

REVIEWER'S REPORT

Manuscript No.: IJAR- 59492

Title: Improving Thermal Cooling Systems for Electric Vehicle Batteries: A Comparative Numerical Study and Meta-Analysis .

Recommendation:

Accept

Rating	Excel.	Good	Fair	Poor
Originality	Yes			
Techn. Quality		Yes		
Clarity	Yes			
Significance		Yes		

Reviewer's ID: JPR- 015

Detailed Reviewer's Report

Reviewer's Comment for Publication.

Acceptance Comment are mentioned below suitable for the paper titled **"Improving Thermal Cooling Systems for Electric Vehicle Batteries: A Comparative Numerical Study and Meta-Analysis"**

Reviewer Comments: Accept

Reviewer Comments –

1. Introduction

The manuscript addresses the critical challenge of thermal management in lithium-ion batteries used in electric vehicles, with particular emphasis on operation in hot climatic conditions. It highlights the importance of effective cooling in improving battery safety, fast-charging capability, and service life. The study focuses on comparing different battery cooling strategies under varying discharge rates and ambient temperatures. The inclusion of fault-tolerant cooling performance further strengthens the practical relevance of the research. Overall, the introduction establishes a clear research motivation and demonstrates the significance of the topic for electric vehicle technology.

2. Literature Review

The manuscript examines different battery thermal management strategies, including air cooling, liquid cooling, phase change materials, hybrid cooling, and immersion cooling. The comparative perspective provides a useful foundation for understanding the relative strengths and limitations of these approaches. The incorporation of a random-effects meta-analysis of eight published comparisons extends the investigation beyond an individual numerical model. This integration of computational analysis and published evidence strengthens the research framework. The literature-based analysis is relevant to ongoing efforts to develop efficient and reliable battery cooling technologies.

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3. Solution Approach / Methodology

The study develops a reduced-order thermal network model for a ten-cell, 21700 lithium-ion battery module. Six cooling strategies are evaluated at discharge rates of 1C, 2C, and 3C under ambient temperatures of 25 °C and 40 °C. The methodology also incorporates a simulated coolant pump failure to assess the resilience of cooling architectures under abnormal operating conditions. Furthermore, a random-effects meta-analysis is conducted to synthesize findings from eight published comparisons. This combined numerical and statistical approach provides a structured framework for evaluating thermal performance and operational reliability.

4. Results and Discussion

The results demonstrate substantial differences in cooling performance among the evaluated thermal management strategies. At 3C and 25 °C, immersion cooling and hybrid PCM-liquid cooling reduce the peak core temperature to 34.02 °C and 34.45 °C, respectively, compared with 58.27 °C under natural air cooling. Under simulated pump failure at 40 °C, the hybrid system maintains a peak temperature of 44.79 °C, outperforming the cold plate system in the reported scenario. The meta-analysis identifies a pooled maximum-temperature reduction of 9.51 °C, although the high heterogeneity indicates considerable variation across studies. These findings provide useful evidence supporting the thermal performance and fault tolerance of hybrid cooling architectures.

5. Conclusion

The manuscript presents a valuable comparative assessment of thermal management strategies for electric vehicle batteries. Its integration of reduced-order numerical modelling and meta-analysis offers insights into both individual cooling performance and broader evidence from published studies. The findings highlight the potential of hybrid PCM-liquid cooling to balance temperature control and resilience under cooling-system failure. The emphasis on high ambient temperatures also enhances the study's practical significance for electric vehicles operating in hot climates. Overall, the manuscript makes a meaningful contribution to battery thermal management research and is suitable for publication.