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Development of Next Generation Battery for Hybrid Electric Vehicle

- Development Status in Vehicle Energy Japan -

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ABSTRACT: Vehicle Energy Japan have been promoting the development of lithium-ion secondary batteries for automobiles for about 20 years. In recent years, based on the knowledge gained so far, we have been promoting the digitalization of development with the main purpose of shortening the development period. Although the design and production of batteries is an analog world, by digitizing the characteristics that appear and incorporating the battery control logic developed by our company, we have made it possible to provide battery models that can be evaluated by vehicle OEMs. In this paper, we will introduce our latest battery development status and an example of the above battery model.

KEY WORDS: hybrid electric vehicle, lithium-ion battery, high power cell, battery management system, battery model

1. INTRODUCTION

Globally, the tightening of automobile fuel efficiency regulations is becoming increasingly serious to prevent global warming and achieve carbon neutrality. Storage batteries are a competitive strategic commodity, and support policies for realizing local production for local consumption in major countries are progressing. Suppliers of battery materials and equipment are also required to build global supply chains. In major markets, electrified vehicle production will grow rapidly from 2019 onwards. Accelerating shift to electrified vehicles (electrified vehicle composition ratio: 16% in '21→ 48% in '26→ 63% in '30)

Also, Hybrid electric vehicle (HEV)　market: 21-26 years Expanding at a high growth rate (HEV market: 31% average annual growth rate). From the backdrop of policies in various countries, a rapid shift to electrification and a large supply of batteries are required.

(1) Carbon footprint reduction (2) Local production (3) Cost reduction (4) Recycling/Reuse are required to battery supplier. Battery suppliers must to answer a lot of requests from the markets.

2. Cell Development Status for Hybrid Vehicle in VE-J

2.1. Direction of Cell Development

Automotive lithium batteries can be roughly divided into power type and energy type according to their application. Each has completely different performance. In HEV applications, power batteries are applied. In HEV batteries, there is a high demand for high power (= high current) in a small cell, and a higher load is required than Electric vehicles (EVs), so a battery design with excellent small load resistance is required.VE-J focus on power type cell for hybrid vehicle in these years.

2.2. Battery cell line-up

In order to meet the ever-increasing demand for high power of HEV batteries, we have evolved the materials and improved the power characteristics.　Mass production of fifth-generation cells begins in 2019.

Table 1. Cell line-up for HEV in VE-J

	Gen.3 (Cylindrical)	Gen.4 (Prismatic)	Gen.5 (Prismatic)
Size (mm)	 Φ40 x 92	 120 x 80.5 x 12.1	 120 x 65 x 12.5
Weight (kg)	0.26	0.24	0.20
Capacity (Ah)	4.4	5.2	5.0
Power density* (W/kg)	3,000	5,000	6,500
Energy density (Wh/kg)	60	80	93
Cathode material	NCM	NCM	NCM
Anode material	Amorphous	Graphite/Amorphous	Graphite
SOP	2013	2015	2019

2.3. Battery cell performance

With evolution of cell generation, power characteristics improve at both room temperature and low temperature. Gen.5 cells are more than twice as powerful as Gen.3 cells.

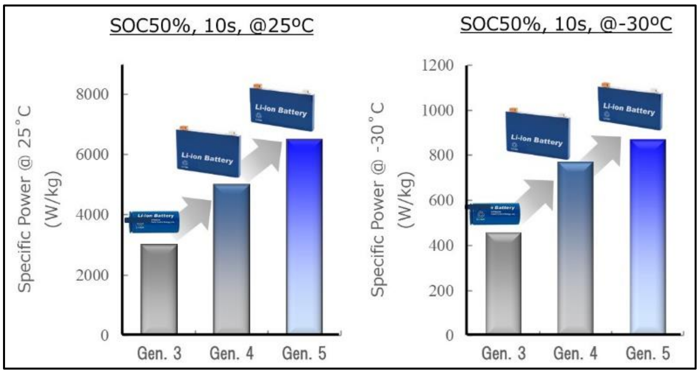

Fig. 1. Specific power improvement along with cell generation

3. Battery Development based on Battery model

Battery systems, which are key devices for electric vehicles, must ensure safety, reliability, and quality in various harsh in-vehicle environments. Up to now, it is important to clarify the requirements and verify them with various evaluations (testing) in actual measurements. By creating a battery model (digital) that links battery design and battery evaluating results (analog), the accuracy of the battery control system (BMS) and vehicle system can be verified in a short period of time. Battery models can be realized efficient development of battery system.

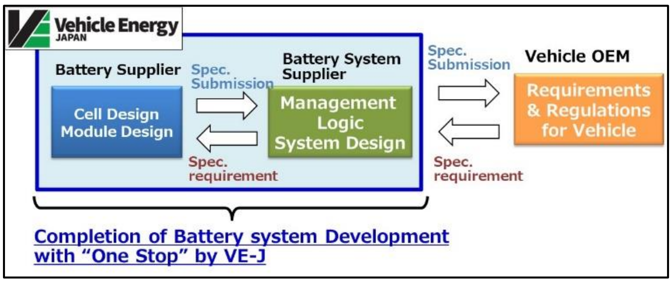

Fig. 2. Image of "One-stop" Development of Battery System

VE-J possesses cells, modules, and BMS, also has rich experience in battery control. We have Battery understanding, system understanding, and get acquainted customer requirements can build optimal control logic. Shortening development time and ensuring reliability with customer systems need "One Stop" development of VE-J's strong point. Also, control technology that maximizes battery performance for vehicle life and incorporating battery status detection and life prediction technology are our advantage.

Based on the battery evaluation technology, we have cultivated so far, we have built a battery model that can reproduce battery behavior. The battery model implements a voltage, temperature, and deterioration model.

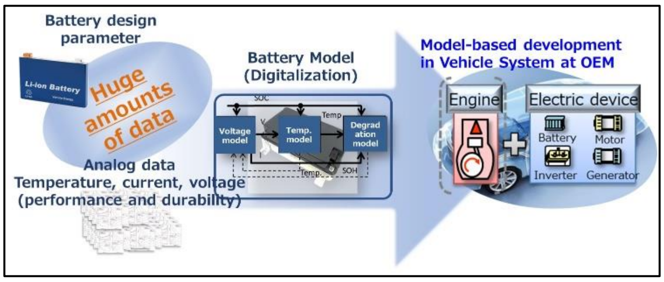

Fig. 3. Scheme of battery development based on battery model

Based on the battery evaluation technology we have cultivated so far, we have built a model that can reproduce battery behavior. Evaluation and analysis of the state of the positive and negative electrodes individually from the battery discharge curve.

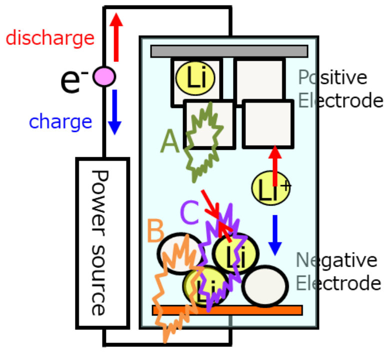

Fig. 4. Schematic view of an internal behavior, cell reaction of lithium ion battery cell.

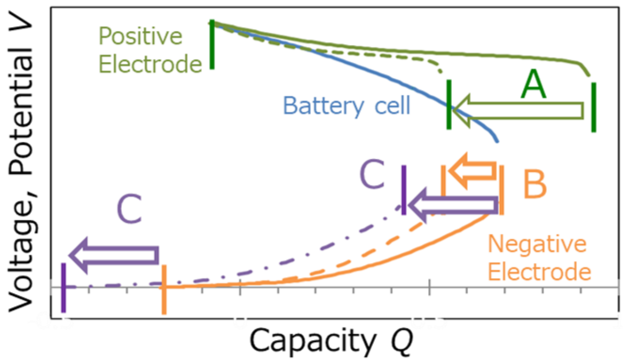

Fig. 5. Image of battery cell voltage discharge curve, and it's breakdown to positive and negative electrode potential.

Incorporating battery parameters extracted by our original evaluation technology into battery models.

Voltage model; Implement equivalent circuit parameters according to battery state (SOC/temperature/degradation).

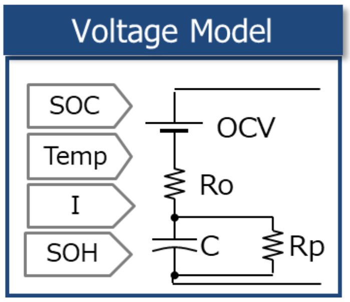

Fig. 6. Schematic view of "Voltage model".

Temperature model; Lightweight, high-speed, and highly accurate battery internal temperature estimation using a thermal network.

Deterioration model; High-precision deterioration prediction by factor-isolated deterioration prediction formula.

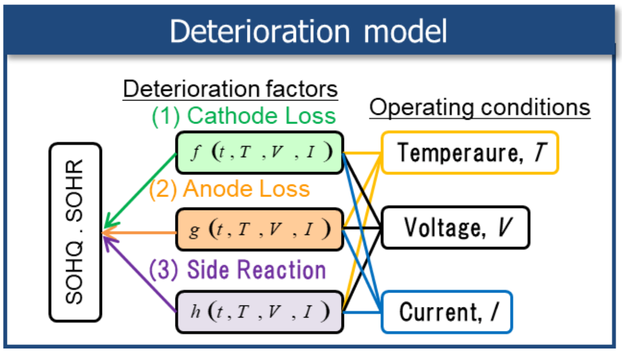

Fig. 7. Schematic view of "Deterioration model".

The constructed battery model is used for control technology to maximize battery performance.

Control conditions are controlled on-board by utilizing a high-precision battery model and incorporating a deterioration model based on life prediction technology. Based on lifespan management, the battery is used up.

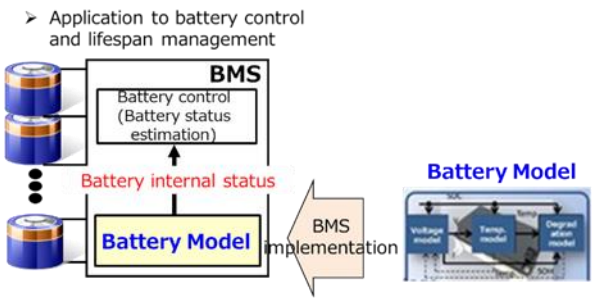

Fig. 8. Schematic view of battery model implementation to BMS.

In addition to being used for system studies within our company, it is provided to customers and can be used for customer vehicle model base development.

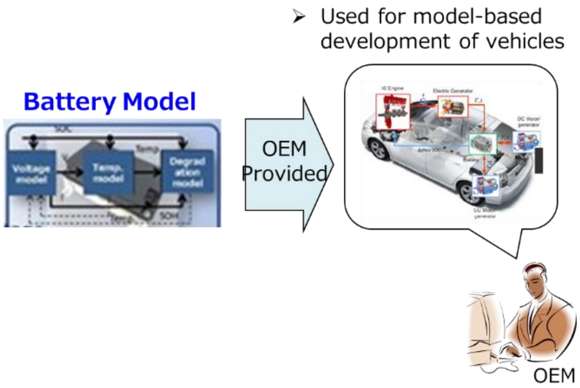

Fig. 9. Schematic view of battery model providing to OEM.

We think that the future of BMS is based on model-based development, and the knowledge accumulated as a battery manufacturer is used for lifespan management. Responding to reuse/recycling trends.

One of the lifespan management is "Control for single use". This management is exhausting battery to ensure its performance and to finish the role firmly in automotive applications, single use. Increasing the operating range or controlling output distribution according to deterioration progresses.

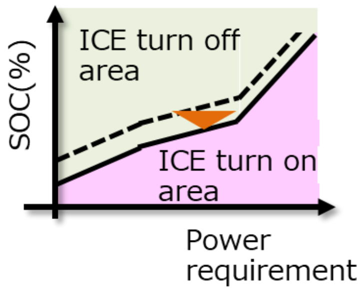

Fig. 10. Image of lifespan management "Control for single use"

Another of the lifespan management is "Control for re-use". (control that remains). This management is targeting secondary use, control to make it last as long as possible.

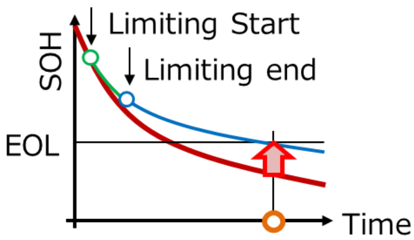

Fig. 11. Image of lifespan management "Control for re-use"

4. CONCLUSION

VE-J have developed a "battery model" that incorporates a battery control algorithm into a voltage, temperature, and degradation model that reproduces the performance of cells with the world's top power characteristics. Utilizing battery models to quickly clarify issues and propose solutions for next-generation electric vehicles. Utilizing high-precision battery models and refined simulation environments, we contribute to further value-added vehicle systems.

REFERENCES

(1) T. Itabashi, “Development of next-generation automotive LIB,” *xEV Testing Initiative 2022*, Japan, September 28-30, 2022.