Ensure quality control for batteries using industrial CT inspection

How new advancements in NDT X-Ray technology help assure quality and consumer safety.

Batteries: what comprehensive quality assurance means

Across major industries, our reliance on batteries and energy storage devices to power devices is on the rise. Batteries provide the power for a multitude of applications such as cars, electric vehicles, scooters, boats, and airplanes, all of which impact public safety. Therefore, assuring battery quality is key to safeguarding lives via comprehensive quality inspections.

Also significant are the implications of battery quality on manufacturing outcomes and achieving standards of compliance. Quality is directly correlated to productivity, managing costs and limiting risk. And, in battery manufacturing, finding potential failure modes prior to end-use is essential to properly mitigate higher-order risks but also significantly reduce scrap rates and related manufacturing costs. Early detection is key.

Early detection—as in prior to end-use in cars and airplanes, for example—must occur during various battery manufacturing stages and encompass internal and external features. Specifically, quality assurance checks are needed to inspect the integrated battery components (anode, cathode, separator, electrolyte) at these production points:

- After electrode stacking (anode, cathode, and separator)
- After pouching the stack and before electrolyte filling
- Before canning the roll (anode, cathode, and separator) in a prismatic cell
- At full cell testing after electrolyte filling and closing of pouch or can

Battery issues that compromise integrity

As innovative applications emerge and existing applications grow, battery design continually strives to increase load capacity and extend lifecycles while manufacturing complies with all quality assurance and safety standards. Non-destructive testing (NDT) with 3-D industrial Computed Tomography (CT) X-ray has evolved to handle the important job of comprehensive battery quality inspections.

To understand why industrial CT is ideally suited for battery quality assurance, let's look at potential sources of failure, which can be mitigated with proper quality inspection during battery manufacture.

Example ONE. Overhang issue
After electrode stacking, the specific distance and alignment of the anode and cathode must be validated. Optimal overhang distance during stacking ensures proper and safe battery performance. If the distance between the electrodes is too small, there is a risk of a thermal event where extensive energy is released in a short amount of time. If the anode-to-cathode distance is too great, then the battery cell will not be as effective as needed in storing energy.

Example TWO. Presence of foreign material

There are multiple sources of potential contamination during battery production. Foreign materials, such as welding residue, excess anode or cathode material and flaked material, can cause electrical shorts, resulting in battery failure or worse, thermal runaway. Inspection helps ensure that batteries are free of performance-limiting foreign materials.

Example THREE. Electrode cutting

Anodes and cathodes are treated in coating machines that distribute paste via copper and aluminum foils rolled off from material coils. After the electrodes are coated and dried, these foils are cut by machine for individual battery cells. Inaccurate cutting can produce sharp edges, which in turn, can puncture the battery pouch and cause electrolyte loss. In addition, inaccurate cuts can lead to the foil overhang and flaked coating issues mentioned above and elevate the risk of electrical shorts and battery failure.

Why conventional quality inspection approaches fall short

Conventional quality inspection techniques within battery fabrication have limited capabilities and involve two primary inspection methods:

1. **Destructive testing** which cuts open the stack and destroys the battery. This means that only periodic samples are tested and the part used in the end-use application is not the part tested. Thus destructive testing is an extrapolation of quality with large time gaps between sampling and checking. For high speed, high volume automotive manufacturing environments, these gaps can cause large amounts of scrap and subsequent losses.
2. **2D X-ray inspection**, often used in-line, only checks one potential failure mode within the stacking case. As shown above, there are multiple potential failure modes within every battery and comprehensive, effective inspections must examine all of them. While 2D inspection is typically faster as only a few images are taken, the overlapping features in the X-ray image projections do not enable it to detect most failure modes automatically or reliably.

Conventional inspection approaches leave potential blind spots of vulnerability in battery quality, safety and performance. Blind spots and hidden losses, although obscured, carry real, tangible costs. As such, they can hinder safety and productivity while increasing vulnerabilities and risks – unnecessarily.

Steep and hidden costs due to conventional inspection limitations can be significant in magnitude. As compared to 3-D industrial CT inspections, which provide comprehensive quality inspection capabilities, the total cost of ownership numbers can look like this:

- The initial cost of conventional inspection is about **40% less** than industrial CT solutions. However, only one type of mechanical failure is typically inspected at a time. This means that most sources of failures are NOT and CANNOT by inspected with 2D X-ray methods. Thus, conventional inspection tests for a mere 20% of potential failures, incurring costly risks of scrap, downtime and ultimately, public safety.
- At a **10% scrap rate**, estimates of battery manufacturing scrap cost are $50,000-100,000 USD per battery plant with multiple lines.
- 3-D industrial CT technology is estimated to reduce battery scrap rate **by 30-50%** over conventional inspection methods.

These costly blind spots are a “best case” scenario. If battery inconsistencies pass through manufacturing undetected, the consequences of failure escalate rapidly. Higher-order costs of failure that occur during end-use and exponentially escalate exposure and risk, can incur irreversible damages.

What's new: game-changing advancements in inspection

Fortunately, new advancements that leverage 3-D industrial CT technology for battery quality inspections, are redefining what is possible. Used in-line or at-line in battery fabrication, CT X-ray, tailored technology offers comprehensive quality inspections across all stages of manufacturing while enabling multiple failure cases to be checked concurrently. CT technology also provides the battery-required high resolution at high inspection speeds. The positive outcomes of industrial CT inspection include:

Tangible, quantified manufacturing outcomes

Less scrap | Faster reaction time | High versatility | Improved quality | Regulatory/supplier compliance | Lower costs

Intangible outcomes: Brand damage

Higher order outcome: Safeguarding lives

In battery production reducing quality blind spots produces big payoffs, including less scrap, faster reaction time, high versatility, improved quality, regulatory/supplier compliance and lower costs.

Summary

The world relies on batteries to power many devices and vehicles used everyday. Thus, comprehensive quality assurance in battery fabrication is essential. For proper quality, you need a partner, not a product. One with deep expertise that integrates knowledge into solution design and support. By adopting apt, state-of-the-art inspection solutions, battery manufacturers can help to ensure quality, boost productivity, and lower costs while safeguarding lives.

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