



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

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Design and Fabrication of Battery Cooling System for Hybrid Cycle

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ABSTRACT: The project focuses on designing an effective battery cooling system for hybrid cycles, addressing the critical need for temperature management in lithium-ion battery packs. As hybrid cycles continue to gain prominence, the thermal performance and longevity of batteries become paramount. The aim is to develop a liquid cooling technology that ensures optimal operating temperatures during charge and discharge cycles.

Existing literature highlights the significance of efficient cooling systems for battery packs, emphasizing the challenges posed by heat generation during high-power applications. Various methods, such as air cooling, liquid cooling, and the use of phase change materials (PCMs), have been explored. However, each method has its advantages and limitations. This project seeks to build upon this knowledge and contribute by designing a liquid cooling system tailored for hybrid cycle applications. This battery cooling optimization project for hybrid cycles is crucial for advancing electric cycles technology, addressing climate change and pollution. It aligns with global efforts to reduce fossil fuel reliance as our battery cooling systems finds its application on electrical vehicles and extending its impact beyond transportation. Beyond influencing battery design, the project holds potential applications in renewable energy storage. Its outcomes contribute to technological innovations in EVs and address pressing environmental challenges.

I. INTRODUCTION

Hybrid cycles, combining the benefits of human-powered pedaling with electric propulsion systems, have garnered increasing attention as sustainable alternatives to traditional bicycles and gasoline-powered vehicles. Central to the performance and viability of hybrid cycles is the efficient management of their battery systems, which store and deliver electrical energy to augment human effort during propulsion. However, the integration of high-capacity batteries in hybrid cycles has given rise to a critical issue: battery overheating.

The phenomenon of battery overheating poses multifaceted challenges to the performance, safety, and longevity of hybrid cycles. Prolonged usage, demanding terrains, and rapid charge-discharge cycles contribute to the accumulation of heat within the battery pack, leading to diminished efficiency, accelerated degradation, and potential safety hazards. Moreover, the discomfort and safety concerns arising from overheating may deter riders from embracing hybrid cycles as viable transportation options.

In response to these challenges, our project embarks on a journey to revolutionize hybrid cycle efficiency by focusing on the implementation of liquid cooling solutions for battery thermal management. Unlike conventional air cooling methods, which rely on passive heat dissipation through airflow, liquid cooling systems offer superior thermal performance and versatility in regulating battery temperature under varying operating conditions. By circulating a coolant fluid through strategically placed channels surrounding the battery pack, liquid cooling systems efficiently absorb and dissipate heat, thereby maintaining optimal operating temperatures and extending battery lifespan.

This report serves as a comprehensive exploration of the rationale, design principles, implementation strategies, and benefits of liquid cooling systems for battery thermal management in hybrid cycles. Through an interdisciplinary approach encompassing thermodynamics, fluid dynamics, materials science, and electrical engineering, we aim to elucidate the advantages of liquid cooling over other methods, such as air cooling and phase-change materials, in addressing the challenges of battery overheating in hybrid cycles.

Central to our investigation is the comparative analysis of liquid cooling systems with alternative thermal management

techniques, highlighting their effectiveness in enhancing battery performance, reliability, and safety.

II. LITERATURE SURVEY

2.1.1. Hybrid Cycles:

1. **Evolving Trends in Sustainable Transportation:** A comprehensive review of literature reveals a global trend towards sustainable and eco-friendly transportation solutions. Hybrid cycles, characterized by the integration of manual pedalling and electric assistance, have gained popularity for their ability to reduce carbon footprints and promote healthier commuting habits (Fishman et al., 2015).
2. **Performance Optimization:** Studies have explored the optimization of hybrid cycle performance by analysing the interplay between human power and electric propulsion. Researchers emphasize the need for seamless integration to provide a user-friendly experience, taking into account factors such as energy management, torque distribution, and control algorithms (Salaudeen et al., 2018).
3. **User Preferences and Adoption:** Literature suggests that user acceptance and adoption of hybrid cycles are influenced by factors such as perceived benefits, ease of use, and infrastructure support. Insights from user surveys and behavioural studies shed light on the key considerations that impact the widespread adoption of hybrid cycling as a mode of transportation (Buehler and Dill, 2016).

2.1.2 Battery Cooling Systems:

1. **Challenges in Electric Vehicle Battery Management:** The literature highlights the critical role of temperature management in electric vehicle (EV) batteries. Elevated temperatures can lead to performance degradation, reduced lifespan, and safety concerns. Various studies discuss the impact of thermal stress on battery cells and emphasize the need for effective cooling strategies (Yazdani and Pesaran, 2019).
2. **Cooling Techniques in Electric Vehicles:** Researchers have explored different cooling methods, including air cooling and liquid cooling, to maintain optimal battery temperatures. Comparative analyses reveal the advantages and limitations of each technique in terms of efficiency, weight, and cost-effectiveness (Al-Zareer and Alam, 2020).
3. **Innovative Approaches to Battery Cooling:** Recent advancements in battery cooling systems include the integration of phase change materials, active thermal management, and advanced heat exchangers. Studies evaluate the effectiveness of these innovations in enhancing battery performance and longevity (Peng et al., 2021).

III. OBJECTIVES

The primary purpose of the project is to:

1. Optimize battery performance and longevity by maintaining optimal operating temperatures through effective thermal management.
2. Ensure uniform cooling across all battery cells to minimize temperature differentials and thermal stress.
3. Improve overall hybrid cycle efficiency and reliability by mitigating the adverse effects of battery overheating.
4. Enhance safety for riders by preventing thermal runaway events and other potential hazards associated with battery overheating.

IV. METHODOLOGY

1. **CONVERTING A CYCLE TO HYBRID CYCLE:** For conversion we are using a kit which includes Electric Motor, Battery Pack, Controller, Throttle, Wiring and Connectors, Mounting Hardware.
2. **BATTERY COOLING SYSTEM:** We are using an indirect liquid cooling system which includes the following components : Reservoir, Submersible pump, Copper Tubes, Peltier element, Ethylene-Glycol, Thermal Sensors.
3. **DISPLAY OF TEMPERATURE:** We are using a LCD screen to display the temperature reading from the thermal sensors to study and record readings of temperature. We are using components such as Arduino, Breadboard, micro-controller, jump-wires and LCD screen for this setup.
4. **PROGRAMMING OF THE ARUDINO:** We are using the ARDUINO IDE 1.8.19. software to program the Arduino which controls the display on LCD and also takes the input from the thermal sensors

4.1 ASSEMBLY DETAILS

4.1.1 CONVERSION OF CYCLE TO ELECTRIC CYCLE



FIG 4.4.1.1 DC MOTOR 250 W



FIG.4.4.1.2 SPEED CONTROLLER



FIG 4.4.1.3 THROTTLE



FIG 4.4.1.4. WALL CHARGER



FIG 4.4.1.5 KEY SW

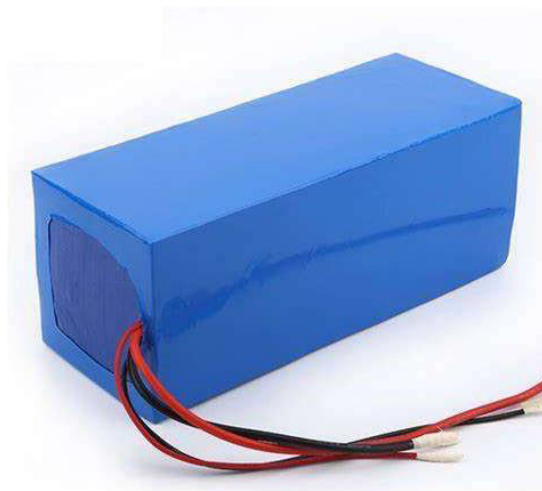


FIG 4.4.1.6 24V LITHIUM-PHOSPHATE ION BATTERY

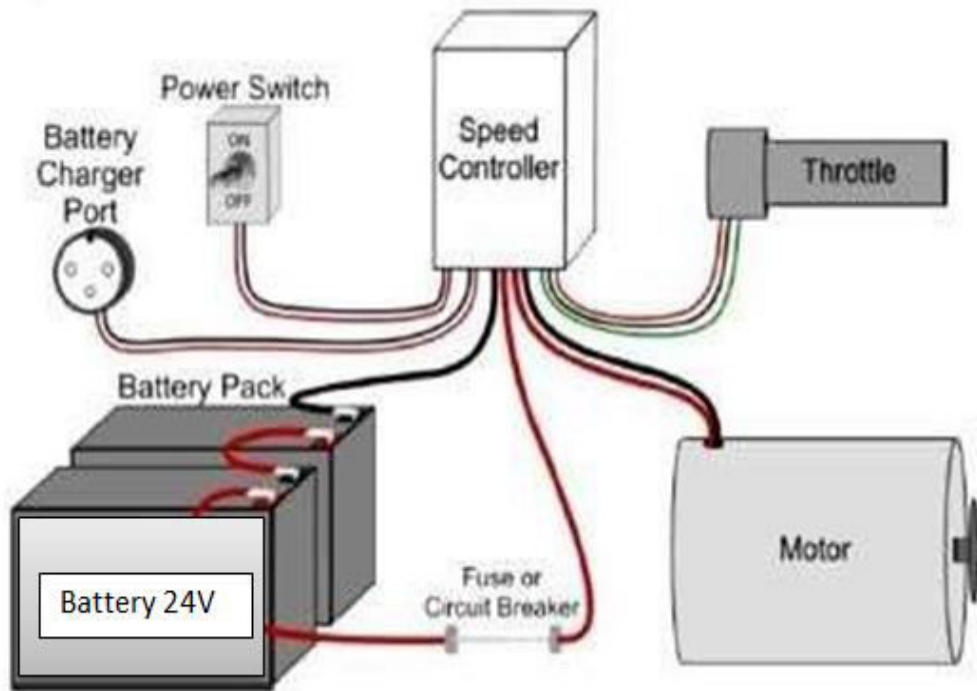
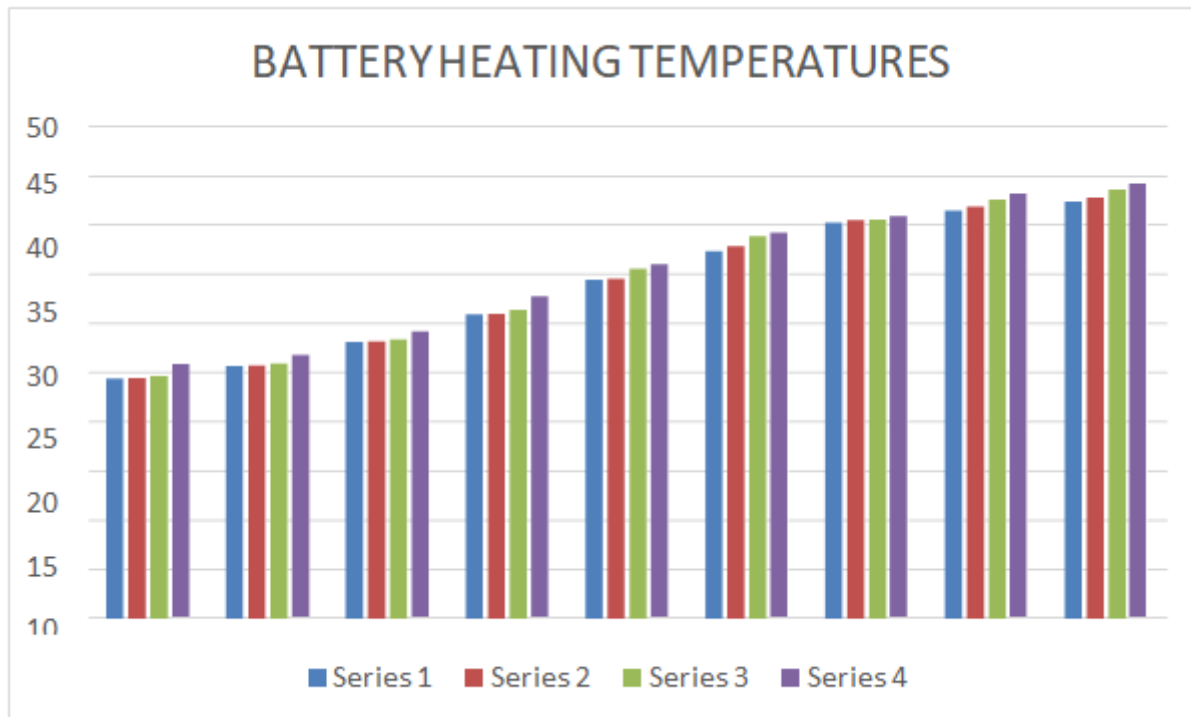


Fig 4.17 CONNECTION CIRCUIT FOR CONVERSION

V. RESULTS

SL.NO.	TRIAL 1 (27-29) °C	TRIAL 2 (32-35) °C	TRIAL 3(37-39) °C	TRIAL 4 (42-45) °C
1	24.3	24.4	24.6	24.9
2	25.6	25.7	25.9	26.3
3	28.0	28.1	28.3	29.1
4	30.8	30.9	31.3	32.7
5	34.3	34.5	35.5	36.0
6	37.2	37.8	38.8	39.2
7	40.1	40.4	40.5	40.9
8	41.3	41.8	42.5	43.2
9	42.2	42.7	43.5	43.9



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