IJIREEICE

ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⯎ Vol. 10, Issue 2, February 2022

DOI 10.17148/IJIREEICE.2022.10202

A Review on Battery Thermal Management System

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Abstract: Due to high energy density and long life, the lithium-ion batteries are mostly preferred for electric vehicles. Temperature has negative impact on performance of battery and life of the battery. maintain the proper range of the battery temperature is most important thing. In this context, The different methods of battery thermal management systems are discussed. This paper reviews the thermal management of Lithium Ion Batteries. This paper is based on the past studies of different cooling methods like Thermoelectric Cooling, Heat Pipe Cooling, Phase Change Material Cooling, The Battery thermal management system is proposed for the effective thermal management of the lithium ion battery.

Keywords: Lithium-Ion-Battery: Thermal Stability: Thermal management system: Cooling Methods.

I. INTRODUCTION

Different cooling method are used for the battery thermal management, such as thermoelectric cooling, phase change material, heat pipe, air cooling , liquid cooling etc. Every cooling methods has its own advantages. Phase Change Material has excellent ability to control the difference of temperature. Also the liquid cooling has strong cooling performance.

For electric Vehicle battery pack to operate affluently in all environmental condition the battery management system is most important. Solid State Cooling is used for battery management system. It uses Thermoelectric coolers [1]. There are various methods for battery management system are reviewed like: Liquid Cooling Battery Management System, Thermoelectric Element Based Battery Management System, Heat Pipe Battery Management System, Phase Change Material, Mini Channel Cold Plate Battery Management System [2]. The first method is Liquid Cooling. The cooling system is depend on the limitation of electric vehicle, external condition, also the cost of installation. Liquid Cooling is most complicated than Air Cooling. The direct liquid cooling has a higher rate of cooling also the temperature uniformity is higher [3]. The second method is Thermoelectric Cooling. The thermal management of battery is a combination of thermoelectric cooling, air cooling, and liquid cooling. With an evaluated voltage at 12 V, this Thermoelectric Cooling can endure most extreme temperature contrast up to 68 ◦C [4].

The third method is Heat Pipe. Maximum temperature could be controlled below 50 □c When the heat generation rate was lower 50W. Under the unsteady operating condition, maximum temperature and temperature difference are kept within range [5] . The fourth method is Phase Change Material (PCM). In phase Change Material cooling two methods of Phase Change Material design are investigated: first is PCM cylinder surrounding the heater, and Second is PCM jacket wrapping the heater [6]. The fifth method is Mini channel Cold Plate To reduce difference between maximum temperature and local temperature of lithium ion battery Mini Channel Cold Plate battery management system is used [7]. The sixth method is Nanofluid battery management system. By using Nanofluid as a coolant show 28.65% reduced the maximum temperature as compare with other cooling modules [8]. The seventh method is Liquid Metal Battery Management System. The Liquid Metal is proposed to be used as a coolant for thermal management of a battery pack [9].

The lifetime of a battery relies predominantly upon the working temperature. Subsequently. refrigeration system applied to batteries temperature control [10]. Heat pipes combined with air, water, or refrigerant cooling present great hotness move effectiveness because of the incredible warm conductivity of HPs, yet to likewise acquire temperature consistency, it is feasible to additional add PCM [11]. Three unique usually utilized temperature control system for electrical gadgets are accessible: blower based, fluid nitrogen module [12]. unfriendly working temperatures can affect battery execution, corruption, and wellbeing, accomplishing a battery warm administration framework that can give an appropriate surrounding temperature climate for working batteries is significant [13].

Two metals with a typical contact point, where the potential is created because of the temperature distinction in the other two closures of metals, is about Seebeck impact [14]. reviewing all these methodologies future challenges and possible solutions can be obtained [15].

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II. THERMAL BATTERY MANAGEMENT STRATEGY

1. Liquid Cooling BTMS
2. Thermoelectric Element Based BTMS
3. Heat Pipe BTMS
4. Phase Change Material BTMS

Cooling Methods of Lithium-Ion Battery

1] Liquid Cooling BTMS

Liquid cooling structures are more complex than air cooling systems. In a battery thermal organization system utilizing liquid cooling, the hotness move among battery and liquid coolant is cultivated by presenting discrete tubing around the battery cells with a coat around the battery cells which places the warmed liquid or cooled plate to the battery cell surface or bringing down the telephones in a dielectric fluid. In the event that the liquid cooling structure uses a non-direct contact method, water, ethylene glycol or refrigerants can be used as the cooling medium. On the other hand, in the prompt contact system, the liquid should be a dielectric, for instance, silicone-based or mineral oils to avoid any short out [3].

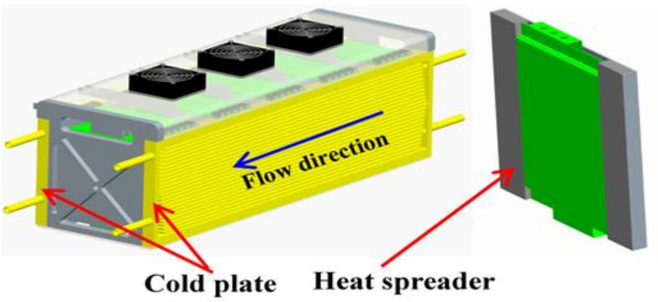

Fig.1 Liquid Cooling

2] Thermoelectric Element Based BTMS

Thermoelectric cooler (TEC) alludes to a Solid state semiconductor gadget which is free of noise, harmless to the ecosystem, and functional and free of cost, and. Essentially, a solitary unit of TEC comprises of a n-type and p-type TElegs where TE legs are associated electrically in series and thermally in equal. Detective requires less voltage and current contrasted with normal cooler. Thermoelectric refrigeration innovation is an electronic refrigeration innovation with high productivity and low energy utilization. Thermoelectric components are portrayed by smaller design, quick reaction, and incorporation of refrigeration and warming, giving new thoughts for BTMs. The thermoelectric components can be partitioned into two classifications, one is a thermoelectric generator (TEG) in light of Seebeck impact, which converts heat into power and uses squander heat as energy. The other is a thermoelectric cooler (TEC) based on Peltier impact, which changes over power into heat for cooling and heating [2].

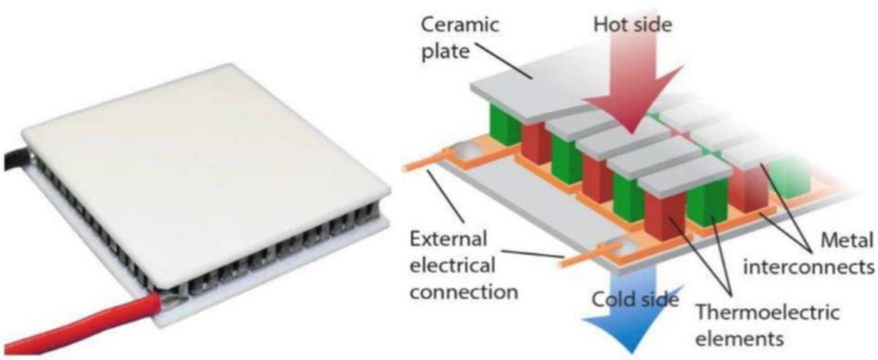

Fig.2 Thermoelectric Cooling

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3] Heat Pipe BTMS

In this innovation the heat lines can be separated into three areas: evaporator segment, isothermal segment, and condenser segment. The functioning system of heat pipe is that: Firstly, fluid cooling medium retains heat and vanishes at evaporator segment. Besides, the fluid cooling medium moves from the isothermal area to condenser segment, delivers its hotness, and changes into fluid. At last, the fluid streams to evaporator segment and proceeds to endothermic like the previous. Because of the unique hotness conduction execution, lightweight and conservative size, it additionally can be utilized to eliminate heat from the inside battery pack to external [5].

4] Phase Change Material BTM's

PCM has a more temperature controlling impact in battery warm administration. It could manage the cost of more uniform battery temperature conveyance, and limit the effect on encompassing batteries when warm rampant happened. Yan planned a sandwich design of PCM board to cool the pack, and the outcome showed that PCM board had brilliant capacity on the typical and manhandling condition contrasted with general air or cooling board.
Paraffin is constantly utilized in stage change materials, credited to cost and inactive enthalpy. In light of low warm conductivity, past examination proposed to improve paraffin composited with different materials, for example, composite paraffin with nanoparticles, metal froth, Cu network, extended graphite, and carbon fiber. Compound paraffin shows higher warm conductivity and better temperature consistency, oppositely lower idle enthalpy. PCM with higher idle enthalpy can work at higher encompassing temperature. Additionally, it could meet the especially prerequisites for battery load with the most fitting warm properties [6].

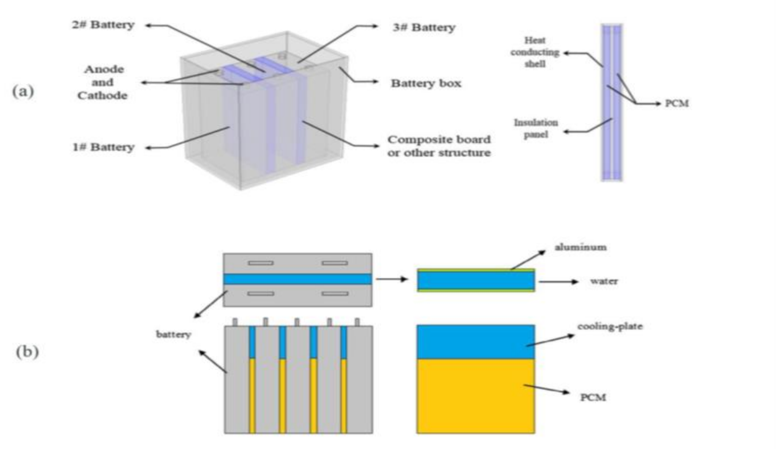

Fig.3 Phase Change Material

III. CONCLUSION

The temperature issues of lithium-ion batteries are critical. For the arrangement of BTMSs, the accentuation should be on the cooling or heating breaking point, the system multifaceted nature, energy use, constancy, and upkeep costs. Batteries' hotness age rates are tangled and immovably associated with their states. This expects an overarching part in the BTMS plan. More careful models watching out for battery heat age may be investigated. Additionally, splendid control approaches of BTMSs can essentially deal with their shows too. Subsequently, more control system may be presented later on. It gives a reference thought to further developing the BTMS cooling execution, and consolidates the genuine issues that BTMS will look in application, as well as the open doors and difficulties later on advancement

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