Is it Time to Switch Your Primary Control Parameter?

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Most lead-acid battery manufacturers control plate pasting lines by weight. But can switching to thickness yield higher-quality batteries?

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Overview

When controlling a battery plate manufacturing line, process engineers must make make a crucial decision about the application of active material: should the process be controlled by **weight**, or by **thickness**?

Most engineers choose to control the application of active material by weight, largely because back when these decisions were originally made, there wasn't an accurate way to measure thickness. Now you can measure thickness accurately using laser gauges.

But switching to thickness control is still not a straightforward decision for two reasons. First, the relation between weight and thickness involves paste density, moisture content, and grid weight. At least 4 process variables need to be considered. So thickness measurements alone don't tell the whole story.

Second, different battery types are more or less sensitive to thickness variations. Flooded lead-acid batteries are the least sensitive, EFBs are moderately sensitive, and AGM batteries are the most sensitive to plate dimensional qualities.

So strap in. We'll do our best to dissect this issue and address some key questions that need to be answered now and in the future.

About the Author

Steve Mate, CEO of Co-efficient

I founded Co-efficient in September 2005 and have served as CEO ever since. These days, most of my time is spent working with customers to help integrate automatic thickness gauging and active material control into battery manufacturing lines. In another life, I worked as a photonics and application engineer at Intelligent Photonics Control and Nortel Networks.

Co-efficient was conceived after I noticed a real desire within the lead-acid industry to introduce automatic control into plate pasting lines. Our focus has always been not just on building the necessary equipment, but creating the full solution, including the software for automatic control. The aim is to produce less scrap, achieve tighter controls, and make better batteries.

I wrote this eBook to contribute to the thickness vs. weight control conversation, a very important issue for today's manufacturers. Please feel free to share it, and do reach out if you have any advice or feedback on how to improve it. I'd love to hear your point of view.

Introduction

The standard practice for quality control in battery plate manufacturing involves manually weighing plates to ensure that they fall within an acceptable range. Then thickness measurements are taken with manual tools (callipers or dial indicators) as a second check to verify that the plates are within the design tolerance.

But manual measurements are impractical. They are time-consuming, imprecise, and inconsistent across different operators. And the malleability of the paste makes the thickness reading sensitive to the pressure applied. This is why most battery manufacturers continue to use weight as their primary control parameter.

But understanding thickness is important. If plates are too thick, they can over-compress the glass-mat. If plates are way too thick, they won't even fit in the battery encasement. And if they’re too thin, the battery will experience capacity deviations and its useable life will be severely shortened. For AGM batteries, thin plates make them prone to vibration failures in dynamic applications like power sports.

In short, significant thickness deviations can spell disaster.

To solve this problem, some manufactures have started to measure plate thickness with automated tools. Adding automatic thickness gauging has allowed them to switch their primary control parameter from weight to thickness. They're now able to get accurate and repeatable thickness readings because they've removed the variation inherent in manual measurements. And the result is better mechanical fit, reduced scrap, and improved battery quality.

But despite the clear process improvements, making the transition to thickness as your primary control parameter is not always easy. It requires some new equipment and a process control deviation.

So the debate, which is practically as old as battery manufacturing itself, persists: which is the ‘best’ control parameter, thickness or weight?

Why Should Battery Manufacturers Care About Thickness vs. Weight Control?

When designing a battery, engineers determine the weight and thickness of the active material (including acceptable tolerances) required to reach the desired amp-hours and cold-cranking amperage (CCA), based on an assumed relationship between plate thickness and weight.

But in real-life battery manufacturing, the relationship between thickness and weight is not perfect. It's impacted by variations in grid weight and, especially, applied paste density, which can fluctuate because of varying moisture content and imperfect application into the pasteable volume of the grid.

To fully understand how this works in practice, we have to look at the three variables that go into manufacturing the 'perfect' plate:

1. **Paste density**: the components of the paste (lead oxide, additives, and water) must be present in consistent amounts.
2. **Lead grid geometry**: the wire thickness and geometry must be consistent from plate to plate.
3. **Paste application**: the paste must be applied evenly and with consistent pasting pressure to the pasteable volume of the plate, whether you're flush pasting or overpasting.

If you can reliably control these three variables, you can output plates with consistent thickness AND weight, every time. The trouble is controlling all three variables consistently in-line is impossible with human operators. Furthermore, since all three variable are interdependent, deviations in one variable will affect the other two.

The main argument I want to make in this eBook is this: The introduction of automatic thickness gauging (and control systems) can greatly improve variable number 3, the paste application process. It also allows you to lock plate thickness in place, so you can accurately determine the root cause of any weight variations. Therefore, the introduction of automatic thickness gauging technology shifts the thickness vs. weight discussion in favor of thickness.

In the following sections, we'll dig deeper into the pros and cons of both weight and thickness as primary control parameters.

The Benefits of Weight Control

Weight is easier to measure manually

There's no doubt that, today, weight is the more common control parameter. But this isn't because it's the *best* parameter. It just happens to be the most practical control parameter with standard tools. In fact, many manufacturers will admit that they have tried to control for thickness instead, but were unsuccessful in finding a method with a high-enough gauge repeatability and reproducibility (R&R).

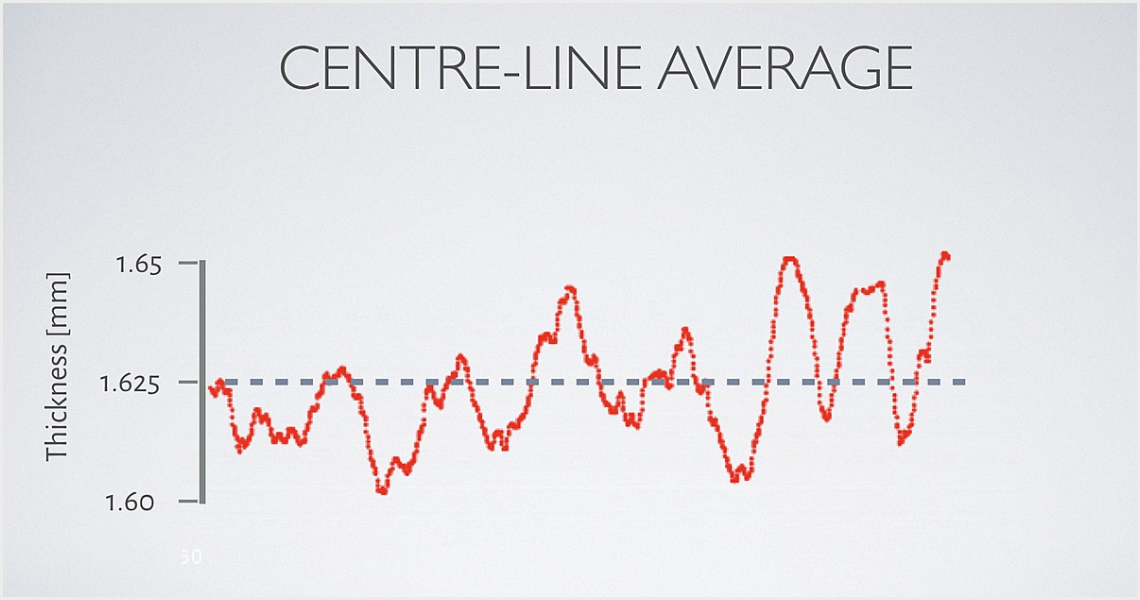
To measure plate weight, you simply place it on a scale and get an accurate reading that's easy to compare across individual plates. It's a single measure for plate quality, which makes quality control super simple.

Measuring thickness with standard tools is a lot harder, mainly because of the soft plate surface. Any pressure applied to the active material can displace it and also dirty the tool surface (making future measurements with the same tool less accurate).

Did you know?

Accurate thickness measurements with manual tools depend on close contact and adequate pressure applied to the plate. The tool touches the highest points of the plate because the surface is not perfectly level. This effect is more severe when measuring cured plates, because the peaks deform less. A laser, on the other hand, can measure the true centreline thickness of a plate. Looking at the figure below, you can see how a laser gauge would return an average thickness value of 1.625 mm, while a manual measurement would return a value of about 1.65 mm.

If manual tools are used on wet plates, the paste will compress, making the measurement dependent on the pressure applied.



The Benefits of Thickness Control

Taking thickness measurements with an automatic gauge gives you more reliable data, a streamlined production process, and tighter quality control.

More granular data

Using thickness as your primary control parameter, even with manual measurements, gives you information about the shape (or profile) of the plate. This is because measurements can be taken at four or more points on the plate, giving you several data points to work with. Weight measurement, on the other hand, can only ever give you a single data point.

This benefit is extended when a laser gauge is used in-line. Lasers can track thickness across the entire plate profile, preventing the production of wedged plates that cause leaning stacks.

No need to remove plates from lines

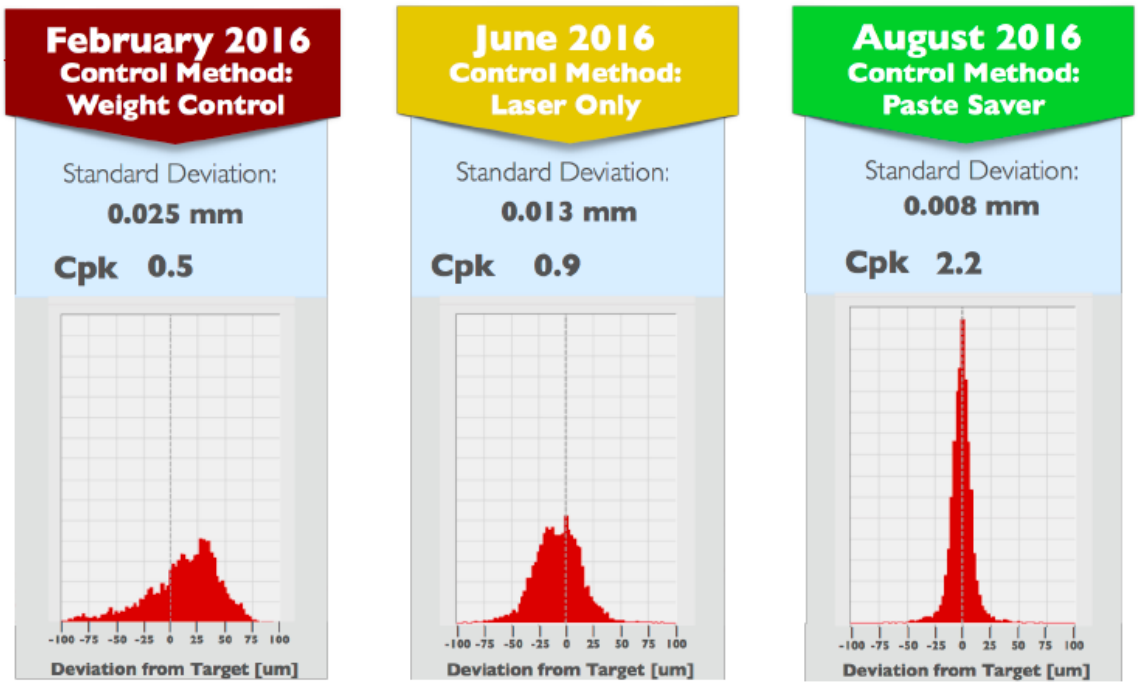
With an in-line system, there's no need to remove plates from the line to measure them. Quality control happens continuously. The measurement process is fast and happens in seconds, rather than whenever operators have time. In-line gauging therefore frees quality assurance personnel from doing repetitive checks, so they can focus on more important tasks. The result is more data, better trending, quicker response, improved traceability, and reduced workload for your operators.

Major quality improvements

An in-line system can be applied at the start of a production line to control for quality upfront. Plates with thickness deviations are identified right away and the issue is resolved promptly. With accurate thickness gauging in place you'll never have to wait until the plates are assembled to find out that they don't fit (or even worse, until your OEM finds a quality issue).

But the biggest benefit of improved quality control is the ability to design batteries with tighter tolerances. This is only possible if you have complete confidence in your process. And the best way to get more confidence is with more accurate gauging systems that automatically collect, store, and use data in defined control algorithms to make minute process control adjustments.

In the figure below, you can see how the introduction of an automatic laser gauge cuts plate thickness variations in half and almost doubles the process capability ratio (Cpk). And with the addition of full automatic control to the process (using our paste control solution, the Paste Saver), thickness variations can be reduced even further.



The Debate Persists

But we believe with today's technology, switching to thickness will have a positive impact on battery quality.

There are several reasons why thickness may become the new 'industry standard' quality control parameter:

#1 — Active material weight, not plate weight, is critical

When we hear that batteries need a consistent plate weight for consistent performance, this is generally an incomplete statement. What needs to be controlled is in fact not plate weight, but the amount of dry active material.

After all, the lead grid that is embedded in the active material does not play a significant role in the electrochemistry of the battery, and neither does the water that is later removed during curing. So if the goal is to control active material volume, controlling for plate thickness has the advantage of being less biased by grid weight.

If, for example, you detect a 1 gram variation after weighing a plate, you cannot know whether the extra weight is coming from the grid or from the active material. If it's from the grid, the plate thickness will be relatively unaffected, with a thickness variation of just 0.005 mm (see table below). But if the extra weight comes from too much active material, the plate thickness would increase by 0.012 mm. This is because the active material is relatively light compared to lead (in fact, it's about half as dense).

Thickness change caused by 1 extra gram of material		
	1g Lead	1g Paste
Thickness change	0.005 mm	0.012 mm

(For a 13 cm x 15.25 cm plate)

Amount of paste missing if the incoming grid is 1g too heavy		
	Weight Control	Thickness Control
Missing paste	1.0 g	0.38 g

#2 – Pasting machines already control to thickness

All paste application machines, including fixed orifice (FOP), drum, and belt (cloth or steel) must be mechanically set to the desired paste thickness. According to the mechanical system, the primary control parameter is always thickness. If you are controlling by weight, you are in fact controlling the pasting machine indirectly. This extra conversion process introduces more error.

Since your pasting machines require a thickness input for control, it just makes sense to control for thickness throughout the whole process.

#3 — There's no need to remove plates from the line

An automatic thickness gauge installed in-line, measuring thickness continuously, lets you measure, record, and track nearly every plate. It can therefore serve as the basis for completely closed-loop thickness control.

#4 — You can avoid leaning stacks

By measuring the top/bottom and operator/non-operator side of each plate, you can record and control the overall plate shape. This gives you the ability to identify misshaped plates and avoid leaning stacks, which can cause downstream manufacturing issues. If you're only weighing plates, there's no way to identify whether a plate is sloped top to bottom or left to right.

#5 — You lock one independent variable

With a reliable thickness measurement, you can identify the root cause of changes in the correlation between thickness, weight, and paste density, allowing you to address abnormalities in the paste mixing process. When the thickness value is locked, you know that deviations must be a result of weight or density fluctuations.

If, on the other hand, you resort to changing plate thickness to adjust for density variations, you will forever be fighting to achieve the right balance, relying completely on the skill of your operators.

The bottom line

If you improve thickness control, you improve your process and can – over the long term – improve your battery designs too.

Conclusion

The introduction of automatic thickness gauges to the lead-acid battery industry is a significant opportunity. Manufacturers of AGM, EFB, and even flooded lead-acid batteries stand to benefit from improved battery quality that is only possible with better gauging and better control over the volume of active material applied to each plate.

We're inviting any interested battery manufacturers to explore the potential of closed-loop active material control with our Mate Gauge and Paste Saver.

We understand that installing new equipment can be a hassle. You need to meet production targets and can't afford any downtime. That's why we've made the installation process as smooth as possible. Our system can be installed in-line or near-process with virtually no service interruption. Plus, our engineers will come to your facility to handle the installation, calibration, and training of key personnel.

As CEO of Co-efficient, I'd like to personally invite you to contact me to schedule a consultation. We'll talk about how you could try our system on one of your lines. I'm confident that you'll see the benefits in no time at all. In fact, I'm so confident that I'll let you install a system risk-free. If you're not satisfied with the results you can return it to us and receive a full refund.

Sincerely,

Steve Mate, CEO of Co-efficient

Share Your Feedback

This is a complex and important topic for our industry. If you have any feedback or advice on how to improve this eBook, I'd love to hear from you.

Share your feedback.