A CONNECTED, INTEGRATED APPROACH FOR LITHIUM ION BATTERY MANUFACTURING

Holistic, end-to-end measurement and control capability eliminates islands of automation and helps improve production performance

Honeywell

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ABSTRACT

Due to today's evolving energy requirements, the Lithium-ion battery (LIB) manufacturing industry is expanding rapidly around the world. Market growth has been driven by the proliferation of hybrid and electric vehicles (EVs), as well as the advent of distributed energy storage solutions. In addition, high performance battery is expected to rise across the electronics industry, owing to the surge in penetration of advanced smartphones and other mobile electronic devices.

LIB manufacturers need to bring new battery solutions to market with the utmost confidence. As such, it is critical for them to develop and implement cost-effective, efficient and safe manufacturing processes while ensuring the highest level of product quality. These objectives can be achieved through the implementation of advanced measurement and control technology.

INTRODUCTION

As the lithium-ion battery industry matures, the pressure to decrease production costs is intensifying. LIB manufacturers are seeking to lower both material and processing costs. Battery production is expected to increase exponentially in the upcoming decade.[1]

The specific business drivers for LIB production include:

- Satisfy customer requirements for battery performance, safety and reliability
- Reduce scrap rates by meeting quality standards for cycling, energy density, cell matching, charge rate, and dimensional fit
- Increase overall production yield (each percentage of yield equals $1M per gigawatt-hour of production)

New LIB giga-factories are spreading from the core Asia-Pacific region to Europe, North America and other global locations. However, the proprietary nature of these operations requires automation solutions that have been proven in use and leverage deep expertise in Lithium-ion (Li-Ion) processes.

CHALLENGES FOR TODAY'S LIB MANUFACTURERS

Lithium-ion batteries generate DC power by utilizing chemical reactions. When batteries are discharged and charged, lithium ions move back and forth between the electrodes (cathode and anode) inside of the batteries.

Both cathode and anode are manufactured using a layered structure and the lithium ions are located in between layers. During charge, the lithium ions move from the cathode to the anode. During discharge, the lithium ions move from anode to the cathode. [2]

Reliability is key to the LiB industry developing as rapidly as forecast. Ensuring such reliability requires expertise not only in cell chemistry and mechanical engineering, but also in developing and implementing cost-effective, repeatable and safe manufacturing processes.[3]

The coating adhesion strength of lithium-ion battery electrodes is a crucial mechanical property, which can influence the electrochemical lifetime of battery cells and the electrochemical handling during cell manufacturing. Disproportionate coating of the electrode cathode or anode can result in poor construction of the battery or create a hotspot lowering its efficiency, reducing its service life, lengthening its charge time and/or increasing the possibility of thermal runaway. Furthermore, coated materials are not recoverable. For these reasons, a precise measurement of the coat weight on both sides of the electrode is essential for controlling the process and boosting yield and quality.

NEED TO IMPROVE QUALITY AND PERFORMANCE

Production of lithium-ion batteries has to meet exceptionally high quality standards in order to optimize performance and safety, as well as enable the longest possible battery lifespan. Manufacturers of these batteries require end-to-end visibility of their supply chain and maximum control of production processes in order to exceed market demands for quality while realizing bottom-line benefits.

For any LiB producer, the goal is to apply measurement and control solutions at critical points in their process to improve overall efficiency, minimize product reject rates and associated environmental concerns, and reduce the cost of manufacturing.

As a leading technology provider to global manufacturers, Honeywell has over 20 years of experience delivering advanced sensors and controls for the LiB market. It has deployed approximately 600 flat sheet scanners worldwide and installed more than 250 measurement and control systems to handle Li-Ion coating processes.

Honeywell understands the unique requirements of the lithium ion battery industry and offers expert insights to help drive increased productivity and profits. Its advanced measurement and control technology is used in many critical areas of LiB manufacturing, from the initial mixing process for anode and cathode electrodes to material coating, drying, winding and unwinding, and calendaring.

Honeywell helps manufacturers scale up operations with reducing scrap rates when processing expensive cobalt, nickel, copper, and manganese raw materials, but lack in-house automation expertise to address this problem and increase their return on investment (ROI). The company can also retrofit existing operations with its unique synchronized "same spot" scanning to improve the precision of foil coating and edge detection as part of their challenging production process.

Honeywell is able to assemble tailored automation solutions from its extensive product portfolio and then implement them in a way that best suits the end user's operational needs and business objectives. This includes the deployment of accurate measurements for automatic controls and the establishment of a roll-to-roll interface to relate real-time batch data to cell-level data.

Unlike point solutions that are difficult to scale up to meet the needs of growing lithium-ion battery production operations, Honeywell offers a holistic, end-to-end measurement and control capability that eliminates islands of automation and helps improve overall manufacturing performance. In particular, this integrated platform optimizes quality parameters associated with the LiB electrode—enabling online quality traceability from coating through pressing and slitting.

The core manufacturing requirements in the LiB industry include:

Reduced variability. LiB manufacturers are finding ways to improve operational reliability, avoid production problems and reduce maintenance costs through

the use of superior measurement sensor technology. The latest sensors designs are able to differentiate sheet characteristics from edge to edge—and identify the smallest variations possible—with faster and more precise measurements. Advanced sensors, including beta, x-ray, infrared and optical sensors, meet diverse weight and thickness measurement needs within Li-Ion processes. This includes anode and cathode loading (coat weight), anode and cathode density (coat weight/thickness), separator film thickness, ceramic coating, etc.

Enhance product quality. LiB manufacturers are also finding the need to enhance product quality can be met by an advanced QCS platform designed to integrate specialty measurement and control strategies. Robust QCS solutions utilize browser-based displays and the latest HTML 5 human-machine interface (HMI) technology for ease of use and efficiency. These systems can perform high-speed, thickness measurement for optimal efficiency, reduced production costs and higher yields.

Gain actionable insights. LiB manufacturers can achieve operational excellence through expanded data access and remote monitoring of key process parameters. A new generation of cloud-based solution provides QCS performance monitoring during the lifecycle after initial system startup. It delivers actionable insights to help bolster process quality and production performance and predict abnormal situations before they happen. Experience has shown this solution can also enhance quality control with significantly lower support costs than a traditional approach.

Expand process visibility. Intelligent scanning has never been more important on LiB production lines. Modern flat sheet scanning systems offer accurate same spot scanning functionality, expand visibility of the process, and provide the basis for fast online measurements of basis weight and thickness of various components—from conductive foils to electrodes and separators. The most sophisticated scanners feature Ethernet data acquisition electronics and integrated signal processing.

Optimize batch control. State-of-the-art batch automation technology ensures consistent mixing quality tracking of anode and cathode coating slurries. The use of an S88-compliant solution meets rigorous demands for recipe management, unit classes, simulation, advanced process control, and redundancy.

Identify production defects. One of the most urgent requirements for LiB production plants is to identify sheet defects and increase matetrial performance to ensure uniform, reliable and functional products. Fully integrated remote monitoring solutions are now available for full web inspection, coating edge measurements, and defect detection and classification. A connected, camera-based detection system can help to identify and resolve defects on the production line, improving quality and efficiency.

Enhance quality management. For LiB manufacturers, nothing is more important than knowing the as-cut roll quality—and its implications for long-term product traceability. Advanced quality optimization systems can provide real-time information to enable detailed analysis of roll-to-roll quality indicators. These systems are designed for use with roll-based data historians with traceability down to cell-level rolls.

Ensure operational scalability. LiB producers can remove the limitations of their computing environment, and ensure easier operational scalability, through implementation of a flexible virtual infrastructure. Virtualization technology is the answer for replicating manufacturing configurations across plants in multiple locations and shortening time to production. It is also the key to simplifying overall system management requirements and lowering hardware/software lifecycle costs.

MEETING CRITICAL APPLICATION REQUIREMENTS

LiB production requires optimized roll-to-roll electrode manufacturing and the use of active materials. Electrodes are coated on a metal current collector foil in a composite structure of active material, binders, and conductive additives. However, this process can affect energy density, and the degree of porosity and compaction in the electrode can impact battery performance.

As already described in this whitepaper, companies producing lithium-ion batteries have to adhere to very high quality standards to ensure maximum performance, the utmost safety and the longest battery lifespan.

LiB manufacturers and original equipment manufacturers (OEMS) require accurate and continuous measurement of the total thickness of electrode material as part of coating and pressing processes. They must identify electrode material defects to reduce scrap and increase productivity, since the thickness and basis weight of the material coating is directly related to the energy density of the battery.

Honeywell's LIB Optical Caliper Sensor—the first chromatic, confocal displacement sensor to utilize an innovative direct measurement technique for coatings—is designed to deliver a new level of performance and visibility for measuring the coat weight applied to aluminum and copper foil substrates. This Industrial Internet of Things (IIoT)-ready sensor provides continuous or single-point measurement of total electrode coating thickness with 1-micron accuracy, thus optimizing the coating thickness of the sheet material.

Using optical caliper measurements with β-ray basis weight measurements, Li-Ion manufacturers can take advantage of the small spot size of the thickness measurement to supplement basis weight measurement for better visibility into coating edges on strip coating and also measure the narrow insulation strips for better cell building.

With Honeywell's advanced optical caliper sensor design, LiB manufacturers also have an effective solution for obtaining direct, edge-to-edge measurements of the thickness of electrode material at the pressing station. This solution helps to maximize battery performance, since optimal compression enhances electrode conductivity and storage density. Additionally, it can help with coating adhesion.

The new, non-nuclear optical caliper sensor's high-precision measurements are key to reducing scrap and increasing battery production yield. This capability differs from systems that do not identify sheet defects until the coating and pressing stage is complete—often resulting in expensive wastage, rejects and reduced productivity.

HONEYWELL'S ROLE IN GREEN ENERGY

In the renewable energy market, peak shaving and load leveling as part of advanced battery energy storage system (BESS) applications require the use of high-performance batteries.

Honeywell is extensively involved in the global green energy business, providing innovative technologies for a wide array of commercial and industrial operations. The company has a direct interest in ensuring that quality batteries produced with the aid of its measurement and control systems are available for use with its BESS solutions.

CONCLUSION

Now, more than ever, there is a need for a complete, integrated and connected measurement and control solution for end users and equipment OEMs in the Lithium-ion battery manufacturing industry. LiB producers are focused on improving manufacturing efficiency, reducing waste and increasing overall performance.

Enhanced production can be achieved by deploying the latest IIoT-ready optical caliper sensor system and pairing it with state-of-the-art process control systems, QCS platforms, remote monitoring capabilities, and Ethernet data acquisition electronics, along other crucial automation assets.

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For more information

To learn more about how Honeywell's LIB Optical Caliper Sensor improves performance, visit hwll.co/sheetmanufacturing or contact your Honeywell account manager, distributor or system integrator.

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