NEC Energy Devices' LIB Electrodes - Their Features and Production Results

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Abstract

NEC Energy Devices develops, manufactures and sells lithium-ion secondary (rechargeable) batteries. For automotive applications, we handle production of electrodes, while Automotive Energy Supply Corporation handles production of cells and other components. Because it is critical that it be possible to mass-produce electrodes used in electric vehicles, while assuring the highest levels of safety and quality, in 2008 we began laying the groundwork by joining forces with NEC's MONOZUKURI Innovation Division to design a plant capable of becoming the world's number-one electrode production line. Mass production and shipment of electrodes for the Nissan Leaf electric car began in July 2010. Since then we have continued to produce and ship electrodes with no quality issues or delivery problems. In this paper, we will focus on the features of our electrodes and discuss their production results.

Keywords

lithium-ion secondary battery (LIB), electrode, electric vehicle (EV), energy storage system (ESS)

1. Introduction

A lithium-ion secondary battery (LIB) has higher energy density than other secondary batteries, so it has conventionally been used for mobile devices such as mobile phones and notebook computers. However, as concern for the environment and demand for energy saving products grow, the market for LIBs is now expanding into electric vehicles (EVs) and electricity storage applications. These large-scale applications require an enormous amount of batteries, meaning that battery production capacity will have to be expanded, requiring a huge investment in manufacturing facilities.

To better meet the demands of automotive applications, we set up the Automotive Energy Supply Corporation (AESC) - a joint venture between NEC and Nissan. AESC was to be responsible for the cell production process and those that followed, while NEC Energy Devices would handle electrode production. Since quality defects in automobiles can lead directly to injury or death, high safety quality standards are essential for batteries and electrodes.

In this paper, we will introduce the features and results of our large-scale electrode production for EVs.

2. LIB Manufacturing Process

Fig. 1 shows the main flow of manufacture of LIBs.

As we mentioned earlier, NEC Energy Devices is an integrated manufacturer of LIBs for applications other than automobiles. For automobile applications, however, we are responsible only for electrode production. Once manufactured, the electrodes are shipped to AESC in Zama, Kanagawa Prefecture or to Nissan plants overseas

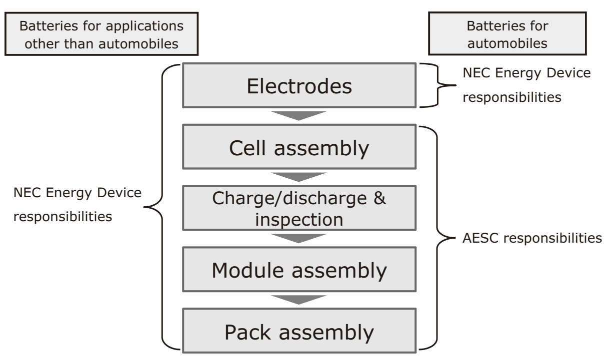

Fig. 1 LIB manufacturing process flow chart.

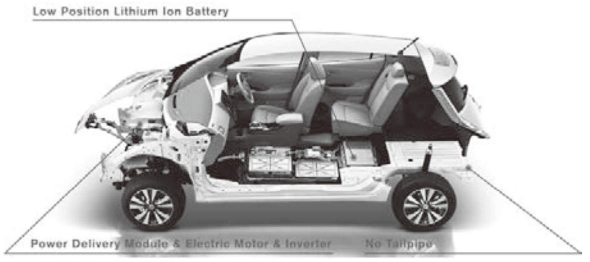

Fig. 2 Battery mounting of the Nissan Leaf.

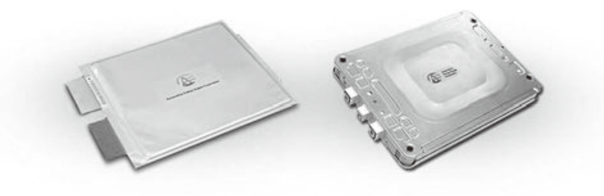

Photo Cell (left) and module (right) manufactured by AESC.

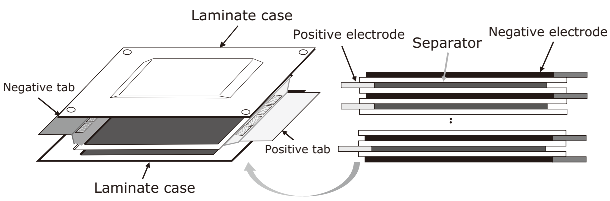

Fig. 3 Cell configuration diagram.

via AESC, in which case we handle the entire production from cell production to the module pack assembly on site.

Now, we will describe the configuration of the LIB using the Nissan Leaf EV as an example. **Fig. 2** shows the battery mounting of the Nissan Leaf, and **Photo** shows the external appearance of the cell and module manufactured by AESC.

The Leaf's battery pack is comprised of 48 modules in series connection that are composed of four 2-serial/2-parallel cells with 360 V electric voltage and 24 kWh capacity. Thus, one vehicle uses 192 cells.

The electrodes are important components that compose the cell. They are processed in sheet-like forms and laminated with positive and negative electrodes alternately sandwiched by separators and housed in a laminate case (**Fig. 3**).

3. Electrode Manufacturing Processes

The first stage of LIB production - the electrode manufacturing step - is comprised of three processes: mixing, coating, and compression. Mixing involves mixing and dispersing the base compound, additive, and binder using an organic solvent. In the coating process, the slurry produced in the mixing process is applied to metal foil. The slurry is applied to both sides of the foil, and the organic solvent is then evaporated and dried in a drying tunnel. In the final process, compression, the coated electrodes are passed through rollers that apply pressure from above and below to increase the density and adhesion of the coating.

Because the electrode material is processed as a continuous textile in the coating and compression processes, the equipment used has a roll-to-roll design. The compressed rolls are shipped after being packed.

Electrodes require both positive and negative poles. The manufacturing methods are virtually the same for both - the only difference being the materials used. To make the positive pole, lithium manganese acid is coated on an aluminum foil (an NEC-original method), while the negative pole is made by coating copper foil with graphite.

4. Features of Our Electrode Production

Our electrode production has three major features.

(1) Large production capacity

There is still a large divergence between our capacity and the actual requirements of the EV market. We currently have the capacity to produce enough electrodes for 220,000 EVs per year according to our initial schedule (24 kWh per EV). This electrode production capacity is equivalent to about 500 million smartphone batteries (3,000 mAh per smartphone). That means, for example, that our Sagamihara Plant alone is capable of producing nearly half the electrodes used in all the smartphones shipped worldwide in FY 2014.

(2) Guarantee of automotive quality

To successfully meet the requirements of an EV battery, the battery must pass a reliability evaluation that extends over long periods of time. It is also essential that the battery's manufacturer has sufficient processing capability to meet detailed specifications. We implement visualization in various manufacturing conditions and assure manufacturing quality in order to prevent the occurrence of defects and shipment of defective products. An IT-based traceability has been set up to facilitate instantaneous data linkage with raw material and manufacturing processes, in the event of an emergency.

(3) In-house production

To optimize these features, we work jointly with

NEC's MONOZUKURI Innovation Division to improve performance, while also designing key production units ourselves and implementing in-house production. By adopting our original manufacturing processes with the support of NEC's MONOZUKURI Innovation Division, we have achieved dramatic improvements in QCD (Quality, Cost, Delivery).

Until recently, there has been a tendency to rely on the intuition and experience of our engineers when producing electrodes, rather than formalizing the quality control process. Visualization of various conditions has been a significant theme for in-house production. Our achievement of visualization has also contributed to an improvement in productivity, as is evident in a 75% reduction of setup time.

5. Electrode Production Results

Fig. 4 shows the cumulative production results for our electrodes. Since the start of mass production in July 2010, there have been no problems related either to quality or delivery dates. As of July 2015, we have achieved cumulative production of approximately 300,000 vehicles when converted into the Nissan Leaf (24 kWh). When the fact that the Nissan Leaf is the world's most marketed EV is taken into consideration, it is also safe to say that we are producing and shipping the world's top class electrodes. Additionally, these figures partially include electrode production for other applications such as hybrid electric vehicles (HEVs) and household storage batteries.

6. Future Tasks

To enable EVs to further be popularized, it is necessary to solve problems that include shorter range and higher vehicle prices (caused by expensive batteries) than gasoline vehicles. In our LIBs, we have used positive electrodes that use manganese-based materials with higher safety. But to solve these problems, we need to develop a material with even higher energy density and lower cost. Understanding that the changes in basic materials can pretty much affect the manufacturing processes of the electrodes, we need to evolve our electrode production line into one that can achieve high-performance, low-cost batteries, while implementing technological development so that we will be able to continue using the existing production facilities as much as possible.

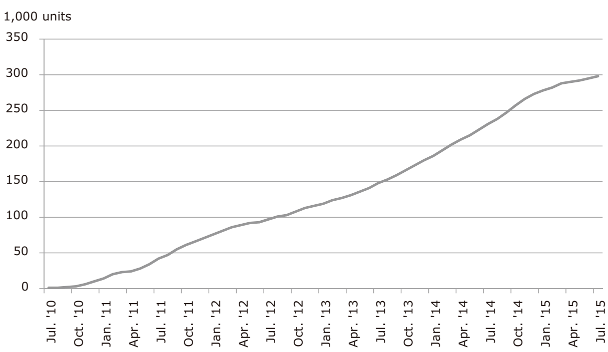

Fig. 4 Cumulative electrode production results.

7. Conclusion

In the future, automakers will release EVs with longer range, significantly expanding the EV market. The market for energy storage systems (ESSs) is also expected to grow dramatically. Expanding sales of EVs and ESSs is the logical result of social solutions for resource and environmental issues as well as assurance of lifelines. The NEC Group is committed to continuing our efforts to help promote the application of LIBs throughout our society, while redoubling our R&D activities to develop safer, higher-performance LIBs.

* Leaf is a registered trademark of Nissan Motor Co., Ltd.

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