Using AI technology to improve EV battery manufacturing efficiency and quality

2022

VISCOM vision technology

In collaboration with

QualityLine

About Us

VISCOM
vision technology

As a global leader in non-destructive imaging solutions, Viscom offers unmatched expertise in customized metrology processes, automation and line integration. With an adaptable system portfolio of X-ray and optical battery inspection solutions, manufacturers benefit from high-throughput, flexible configurations and 100% quality control.

Our dedicated team of highly experienced battery inspection professionals support the integration of inline metrology solutions as quality gates into the production process. With our innovative technologies, world-class companies rely on Viscom solutions to produce long-lasting, high quality and reliable battery cells.

QualityLine

QualityLine is a manufacturing Analytics software solution with a patented pattern AI recognition technology that automatically integrates, interprets and analyses different formats of manufacturing data from any factory worldwide.

QualityLine's AI analytics and automated data integration maximize manufacturing efficiency and product quality by continuously collecting all manufacturing data into a unified digital twin database. Data sources from multiple global locations are harmonized and analyzed in real time.

The solution is already implemented in over 150 factories worldwide (such as General Electric, Siemens, Emerson,Stanley Black & Decker and others).

EV Demand

A Brief Story About The demand

In recent years, the demand for battery storage has grown exponentially.
Globally, investments have flowed into the battery industry to develop sustainable storage solutions to contribute to the energy transition.

Lithium-Ion batteries first appeared commercially in the early 1990s and are now the main choice for powering everything from electronics to electric vehicles.

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Vision

Lithium-ion batteries as a key technology for electronic cars (EVs) and the most important drive technology of the future.

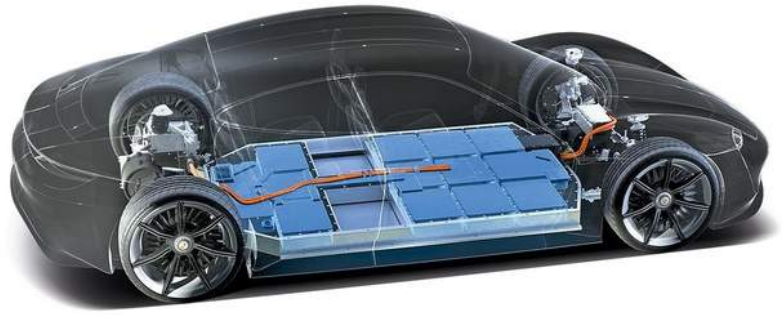
Mission

Optimize the efficiency and quality of EV battery manufacturing

Lithium-ion battery cells have come a long way since the first commercially available cell in 1991. Whilst the initial driving force in the first two decades was the consumer electronics industry, the market experiences now a major shift towards ESS and of course xEV applications on a large scale.

This vastly growing demand on battery storage creates some challenges, as new cells need to be developed, manufacturing plants have to be build, and efficient processes need to be established to safe as much energy, materials, floor space and production equipment.

A need for efficient processes



If we take a look at the value added share of a BEV today, the battery system costs alone can make up to 40% or more. The share of the cells is again approx. 85% of the total value of a battery system. The major cost factor on cell level on the other hand are materials, which are responsible for app. three quarters of the total cell costs. To put it into perspective, the share of the cathode materials alone is already responsible for about 50% of the total cell costs.

Only one quarter of the cell costs are actually needed for manufacturing and depreciation, with factories, equipment, staff, energy and so on. So, the costs of material play an important role in order to lower the battery system prices in general. But not only are the costs of the materials an issue.

The availability of materials might be a bottleneck in the next years, as the raw materials industry need to keep up with that tsunami of demand. So, setting up Gigafactories is one thing, but all the materials need to be mined and processed as well and this creates again challenges on its own.

In fact the potential scarcity of materials in conjunction with the high demand, could cause and increase in price, resulting in higher battery prices rather than lower prices as everyone expects. The recent cost explosion of nickel, although it was short lived, showed the volatility of price developments. It also shows that circular economy for materials is not only important, but it seems just inevitable on the long run, but this is another story.

An in-depth look at values

- **The cost of the battery alone accounts for up to 40% of the car's price**
- **Cathode materials alone account for about 50% of total cell costs**

Yield

Enhancing yield through data analysis

The previous chapter already indicated that efficient processes are needed to manufacture cells.

Not only because of the reasons mentioned above, but also simply to have enough cells available to make cars for instance. In order to keep up with the demand, you either have to produce more cells to compensate your scrap or you have to optimize your processes in order to maximize your yield.
In order to optimize it is important to understand the processes on a deep level.

However, to understand something requires information and this means data, a lot of data. There are different types of data: machine data from sensor or log files for instance, process data and quality data. Let's simply matters and focus on quality data and also on certain processes in cell assembly. All quality data from cell manufacturing would go beyond the scope of this articles, but the examples are representative and describe the general way of thinking.

VISCOM
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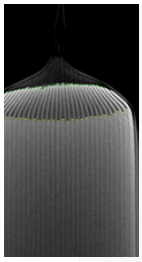
Viscom from Hanover in Germany are experts in X-ray inline metrology on cell level, whether coins, stacks cylindrical or prismatic cells.

QualityLine

QualityLine's AI technology- data correlation and diagnostics delivers immediate insights from x-ray data when something is wrong either from the quality of materials used, or either the process itself. Through a greater understanding of the battery cell manufacturing machinery, better yields and product quality can be achieved, maximising capacity, and reducing waste.

Lithium-ion battery cell waste can be reduced through improved yields

Process parameters: The anode - cathode overhang



There are different types and sizes of cells, depending on their application, like coin, pouch, prismatic or cylindrical cells. However, the main distinction in terms of manufacturing is the process of how the electrodes – anodes and cathodes are assembled. There are basically two ways of doing it: winding or stacking. In the winding process, the electrodes are wound to a cylindrical shape, sometimes flattened to fit into prismatic housing, but predominately used in cylindrical cells and coins. In the stacking process, the electrode sheets are alternately stacked on top of each other. This electrode assembly is also often referred to as jelly rolls or stacks. Either way, the anode sheets are larger than the cathode electrodes. The distance between the larger anodes to the smaller cathodes is also known as the anode overhang or anode – cathode overhang (ACO). The anode overhang can vary between of some tenths of a millimeter up to a couple of millimeters, depending on the cell size. An ideal battery cell has a perfectly aligned cathode and anode level, resulting in a uniform AC overhang.

To get the alignment of the anodes and cathodes right, is actually not as trivial as it sounds. The substrate material is either copper for the anodes or aluminum for the cathodes. They are double sided coated with either carbon black (anodes) or a composition of lithium, nickel, manganese or cobalt, depending on the cell chemistry. These coated electrodes are then compressed in the calandering process. This process leads to a tension of the foils, which are often sensitive to process parameter or material variations.

But why is the ACO such a crucial parameter in a battery cell? The carefully balanced tolerance zones are designed to prevent the development of dendrites, which are small crystals that can grow out the coating material over charging cycles. They can potentially become a safety hazard, because they might damage the thin separator foil, which shield the different potential of the electrode, resulting in a short circuit in the cell. Since the electrolyte in the cell is a flammable substance, this immediate discharge can lead to a thermal runaway of the entire cell. This is bad enough in devices where only a single cell is used, but in applications where more cells are packed tightly together, like in a battery module, the consequences can be even more severe, since one thermal runaway might trigger a chain reaction of other cells to fail. Another reason with similar consequences is to prevent the accumulation of highly reactive lithium around the tips of the cathodes, known as lithium plating. The long term performance, which means the remaining capacity of cells over charging cycles, is also depending on uniformly ACO's and therefore important for long lasting cells.

Where to X-ray in production?

There are two main quality gates in production which are reasonable to use. The first can be deployed directly after the winding or stacking process, following the logic that if the jelly roll or stack is out of tolerance at this stage, it will also be in the final assembled cell. The jelly roll can be rejected at this stage and more easily recycled and no further energy, equipment and
materials are wasted. In addition the measured data or respectively the deviations to nominal data can be used inversely to correct these winding and stacking processes. This means the inspection data can be used to judge the quality of a product but also actively deliver correction data to compensate any imperfections to eventually perfecting the product and therefore to prevent out of tolerance products in the first place. The goal is of course to extend to a maximum without compromising the safety of a product itself.

Collaboration: Viscom/QualityLine

We have seen so far that having quality data available from gates like X-ray play an important role in order to understand production. However, this quality information is interconnected to prior processes. So, if this data shall be used to improve these prior processes all data need to be merged and analyzed to find cross correlations. The benefit of this approach is, that potential failure patterns are recognized immediately and counter measures can be initiated very quickly to keep a high quality level in the first place. All this in the scope of keeping the yield high and to avoid any downtime of the line. This is exactly the expertise of QualityLine to gather process data and analyze and therefore the collaboration of Viscom and QualityLine makes perfect sense in order to deliver solutions on a broader scale.

QualityLine AI technology

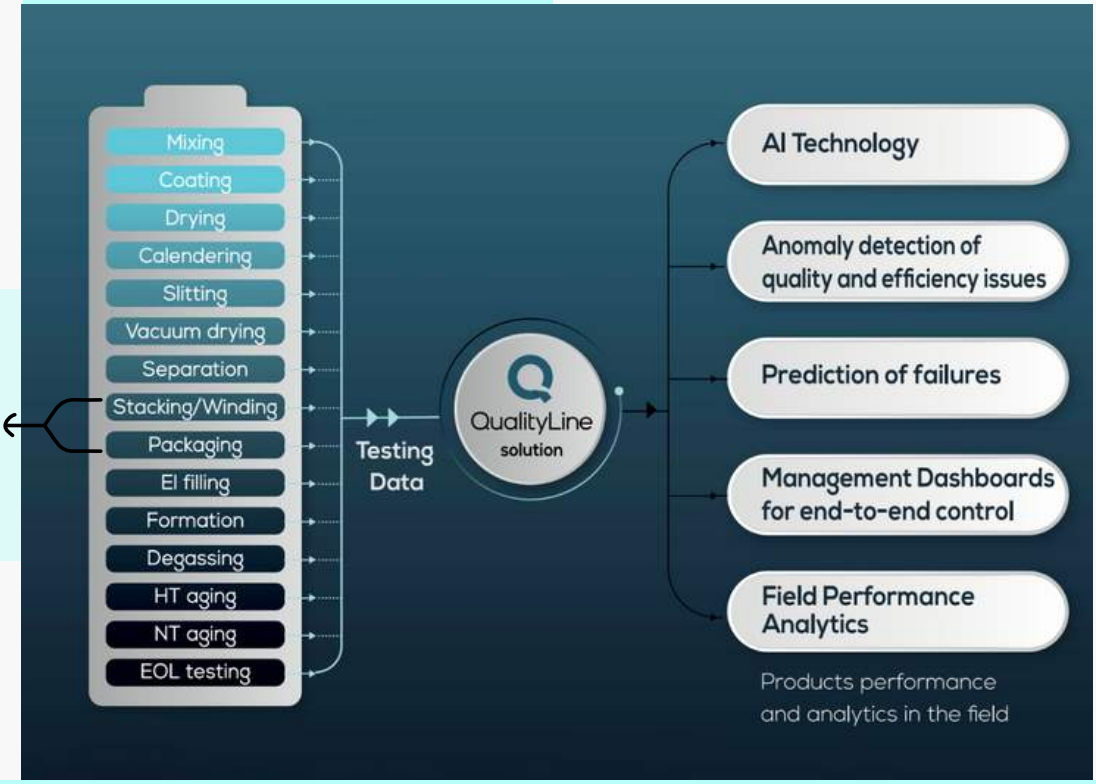
enhancing the quality and efficiency of EV batteries

INTEGRATE PROCESS WITH ENTIRE FACTORY DATA

COLLECT AND UNIFY FACTORY DATA INTO A DIGITAL TWIN DATABASE

ANALYZE FACTORY DATA USING AI ALGORITHMS

VISUALIZE BI ANALYTICS FOR THE FACTORY



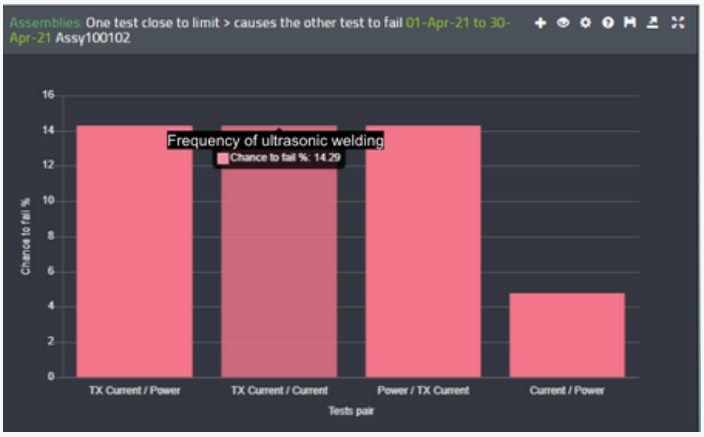
Managing data from Batteries manufacturing process to prevent malfunctions

Batteries generate massive amounts of data during production, testing, and in-vehicle use. Currently, Battery Management Systems (BMS) capture some data (such as current state of charge) but the information is static and does not provide insight into the quality of the battery, making it difficult to generate meaningful data.

QualityLine AI technology delivers end-to-end control of the manufacturing process by analysing automated data integration of any manufacturing data, including inspection data from battery production.The technology enable teams to cross correlate between different data sources for a quick and accurate root cause analysis and prevention that improves processes

Illustration of cross correlation analysis between tested parameters

- Tests that when one test close to limits > cause other test to fail



- Tests that fails together

Illustrations of base level information elements

Process parameters & requirements

- Frequency of ultrasonic welding: approx. 15 kHz - 40 kHz.
- Flexible beam guidance and shaping during laser welding of the lid of the prismatic cell.
- Correlation between anode and housing: resistance welding.
- Correlation between cathode and cell lid: laser welding.

Illustration ⅓

- Histogram
  - View the distribution of the tests results.

Illustration ⅔

- Cp/Cpk long term analysis
  - Distribution in case of mass production.
  - Prediction of failures.
  - Recommended thresholds.

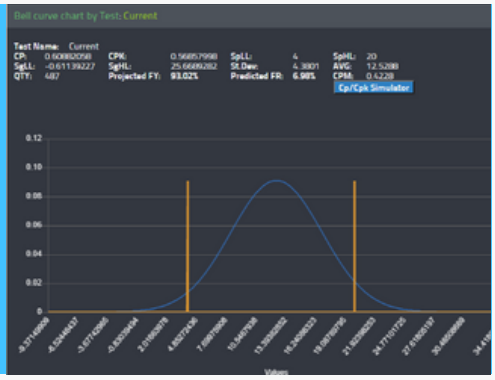
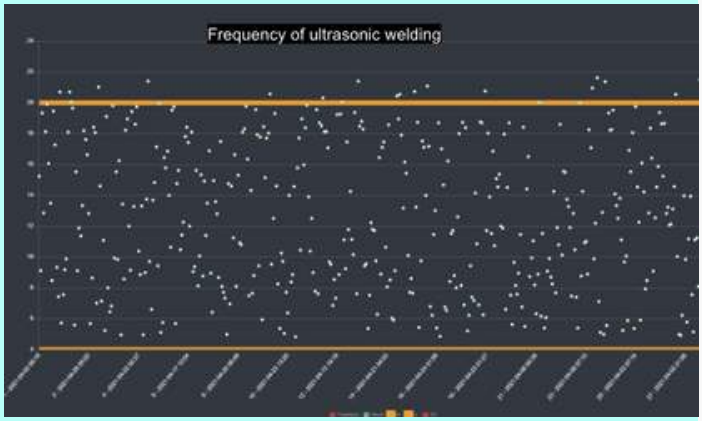


Illustration 3/3

- Control chat



Q&A

The battery inspection department at Viscom AG and QualityLine solution came up with the most relevant questions on how to improve battery quality and efficiency.

1- What is the connection between Viscom, QualityLine and the battery business?

Viscom is an SMT testing business – and knows what challenges are and how AI analytics can contribute to process learning. Since I'm in the field of battery inspection and with all the massive investments that are put today to gigafactories, I know that process learning is very important to the battery business in those days. So I came across the QualityLine solution and so far we made good steps testing the solution to this vertical. We're already doing the second proof of concept with our machines that we would like to use for our customers. There is still a lot to do for sure, but we can say that we're getting to a great solution for the battery business.

2- How QualityLine is able to capture failures immediately? In what ways can this help improving efficiency?

By data monitoring you can get immediate information about your process. At the very short initial phase you can find what log files tell, which you can evaluate and understand without any extra effort. However log files are stored in every machinery for a short period of time. With QualityLine's solution, you can get an immediate picture of what is going on.

In addition, Qualityline's solution uses correlations for prediction of production quality and when production machinery maintenance is needed. As there is a higher battery demand than can be produced, not stopping production every other week due to maintenance of different machinery and being able to plan is a crucial benefit.

3- What is the biggest value delivered by the QualityLine solution to the automotive battery industry?

QualityLine solution provides a deep understanding of the battery cell production line through data correlation and diagnostics to give you an understanding of your manufacturing machinery and a higher product quality. You get full transparency and end-to-end control of your manufacturer.

In the automotive industry, you cannot afford battery defects. With the right tools you can increase your ability to identify and prevent such battery defects before they hit the road.
QualityLine delivers enormous flexibility for changes, the solution is easy and flexible and the automotive market was looking for such a solution for years.

For example, the staff can search for cells, sorting good and bad cells, and when there is something wrong with the production, they can start sorting more and more bad cells but they don't know where the bad cells are coming from.

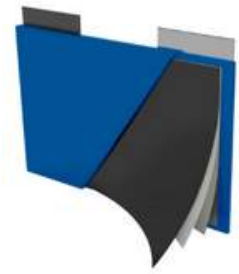
This is something QualityLine solution is looking at, finding the source to provide a more stable production and in case something happens you can immediately see where the failures are coming from. That is the biggest contribution to the automotive market

4- How can this process knowledge be exploited?

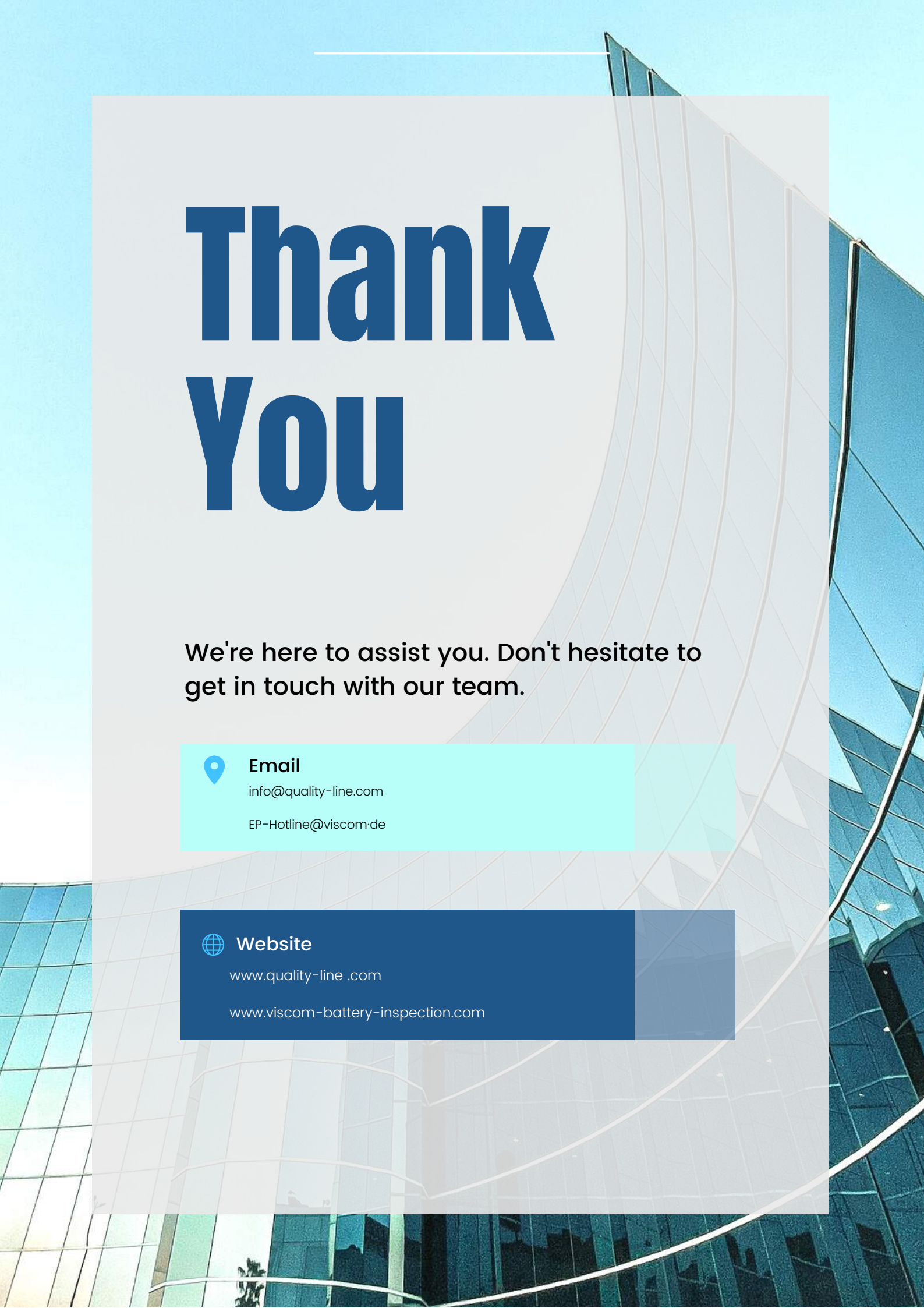
For battery production we need more cells everyday, faster, and at the same time a very high quality. In order to reduce the risks of battery fires and any other defects or failures, we need to quickly understand which stations in the manufacturing line are causing faulty units.
The cycle time is very important, if you look at the SMT process, every board that is produced takes around 30 sec up to a minute. At the battery we're talking about a cycle time, depending on cell type and size, of 3 to 10 seconds per battery cell (pouch) but for a cylindrical battery the cycle time is lower. You produce 180 batteries per minute and even more, so there is a need to get real-time insights from your production.

Using QualityLine's AI technology you can get immediate insights from x-ray data when something is wrong either from the quality of materials you are using, or either the process itself. We can quickly see a failure pattern at the x-ray that hasn't been there before, so instead of having to investigate an enormous amount of data, and doing a lot of testing, you can immediately solve issues by having the inspection data available.

The solution analyzes every step of the process. If there is no failure along the process, then you narrow down to analyzing the quality of the material used at the production. On the other hand, if parameters change, then you can understand them and analyze the influencing factors. Thus, QualityLine's inspection data enables you to have deeper and faster insights as well as full transparency for your entire production process."



In order to identify failure patterns, manufacturing data is harmonised and analyzed by QualityLine solution to find cross correlations.



Thank You

We're here to assist you. Don't hesitate to get in touch with our team.

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