Australian Journal of Basic and Applied Sciences, 8(4) Special 2014, Pages: 683-686

AENSI Journals

Australian Journal of Basic and Applied Sciences

ISSN:1991-8178

Journal home page: www.ajbasweb.com

Analysis Study on Electric Vehicle Lithium Ion Polymer Batteries COP in various Temperature Condition in a Confined Space – Review of Recent Literature

[1]Rhenita G.L. Heng, [1]Zuradzman M Razlan, [1]Shahriman AB, [2]I Zunaidi, [1]D Hazry, [1]Khairunizam Wan, [3]Nazrul H Adnan

[1]*Centre of Excellence for Unmanned Aerial System, University Malaysia Perlis (UniMAP), 01000 Kangar, Perlis, MALAYSIA.*
[2]*Faculty of Electrical & Automation Engineering Technology, TATI University College, Jalan Panchor, Telok Kalong, 24000 Kemaman, Terengganu, MALAYSIA.*
[3]*School of Mechatronic Engineering, University Malaysia Perlis (UniMAP), Pauh Putra Campus, 02600 Arau, Perlis, MALAYSIA.*

ARTICLE INFO

Article history:
Received 20 November 2013
Received in revised form 24 January 2014
Accepted 29 January 2014
Available online 5 April 2014

Key words:
electric vehicle (EV); lithium ion polymer battery; COP; ambient temperature condition

ABSTRACT

The lithium ion polymer batteries are quickly emerging as the preferred electrical energy storage technology and generally used in portable electronics products such as notebook computers, tablets, smart phones and so on. Besides, this technology also attracts worldwide attention in transportation application including the electric vehicles. Electric vehicles (EVs) are becoming more appealing options over combustion engine based vehicles, due to ever rising fuel prices and growing environmental concerns. Demand for electric vehicles (EVs) is increasing, and lithium ion polymer batteries with increased ranges will be critical to increase the marketability and important step in reducing greenhouse gas emissions. However, the current electric vehicles (EVs) are a temporary solution to create more zero emission when run on the road. In additional, the temperatures of lithium ion polymer batteries play an important role in determining the performance of an electric vehicle (EV). It also directly affects the vehicle dynamic performance, reliability, long term durability and safety. From the review, I found that the battery should operate within a temperature range to achieve desired performance and calendar life. All electrochemical batteries are strongly linked to their thermal state. The electrical characteristics are strongly dependent on temperature while the thermal state is a result of both their environmental temperature, but also the electrical usage due to internal heat generation. This is because higher or lower than normal temperature might affect the performance, charging and discharging rate, battery lifespan, battery capacity and maintenance requirements. In general, a battery in a cool location has a longer lifespan than in a warm location. Therefore a solution needs to be solved to maximizing the COP of the battery management. In this paper a brief review of related current literature on electric vehicles (EVs), lithium ion polymer batteries, and ambient temperature conditions are provided. This paper also concludes with direction for future research.

To Cite This Article: Rhenita G.L. Heng, Zuradzman M Razlan, Shahriman AB, I Zunaidi, D Hazry, Khairunizam Wan, Nazrul H Adnan., Analysis Study on Electric Vehicle Lithium Ion Polymer Batteries COP in various Temperature Condition in a Confined Space – Review of Recent Literature. ***Aust. J. Basic & Appl. Sci.,*** *8(4): 683-686, 2014*

INTRODUCTION

Electric vehicles (EVs) are powered solely by storing energy in on-board batteries in the form of electricity. The key advantages of electric vehicle (EV) technology include the potential to significantly reduce the greenhouse gas emissions and the usage of fossil fuels. This can benefit for improving energy security, reduce criteria emissions and importantly, these technologies also lead to substantial reductions in life cycle emissions of CO_2. Therefore this research aim is to improve the COP of an electric vehicle (EV) lithium ion polymer battery, technically by analysing the efficiency of the battery in various ambient temperatures. According to Suh, Cho and Rim (2011), this technology is not only to reduce the greenhouse effect but also reduce the usage of the combustion engine powered by fossil fuel (Suh, Cho, & Rim, 2011).

The solution for the usage of the fossil fuel for combustion in the automobile is transitioning the traditional petrol and diesel vehicles to the full electric vehicles (EVs) (AllianceBernstein, 2006; Economist, 2008, 2006; Romm & Fox-Penner, 2007; IBM, 2008; Sperling & Gordon, 2008). Our national cars, Proton also are in progress to produce mass production of electric vehicles (EVs). Yan *et al.* (2010) stated that the alternative power sources must be more powerful with high voltage and large capacity to meet the requirements of the electric vehicle (EV) batteries (Yan *et al.*, 2010). In general, the battery management is essential to achieve the

Corresponding Author: Rhenita G.L. Heng, Centre of Excellence for Unmanned Aerial System, University Malaysia Perlis (UniMAP), 01000 Kangar, Perlis, MALAYSIA.
E-mail: rhenita.heng86@gmail.com

desired performance and life cycle. Therefore, the R&D centre is in struggling to develop for maximizing the battery COP.

Further in this research, an analysis study shall be conducted to verify the optimum condition of ambient temperature that could maximize the usage of the battery. The car using lithium ion polymer type battery works efficiently in a specified range of ambient temperature as written in the specification by the battery maker. In the near future, this research is mainly to study experimentally the efficiency of the battery in various ambient temperatures in a confined space.

Literature Review:

Electric vehicles (EVs):

Electric vehicles (EVs) are fun to drive, easy to run and importantly, these technologies can create more zero emissions vehicles on the road. The transition from traditional petrol and diesel vehicles to full electric vehicles started from the stage of convention internal combustion energy, to hybrid electric vehicles (HEVs), to plug-in hybrid electric vehicles (PHEVs), and finally to battery electric vehicles (BEVs) (Prud'homme and Koning, 2012). This idea began nearly a century ago (Brown, Pyke, & Steenhof, 2010). During that century, the news media was already publishing: the electric car "has long been recognized as the ideal solution" because it "is cleaner and quieter" and "much more economical" (The New York Times, November 2, 1911). However, from many years, the electric car only became a dream, or a conception, or a curiosity to the car followers.

An electric vehicle (EV) is any vehicle that powered by electricity as energy for propulsion. The main differences between a fully electric vehicle (EV) and a conventional internal combustion engine vehicle which are included electric vehicles (EVs) have the electric motors instead of the internal combustion engines; electric vehicles (EVs) store energy in the battery rather than a fuel tank and also electric vehicles (EVs) source energy via plug rather than a petrol pump.

Currently, the electric vehicles (EVs) are seen as the temporary solution to the transport sector's problems by reducing the usage of fossil fuel and global warming problem (Zackrisson, Avellán, & Orlenius, 2010). Today, many significant efforts are being produced to develop battery systems for vehicles if electricity (which is replacing the fuel) possible to generate by renewable energy sources and additionally, these technologies can help to reduce traffic noise.

Lithium-ion Polymer Batteries:

The automobile manufacturers found that, using rechargeable lithium ion polymer batteries can reduce the greenhouse effect caused by emission of CO_2 (Suh *et al*., 2011). Lithium ion polymer batteries potentially have much higher energy density (~ 400 Wh^{-1}) and become a common replacement for other battery technologies (Bandhauer, Garimella, & Fuller, 2011). The high power/energy density of lithium ion polymer battery has also equipped them a powerful power source in electric vehicles (EVs) which are not only offer a longer driving range but also provide higher acceleration (Chacko & Chung, 2012).

Tang, Ci and Qilu (2006) presented that a novel method to manufacture lithium ion polymer batteries has been developed (Tang, Ci, & Qilu, 2006). A typical battery pack is composed of a large number of cells is essential for achieving involved power and the compactness of battery modules poses a challenge for effective thermal management in the electric vehicles (EVs) application (Bandhauer *et al*., 2011; Chacko & Chung, 2012). In the previous study by Pesaran and Keyser on thermal features and performance of the electric vehicle (EV) and lithium ion polymer battery, showed that the heat generation rate depends on the initial state of charge, initial temperature, and charge/discharge profile (a. a. Pesaran & Keyser, 2001).

Battery Condition:

According to the Pesaran, Vlahinos and Stuart (2003), the aim of thermal management system in the electric vehicle (EV) is to maintain an adequate temperature range in a battery pack with even temperature distribution. However, the thermal management system must be inexpensive, lightweight, easily packaged, compact and compatible with location (A. Pesaran, Vlahinos, & Stuart, 2003).

The battery temperature is important (A A Pesaran, Burch, & Keyser, 1999) because it also affects the vehicles performance, reliability, lifespan of the electric vehicles (EVs) (Ahmad A Pesaran, 2001). High battery compartment temperature can cause a shortening of the lifespan of the battery (Motloch *et al*., 2002). To accomplish a full lifespan, the compartment temperature difference should be maintained below 5°C (Park and Jaura, 2003). Therefore, a battery thermal management system enabling operational temperature control becomes required for performance, reliability, safety, and lifespan (Chacko & Chung, 2012; a. a. Pesaran & Keyser, 2001; A. Pesaran *et al*., 2003) and batteries should operate within a temperature range that is optimum for performance and life (Ahmad A Pesaran, 2001).

Review of Related Work:

In this section, a review on electric vehicle lithium ion polymer batteries in ambient temperature is presented. Some of the work has been reviewed and reported in the literature to support the statements.

Wicks and Doane studied temperature dependent performance of a lead-acid electric vehicle (EV) battery. Thus they found that the efficiency and maximum operating power increase in temperature over a range of -26°C to 65°C (Wicks and Doane, 1993).

Dickinson and Swan (1995) reported on the performance and lifespan of battery packs, and found that the temperature gradient between modules diminishes the overall pack capacity. They suggested that maintaining an even temperature distribution in the pack and a temperature of 35°C to 40°C (Dickinson and Swan, 1995). Besides, they also mentioned that the temperature uniformity in the battery pack also affects the performance of energy storage system.

Pesaran *et al*. (1999) studied thermal performance of EV battery modules and packs. In order to accurately design the thermal management system for electric vehicles (EVs), thermal analysis should be conducted. Also, to get the prediction for the thermal performance, finite element analysis software and heat transfer principles have been used (A A Pesaran *et al*., 1999).

Ahmad A Pesaran *et al*. (2001) introduced a methodical approach to design and analyse the thermal management inside the battery pack. The thermal management system is necessary for controlling and maintaining the electric vehicle (EV) battery pack temperature. They outlined that battery pack must compatible with all modules in order to operate in the preferred temperature range. Besides, the uneven temperature distribution between the modules should be reduced to minimize the electric imbalance and this result in improving battery performance and lifecycle (Ahmad A Pesaran, 2001).

Pesaran, Vlahinos and Stuart worked on thermal management of batteries. They concentrated on methods to cool and preheat the batteries to improve the performance and operation in many different temperatures. They also analysed the transient thermal behaviour by using the finite element thermal analysis. Finally they found that the most effective method for warming the battery quickly with the least amount of energy was the battery core heating (Pesaran, Vlahinos, & Stuart, 2003).

Tang, Ci, and Qilu developed a novel method to manufacture lithium ion polymer battery and the performance of $LiMn_2O_4$/NG based. In their paper, simple process to coat the electrodes with micro porous composite polymer films have been conducted. As the result, of the improvement results that the graphite is protected by the composite polymer film from reacting with Mn2+ dissolved from the spinel LiMn2O4 cathode leads to the excellent performance of the NG anode (Tang, Ci, & Qilu, 2006).

Okamoto *et al*. developed an implantable battery system and evaluation of temperature rise of lithium ion battery. They found that lithium ion battery and lithium ion polymer battery have the same heat characteristics. However the internal resistance of the lithium ion battery is much larger. They described that the lithium ion polymer battery has the capability to keep cooler itself due to higher specific heat and lower internal resistance. Hence, they concluded that lithium ion polymer battery is more suitable for usage in the implantable battery system because it has an advantage in temperature rise during operation (Okamoto *et al*., n.d.).

Yuan *et al*. (2012) studied battery thermal management system with liquid cooling and heating in electric vehicles. They found that life and performance of electric vehicle battery systems are affected by the temperature (Hao, Lifang, & Liye, 2012). They reported that a liquid cooling/heating Battery Thermal Management was designed to keep the average battery-system temperature in the range from 20°C to 45°C and the temperature gradient within 3°C.

Sandy Thomas mentioned that the battery electric vehicles (BEVs) are often labelled "green". This technology is to reduce greenhouse gas and oil consumption from the transportation sector. They also discovered higher specific power battery is needed to develop and replace larger cars with long driving capacity to make substantial reduction in greenhouse gas and oil consumption. They also stated hydrogen and electricity can be made from lower carbon sources to further reduce the greenhouse gas in the future (Sandy Thomas, 2012).

Conclusion:

Currently, the analysis is still in preliminary stage involves gathering literature from previous work. In the near future, various testing conditions will be set and the efficiency of the batteries will be studied and report. The plan and the research flow will be the design of the air conditioning system for the confined space, i.e. batteries compartment at the beginning stage. Secondly, the air conditioning system and the experimental apparatus will be installed and equipped inside the electric vehicle (EV) car. The experiment will be conducted after confirming the reliability of the air conditioning system to main the compartment temperature distribution. The result will be analysed and studied before concluding the result of future development strategy.

REFERENCES

Alliance Bernstein, 2006. The emergence of hybrid vehicles: Ending oil's stranglehold on transportation and the economy.

Bandhauer, T.M., S. Garimella, & T.F. Fuller, 2011. A Critical Review of Thermal Issues in Lithium-Ion Batteries. Journal of The Electrochemical Society, 158(3), R1. doi:10.1149/1.3515880.

Dickinson, B. and D. Swan, 1995. EV Battery Pack Life: Pack Degradation and Solutions. Proceedings of the Future Transportation Technology Conference and Exposition, pp: 145-154.

Brown, S., D. Pyke, & P. Steenhof, 2010. Electric vehicles: The role and importance of standards in an emerging market. Energy Policy, 38(7): 3797-3806. doi:10.1016/j.enpol.2010.02.059

Chacko, S., & Y.M. Chung, 2012. Thermal modelling of Li-ion polymer battery for electric vehicle drive cycles. Journal of Power Sources, 213: 296-303. doi:10.1016/j.jpowsour.2012.04.015

Economist., 2006. Plugging into the future. Economist.

Economist., 2008. A global love affair: A special report on cars in energy markets. Economist.

Wicks, F. and E. Doane, 1993. Temperature Dependent Performance of a Lead Acid Electric Vehicle Battery. Proceedings of the 28th Intersociety Energy Conversion Engineering Conference.

Hao, Y., W. Lifang, & W. Liye, 2012. Battery Thermal Management System with Liquid Cooling and Heating in Electric Vehicles, 3(4).

IBM., 2008. Automotive 2020: Clarity beyond the chaos.

Okamoto, E., Y. Inoue, Y. Akasaka, S. Okada, T. Ebina, T. Kasai, … Y. Mitamura, (n.d.). Evaluation of temperature rise of lithium ion secondary battery used in implantable battery system of UP-VAD, 14: 4142-4145.

Motloch, C., J. Christophersen, J. Belt, R. Wright, *et al*. 2002. High-Power Battery Testing Procedures and Analytical Methodologies for HEV's. SAE Technical Paper 2002-01-1950, 2002, doi:10.4271/2002-01-1950.

Park, C. and A. Jaura, 2003. Dynamic Thermal Model of Li-Ion Battery for Predictive Behavior in Hybrid and Fuel Cell Vehicles. SAE Technical Paper 2003-01-2286, 2003, doi:10.4271/2003-01-2286.

Pesaran, a.a., & M. Keyser, 2001. Thermal characteristics of selected EV and HEV batteries. *Sixteenth Annual Battery Conference on Applications and Advances. Proceedings of the Conference (Cat. No.01TH8533)*, 219-225. doi:10.1109/BCAA.2001.905129.

Pesaran, A.A., S. Burch, & M. Keyser, 1999. An Approach for Designing Thermal Management Systems for Electric and Hybrid Vehicle Battery Packs Preprint, (January).

Pesaran, A., A. Vlahinos, & T. Stuart, 2003. TED-AJ03-633 Cooling and Preheating of Batteries in Hybrid Electric Vehicles.

Pesaran, Ahmad A., 2001. Battery Thermal Management in EVs and HEVs : Issues and Solutions.

Rémy Prud'hommea & Martin Koning, 2012. Electric vehicles: A tentative economic and environmental evaluation. Transport Policy, 23: 60-69.

Romm, J., & P. Fox-Penner, 2007. Plugging into the grid. A publication of the Progressive Policy Institute.

Sandy Thomas, C.E., 2012. "How green are electric vehicles?" International Journal of Hydrogen Energy, 37(7): 6053-6062. doi:10.1016/j.ijhydene.2011.12.118

Sperling, D., & D. Gordon, 2008. Advanced passenger transport technologies. Annual Review of Environment and Resources, 33.

Suh, N.P., D.H. Cho & C.T. Rim, 2011. Global Product Development. (A. Bernard, Ed.). doi:10.1007/978-3-642-15973-2

Chacko, S. and S. Charmer, 2011. Concept development and CAE for EV battery thermal management. In IMechE Conference VTMS10, pages C1305e028, Gaydon, UK.

Tang, D.-G., Y.-X. Ci, & Qilu, 2006. A novel method to fabricate lithium-ion polymer batteries based on LiMn2O4/NG electrodes. Journal of Solid State Electrochemistry, 11(3): 350–354. doi:10.1007/s10008-006-0145-8

Zackrisson, M., L. Avellán & J. Orlenius, 2010. Life cycle assessment of lithium-ion batteries for plug-in hybrid electric vehicles e Critical issues. Journal of Cleaner Production, 18(15): 519-1529. doi:10.1016/j.jclepro.2010.06.004