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ROAD COOLING USING MIST SYSTEM

[1]Prof. S. M. Borate, [2]A.S.Jadhav, [3]S.S.Tiwari, [4]A.S.Kadam

[1]Assistant Professor, E & TC Engineering Department, S. B. Patil College of Engineering, Indapur (MH), India,

[2 3 4] UG Student, E & TC Engineering Department, S. B. Patil College of Engineering, Indapur (MH), India

Email: borate.shraddha@gmail.com, jadhavankita603@gmail.com, tiwarisiddhi408@gmail.com, kajinkya136@gmail.com

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Abstract

The Automatic Outdoor Cooling System is designed to provide a smart and efficient method for reducing ambient temperature in outdoor environments using a mist cooling mechanism. The system operates automatically by sensing environmental conditions such as temperature and humidity, and activates the pressure pump and foggers accordingly to spray a fine mist, which cools the surrounding air through evaporation.The system is powered by a power source that supplies energy to all components, including the microcontroller, sensors, and pump. The temperature and humidity sensor continuously monitors the weather conditions and sends real-time data to the microcontroller, which serves as the central control unit. Based on the sensed data, the microcontroller processes the inputs and decides whether the cooling mechanism needs to be turned ON or OFF.A 16×2 LCD display is interfaced with the microcontroller to display system information such as current temperature, humidity, and operating status. Additionally, a manual control panel is provided, allowing users to manually operate or override the automatic function when required.To enhance user convenience, the system is also equipped with a wireless communication module that connects to a mobile dashboard. Through this dashboard, users can remotely monitor environmental data and control the system via a web-based or mobile interface, mirroring the LCD display and control panel functions.This system ensures efficient water utilization, energy savings, and improved comfort in outdoor areas such as gardens, patios, greenhouses, and open-air spaces. By automating the cooling process based on real-time conditions, it eliminates the need for constant manual intervention, offering a reliable and eco-friendly solution for outdoor temperature regulation.

Introduction

In cities, roads and buildings become very hot during the day because they absorb heat from the sun. This makes the surrounding area hotter than villages, a problem called the Urban Heat Island effect. Hot roads cause discomfort to people, damage the road surface faster, and make the environment unhealthy.

To reduce this problem, a road cooling system using mist can be used. In this system, very small water droplets (mist) are sprayed on the road through special nozzles. When the mist touches the hot road or hot air, it quickly evaporates and takes away heat. This process lowers the temperature of the road and makes the surroundings cooler.

In short, the road cooling mist system is a smart, eco-friendly, and effective way to cool roads, reduce heat, and improve comfort in cities.

In recent years,warming of urban areas in summer has become a problem known as the“urban heat island effect”.One means of mitigating this effect is to spray micro water droplets.This method suppresses the temperature rise in urban areas by using the heat of water evaporation,while using only small amounts of water and energy.If water Mist is sprayed in a semi-outdoor area, for example, under a canopy, it could potentially improve conditions on hot days. Through a field experiment(Yamada et al. 2006),we have verified the effectiveness of this method and confirmed a temperature reduction under a canopy of up to about 3 c.Such water mist systems are expected to be used increasingly in the future,yet there is little reference data concerning the design or control of such system.Therefore,this study proposed a method for designing and predicting the performance of water mist systems.In this study, we conducted a numerical fluid analysis and then examined the particle size distribution and the cooling effect of water mist.

Literature Survey

This study analyzed the impact of fog cooling on temperature reduction and optimized its layout for Daegu Metropolitan City. Using indoor experiments and CFD analysis based on the Finite Volume Method (FVM), the system’s cooling performance was verified with high accuracy ($R^2 \geq 0.8$). Results showed that arranging fog units vertically to the wind direction reduced temperature by up to 3.02°C.

Closer spacing (≤5 m) improved efficiency compared to wider spacing (≥10 m). The findings provide useful guidelines for urban planners to estimate temperature reduction and humidity increase through fog cooling systems[3].

This study investigated the effectiveness of a spray cooling system in reducing heat release from air-conditioning units, which contribute to urban heat island effects. Experiments on identical buildings showed that installing sprays at the inlet, outlet, and both locations reduced outlet air temperatures by 4.0°C, 6.3°C, and 7.9°C, respectively. Corresponding energy savings were 18.8%, 13.9%, and 37.3%. The best results occurred when sprays were placed at both the inlet and outlet, improving heat dissipation and lowering ambient air temperature through enhanced evaporation[4]. This study examined the impact of adverse weather, particularly fog, on road traffic safety and driver behavior. Various mechanisms and speed responses were analyzed under changing fog conditions to assess visibility and reaction. Recent research proposed algorithms to enhance visibility using artificial and camera- generated fog images. The study emphasizes the need for effective fog detection and warning systems based on speed and headway. It also highlights the importance of analyzing deicing material effects on transport safety[5].

This study presents a reliable and secure service delivery approach for smart cities using fog and mist computing integrated with an intrusion detection system. The proposed method enhances the availability, dependability, and security of IoT-based applications while reducing end-to-end delay. Simulation results showed a 40.3% delay reduction in dense areas and 60.6% in moderately dense areas. The system also achieved high detection accuracy with low false negatives, improving overall network performance and efficiency in smart city environments[2].

This study reviewed existing methods for estimating visibility distance under foggy conditions and proposed a new hybrid approach combining deep learning for feature extraction with an SVM classifier. Experimental results showed that this method outperformed earlier ANN-based approaches in accuracy and reliability. The proposed system supports next-generation cooperative situational awareness and collision avoidance technologies, contributing to safer driving in foggy weather conditions[6].

Proposed Methodology

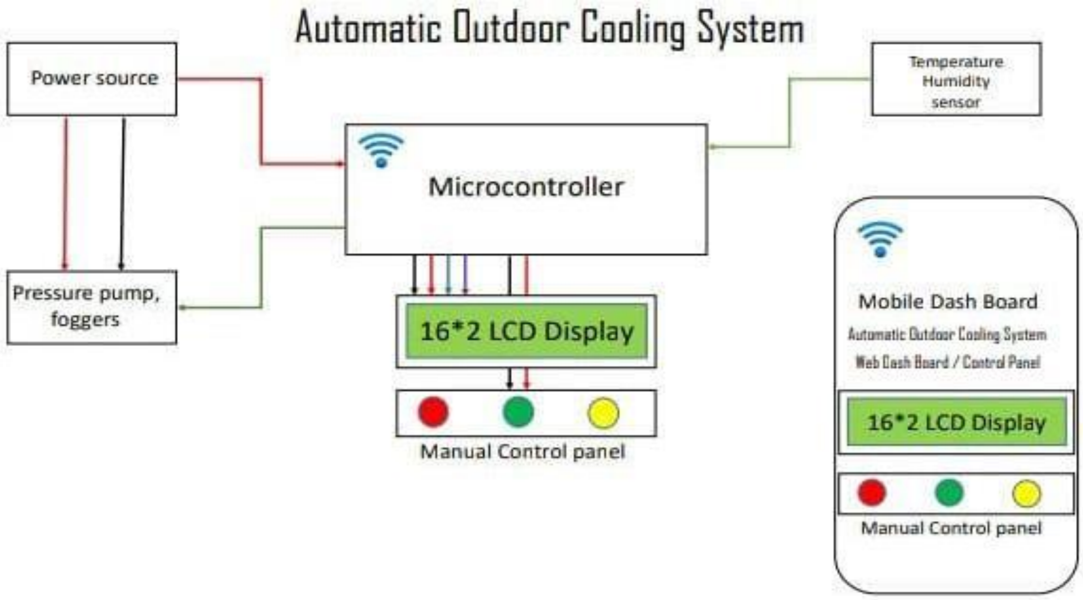

Fig.1.Block Diagram of road cooling using mist system

The workflow of the block diagram represents the step-by-step operation of the proposed system.

1. **System Overview**

The proposed system is a Cooling Mist System that utilizes an STM32 microcontroller for automation and control. The main objective is to reduce temperature and maintain humidity using a misting mechanism.

- Power Supply: Provides regulated power to the entire system, including the STM32 MCU, sensors, relay module, and display unit.
- Humidity Sensor: Continuously monitors the surrounding humidity and sends real-time data to the STM32 microcontroller.
- STM32 MCU: Acts as the central controller, processes sensor inputs, makes decisions, and controls other modules.
- LCD Display: Displays system parameters such as current humidity, system status, and misting activity.
- Relay Module: Functions as a switching interface to control the water pump and sprinkler system based on MCU commands.
- Sprinkler & Water Pump: Responsible for pumping water to the nozzle for mist generation.
- Water Filter & Nozzle: Ensures clean water mist is sprayed efficiently to cool the environment and prevent nozzle clogging.
- This system ensures efficient cooling by activating the mist only when needed, thereby saving water and power.

2. **Initialization Stage**
   - Power supply activates and initializes the STM32 MCU.
   - LCD display shows system start- up and standby status.

3. **Sensing Stage**
   - The humidity sensor measures environmental humidity and sends analog/digital signals to the STM32 MCU.

4. Processing Stage
   - The STM32 compares the measured humidity with the pre- set threshold values.
   - If humidity is below the set level (indicating hot/dry conditions), the system triggers cooling mist.

5. **Control Stage**
   - The MCU sends a signal to the relay module.
   - The relay switches ON the water pump and activates the sprinkler system.

6. **Misting Stage**
   - Water passes through the filter to remove impurities.
   - The nozzle sprays fine mist droplets into the atmosphere, lowering ambient

temperature and increasing humidity.

7. **Monitoring Stage**
   - The LCD continuously displays humidity values and system status (ON/OFF).
   - Once the humidity reaches the desired level, the MCU turns OFF the pump via the relay.

8. **Feedback & Optimization**
   - The system operates in a closed- loop manner, maintaining humidity and temperature within the desired range.
   - Water usage and power consumption are minimized due to automatic control.
   - Used in orchards, vineyards, and open-field farming for better growth and yield.

9. **Greenhouses**
   - Provides controlled humidity and temperature inside greenhouses, ensuring optimal plant growth.
   - Prevents leaf burn and dehydration in delicate crops.
   - Reduces dependency on heavy air-conditioning or irrigation, making it energy- and water-efficient.

10. **Industrial Cooling**
    - Applied in factories, warehouses, and workshops to maintain a safe working environment.
    - Helps control dust particles, odor, and excess heat in industries such as textile, steel, and food processing.
    - Prevents machinery from
    - Overheating and increases worker comfort.

11. **Residential Use**
    - Used in balconies, patios, terraces, and gardens for personal comfort during summer.
    - Provides a cost-effective alternative to air conditioning in open spaces.
    - Compact mist fans or portable misting kits are popular for home outdoor relaxation and small gatherings.

Applications

1. **Outdoor Cooling**
   - Cooling mist systems are widely used in open areas such as parks, stadiums, gardens, and outdoor restaurants.
   - They help lower ambient temperature by 5–10°C through evaporation.
   - Useful in public gatherings, events, and outdoor recreational spaces to improve comfort in hot climates.

2. **Agriculture**
   - Helps in maintaining soil moisture levels and preventing crop wilting during high heat.
   - Reduces heat stress on plants and livestock, improving overall productivity.

Conclusion

A mist cooling system is a practical, effective, and energy-efficient solution for reducing temperature and enhancing comfort in various applications, including outdoor spaces, industrial processes, and agriculture, while also offering benefits like dust suppression and increased humidity.

The system's effectiveness relies on proper design, installation, and maintenance, as well as consideration of the local climate, particularly humidity levels.

Overall, mist cooling provides a valuable tool for improving living and working environments, boosting productivity, and promoting sustainability

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