MACRO
Letter
Announcing Solutions For Flexible Film
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Taking Control of Blown Film Gauge

By Andrew Erskine

The blown extrusion process is used to make single and multilayer films that act as starting materials for printing, lamination and converting (PLC). Today's PLC industry demands blown film processors to make both exceptionally flat films that can be converted at high speeds, and large diameter rolls for minimized changeovers. These requirements call for tight control of the gauge distribution over the total thickness of the film. When blown film is used for specific applications, such as barriers for meat packaging, the control of individual layer thickness for the specialty layer is also critical and should be held to tight tolerances. Examples of these specialty layers include a sealant layer which has EZ-peel and antifog properties in a 3-layer PE based film and barrier layers (nylon or EVOH) in multilayer coextrusion films. With tight gauge control a more uniform performance of the film is achieved in the field.

Aside from the benefits of increased product performance, there is also a significant cost saving to having good gauge. Amidst rising polymer costs and highly competitive markets a processors ability to produce film with uniform thickness has become a necessity. It's no secret that processors spend more

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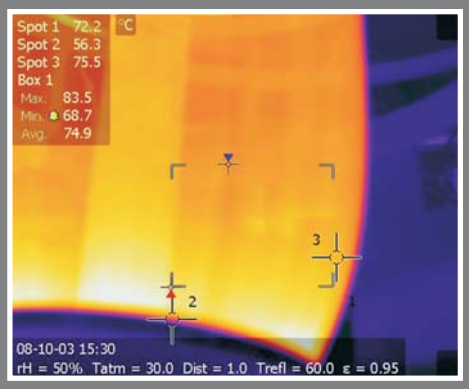
Machinery Spotlight

AUTOMAX Surface Winders Go Reversible

Unlike traditional gap surface winders that can only wind film in one direction, the **AUTOMAX-SBG Reversible Surface Winder** features a reversible winding mode, which allows the processor to choose whether to wind jumbo rolls with the film's treated side in or with the treated side out. The winder features straight edge cutovers that are done without fold-over to produce rolls with flat, wrinkle-free film completely to the core. This allows the converter to utilize the entire roll and save costs from scrap.

Other advantages of the AUTOMAX-SBG are the gap winding mode, programmable tension controls, fully automatic roll transfers, and an integrated shaft hoist that returns the shaft to the loading position without heavy lifting by the operator.

The winder can handle rolls up to 1.5 m (4.9 ft) in diameter and film thickness from 15 to 400 microns (0.6 to 16 mil). Winding shafts are available in 76 mm (3 inch) and 152 mm (6 inch) sizes. It will wind materials up to 3 m (9.8 ft) wide at speeds up to 200 m/min (656 ft/min). As with other Macro winders, the AUTOMAX-SBG features excellent tension control, simplified operation and requires minimal maintenance. Go to www.macroeng.com/reversible-surface-winders.php for more details.



Thermal Imaging Provides Peace of Mind

Macro's **Supercom Supervisory and Control System** for blown and cast film lines has been upgraded to include an optional thermal imaging system that allows processors to monitor bubble temperatures from anywhere an internet connection is available. The system consists of one or more infrared cameras that target specific points on the bubble to monitor temperatures. The data is displayed in real-time on the Supercom HMI and stored by the supervisory system for future analyses.

Alarms are easily programmed to bring attention to any temperatures that fall out of the desired thresholds. In addition to on-site alarm signals, an email is automatically generated with a snapshot of the screen and sent to offsite personnel for immediate notification. The cameras can be directed at specific line equipment, such as the die or extruders, to monitor preheating during early morning or overnight startups when supervision may be limited. If equipment temperatures reach unsafe levels the system will automatically shut down heating to avoid damage to the line. For more details on Macro's Supervisory and Control Software visit www.macroeng.com/supercom-9000.php.

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than 50% of their operating costs strictly on resin, masterbatches and special additives, and excessive use of these materials, particularly costly barrier and tie resins or additives, reduces the profitability of the business.

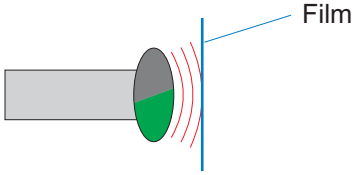
Unfortunately, no matter how good your blown film system is there will always be some variation in gauge. These gauge variations can be created by a number of processes and/or equipment, such as temperature variations in the die, and uneven cooling by the air ring or IBC.

To reduce the amount of gauge irregularities in the film a gauge control system is often employed. These control systems vary in configuration and sensing technologies, typically to match certain applications; however, they all share several common elements:

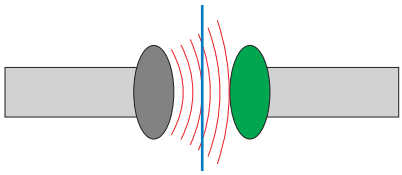
- **Sensing device**
- **Scanning device**
- **Method of correction**

Sensing Devices

There are a number of sensing technologies currently employed in blown film gauge control systems. Common types used include: capacitance sensors, gamma backscatter sensors, and infrared sensors.



Single-Sided Sensor - *transmitter and receiver on the same side of the film*



Two-Sided Sensor - *transmitter and receiver on opposite sides of the film*

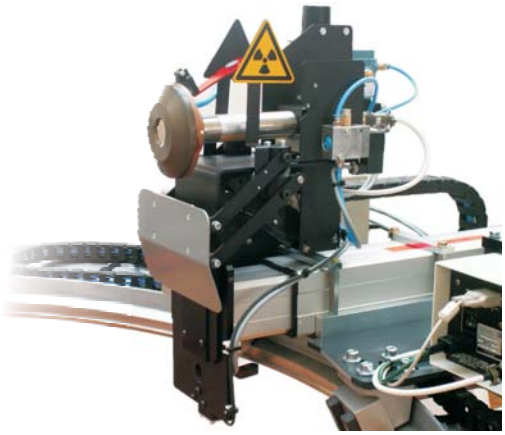
Capacitance Sensors

Capacitance sensors are relatively inexpensive sensors that are capable of measuring a wide range of polymers accurately, including opaque polymers; yet they are used mainly for PE and PP. They are single-sided sensors. They are sensitive to temperature and moisture, incapable of reading certain combinations of polymers correctly (such as Nylon/PE, EVOH/PE) and cannot distinguish different polymer layers.

Capacitance Sensor mounted on a Rotating Scanning System[1]

Gamma Backscatter Sensors

These sensors use a radioactive source to measure film thickness. They are relatively inexpensive, accurate and different radioactive sources can be used to read the thickness of a wide range of polymers. The sensor's isotopes generally have very long half-lives, meaning that the sensor remains stable and accurate without the need to recalibrate. These sensors are also insensitive to air temperature fluctuations. The main disadvantage of this type of sensor is its radioactive source; some countries do not allow the use of these sensors, others require certification and safety training. Like capacitance sensors, radioactive sensors cannot distinguish different polymers in a multilayer film.



Gamma Backscatter Sensor mounted to a Rotating Scanning System[1]

Gauge & Sigma

Gauge variation in film thickness is typically reported as the percent variation from the target thickness (relative to the total film thickness). For the sake of illustration, lets assume the following example:

Thickness readings of a film with a target thickness of 30 µm are taken. Of these readings the following extremes are noted:

Max. Value = 31.0 (+ 3.2%)
Min. Value = 28.8 (- 4.0%)

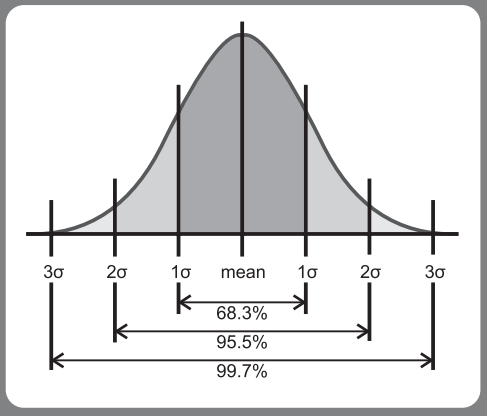
This means that the gauge variation can be reported as +/- 4.0% (if all data points are accepted). Yet for practical purposes, extreme values, ones that exceed a specified level of resolution, are not always included in the reported gauge variation value. Assuming the data forms a normal distribution it is common practice to exclude points that fall out of 1, 2 or 3 deviations from the mean. Reported gauge values that only include one deviation (or sigma (σ), as it is referred to in the industry), will include 68.3% of the data values; meaning the other 31.7% of the data points (the ones that are further from the mean) are not included in the reported value.

A reported value that includes values encompassing two deviations (2 sigma) will include 95.5% of the data points, meaning only 4.5% of those extreme misses are not included.

A reported value that includes three deviations (3 sigma) will include almost all values, with a mere 3% of the most extreme values being excluded.

This differentiation is critical when comparing the true ability of gauge control systems. It is vital to ensure that a uniform comparison is made when examining gauge values (+/- 4% within 2 sigma vs. +/- 4% within 3 sigma). A system that reports to 2 sigma will always appear to be more accurate than one reporting to within 3 sigma.

The industry norm is to report to 2 sigma.



Plot of a Normal Distribution (Bell Curve) Showing Standard Deviations (σ)

[1] *image courtesy of Kündig Control Systems*

Infrared Sensors

Infrared (IR) sensors are two-sided sensors capable of reading the thickness of barrier polymers, such as Nylon, EVOH and EVA. This can prove beneficial to maintaining tight tolerances on those expensive barrier layers. The main disadvantage of infrared sensing is its difficulty measuring black polymers.

Within the infrared group of sensors are enhanced technologies that feature the ability to measure the thickness of individual materials within a multilayered film. These advanced technologies allow the processor to keep tight tabs on the use of specific resins in their films, such as the costly barrier resins used in food packaging.

Aside from the sensors discussed above, there are a variety of other sensing technologies available, such as beta, X-Ray, and infrared interferometry sensors, all of which have their own advantages. To discuss these technologies, please contact us.

Scanning Devices

In addition to having choice when it comes to the type of sensing device to use, there are also different ways to position the sensing device. Because the sensor has to traverse the width of the film in order to gather complete thickness readings it must be mounted to a scanning device. There are limitations to where it can be positioned on a production line. Most commonly, the sensor is positioned at the perimeter of the bubble shortly after it is formed; however, technology also exists to position the sensor around the flattened tube, after the bubble has been collapsed.

Rotating Scanning Systems

Traditionally, blown film scanners are set up to oscillate or rotate around the rising bubble, taking measurements of film thickness as the bubble passes by on its way up to the primary nip. These systems have been shown in commercial production to generate consistently reliable results.

These systems require the use of a rotating scanner to carry the sensor around the perimeter of the bubble in a controlled manner. Unless twisting occurs in the bubble or a rotating die is being used, the thickness data collected can be directly mapped to the die/air ring position directly below the point where the reading was taken. The use of a rotating scanner requires that the sensor be one-sided, such as capacitance and gamma backscatter sensors. Two sided sensors, such as infrared sensors, cannot be used with a rotating scanner setup.

Flat Scanning Systems

Unlike traditional blown film gauge scanning setups that read film thickness by rotating a scanner around the bubble's perimeter, flat-based scanning systems read film thickness after the bubble has been collapsed. The main limitation to this configuration is that the positions of any gauge irregularities are not as easily traced back to the position on the die lip responsible for the anomalies because of the randomizing that occurs between the die and the scanner. Sophisticated software is required to take into account the rotation of the tower's randomizer and extrapolate the precise location at either the die or air ring where the film passed through.

A considerable benefit of the flat scanning setup is that it can be equipped with highly advanced IR technology capable of measuring individual material thickness within multilayer structures.

Rotating Scanner consisting of a Gamma Backscatter Sensor mounted to a Telescoping Probe Positioner[2]

Flat Scanning System with FG710 IR Sensor (capable of measuring individual material thickness in multilayer films) and Profile Control Operator Interface[2]

Flat Scanner equipped with full spectrum infrared (FSIR) Sensor[3] (capable of measuring individual material thickness in multilayer films)

[2] *image courtesy of NDC Infrared Engineering*

[3] *image courtesy of Thermo Fisher Scientific*

Methods of Correction

No matter what method of sensing is applied, the ability to correct the gauge will only be as good as the last part of the system; the method of correction. In general, the thickness data retrieved by the sensor/scanner is examined by the gauge control software, which in turn makes adjustments to the process to make the necessary corrections.

Commonly used methods of correction in commercial applications are to use either an automatic die or an automatic air ring.

Automatic Die Approach

The automatic die approach is based on precise temperature control at segmented portions of the die lip. Small heaters are distributed along the perimeter of the die lip that can be turned on or off by the gauge control system software to make precise adjustments to the die lip temperature at specific points.

With a greater number of heaters a greater resolution of temperature control is possible.

This configuration allows for fine control of film thickness as it leaves the die:

If a thick spot is read, the cartridge heater will increase the die lip temperature to raise the melt temperature at the zone. This will lower the melt viscosity and increase downgauging at the zone, effectively reducing the thickness.

If a thin spot is read, the system will stop applying heat at the particular zone causing the melt to cool and downgauge less.

The advantage of the die-based approach is its mechanical simplicity; it does not contain moving components. The downfalls are the system is not as effective with low blow-up ratios, and there is a small lag time (minutes) in response while the die zone heats or cools.

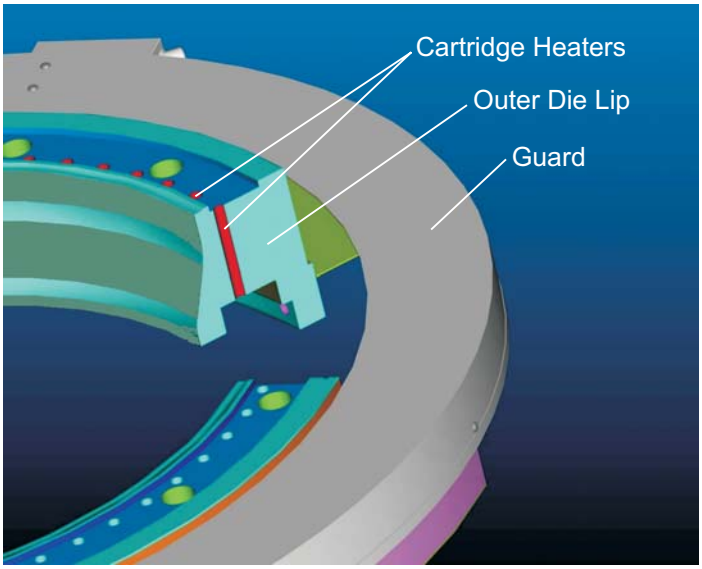
The die-based approach can be implemented in retrofit projects; however, the die lips may have to be completely replaced to incorporate the special heaters.

Automatic Air Ring Approach

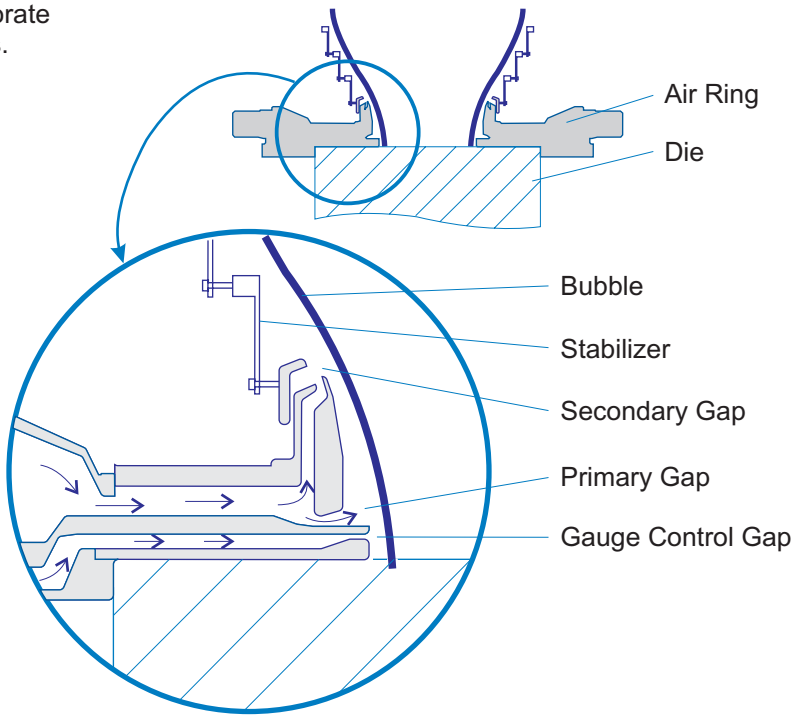
The automatic air ring approach is based on making small adjustments to the cooling air supplied by the air ring to correct the gauge. By adjusting the amount of cooling air at specific areas where thickness disparity occurs the polymer is cooled faster or slower to make the appropriate corrections:

When a thick spot is detected, the air flow on the corresponding segment is restricted to locally reduce the cooling of the melt. This permits the melt to be drawn out further towards the deflector lip to stretch the film and thin the gauge.

When a thin spot is detected, the air flow on the corresponding segment is increased to locally intensify the cooling of the melt. This restricts the melt from being drawn out towards the deflector lip, which reduces downgauging to leave the film thicker.



Representation of the arrangement of heat cartridges around the perimeter of the outer die lip. The guard protects the cables that feed power to the cartridge heaters



Cross-section schematic of the automatic air ring showing gauge control air passage and air flow control valve

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The air ring system's main advantage over the die-based approach is that it reacts must faster; there is no lag time for small temperature changes. The auto air ring approach also works better for low blowup ratios, and is much easier and less costly to retrofit to older systems. The disadvantage of the auto air ring is that it's a more complex system that requires more maintenance than automatic die systems.

Macro provides highly advanced gauge control systems for both die and air ring systems. All configurations are available for testing/viewing in our lab facilities.

ACCUPRO Die Based Gauge Control System

Macro's die-based system of blown film gauge control, the ACCUPRO system, uses a series of die lip temperature zones to make fine-tuned heating adjustments at the die exit. The system provides reliable and consistent response to improve gauge with minimal maintenance. The ACCUPRO works in conjunction with a rotating scanner. Macro also offers its ACCUPROflat system, which provides die-based gauge control with the use of a flat scanning system.

D10 PRO Dual Lip Automatic Air Ring

For either flat or rotating scanning systems using the air ring, Macro offers its D10 PRO Automatic Air Ring. The D10 PRO uses patented valve technology that redistributes the cooling air supplied to the air ring to make appropriate film gauge corrections. This makes the D10 PRO highly efficient compared to other automatic air rings as no additional air is needed, or wasted. Since it is based on the company's D10 Air Ring design, the D10 PRO is easy to use and provides excellent bubble stability and reliable gauge improvements.

Advanced gauge control is an effective tool to improve product quality and performance and to minimize excess use of costly resins and additives. The configuration and type of gauge control system that a processor should use depends on the gauge tolerances; the required sophistication, such as measuring individual layers; and the amount of capital investment that is feasible. This article served to introduce the reader to a common variety of sensing devices and control systems and identified the basic advantages and limitations of each. Before purchasing a gauge control system it is vital that a comprehensive understanding of these systems is achieved to ensure a successful solution is delivered.

Blown Film Die Outfitted with an ACCUPRO Die-Based Gauge Control System

Blown Film Line Outfitted with the D10PRO Automatic Dual Lip Air Ring

Customer Service

We understand that things don't always go exactly as planned. When this happens it's good to have someone to lean on. If you're experiencing technical problems and need some assistance contact our Customer Service Department at *service@macroeng.com*. For immediate assistance, call our 24-hour Service Line at 1 (905) 507-9000 and select option 8 from the menu.

Macro's Customer Service Department is ready to assist you with technical problems, start-up issues, spare parts and training.

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