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Project Number: 47S_BE_0012

THERMAL MANAGEMENT SYSTEM FOR ELECTRIC VEHICLE BATTERY BANK APPLICATION		
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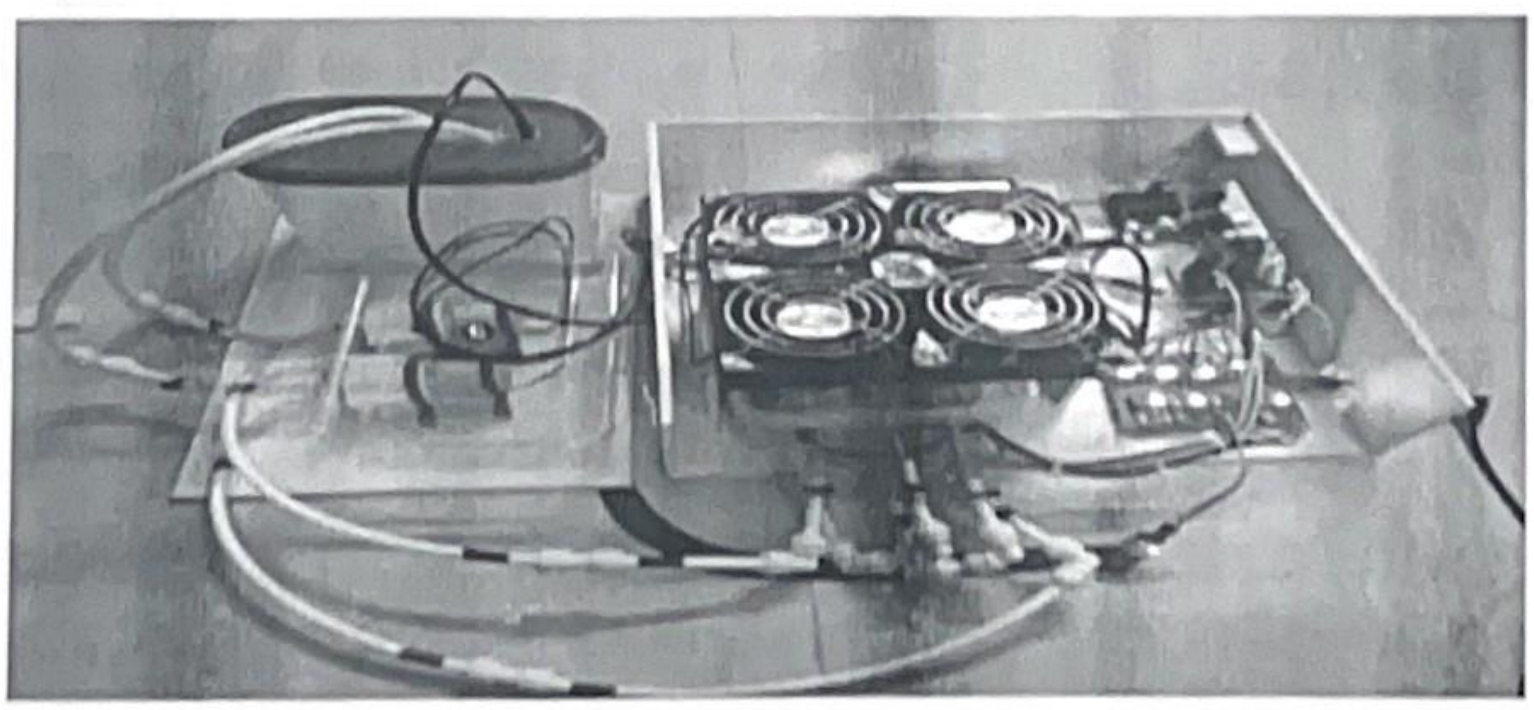
3.	Keywords	
	Introduction	As an important part of national economy, with high consumption of energy, especially petroleum resource, transportation industry has received much attention.Under the pressure of energy shortages and environmental pollution, automakers must turn their attention to green energy and clean cars.As a key component of electric vehicles, power batteries are particularly important for electric vehicles.A Battery Thermal Management System (BTMS) is an important part of battery management systems. It allows researchers to improve the performance, extend the life, and enhance the safety of a battery. The BTMS´s objective is to prevent accelerated battery deterioration by managing the heat generated by its components so that it operates continuously under optimum temperature conditions.The BTMS ensures that the battery is being operated under safe operating conditions by continuously monitoring the battery parameters.
4.	Objectives	To develop a thermal management system that can maintain the battery cells (20) within the safe and efficient temperature range (0 – 50) °C.To improve the performance of the battery by regulating its temperature conditions.To enhance the safety of the battery by preventing accelerated battery deterioration by managing the heat generated by its components so that it operates continuously under optimum temperature conditions.Implement innovative BTMS solutions to mitigate the impact of heat generation on battery degradation, thereby enhancing the overall safety and reliability of electric vehicles.Facilitate the widespread adoption of electric vehicles by advancing BTMS technology, making electric transportation more sustainable, environmentally friendly, and economically viable.

5.	Methodology	Developed an innovative battery bank thermal management system integrating both air- and water-cooling techniques to enhance overall efficiency and safety of energy storage systems.Investigated and optimized the synergistic effects of air and water cooling, providing a comprehensive understanding of how these methods can be combined to maintain optimal temperature levels, prolonging battery lifespan and minimizing thermal-related issues. Implemented a robust control strategy to dynamically regulate the cooling system based on real-time temperature data, ensuring adaptive and efficient thermal management across various operating conditions. Conducted in-depth experimental analysis and validated the effectiveness of the proposed cooling system through rigorous testing, providing valuable insights into its performance, energy consumption, and scalability for different battery bank configurations.Contributed to the advancement of sustainable energy storage technologies by addressing thermal challenges in battery banks, offering a practical and scalable solution that can be applied to diverse applications, from renewable energy integration to electric vehicles. Components used are ;SYSPRO Automatic Battery Charger with 7 AH to 100 AH Battery Charging AMF Panel Bike Truck Car Toys 12V Charger,7850 IC Regulator,18650 Li-ion 2500mAh Rechargeable Battery(3.7v 2.2maH),TP5100 CELL Charging module ,Aluminium Water tube for cooling,Water Pump(Dc motors 12 V ,1amps),BME280 Temperature Sensor Module,Arduino UNO .  Hardware Module

6.	Results and Discussion	Development is always meant to produce good results. Interpretation of the results obtained from the study plays a major role in determining the success of the developed item or concept. Interpreting the results is not as easy as getting a result. It very much depends on the level of understanding of the interpreter on the relevant topic. Most of the results obtained in this study are qualitative, comparison, thermal performance, and optimization, and lastly, the weight comparison. For the scope of qualitative, there are no numerical values to be compared, so it is quite hard to interpret. It mainly relies on the graph comparing the packaging and cooling solution against the temperature uniformity. It can be said that from the comparison, air cooling solution with east-west packaging has better temperature uniformity than the others. Whereas optimized liquid cooling solution with alternate arrangement packaging on the batteries has shown great results compared to optimized air cooling and liquid cooling east-west packaging. Results from comparison are always relative, at least there is something that is better than the others. Regarding the iteration of the design of the Battery Thermal Management System, the best solution would be a liquid cooling system with alternate arrangement packaging on the batteries. This type of battery packaging is more effective in eliminating the hot spot on the battery due to the good temperature uniformity between the battery cells.
7.	Conclusions	Development is always meant to produce good results. Interpretation of the results obtained from the study plays a major role in determining the success of the developed item or concept. Interpreting the results is not as easy as getting a result. It very much depends on the level of understanding of the interpreter on the relevant topic. Most of the results obtained in this study are qualitative, comparison, thermal performance, and optimization, and lastly, the weight comparison. For the scope of qualitative, there are no numerical values to be compared, so it is quite hard to interpret. It mainly relies on the graph comparing the packaging and cooling solution against the temperature uniformity. It can be said that from the comparison, air cooling solution with east-west packaging has better temperature uniformity than the others. Whereas optimized liquid cooling solution with alternate arrangement packaging on the batteries has shown great results compared to optimized air cooling and liquid cooling east-west packaging. Results from comparison are

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8.	What is the innovation in the project?	The innovation in the project lies in the advanced thermal battery management system that combines air cooling and water cooling techniques using SMPS fans and flat aluminum water tubes. This hybrid approach significantly enhances the cooling efficiency and thermal stability of the battery system.The core of this innovation is the dual cooling strategy.Air cooling utilizes Switch Mode Power Supply (SMPS) fans, known for their energy efficiency, precise control, and consistent airflow. These fans ensure effective cooling by maintaining the battery temperature within optimal limits. SMPS fans consume less power compared to traditional fans, making them an energy-efficient choice.Water cooling is implemented using flat aluminum water tubes. Aluminum is selected for its high thermal conductivity, lightweight nature, and resistance to corrosion. The flat design of the tubes increases the surface area, facilitating superior heat exchange and rapid cooling. This method is particularly effective in managing high thermal loads, ensuring that the battery remains within a safe temperature range.By combining these two cooling methods, the system can dynamically adapt to varying thermal loads. During high thermal loads, the water cooling system can be activated to handle excess heat, while the air cooling system manages lower thermal loads efficiently. This dynamic adjustment ensures consistent performance and prevents overheating or thermal runaway.
9.	Scope for future work	These will be important tools in the future design and testing of passive and active management systems and for accurate prediction of temperature effects on battery life. Also, development and testing of new phase change materials and use of micro or mini channel cooling systems as these have the potential to provide the most effective and lightweight solutions. Understanding transient behavior of heat generation and effects of its distribution in the cell due to different operating, dynamic and road load conditions is a new area that needs to be explored. This is

		important since it is these conditions that are difficult to cater from with a limited energy effect system. Further research will also need to be focused on understanding the relationships between temperature and battery life and developing management systems that can optimize life and performance at minimum energy consumption. This will be the goal in the design of any BEV and system that can accurately predict and control battery temperature for different types of users and operating conditions will be a virtual tool for the design and development of the vehicle.

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