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Performance Improvement of Multi-type Batteries for Electric Vehicles Using Python Programming

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Abstract— In recent times, Electric Vehicle for domestic transportation has seen a significant increase. As per Federation of Automobile Dealers Association-sourced industry statistics, retail sales of EVs there is a 218% increase in FY2022 when compared with previous year. The EV has different and some crucial component which decide the functioning of EVs efficiently, of which Batteries are the most significant ones. It is conventional to use batteries manufactured from single source material. Batteries accounts for29% of Electric vehicle density. So reducing the weight of the battery would actually increase the efficiency of the vehicle in performance and occupancy of the passengers for the same ratings of the drive. In this project it is aimed to use Multi-type batteries for EVs, which have different weight densities. In this work when batteries of different density were used the drive setting were undisturbed. The problem associated with multi- type batteries is that temperature has to maintained and necessary counter cooling techniques should be needed. The result of the project is focused on the batteries parameters control for having the desired performance.

I. INTRODUCTION

In the year 1996 General Motors (GM) introduced the EV1, an all-electric vehicle powered by a large lead-acid battery. The EV1 was well received, but due to a number of financial, legal, and technical issues led GM to end car's lease programmed in 2002. The EV1 was generally seen as a failure rather than the beginning of the era of electric vehicles. But now, in part because of significant advancements in battery technology, electric vehicles are finally getting their due. Nissan will start selling the Leaf, an all-electric passenger car with a 100-mile range, and GM will start selling the plug-inhybrid Chevrolet Volt later this year. Tesla Motors acquired a former Toyota facility inFremont, California, in May to start producing its all- electric Model S-sedans there. Electric vehicles are gaining popularity because of the advantages they provide for the environment and energy security. By moving that demand to domestic electricity production, reducing the demand for gasoline would aid in reducing reliance on imported oil.

Depending on whether their electric power originates from fossil fuels or renewable sources—a combination that varies from country to country—electric vehicles will either help cut greenhouse gases or not. What will it take for plug-in hybrids and all- electric vehicles to become widely used? Battery- powered cars should be reasonably priced, have a range that can handle the typical commute, and have a fair recharge time. To meet all of these demands, battery technology must advance continuously, and a recharging station infrastructure must be built. The hybrid vehicles of today, like the Toyota Prius, use nickel-metal hydride batteries, whereas the new generation of vehicles uses lithium-ion batteries. The disparity in power requirements between plug-in hybrids and hybrids has been the driving force behind the switch to lithium-ion. When the engine is operating inefficiently, like while idling or accelerating and decelerating, it engages. As with a conventional car, the driver simply needs to top off the gas tank because regenerative braking recharges the battery. In a plug-in hybrid (PHEV), like the Chevrolet Volt, the drive train is powered by the battery, with a backup provided by the internal combustion engine in case the battery runs out while the vehicle is in motion. For a battery recharge that could take several hours, the driver plugs in the vehicle. The Nissan Leaf is an example of an all-electric car that runs solely on battery power. These cars are often referred to as battery electric vehicles (BEVs). This study focuses primarily on two types of batteries, which are represented by thetwo following three instances.

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II. VARIOUS BATTERY TYPES

This study focuses primarily on two types of batteries, which are represented by thetwo following three instances.

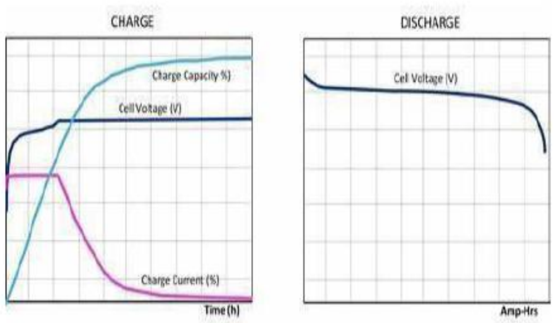
- Individual lithium-ion battery
- Individual li-polymer battery
- Both li-ion and li-polymer

Case 1: individual lithium- ion battery

The advantages of lithium-ion batteries for vehicle applications are their light weight, high energy density, lack of memory effect,and ability to be recycled. Lithium-ion batteries are now widely used in portable consumer gadgets. However, an automobile places significantly greater demands on a lithium-ion battery than a phone or laptop do. A battery for a plug-inhybrid electric vehicle (PHEV) with a 40- mile range should be able to withstand 5,000 charging cycles, last 15 years at 35°C, weigh no more than 120 kg, and cost $3,400 at maximum production, according to the U.S. Advanced Battery Consortium, whose members include Chrysler, Ford, and GM (100,000 units per year)."No battery meets all of the mass and volume goals today," said Mark Verburgge, director of the Materials and Processes Laboratory at the General Motors Research and Development Center in Warren, Mich. Advances in the materials used in the cathode, anode, and electrolyte have helped to improve the performance and lower the cost of lithium-ion batteries. Cathodes in conventional lithium-ion batteries are made of lithium cobalt oxide ($LiCoO_2$), but due to safety concerns, researchers have moved towards using other materials in vehiclebatteries.

Python program for case 1:

```
Import pybamm
model=pybamm.lithium-ion.spm()
Sim=pybamm.simulation(model)
Sol=sim.solve([0,3600])
Pybamm.dynamic plot(sols)
```



Case 2:li-polymer battery analysis

The lithium polymer battery cell under consideration is rated at 3.7 volts and 100 Ah. A power rating could not be determined in the same way. The battery has a volume of 1.065 litres and measures 0.72cm thick, 45.5cm wide, and 32.5cmlong. The weight of the battery is 2.7kg. This corresponds to a specific energy density of 373 Wh/L and a specific energy density of 146 W-h/kg. These ratings will beevaluated, and the power capacity determined [5]. The manufacturer estimates the battery life cycle to be over 1200 cycles at 80% depth of discharge. The lithium battery has a low self discharge rateof about 5% per month, compared to over30% in nickel metal hydride batteries and 20% in lead acid batteries.

Chemistry:

The lithium polymer battery makes use oflithium cobalt dioxide as the positive electrode and a highly crystallized specialty carbon at the negative electrode. Both reactions are mediated by electrolyte. Liquid electrolyte in lithium polymer battery consist of $LiPF_6$ (Lithium Hexafluorophosphate) and organic solvents.

Positive Electrode:

$$LiCoO_2 \leftrightarrow Li_{(1-x)}CoO_2 + Li + xe^-$$

Negative Electrode:

$$C_n + xLi + xe^- \leftrightarrow C_nLi_x$$

Overall:

$$LiCoO_2 + C_n \leftrightarrow Li_{(1-x)}CoO_2 + C_nLi_x$$

Python program for case 2:

```
Import pybamm
model=pybamm.lithium-polymer.spm()
Sim=pybamm.simulation(model)
Sol=sim.solve([0,3600])
Pybamm.dynamic plot(sols)
```

Performance curve for li-polymer battery

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Case 3: li-ion + li-polymer

The li-ion battery and li-polymer batteries both combining the by using the Pybamm software in this software plotting the graphs. Two batteries are connecting by using switches according to requirement they connected series or parallel.

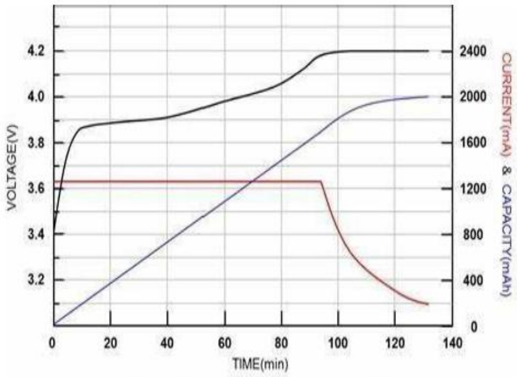
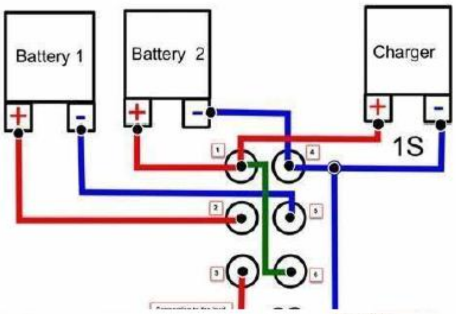
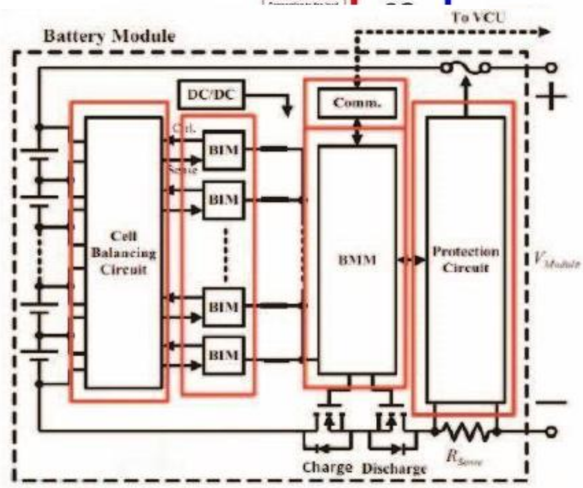


Fig. 2: Connection diagram of both batteries

Python program for case 3:

Import pybamm model= {

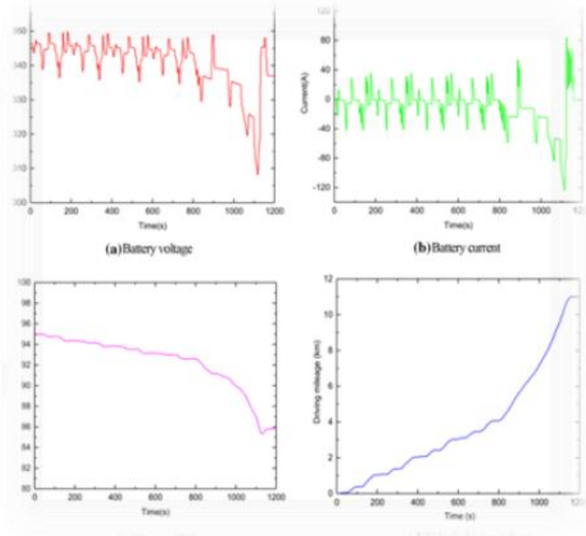




pybamm.lithium -ion.spm()
pybamm.lithium -polymer.spm()
}
Slos=[]

For model in models:
Sim=pybamm.simulation(models)Sol=sim.solve([0,3600])
Sols=append(sol)
Pybamm.dynamic plot(sols)

Graphs for the both li-ion and li-polymer as given below



III. BATTERY MANAGEMENT SYSTEM

Battery Management System (BMS) is simply battery monitoring which keeps checking on the key operational parameters during charging and discharging such as voltages, currents, and temperatures (internal and ambient). The BMS normally provides inputs to protection devices which generate alarms or disconnect the battery from the load or charger when any of the parameters become out of limits. The major objectives of BMS are [13,14]: (1) to protect the cells or the battery from damage; (2) to prolong the life of the battery; and (3) to maintain the battery in a state in which it can fulfill the functional requirements of the application for which it was specified. Thus, the BMS may incorporate one or more of the following functions: cell protection, charge control, demand management, state of charge (SOC) determination, state of health (SOH) determination, cell balancing, communication, and etc.

Fig. 2(a) shows the BMS which was developed in the previous study [1]. The SOC of each cell can be monitored by a BIM (Battery Interconnect Manager), as shown in Fig. 2(b), and each BIM is instructed by the BWM (Battery Module Manager), as shown in Fig. 2(c), to communicate with its next neighbor BIM through a communication bus [15]. Once overcharging or over-discharging of a cell occurs, the BIM reports to its supervised BWM and self-purge to maintain the safety of the system. The BIM configuration provides very easy interface with its neighbors and offer the salient of feature and block digram given below.

IV. PYBAMM SOFTWARE

PYBAMM offers improved collaboration and research impact in battery modeling by providing a modular framework through which either existing or new tools can be combined in order to solve continuum models for batteries. For example, PYBAMM can easily be adapted to incorporate new models, alternatives partial discretization, or new time-stepping algorithms. Any such additions can then immediately be used with the existing

```
pip install pybamm
```

suite of models already implemented, and comparisons can be made between different models, discretization, or algorithms with variables such as hardware, software and implementation details held fixed. Similarly, additional physics can be incorporated into the existing models, without needing to start from scratch to study each new effect. This facilitates the simultaneous study of a range of extensions to the standard battery models, for example by coupling together several degradation mechanisms. PYBAMM is one of the major components of the Faraday Institution's 'Common Modeling Framework', part of the Multi-Scale Modeling Fast Start project, which will act as a central repository for UK battery modeling research. PYBAMM has already been used to develop and compare reduced-order models for lithium-ion and lead-acid batteries, and further research outcomes are antacid. the programof three cases are given below

Installation of PYBAMM
Prerequisites
Install PyBaMM
User install
Uninstall PyBaMM
Installation using WSL

Prerequisites
To use and/or contribute to PyBaMM, youmust have Python 3.8or 3.9 installed.
To install Python 3 download the installation files from Python'swebsite.
Make sure to tick the box on Add Python 3.X to PATH. For more detailed instructions please see the official Python on Windows guide.

Install PyBaMM
User install
Launch the Command Prompt and go to the directory where you want to install PyBaMM. You can find a reminder of how to navigate the terminal here.
We recommend to install PyBaMM within a virtual environment, in order not to alter any distribution python files.

To install virtualenv type:

```
python -m pip install virtualenv
```

To create a virtual environment env within your current directory type:

python -m virtualenv env
You can then "activate" the environment using:

```
env\Scripts\activate.bat
```

Now all the calls to pip described below will install PyBaMM and its dependencies into the environment env. When you are ready to exit the environment and go back to your original system, just type:

Deactivate
PYBAMM can be installed via pip:

PyBaMM's dependencies
(such as numpy, scipy, etc) will be installed automatically when

you install PyBaMM using pip.
For an introduction to virtual environments, see *(https://realpython.com/python-virtual-environments-a-primer/).*

Uninstall Py BaMM
PyBaMM can be uninstalled by running in your virtual environment.
pip uninstall pybamm

Installation using WSL
If you want to install the optional PyBaMM solvers,

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you have to use the Windows Subsystem for Linux (WSL). You can find the installation instructions here.

V. CONCLUSION

In this work, three cases were considered for performance analysis of the batteries. Among all cases, case-3 were li-ion and li-polymer batteries of are taken as a combo to analyze the performance of battery through parameters like Voltage, current, capacity, charging and discharging. For modeling *Pybamm* tool is used and the results obtained shows that the combination of employing two different types of batteries give result which are promising.

VI. FUTURE SCOPE

- Two different batteries are using this paper one is li-ionand li-polymer.
- One battery is fully charged by the grid
- This charged battery is given to the power supply to the motor of electric vehicle now the EV is running condition.
- By applying the regenerative braking tothe EV charge the battery.
- And another method is the on top of the electric vehicle arrange the solarpanels and it is renewable energy using this energy charge the battery in running condition.

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