



MEGTEC

Process Development

Advancing Innovative Coated Materials

Proven capabilities and tools for mixing; coating; drying & curing; and product development



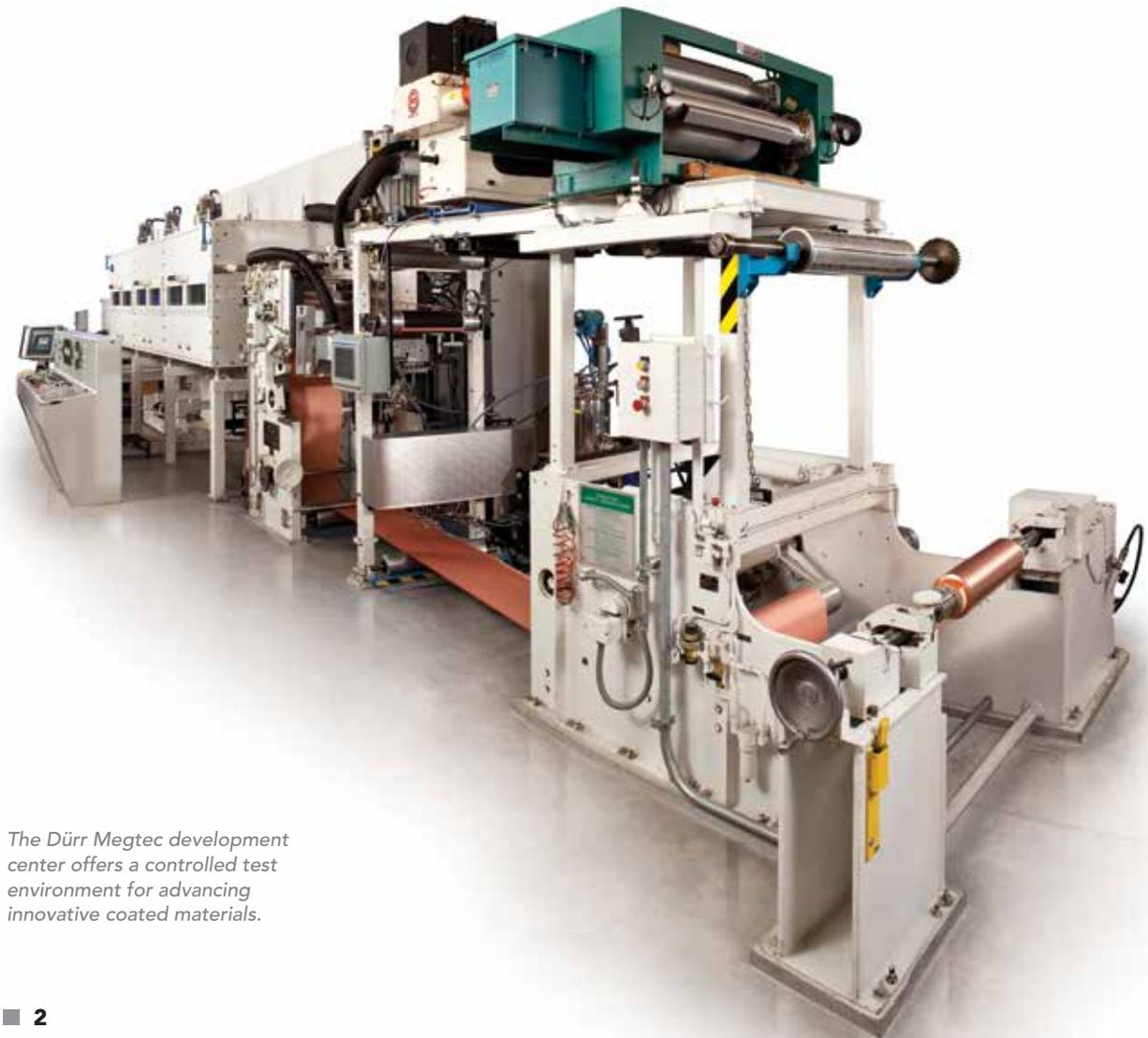
Process Development Services

Dürr Megtec is a global OEM and supplier of drying, curing, and specialty coating systems. To support the development of specialized coating and drying applications, Dürr Megtec has an in-house development center located at its headquarters facility in De Pere, Wisconsin, USA. The foundation of our capabilities is 45+ years of experience, the hallmark of which is more than 100 patents.

The development center features world-class laboratory bench-top tools and a complete roll-to-roll pilot coating line that can be rented. The pilot coating line includes full coating and drying capabilities, providing a controlled test environment for process development of short production trial runs for roll-to-roll processing applications such

as advanced battery materials, composites, solar films, membranes, flexible packaging, nonwovens, and other materials.

The development center is staffed with process engineers and technicians who can provide solutions for many drying and coating challenges. Their ability to assess and solve problems enables our customers to test, develop and improve their products and processes. A wide range of coated products have been brought to market using these tools and services.



The Dürr Megtec development center offers a controlled test environment for advancing innovative coated materials.

Bench-Top Process Tools

Dürr Megtec offers small-scale capabilities for determining initial drying process characterization. This customized approach is cost-effective and can be accomplished with minimal material use.

Bench-Top Drying Lab

The Dürr Megtec in-house drying lab is a bench-top system that captures complete drying characteristics of coated substrates from small-size samples. The system enables our process engineers to track rates of evaporation for water and organic solvents, along with determining the drying time required to reach target solvent or moisture residuals in the product.

In parallel with the development of new coatings, researchers often need to define a method/process for proper drying. Our bench-top laboratory methods make it possible to leverage early returns on key data to help assess the commercial viability of web-based substrates.



The in-house drying lab features a bench-top system for capturing the drying behavior of coatings on web-based substrates using small-size samples approximately 5 inches by 5 inches. The drying lab allows for early scale-up steps in coating formulation development, dryer optimization, and overall process trouble shooting for coating paper, films, foils, laminates, fabrics, membranes, and other flexible web materials.

The drying lab is geared toward the early scale-up steps in formulation development, drying characterization, optimization and troubleshooting. Process developers require relatively small samples of test materials to prepare coated samples. The results drive the selection of drying technology with follow-up tests on the pilot line. It is possible to simulate a wide range of drying conditions representing full-scale drying hardware options. This tool is especially suited to diffusion-limited mass transfer drying.

Heat Transfer Stand

The heat transfer stand is a bench-top system used for thermal characterization of drying and curing nozzles over a wide range of application conditions. Capabilities include:

- Quantitative heat transfer coefficient characterization
- Qualitative analysis of drying conditions to prevent defects
- Optimization of dryer nozzle selection for efficient dryer system engineering
- Measurement of heat transfer values for application-specific nozzle designs:
 - Flotation air bars
 - Impingement jet nozzles — slot or hole array types
 - Combination infrared (IR) and convection air bar arrays
- Uniformity measurements and identifying outside air disturbances (e.g., interaction of tenter rails with air jets)

Pilot Coating Line

The Dürr Megtec in-house pilot coating line enables customers to test, develop and improve web-based processes by evaluating system variables and components without having to invest in full-scale production. The goal is to optimize coating, substrate performance, and web-based operation to shorten the time between trial and commercialization.

The pilot coating line is fully equipped—from mixing to coating, drying to rewind. The system is engineered to allow for translation of the bench-top results to production-ready processes, confirm predictions of drying process models, and solve the most-challenging coating and drying process problems.

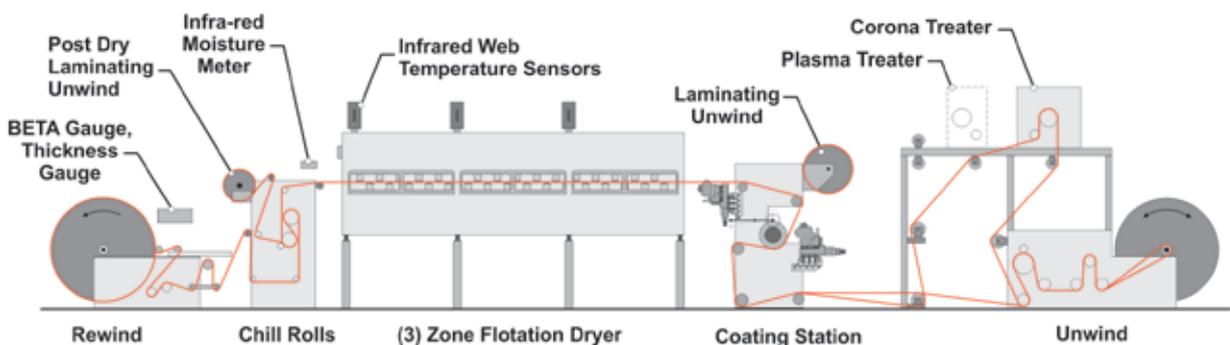
The pilot coater is an important factor in establishing the viability of emerging and advanced materials applications. It can help confirm the potential for technology patents by providing a highly confidential environment needed for new-product development. It's also the ideal environment to produce prototype materials for further research, marketing, and quality testing.

Related services and equipment capabilities of the pilot coating line include preparing coating and slurry mixtures, access to multiple

coating methods, a three-zone dryer that can be used with a wide range of substrates and tensions, plasma and corona treaters, and on-line coating thickness measurement and performance tracking.

Customers may apply their own proprietary expertise in a confidential setting. If required, our process engineers, R&D technicians, and analytical staff are available to leverage their collective process and materials expertise to solve drying and coating challenges for an ever-increasing array of substrates. Mixing, coating, and drying capabilities of the pilot coating line include:

- Manual unwind and rewind
- The ability to run multiple coating methods with precision coating modules for single- or dual-side slot die coating
- A flexible machine layout that can accommodate custom changes to the line as needed
- Convection dryer with either impingement or flotation nozzles to dry the coated side of the web
- The ability to handle substrates up to 600 mm wide
- Line speeds up to 200 meters/minute



The Dürr Megtec pilot coating line is available to test, advance and improve web-based coating and drying processes. The pilot line is a cost-effective tool for evaluating system functionality and design with the goal of optimizing their performance and operation with various coatings and substrates.

Whatever your mixing, coating and drying process challenge, we'll turn it into a workable process with:

- Experienced process engineers, line operators, R&D technicians, and analytical staff
- Experts in process development for slurry mixing, slot-die coating, gravure and roll coating, and drying



Dürr Megtec provides complete turnkey solutions for the production of advanced web-based materials such as lithium-ion battery cathode and anode electrode materials. Our expertise includes raw material handling, coating/slurry mixing and fluid delivery, web handling, coating and drying, solvent recovery and purification, calendaring, and slitting.

- Six Sigma training for problem solving and analysis
- Experience that can take Lab Bench/R&D/Pilot results to mass production
- Ability to assess problems and apply solutions in real time to resolve process challenges during trials



Producing advanced web-based materials, like lithium-ion battery cathode and anode electrode materials, begins with the right chemistry. Dürr Megtec process engineers understand raw material handling, slurry mixing, and fluid delivery.

Pilot Coater Technical Overview

- Multiple coating methods are available, including slot-die with skip and stripe coating capabilities
- (3) 1.5 meter (5-foot) zones
- 4.5 meters (15 foot) total effective drying length
- Web widths up to 600 mm (24 in.)
- Maximum substrate roll diameter:
 - 1200 mm (48 in.) unwind
 - 1000 mm (40 in.) rewind
 - 650 mm (27 in.) laminator
- Core size: 76 mm (3 in.) or 152 mm (6 in.) inside-diameter (three 76 mm shafts and two 152 mm shafts)
- Rated mechanical speed up to 200 mpm (650 fpm)

- Tension range: 2.27 kg (5 lb.) to 45.36 kg (100 lb.)
- Laminator: both wet and dry ends
- Corona and plasma treaters
- High-performance fluid delivery systems
- Ross dispersing mixer
- Thickness gauges
- TA instruments DHR 1 parallel plate rheometer
- MeSys ultrasonic coat-weight gauge
- Solvent capabilities: electrical equipment in the lab is rated for Group D and limited Group C atmosphere. Solvents listed under Group A or B of Table 500-3 of the National Electrical Code (1996) cannot be run. Group C solvents subject to review.

Coating Technical Overview

Dürr Megtec has pioneered industrial web coating and drying processes. As an OEM, our patented technologies have made us a global leader in providing engineered solutions that optimize advanced manufacturing processes. We leverage our industrial products and services capabilities to a diverse customer base serving a wide variety of market sectors.

From a coating line that meets the basic and competitive needs of a new player in the market to a fully integrated production line for high-volume runs, Dürr Megtec is a single-source OEM that can meet all your production requirements, including support during process development.

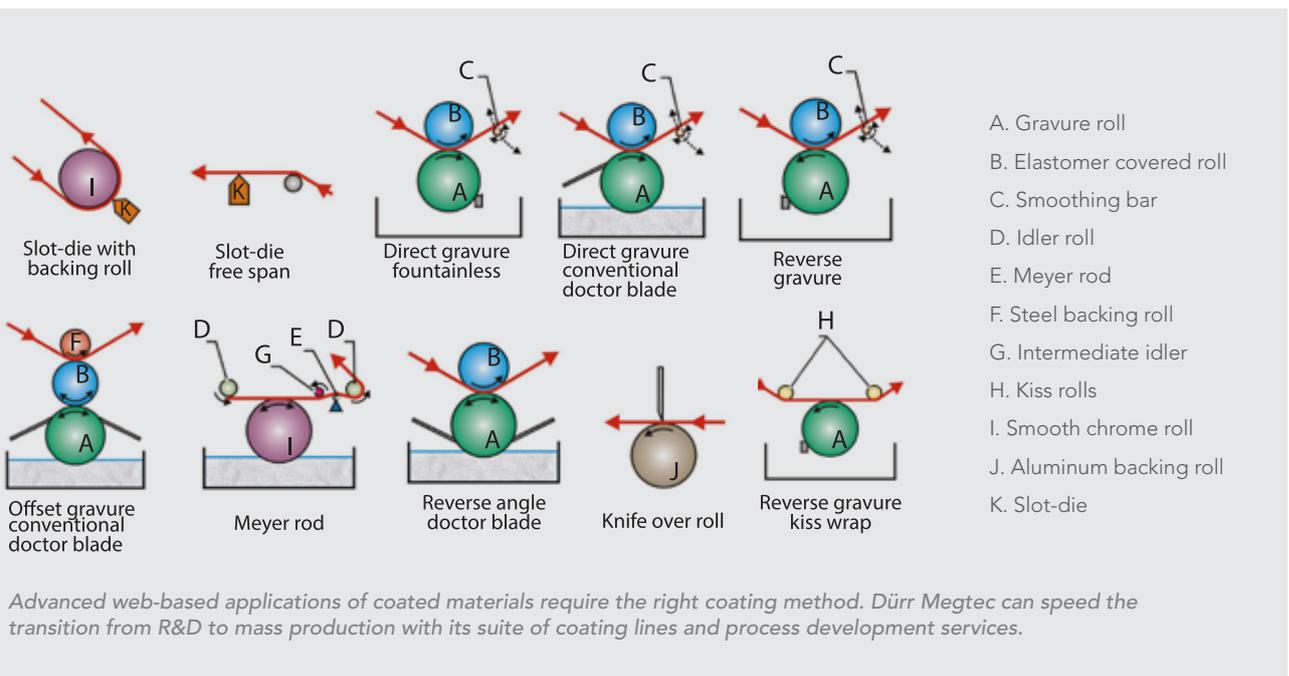
Our development center coating capabilities include:

- Gravure*
 - o Direct gravure
 - o 3-roll offset gravure (vertical)
 - o Reverse gravure

*Both gravure and impression rolls are independently driven and can be run at variable speeds in either direction. Either roll can be controlled by load cells to maintain a desired tension. Any gravure method can run either with pan feed or a fountainless feed system.

- Meyer rod
- Metering knife over roll
- Dip and squeeze/saturation
- Slot-die coating (fixed and adjustable lip dies)
 - o Wet coating thickness: 10-800 microns
 - o Dry coating thickness: 5-200 microns
- Slot-die
 - o Tensioned web over slot-die
 - o Backing roll
 - o Simultaneous two-sided coating**

**Dürr Megtec pioneered simultaneous two-side horizontal free-span coating.



Additional Coating & Drying Tools

Dürr Megtec designs and manufactures drying and conditioning equipment for web substrates at any speed and width. Our capabilities are further enhanced with the following equipment and tools.

Bench-Top Rheometer

Dürr Megtec has a TA Instruments parallel plate rheometer for characterizing the rheology of coating fluids to set up the slot dies for optimal performance during coating trials. Rheometer output includes:

- Graphical rheology curves for visual interpretation
- Ability to import files into Excel for further analysis
- Ability to import files into the TA Instruments Trios software for further analysis—the software is a free download from TA Instruments.

Drying Process Model

We have developed and maintain a computer drying model to characterize processes as well as define proper design choices for equipment needed to properly dry coatings.

3D Microscope

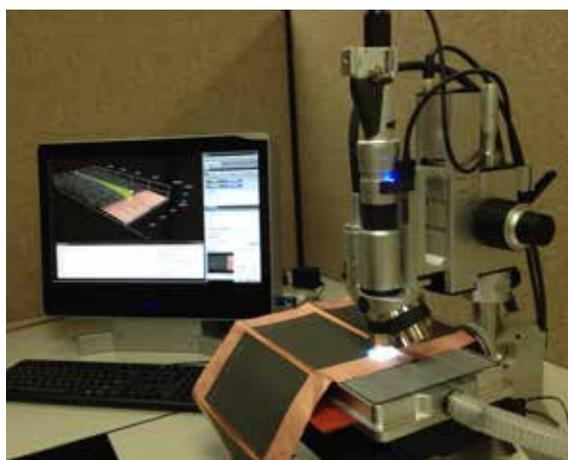
Hirox Digital 3D microscope for measuring coated samples, quality, defect analysis, and visual characterization of 3D objects/samples (catalyst, media, etc.):

- Measures features down to about the micron level
- Saves images in 2D and 3D JPG and MPG formats
- Available for customer use, requiring less than one hour initial training time

Machine Shop

When unexpected coating behaviors are encountered, our engineering team quickly adapts and has a wide range of tools readily available onsite. Using problem-solving methodologies, solutions can be quickly identified, prototyped, and implemented to help the customer complete the trial objectives on time. Examples include:

- Addition/subtraction of idlers in the web path
- Special prototypes for stabilizing the web or coating bead
- Miscellaneous mechanical fixtures for mounting customer-provided equipment, setting up of the fluid delivery system, etc.



The Dürr Megtec development center provides a wide assortment of tools to help process formulators, plant process engineers, and drying process engineers capture key information that can help guide process design decisions. Pictured is our Hirox® digital 3D microscope.



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