One system – limitless possibilities

Can completely different products such as battery electrodes and organic solar cells be processed on the same coating system? OPE journal asked a leading coating system manufacturer, Hamburg-based KROENERT GmbH & Co KG to comment

When it comes to designing a coating system, answering the question of which came first, the chicken or the egg, is easy and straightforward. The product is the measure of all things. It determines the thickness of the coating to be applied, the processing characteristics of the coating materials, the drying and cross-linking process, and even the handling of the substrate.

The "art" lies not just with the product but also in knowing each technical step of the process accurately enough to be able to define the best possible coating system layout. Theoretical knowledge and practical experience are the essential foundations on which to build and develop tests and research into coatings.

One of the leading exponents of this type of testing and research is the Hamburg-based company Kroenert GmbH & Co KG, whose coatings technology centre has been setting standards for years. "With our new lab-based system, LabCo, we can offer our customers a test facility that is able to process the full spectrum of new products such as electrodes for lithium batteries and organic solar cells", explains the company's CEO, Dr. Tarik Vardag, in an interview with OPE Journal. "LabCo's system layout gives us such a high level of flexibility that we can manufacture new products with only minor adjustments," adds Frank Schäfer, sales director new products.

We asked Kroenert experts to demonstrate the flexibility and adaptability of their LabCo system in relation to two products – electrodes for lithium batteries and organic solar cells.

The LabCo coating system at Kroenert Group's Technology Center in Hamburg

Background

Even with two very different end products – battery electrodes and solar cells – when it comes to process engineering, there is one important similarity. With the precise application of a functional coating on a moving substrate, the required functions are obtained, in other words the substrate receives the reaction layer that is essential for each application. Only the combination of substrate and coating layer will produce a fully usable product. The substrate is the carrier, and thus defines the physical properties such as tensile strength and heat resistance. The coating enables the special function of the product, such as conducting electrical current, ion exchange or transport. The process engineering behind coating and drying depends to a large extent on functional chemistry, and the substrate and its reaction to moisture and heat also affect the process significantly.

If readers think of the application system as the core component of a coating plant, then the drying and cross-linking technology is the cycle without which it is impossible to obtain a perfect end product. The final drying and cross-linking at a later stage is considered from the very first stage of the design of a coating system.

1. Electrodes for lithium batteries

Which technical product parameters apply to the manufacturing of electrodes for lithium batteries?

When manufacturing electrodes for lithium batteries, a compound containing carbon or graphite is applied to very fine aluminium or copper foil which usually has low tear resistance. Viscosity is approximately 1,000-3,000mPas.

The coating can be water-based or dissolved in a solvent and has thixotropic and pseudo-plastic properties.

What technical and procedural factors are important for the coating?

The coating compound has to be applied with extreme precision, longitudinally and transversely. Geometrically-defined structures are applied with thicknesses of 100-150μm. Strict standards need to be met with regard to temperature and air flow control in order to guarantee the quality of the coating.

Can you describe the optimal coating process for lithium battery electrodes?

In order to adapt the battery electrodes longitudinally to the geometrical measurements of the batteries, an intermittent coating (applied at intervals) is preferred. For wound cells, the length of the intermittent mode corresponds to the length of the wound electrode.

The intermitted coating can be achieved either with modified slot die or commabar technology. Although both processes are commonplace, slot die technology has the advantage of being a closed coating system, which significantly reduces the effect of evaporating solvents on the behaviour of the coating compound during application.

However, a sufficiently low viscosity is required to apply slot die technology.

When dealing with higher viscosities, extrusion technology becomes a more attractive option. Where longitudinal stripes are required, they can either be achieved using anilox roller technology or by transfer from detached rollers.

"All these processes can be carried out on our modular LabCo system", emphasises Andrea Glawe, director R&D at the Kroenert Group. "Changing from roller transfer to slot die coating is easy at any time, without any mechanical adjustments".

What do you need to consider when designing a drying system for battery electrodes?

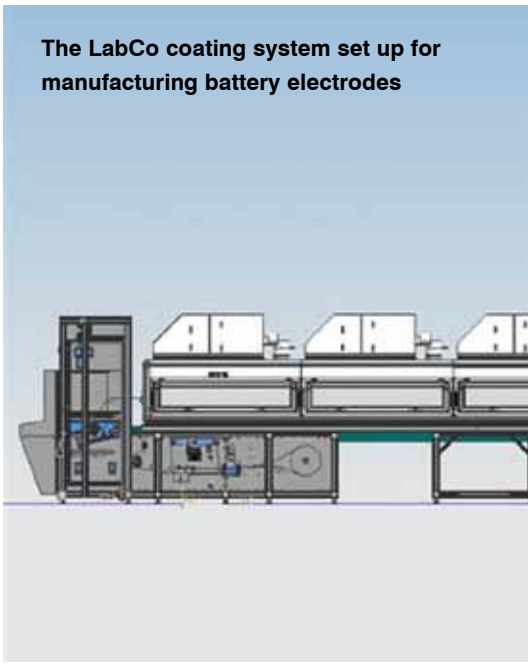
Since the drying process has a major influence on the quality of the finished electrode, highly accurate control of air flow and temperature is critical. Flawed drying can directly alter the concentration of a coating layer.

"If the drying is too intense in the first section of the dryer, the solvent on the upper layer evaporates too quickly", explains Dr. Wolfgang Neumann, director of the Kroenert Technology Center. "This can lead to tears in the coating and floating additives or solvents can even cause the binder to settle in the lower layers. Both these things can permanently affect the long-term stability of the coating".

In order to avoid these and similar problems, and to optimise the design of the LabCo system for functional coatings on battery electrodes, the Kroenert experts believe that the following factors need to be considered:

- In the first section of the dryer, it can be useful to have a flash-off ventilation circuit similar to that found in an oven, with little air movement and saturated air.
- Inert dryers offer a number of advantages with regard to preventing explosions.
- To reduce the length of the dryer, the integration of medium-wave IR technologies should be considered. To optimise the final result, however, this is usually only helpful at the end of the dryer.

Research into intermittent-mode battery electrode production at the KROENERT-BMB-DRYTEC Technology Center



The LabCo coating system set up for manufacturing battery electrodes

2. Organic solar cells

A detail of the LabCo inert drying system

What technical production parameters apply to the manufacture of organic solar cells?

Unlike battery electrodes, where very fine, low-resistance films are used the substrate on organic solar cells is less problematic, because for the most part, highly stable polyester films are used. The coating solution is different since it contains critical solvents that cause faster corrosion of the system components, due to highly acidic pH values.

What are the technical procedural requirements for the coating to be applied?

Several very fine coatings are sometimes applied in narrow strips, to the substrate. This calls for extreme precision of application both longitudinally and transversely. The layers applied each have a thickness of less than 1μm (wet).

Can you describe the optimal coating process for organic solar cells?

Slot die technologies are generally used to apply the very fine coats needed for the manufacture of organic solar cells. The specific challenge here lies in adjusting the exit slit of the slot die and the distance between slot die and substrate to produce a thin enough coating.

"Roller-based printing techniques offer other possible application solutions," adds Glawe. "Here, through accurate design of the roller and dosing technology, we can achieve a very accurate coating result."

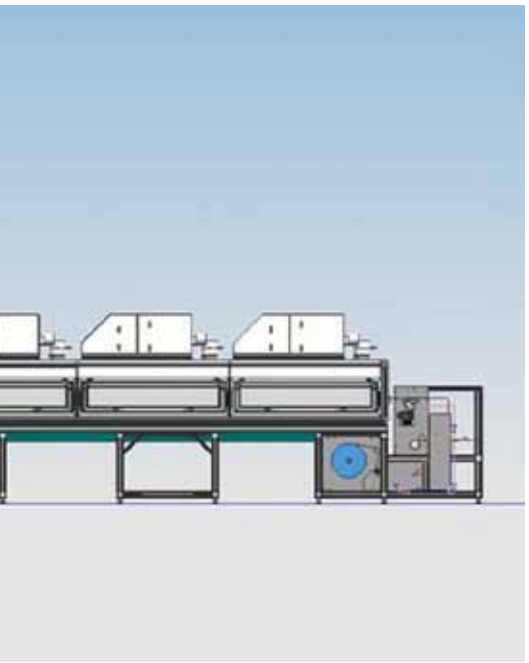
Both processes are suited to the application of a striped coating.

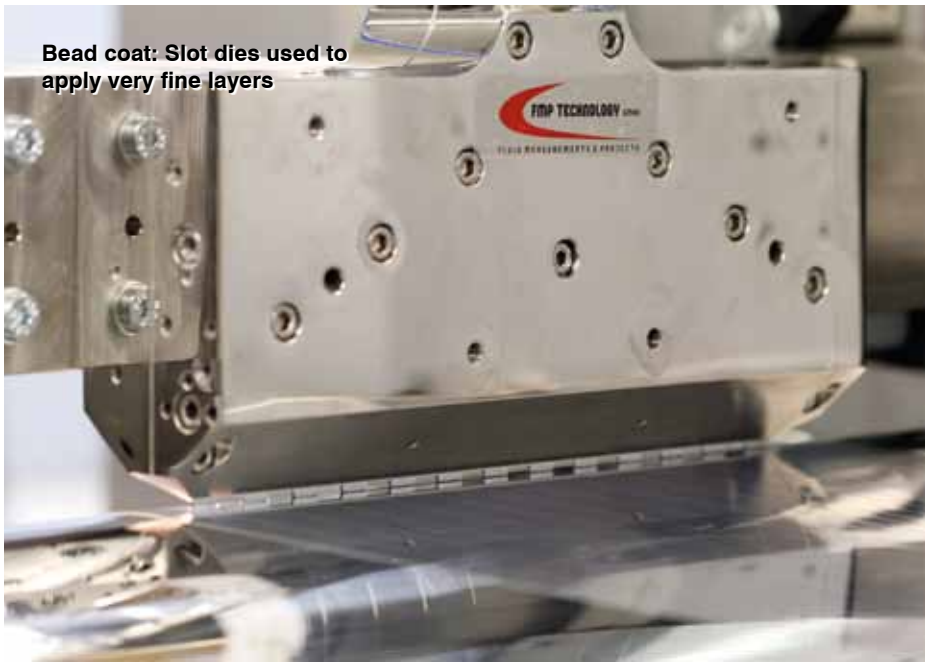
"Through accurate register control, corresponding to the layer structure of a solar cell, we can also position different coatings accurately over each other," adds the Kroenert expert. "This is possible because at the LabCo we can 'cascade' several coating and drying processes, or allow the material to run through the system two or more times," continues Neumann. Both variants are supported by an optimised web guidance system.

What are the important factors in the design of a dryer for organic solar cells?

When it comes to drying or cross-linking functional coatings, the choice of drying technology has a critical impact on the quality of the end product. The spectrum ranges from contact roller and air flotation dryers through to IR or UV technologies.

If a near-oxygen free process is required, inert drying processes are preferable. "For this purpose, LabCo equipment can be fitted with high-density inert dryers able to achieve the highest standards", says Neumann.





Bead coat: Slot dies used to apply very fine layers