-effective, uses regular tap water, and is suitable for DIY enthusiasts. However, it generates noticeable mechanical noise and may require more maintenance due to moving parts.

IV. COMPARATIVE ANALYSIS

Parameter	Ultrasonic Humidifier	Mechanical Humidifier
Humidification Method	Fine mist through ultrasonic vibrations	Water splashing through mechanical motion
Noise Level	Silent	Noisy due to motor and mechanical parts
Cost	Higher	Low
Water Requirement	Distilled water preferred	Normal tap water is sufficient
Maintenance	Requires ultrasonic plate cleaning	Mechanism needs occasional servicing
Smart Control	Yes (NodeMCU + Relay)	Yes (NodeMCU + Motor Driver + Relay)
Complexity	Compact and minimal mechanical components	Complex due to crank mechanism
Efficiency	Moderate humidification rate	Faster humidification rate

V. RESULTS

After successful development and testing of both humidifier models, various performance parameters were analyzed. Both systems were evaluated under similar room conditions for consistency in comparison. The results are presented based on efficiency, noise, cost, response time, maintenance, and ease of use. The ultrasonic model performed better in terms of silent operation and compact design. It is more suitable for home and office environments where noise sensitivity is a concern.

The mechanical model showed quicker humidification, making it suitable for larger or less noise-sensitive environments. However, the mechanical nature made it slightly harder to maintain. The NodeMCU-based automation functioned effectively in both models, accurately triggering the systems when humidity dropped below the threshold.

Both models successfully maintained humidity within the target range of 45% to 55%.

VI. CONCLUSION

This project successfully demonstrated the development, automation, and comparative analysis of two types of room humidifiers—an Ultrasonic Humidifier and a Mechanically Operated Humidifier, both controlled using a NodeMCU microcontroller and a DHT11 humidity sensor. The aim was to maintain optimal indoor humidity levels through smart automation, while evaluating the differences in performance, cost, and user experience between the two models.

A. Key Findings

1) The Ultrasonic Humidifier provided silent, steady, and energy-efficient humidification, making it ideal for residential and office environments. However, it required distilled water and periodic maintenance of the ultrasonic plate.
2) The Mechanical Humidifier was more cost-effective, used easily available materials, and showed a faster humidification rate, but it generated more noise and involved a more complex assembly.
3) The NodeMCU-based control logic proved effective in both models, offering real-time monitoring and automation based on humidity levels, thus eliminating the need for manual intervention.

B. Final Verdict

Both humidifier models have their own advantages and are suitable for different use-case scenarios. The Ultrasonic model is best suited for users looking for convenience, aesthetics, and quiet operation.

The Mechanical model is a great DIY, budget-friendly alternative, ideal for learning purposes or for environments where noise is not a constraint.

This project also showcases the integration of IoT and mechatronics principles for improving indoor comfort through automated control systems. It opens up further scope for developing advanced versions with features like mobile app control, real-time data logging, and adaptive environmental response.

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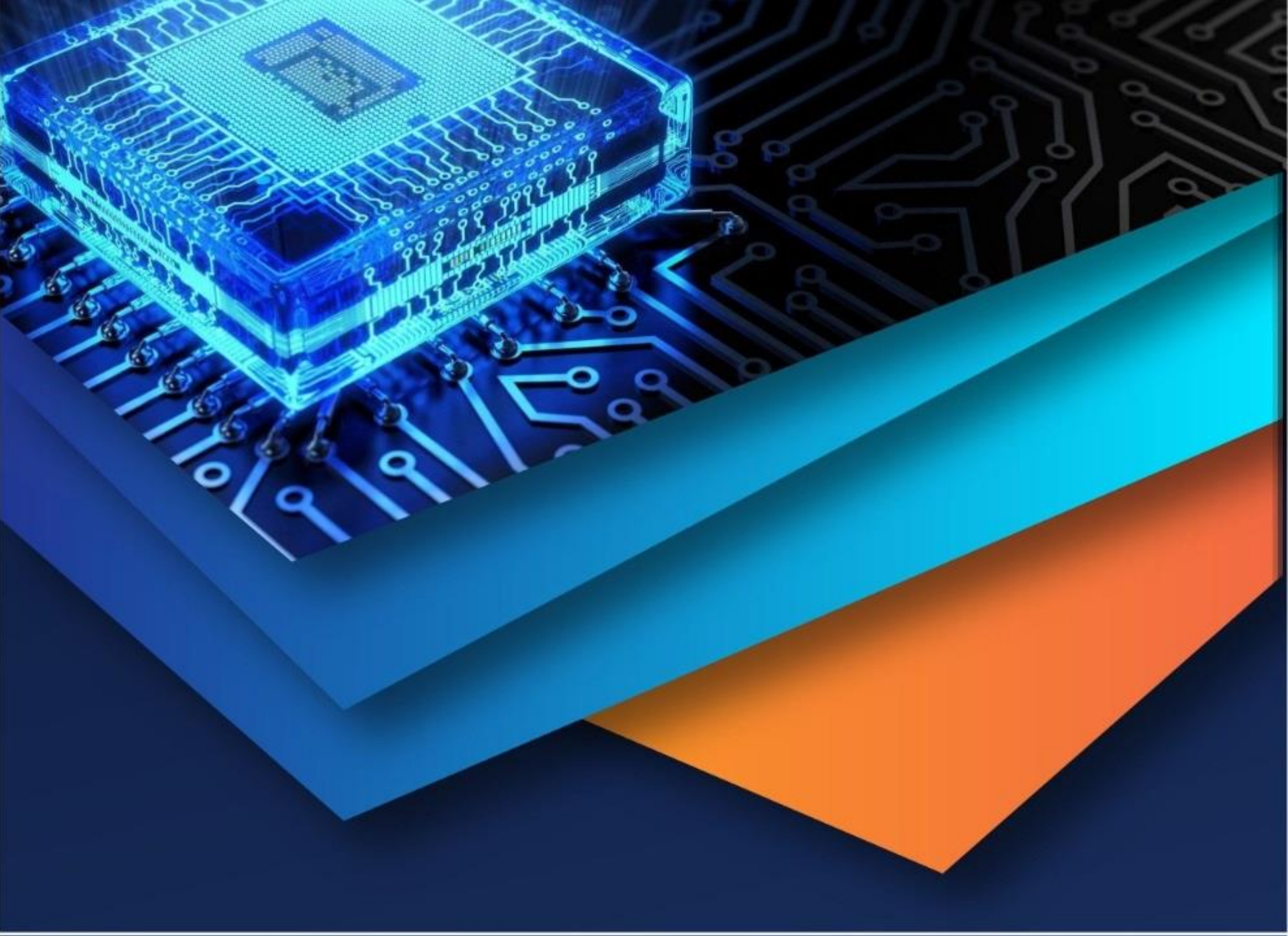

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