International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Investigation of Air-Cooling Effectiveness on a Thermal Behaviour of a Cylindrical Shaped Lithium-Ion Battery Used for Two-Wheeler Electric Vehicles

[1]**Mr. B. PRASAD** (MTech Assistant professor)

[2] **ABDUL REHMAN,** [3] **GANDREDDI BHARATH,** [4] **BOYA VENKATA TEJA,**

[5] **PEETALA GEETHIK,**[6] **CHUKKA BALAJI**

Department of Mechanical Engineering

Wellfare Institute of Science Technology and Management, Pinagadi, Visakhapatnam

---***---

Abstract - Internal combustion engines that use conventional fuels are significant contributors to carbon emissions, which result in environmental degradation. Electric Vehicles (EVs) are a more efficient and cost-effective solution to this issue, especially if the battery charging is done using renewable energy conversion-based routes instead of conventional-based routes. The use of renewable energy to power EVs can reduce carbon emissions and air pollution. EVs use lithium-ion batteries for energy storage, but these batteries face many challenges. The low efficiency at extreme temperatures is one of the significant challenges that limit the performance and range of EVs. Additionally, the decreased electrode life at high temperatures and safety concerns related to thermal runaway are other challenges. These challenges directly affect the vehicle's performance, reliability, cost, and safety. The batteries can be fatally destroyed due to overheating caused by electrons' movements during the charging and discharging process in elevated temperatures. Therefore, an effective battery thermal management system (BTMS) is critical to the success of electric vehicles in the long term.

Key Words:

- Electric Mobility
- Two-Wheeler Electric Vehicles (EVs)
- Lithium-Ion Battery
- Thermal Management
- Air-Cooling System
- Heat Generation
- Temperature Distribution
- Cylindrical Battery Cells
- Battery Performance
- Energy Storage Systems
- Internal Resistance

1.INTRODUCTION

The rapid advancement of electric mobility has led to a growing demand for efficient energy storage systems, especially in developing countries. Two-wheeler electric vehicles have become a popular choice for urban transportation due to their affordability and energy efficiency. Lithium-ion batteries serve as the core component of these vehicles because of their high energy density and long-life cycle. However, these batteries are highly sensitive to temperature variations, which significantly affect their performance and safety. During operation, heat is generated due to internal resistance and electrochemical reactions, especially under high load conditions.

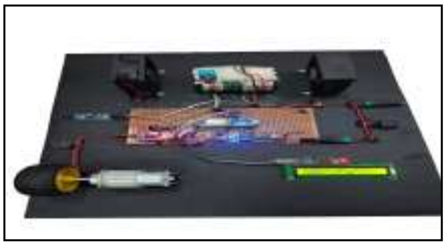


Fig:1

If this heat is not properly managed, it can lead to reduced efficiency and potential safety risks such as thermal runaway. Cylindrical lithium-ion cells are commonly used due to their structural stability and cost-effectiveness, but their compact arrangement creates thermal challenges. Effective thermal management is therefore essential to maintain optimal battery performance. Among various techniques, air-cooling is widely preferred due to its simplicity and low cost. It works by dissipating heat through airflow around the battery cells. The use of systems like Arduino Uno further enhances monitoring and control, making the cooling process more efficient and reliable.

SYSTEM DESIGN CONCEPT

The system is designed to analyze and improve the thermal behavior of a cylindrical lithium-ion battery using an air-cooling mechanism. It combines mechanical and electronic components to monitor and regulate battery temperature during operation. Heat generated due to internal resistance and electrochemical reactions is removed using DC fans that provide forced airflow over the battery surface. A temperature sensor continuously measures battery temperature and sends data to the Arduino Uno for processing and control. The system automatically activates cooling and displays real-time temperature on an LCD, ensuring safe and efficient battery performance.

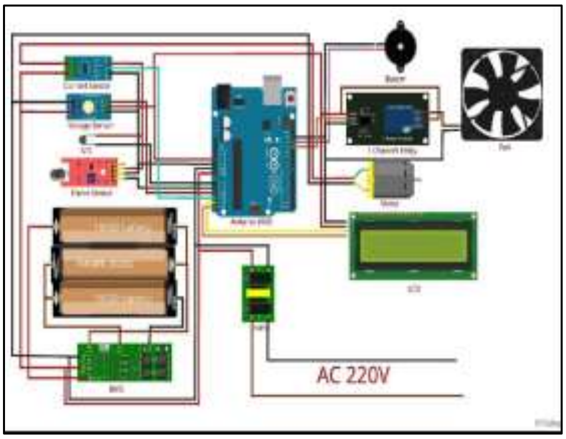


Fig.2: Layout of Experimental Setup for Investigating Air-Cooling Effectiveness on 18650 Lithium-Ion Battery

LITERATURE REVIEW

[1] Gachot et al. (2012)
Investigated the thermal behavior of electrochemical interfaces, explaining that heat generation originates from internal chemical reactions within the battery.

[2] Liu et al. (2014)
Analyzed thermal behavior in battery stacks and observed that inadequate airflow between cells leads to heat accumulation and hotspot formation.

[3] Wang et al. (2014)
Examined the effects of cell arrangement and air-cooling strategies, concluding that airflow distribution plays a crucial role in maintaining temperature uniformity.

[4] Wang et al. (2015)
Experimentally analyzed battery cooling and heating systems, concluding that although liquid cooling is more efficient, air cooling remains a simpler and cost-effective solution for practical applications.

[5] Liu et al. (2018)
Studied the optimization of charging patterns and found that charging rates significantly influence heat generation.

[6] Mohammed et al. (2019)
Investigated a dual-purpose cooling plate designed to manage thermal behavior during both normal operation and thermal runaway conditions, emphasizing uniform temperature distribution.

[7] Xu et al. (2019)
Conducted a numerical study on water cooling systems for $LiFePO_4$ batteries, showing superior heat dissipation compared to air cooling.

COMPONENTS REQUIREMENT

BASE BOARD

The base board is a 1 × 1.5 feet rigid frame made of plywood or mild steel, providing structural support and stability for all components. The lithium-ion battery is centrally placed to ensure uniform airflow and effective cooling. A DC fan is mounted at one end to direct air across the battery, enabling efficient heat dissipation through forced convection.

Cylindrical Lithium-Ion Battery (18650 Cell)

The cylindrical 18650 lithium-ion battery is the primary energy source and the main subject of thermal investigation in this project. Each cell has a nominal voltage of 3.7 V and is widely used in electric vehicles due to its high energy density, long cycle life, and compact cylindrical structure. The battery consists of a graphite anode, lithium metal oxide cathode, electrolyte, and separator enclosed in a metallic cylindrical casing

Fig.3: Cylindrical Lithium-Ion Battery (18650 Cell)

Temperature Sensor (NTC Thermistor)

An NTC thermistor is a temperature sensor whose resistance decreases as temperature increases, offering high sensitivity and fast response. In this project, a 10kΩ NTC thermistor is attached to the battery surface and used in a voltage divider circuit to measure temperature via a microcontroller.

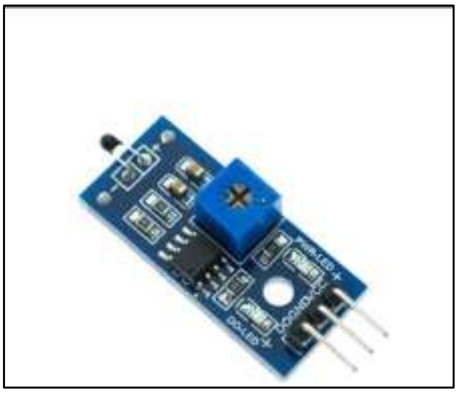


Fig.4: Model of Temperature Sensor

It helps maintain battery safety by detecting temperature rise and triggering cooling when it exceeds a set limit.

Connection of Temperature Sensor (NTC Thermistor)

Arduino-based temperature monitoring system using a sensor and LCD display.

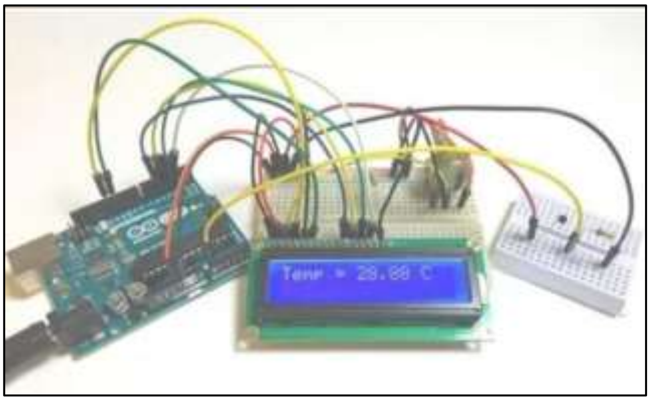


Fig.5: Connection of Temperature Sensor (NTC Thermistor)

The temperature sensor measures ambient conditions and sends the data to the Arduino board for processing. The measured temperature is displayed in real time on the LCD screen.

Microcontroller Unit:

The microcontroller unit is the central control component of the prototype, responsible for monitoring, processing, and controlling the overall system operation.

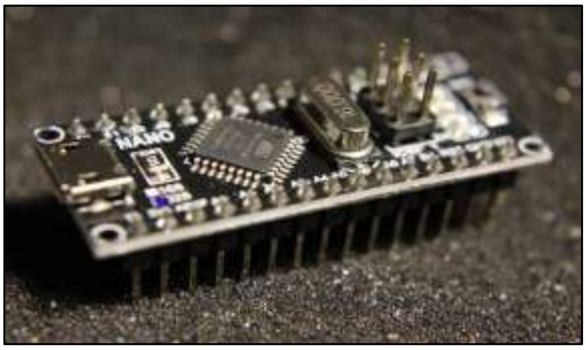


Fig.6: Microcontroller Unit

It continuously receives input signals from temperature (NTC thermistor), voltage, and current sensors and converts them into digital values using the ADC.Based on programmed logic, it compares the measured temperature with a predefined threshold to ensure safe battery operation.

When the temperature exceeds the limit, it activates the relay module to switch ON the cooling fan and maintains thermal balance.

It also updates real-time data on the LCD display and triggers alerts, making it the brain of the entire system.

12V Cooling Fan

The **12V DC cooling fan** is used in the prototype to provide forced air cooling for the cylindrical lithium-ion battery pack. It operates on a 12-volt direct current

Fig.7: Microcontroller Unit

supply and is ed near the battery cells in such a way that the airflow is directed uniformly across their surfaces. During battery charging and discharging, heat is generated due to internal resistance (I^2R losses) and electrochemical reactions

Parameter	Specification
Type	DC Brushless Fan
Rated Voltage	12 V
Current Rating	0.15–0.30 A
Cooling Method	Forced Convection
Mounting Position	Adjacent to battery pack

Cooling Fan Specification Table

Relay module

The relay module is an electrically operated switch used in the prototype to control a 12V DC cooling fan by

interfacing the low-power microcontroller circuit with the high-power load circuit. Since the microcontroller operates at 5V and cannot directly drive the fan, the relay enables safe switching of higher voltage devices

Fig.8: Relay module

It works on electromagnetic induction, where energizing the coil with a 5V signal shifts the contacts from Normally Closed (NC) to Normally Open (NO), allowing current to flow to the fan.

Parameter	Specification
Operating Voltage	5 V
Switching Voltage	250V AC / 30V DC
Type	Electromagnetic Relay
Function	Automatic Fan Switching

Relay Module Specification Table

In this project, the relay is automatically activated when the battery temperature exceeds a set threshold, and it turns off when the temperature returns to safe limits. This ensures safe isolation, reliable operation, and protection of the control circuit from high current and voltage spikes.

Voltage Sensor Module

The voltage sensor module is used in the prototype to continuously monitor the battery pack voltage during charging and discharging operations. Maintaining the correct voltage range is very important

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Fig.9: Voltage Sensor Module

in lithium-ion batteries because over-voltage can cause overheating and damage, while under-voltage can reduce battery life and performance. The voltage sensor helps in analyzing how the battery voltage varies with temperature rise and load conditions, which is essential for evaluating thermal behavior.

Node MCU

The **NodeMCU** is an open-source development board based on the ESP8266 Wi-Fi microcontroller, widely used for Internet of Things

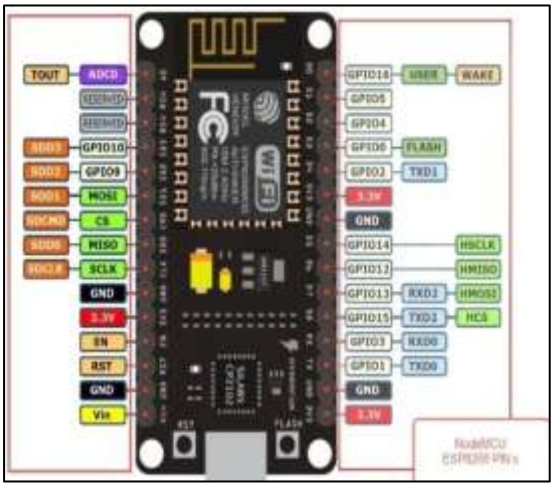


Fig.10: Basic Structure of NodeMCU

(IoT) applications. It combines a microcontroller unit with built-in Wi-Fi capability, allowing devices to connect to wireless networks and transmit data to cloud platforms or mobile applications. In battery thermal management systems, NodeMCU can be used for remote monitoring of temperature, voltage, and current parameters, enabling real-time supervision of battery health from anywhere.

Current Sensor Module

The current sensor module is used in the prototype to measure

the charging and discharging

Current Sensor Specification Table

current of the lithium-ion battery pack. Monitoring current

Parameter	**Specification**
Current Range	0–5 A
Output	Analog
Supply Voltage	5 V
Measurement Type	Hall Effect

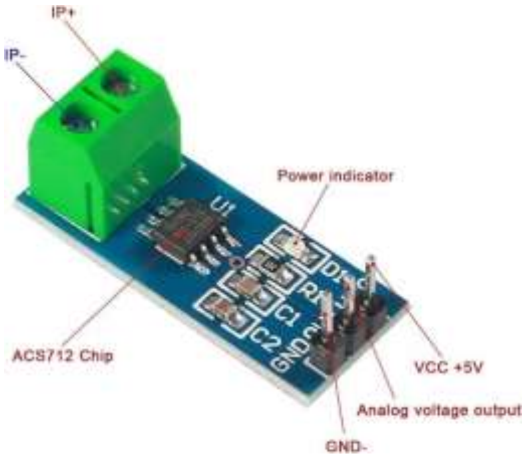


Fig .11: Current Sensor Module

tis essential because heat generation inside the battery is directly proportional to the square of the current (I^2R losses). When higher current flows through the battery during heavy load conditions, more heat is produced due to internal resistance.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Safety Components (Buzzer & Flame Sensor)

The buzzer is an audio alert device that produces a sound when triggered by the microcontroller. In this project

Parameter	Specification
Type	Piezoelectric Buzzer
Operating Voltage	3V – 5V
Current onsumption	< 30 mA
Sound Output	Audible Alert Tone
Control Type	Digital Signal

,

the buzzer is activated when the battery temperature exceeds a preset safety threshold (for example, 45°C).

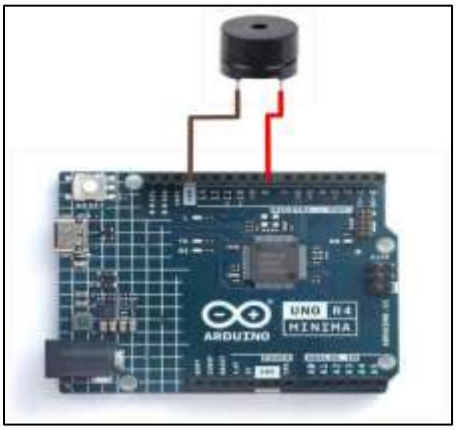


Fig 12: Buzzer Sensor Module

Flame sensor

The flame sensor is used to detect the presence of flame or intense infrared radiation that may occur due to battery thermal runaway or short circuit conditions

It works based on infrared light detection and produces an analog or digital output when flame is detected. The sensor continuously monitors the surroundings of the battery pack.

Parameter	Specification
Detection Type	Infrared Flame Detection
Operating Voltage	3.3V – 5V
Detection Angle	~60°
Output Type	Analog and Digital
Detection Wavelength	760 nm – 1100 nm

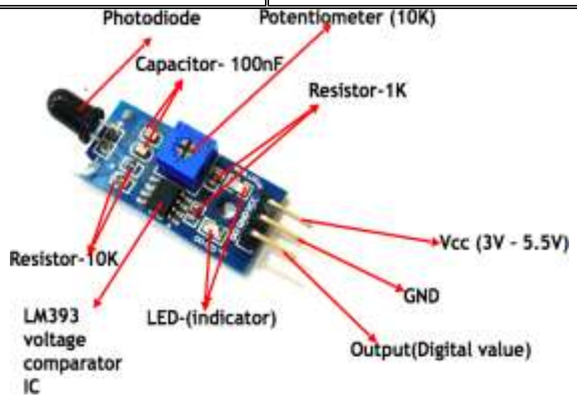


Fig 13: Flame Sensor Module

Electric Motor

The electric motor used in this project functions as the driving element of the cooling system. In the prototype, the motor is integrated with the cooling fan to generate airflow for removing excess heat from the cylindrical lithium-ion battery pack. It operates on a 12V DC supply and converts electrical energy into mechanical rotational energy. When powered, the motor rotates the fan blades, creating forced air convection over the battery surface. This airflow increases the rate of heat dissipation, helping to maintain the battery temperature within safe operating limits.

Parameter	Specification
Motor Type	DC Motor
Rated Voltage	12 V DC
Current Rating	0.15 – 0.50 A (depending on ›ad)
Control Iethod	Relay / PWM
Operating rinciple	Electromagnetic Induction

DC Motor Specifications

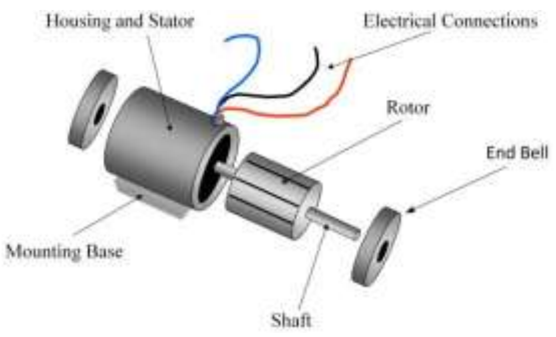
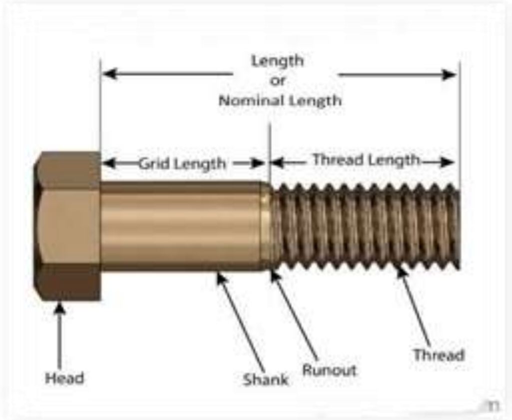


Fig 14: Electric Motor

Nuts

Nuts are internally threaded fasteners that are used along with bolts to secure two or more components together



Washers

Washers are thin circular plates with a hole at the center that are placed between the nut or bolt head and the surface of the component being fastened. The main purpose of a washer is to distribute the load of the fastener over a larger surface area. This prevents damage to the surface of the material and ensures a more secure connection

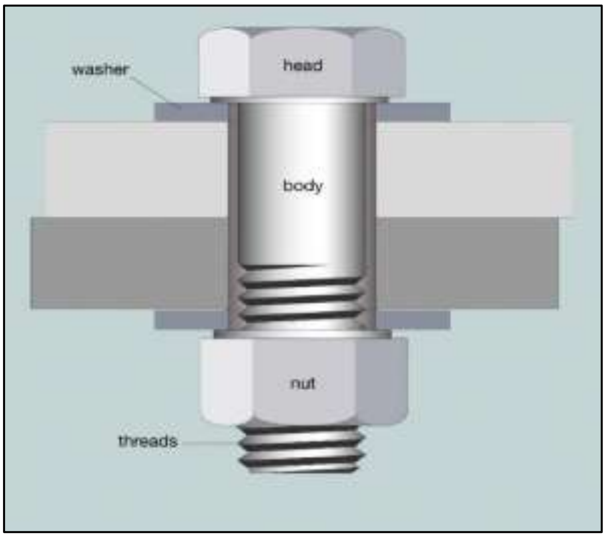


Fig 15: Bolt, Nut, Washer Assembly

CONCLUSION

In conclusion, this project successfully developed and validated a robust, low-cost, and scalable Thermal Management System for electric vehicle battery packs. The experimental results unequivocally prove that passive cooling is insufficient for high-density lithium-ion configurations, whereas an intelligent, logic-driven active cooling system can significantly mitigate the risks of thermal degradation and runaway. By utilizing the NodeMCU (ESP8266) as a central controller, the project demonstrates that high-performance thermal regulation can be achieved without the need for expensive, high-complexity industrial hardware.

The three-stage logic (Passive, 50% PWM, and 100% PWM) provides an ideal balance between energy efficiency and thermal safety. Furthermore, the inclusion of IoT-based remote monitoring addresses one of the most critical gaps in current EV safety: real-time user notification and historical data loggin

REFERENCE

[1]Bernardi, D., Pawlikowski, E., & Newman, J. (1985). “A general energy balance for battery systems.” *Journal of The Electrochemical Society*, 132(1), 5–12.

[2]Bandhauer, T. M., Garimella, S., & Fuller, T. F. (2011). “A critical review of thermal issues in lithium-ion batteries.” *Journal of The Electrochemical Society*, 158(3), R1–R25.

[3]Pesaran, A. A. (2002). “Battery thermal models for hybrid vehicle simulations.” *Journal of Power Sources*, 110(2), 377–382.

[4]Jaguemont, J., Boulon, L., & Dubé, Y. (2016). “A comprehensive review of lithium-ion batteries used in hybrid and electric vehicles at cold temperatures.” *Applied Energy*, 164, 99–114.

[5]Saw, L. H., Ye, Y., & Tay, A. A. O. (2016). “Electrochemical–thermal modeling of 18650 lithium-ion battery.” *Journal of Power Sources*, 295, 569–580.

[6]Kim, G. H., Smith, K., Ireland, J., & Pesaran, A. (2011). “Fail-safe design for large capacity lithium-ion battery systems.” *Journal of Power Sources*, 196(23), 10033–10041.

[7]Wang, Q., Ping, P., Zhao, X., Chu, G., Sun, J., & Chen, C. (2012). “Thermal runaway caused fire and explosion of lithium-ion battery.” *Journal of Power Sources*, 208, 210–224.

[8]Liu, K., Li, K., Peng, Q., & Zhang, C. (2019). “A brief review on key technologies in the battery management system of electric vehicles.” *Frontiers of Mechanical Engineering*, 14(1), 47–64.