Advantages of Slot Die Systems for Applying Water-Based Coatings

by Keith Wheeler, Director, Global Fluid Coating Business, Premier Coating Division, Nordson EDI

As environmental and workplace safety concerns cause more and more web converters to change from solvent-based to water-based coatings, the advantages of slot dies over roll coating systems have become even greater. Slot die coating has historically made possible higher line speeds, tighter coat weight tolerances, and lower operating costs, along with potential for thinner coat weights. With the move to water-based coatings, slot die systems are proving better able to accommodate the properties of these fluids.

One problem that roll coating presents in applying water-based adhesives is the risk of its continuous recirculation of the coating fluid, which subjects it to repeated shearing. While solvent-based coatings are normally undamaged by this, water-based coatings often undergo a property change. In addition, as water-based systems have been reformulated for improved adhesion to substrates, the resulting increase in tackiness makes them more difficult to apply via roll coating.

As the same growing number of converters are discovering the benefits of applying two or more layers in one pass, which is beyond the capabilities of conventional roll coating but readily achievable with slot dies. The savings in time and cost over multi-pass coating are obtainable in many forms of application, from coatings that combine fluids with different functions to side-by-side or side-by-side coatings of paints and other materials. Since water-based coatings wet-out less readily than solvent-based, one-pass multi-layer application is an option in many cases.

One of the most notable advantages of slot die coating is the ability to set the overall coating width and to minimize edge bead. This rear view of a dual-slot Premier™ fixed-lip die shows the fluid delivery system, die positioner, and vacuum box.

The Nordson exhibit at ICE USA (Booth 715) will feature the company’s entire coating product range, including the hot melts systems long offered by Nordson and the fluid coating and extrusion coating systems developed by Extrusion Dies Industries (EDI), which Nordson acquired in 2012. As ICE Europe (Hall A5, Stand 1026), the Nordson exhibit will include the Premier Coating Division, which was part of the EDI acquisition. Widespread use in the US, Premier™ dies are now offered globally.

Some of the systems now available from Nordson for web coating include:
- Premier™ fixed-lip fluid coating die, capable of applications as thin as one micron (μm) with coat weight accuracy of +/- 1 to 2%
- UltraCoat™ adjustable-lip coating dies for cold fluids or hot melts, in which coating gap and width can be adjusted without dismounting the die
- TrueCoat™ fixed-lip hot melt die coating, with capability for quick job changes
- EPIC™ extrusion coating die, whose internal deckle has independently adjustable components that can be set to obtain overall coating width and to minimize edge bead.

This product-line versatility is just one of the capabilities that set Nordson apart as a supplier to the web converting industry. Nordson is the only truly global supplier of coating systems, offering sales and technical support through a network of directly-operated facilities in more than 30 countries. The company manufactures both slot dies and extrusion dies in the US, Europe, and Asia. It maintains trial laboratories for slot die coating at seven locations in China.

Nordson is a publicly traded multinational with annual sales of nearly US $1.7-billion. It has a substantial commitment to investment in R&D and in local infrastructure, notes John J. Keane, senior vice president of technology, “Nordson’s way of doing business is to operate in each region of the world as a local company that is backed by a strong central organization but engages customers in their own language, culture, and time zone,” says Mr. Keane. “Our goal is to be able to make products where we sell it, and we already have the leadership and infrastructure in place worldwide that enables us to do so.”

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At ICE, Nordson Highlights the Diversity and Global Availability of its Coating Systems

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Inside:
- Benefits of slot dies for converting to water-based coatings
- Flexible packaging producer eliminates edge bead in extrusion coating

Nordson on the Web
For information on all Nordson Polymer Processing Systems brands, readers are invited to visit www.nordsonfluidcoating.com.

For information specific to fluid coating, visit www.nordsonfluidcoating.com.

Nordson Corporation (Nasdaq: NDSN) engineers, manufactures and markets differentiated products and systems used for the precision dispensing and processing of adhesives, coatings, polymers and plastics, sealants, biomaterials and other materials, and for fluid management, test and inspection, UV curing and surface treatments, all supported by application expertise and direct global sales and service. Nordson serves a wide variety of consumer non-durable, durable and technology markets and includes packaging, nonwovens, electronics, medical, appliances, energy, transportation, construction, and general products assembly and finishing. Founded in 1954 and headquartered in Westlake, Ohio, the company has operations and support offices in more than 35 countries.


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DUAL-LAYER CAPABILITY: This rear view of a dual-slot Premier™ fixed-lip die shows about two fluid entry ports. With any die, Nordson can supply fluid delivery system, die positioner, and vacuum box.

At ICE, Nordson Highlights the Diversity and Global Availability of its Coating Systems

Advances in News and Concepts from Nordson’s Polymer Processing Systems Group

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Extrusion Coating Die Eliminates Edge Bead and Enhances Coat Weight Uniformity

While Nordson’s EPC™ extrusion coating die is designed to reduce edge bead, it has enabled one leading producer of foil-laminated flexible packaging to actually eliminate it—as well as reducing coat weight variation by half or more.

After a die for applying LLDPE on an existing production line for flexible food packaging had been causing problems with die lines and leakage, Korea Aluminium Co. Ltd. recently replaced it with the Nordson EDD Edge Profile Control (EPC) die. The new die has not only eliminated the previous problems but has also made it possible to address the issue of edge bead and the waste of coating and substrate material that results from it, according to Mr. Jonghyeon Hoo, senior sales manager of Korea Aluminium’s headquarters facility in Changwon.

While the degree of edge bead reduction achievable with the EPC die depends on a number of factors, the reduction in the Korea Aluminium coating line was 100%.” We are now manufacturing product with zero edge bead,” says Mr. Hoo.

In addition, he notes, the EPC die reduced coat weight variation by 50 to 60%. “Thickness uniformity was +/- 2 or 2.5 microns with the old die, but with Nordson’s EPC die uniformity has been improved to almost +/- 1.5 microns.”

The EPC unit installed on Korea Aluminium’s coating line was a manual die, notes Sam G. Iuliano, Nordson EED chief technologist. “The 4 to 5% range of variation from target coat weight is very good indeed for a manual die,” he says. “With an automatic die, the range could easily be cut in half.”

Nordson EED is represented in South Korea by Dae Cho Industrial Co., whose president is S.J. Kang. Nordson field service agent Andy Sweeneyngton traveled from the USA to provide on-site startup support for Korea Aluminium, and Choong Kim, senior sales manager for Nordson in South Korea, supplied technical recommendations for enhancing coat weight uniformity.

Fine Tuning the Edge Profile of a Coating

An EPC die includes an external deckle as a secondary seal to prevent leakage and an internal deckle system that sets coat width and seals polymer at the die exit. Internal deckle parts provide independently adjustable components that seal off the internal flow channel and can be positioned to set the overall coating width and to minimize edge bead (see schematic). Similarly, a manual or automated system for adjusting a flexible lip of the die makes it possible to maintain coat weight uniformity.

Internal deckle systems used for fine-tuning the edge profile of a coating are effective because of the tendency of modern polymers to exhibit transverse flow if lateral barriers to flow are removed at the die exit. In the EPC die, the internal deckle components for adjusting the edge bead profile are located upstream of the lip land—one in the primary manifold section, the second in the preland area. By adjusting the positions of these components relative to the deckle rod, it is possible to reduce the flow of polymer at the extreme edges of the coating, thereby minimizing edge bead.

Korea Aluminium Co. Ltd. has been a producer of aluminium foil since 1987 and is a manufacturer of pharmaceutical, food, and confectionary packaging that complies with U.S. and EU codes and standards. Visit www.kool.co.kr.

How Edge bead Is Reduced. Schematic shows how the internal deckle system (orange and yellow components) of the EPC™ extrusion coating die can be adjusted to reduce edge bead in a coating (shown in gray). In this example, edge bead is reduced from six times the target coating thickness to twice that thickness.

Advantages of Slot Die Systems – continued from P. 4

Large Economic Benefit of Converting to Slot Die System

One way to put into perspective the economic benefits of converting to a slot die/water-base system is to consider the potential annual cost savings, compared with roll coating/solvent-base, for a typical 60-in. width application. Depending on a number of factors, savings can range from $500,000 to $1,000,000, often amounting to a reduction of 20% or greater:

To understand how these savings are realized, it is useful to review first how the fluids have different surface tensions to prevent the fluids from mixing. In general, to promote complete spreading, the top layer needs to have slightly lower surface tension than any of the other layers.

This precise control over coating application afforded by the slot die yields a coat weight uniformity equal to or better than that obtained with roll coating/solvent-base systems, along with these advantages:

- Tighten coat weight tolerances. By holding tolerances to +/- 1% or 2%, slot die coating allows for reduced coating material consumption without compromising the quality of the finished product. In fact, new formulations with customized slot die design often yield products with thinner coat weights and better performance.

- 20% or greater increase in line speed. Maximum line speeds for slot dies are 3,000 feet (915 m) per minute; by contrast, roll coating typically runs no faster than 1,350 to 1,500 feet (405 to 460 m) per minute.

The accompanying table, based on one customer’s use of a Premier slot die system to coat film for an electronics application, shows how these slot die coating advantages translate into cost savings.

Key to the success achieved in this improved process was the achievement of even surface tension uniformity with the Premier die, which held cross-web thickness variation to +/- 2%. The Nordson dual-layer coating process required 3.5 gpm wet when wet and 2.5 microns when dry. Another contributor to this success was the even application of the coating fluid, which enabled the coating process to cover the entire web thickness.

Also, the slot die coating process often provides significant increases in production yield. Defects, such as ribbing, streaks, bubbles and web breaks will often limit the line speed when applying fluids via roll coating. Slot die systems help to reduce these defects, often allowing for significantly higher production speeds. Since roll coating allows only a partial transfer of the coating fluid from the applicator roll to the substrate, production defects can develop at high speeds as a result of film splitting.

The savings achieved in this electronics film application included annual savings of $280,000 in coating fluid, $39,553 in substrate material, $298,718 from improved yield, and $569,223 in labor, for a total annual savings of $1,247,322.

Additional Slot Die Benefits from Multilayer Coating

Simultaneously coating two or more layers in one pass can dramatically improve production efficiency. In a Premier dual-layer slot die (see schematic), a wedge-shaped center body adds an additional slot, but the die can also be used as a single-slot die by using the lower and center bodies together. A triple-slot Premier die has two wedge-shaped center bodies instead of one, and it too can be used as a single- or dual-slot die by using the lower and center bodies together.

Conclusions for Switching to Slot Die Coating

Below are some equipment recommendations for a successful slot coating process.

The die should be capable of performing both on- and off-roll coating to accommodate multiple application methods. A lip gap tolerance of +/- 1.25 microns is important to ensure smooth performance. The die delivery manifold should be designed for low-shear distribution of multiple coating fluids, and the fluid delivery system should also be low-shear. A precision die positioner or coating station which includes a precision backing (coating) roll is also an important component for ensuring coating repeatability.

The Premier Coating Division of Nordson EED supplies a full range of single-, dual-, and multi-layer fluid/lip slot dies. Nordson manufactures a wide range of related equipment essential for fluid coating accuracy and productivity. Fluid delivery systems provide a non-pulsing, consistent flow of fluid to the die, ensuring consistent coating volumes. Die positioners or coating stations provide precise position control, a critical component for allowing the slot coating head and the processing window for developing surface properties. Also available are complete modular coating systems for lease or purchase by customers, as well as for on-site customer trials.
Extrusion Coating Die Eliminates Edge Bead and Enhances Coat Weight Uniformity

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Advantages of Slot Die Systems

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To understand how these savings are realized, it is useful first to review how the fluids have different surface tensions to prevent the fluids from mixing. In general, to promote complete spreading, the top layer needs to have slightly lower surface tension than any of the other layers.

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- Tighter coat weight tolerances. By holding tolerances to +/- 1% or 2%, slot die coating allows for reduced coating material consumption without compromising the quality of the finished product. In fact, new formulations with customized slot die design often yield products with thinner coat weights and lower porosity.
- 20% or greater increase in line speed. Maximum line speeds for slot dies are 3,000 feet (915 m) per minute; by contrast, roll coating typically runs no faster than 1,350 to 1,500 feet (350 to 460 m) per minute.
- Higher productivity and better performance. The accompanying table, based on one customer’s use of a Premier slot die system to coat film for an electronics application, shows how these slot die coating advantages translate into cost savings.

Key to the success achieved in this improved process was the improved coat weight uniformity with the Premier die, which held cross-web thickness variation to +/- 2% and made possible a 28% reduction in the thickness reduction at 57 psi when wet and 2.5 microns when dry. Another contributor to this success of the system upgrade was the use of a vacuum chamber, which stabilized the coating process at very thin coat weights.

Also, the slot die coating process often provides significant increases in production yield. Defects, such as ribbing, streaks, bubbles and web ends will often limit the line speed when applying fluids via roll coating. Slot die systems help to rectify these defects, often allowing for significantly higher production speeds. Since roll coating allows only a partial transfer of the coating fluid from the applicator roll to the substrate, product defects can develop at high speeds as a result of film splitting.

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The Premier Coating Division of Nordson EED supplies a full range of single-, dual-, and multi-layer fixed-lip slot dies. Nordson manufactures a wide range of related equipment essential for fluid coating accuracy and productivity. Fluid delivery systems provide a non-pulsing, consistent fluid feed of the die, ensuring consistent coating volumes. Die positioners or coating stations provide flexibility for quick die changeovers and center bodyswap. A die positioner helps to control the length of the coating bead and the processing window for developing surface properties. Also available are complete modular coating systems for lease or purchase by customers, as well as for on-site customer trials.
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One problem that roll coating presents in applying water-based adhesives is the result of its continuous recirculation of the coating fluid, which subjects it to repeated shearing. While solvent-based coatings are normally undamaged by this, water-based coatings often undergo a property change. In addition, as water-based systems have been reformulated for improved adhesion to substrates, the resulting increase in tackiness makes them more difficult to apply via roll coating.

As the same growing number of converters are discovering the benefits of applying two or more layers in one pass, which is the beyond the capabilities of conventional roll coating but readily achievable with slot dies. The savings in time and cost over multi-pass coating are obtainable in many types of applications, from coatings that combine fluids with different functions to side-by-side or side-topaintings of paints and other materials. Since water-based coatings wet-out less readily than solvent-based, one-pass multi-layer application is an efficient way to apply both subcoatings and primary coatings at the same time.

The Premier Coating Division of Nordson EDI supplies a range of fixed-lip fluid coating dies and related equipment and can assist customers looking to make the transition to water-based coatings. Key advantages of Premier™ fixed-lip die systems include high precision, ease of use, and capability of applying very thin coatings. Because the lips are fixed, the die provides a high degree of precision and run-to-run repeatability with minimal operator intervention. Gap adjustment must be carried out by means of shims. The die can apply coatings with viscosities in the 1 to 175,000 cpo range. Minimum wet coating thickness is 1 micron. Coat weight accuracy is held to +/- 1 to 2%.

Rate of Conversion to Water-Based Is on the Rise

While in past years there was a slow but steady conversion to water-based coatings, today roughly half of the web-coating market in the U.S. is still using roll coating techniques to apply solvent-based fluids, in China and elsewhere in Asia, roll coating is by far the dominant process. Two reasons for this are the substantial investment tied up in existing equipment and the comfort factor associated with a long-used, familiar process. In addition, solvent-based coatings are relatively easy to mix (consistency of fluid properties), dry rapidly, and exhibit good wet-out with many common substrates.

Regulatory pressure has now greatly accelerated the conversion to water-based coatings. Solvent-based coatings contribute to emissions of volatile organic compounds (VOCs). In addition, they present the potential for fires and even explosions in the workplace.

Applications where the focus on conversion to water-based coatings is most intense include: tape and label (from acetone, toluene, or MEK to acrylic or latex); battery (from NMP to aqueous slurry); building products (from solvents to water-based); optical films (from MIEK to new water-base polymers); nano films (less than 5% solids); paint (solvent-free urethanes and two-part epoxies); and subwettings (barrier layer, anti-static adhesive promoter, and other coatings with less than 2% solids).

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**At ICE, Nordson Highlights the Diversity and Global Availability of its Coating Systems**

A key message of Nordson Corporation at the ICE shows is that the company now offers the most diversified range of coating die systems available for web converting. Its die systems for applying solvent fluids in hot melts include fluid delivery and die positioning equipment. In extrusion coating dies for applying polymers feature internal devices that can be adjusted for edge profile control. The entire Nordson portfolio is backed by many decades of experience serving the converting industry and supported by a worldwide sales and support network.

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- **UltraCast™ adjustable-lip coating dies for cold fluids or hot melts**, in which coating gap and width can be adjusted without disassembling the die.
- **TrueCast™ fixed-lip hot melt coating die**, with capability for quick job changeovers.
- **EPC™ extension coating dies**, whose internal dieke has independently adjustable components that can be set to the overall coating width and to minimize edge bead.

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