Lithium-Ion Battery Cells

TECHNICAL CHALLENGE

The production of lithium-ion battery cells has recently ramped up significantly, driven by increasing numbers of mobile devices, as well as the growing market of New Energy Vehicles with electric cars, hybrid cars and fuel cell vehicles. The functional safety of a lithium-ion battery is very important, but sufficient lifetime and performance of the battery is also needed. This is especially true with the new drive train technology application where high quality batteries are indispensable to create a positive reputation for the new technology.

There are four different mechanical designs of a battery cell: cylindrical cells, coin cells, prismatic cells and pouch type cells. Cylindrical cells, coin cells and prismatic cells have a sturdy housing, whereas pouch-type cells have a flexible housing (they are also referred to as flexible battery cells).

Different designs of battery cells are used to create power batteries for electrical and hybrid vehicles. Cylindrical cells are used in the Tesla Model S for example, but more commonly prismatic and pouch-type cells are used. Pouch cells as well as coin cells are also widely used in mobile devices.

Battery cells need to be tested for physical leakage because:

- Humidity must not get into the battery, as humidity will also negatively impact the battery's performance and even destroy the battery completely over time
- For pouch cells any air intake will also increase the internal pressure so that the pouch cell will lose its mechanical integrity which leads to a loss of capacity
- No electrolyte must leak out of the battery cell, as missing electrolyte will have a negative impact on the battery's performance

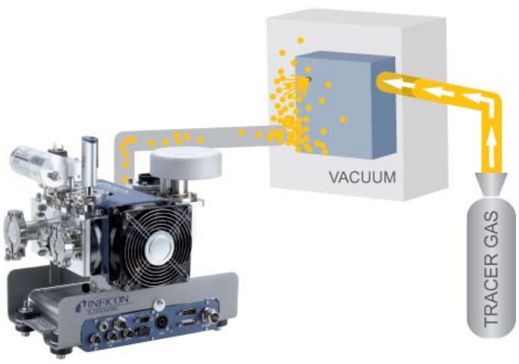
To guarantee these requirements, modern battery cells must be leak tested to leaks in the range of a few micrometers in diameter equaling leak rates in the range of 10^{-6} mbar*l/s. These small leaks cannot be detected with older technologies like water bath or soap spray testing, nor with pressure decay testing.

THE INFICON SOLUTION

Production testing of prismatic cells is performed in several steps:

Pretesting of prismatic battery cells

Sometimes the battery cell housings of prismatic battery cells are pretested before filling with electrolyte to ensure e.g. electric feedthroughs do not leak. This pretesting is usually performed in vacuum chamber leak testing with high throughput. The housing of the battery cell is filled with helium and then placed in a testing chamber connected to a vacuum system. Once the chamber lid is closed, large vacuum pumps pull a vacuum on the testing chamber. Helium then has the opportunity to migrate outwards and if a leak is present, an LDS3000 Helium Leak Detector (connected to the vacuum chamber) detects the helium as it emerges from the battery cell.



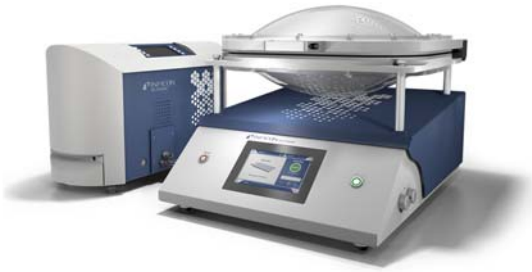
Battery cells prefilled with helium are typically tested via vacuum chamber leak detection. This process is very common for prismatic battery cells.

Only if the housing of the battery cell tests okay, can it be filled with electrolyte and finally be sealed. This type of pretesting cannot be applied to pouch cells.

Even if the housing of the battery cell has been pretested as described above, the filled and sealed battery cell must be retested to ensure the integrity of the final seal. Pouch-type batteries are typically only tested once after final sealing.

End-of-line testing of fully assembled hard case battery cells

For integrity testing of filled hard case cells (prismatic, round, coin) the process of direct electrolyte detection is used. For this process, the battery cells to be tested are placed in a test chamber which is evacuated to a pressure level below the vapor pressure of the electrolyte solvent. Electrolyte will leak from any leak channels into the test chamber where the solvent of the electrolyte will evaporate. The solvent will then be detected by the sensor, in this case a quadrupole mass spectrometer in the ELT3000 battery cell leak detector.



The ELT3000 battery cell leak detector can detect smallest leaks down to the µm level by direct electrolyte detection. Different chamber designs are employed for different cell designs.

End-of-line testing of filled and sealed pouch cells

For integrity testing of hermetically sealed pouch cells, the same process of direct electrolyte detection can be used. However, a different type of chamber is needed as pouch cells inflate in a vacuum chamber damaging the sealing of the pouch cell. This challenge is overcome by the use of a flexible chamber consisting of two layers of a flexible material. The pouch cells to be tested are placed in-between the two flexible layers and a vacuum is created in this “customized” test chamber. The flexible material supports the pouch cell during the vacuum test and allow for a true non-destructive leak test. The solvent escaping from any potential leaks are also detected by an ELT3000 battery cell leak detector.

BENEFITS OF LEAK TESTING WITH TRACER GAS

- Accurate and repeatable measurements for reliable leak testing
- Highly sensitive testing method for detecting smallest leaks of a few micrometres diameter (~10^{-6} mbar l/s range)
- Highly automated process with high throughput
- Test result independent of operator intervention
- Dry, non-destructive process

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