FACT SHEET FOR THE PRESS

Updated October 2008

EXTRUSION DIES INDUSTRIES, LLC (EDI) designs, manufactures, and reworks precision tooling used in plastics processing and web converting. The company is a global supplier of flat die systems for extrusion, coextrusion, and fluid coating. EDI also builds or reworks tooling for other processes, such as blown film extrusion, coextrusion blow molding, and strand palletizing. From its world headquarters in Chippewa Falls, Wisconsin, U.S.A., EDI exports more than half of the dies that it manufactures. Its subsidiaries, ***EDI GmbH*** in Germany and ***EDI China***, provide sales and technical service, parts, and die rework. Visit EDI online at ***www.extrusiondies.com***.

EDI sells directly to customers in the U.S. and Canada through its headquarters and regional sales representatives. In Latin America, Europe, the Middle East, Asia, Australia, and New Zealand, EDI works with a longstanding ***international network of agents*** that provide sales and support services. In addition, the company maintains a Rapid Response Team prepared to assist customer needs as they arise anywhere in the world.

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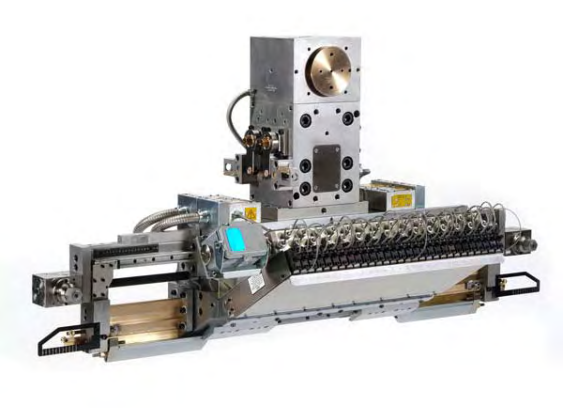
Extrusion Dies: Core Systems and Specialties

The die is the heart of the extrusion process, transforming a stream of molten polymer into film, sheet, or coating of a desired width and thickness and maintaining these dimensions within tight tolerances throughout the product run. EDI manufactures mono- and multi-layer flat dies ranging in width from less than 6 in. (15.24 cm) to over 33 ft. (10 m). Virtually every die it builds is a custom product.

The company's ***Contour Die™ design*** (described in a subsequent section) is standard for all cast film dies and available with some other dies as well. Contour Dies incorporate either the Ultraflex® or the Autoflex® gauge control system. With film dies, EDI supplies ***dual-chamber vacuum boxes*** that yield

uniform, high-quality film by first removing entrained air from between film and casting roll, then using high vacuum to stabilize the film forming area, reduce neck-in, and control film edge movement. Extrusion systems from EDI include:

▪ ***Ultraflex® manual gauge control.*** An extrusion industry workhorse, the Ultraflex die incorporates a manually actuated adjusting mechanism for gauge profiling that centers on a flexible lip made up of identical adjuster blocks arrayed along the width of the die exit.



Autoflex VI-R extrusion coating die with EPC system and Accuflow feedblock

▪ ***Autoflex® automated gauge control.*** When linked to a computerized gauging system, the lip-adjusting system in an Autoflex die controls the transverse thickness profile of the film, sheet, or coating. Autoflex dies typically reduce gauge variation to half of the minimum achievable with manual systems, yielding more on-specification product and making it possible to conserve raw material.

Autoflex systems center on a flexible lip made up of thermally actuated adjuster blocks. When a thicker-than-target area is detected in the film, sheet, or coating, power to the cartridge heaters at corresponding points in the lip is automatically increased; this causes the blocks to thermally expand, which tightens the lip gap in the area. Conversely, thinner-than-target areas are addressed by a reduction in power. Several thousand Autoflex systems are in operation worldwide, ranging from the industry-standard Autoflex IV to the Autoflex VI-R, whose gauge profiling system is a self-contained module for faster maintenance and product changeovers.

▪ ***Heavy Duty™ and Magnum™ for sheet.*** For products up to 0.7 in. (17.8 mm) thick, these dies have sliding upper lips for gauge versatility and replaceable lower lips for varying gap and land length.

▪ ***Specialty dies.*** EDI regularly builds application-specific dies such as those for twin-wall sheet, raffia tape, and strand palletizing.

Manifold Designs: Key to Streamlining and Uniformity

Integrally machined into the die between its upper and lower halves, a manifold is the flow channel that distributes the molten polymer pumped into the die by the extruder to the target end-product width, develops a uniform flow pattern, and establishes the desired product thickness. It is the heart of every die.

▪ ***Multiflow I***: coathanger manifold whose teardrop-shaped cross section provides streamlined flow suitable for all polymers.

▪ ***Multiflow II***: coathanger manifold whose elongated-teardrop cross section minimizes interface deformation in coextrusions of polymers with differing rheological properties.

▪ ***Multiflow II-CG***: a modification of the Multiflow II design which incorporates a constant cross-sectional segment that accommodates full-manifold plug deckling.

▪ ***Multiflow IV***: "T"-shaped design with an elongated-teardrop cross section whose volume is constant. Widely used in mono- and multi-layer extrusion coating, this design is the basis for EDI's ***EPC™ (Edge Profile Control) system*** for reducing or eliminating edge-bead formation when product widths are changed frequently.

▪ ***Multiflow V-C***: elongated-teardrop cross section whose aspect ratio increases towards the ends of the die and whose backline is parallel to the die lip exit, minimizing differential die body deflection.

▪ ***Multiflow V-CG***: a modification of the Multiflow V design which incorporates a constant cross-sectional segment that accommodates full-manifold plug deckling.

▪ ***Multiflow I-R***: almost completely rounded back wall, providing processors of heat-sensitive resins with the highest degree of protection from polymer degradation.

Coextrusion Systems I: Feedblocks

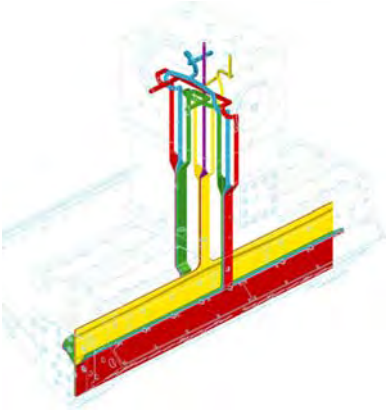
Mounted at the rear of the die, a coextrusion feedblock accepts multiple streams of polymer from two or more extruders, shapes each stream into a layer, and combines the layers into a single "sandwich" structure to be distributed by the die manifold to the full width of finished product. Die-feedblock combinations are the simplest, least costly systems for coextrusion and are the most widely used.

▪ ***Accuflow™ adjustable feedblocks*** make it possible to tune the thickness profile of each layer on-line by adjusting special combining spools. With conventional feedblocks, operators must exchange one set of flow inserts for another to make adjustments for changes in product dimensions or to change layer ratios; this prolongs startups or stops production. The Accuflow feedblock, on the other hand, incorporates continuously adjustable combining spools that are adjustable on-line, accelerating startups, speeding up repeat runs, and eliminating downtime.

▪ ***Ultraflow™ fixed-geometry feedblocks*** incorporate specially machined flow inserts for tuning each layer. These inserts can be interchanged without disassembling the feedblock.

▪ ***I-S flow sequencing spool,*** which can be incorporated in Accuflow and Ultraflow feedblocks, makes it possible to change the sequence of layer materials without having to block off channels or disassembling the feedblock. This provides versatility for processors who periodically switch material from the core layer to the skin layer, for example, or from the inside skin to the outside skin.

Coextrusion Systems II: Multi-Manifold Dies



In a multi-manifold die, polymer for each layer is distributed to final product width in its own manifold before being combined with other layers into a multilayer structure. The combination of layers takes place just before the lip exit. There are two advantages to this system: 1) it minimizes deformation at the interfaces between layers; and 2) it maximizes the uniformity of the overall structure.

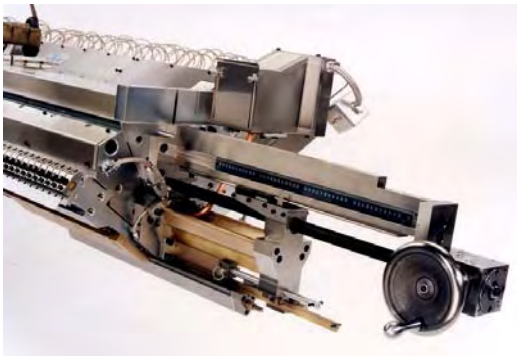
EDI builds multi-manifold dies with individual manifolds for up to seven layers, plus dies with Ultraflow feedblocks that feed multi-layer structures into different manifolds.

Illustration at left shows flow paths for a nine-layer, three-manifold die system.

Deckling Systems: Internal, External, and Dual

Deckles make it possible to vary end-product width by blocking off portions of the die slot from both ends of the die. EDI's many deckling systems fall into three categories:

External deckles apply wedge-driven, compressible seals over portions of the exit gap, providing leak-free operation but tending to create stagnant areas behind the deckle barrier. In addition, they may contribute to formation of relatively large edge beads along either edge of the film or extrusion coating.



Dual-deckle, dual-manifold die

Internal deckles completely seal off the ends of the internal flow channels of the die, eliminating areas of stagnation. In addition, because the deckle for cast film and extrusion coating consists of multiple, independently adjustable blades, it can be used to fine-tune the edge profile of the polymer flow as it exits the die, minimizing edge bead formation. On the other hand, internal deckles require a great deal of operator experience and skill to carry out these adjustments without leakage. EDI supplies manual and motorized internal deckles, including EPC™ full-bore manifold plug systems with edge profile control; EPC-R™ partial internal deckles (lip-land blades) for edge profile control; and "Gull-Wing" deckles in Multiflow VI manifolds, with specific designs customized for each application.

Dual deckling systems combine the advantages of internal and external deckles. The internal and external deckles are linked to the same drive and move as one. The system can run leak-free for weeks at a time and by its nature is simple and easy to adjust.

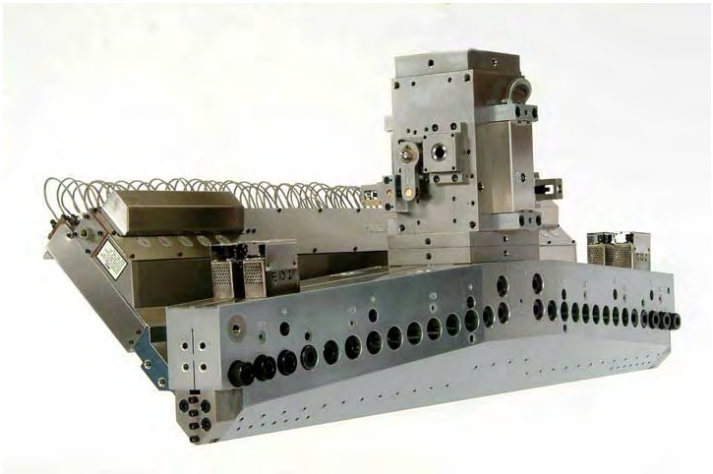
Subsystems and Accessories: Components that Maximize Uptime

One of the great barriers to maximizing productivity is the downtime that occurs while dies are cleaned, serviced, or adjusted for job changeovers. Many of the die-system components that EDI has developed are designed to reduce or eliminate downtime.

- ***Fast Gap™,*** available on most Autoflex and Ultraflex dies, is a single-point adjustment system that enables processors to quickly change thickness settings for new runs, or return to previous settings after purging or lip cleaning
- ***UltraLock™ Boltless Dies*** make it possible to split and clean a die on-line, eliminating the time and labor of loosening and tightening body bolts.
- ***UltraLip™ die lip scraper*** consists of lip-scraping assemblies for the upper and lower lip faces that traverse the width of a typical die in less than a minute to scrape the buildup from the lips. The assemblies move in unison along threaded drive screws that can be operated from either side of the die by using a simple hand crank to activate a chain-and-sprocket drive.
- ***UltraSplit™ on-line device*** frames the die as it operates on-line, splits it, and orients the die bodies to provide access for operators. The system can be manual or motorized.
- ***Ultracart® die service systems*** speed off-line die cleaning and maintenance by simplifying disassembly and reassembly and preventing damage to die surfaces. Die halves are easily rotated to access flow surfaces.
- ***Motorized deckles*** enable processors to automate width changes, increase the precision of deckle settings, and reduce or eliminate manual adjustment.
- ***High-durability coatings.*** As an alternative to standard chrome-plated tool steel, EDI can supply high-hardness stainless steel dies as well as a range of coatings designed to reduce lip wear, resist corrosion, or otherwise extend the working life of the die and maintain product quality and uniformity. Two examples: ***EverSharp™ tungsten-carbide coated lip edges*** can be made as sharp as stainless steel (typical radii of 25 microns), are invariably sharper than standard industrial chrome-plating (250 microns), and are more durable than either. ***Chromium nitride-coated lips*** exhibit outstanding consistency and accuracy, particularly in comparison with chrome plating. Their edges can be made as sharp as stainless steel yet are more wear-resistant than either stainless or standard industrial chrome plating, though not as hard as tungsten carbide.

Contour Die™: Unique Die Shape Yields Uniform Product

In comparison with conventional dies, the unique shape of EDI's patented Contour Die enables it to reduce the downtime for lip adjustment required with each new product run, enhance gauge profiles, and yield a more uniform layer structure in coextrusion



The Contour Die solves a longstanding problem caused by the pressure of the molten polymer in the manifold or flow channel that is situated between the upper and lower halves of the die, called the die bodies. This pressure (in the range of 1,000 to 3,000 p.s.i., or 70 to 200 BAR) is great enough to deflect the heavy steel die bodies. In conventional dies, because the surface area that is in contact with molten polymer is greater at the center than at the ends, the result is non-uniform deflection; this in turn causes a end-product distortion commonly called "clamshelling." While it is possible to correct the problem with the lip-adjustment systems that are standard on flat dies, the frequent adjustments required when there are

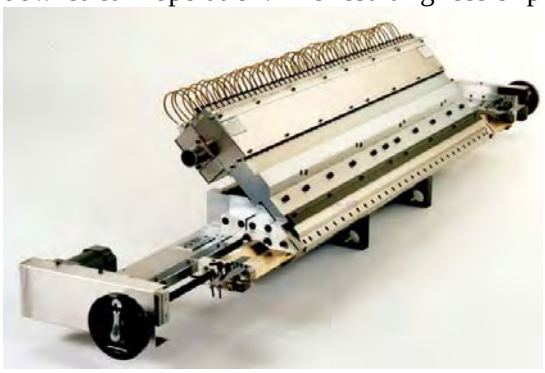
many small-run jobs cause a substantial loss in productivity. The problem is even more serious in coextrusion, since lip adjusters cannot correct the distortions at the interface between layers.

The Contour Die has a tapered or "sculpted" shape: thicker in the center, where the bending force is greater, than at the ends. This design enables EDI to retain the triangle-shaped "coat hanger" manifold that is widely used in the industry because it promotes a streamlined flow of molten polymer through the die.

Previous 'constant-deflection' dies built by EDI and others dispensed with the coat hanger manifold in favor of a 'broad shoulders' manifold with a straight back wall parallel to the die exit. This produced uniform die body deflection, but with a sacrifice in streamlining. The corners at either end of the back wall constituted dead spots where low-velocity flow or polymer hang-up could cause degradation, manifested in the finished product as gels, pinholes, and other defects.

Extrusion Coating: Reducing Edge Bead

The edge beads that form along either edge of an extrusion coating are so called because they are thicker than the target gauge that is maintained in the rest of the coating. Edge bead forms because the machine-direction tension applied to the moving web causes it to "neck in" or become slightly narrower, resulting in a buildup of polymer along either edge of the coating that must be trimmed away in a downstream operation. The resulting loss of polymer and substrate material can be very costly.

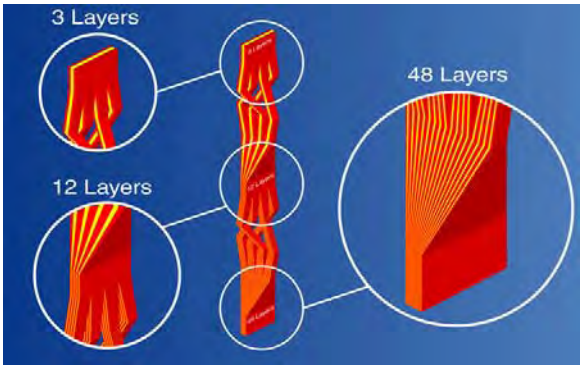


Autoflex VI-R extrusion coating die with EPC system

EDI has developed internal deckle systems for fine-tuning the edge profile of a coating. The deckles are effective because of the tendency of molten polymer to exhibit transverse flow if lateral barriers to flow are removed in the lip land—the final section of the die flow channel before the exit. In EDI's EPC™ ***full bore internal deckle with edge profile control***, there are three deckle blades, or "flags," that seal off the internal flow channel from either end of the die—one in the preland section of the flow channel, the second in the secondary manifold section, and the third in the lip land. By positioning the lip land flags so that they are somewhat farther from the centerline of the coating curtain than the other flags, sufficient lateral flow takes place as the polymer approaches the exit of the die to thin it out, reducing edge bead.

Layer-Multiplier System for Microlayer Film

A layer-multiplier die system produces films and coatings with an order-of-magnitude greater number of layers than conventional coextrusions, yielding microlayer structures that improve moisture and gas barrier, encapsulate gels and "un-melts," and enable manufacturers to make more economical use of high-cost materials. These structures may contain dozens of layers yet have standard overall thickness.



The technology is based on a patented system developed by The Dow Chemical Company and licensed from Dow by EDI. In a typical configuration, three or more extruders feed melt streams into an EDI-streamlined feedblock, which produces a uniform multi-layer "sandwich"; this in turn is fed into a layer-multiplier device built by EDI using Dow's patented design. In this device the layers are multiplied in stages: for example, three layers are multiplied into twelve, which are multiplied into forty-eight. The finished micro-layer structure is then distributed in an EDI manifold to the target product width.

Microlayer film exhibits these advantages over conventional multilayer film of five, seven, or nine layers:

• ***Enhanced barrier properties.*** The sheer increase in the number of barrier layers allows more flexibility and can increase the barrier properties of the film.

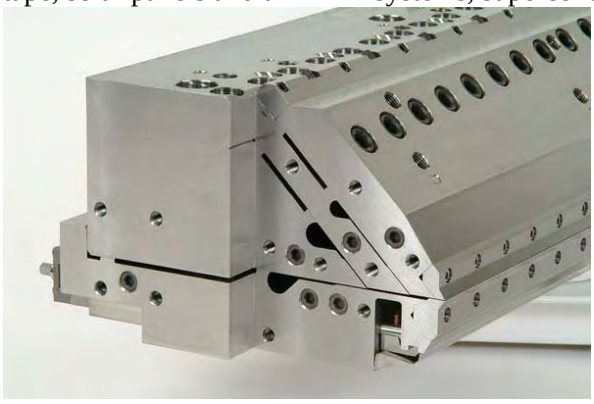
• ***Economizing on costly materials.*** Because many key properties of a polymer do not decrease proportionately with layer thickness, microlayer technology makes it possible to economize on costly high-performance resins while still achieving target properties.

• ***Fewer web breaks***. The greater the number of layers, the less the likelihood of breakage caused by pinholes in film, particularly in biaxially oriented products subjected to post-extrusion stretching. This is because the large number of layer-to-layer interfaces increases the chances for gels and other defects to be encapsulated and rendered harmless.

• ***New combinations of properties.*** The same polymer exerts different effects on end product properties according to whether it is distributed into one or two layers or into many super-thin layers. Layer-multiplier technology makes it possible to produce film that is more flexible, for example, without reducing the overall amount of a rigid polymer used as one of the raw materials. One benefit is greater processing latitude in subsequent thermoforming processes.

Slot Die Coating: Advantages over Roll Coating

While extrusion coating involves the application of molten polymer onto a substrate, in slot die or proximity coating the coating material is often a non-polymeric fluid (with the notable exception of some adhesives). The continuous-web substrates to be coated are used in products as far-ranging as packaging, window glazing, automotive windshields, flexible batteries, ceramic capacitors, decorative surfaces, electronic display media, filter membrane castings, flooring, fuel cells, health and beauty wipes, labels, laminate layers for printed circuit boards, magnetic tape, medical patches and liners, pressure sensitive tape, solar panels and thin-film systems, superconductors, and window films.



Ultracoat triple-manifold slot die

Slot dies apply coatings to substrates with a high degree of uniformity because they are pre-metered systems. An extruder or positive displacement pump feeds the fluid into the die at a pulse-free, uniform rate, and all of the fluid that goes into the die is applied to the web. The process permits accurate control over coat weight and cross-web distribution. In roll coating, by contrast, only a portion (perhaps 50 to 80%) of the coating on the applicator roll is actually deposited on the web, the amount varying with many factors.

There are other important advantages over roll coating:

• ***Higher line speeds.*** Because roll coating allows only a partial transfer of coating fluid from an applicator roll to an impression roll or offset roll, product defects can develop at high throughput rates as a result of film splitting.

• ***Prevention of contamination.*** Because the coating fluid on the applicator roll is only partially used, the remaining fluid must be recirculated. The contamination that can result damages product quality and leads to raw-material waste.

• ***Prevention of VOC emissions.*** As a closed system, slot die coating dies help manufacturers comply with the growing mandate for reductions in emissions of volatile organic compounds (VOCs) from solvent-borne coating systems.

Liberty® and Ultracoat® Slot Die Systems

EDI builds two types of slot die coating system: the Liberty® fixed-lip system, and the Ultracoat® adjustable-lip system.

• ***Liberty slot dies*** are particularly suited for very thin and optically clear coatings requiring very close tolerances. They can be adapted for a broad spectrum of single- and multilayer applications and specialty techniques like “stripe” and non-continuous “patch” coating. Unlike systems that wipe coating

fluids onto the substrate, Liberty coating heads have relatively large lip gaps (e.g., up to 3 mils) from which fluids can be drawn to coatings as thin as 1 micron, a reduction of as much as 98%. In commercial uses involving many fluids and substrates, Liberty slot dies maintain cross-web coat weight tolerances within 3 to 5% even at coating thicknesses of only 0.00008 in., or 2 microns.

Liberty slot die in patch coating system

While the lip of the Liberty die is fixed, coating thickness and width can be varied by means of Interchangeable shims. For coatings of more than one layer, two options are available: 1) Dual- and triple-slot dies have one or two wedge-shaped center bodies that add a second or third slot but can be removed, leaving the two upper and lower die bodies that are standard for monolayer coating. 2) 'Slide' or 'cascade' dies, for up to ten layers or even more, are made up of an array of die bodies set at an angle to the web. The array provides multiple slots. The coating fluid from the slot farthest from the web becomes the topmost layer; as this fluid slides down the face of the die toward the web, additional coating layers flow in beneath the top layer; the fluid from the slot closest to the web becomes the bottom layer.

• ***Ultracoat slot dies*** have a flexible lip, whose adjustability is the key to controlling the lip gap profile and thus the coat weight. The flexible lip can be adjusted manually or by means of EDI's Autoflex® gauge profiler. The die lip is used to "wipe" the coating fluid onto the substrate. The minimum wet-coating thickness achieved is typically 10 to 12 microns. The adjustability of Ultracoat dies enables the operator to fine-tune coating application as line speeds change and to achieve high throughputs.

Modular Slot Die Coating Systems for Trial and Production Runs

EDI offers two modular systems that manufacturers can install in their coating lines:

• ***Production-scale modules.*** EDI's Modular Coating System (MCS) rolls into place on nearly any commercial coating line, enabling operators of roll coating systems to switch readily between roll and slot die coating or use slot die coating on a trial basis. EDI custom-designs each MCS to meet user requirements and can supply the system with an Ultracoat® adjustable-lip or Liberty® fixed-lip die. The MCS typically includes a fluid-delivery system, an adjustable support for positioning the die lip with respect to the web, idler rolls, and a precision backing roll. These components are unitized within a steel frame whose crossbars maintain straightness during operation and adjustment. The coating station is mounted on casters.

Modular Coating System

• ***Trial runs of Liberty® dies.*** The WetWare™ module is a trial-size coating system that enables converters using conventional roll coating processes to test-run slot die coating in their own plants.

Rework: Protecting the Customer's Die Investment

Extrusion processors and web converters can use EDI rework services to protect their investment in ***flat extrusion or coating dies or blown film dies***, increase productivity and quality assurance, and even upgrade dies with new capabilities.

EDI operates fully equipped rework facilities in the U.S., Germany, and China. In addition, a licensee of EDI rework technology operates in Japan. Besides refurbishing or remanufacturing EDI dies, EDI can apply its proprietary technology to dies built by other suppliers and even provide some spare parts for them.

Rework services include two broad categories of remanufacturing:

• ***Basic rework.*** For every die, EDI cleans all parts; strips away plating; repairs worn or damaged surfaces; refinishes flow surfaces; regrinds seals, prelands, and lip openings; replaces worn or failed

Machining operation at EDI China rework facility.

electrical and mechanical parts; re-establishes internal dimensions and proper sealing; and chrome plates, polishes, and reassembles the reworked die.

• ***Special services.*** These range from simple cleaning to incorporation of whole new die subsystems such as automatic gauge profiling. Examples of other services are redesign of flow surfaces, changing the size or location of entrance ports, special coating or plating, and resizing of dies that are too long. EDI offers expedited service for time-sensitive projects and can make small or temporary repairs at the customer's plant.

Process Laboratories for Rent

By renting one of three laboratories at EDI's Chippewa Falls headquarters, extrusion processors and web converters can carry out product-development and process testing without the high raw material costs and lost output of trial runs on their own commercial-scale equipment. These companies do not have to be EDI customers to take advantage of the facilities, and they can carry out their lab work in the strictest confidence, affirmed in a nondisclosure agreement that EDI signs with every company that rents its labs.

Cast film process laboratory at EDI facility in Wisconsin

There are three fully equipped processing laboratories:

• ***Cast film extrusion.*** This facility provides an opportunity to test options in resins, multilayer structures, feedblock settings, and other variables. Included are a coextrusion line with three extruders, a die, feedblocks, and a roll face. Also available is "layer-multiplier" tooling that yields dozens of layers in film of standard overall thickness.

• ***Extrusion coating and laminating.*** This converting line makes it possible to experiment with various polymers, substrates, and web structures and test out EDI's systems for fast width changes and edge bead control. Components include an extruder, a die, a single-position brake unwind, a corona pre-treater, a coating nip, two spare chill rolls, air knife, post-conditioning rolls, edge slitters, winder, and water recirculation system.

• ***Slot die coating.*** Customers can use this facility to test alternative fluid formulations, coating/substrate combinations, and other parameters. Practitioners of roll coating can explore the advantages of slot die coating before investing in a commercial-scale system. EDI offers two slot-die alternatives: Ultracoat® II or V adjustable-lip coating heads with support system and a range of lip inserts; or WetWare™ trial-size coating module incorporating a Liberty® fixed-lip coating head. Other

components include four different fluid pumps, a polished chrome-plated steel backing roll, and three hot air dryers.

Precision Manufacture: From Rheology Lab to Hand Polishing

EDI utilizes proprietary software to model the rheological behavior of polymers and design complementary flow paths in manifolds, feedblocks, and other components. ProEngineer® CAD-generated designs are networked with CNC machine tools to ensure that all flow surfaces, particularly nonlinear shapes, are precisely replicated. EDI has developed techniques for ***fully three-dimensional die manufacture,*** from initial designs to cutting of steel, that make possible complex flow-channel geometries that would be too difficult and costly with conventional methods.

Die-manufacturing cells include specialized equipment such as five-axis machining centers, precision CNC surface grinders, proprietary superfinishers, and other advanced machining systems. Highly skilled polishers put the final surface finish on all of the company's high-quality dies.

EDI is ISO 9001-compliant for all engineering and manufacturing operations. Manifolds, lands, and other die surfaces are checked using laser inspection equipment to verify planarity and surface characteristics at sub-micron levels, among other quality assurance techniques. Remanufactured dies undergo the same level of scrutiny.

EDI Serving All Major Markets

• ***Packaging***: food bags and wraps; barrier film; stretch wrap; retort containers; see-through windows; dairy tubs and lids; coated paperboard; meat, produce, and cookie trays; blister packs; ovenable trays; egg cartons; "clamshell" containers; plates and cups; labels.

• ***Building and construction:*** vinyl siding; glazing; vapor barriers; pool and pond liners; geomembranes; insulation board; flooring; wallboard; specialty tapes; window films; door shells; shutters; corrugated panels; shower stalls and sanitaryware.

• ***Durable goods:*** equipment housings and enclosures; appliance liners; luggage shells; spas and hot tubs; sporting goods; pallets.

• ***Transportation:*** windshield interlayers; mud flaps; camper tops; panels and housings; fuel tanks.

•***Electrical and electronics:*** capacitor films; flexible circuit boards; data, audio and video recording media; antistatic flooring; electronic packaging; flat panel displays; flexible batteries; solar panels and thin-film systems.

• ***Medical:*** liners; drapes; surgical kit trays; transdermal patches; blood and solution bags; hygiene products; pharmaceutical and device packaging.

• ***Specialty and Miscellaneous Products:*** photographic media; disposable dinnerware; filter membranes; pressure sensitive tapes.

For More Information…

Visit the EDI website at www.extrusiondies.com for more information about the company and for a list of agents around the world.

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