Real Time Tire Temperature Monitoring and Control System with Integrated Water Spray

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Abstract

Road safety remains a critical concern, particularly in regions facing extreme temperatures, where tyre bursts contribute significantly to accidents. Over 110 such incidents were reported in the past year, emphasizing the urgency of mitigation strategies. This project introduces an advanced cooling system designed to prevent tyre overheating in high-temperature environments. Utilizing an Arduino microcontroller, the system activates a water spraying mechanism through strategically positioned nozzles, ensuring timely cooling and improved vehicle stability. Beyond preventing tyre bursts, this innovation enhances traction, road safety, and reduces tyre wear, leading to extended lifespan and lower maintenance costs. By integrating smart safety features, this solution addresses road hazards comprehensively, offering a proactive approach to vehicle safety in extreme climatic conditions.

Keywords: Arduino, Healthcare, Hospital Beds, Patient Comfort, Hygiene, Mechanical Design

1. Introduction

The escalating temperatures in regions like the UAE have led to a surge in tyre bursts, resulting in approximately 110 accidents in the past year. This pressing issue highlights the immediate necessity to address the detrimental effects of high temperatures on tyre integrity, significantly impacting road safety. In response, this project proposes an innovative solution a smart cooling system utilizing an Electronic Control Unit (ECU) to counteract the adverse impact of heat on tyres. The ECU, as the central control mechanism, continuously measure ambient temperatures, triggering a precise water spraying mechanism to regulate tyre temperatures and mitigate the risk of bursts. This research aims to deliver an automated and efficient solution to combat safety hazards induced by high temperatures on roads, ultimately striving to elevate road safety standards and curtail accidents associated with tyre bursts. The proposed system introduces a crucial and practical approach to address climate induced safety challenges prevalent in regions characterized by extreme temperatures, emphasizing the vital need for proactive measures to ensure safer roadways

2. Literature Review

Several studies have focused on hospital bed innovations to enhance patient comfort.

1. **Dipak Ranjan Jana, Sumalatha Emmela, Ch.Monika, D.Archana, K.Thulasi Priya, K.Yamini August 2020.** “Detection and Prevention of Wheel Unbalancing and Tire Burst in Moving Vehicles” this international journal discusses the atal accidents are increasing day-by-day due to the failure of wheel bearing, unbalancing of wheel and tyre bursting due to increase in the temperature

2. **Genovese, Andrea, and Francesco Timpone.** “Tyre mechanics and thermal effects on tyre behaviour.” In Vehicle Dynamics and Control, 1-28. Springer, Cham, 2020. This article discusses the effects of temperature on tyre behaviour and the importance of understanding tyre mechanics. The authors present a mathematical model that can be usedto predict the behaviour of tyres under different conditions.

3. **Ejsmont, Jerzy, Stanislaw Taryma, Grzegorz Ronowski, and Beata Swieczko-Zurek.** “Influence of temperature on the tyre rolling resistance.” International Journal of Automotive Technology 19, no. 1 (2018): 65-72. This article investigates the effect of temperature on the rolling resistance of tyres. The authors conducted experiments to measure the rolling resistance of tyres at different temperatures and found that the rolling resistance decreases as the temperature increases.

4. **Jana, Dipak Ranjan, Sumalatha Emmela, Ch.Monika, D.Archana, K. Thulasi Priya,and K. Yamini.** “Detection and prevention of wheel unbalancing and tire burst in movingvehicles.” International Journal of Engineering Research and Technology 5, no. 4 (2016): 1-5. This article discusses the detection and prevention of wheel unbalancing and tyre

burst in moving vehicles. The authors propose a system that can detect unbalanced wheelsand prevent tyre bursts by monitoring the pressure and temperature of the tyres.

5. **Bijina, V., P. J. Jandas, Sherin Joseph, J. Gopu, K. Abhitha, and Honey John.** "Recent trends in industrial and academic developments of green tyre technology." Journal of Cleaner Production 237 (2019): 117794. This article discusses recent trends in industrial and academic developments of green tyre technology. The authors provide an overview of the different types of green tyres and their benefits, such as reduced fuel consumption and lower emissions.

6. **Velmurugan, K., P. Venkumar, and R. Sudhakarapandian.** "Performance analysis of tyre manufacturing system in the SMEs using RAMD approach." International Journal of Industrial and Systems Engineering 33, no. 2 (2019): 241-259. This article presents a performance analysis of tyre manufacturing systems in small and medium-sized enterprises (SMEs) using the reliability, availability, maintainability, and dependability (RAMD) approach. The authors propose a framework for evaluating the performance of tyre manufacturing systems in SMEs.

7. **Boccaletti, Chiara, Daniele Landi, and Luca Pugi.** "A comprehensive study on technologies of tyre monitoring systems and possible energy solutions." Energies 10, no.6 (2017): 776. This article provides a comprehensive study of technologies used in tyre monitoring systems and possible energy solutions. The authors discuss the different types of tyre monitoring systems and their advantages and disadvantages. They also propose possible energy solutions for these systems.

8. **Chen, Yu-Cheng, and Chih-Hung Chen.** "Tire pressure monitoring system using SoC and low power design." In 2016 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW), 1-2. IEEE, 2016. This article proposes a tire pressure monitoring system using system-on-chip (SoC) and low power design. The authors present a design that can monitor the pressure of tyres in real-time and alert the driver if the pressure is too low. The system is designed to be low power and can be integrated into existing vehicle

3. Methodology

The methodology for the project report involves a systematic approach encompassing various stages. Initially, the installation of the Infrared Temperature Sensor is strategically executed to ensure precise monitoring of tire temperature, with a clear line of sight to the tire's surface. Subsequently, the Arduino-based ECU is set up, connecting the sensor and coding the Arduino to process temperature data, thereby establishing a predetermined optimum temperature threshold for tire cooling. The pump activation system is then implemented, connecting the pump to the Arduino-based ECU and programming it to activate when the sensed tire temperature surpasses the predefined threshold. Following this, the water supply system is established by connecting the pump to a dedicated water tank using tubing and connectors to ensure a consistent and reliable water flow. Nozzles are strategically integrated around the tire to facilitate efficient cooling coverage, connected to the pump's outlet via tubing for uniform water distribution. The cooling process is initiated and tested to ensure the pump activates at the predetermined temperature threshold, with observation of the mist released by the nozzles to confirm effective evaporative cooling on the tire's surface. An automatic shutdown mechanism is then developed by coding the Arduino to continuously monitor tire temperature and instruct the pump to switch off automatically upon reaching the optimum level. Power source integration follows, ensuring the entire system is connected to a reliable power source with proper grounding and safety measures. Environmental considerations are addressed by confirming the system's eco-friendliness due to its water-based coolant, with thorough calibration and testing conducted under various conditions to validate accurate temperature thresholds and system reliability. Finally, performance evaluation is undertaken to assess the system's efficacy in managing tire temperatures and its impact on overall vehicle performance and safety.

Experiment (sample 1)

Before cooling

Initial temperature =33.5°C

Initial pressure =28psi

Heating temp up to= 44 °C

Final pressure = 28.7psi≈29psi

After Cooling

When temperature system is on and set to threshold 33.5 °C

Then the temperature change from 44°C to 33.5°C

Initial temperature 44 °C

Initial pressure =28.7psi≈29psi

Time taken for change in temperature (10°C)=30sec

Final pressure =28.2psi≈28psi

Milliliter of water consumed =15 ml

BEFORE COOLING

initial temperature	Initial pressure	Final temperature	Final pressure
°C	psi	°C	psi
33.5	28	44	28.7
44	28.7	54	29.9
54	29.9	64	30.8
64	30.8	74	31.8

AFTER COOLING

initial temperature	Initial pressure	Final temperature (Threshold temperature)	Final pressure	Time taken for cooling
°C	psi	°C	psi	s
44	28.7	33.5	28.1	30
54	29.9	44	28.7	29
64	30.8	54	30	31
74	31.8	64	30.8	32

Mass flow rate =(can be changed by using different pump)

In average Δ10°C there is a change of .9psi≈1psi proved by experiment.

$\Delta 10°C = 1\text{psi}$

3.1 Drawings And Design

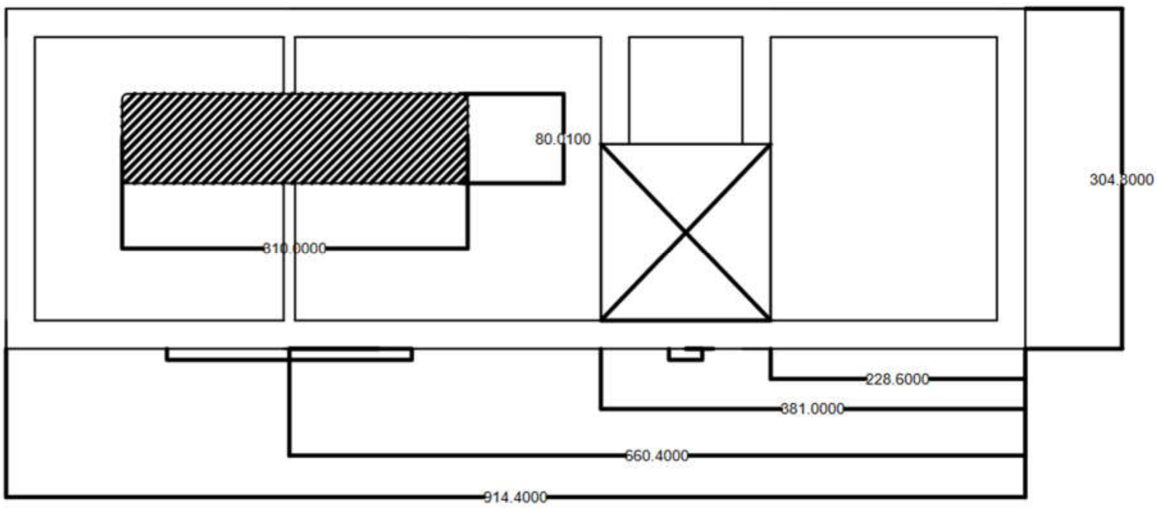

Fig 1 Top view of experimental setup

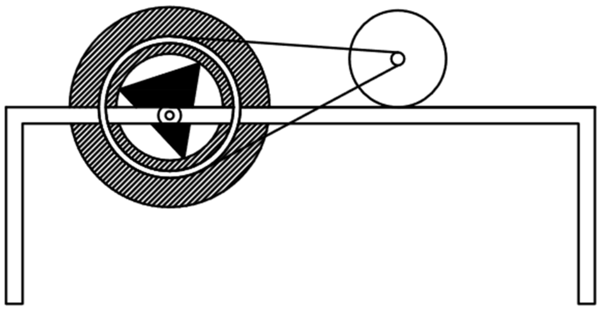

Fig 2 side view of experimental setup

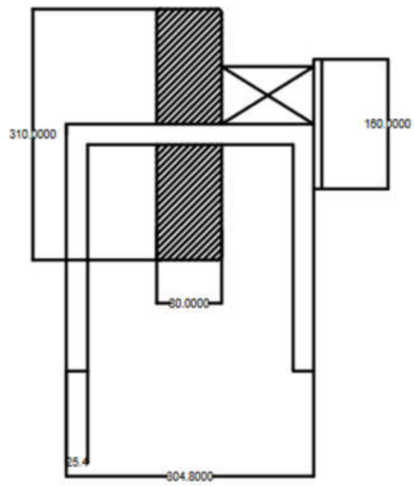

Fig 3 front view of experimental setup

Fig 4 Proposed Model

3.2 COMPONENTS

The main components of the experimental study on a tyre temperature control system for car tyres are listed below: -

3.2.1 ESP32 MICROCONTROLLER

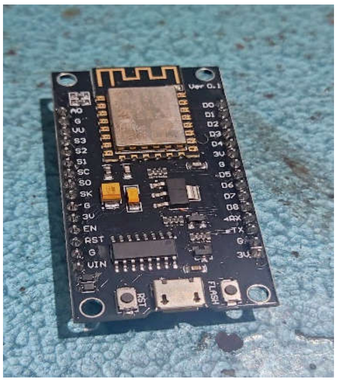

Fig 3.4.1Microcontroller

- Role: Main control unit.
- Function: Reads temperature data, controls motor pump, activates laser, interfaces with OLED display, hosts web server.
- Features: Dual-core processor, Wi-Fi and Bluetooth capabilities, numerous GPIO pins.

3.2.2 LASER MODULE

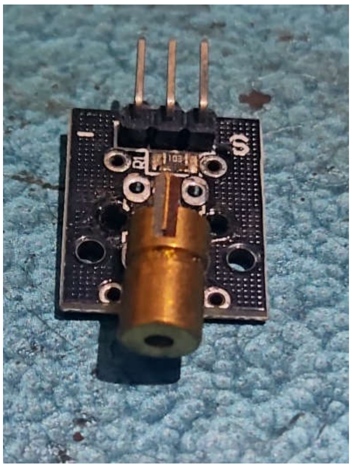

Fig 3.4.2 Laser Module

- Aligns and focuses IR temperature sensor.
- Function: Aids in accurate temperature measurements.
- Role Operation: Emit focused beam of laser light.

3.2.3 IR TEMPERATURE SENSOR (MLX90614)

Fig 3.4.3 IR Temperature Sensor

- Role: Measures temperature without contact.
- Function: Detects infrared radiation emitted by objects.
- Features: Non-contact, accurate temperature readings

3.2.4 12V RELAY MODULE

Fig 3.4.4 Relay Module

- Role: Controls operation of motor pump.
- Function: Acts as electromechanical switch.
- Control: Responds to electrical signals from ESP32.

3.2.5 12V POWER SUPPLY

Fig 3.4.5 12v Power Supply

- Role: Provides power to motor pump and other components.
- Function: Converts AC mains voltage to stable DC voltage.

3.2.6 OLED DISPLAY

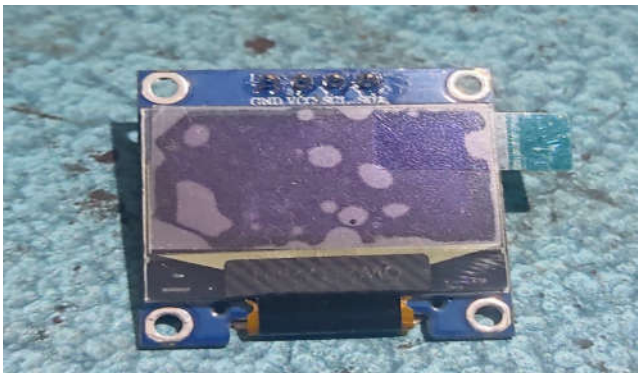

Fig 3.4.6 OLED Display

- Role: Provides visual feedback.
- Function: Displays temperature readings, system status.
- Advantages: High contrast, wide viewing angles, low power consumption.

3.2.7 5V VOLTAGE REGULATOR

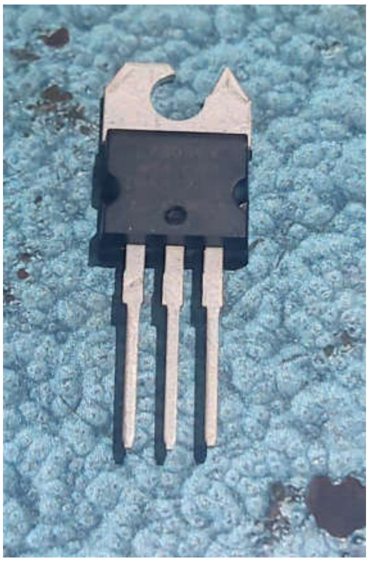

Fig 3.4.7 5v Voltage Regulator

- It’s an electronic component that takes in a higher voltage input and outputs a stable 5V voltage. It's commonly used in electronic circuits to power devices that require a consistent 5V supply, such as microcontrollers, sensors, and logic circuits

3.2.8 SUBMERSIBLE MOTOR

Fig 3.4.8 Submersible motor

- Role: A 5V submersible motor provides mechanical power underwater, commonly driving pumps or propellers.
- Functions: It rotates to generate motion and is designed for efficiency, durability, and compatibility with 5V electrical systems.

4. Working Process

We developed a tire cooling system using an Arduino microcontroller, an IR temperature sensor, and a water-cooling mechanism. The system aims to monitor and maintain optimal tire temperatures to ensure safety and performance. An IR temperature sensor, strategically positioned near the tire, measures the tire's surface temperature in real-time. The Arduino receives this data and processes it to determine if the temperature exceeds a predefined threshold. If the tire temperature is too high, the system activates a water-cooling mechanism. This mechanism can involve spraying or misting water onto the tire to reduce its temperature efficiently. The cooling system operates automatically, ensuring the tires remain within a safe operating range, which enhances both vehicle performance and longevity. This setup is efficient and adaptable, making it suitable for various types of vehicles and driving conditions.

The working process for the project report entails a systematic approach encompassing various stages to develop and implement an automatic tire cooling system. Initially, the installation of the Infrared Temperature Sensor is meticulously executed to ensure precise monitoring of tire temperature, positioning it strategically for an unobstructed view of the tire's surface. Following this, the setup of the Arduino-based Electronic Control Unit (ECU) is undertaken, connecting the sensor and coding the Arduino to process temperature data. This stage establishes a predetermined optimal temperature threshold for tire cooling. Subsequently, the activation mechanism for the cooling system is implemented, linking the pump to the Arduino-based ECU and programming it to activate when the sensed tire temperature surpasses the predefined threshold. With the foundation set, the water supply system is established by connecting the pump to a dedicated water tank using tubing and connectors to ensure consistent water flow.

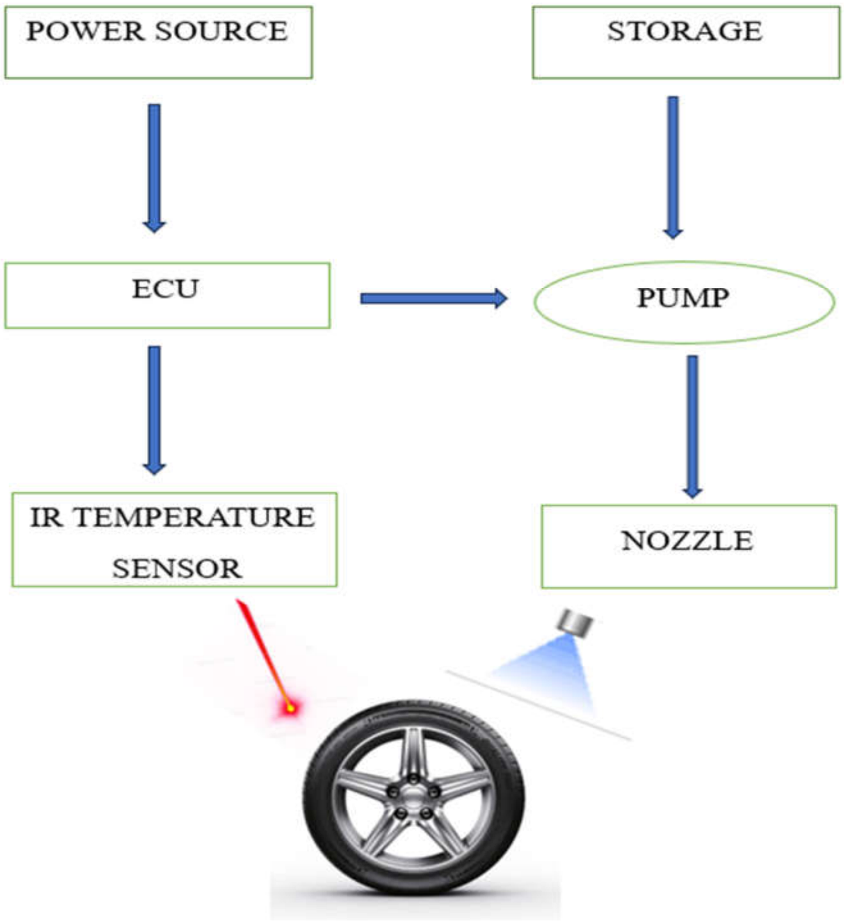

Fig 3.5.1 schematic diagram

Nozzles are strategically integrated around the tire to facilitate efficient cooling coverage, connected to the pump's outlet via tubing for uniform water distribution. The cooling process is initiated and tested, ensuring the pump activates at the predetermined temperature threshold and observing the mist released by the nozzles to confirm effective evaporative cooling on the tire's surface. An automatic shutdown mechanism is developed, enabling the Arduino to continuously monitor tire temperature and instruct the pump to switch off automatically upon reaching the optimum level. Integration with a reliable power source follows, ensuring proper grounding and safety measures. Environmental considerations are addressed by affirming the system's eco-friendliness due to its water-based coolant, with thorough calibration and testing conducted under various conditions to validate accurate temperature thresholds and system reliability. Finally, performance evaluation is undertaken to assess the system's efficacy in managing tire temperatures and its impact on overall vehicle performance and safety.

5. Results

The experimental setup implemented in this project has yielded compelling results regarding the relationship between temperature variations and tire pressure. Analysis of the data collected demonstrates a consistent trend: for every 10-degree Celsius decrease in temperature, there is an associated decrease of approximately 1 psi in tire pressure. Our methodology, meticulously executed in various stages, ensured accurate and reliable outcomes. Beginning with the installation of the Infrared Temperature Sensor for precise temperature monitoring, we proceeded to configure the Arduino-based ECU to establish optimal temperature thresholds for tire cooling. The integration of the pump activation system, coupled with strategic nozzle placement, facilitated efficient cooling across the tire's surface. Observation of mist release from the nozzles provided tangible evidence of effective evaporative cooling. Moreover, the implementation of an automatic shutdown mechanism enhanced operational efficiency and safety by deactivating the pump upon reaching the optimum temperature level. Attention to detail extended to power source integration, guaranteeing uninterrupted system functionality while prioritizing safety protocols. Environmental considerations were addressed through the use of a water-based coolant, aligning with sustainability principles. Thorough calibration and testing under diverse conditions validated the system's performance and reliability. The outcomes of these tests offer valuable insights into the efficacy of our tire temperature management system in maintaining optimal tire pressure, thereby ensuring vehicle safety and performance. In conclusion, the results obtained from our experimental setup underscore the significance of temperature management in preserving tire pressure and, consequently, vehicle operational integrity. These findings pave the way for further advancements in tire temperature monitoring and cooling systems, contributing to enhanced vehicle safety and performance in diverse environmental conditions.

6. Conclusion

In conclusion, the tire temperature sensing and cooling system present a comprehensive solution aimed at enhancing vehicle safety, performance, and environmental sustainability. By integrating an Infrared Temperature Sensor with an Arduino-based ECU, this system enables continuous monitoring and precise control of tire temperatures. The advantages of this system are manifold. It ensures enhanced safety by preventing tire overheating, thereby reducing the risk of tire blowouts and potential accidents. Simultaneously, it optimizes vehicle performance by maintaining tire temperatures within an ideal range, leading to improved traction, handling, and overall efficiency. The system's automated nature, coupled with its real-time monitoring capability, allows for prompt responses to temperature variations without the need for constant human intervention. Moreover, its eco-friendly approach, using water as a coolant, aligns with environmental considerations, promoting sustainability compared to traditional methods. Notably, the system's adaptability, reliable power source, and safety shutdown mechanism further reinforce its effectiveness and reliability. Thorough testing, calibration, and the potential for future enhancements underscore a commitment to continuous improvement and innovation. Ultimately, this tyre temperature sensing and cooling system not only contribute to a safer and more efficient driving experience but also exhibit a forward-looking approach towards technological advancements in vehicle systems, demonstrating a harmonious blend of safety, performance, and environmental consciousness.

7. Acknowledgment

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8. References

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