APPLICATION NOTE

7 costly mistakes to avoid when choosing a lithium-ion battery coating thickness gauge

Introduction

Acceleration of global electrification efforts, driven by climate initiatives and supported by the regulatory framework, creates a rapidly increasing demand for lithium-ion batteries. The lithium-ion battery manufacturing sector has been growing rapidly over the last few years and this growth is expected to accelerate.

Market forecasts predict the expansion in the battery segment to be more than 20% CAGR until 2025 with no slowdown in sight. This tremendous growth continues to place an extraordinary demand on manufacturing capacities, making any loss of production time painful and costly for the manufacturing plants.

Battery cell manufacturers race to ramp up production while technology innovation seeks to increase the energy storage capacity, lifetime, and safety of lithium-ion batteries for electric vehicles (EV) and mobile devices.

To compete effectively in a dynamically evolving market, where demands for quality and production throughput are growing fast, manufacturers must carefully choose their process metrology tools to meet both present and future demands for precision, accuracy, and reliability.

One of the most critical quality parameters in the process of making lithium-ion batteries is controlling the thickness and profile uniformity of the cathode, anode, and separator film materials. In-process coating thickness gauges are, therefore, a critical part of the production quality assurance toolkit. As with any product - you get what you pay for! And the consequences of choosing a low-performing gauge can be severe. Variations in coating thickness, uneven profile, or missed defects can drastically impact battery performance and increase the risk of a thermal runaway. Lower price often means lower reliability. This will cost you more in the long run!

On the other hand, a top-performing gauge will pay for itself in a matter of months by giving you better control of your process, higher confidence in the quality of your product, and help you maximize production uptime!

1. Slow scanning speed = more defects missed

Scanning thickness gauges operate by shuttling a sensor back and forth across a moving sheet of electrode or separator film material. The sensor, typically a beta, x-ray, or confocal laser (depending on the application), collects thickness data for each point in its path. The ability of the sensor to detect surface variations and defects in the coating is dependent on two core parameters. One is the resolution of the sensor. A higher resolution sensor will detect smaller surface features. More on that later. The other - the sensor must be in the right place at the right time!

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Scanning speed is a critically important parameter to consider when selecting a thickness gauge. This speed is not simply a function of mechanics. The ability to move faster while maintaining the required measurement accuracy and defect detection requires a faster sensor response time, higher source strength, signal- to-noise, and spatial resolution.

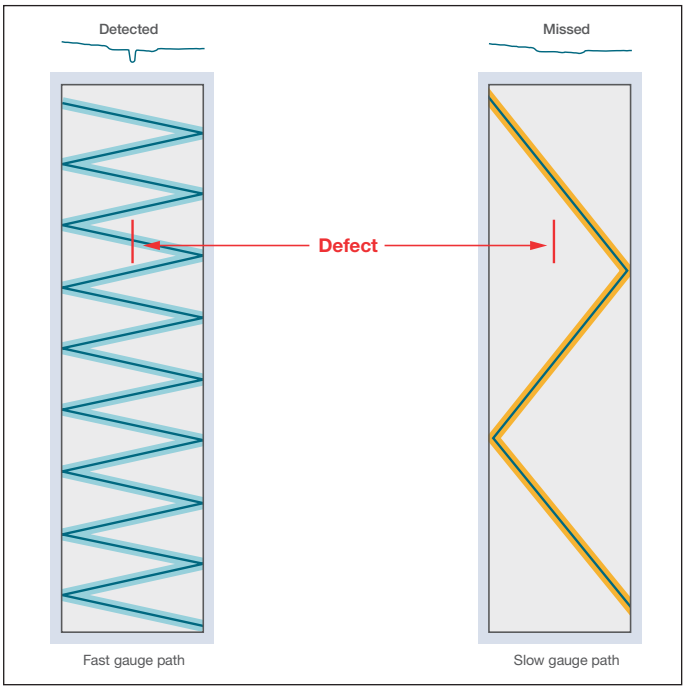

Figure 1: Scanning path of a gauge over a moving sheet

The difference between a low-performing gauge and a leading product like Thermo Scientific™ LInspector™ Measurement and Control System can be significant. LInspector Measurement and Control System can scan a 1350mm wide sheet in 3 seconds while delivering best-in-class measurement repeatability of ±0.05% or 0.1gsm, whichever is greater. Other gauges scan at about half this speed, offer inferior resolution and an order of magnitude lower accuracy.

Compromising on the scan speed and performance of your gauge increases and often more than doubles the risk of missing critical defects. This translates to higher overall quality risk, limits your ability to access premium market segments, and can result in damage to customer relationships and your brand reputation. Can you afford it?

2. If you can't measure it, you can't fix it!

The ability to resolve and spatially characterize surface features is one of the most critical performance characteristics of a coating thickness gauge. Increasing demands on battery performance force tighter tolerances and more stringent quality controls in the coating process, all in the effort to produce a more uniform energy density profile.

The surface features at the edge of the coating layer, in particular, have to be carefully controlled. Choosing a gauge with low spatial resolution, poor sensitivity or a slow sensor response time can easily translate to a lost contract or inability to meet future specs for your key customers!

Lower performing gauges can only reliably resolve streaks wider than 10mm in width. This is a limitation resulting from reliance on inferior sensors with a poorly optimized beam geometry, lower source strength, and sluggish response time.

In contrast, a best-in-class gauge like LInspector Measurement and Control System can resolve 3mm streaks per IEC61336 standard by using a sensor with the highest resolution and fastest signal response time, combined with a beam technology that doesn't require a mask. Even smaller streaks, down to 1mm, can be resolved when operating at reduced scanning speeds. Sensor performance, reproducibility of the measurement, and speed of response all add to a better representative uniformity profile and as a result a better end product.

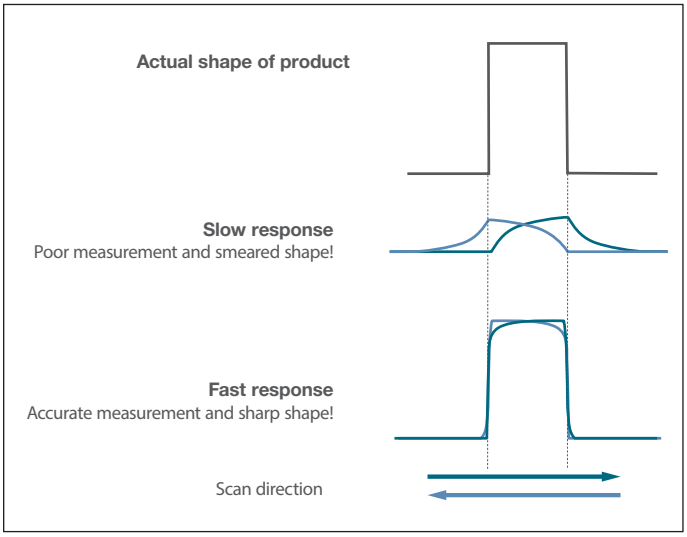

Figure 2. Accuracy in measurement of feature dimensions

Taking a risk with an inferior gauge leaves you half-blind to some of the most critical quality challenges in your coating process. To paraphrase a famous quote by Peter Drucker – if you can't measure it, you can't fix it!

3. No automatic profile control? It will cost you…a lot!

Reliance on the operator to manually adjust process parameters may seem like a way to reduce costs but this can be deceptive. Manual adjustments to control the

coating thickness or profile can only be made infrequently and much depends on the operators' experience and skill. This not only puts your ability to maintain the required coating uniformity at risk, but can also result in waste of expensive raw materials.

Let's consider an example of a cathode coating line where customer specifications call for a minimum coating weight of no less than 200 gsm (grams per square meter). To ensure that the product consistently meets the requirements, the target thickness will have to be set higher to account for variability in the coating process. Profile variability can be on the order of 2% even at a steady state in a manually controlled production and can manifest itself as non-uniformity in both cross-track and along-track directions. Since the thickness profile can fluctuate ±4 gsm, the process setpoint must be set higher to ensure the minimal thickness specification is met.

When the LInspector Measurement and Control System, is controlled by APC (Automatic Profile Control), instead of relying on the operator, the variability in average thickness and profile uniformity can be reduced to well under 1%. This is made possible by advanced control loop algorithms that adjust process parameters and automatically compensate for changes in the coating. This automatic control (think cruise control in your car that keeps the speed steady) allows you to operate closer to the lower limits of the specification.

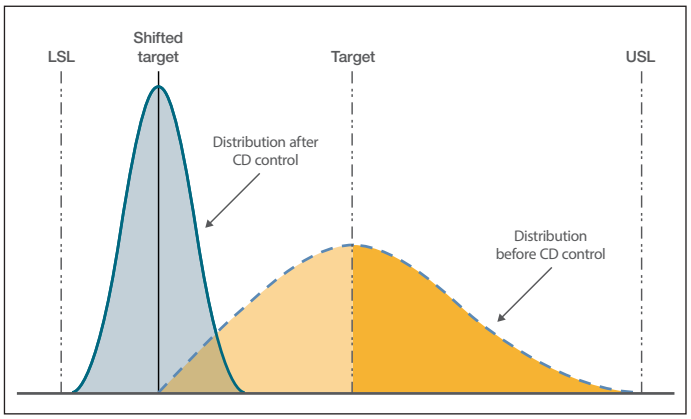

Figure 3. Improvement in profile uniformity through the use of APC in a cross-track direction (CD)

The economic impact of operating closer to the specification can be significant. Savings of just 1 gsm of NMC (Lithium Nickel Manganese Cobalt Oxide) on a production line 1 meter wide can translate into savings of approximately 25 tons of NMC per year. With NMC cost of US $26 per kg (CNY ¥170 per kg) this translates to US $0.7M per year!

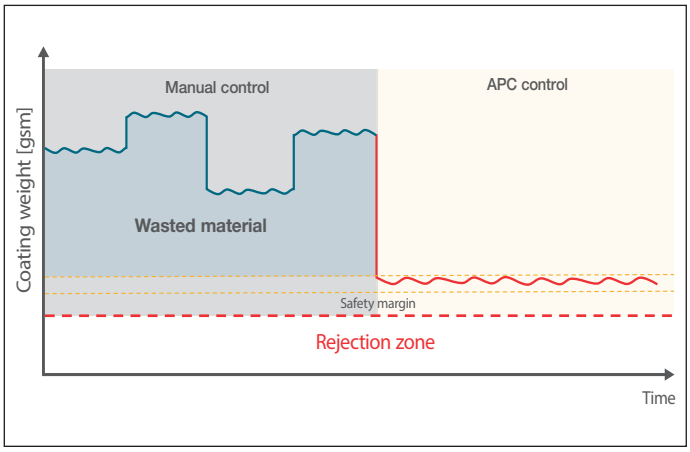

Figure 4. Reduction in coating material consumption through the use of APC

4. Ignoring the costs of production line start-up.

Getting a coating process into a steady state requires careful tuning. When done manually, the tuning process becomes somewhat of an art and results can differ greatly between operators of various skill levels. A trained operator typically takes about 35-45 minutes to start a coating line and get it to a target specification.

Automated controls using APC algorithms of the LInspector Measurement and Control System can cut down your start-up time to 15-20 minutes. It may not sound like much but when running at line speeds of 60 meters per minute that's another 1200 meters of coated electrode sheet you can sell.

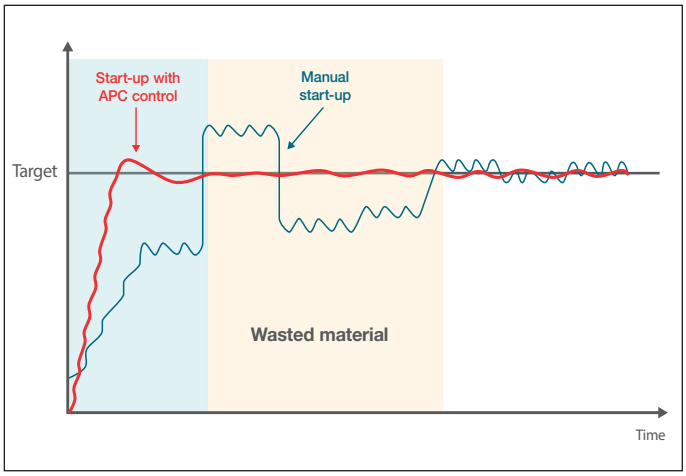

Figure 5. Reduction in start-up time through the use of APC

A typical cathode production line can see savings of more than US $50k per year in materials, machine time, and throughput increase by switching to APC.

5. Not thinking forward? Total cost of ownership and futureproofing.

The purchase price of capital equipment is a very important factor when scoping projects and selecting suppliers for a new production line or when upgrading existing equipment. The purchase price alone, however, does not tell the whole story.

Total cost of ownership must be taken into consideration when selecting your new coating thickness gauge. This cost includes maintenance requirements of the equipment, consumables, cost of a service contract (make sure your supplier can offer one), plus cost of operator and maintenance personnel training, and operational costs. Choosing a gauge that requires more maintenance can easily result in lost production time and revenue.

When making a capital equipment purchase you should consider not only the performance characteristics needed for today's process but also consider developing customer requirements. A thickness gauge can be expected to serve you for years. Choosing a low-performing gauge today may result in having to spend more capital funds. Lithium-ion battery technology is evolving rapidly. Requirements for coating uniformity and overall precision in production processes continue to increase. A best-in-class technology like the LInspector Measurement and Control System will futureproof your investment and pay dividends for years forward.

6. Underestimating the importance of reliability and support.

The reliability of production equipment plays a critical role in making the plant run smoothly. Just as critical is the reliability of in-process metrology tools, like thickness measurement gauges. Here, in addition to the reliability of mechanical parts and electronics, you should ensure that the results produced by the gauge do not drift over time. Top-tier gauging equipment manufacturers like Thermo Fisher Scientific invest in rigorous quality programs, adherence to international standards, certification, and training to maximize the reliability and uptime of their products.

The ability of the manufacturer to offer timely service and rapid response in machine-down situations can easily outweigh differences in the initial price offer.

The Thermo Scientific™ LInspector™ Measurement and Control System

Thermo Fisher Scientific has the strongest network of service and support specialists around the world and can tailor a support contract to your specific requirements, up to and including a resident engineer on site.

Another aspect to consider is Digital Solutions. Being able to monitor the health and performance of your thickness gauge remotely, analyze historical trends, send and receive support notifications can help you maximize the value of your investment. The Thermo Scientific™ Instrument Performance Management (IPM) suite of tools makes our thickness gauge part of your Industry 4.0 and Smart Factory initiatives. This IIoT based solution helps you transform your maintenance program from a responsive into a predictive model and helps you maximize equipment uptime.

7. Any gauge will do? Choose your brand partner carefully.

The highly competitive nature of today's battery market means that you should choose your technology partner carefully.

- Can the supplier offer measurement performance that will give you a top-quality product today and in the future?
- Do they have technical experts on staff to support your development efforts?
- Can the supplier offer timely and experienced support in every location you plan to build?
- Can the supplier meet the quality, reliability, and safety standards required by each of your regional operations?
- Are their supply chains managed and secured to ensure continuity of supply and support for you?
- Is the supplier staying on top of the rapid innovation pace of the industry and will be able to develop new solutions when you need them?

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These are just some of the questions you should ask when selecting your gauge supplier.

We at Thermo Fisher Scientific are not just a supplier of quality products - we are a partner you can trust with the most important things - the quality of your product and your brand reputation. Thermo Fisher Scientific is a global organization with annual revenue exceeding $30 billion. Our Mission is to enable our customers to make the world healthier, cleaner, and safer. Our global team of more than 80,000 colleagues delivers an unrivaled combination of innovative technologies and services to customers throughout the world. Our brand is trusted by the leading companies in every industry we serve. For the battery industry, we offer a wide range of solutions to support research, manufacturing, quality assurance, and quality control. Visit our Advanced Battery Technology web page to learn more.

Our experience in flat sheet gauging spans over 70 years. Our thickness and basis weight measurement solutions are used by leading battery manufacturers and offer best-in-class reliability and performance. We invest billions in R&D every year and our service organization is second to none. When you choose Thermo Fisher Scientific as your project partner, you secure your success!

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