A Research on Water Cooled System for Battery Pack of Electric Vehicle

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***Abstract*- Thermal management design for electric vehicles (EV) is very important in order to manage the thermal dissipated by operating components. The project is about cooling system which is used to reduce heat dissipation from battery and increase the life of battery pack. Electric and hybrid cars is one of the technologies to reduce the uses of fossil fuel. What is common with an electric car and a hybrid car is the use of battery to store electrical energy. To sustain high performance, long lifetime and to keep high safety in an electric vehicle it's very important to control the temperature of the battery cells. Therefore, it's important to have a sufficient and well-designed cooling system that can keep the battery cells within recommended temperature range when the car is driving.**

Index Terms- lithium-ion battery, battery module, thermal model, thermal management, Electric vehicles

I. INTRODUCTION

Electric vehicles become future of the transportation industry since it is eco-friendly and zero emission. There are certain limitations when developing electric vehicles such as life time, cost and the performance. Temperature greatly affects the performance and life of batteries, so battery thermal control must be used in electric, hybrid, and plug-in hybrid electric vehicles under real driving conditions. In recent years, automakers and their battery suppliers have paid increased attention to battery thermal management, especially with regard to life cycle and related warranty costs. By using a proper cooling system, we can reduce such limitation to a minimum level by reaching the maximum performance. For the electric vehicle main heat dissipation components are battery and motor where it should be controlled to a certain level in order to get maximum performance so thermal management system is essential key factor to the EV which improves the reliability, life time, safety of the batteries and the motor.

The EV travel range has been under focus as limiting factor for penetration of EV in the market as commercial vehicle. However, technologies in electric vehicles are not fully matured and still undergo rapid development on the thermal management for battery modules, controller and electric motor. The main concern is still on the battery module since it is the heart of an electric vehicle. Challenges in battery modules are such as recharging time, cost, vehicle driving range and cooling system. To make battery electric vehicles fit for the mass market, the energy density and efficiency of battery packs must be increased.

LITHIUM ION BATTERIES

A lithium-ion battery consists of an anode, cathode and electrolyte as well as a separator. The anode, is the oxidised electrode which removes electrons to the external circuit during discharging. Correspondingly, the cathode, is the oxidising electrode which receives electrons from the external circuit. The electrolyte is the medium to transfer ions between electrodes inside the cell and the separator is used to isolate electrodes. Also, the solid electrolyte interface (SEI) is thin passivation layer which is formed on the surface of the carbon anode during the first charge. It slows down the reaction rate and decreases the current. Secondly a Li-ion battery is rechargeable which means its electrochemical reactions are reversible. Three types of lithium batteries are particularly

suitable for an EV battery, namely LiMn2O4, LiFePO4, and LiNiMnCoO2

THERMAL ISSUE OF LI-ION BATTERY

Lithium-ion cells performance depends on both the temperature and the operating voltage. Lithium-Ion cells work well when cells operate within limited voltage and temperature. Otherwise, damage will occur to the cells and will be irreversible.

At excessive currents the Lithium-ions are deposited more rapidly than intercalation to the anode layers, Lithium ions are then deposited on the surface of the anode as metallic Lithium. This is Lithium plating. It gives rise to the reduction in the free Lithium ions and an irreversible capacity loss. There are two types of metal lithium plating, namely homogeneous lithium plating and heterogeneous lithium plating, but the lithium plating is dendritic in form. Eventually it can result in a short circuit between the electrodes. As with over-voltage, undervoltage also brings about problems which give rise to the breakdown of the electrode materials.

So it is very important to maintain the temperature of li-ion batteries within given range. When temperature ranges from 20°C to 40°C, battery power reaches maximum.

II. LIQUID COOLING SYSTEM

Besides air, liquid is another heat transfer fluid to transfer heat. There are generally two groups of liquids applied for thermal management systems. One is dielectric liquid (direct-contact liquid) which can contact the battery cells directly, such as mineral oil. The other is conducting liquid (indirect-contact liquid) which can only contact the battery cells indirectly, such as a mixture of ethylene glycol and water. Depending on the different liquids, different layouts are designed. For directcontact liquid, the normal layout is to submerge modules in mineral oil. For indirect-contact liquid, a possible layout can be either a jacket around the battery module, discrete tubing around each module, placing the battery modules on cooling/heating plate or combining the battery module with cooling/heating fins and plates. (Pesaran, 2001) Between these two groups, indirect contact systems are preferred in order to achieve better isolation between battery module and surroundings and thus better safety performance.

III. VARIOUS COMPONENTS OF ENGINE COOLING SYSTEM

1)Reservoir: It supplies the coolant to the radiator. It serves the extra amount of coolant in it and give it to radiator in the case of coolant level in radiator goes down.

2)Fan: It is attached behind the radiator to increase cooling capacity. It drew fresh air through the radiator. It increases the mass flow rate of air which increases the effectiveness of the system.

3)Radiator: The radiator is a type of heat exchanger in which the coolant transfers its heat to surrounding air by convection and conduction phenomenon. It consists of a fins attached to the no. of tubes which increases area exposed to surrounding.

4)BMS: It controls the temperature by varying the amount of coolant going to radiator.

5)Heat Pipes: It transfers the coolant from engine to radiator and again from radiator to engine.

6)Peltier:A Peltier used either for heating or cooling although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools.

IV. FEATURES

- Reduce thermal losses.
- Reduce the battery temperature.
- Increase the efficiency of electrical and hybrid vehicle.
- Reduce the danger of explosion of Li-ion battery.
- Cost effective into integrated system design.
- Promote safety and improve working condition of EV

V. LITERATURE REVIEW

1. Mohsen Mousavi et. al, designed a Li-ion battery was designed to be positioned in front of the vehicle dash panel. Longitudinal tubes were designed in a battery pack that provides a medium to pass the ambient air through the battery pack. The heat transfer model was developed for the design and an

objective function was introduced, involving the NTU and variables of cooling, tube diameters, air velocity, as well as their limits. The results show that the optimum value of NTU is obtained when tube diameters are at their upper limit and the air velocity is about 2.6 m/s for this specific design.

2. Simone Orcioni et. al, presents a complete environment forth simulation of a battery pack while considering the statistical variations of the parameters among the cells Experimental measurements were carried out to validate our model and the extraction procedure. Finally, an extension of the simulation environment at the system level can be easily done; for example, integrating the BMS with an automotive control system or the extension to a vehicle-to-grid integration.

3. Mahesh Suresh Patil et. al, studied the numerical investigation was carried to check the feasibility and analyse the oil cooling performance for Lithium ion battery pack with mineral oil as coolant. The study reveals that the mineral oil cooling can be a promising option to resolve three issues related to thermal performance of Lithium ion battery for EVs. Firstly, the bulkiness of the battery system can be reduced due to effective direct cooling method using mineral oil. Secondly, the risk of explosion due leakage of coolant into the battery system can be reduced due to electric non-conductive behaviour of mineral oil. Thirdly, the temperature uniformity can be maintained below 1 ºC, which is crucial to extend lifetime and ensure operating safety.

4] Gi-Heon Kim and Ahmad Psarian shows that Liquid cooling is more effective in heat transfer and takes up less volume, but the added complexity and cost may outweigh the merits. Maintenance and repair of a liquid cooled pack is more involved and costlier. Indirect liquid cooling, with jackets, is easier to handle than direct liquid cooling

VI. PROBLEM DEFINITION

Nowadays different blending levels of hybrid electric vehicle and pure electric vehicle available on the current automobile market. According to the blending level, various size, type and number of battery cells are mounted in EVs. Unlike conventional fuel, battery cells as an energy source have stricter requirement on working environment. They are especially sensitive to temperature. To ensure a proper thermal working environment, a Battery Thermal Management System (BTMS) will normally be integrated with battery cells. Thus, knowledge about the proper working requirements of battery is vital, and what kind of management systems can sufficiently and efficiently meet these requirements. With this cornerstone, the performance and durability of battery pack can be maximized in an electric vehicle. Furthermore, the electric range of vehicle is restricted due to limited capacity of the battery. It is very useful to investigate carefully the electric energy consumption of BTMS and to look for potential savings. This investigation will help battery performance by reducing the energy consumption of BTMS and extending the electric range of EVs.

VII. OBJECTIVE

- The primary function of the cooling system is to maintain the battery temperature at certain limit.
- Increase the efficiency of battery pack.
- Increase the efficiency of electric vehicle.

VIII. DESIGN OF COLLING SYSTEM

I)Selection of material

As the material plays important role while working of a system. It is necessary to consider all parameters of a material which affects the performance of cooling system. The main goal of the car is to minimize its overall weight, so it becomes important to design a cooling system which has minimum weight. While selecting material we have to take care that the material should be less in weight and also has high heat transfer rate. Material also electrically conductive. So we select copper pipe.

Thermal Conductivity	394 W/m K
Density	8.94 g/cm3
Specific heat capacity	394 J/Kg K

Table 2: properties of copper

II) Selection of coolant

We use Distilled water as a coolant in cooling system. Water causes the metal parts, ions so there is possibilities of corrosion. Distilled water is neutral, non-conducting there are no ions, there are only

neutral water molecules and these neutral molecules don't have charge.

Property	Specification
Density(kg/m^3)	1000
Specific Heat capacity(J/Kg K)	4185.5
Dynamic Viscosity(Pa.S)	8.90×10^{-4}
Thermal conductivity9W/mK)	0.556

Table 2: properties of Distilled water

III) Selection of cooling method

Due to High energy and power densities Lithium-ion batteries are very important component of electric vehicle. But major challenge using with li-ion batteries is thermal management. So effectiveness of thermal management system is vital in order to maximize the lifetime performance of pack. There are many different techniques that can be used to thermally managed batteries in electric vehicle. Here we are used either air or liquid cooling system in direct or indirect way. But air cooling system is not as efficient as liquid cooling system. In liquid cooling system we use mineral oil water or distilled water as a coolant. Also by adding a cooling plate in between two battery pack layers, which helps to transfer the heat from battery pack to the atmosphere. In addition, we can cool different areas of the cells i.e. surface or tab cooling system. Li-ion is made of different layers. So in surface cooling side layers get cooled but the inside core of Li-ion batteries gets heated and degradation of li-ion batteries takes place. Performance, efficiency of batteries gets decreases. But in tab cooling system cooling starts from inside layer and give better performance than the surface cooling system.

IV) Battery pack design

We design cooling system for li-ion battery pack which is used in electric vehicle. We use tab cooling system and distilled water as a coolant. We use cooper tab in this cooling system, which can good conductor of electricity and having good heat transfer rate. The tab is mounted on battery on both side in which pipe is going to attached. The pipe is arranged as 's' means as a serpent manner. So coolant is get contact with the cell more time. The cad model for the battery pack cooling system is shown in fig.

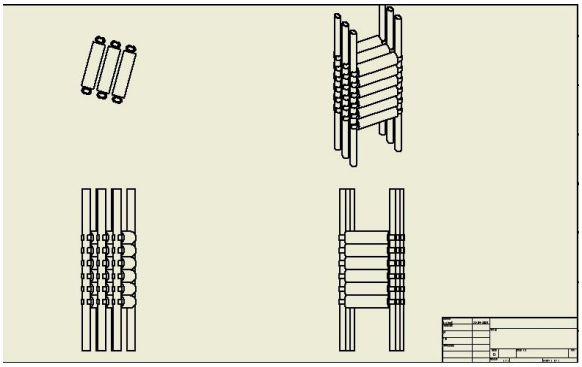

Fig 1: battery pack cooling system design sheet

In which each cell is connected with the copper tab as shown in fig. The tab is connected to the cell with help of soldering.

From this tab pipe is passed and get connected with other cell.

From which coolant is get passed.

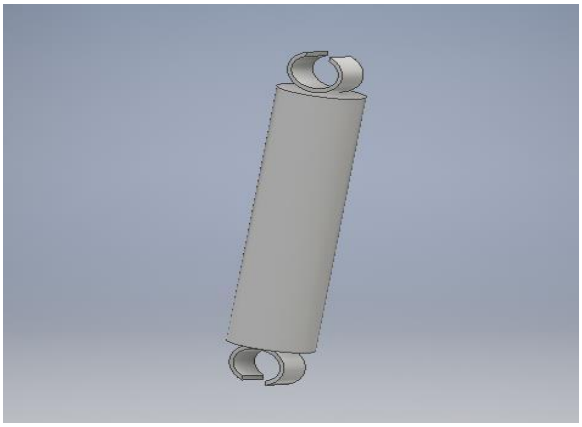

Fig2: Inventor model of cell

IX. CONCLUSIONS

With the increasing consumption of natural resources of petrol, diesel it is necessary to shift our way towards alternate resources like the Electric bike and others because it is necessary to identify new way of transport. Electric bike is a modification of the existing cycle by using electric energy and also solar energy if solar panels are provided, that would sum up to increase in energy production. Since it is energy efficient, electric bike is cheaper and affordable to anyone. The most vital feature of the electric bike is that it does not consume fossil fuels thereby saving crores of foreign currencies. So cooling system for battery pack in electric vehicle is very important, which increase efficiency of electric bike.

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