SICK AG WHITEPAPER

BATTERY INDUSTRY: ELIMINATE DOUBLE LAYERS DURING CELL PRODUCTION

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Introduction

Battery cells, whether for mobile devices, energy storage systems or electric cars, can be manufactured in many different processes. Their design is not only differentiated in the various housing types or chemical compositions. The internal structure of a battery cell can also consist of a cell stack or the so-called “jelly roll,” for which various process solutions exist.

A big challenge for producers and machine manufacturers in the battery industry is to prevent double layers during the stacking process. This does not only involve detection of the double layer, but also adhering to important process data and the easy integration of solutions to save production time and costs.

Using intelligent sensors with different technology platforms can help overcome these challenges.
Here is a selection guide to these sensor solutions:

- Double layer detection of electrodes with intelligent inductive technology
- Double layer detection of separators with optical fiber technology
- Double layer detection of both electrodes and separators using ultrasonic technology

Relevance of double layer detection
Battery cells must satisfy many increasing requirements due to their application in the automotive industry or as energy storage systems for households and grid regulation.
When several film webs are wound up while battery cells are being wound, individual electrodes or separator sheets are handled during stacking or hybrid forms such as so-called “Z-folding.” Vacuum grippers are used for this purpose, for example.

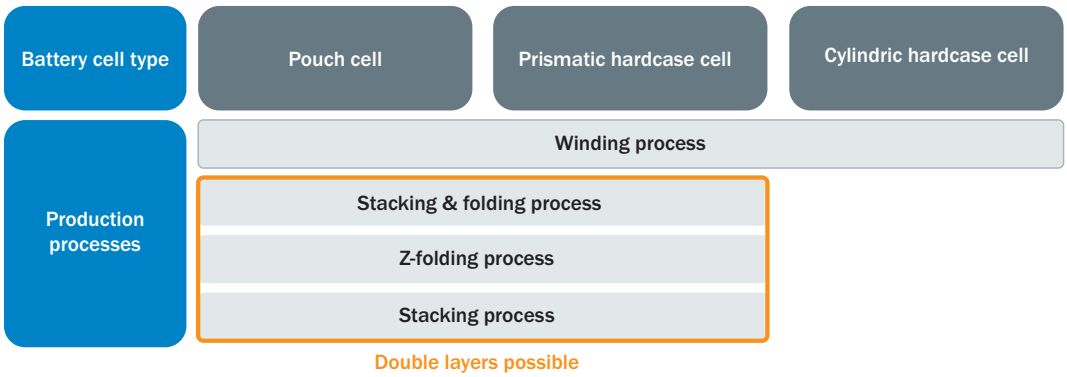

Figure 1: Linking of cell types and processes.

The individual sheets are typically added to the process on different trays. When picking up material layers using the gripper, sometimes several electrode or separator sheets are stuck together and are picked up that way.

If a double layer of material is picked up, it should be immediately detected and removed from the stacking process. Machines feature rejection trays for the double layers, which enables a quick restart of the stacking process after the double layer has been dropped off.

Quality and costs: Key KPIs for battery production

Compared to batteries for mobile devices such as smartphones, batteries for electric cars and private or industrial energy storage systems must meet high requirements on quality and cost. High battery cell quality does not only increase the performance of the battery system; it can also increase the range of an electric car. High-quality cells are also required for safety reasons. Furthermore, the costs of a battery system determine its success for economic use in energy storage systems for private households and automobile applications. The relatively time-consuming stacking process is a perfect example of a process having optimization potential.

In order to guarantee the quality of the individual battery cell, adding joined electrode or separator sheets to the stack must be prevented. Poor quality of an individual cell negatively affects the quality of the overall system of the final battery. That is how double layer detection not only prevents a possible reduction in product quality, but also lowers costs by minimizing low-quality battery cell scrap.

Figure 2: Cell stacking machines contain several grippers for stacking different materials.

Process costs also play an important role for the selection of different sensor solutions for double layer detection.

- Does the solution offer time savings and minimize costs due to a higher rate of production?
- Which solution can be most easily integrated into the machine, reducing the development costs?

With a diverse technology and product portfolio, SICK offers several solutions for double layer detection in order to fulfill different customer requirements. These solutions are described in the following sections.

Materials and their handling

Several gripper systems are used in one machine to stack battery cells. The different materials are handled by different grippers, for example to prevent material cross-contamination, but also to speed up the stacking process. An additional gripper can pick up a sheet while another one is just being placed on the stack.

If several grippers are used in one machine, different solutions for double layer detection can also be used in one machine. This can be necessary to optimally utilize technically diverse solutions, some of which cannot be used for all materials, and their individual advantages (e.g., in the integration of the solution into the process).

There are solution options for double layer detection that are both material-dependent and -independent. Material-dependent options can either detect separators or electrodes.

Electrodes consist of active material and a carrier film. The carrier film is either a copper (anode) or aluminum film (cathode). Separator films, on the other hand, are not metallic, but are very porous. Both the carrier film of electrodes and the separators are very thin materials (< 25 micrometers). The tendency is to use thinner and thinner films. For example, using thinner electrode carrier films can result in cell weight reduction with unchanging capacity.

Select your solution for double layer detection

Double layer detection of electrodes with intelligent inductive technology

With the IDF double layer sensor, double layers are detected immediately, improving process quality without increasing the process time. The sensor uses inductive technology with high sensitivity to distinguish between a single or a double layer of electrodes from a single sensing point.

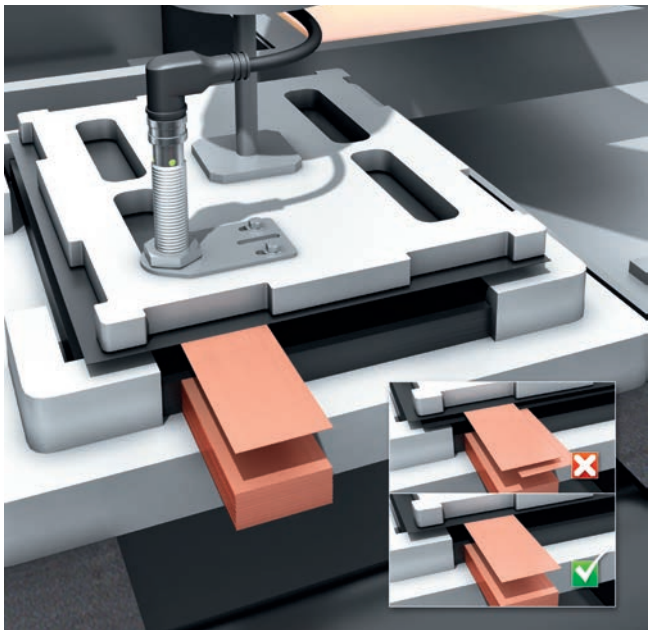

Figure 3: Intelligent IDF double layer sensor.

The sensor has a small form factor and can be integrated directly onto the gripper. This ensures that identification of a single or a double layer happens without interruption of the standard process. This means the stacking process can be continued without interruption and without the gripper having to approach a particular point of the machine in order to inspect the material layer as in opposite-side sender/receiver systems.

The inductive technology allows the same sensor to be used on anode and cathode sheets. Various film thicknesses can also be detected. Due to its high sensitivity, the sensor provides measured values in accordance with material thickness and thus differentiates between different material layers. To provide this level of flexibility, it is possible to simply teach the sensor for the material thickness. Separator films are typically nonmetallic, so the inductive technology cannot be used with them. Detection technologies suitable for them are being discussed in the next section.

There are three different detection states typically needed in the application:

- No electrode sheet is on the gripper
- One layer is on the gripper
- Two layers are on the gripper

During integration, please note that there should not be any conductive material in a 20 mm radius of the sensor. The intelligent double layer sensor is available in M8 and M12 cylindrical thread designs.

Advantages

- Optimization of the process time by quick “on-the-fly” detection
- High material flexibility thanks to easy teach-in
- Quick and easy commissioning thanks to teach-in option via cable or IO-Link

Double layer detection of separator films using optical fiber technology

Separator films prevent direct contact of the active material of the electrodes, thereby avoiding a short-circuit inside the battery cell. However, charge balance between the anode and cathode must be possible, which is why separators typically consist of very thin, porous, nonmetallic membranes.

Double layer detection of separators is not necessary for all stacking processes for battery cell manufacture. For Z-folding, the separator film is not separated into individual sheets. That is why monitoring separator layers in the gripper is not necessary for this process.

Conventional stack processes and other hybrid forms, such as stack & folding, however, depend on separated separator sheets, which can lead to double separator layers.

Figure 4: Fibers from SICK can detect double layers of separators.

A solution with fibers can be used to detect double layers of separator films. The very thin separator film allows enough light to pass through the layers, which can then be sensed, e.g., by using fibers (through-beam system). This is how double layers are reliably detected. Fiber-optic sensors such as the WLL180T from SICK offer very short response time of 16 µs and are available in variants with two switching outputs. This means that the different states in the gripper can be output.

This solution is not suitable for electrode films, since they are not thin and porous enough for optical technology to work.

In sender/receiver systems such as the solution for double layer detection of separators with fibers, the sender fibers are typically integrated into the gripper. If the gripper has picked up a material layer, it moves towards the tray for the cell stack to put down the material layer. During this movement, the number of layers that have been picked up is checked to sort out any possible double layers. In contrast to the previously described solution with the IDF double layer sensor, the material layer is not checked immediately at the time the material is picked up from tray.

The second set of receiver fibers are integrated into the machine so that the gripper is at the respective point during the course of movement soon after picking up the material. If sender/receiver fibers are located opposite one another, a double layer can be checked. Depending on the result, stacking can be continued or the double layer of separators can be sorted out.

There is a wide range of different fiber designs. This results in a high level of flexibility when integrating them. Their low weight and a high number of fiber bend cycles are significant here.

Advantages
- Reliable detection of double separator layers
- Flexible mounting options due to a large selection of fibers
- Easy integration of fibers into gripper

Double layer detection with ultrasonic sensor technology for both electrodes and separators

With the help of solutions based on ultrasonic technology, double layers of both electrodes and separators can be detected.

The ultrasonic double layer detection with UD18-2 consists of one sender and one receiver with an integrated evaluation unit. Differentiation between the three detection states named above is also possible: missing, single, and double material layer. Integration can therefore be described as with the solution with fibers.

Due to various selectable sensitivity levels as well as the option of selecting various settings via teach-in, double layer detection with ultrasonic technology is possible for various film thicknesses. The sensitivity levels can also be changed during running operations, reducing downtime and increasing process efficiency. This detection principle satisfies both the different requirements of various battery manufacturers as well as the increasing challenge of ever-thinner electrode films.

Figure 5: With the UD18-2 ultrasonic sensor, layers of different materials can be detected.

Advantages
- Double layer detection for electrodes and separators
- Detection of materials of different thicknesses thanks to selectable and teachable sensitivity levels
- Variable mounting distance of the sensor heads

Selection matrix

	IDF	WLL180T + LL3	UD18-2
Double layers of electrode films	✔	X	✔
Double layers of separator films	X	✔	✔
Single-sided sensing principle of operation	✔	X	X
Sender/receiver principle of operation	X	✔	✔

Summary

The detection of double layers in the manufacturing of battery cells during the stacking processes is very important for the economic efficiency of the battery. There are different approaches based on different technologies to overcome this challenge. On the one hand, these technologies differ depending on the materials that can be detected. Another differentiation must be made between single-sided principles of operation and sender/receiver systems: While a single-sided solution integrated in the gripper can check the material layer when it is picked up, two-sided systems must execute a partial movement in order to detect the double layer with sensor heads on the opposite side. Only then can the faulty material layer be sorted out and the stacking processes be continued.

Despite of the advantage of single-sided double layer detection resulting from the shorter process time, certain process and machine conditions require a sender/receiver system. Selecting the right sensor for the right application helps maintain the desired process times which are critical to the throughput of the machines.

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