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BATTERY INDUSTRY

INTRODUCTION INTO **BATTERY PRODUCTION**

From life saving devices to transportation, from video games to jewelry and watches, and from computers to phones our life has changed with the advancements of batteries. Currently battery technology is on the verge of carrying literally every aspect of life we are involved in and reliability and sustainability are no longer an option. Battery performance and life expectancy constitute a bottleneck for electric world as we have grown to rely on the cordless devices as the allow us to explore life untethered. One thing is already perfectly clear: the processes throughout battery manufacturing operation needs to be optimized in order to achieve target properties and sustainability.

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GOALS OF
BATTERY MANUFACTURERS

Sustainability – Reduced consumption of energy and raw materials

When we discuss manufacturing batteries, there is a large amount of energy used in the manufacturing process. This process is the focus of reducing energy consumption in the manufacturing process. A circular manufacturing approach, using clean energy to power battery cell manufacturing, and conscientious sourcing of raw materials are required to create a sustainable process that makes the world a better place.

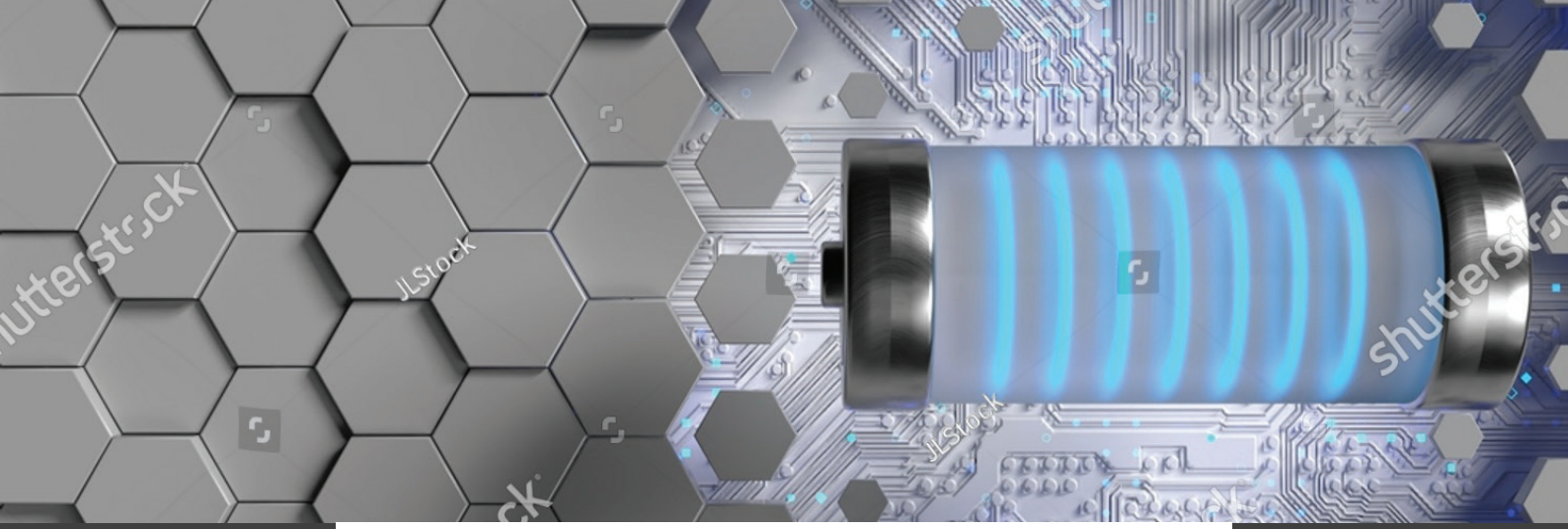
Stable, competitive production process

When we discuss battery production, all batteries have a cell and this cell is the focus for all manufacturers. To achieve higher capacity, a battery is made up of many small cells connected in series and parallel. In the world of battery production and creating the best battery, this set of cells is the key as a battery is only as strong as it weakest cell. Therefore cell continuity is crucial for all manufacturers.

There can be a significant difference in the cycle life and quality of the best and the worst cells. By repeating and stabilizing manufacturing processes, battery solutions in demanding applications will be of higher quality.

Increasing production capacity

Leading battery manufacturers such as Panasonic, LG, Samsung, and are fighting to win orders and capture global marketshare from global automobile OEMs. In doing so, they are also providing an excellent stimulus to each other. Capacity expansions have accelerated sharply since the electric vehicle portion of global vehicle sales volume began to look significant. According to Counterpoint Research, it is expected that the cumulative battery production capacity for electric vehicles to increase to nearly 800GWh by 2025, led mainly by the expansion of the top players. And with local and federal governments offering incentives to buyers of electric vehicles, this growth expansion will remain sustainable.



BATTERY PRODUCTION

The first step in the assembly of a battery cell is the deposition of a suspension containing the active material, conducting material and polymeric binder in a solvent on to a copper film or an aluminum film (slurry preparation and coating). This is followed by drying, calendaring and sizing of the electrodes. To deliver desirable electrochemical performance, the multistep manufacturing process of battery electrodes need to be closely controlled. Slurries are a very complex suspension system containing large percentage of solid particles of different chemicals, sizes and shapes in a highly viscous media. A thorough mixing of slurry is essential for homogeneity. Rheological properties of slurries affect important attributes: slurry stability, ease of mixing and coating performance, which impact finished electrodes. Composition and applied processing conditions can have an impact on the rheology of the resulting suspension. Density and viscosity quantify flow properties and characterize the degree of structure within the sample and the extent to which solid- or liquid-like behavior dominates. In electrode manufacturing process, viscosity of in-process constituents is especially significant and plays a critical role battery fabrication processes such as coating. Viscosity of the polymeric binder solution affects coating performance. It influences the ease with which the powders are dispersed within it, the power required for mixing and the speed of application of uniform coating. The Porous Electrode Theory(PET) suggests the relevance of positive electrode density on overall performance of Lithium-ion battery cells, validated by experiments. Cells with high positive electrode density show a slightly higher discharge capacity at low current rates but at high current rates, cells with a low positive electrode density show a better performance.

STEPS IN THE BATTERY MANUFACTURING PROCESS

1. Mixing
2. Coating
3. Calendaring
4. Slitting
5. Electrode Making

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PROBLEM STATEMENT

The dispersion of slurry constituents and their states, which determine the physical properties of slurries, are critical in design and development of mixing and coating processes for producing lithium ion batteries.

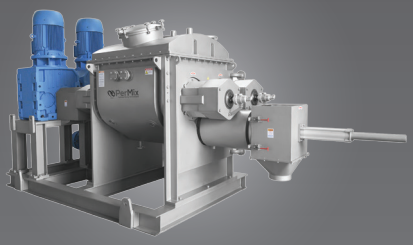
- Conventional production methods for Lithium-Ion Battery (LIB) electrode slurries are based on batch or continuous processes.
- Continuous mixing process consists of controlled dosing of all the liquid and solid components and micro distribution of the solid particles in the liquid phase.

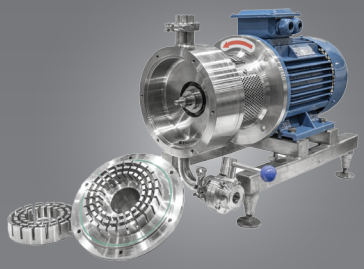
The sensitive chemistry of the cells means that time and cost savings cannot come at the expense of quality, which needs to remain very high. Controlling density and viscosity to optimize the batch processes ensures consistency, quality and significant material cost savings. Process control and traceability of the continuous mixing process can be improved with inline monitoring and control of density and viscosity. Automation supported by in-line integration makes it possible tooptimize all the processes throughout the production lines to make battery manufacturing faster to meet growing demands.

Process Challenges

Monitoring and controlling of important electrode slurry parameters – density and viscosity are extremely relevant in development and manufacture of high performance electrodes and its fabrication. Key reasons:

- During mixing of slurry, unneeded agitation deteriorates and degrades internal structures with time. The target is to achieve thorough mixing of constituents with maximum homogeneity and without breakup of particles. Density control ensures correct material composition and constituent fraction and viscosity control ensures consistency of the slurry preparation process.
- A high viscosity slurry causes problems in the coating process and poor dispersibility results in low film uniformity. Uniformity of the coating thickness and the layer density are crucial to guarantee control over the life time (recharge cycle time) and ion transfer rate of the battery, while regulating the layer thickness enables a smaller battery to be created. Viscosity control is essential to achieve homogeneous coating thickness and minimal coating thickness deviations.
- Higher viscosity of battery slurry increases resistance to sedimentation on standing and delivers a thicker electrode film on coating. The higher viscosity may also render the coating process harder to control, possibly leading to an irregular coating and variable layer density, which in turn brings about a variable ion transfer rate and hence unpredictable battery life time (and unpredictable recharge cycle time).
- Electrode density has effect on cycle performance and irreversible capacity loss in lithium-ion batteries. It needs to be monitored and controlled within appropriate ranges based on the requirement in the calendaring process.





PERMIXS' SOLUTION

Automated batch or in-line mixing and control is crucial to control the electrode slurry parameters in the slurry preparation and coating and drying stages of the battery manufacturing process. As a result, whether batch type of continuous mixing, PerMix has mixers for the precise mixing of slurry.
Prior to make the slurry, the anodes have a variety of materials that are mixed together, the most common materials are carbon/graphite as the active anode power. This is mixed with CMC as the binder/film former. The CMC is mixed with the other powders in dry mixing. This will prevent clumping when added into water. PerMix has powder mixers that result in a perfect mix of the powders prior to making the slurry also

PerMix Powder Batch Mixers

- PerMix Plow Mixers
- PerMix Vertical Paddle Mixer

PerMix Paste/Slurry Batch Mixers

- Sigma Mixer
- PerMix Double Planetary Mixers
- High Speed Dispersion Mixers

PerMix Continuous Mixers

- PerMix Emulsifiers & Inline Homogenizer Mixer

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