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To Increase Efficiency of Battery by Thermal Analysis

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A B S T R A C T

In hybrid electric vehicles (HEVs), thermal control of battery packs is critical for maximizing pack performance and life. Thermal study and testing of a battery pack for the GMIDOE series HEV made up of high-power lead-acid battery modules. For adjusting module temperature in the HEV battery pack, forced air was used as the medium. For even temperature distribution in the pack, a unique air manifold was employed to provide airflow uniformly to each module.

Keywords:Battery, Thermal analysis, Heat transfer, Efficiency of EV cell, Loss of power, Electrical power conversion.

Nomenclature

Nominal Capacity @ C/5 (Ah)
AverageOperating Voltage@ C/5 (V)
Internal Impedance@ 1kHz, AC (mΩ)
ContinuousDischarge (A)
Charge Current (A)
HighOperating Temp (°C)
Low OperatingTemp (°C)

1. Introduction.

Evaporation is a widely used method for concentrating aqueous solutions. It requires boiling the liquor in a suitable vessel, such as an evaporator, and then extracting the vapour. If dissolved materials are present in the solution, the resulting strong liquor may become saturated, causing crystals to form. The following are the several types of liquids that can be evaporated:
Today's vehicles run in a wide variety of temperatures. Future HEVs would be able to function in both cold and hot areas. As a result, performance tests using the Optima module were carried out at various operating temperatures. Peak power tests and operating under FUDS 1.0 profiles in HEV operation for various amp-hour (Ah) depletions were among the performance tests. The 1.0 factor reflects its relative power to the regular FUDS. FUDS stands for "federal urban driving schedule." The battery efficiency and charge/discharge resistance were estimated using the FUDS 1.0 profile. The testing were

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carried out in an Aerobatha climate apparatus with temperature control and air circulation. Throughout the testing, the core battery temperature (measured via a thermal well) was kept within 2 degrees of the target value.

1.1. Working of Battery

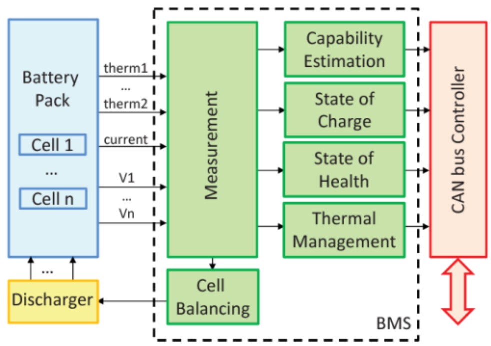

Fig 1 Flow of Current throughBattery [1]

The lithium-ion battery is the most popular type of battery used in electric vehicles. This type of battery is used in most portable electronics, including cell phones and PCs, so it may sound familiar. Lithium-ion batteries have a good high-temperature performance, a high power-to-weight ratio, and a high energy efficiency. In fact, this implies that the batteries can store a lot of energy for their weight, which is important for electric cars because lighter cars can drive further on a single charge. Lithium-ion batteries also have a low "self-discharge" rate, which means they maintain their ability to hold a full charge over time better than other batteries.

Furthermore, most lithium-ion battery parts are reusable, making these batteries an environmentally friendly option. This battery is found in both AEVs and PHEVs, albeit the chemistry of these batteries differs from that of consumer electronics batteries.

1.2 Thermal analysis of battery

Thermal analysis is done as per the following criteria.

1. Individual batteries have their own operational temperature ranges.
2. Many Li-Ion cells do not function well above 60 °C.
3. A good understanding of the thermal behavior of the batteries has its significance during designing safe and robust battery packages.

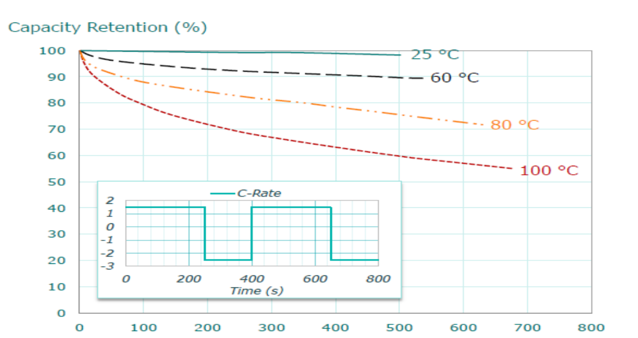

Figure 1 . Capacity Retention Vs Cycle Numbers

Thermal management system numerical simulations have shown to be a good tool to research and enhance battery design at a fraction of the cost of actual testing. A well-defined and constructed simulation approach can aid in precisely predicting thermal thermodynamics inside a battery, making it a useful tool throughout the early phases of the design process.

From simple lumped capacitance models on one end of the spectrum to full-blown 3D simulation models on the other, several different simulation models have been used to analyze the thermal performance of a battery cell. All of these models, however, are built using the same basic components of the fundamental energy balance equation: (a) what are the heat generation sources? (a) What are the battery cells' geometric and thermal properties? Finally,

(c) What kind of cooling system is in place? To fit the desired accuracy and cost constraints, different models account for these components to differing degrees of fidelity.

There are two sources of heat:
1 Electrochemical operation, which is concerned with the heat produced by chemical reactions within the battery.
2 Joule heating, commonly known as Ohmic heating or heat produced by electricity flow.

2. Observation of Heat release quantity

The theoretical model was employed for the model analysis, and the output of the model was compared to the real process output as in The values experimentally determined by [3] et al. were used to determine the beginning values of the battery parameters. With an approximate inaccuracy of 5%, the model output for the first measurement set utilizing empirically obtained parameters was found to be rather adequate. The variances for both output measurements were reduced by iteratively adjusting the values of the experimentally measured parameters using the Trust-Region-Reflective algorithm and a nonlinear least square approach. The new parameter values were determined to accurately represent the measurements with an approximate variation of roughly 0.5–1%.

3. Battery details

Observations of heat conduction inside the core and poles were done in order to determine the proper battery model to be employed. The electroactive part of a cell (the core) has a transversal heat conductivity of around 0.8 [W/K-m] [16], and the typical length is about 20 [mm], therefore the heat conduction inside the core is = 40 [W/K•m]. It is also calculated that the heat conduction in the cell's 5 [mm] thick polypropylene casing is = 30 [W/K-m]. This is based on polypropylene's average heat conductivity of 0.15 [W/K-m] [17]. As measured in the laboratory, the heat conductivity of the case to the ambient is 6.9 [W/K-m] (which is a not ventilated room). Also, because the article focuses on the temperature of the core and poles, and all heat dissipation occurs in the poles and core, and they contribute the most to a cell's total heat capacity, the number should be calculated as the ratio of heat conduction inside the core to conduction outside the core. Inside the core, heat conduction is 40 [W/K-m]. Heat conduction outside the core is equivalent to 5.6 [W/K-m], which is the sum of heat transmission through the casing and convection. As a result, a lumped thermal model can be assumed with a -number of 0.14.

However, because the internal design of a battery is not usually well understood, a model is offered that is characterized by only three heat capacities (2 poles and the core) and the related thermal resistances. Heat capacity are physical quantities that are constant and nearly time invariant, and may be calculated or determined through experiments. The determination of heat capacity (among other things) is incorporated in the parameter identification process in this contribution.

4. Results of Battery heat data

The pack thermal management system's purpose is to keep the modules cool when driving a HEV or a zero-emission vehicle (ZEV). Second, the thermal management system should reduce temperature gradients in the pack when cooling it. The module was cooled using ambient air according to the test bed vehicle's requirements. This restricts module cooling to that of ambient air, making it impossible to cool the pack at high ambient temperatures.

The battery pack for the series HEV was made up of 30 (16.5-Ah) Optima modules, which were organized into two decks of 15 modules each (two of the modules were used as service batteries for vehicle starting, ignition, and lighting).
The battery pack is around 1.8 meters long and lies between the driver and front passenger seats in the vehicle's center. The thin area in the front of the car is one module broad, while the wide piece in the back seat section is two modules wide. A pair of pressurized air plenums that jet air along the sidewalls of each module make up the pack thermal management system. Ambient air is drawn through the two plenums by a blower at the back of the pack. It is vital that pressure along the length of the plenum be uniform in order to provide uniform cooling to each module.

We determined the size of the holes and the shape of each plenum through tests and trial and error in order to offer a uniform flow rate to each module even in the transition from narrow to wide sections while retaining a low airflow path resistance.

The new air flow path design had an air flow uniformity of 7.5 percent, which was significantly better than the previous best design, which had a flow uniformity of 25 percent. These design suggestions were incorporated into the most recent battery pack assembly, which was then installed in the GM/DOE test vehicle.

Several battery packs utilizing the heat management technology described here were built and tested. The pack is divided into four pieces to simplify discussion of the thermal performance test results: upper single-wide, upper double-wide, lower single-wide, and bottom double-wide. This relates to the upper and lower decks, as well as the one and two module wide sections. Figure 9 depicts the subsections. The thermal tests were designed to establish the pack's steady-state operating temperature during HEV operation, heat transfer rate during HEV operation, pack thermal gradients during HEV operation, and module warm-up time during ZEV operation. AeroVironment's ABC-150 Battery Cycler was used to cycle HEVs using FUDS 1.0 and FUDS 1.3 profiles with a specific auxiliary power unit strategy. The pack was wrapped with a thermal blanket during all tests in which it was out of the car to imitate the insulation of the battery box in the vehicle. This was done to avoid radiation losses that would occur if the pack were not in the vehicle. The pack received 66 litis (140 cfm) when the fan was turned on full power. Throughout the experiments, the temperature in the lab was between 22 and 23 degrees Celsius. At 8°C, ice will have formed on the heat transfer surface, reducing performance significantly. As a result, wastewater must be discharged at this temperature, and if the required heat is still not available at this time, the fan will turn on.

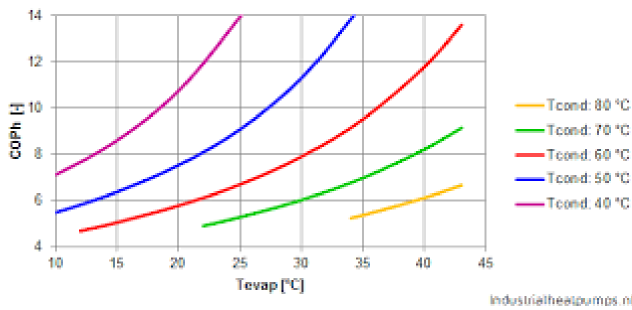

Fig 2.COP at various conditions.[3]

Conclusion

Because of the multiphysics character of this problem, certain features of each of these approaches have been simplified. As a result, there is always space for growth. The following is a list of only a few of these difficult aspects:

Researchers have been able to account for more of these variables properly and efficiently as processing capacity has increased. Increasing our trust in simulations' ability to forecast outcomes. Despite the obstacles that remain, numerical simulations have made a significant contribution to the development of better thermal management systems for battery design and will continue to do so in the foreseeable future.

Thermal management solutions are required in HEV battery packs to keep module temperatures uniformly within the specified operating range. Thermal analysis and tests for the modules and the pack are required to properly develop a thermal management system. Thermal analysis and testing were used to design and build the pack thermal management system for the GMIDOE series HEV's high power battery pack. The temperature management system in the pack worked as expected. It cooled the modules uniformly, with the exception of the high thermal load of the hybrid FUDS 1.3 operation, which was caused by the inability of the selected fan to deliver a greater airflow rate due to higher than predicted resistance in the airflow route.

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