Breaking News: Liberty Coating Equipment acquired by EDI.

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EDI **Advances**

News and Concepts from Your Global Partner in Extrusion, Coextrusion & Converting

ISSUE NO. 15

Coating Simulation Pinpoints Ideal Slot Die Setup

The advantages of slot die or proximity coating over conventional roll coating are now even greater. Using new software to determine the ideal geometry for the die-lip/substrate interface by simulating how it affects coating application,

MORE ACCURATE POSITIONING of this Ultracoat® slot die is the benefit of new software used by EDI to simulate how variations in the die lip/substrate interface affect the application of coatings.

EDI can enable converters to shorten or eliminate costly trial runs. In fact, says product manager Sam G. Iuliano, EDI has already successfully employed the software to help customers improve product quality, increase productivity, and reduce costs.

EDI is the only flat die manufacturer to employ the software, tradenamed Top-Coat by RheoLogic Ltd., Leeds, UK. The software was developed with input from EDI, and Iuliano has presented a technical paper on its use, ***Using Simulations to Predict Coating*** *Continued on P. 2.*

Inside...

- ***Rheology: Key to Optimizing Your Die's Performance***
- ***EDI Receives Patent for Contour Die™ and UltraLip™ Scraper***

Die Innovations Are Key to 'Next-Generation' Barrier Packaging

Business for producers of barrier packaging is growing worldwide, but staying competitive is more challenging than ever. These companies face two intensifying pressures: to meet ever more demanding processing and end-use requirements, and to convert more and more of their operations to lean manufacturing while maintaining profitability. Innovative flat-die technology from EDI is an essential tool for meeting these challenges, according to president and CEO Timothy C. Callahan.

"What was state of the art flat-die technology for barrier film and sheet just three years ago is today's 'legacy' system," says Callahan. "Barrier structures now often have more layers than in the past and are expected to do more, exhibiting enhanced performance not just in barrier function but in printability, formability, sealability, and structural integrity. At the same time, manufacturers increasingly face a choice of getting better at managing many short-run jobs or accepting lower operating margins."

Meeting these dual challenges with legacy die systems is becoming more and more difficult, according to Callahan. "To help our customers compete in a very different business environment from what legacy systems are designed for, EDI has developed next-generation die systems capable of yielding superior products of five, seven, nine, or even eleven layers," he says.

Gel and Pinhole Reduction Plus Increased Uptime

Recent EDI advances in flow optimization have the potential to benefit all customers serving barrier packaging markets. Among these customers are many custom processors who make frequent product changes and rely on the versatility of EDI's Contour Die™ single-manifold die systems with streamlined coextrusion feedblocks. In *Continued on P. 2.*

GELS AND PINHOLES ARE PREVENTED with EDI's Contour Die™ through use of a "coat-hanger" manifold (schematized at top) instead of the "broad-shoulder" design (bottom) in previous "constant-deflection" dies. Because the body bolts in broad-shoulder manifolds are parallel to the die exit, the die bodies deflect uniformly across the width of the die; but since flow slows and material lingers in the sharp corners at the ends of the back wall, polymer degradation can occur. Coat-hanger manifolds provide more streamlined flow, minimizing gels and pinholes.

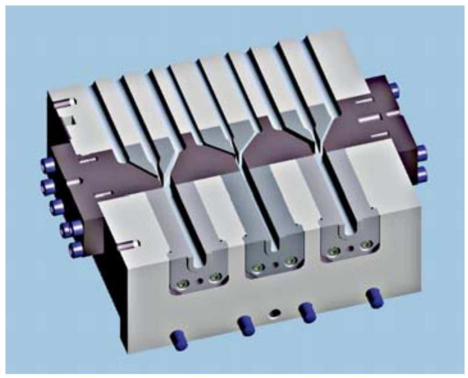
Continued from P. 1. addition, a growing number of customers with extrusion lines dedicated to specific products are taking advantage of the enhanced layer-to-layer uniformity provided by EDI's multi-manifold dies, with feedblocks delivering the inner-layer structure to the central manifold.

The recent innovations provide these improvements:

● ***Reduced downtime for product changeovers.*** One major innovation that did not exist more than three years ago is EDI's Contour Die, whose unique shape eliminates distortion caused by die body deflection and whose "coat-hanger" coextrusion manifold provides the streamlined melt flow that was unobtainable with previous "constant-deflection" dies. Now patented (see p. 3), this design reduces downtime between jobs by 1) reducing the time needed for adjusting the gauge profiling system in order to achieve target gauge; and 2) reducing the time required for purging the die for color or resin changes. At the same time, the combination of uniform die body deflection and streamlined flow provides greater leeway for increasing extruder output without compromising product quality.

● ***Reduction in gels and pinholes.*** EDI has achieved two advances in flow optimization that yield fewer defects than in legacy systems, particularly in the case of heat-sensitive barrier materials like EVOH.

1) In comparison with standard constant-deflection dies widely used for barrier film and sheet, the Contour Die does not force a tradeoff between uniform die body deflection and melt streamlining. To achieve uniform deflection, legacy dies have "broad-shoulder" manifolds whose back wall is parallel to the die exit. The large-volume corners at either end of this back wall are lower-velocity flow points or "dead" spots—low-flow, high-inventory regions where there is a greater likelihood of polymer degradation. In contrast, the coat-hanger coextrusion manifold in the Contour Die has a back wall whose ends are closer to the exit than the melt entry port at its center, eliminating the broad shoulder corners.



STREAMLINED COMBINING OF LAYERS is achieved in Ultraflow® feeblock through use of interchangeable flow inserts that act as miniature manifolds. Result, shown in this cutaway schematic, is combination of layers in a parallel-path manner.

2) Streamlined flow is also a key advantage of the interchangeable flow inserts that are used to develop each layer of a multi-layer structure produced in EDI's Ultraflow® feedblock. Each insert is designed as a miniature manifold that fine-tunes a given layer before it is combined with others. As a result, the melt streams are combined in a parallel-path manner.

Since EVOH has an affinity for metal

Coatings *continued from P. 1.*

Characteristics of a Slot Die System.

"Top-Coat software enables EDI to improve die designs and speed troubleshooting, helping customers to achieve greater quality assurance, reduce scrap, and economize on raw materials," says Iuliano.

The software innovation has broad implications in the converting industry, which employs EDI's Ultracoat® slot dies for applying hot melts, pressure-sensitive adhesives, photosensitive materials, magnetic media, transdermal patches, inks, waxes, and other low-viscosity fluids. EDI also builds adjustable support systems that position Ultracoat dies at the optimum angle and proximity to the roll and isolate the die from vibrations that can affect coating application.

While the Ultracoat support system clearly is crucial for maintaining the desired die/substrate interface, the new TopCoat software uses rheological and surface-tension data to identify, more precisely than ever before, the geometry of the interface that will yield the optimal result for the coating material used in a specific application. Key variables in this geometry are the radius of the backing roll, the contour of the lip face, the die angle, the distance between die and the substrate, and the lip-face offset.

Big Advantages Over Roll Coating

The advent of this capability to simulate the proximity coating process will hasten converters' shift from conventional roll coating to slot die coating, according to Iuliano. The key advantages of proximity coating over roll coating cited by Iuliano are:

● ***Control over material application.*** A slot die coating head is a "pre-metered" system that applies a coating fluid to the web at a constant rate and permits precise control over coat weight and cross-web distribution; this reduces waste, allows higher line speeds, and increases product quality and uniformity. By contrast, the amount of fluid applied in roll coating varies with factors such as viscosity and roll speed.

● ***Elimination of volatile organic compound emissions.*** While a slot die coating head is an enclosed system and applies to the substrate all of material fed into the die, a roll coater exposes the environment to emissions from excess coating fluid.

● ***Higher line speeds.*** Slot die application is less susceptible to "film-splitting" and "ribbing" defects that can develop at high throughputs. A sharp final edge on the wiping lip provides a clean breakaway point for the coating, so none remains on the applicator.

Information on RheoLogic Ltd. and Top-Coat™ software is available at *www.rheologic.co.uk*. For a copy of the technical paper *Using Simulations to Predict Coating Characteristics of a Slot Die System* by Sam Iuliano, email *sales@extrusiondies.com*. ◆

Global Report

CONTOUR DIE™ AND ULTRALIP™ SCRAPER NOW PATENTED. EDI has received U.S. Patent No. 7,056,112 B2 for "an improved extrusion die and a method for using the same that minimizes the deflection of the die exit" because the thickness of the die bodies increase from the ends of the die to its center. The uniquely shaped Contour Die **eliminates 'clamshelling' distortions without sacrificing streamlined flow** and is now operating successfully in dozens of installations worldwide. Another U.S. patent, No. 7,074,030 B2, is for a device that **eliminates downtime for scraping buildup from die lips**. Called the UltraLip scraper, the device traverses the width of a die in less than a minute.

Miller

MARK MILLER ASSUMES KEY TECHNOLOGY ROLE. EDI has appointed Mark D. Miller as project and manufacturing engineer. He works closely with John A. Ulcej, executive vice president of engineering and technology, on developing new die manufacturing processes, designing innovative die systems, and providing technical support to customers. "Mark's professional background in polymer science and process development has given him an **expert understanding of extrusion and coating die systems**," says Ulcej. Miller holds undergraduate and graduate degrees in chemical engineering and polymer science, respectively. He comes to EDI after nine years at 3M Company, where his responsibilities included R&D on applications involving slot and extrusion coating dies, development of polymeric adhesive formulations for coating systems, and production of optical films for a wide range of electronic devices.

CORY MCILQUHAM IS NEW INSIDE SALES COORDINATOR. EDI has promoted Cory McIlquham to the position of internal sales coordinator. In this role **McIlquham will work directly with customers**, preparing quotations on die orders, providing technical consulting services, and assisting customers during visits to EDI. In addition, he will support EDI's outside sales staff and agents worldwide. "Cory can draw on extensive experience in both manufacturing and technical service at EDI as he carries out inside sales responsibilities," said Todd Bryan, manager of sales administration. "At the same time, he will continue in one technical service role as part of our Rapid Response field service team, making calls anywhere in the world as customer need arises." Cory McIlquham joined EDI in 1993 and worked in die production and finishing for many years.

McIlquham

TWO NEW ENGINEERS JOIN EDI. Mike Bourget and Kyle Hable are both recent graduates of Wisconsin Indianhead Technical College, not far from EDI headquarters in Chippewa Falls, WI. The two engineers hold degrees in mechanical design and are trained in software for designing industrial components. They are the **latest in a series of additions to EDI's engineering staff** and are representative of the large pool of skilled individuals in Northwest Wisconsin that has proven valuable to the company as it expands its capabilities.

EDI APPOINTS AGENT IN MIDEAST. Arabian Commercial & Industrial Services, or ACIS, has become an agent for EDI in nine countries in the Mideast. The countries include the six members of the Gulf Cooperation Council (GCC), including **the Kingdom of Saudi Arabia, the United Arab Emirates, Oman, Qatar, Bahrain**, and **Kuwait**, plus **Lebanon, Syria,** and **Jordan**. Founded in 1988, ACIS is well established in the region as a representative for plastics companies, notes general manager George A. Valassidis, and is particularly experienced in sales and service of extrusion equipment and related systems such as thermoformers and auxiliaries. In addition to the company headquarters in Saudi Arabia, other offices supporting EDI sales and service are in Lebanon, Jordan, Syria, and Yemen. ACIS is headquartered in Riyadh, Kingdom of Saudi Arabia. Tel: 966-1-206-4804. Fax: 966-1-206-4875. Email: *gvalassidis@acis-pt.com*

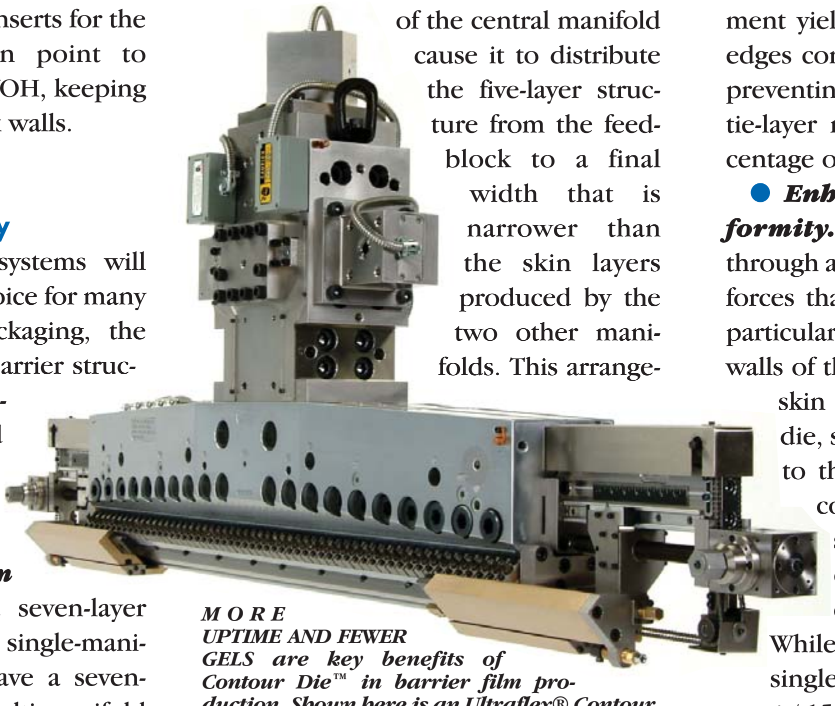
surfaces, EDI designs the inserts for the tie/EVOH/tie combination point to slightly encapsulate the EVOH, keeping it away from the feedblock walls.

Multi-Manifold Dies Yield Enhanced Quality

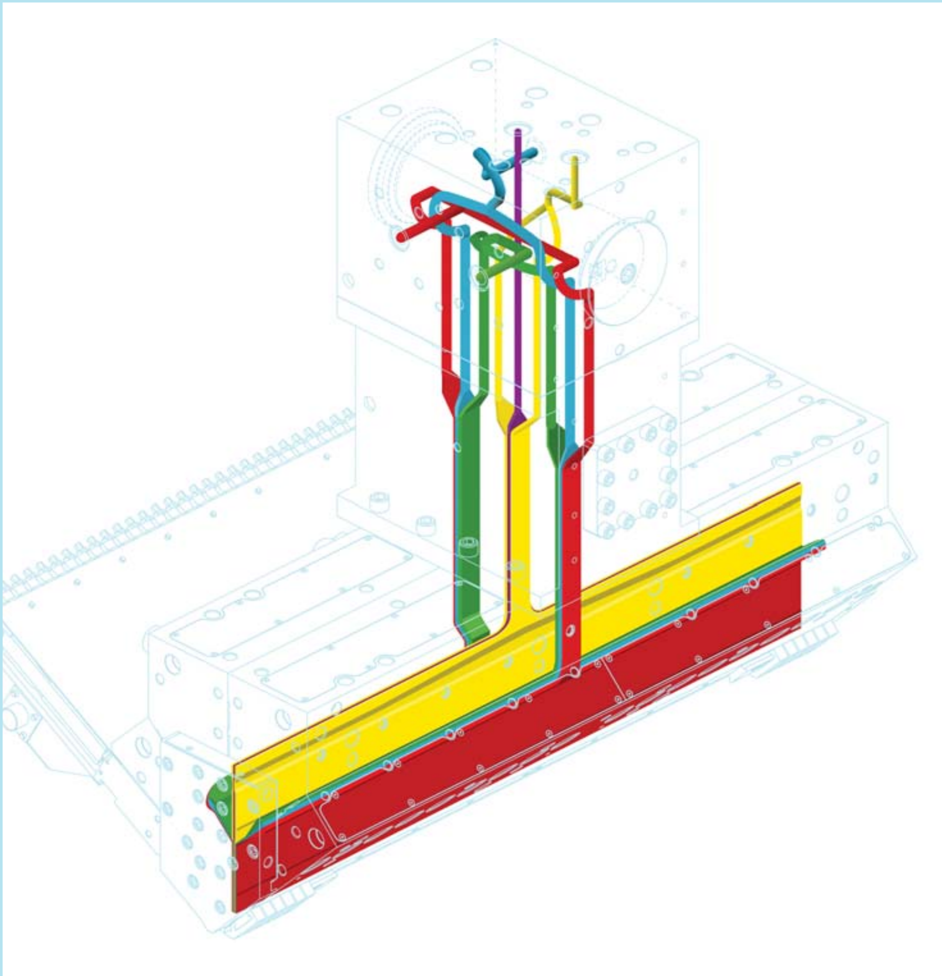
While single-manifold systems will continue to be the best choice for many producers of barrier packaging, the increasing complexity of barrier structures has made the advantages of multi-manifold systems loom even larger. Among these benefits are:

● ***Improved edge-trim management.*** Taking a seven-layer structure as an example, a single-manifold die system would have a seven-layer feedblock, while a multi-manifold system would typically include a triple-manifold die with a five-layer feedblock. Streamlined deckle inserts at either end of the central manifold cause it to distribute the five-layer structure from the feedblock to a final width that is narrower than the skin layers produced by the two other manifolds. This arrangement yields well-defined encapsulated edges consisting of skin-layer material, preventing waste of costly barrier and tie-layer resins and reducing the percentage of barrier resin in edge trim.

● ***Enhanced layer-to-layer uniformity.*** Processing several layers through a single-manifold die generates forces that distort the layer interfaces, particularly when they are close to the walls of the manifold, as with very thin skin layers. In a multi-manifold die, skin layers are fully developed to their final width before being combined with the rest of the structure, just before the lip exit. As a result, skin-layer tolerances can be narrower. While tolerances in a seven-layer single-manifold die system typically are +/-15 to 20% for each layer (or larger for very thin layers), the triple-manifold die system permits tolerances of only +/- 5%.



MORE UPTIME AND FEWER GELS are key benefits of Contour Die™ in barrier film production. Shown here is an Ultraflex® Contour Die with an Ultraflow® coextrusion feedblock. Bronze-colored components at bottom are for UltraLip scraper system. Both Contour and UltraLip concepts recently received U.S. patents.



INNOVATIONS FOR BARRIER FILM help meet demand for increasingly complex products, like this 11-layer structure in a manifold die/feedblock combination. Colors indicate PETG (red), PET (blue), PET plus regrind (green), adhesive (yellow), and EVOH barrier (purple).

- ***Reduced skin-layer contamination.*** The distance traveled between the point where all layers are combined and the die exit is roughly one-fourth as long in a multi-manifold die / feedblock system as in a single-manifold system. This leaves little time for residual barrier material in the regrind layer, such as EVOH, to migrate into the virgin skin layers. In cases where skin layers are very thin, such migration can cause a rough skin surface, as well as delamination during thermoforming.

New Die Systems Help Improve Margins

"EDI sells die systems all over the world, and we hear the same issues from the Americas and Europe to Japan, China, Malaysia, and India," Callahan says. "There is worldwide strong growth in the applications and functionality of barrier products. At the same time, there is an intensifying mandate for more frequent gauge, width, structure, and throughput changes, shorter product runs, and smaller or nonexistent inventories. Most legacy systems are designed for long-run, high-inventory production, and in today's environment, they can generate large penalties in terms of downtime and scrap. This conventional die technology has worked well and performed with increasing gauge and structure uniformity, but it is no longer enough. We have designed our next-generation die systems so that our customers will not only survive in the new business model but will see profitable, sustainable growth." ◆

Technoscope *continued from P. 5*

lar materials apart. Layer interface stability is controlled by shear stress applied to the polymers and viscosity inherent in the polymers. This is more problematic as skin layers become thinner. If the core material is the thickest and has the highest elongational viscosity, the flow is more stable.

While analyzing the flow properties of polymers is especially important for coextrusion, the fact is that rheological data are critical in designing any die. EDI asks each customer to provide as much information as possible on the polymers they plan to process with the die they are ordering. Besides carrying out this customized work for each specific new die, our engineers employ rheological analysis for broad-based innovations that benefit all customers. We are continually perfecting our understanding of how polymers flow, and we use this knowledge to develop new types of dies and feedblocks that perform even more efficiently, accurately, and reliably than before. ◆

EDI Will Be There…

ExpoPlasticos *(Mar. 13-15, Monterrey):* EDI to exhibit at the stand of its agent ABC Plásticos.

Multilayer Packaging Films Conference *(Mar. 27-29, Cologne):* Presentation by Project and Manufacturing Engineer, Mark Miller. EDI tabletop display.

BOPP Film conference *(Apr. 16-18, Dubai):* Presentation by EDI product manager Jay Hanson. EDI tabletop display.

Plastimagen *(Mar. 28-31, Mexico City):* EDI at the exhibit of agent ABC Plasticos, Stand No. 2715.

CMM Japan *(April 25-28, Tokyo):* EDI to exhibit at the stand of its agent Kodama Chemical Industry Co., Ltd.

Brasilplast *(May 7-11, São Paulo):* EDI to exhibit at the stand of its agent BY Engenharia & Comércio Ltda.

Chinaplas *(May 21-24, Guangzhou):* EDI to exhibit in Hall 1D, Stand 1D-605.

CMM International *(Jun. 4-7, Rosemont, Illinois):* EDI to exhibit at Booth 1615.

CPP Expo *(Oct. 15-17, Las Vegas):* EDI to exhibit.

K-2007 *(Oct. 24-31, Düsseldorf):* EDI to exhibit.

Technoscope *continued from P. 6*

the polymer molecules move around more, allowing them to be sheared more readily. Viscosity decreases as temperature increases. Another way to lower viscosity is to mix a lower viscosity material in with a higher viscosity material. The shear force will now have a low viscosity plane to push on, lowering the overall viscosity of the mix. High molecular weight materials are larger and more difficult to shear. This is also true of highly branched polymers. The bigger the polymer particle, the more force it will require to move it into the shape we want.

While mayo shear-thins, Silly Putty shear-*thickens*. It is soft and pliable at low shear rates (squeezing it with your hand), but have you ever hit Silly Putty with a hammer? It shatters! If you pick the pieces up, however, they are still soft and pliable, and will actually combine into one blob.

What is Viscosity?

We've established that viscosity is important to how a polymer is going to flow in a given process, but what is it exactly? Viscosity is resistance to physical change or deformation. You could also refer to viscosity as the consistency of the material. ***Shear viscosity*** is resistance to deformation between layers of a polymer, while ***elongational viscosity*** is resistance to deformation from stretching the polymer.

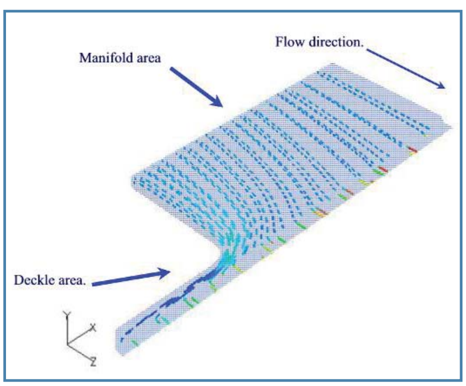
Picture the polymers that make up a certain volume of plastic as a clump of coils or springs. The cooler the polymers, the tighter the springs are. The warmer the polymers, the more relaxed the springs become. Upon cooling, the polymer would like to "spring back" into a tight set of coils (this can result in edge bead). The trick is to "teach" the polymer a new position of rest (as a sheet instead of a pellet). Once the polymer is in motion, the best thing is to keep it in motion until you have the final shape you want. Polymers move at a speed and in a direction controlled by the force you apply. So, by a series of contractions, expansions, and diminishing patterns in the die, the polymer responds to form the sheet, film, or coating we are interested in.

Key to Optimum Die Design: Rheology

The viscosity of a polymer characterizes that material and tells the die designer what to expect when it comes to flow and pressures throughout the die. To measure viscosity we use a ***rheometer***. Different rheometers are available, but EDI uses a capillary rheometer. In a capillary rheometer, the pressure, flow rate and fixed geometry of the rheometer head determine the calculated viscosity. The calculated viscosity provides the basis for the design of the flow channel for the manifold.

'There's good reason why EDI asks you for a resin sample or rheology curve. It helps us to build you a die that performs as efficiently as possible'

As you can imagine, understanding how a polymer flows in and around surfaces can be critical when you are designing a die to transform molten polymer into an essentially flat end product. One key to gaining this understanding is to study the shear viscosity of the polymer melt at the processing temperature utilized in your production line. This is



ANTICIPATING FLOW UNIQUE TO POLYMERS is one reason why rheological analysis provides valuable information for EDI designers. Unlike ordinary liquids, which exhibit turbulence effects, molten polymers exhibit a relatively smoother and more streamlined laminar flow, apparent in this schematic. It is laminar flow that makes coextrusion possible, since there is less commingling of materials in adjacent layers.

because shear viscosity is the resistance to flow between layers of a polymer (think of a stack of playing cards). Once we know the motion of the polymer fluid, layer by layer, we can apply our expert knowledge to form a manifold to shape the polymer into a sheet-like product of optimal quality and consistency.

Another key rheological pararmeter is elongational viscosity—the resistance of a polymer to stretching (think of a rubber band or bed spring). Viscoelastic materials are materials where we have to be concerned with both the (shear) viscosity *and* the elasticity (elongational viscosity). Materials, like polystyrene and PVC, which exhibit elastic characteristics and resist stretching, also resist filling corners in a die manifold. To work with elastic materials, the die manifold must be designed to allow the stretchy polymer to fill the shape we require more gradually. Otherwise, the "elastic memory" of these polymers prevents the shape from holding the way we would like.

Rheology Is Also Critical for Coextrusion Dies

I was told once that anything can be described in terms of beer. I have found this to be true, even in discussing rheology. Unlike polymers, which are shear-thinning materials, beer does not shear-thin. If we double the head (pressure) as beer goes through a tap (pipe), the flow rate doubles; if we double the pressure on polymers, however, the flow rate *more than* doubles, because of shear thinning.

If you plan on asking EDI to build you a coextrusion die, here is why this is good news: Beer flows like water and exhibits turbulence effects, such as mixing. Molten polymers, in contrast, exhibit ***laminar flow***—flow that is smooth and streamlined. Laminar flow makes coextrusion possible. While the different layer materials in a turbulent fluid would intermingle, molten polymers exhibit smooth, streamlined flow.

Why don't polymers mix easily? Besides chemical incompatibility, the viscous forces that are high in polymers and low in beer push dissimi- *Continued on P. 4*

Technoscope

EDI Uses Rheology to Build a Die that Best Meets Your Needs

by Mark D. Miller, Project and Manufacturing Engineer

When you order a die from EDI, you can expect to be asked to provide us with either a sample of the resin you plan to run or a rheology curve for that resin. There is a good reason for this, and it has to do with building you a die that performs as efficiently, as accurately, and as reliably as possible.

Rheology is the key to understanding how a particular polymer behaves in the die manifold. This is the channel within the die through which the polymer flows, from where it enters the die to where it exits as film, sheet, or coating. The geometry of the manifold varies in the course of this passage in order to condition the polymer and shape it into a consistently uniform end product within specified tolerances.

To design this complex geometry, EDI engineers employ computer simulation to determine the optimum flow through the manifold under a specific customer's process conditions. These conditions include the melt temperature of the polymer to be processed, its flow rate, and its characteristic rheology. Based on these data, the computer simulation calculates the overall flow distribution, residence time, and pressure drop to which the polymer must be subjected inside the die.

In other words, pushing fluid polymer through a die is not as simple as it sounds. The more rheological data that customers provide us, the better the die we design. But this still leaves a key question unanswered...

What is Rheology?

παντα ρει — It's all Greek to me! Yes it is. But it doesn't need to be. The term rheology comes from the Greek word rheos which means "to flow". Rheology is the study of flow. When you talk about squeezing, spreading, or lubricating a fluid, you are talking rheology. When you apply a force that causes a fluid to move, rupture, or flow you are describing a rheological force.

KEY TO OPTIMUM DIE PERFORMANCE is rheology, the study of flow. In EDI's rheology lab, shown here, sophisticated instruments are employed to determine how specific polymers flow under certain defined forces encountered inside a die. EDI engineers use this knowledge to design a die that provides optimum flow under the processing conditions anticipated by the customer.

In plastics, everything boils down to mayonnaise and Silly Putty®. While Silly Putty is more fun to play with, let's examine mayonnaise first, because most plastics in the melt phase behave just like this tasty sandwich spread. Both plastics and "mayo" are solid at room temperature and liquid when broken by a ***shear force***, which is a force applied in the same direction as the polymer is flowing. When you apply mayo to a sandwich with a bread knife, you are generating shear force. A common example in plastics is the force applied by the flights of an extruder screw as polymer moves through the barrel. Another is the forces exerted on polymer by the surfaces inside the manifold as the material flows through a flat die.

Like mayo, most polymers are ***shear-thinning*** materials. The faster they move, the softer (less viscous) they become. The heat in your equipment system helps each polymer you process get to the right consistency before this shear force is applied. Heat makes *Continued on P. 5.*

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For more information, readers of EDI ADVANCES are invited to visit our web site at the address above. We also welcome your e-mail, which you can post from the web site or by keying in our ***sales@extrusiondies.com*** address. The web site is your resource for information on:

- EDI dies, feedblocks, deckling systems, vacuum boxes, die carts, and related equipment.
- Sales, technical service, customer service, spare parts, and other departments.
- Agents in our worldwide sales & service network.
- Remanufacturing facilities in the U.S.A., Germany, and Japan.
- Visiting EDI headquarters.

Extrusion Dies Industries, LLC is a leading international supplier of flat dies for sheet and film, coating, and pelletizing. We draw on extensive engineering capabilities to design systems that are highly tailored to specific customer needs. Headquartered in Chippewa Falls, Wisconsin, U.S.A., we sell half of our dies to customers in other nations around the world.

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