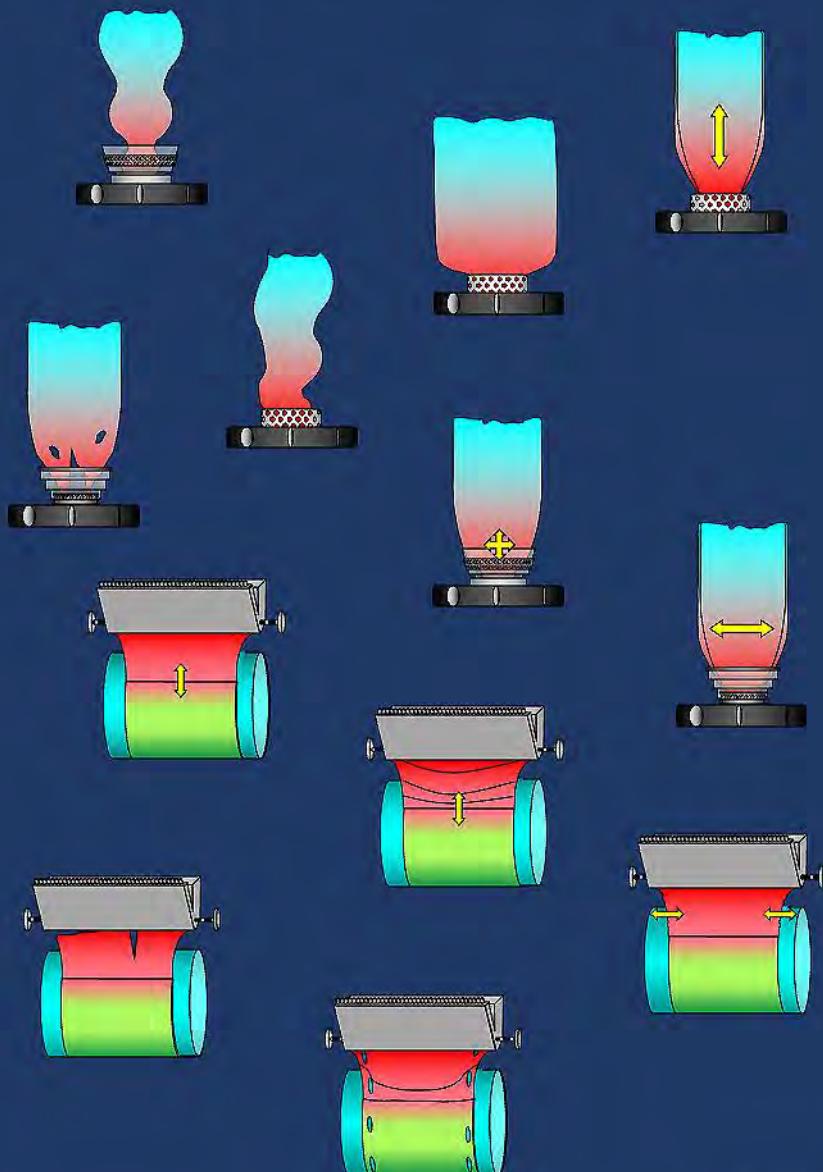


Blown and Cast Film Processing and Troubleshooting



2nd Edition

Plastics Touchpoint Group, Inc.


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1.0 Four Strategies to Improve Profitability

Profitability can be maximized by focusing on four strategies:

1. Decrease scrap rates
2. Improve quality and consistency
3. Increase production rate
4. Adapt modern technology to add value to your product

The extrusion process involves producing the most output of an evenly mixed (homogeneous) melted blend. The key variables that operators use to control the process are temperature, pressure, output rate and quality or consistency of the melt. Shaping the melt into its final form involves another set of challenges that will be described later in this book.

1.1 Film Property Relationships

The fundamental relationships that control cast film processes are summarized in Figure 1.1.

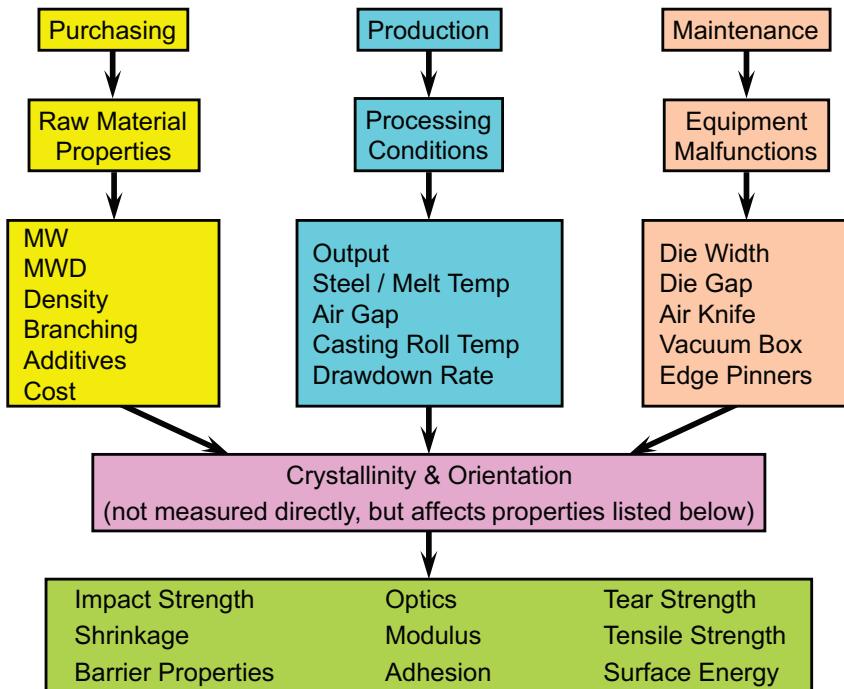


Figure 1.1 Cast film property relationships

Chapter 1 – Polymer Properties and Terminology

The fundamental relationships that control blown film processes are slightly different and are summarized in Figure 1.2.

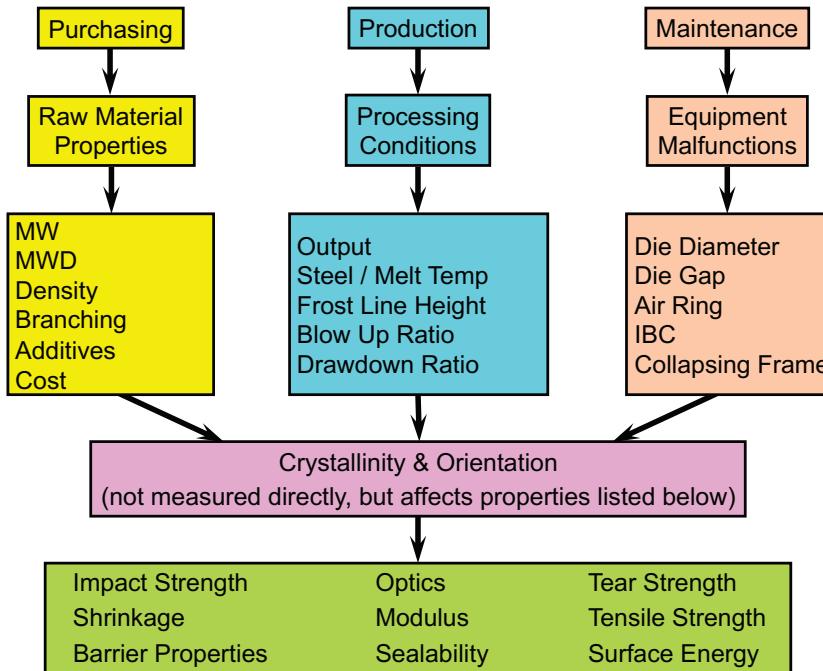


Figure 1.2 Blown film property relationships

The purchasing department selects the raw materials. The production department is responsible for selecting the processing conditions. The maintenance department is responsible for selecting and maintaining the production equipment. All three factors control the ultimate crystallinity and orientation of the molecules in the film structure.

1.2 Typical Cast Film Line Layout

The major components of a cast film line are illustrated in Figure 1.3. The polymers are dosed into the extruders by the blenders, melted in the extruders, and the molten polymer is pushed through the cast film die. The melt curtain is cooled and solidified upon contact with the casting drum. Annealing of the web takes place downstream in the roll stack before the film travels along its path to the winder. Edge trim is removed prior to windup and is reprocessed when possible.

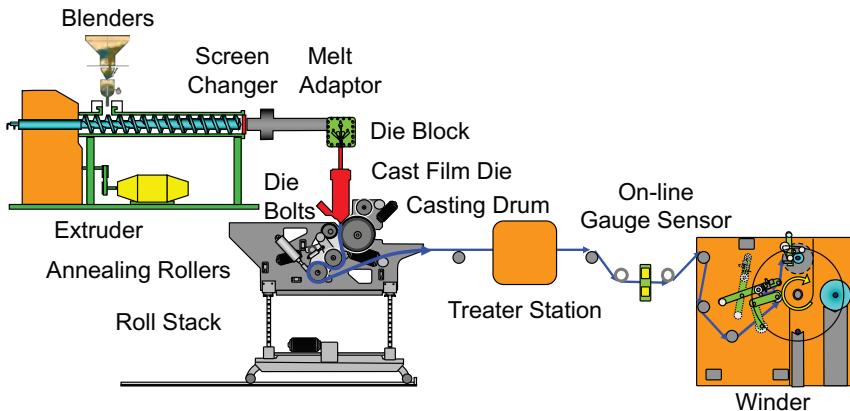


Figure 1.3 Cast film line layout

1.3 Typical Layout for Blown Film Line

The major components of a blown film line are illustrated in Figure 1.4. The extrusion portion of a blown film line is similar to cast film. Blown film dies are round. The air ring cools and stabilizes the bubble, which is then flattened by the collapsing frame. The oscillating nip pulls the bubble from the die lips and entraps air inside the bubble so that the bubble diameter remains constant. The flattened tube, referred to as layflat tubing or web travels through the treater station where a corona discharge modifies the surface energy of the film so that ink or adhesives will spread out and adhere to the surface. The web is split into two sheets with trim slitters inside the secondary nip and wound up on individual winding stations.

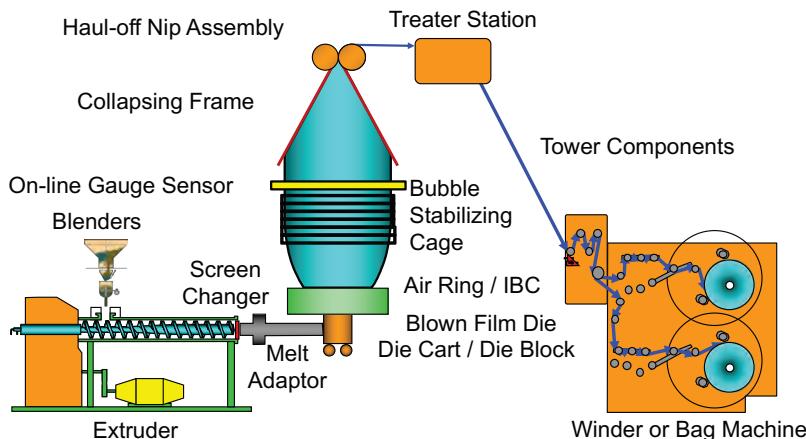


Figure 1.4 Blown film line components

1.18 Barrier Properties and Definitions

1.18.1 Commonly Used Terms

The most common way to measure barrier properties is by measuring the rate at which a permeant travels through a barrier. This is referred to as the Transmission Rate. Permeance is the transmission rate normalized to take into account the difference in concentration between both sides of the barrier (driving force). The transmission rate is often normalized to take into account the thickness of the barrier. The Permeability Coefficient is often calculated using the transmission rate, barrier thickness and driving force. A summary of the relationships is shown in Figure 1.39. A more detailed explanation is included in sections 1.18.2 to 1.18.2.7.

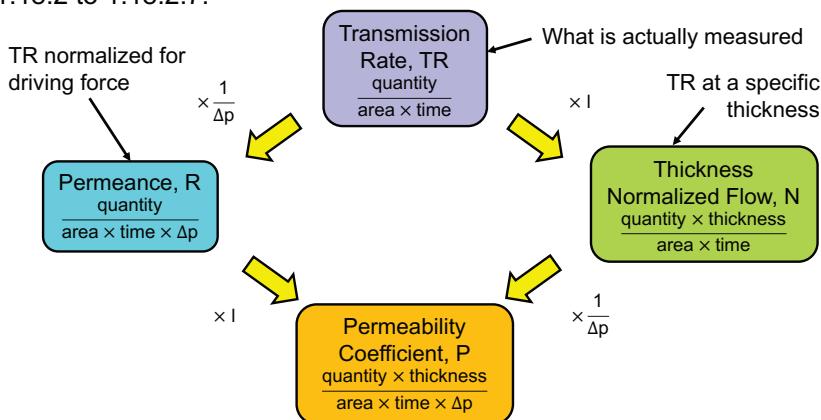


Figure 1.39 Summary of commonly used barrier terminology

1.18.2 Permeation Mechanism

The permeant is the substance that moves from one side of a barrier to the other side. The process takes place in the following sequence:

- Permeant dissolves at the polymer interface
- Permeant diffuses within the polymer, travelling from the high concentration side to the low concentration side
- Permeant diffuses out of the opposite side polymer interface

The variables that affect the permeability of a polymer barrier include:

- Chemical structure of the polymer
- Physical structure of the polymer (orientation of the molecular chains, quantity and size of the crystalline portion of the polymer matrix)
- Chemical structure of the permeant
- Temperature
- Relative humidity
- Permeant concentration

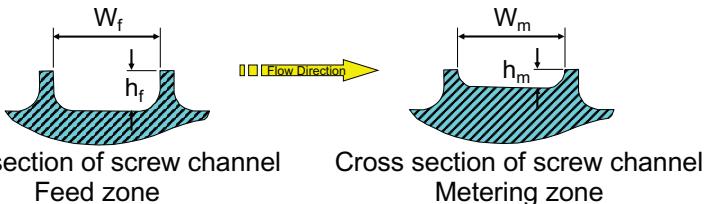


Figure 3.4 Terminology to calculate Volumetric Compression Ratio

$$\text{Equation 3.3: } \text{VCR} = \frac{W_f \times h_f}{W_m \times h_m}$$

Where:

	Metric	US
VCR = Volumetric compression ratio	xx:1	xx:1
h_f = Height of feed zone screw channel	mm	inches
W_f = Width of feed zone screw channel	mm	inches
h_m = Height of metering zone screw channel	mm	inches
W_m = Width of metering zone screw channel	mm	inches

3.4.2.3 Shear Rate at Screw Flight Tip

The clearance between the screw flight tip and the barrel is often referred to as the “zap gap” because it is the location of the highest shear rate in the extruder. A shear rate that is too low will not melt the polymer sufficiently. A shear rate that is too high results in overheating that can create gels and change the color of pigments. Refer to Equation 3.4 for details.

$$\text{Equation 3.4 } \dot{\gamma}_{\text{Flight Tip}} = \frac{D \times N}{19.1 \times G}$$

Where:

	Metric	US
$\dot{\gamma}_{\text{Flight Tip}}$ = Shear rate at tip of flight	sec^{-1}	sec^{-1}
D = Screw diameter	mm	inches
N = Screw rotation speed	RPM	RPM
G = Clearance (gap) between tip of flight and barrel wall	mm	inches

3.4.2.4 Shear Rate Inside the Screw Channel

When scaling up from pilot size extruders to production equipment, the diameter of the extruder increases and output increases. The viscous heat input by the screw increases because the circumferential speed of the screw near the barrel increases. The shear rate inside the extruder (not the critical shear rate) can be expressed by Equation 3.5. A shear rate that is too low will cause polymer to hang up and degrade because the residence time is too long. A shear rate that is too fast may cause overheating along the surface of the screw, resulting in a buildup of gels, carbonized polymer and degradation products that can etch the surface of the screw.

3.6.2 Melting Progression in the Transition Zone

The melt pool size increases while the solid bed decreases. Eventually, the solid bed breaks up. At this point, melting efficiency declines and internal friction between the melt and remaining solid particles must be completed in the metering zone. Refer to the progression along the screw for both grooved feed and smooth bore feed throats is illustrated in Figure 3.9.

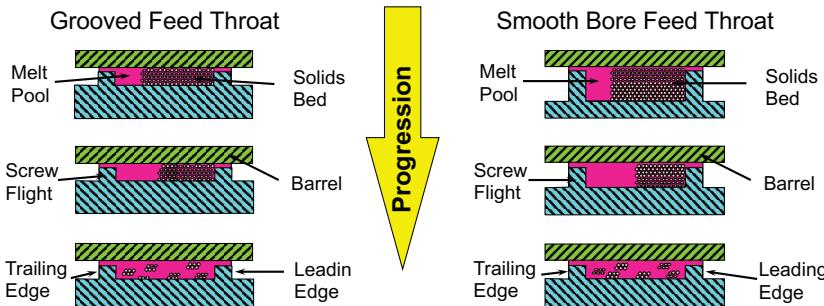


Figure 3.9 Melting progression along metering (single flight) extruder screw

The solids bed ratio indicates the melting capacity of a screw at each point along the screw channel in the transition zone. It is defined in the Equation 3.7 and illustrated by the unwrapped screw channel in Figure 3.10.

$$\text{Equation 3.7: } \text{SBR} = \frac{\text{Width}_{\text{Solids Bed}}}{\text{Width}_{\text{Screw Channel}}}$$

Where:

	Metric	US
SBR = Solids bed ratio	xx:1	xx:1
Width _{Solids Bed} = Width of solids bed	mm	inches
Width _{Screw Channel} = Width of screw root channel	mm	inches

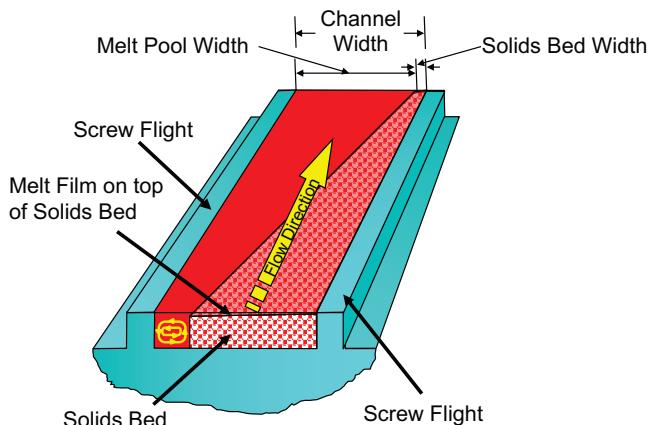


Figure 3.10 Solids bed ratio

5.1 Useful Formulas

5.1.1 Film Width

5.1.1.1 Film Width for Cast Film Lines

Productivity of the cast film process is measured by output and gauge uniformity. Film width can be calculated with Equation 5.1.

$$\text{Equation 5.1: } FW = DW - (2 \times N) - (2 \times E)$$

Where: FW = Trimmed film width mm inches
 DW = Die width mm inches
 N = Neck in per side mm inches
 E = Edge trim mm inches

5.1.1.2 Film Width for Blown Film Lines

Productivity of the blown film process is measured by output and gauge uniformity. Film width can be calculated with Equation 5.2.

$$\text{Equation 5.2: } FW = \frac{\pi \times D_{\text{Bubble}}}{2} - (2 \times E) = 1.57 \times D_{\text{Bubble}} - (2 \times E)$$

Where: FW = Trimmed film width mm inches
 D_{Bubble} = Diameter of the bubble mm inches
 E = Edge trim mm inches

5.1.2 Production Rate

Film production can be estimated using Equation 5.3.

$$\text{Equation 5.3: } Q = C \times FW \times L \times G \times SG$$

Where: Q = Production rate kg/hr lb/hr
 C = Conversion factor 5.1 0.026
 FW = Film width mm inches
 L = Line speed meters/min feet/minute
 G = Film gauge = microns mils
 SG = Specific gravity of film no units no units

5.1.3 Die Specific Output Rate

Dies of different sizes can be compared by calculating the *Specific Output*.

5.1.3.1 Die Specific Output Rate for Cast Film Lines

Refer to Equation 5.4 to calculate specific output rate for cast film dies. Die width refers to the width of the gap from which polymer is extruded, not the full width of the die.

$$\text{Equation 5.4: } DSO = \frac{Q}{W_{\text{Die}}}$$

Where:
 DSO = Die specific output rate kg/hr/mm of die lb/hr/in of die
 Q = Production rate kg/hr lb/hr
 W_{Die} = Die width mm inches

5.7.2.1 Zig Zag Pattern Interfacial Instability

Zig zag interfacial instability occurs when shear stress at the interface between adjacent layers exceeds critical values. It can be predicted by measuring the shear viscosity of adjacent layers. Refer to Figure 5.36 for an example and Figure 5.37 for an illustration of the root cause. The watch is included to show the scale of the pattern.



Photograph courtesy of Compuplast North America

Figure 5.36 Zig Zag interfacial instability pattern

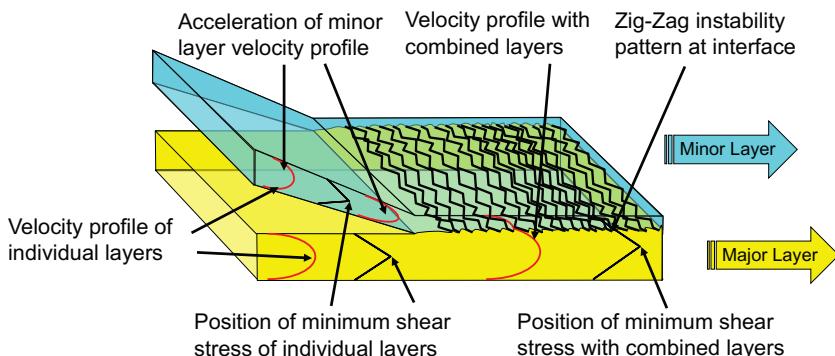


Figure 5.37 Root cause of Zig Zag interfacial instability pattern

5.7.2.1.1 Strategies to Prevent Zig Zag Interfacial Instability

Raw Material

- Modify formulation to minimize shear viscosity differences of adjacent layers
- Change layer ratio to shift layer interface towards the center of the merged flow channel where shear stress is minimized
- Reduce shear stress at the merge point by adding polymer processing aid (PPA) to the minor layer

Processing Conditions

- Reduce shear viscosity and stress at layer interface by increasing melt temperature of adjacent layers. Change in 5°C (10°F) increments and wait 15 to 20 minutes for process to stabilize. Do not overheat.
- Decrease output rate gradually to decrease shear stress at layer interface (slower screw rotation speed). Decrease line speed to maintain correct gauge.

Equipment

- Reduce coefficient of friction of die block and die surfaces (replace worn out plating)

- Inspect and replace defective thermocouples or heaters in die block or die (if required)

5.7.2.2 Long Wave Pattern Interfacial Instability

Long Wave interfacial instability occurs when one of the layers, usually the minor one, exhibits strain hardening. It can be predicted by measuring extensional viscosity of each layer. Refer to Figure 5.38 for a photograph on Long Wave interfacial instability and Figure 5.39 for an illustration of the root cause. Long Wave interfacial instability is strongly affected by the layer thickness ratio, the change in channel depth for each layer, the angle at which the layers merge and the formulation. Long wave interfacial instability frequently occurs when the minor layer is too thin.

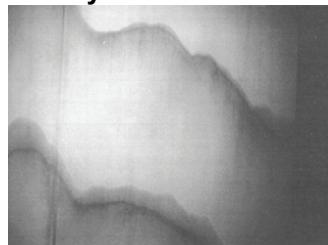


Figure 5.38 Long Wave interfacial instability pattern

Photograph courtesy of Compuplast North America

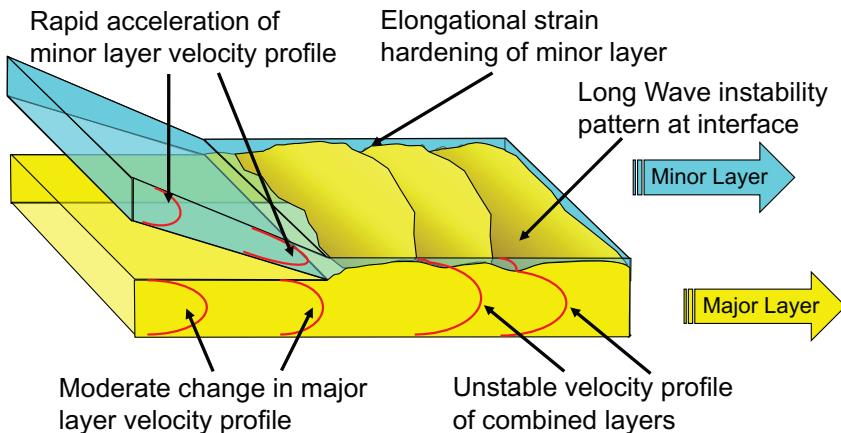


Figure 5.39 Root cause of Long Wave interfacial instability pattern

5.7.2.2.1 Strategies to Prevent Long Wave Interfacial Instability

- | | |
|-----------------------|--|
| Raw Material | <ul style="list-style-type: none"> • Modify formulation to delay onset of strain hardening, usually of the minor layer • Change the layer ratio so that the minor layer is a larger percentage of the total film structure • Reduce shear stress at the merge point by adding polymer processing aid (PPA) to the minor layer |
| Processing Conditions | <ul style="list-style-type: none"> • Reduce extensional viscosity and stress at layer interface by increasing melt temperature of minor layer. Change in 5°C (10°F) increments and wait 15 to 20 minutes for process to stabilize. |

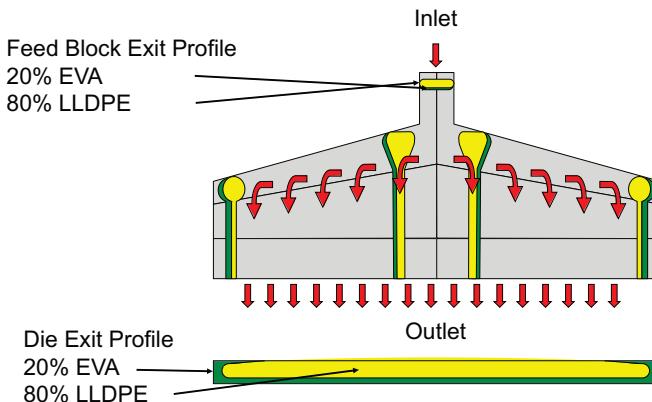
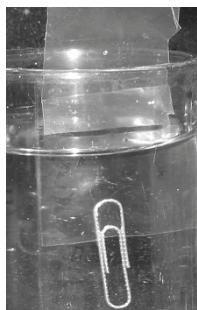


Figure 5.41 Polymers change relative position inside single manifold cast film die

5.7.4 Test to Distinguish Melt Fracture from Interfacial Instability

Melt fracture is only present on the outside surface of the film. Although it looks like interfacial instability in transparent films, it disappears when the film is immersed in water. Interfacial instability is like melt fracture between two layers of film. The interface between two layers does not come into contact with the water, so it remains hazy. Refer to Figure 5.42 for details.



Melt fracture becomes transparent



Interfacial instability remains hazy

Figure 5.42 Test to distinguish melt fracture from interfacial instability

5.7.5 Optical Properties

The four most common terms to describe optical properties of film are illustrated in Figure 5.43. Standard test for haze is to measure the amount of light that is deflected by more than 2.5° when it passes through film. Gloss is a measure of how much light is reflected. The standard angle of measurement is 45° , but 60° is used for specialized applications. Clarity is a measure of the distortion when light passes through the film. Opacity is a measure of how well the film blocks light. It is the inverse of transmittance.

6.2 Cast Film Instability Patterns

The critical factors that control cast film geometry between the die and casting drum are frost line position, air gap, draw ratio, gauge, line speed and neck-in. Five of the most common types of instability are draw resonance, lazy melt curtain, weak melt strength, unstable neck-in and tear off or snap off.

6.2.1 Pulsating Melt Curtain

The root cause is draw resonance which is described in Section 1.6.6. The position where the melt curtain contacts the casting drum changes rapidly, resulting in unstable film gauge and width. The movement cannot be controlled by the autogauge feedback controls because the gauge is uniform when exiting the die, but the gauge changes during draw down. Refer to Figure 6.5 for an illustration of the symptoms. Both gauge and frost line height changes are rapid and erratic.

Note that a dimensional stability test must be completed after any temperature adjustment to ensure the film still meets product quality standards.

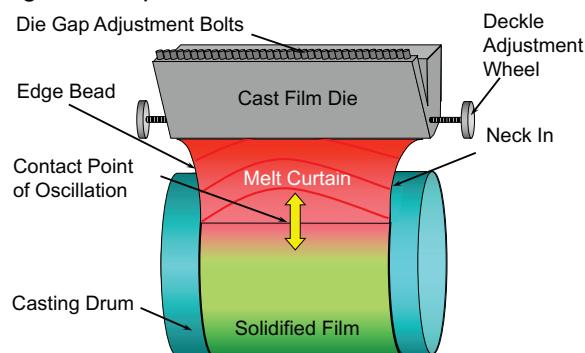


Figure 6.5 Pulsating melt curtain contact with at casting drum

6.2.1.1 Strategies to Prevent Pulsating Melt Curtain

- | | |
|-----------------------|--|
| Raw Material | <ul style="list-style-type: none"> Select resin(s) that increase extensional force in the melt as elongation increases (melt strain hardening) |
| Processing Conditions | <ul style="list-style-type: none"> Reduce melt curtain instability: <ul style="list-style-type: none"> Increase cooling rate on melt curtain Increase vacuum exhaust rate Increase extensional viscosity and accelerate onset of melt strain hardening: <ul style="list-style-type: none"> Adjust extruder temperature profile to decrease melt temperature Reduce drawdown rate by slowing down extruder screw and line speed (less output) |
| Equipment | <ul style="list-style-type: none"> Reduce amplitude of oscillations by reducing air gap between die and casting drum Increase die gap to increase extensional shear rate and accelerate onset of melt strain hardening Check and repair die lip heaters and thermocouples |

6.5 Air Ring Adjustment Principles

We can flip the surfaces vertically and now have the general principle that controls air rings. Bubbles that are not locked securely into the air ring will wobble or “dance”, causing severe gauge variation. Most air rings have two or three components where adjustments can lower pressure between the bubble and the metal surfaces, forcing the bubble to lock into position. Refer to Figure 6.13 for details.

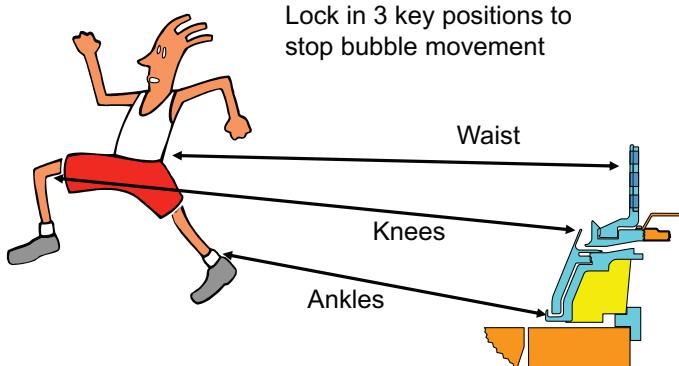


Figure 6.13 Air velocity and pressure stabilize bubbles

6.5.1 Air Ring Adjustment Rules

Operators need only remember the 3 rules illustrated in Figure 6.14 to adjust all brands of air rings.

1. Velocity CONTROLS
(Venturi Effect)



2. Volume COOLS
(Controls frost line height)



3. “CLIMB THE STAIRS”
Start at the bottom and work your way up.

Figure 6.14 Air ring adjustment rules

6.5.2 Air Ring Control (Locking) Points

One style of single lip and three distinct styles of dual lip air rings are commonly available. The Venturi effect between the bubble and the air ring surfaces can be adjusted by changing air velocity at specific points. Figure 6.15 illustrates the “control” or “locking” point positions as circles on the cross sections of these styles of air rings.

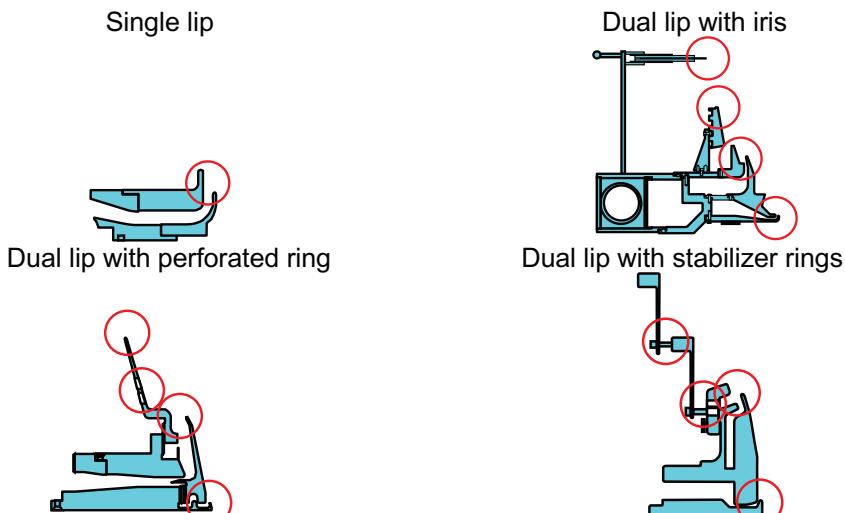


Figure 6.15 Air ring control (locking) points

6.5.3 Manipulation of Air Ring Control (Locking) Points

Adjustments and the effect of air volume delivered by the air ring or Internal Bubble Cooling (IBC), if available, are illustrated in Figure 6.16.

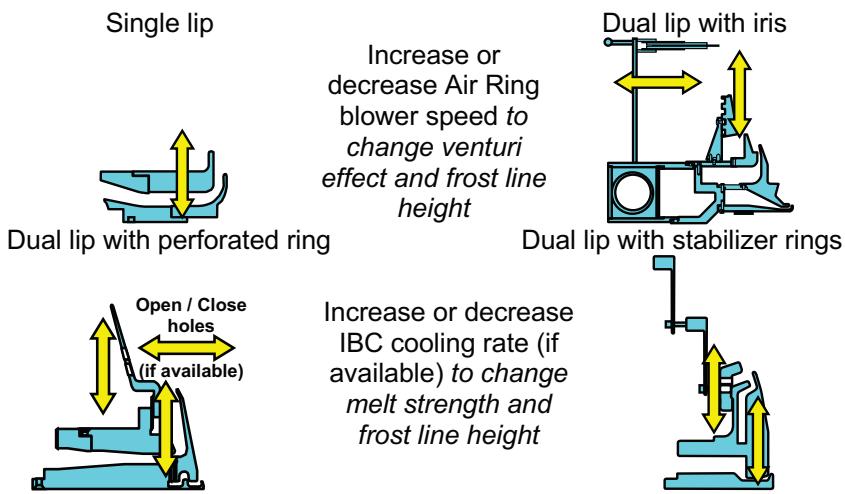


Figure 6.16 Manipulation of air ring (locking) points

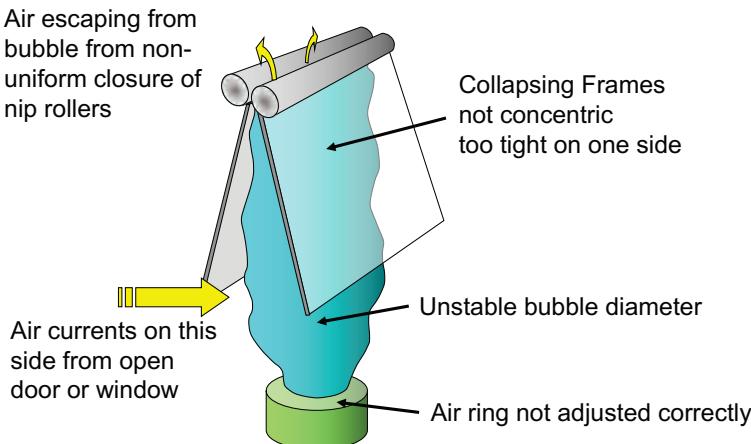
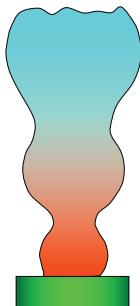


Figure 6.36 Common factors that destabilize bubbles

6.5.15 Pulsating Bubble Diameter

The bubble, often referred to as ‘hour glassing’ is illustrated in Figure 6.37. It is caused by premature strain hardening which causes internal bubble pressure to increase rapidly and restrict expansion of the bubble. This problem is common during start-ups. The most common causes are listed below.

6.5.15.1 Root Causes of Pulsating Bubble Diameter



- | | |
|-----------------------|---|
| Raw Material | <ul style="list-style-type: none"> • Resin is strain hardening • Melt index too low • Too much LDPE in formulation |
| Processing Conditions | <ul style="list-style-type: none"> • Frost line too low • Line speed too slow • Too much bubble cooling • Melt temperature too cold |
| Equipment | <ul style="list-style-type: none"> • Die gap too wide
(reaching draw down limit) |

Figure 6.37 Draw resonance

6.5.15.2 Adjustments to Prevent Pulsating Bubble Diameter

Decrease the air volume and velocity from the air ring. Adjust the movable parts of the air ring, the air ring blower and IBC (if available) in the sequence described in Figure 6.38, depending on the type of air ring.

in the sequence described in Figure 6.40, depending on the type of air ring.

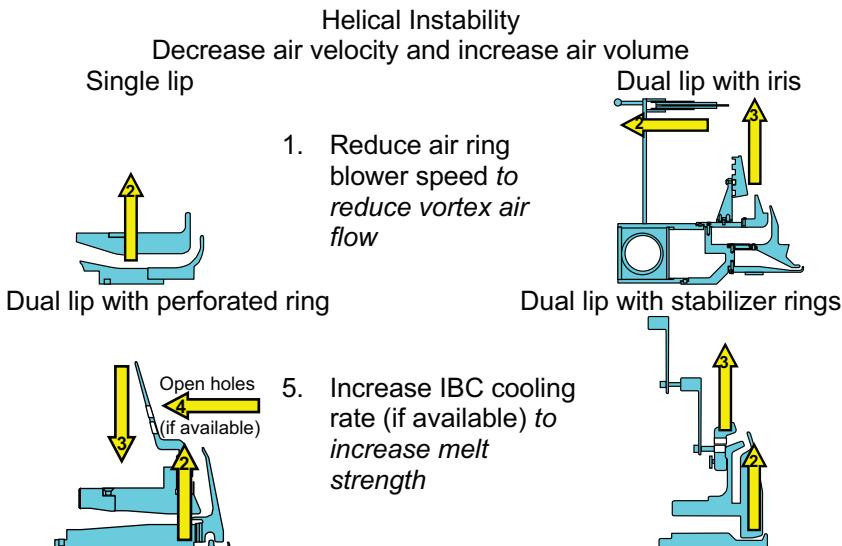
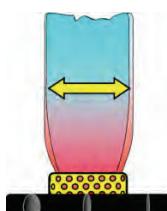


Figure 6.40 Air ring and IBC adjustments to eliminate helical instability

6.5.17 Slow Bubble Breathing

Bubble breathing occurs when the shape of the bubble changes in a cyclical pattern. The frost line will go up and down and the layflat width will decrease and increase in the same cycle of at least 5 seconds. It is important to measure the amount of variation and the speed of the cycle accurately. The next step is to determine what other changes coincide with the same cycle, such as die rotation or nip oscillation. Bubble breathing can be divided into slow (Figure 6.41) and fast (Figure 6.45) cycles. The causes for each type of cycle are different.

6.5.17.1 Strategies to Prevent Slow Bubble Breathing



- | | |
|------------------------------|---|
| Raw Material | <ul style="list-style-type: none"> • Increase melt strength <ul style="list-style-type: none"> • Use more LDPE in formulation • Use lower MFI formulation • Improve melt mixing by using components with similar viscosity |
| Processing Conditions | <ul style="list-style-type: none"> • Adjust extruder temperature profile to prevent surging • Lower the frost line <ul style="list-style-type: none"> • Increase air ring blower speed • Adjust temperature profile to reduce melt temperature |

7.1 Useful Formulas

7.1.1 Film Yield

Film yield is related to film density and gauge. Refer to Equation 7.1 and for details. Note that this formula is for total area, and does not distinguish between sheeting and tubing.

$$\text{Equation 7.1} \quad \text{Film Yield} = \frac{K}{\rho_{\text{Film}} \times T}$$

Where:

	Metric	US
Film Yield = area per unit weight	m^2/kg	in^2/lb
K = Conversion Factor	1,000	27,680
ρ_{Film} = Average film density	g/cm^3	g/cm^3
T = Average film gauge	microns (μ)	mils

7.1.2 Roll Length using Roll Diameter

$$\text{Equation 7.2} \quad L = \frac{\pi \times (R^2 - r^2)}{T \times P} = \frac{K \times (D^2 - d^2)}{T \times P}$$

Where:

	Metric	US
L = Length of film on roll	meters	inches
π = pi	3.14156	3.14156
K = Conversion Factor	0.7854	65.45
R = Outside roll radius	mm	inches
r = Inside roll radius	mm	inches
D = Outside roll diameter	mm	inches
d = Inside roll diameter	mm	inches
T = Average film gauge	microns (μ)	mils
P = Plies for sheeting	1	1
Plies for tubing	2	2

7.1.3 Roll Length using Roll Weight

$$\text{Equation 7.3} \quad L = \frac{K \times (Wt_{\text{Roll}} - Wt_{\text{Core}})}{\rho_{\text{Film}} \times T \times W \times P}$$

Where:

	Metric	US
L = Length of film on roll	meters	feet
K = Conversion Factor	1,000,000	2,307
Wt_{Roll} = Total weight of roll	kg	lb
Wt_{Core} = Weight of core	kg	lb
ρ_{Film} = Average film density	g/cm^3	g/cm^3
T = Average film gauge	microns (μ)	mils
W = Roll width	mm	inches
P = Plies for sheeting	1	1
Plies for tubing	2	2

7.3 Transverse Direction Gauge Variation

In almost all cases, transverse direction gauge variation will result in wrinkles, creases and unacceptable roll geometry. In cast film, the two critical zones are between the die lips and the casting drum (melt curtain) and between the casting drum and the winder (solidified film). In blown film, the critical zones are between the die lips and the haul-off nip (bubble) and between the haul-off nip and the winder.

7.3.1 Dithering to Minimize Gauge Band Build-up (Cast Film)

Some suppliers, such as NDC, supply dithering software that varies the die gap by oscillating the die lip bolt heater voltage in cast film dies. The voltage deviation is programmed to sweep across the web. Refer to Figure 7.6 for details. This technique randomizes the very small stationary gauge bands that result in corrugated rolls. Refer to Section 7.8.6 for details.

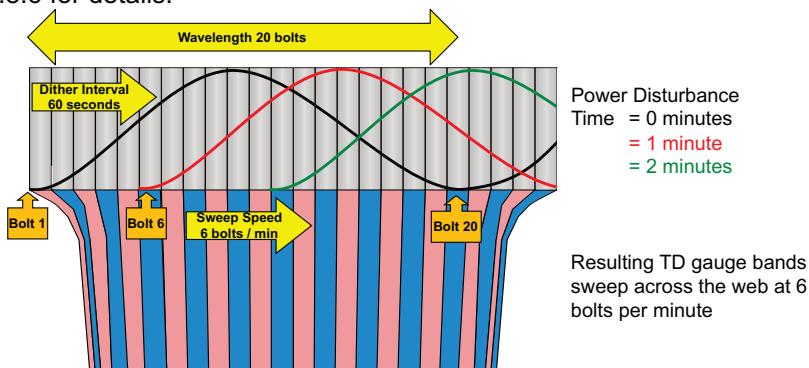


Figure 7.6 Dithering technique to minimize buildup of TD gauge bands

7.3.1.1 Dithering Technique Terminology (Cast Film)

7.3.1.1.1 Amplitude

Controls the maximum and minimum deviation of power (voltage) supplied to each bolt heater in a sinusoidal pattern. For example, an amplitude of 2.0 = $\pm 2\%$ of maximum power applied to the heater. If the nominal power is 70%, an amplitude of 2% means the power disturbance range is between 68% and 72% of maximum power. Expressed as % of maximum voltage.

7.3.1.1.2 Wavelength

Controls the peak to peak span of the power supply disturbance. Expressed in die bolts. A wavelength of 20 means the peak to peak span will be 20 bolts wide.

7.3.1.1.3 Dither Interval

Frequency at which power supply to die bolt heaters is modified. Measured in seconds.

- Film in exit span is too short and stiff to wrinkle

Figure 7.21 Effect of kiss roller

The two most common web tension isolating techniques are nip rollers and S-wrap rollers. In all cases, web tension is always controlled by the speed of the downstream puller. Nipped pull rollers isolate tension ‘waves’, but often compress wrinkles into permanent creases. Refer to Figure 7.22 for details.

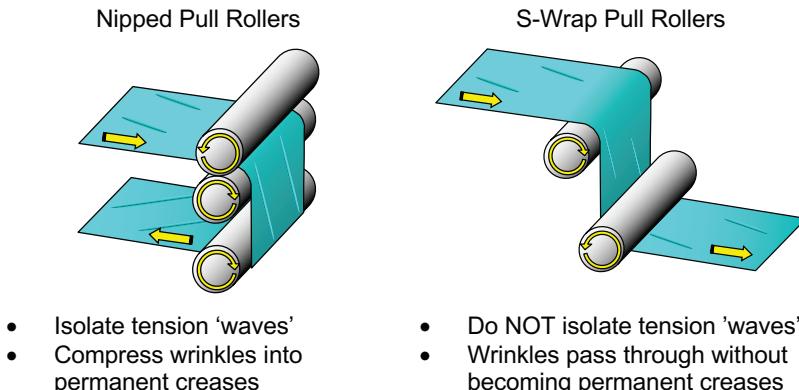


Figure 7.22 Nipped as S-wrap pull rollers

7.5.7.3 Change Web Tension

Lateral stresses cause diagonal wrinkles to form in a transient pattern, so they appear to travel towards the higher tension side of the web. At the same time, slack edges appear on the low-tension side closest to the upstream roller. Refer to Figure 7.23 for details. Decreasing web tension reduces friction and roller traction, allowing the web to relieve stress by sliding sideways along the downstream roller. Increasing web tension stiffens the web so that it can resist buckling that forms wrinkles. A graph showing how web tension changes film from flat to wrinkled as a function of roller misalignment angle is shown in Figure 7.24.

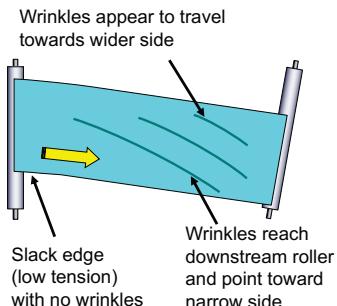


Figure 7.23 Symptoms of roller misalignment

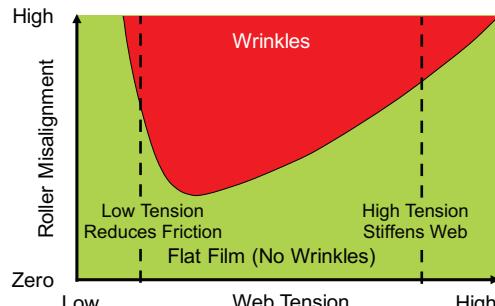


Figure 7.24 Web tension effects roller misalignment wrinkles

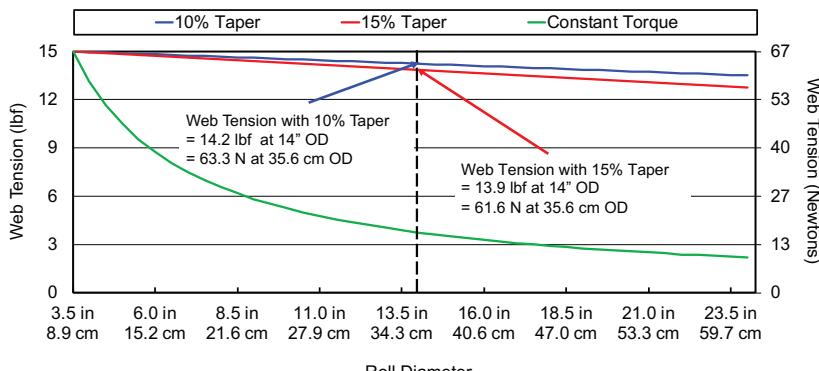


Figure 7.50 Taper tension reduces web tension as roll diameter increases

71.1.1.1 Formula to Calculate Taper Tension

Web tension is frequently reduced as the roll diameter builds-up, to minimize the increase in strain that causes roll deformation. In most cases, the taper program is linear. Web tension in the outermost roll layer can be calculated using Equation 7.11. In this equation, web tension is normalized for web width and thickness. For winders with a linear taper program, full taper only occurs at maximum roll diameter.

$$\text{Equation 7.11: } T_{\text{Web}} = T_{\text{Start}} \times \left(1 - \text{Taper} \times \frac{[\text{OD}_{\text{Roll}} - \text{OD}_{\text{Core}}]}{\text{OD}_{\text{Max}} - \text{OD}_{\text{Core}}} \right)$$

Where:

	Metric	US
T_{Web}	N/cm/mm	lbf/inch/mil
T_{Start}	N/cm/mm	lbf/inch/mil
Taper	%	%
OD_{Roll}	cm	inches
OD_{Core}	cm	inches
OD_{Max}	cm	inches

Web tension is frequently reduced as the roll diameter builds-up, to minimize the increase in strain that causes roll deformation. In most cases, the taper program is linear. Web tension in the outermost roll layer can be calculated using Equation 7.11. For winders with a linear taper program, full taper only occurs at maximum roll diameter.

Example:

	Metric	US
T_{Start}	8 N/cm/mm	0.116 PLI/mil
Taper	10%	10%
OD_{Roll}	38.1 cm	15 inches
OD_{Core}	8.9 cm	3.5 inches
OD_{Max}	76.2 cm	30 inches

At a roll diameter of 38.1 cm with a 10% taper:

$$T_{\text{Web}} = 8 \times \left(1 - 0.1 \times \frac{[38.1 - 8.9]}{76.2 - 8.9} \right) = 0.765 \text{ N/cm/mm}$$

Chapter 9 – Troubleshooting Techniques

This chapter summarizes the troubleshooting tips described throughout the book. Each problem includes causes split into raw material, processing conditions and equipment. Refer to Figure 9.1 for details. The cast film line is split into several zones to remind operators which area of the line should be examined when problems occur. Refer to Figure 9.2 for details. Recommendations for each cause are included.

Note: Causes common to both blown and cast film extrusion are displayed in black font.

Causes unique to blown film extrusion are displayed in **blue** font.

Causes unique to cast film extrusion are displayed in **red** font.

Layout of Troubleshooting Zones for Blown Film Line

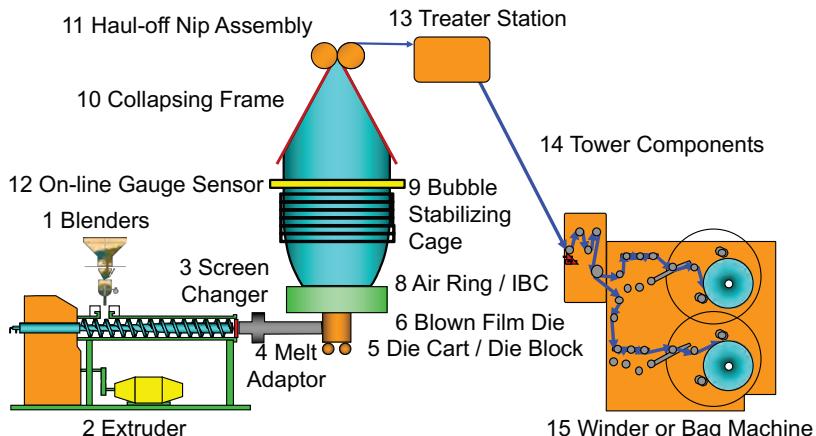


Figure 9.1 Layout of zones for blown film line

Layout of Troubleshooting Zones for Cast Film Line

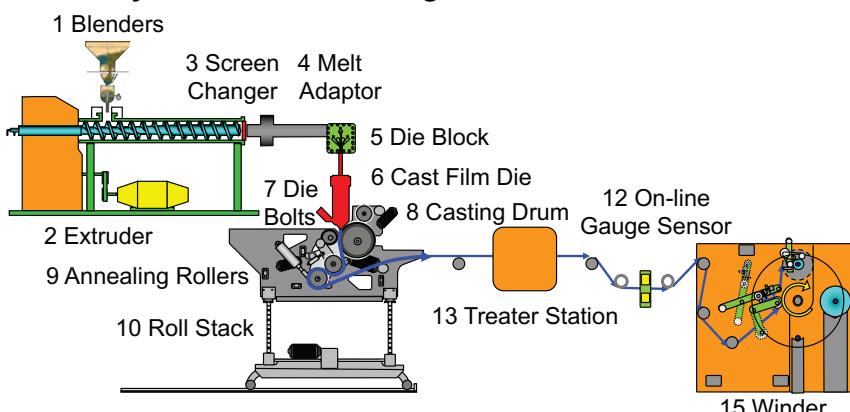


Figure 9.2 – Layout of Zones for cast film line

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Film and Sheet Defects Troubleshooting Guide

Problem	Type	Causes	Zone	Solutions
Weak slit seals – wavy / rippled edges	P	Sealing temperature is too hot.	14	Lower slit sealing knife temperature.
		Sealed edges are pulled away before they are cured.	14	Decrease web tension.
		Increase dwell time to stabilize seal geometry.	11	Decrease line speed.
	E	Unstable web tension distorts seals while they are curing.	14	Realign web path to diminish lateral forces at slitter blade.
		Slit seal knife temperature is too hot.	14	Calibrate heater and controller. Repair or replace if required.
Wet marks	M	Melting temperature is low.	1	Change to formulation to a higher melting point (lower MFR).
	P	Film cooling rate is too slow.	8	Reduce casting drum temperature in 5°C (10°F) increments, but no more than 15°C (25°F) below the minimum allowable temperature.
		Film cooling rate is too slow.	9	Increase temperature of annealing rollers in 5°C (10°F) increments if adjustments to casting drum temperature cause dimensional stability problems.
		Film cooling rate is too slow.	2 8	Reduce extruder screw and line speed to decrease cooling requirements from casting drum (less output).
		Melt curtain is too hot.	6	Reduce die lip temperature in 3°C (5°F) increments.
			6	Reduce die body temperature in 3°C (5°F) increments.
			2	Adjust extruder temperature profile to reduce melt temperature.

Roll Geometry Defects Troubleshooting Guide

Problem	Type	Causes	Zone	Solutions
<i>Helical bubble instability</i>	M	<i>Melt strength is too weak.</i>	1	<i>Change to formulation with higher molecular weight (lower MFR).</i>
			1	<i>Change to formulation with more branched molecular structure (more LDPE)</i>
	P	<i>Helical air flow from air ring is destabilizing bubble.</i>	8	<i>Reduce air ring velocity by opening air lip gap or reducing air volume (less static pressure in air ring chamber).</i>
		<i>Frost line is too low.</i>	8	<i>Raise frost line height by reducing air ring and IBC cooling rate (less air velocity and more air volume).</i>
			2	<i>Increase extruder screw and line speed (more output).</i>
			2	<i>Adjust extruder temperature profile to increase average melt temperature.</i>
	E	<i>Too much shear heating in die lips.</i>	6	<i>Change to wider die gap.</i>
	M	<i>Insufficient melt strain hardening to stabilize melt curtain.</i>	1	<i>Reformulate with higher extensional viscosity formulation (higher average molecular weight).</i>
	P	<i>Melt temperature variation is too large.</i>	6	<i>Increase die lip temperature.</i>
			6	<i>Increase die end plate temperature.</i>
			2	<i>Adjust extruder temperature profile to increase melt mixing in metering zone.</i>
	E	<i>Die gap is too narrow.</i>	7	<i>Open die gap to increase extensional shear rate and accelerate onset of melt strain hardening.</i>
		<i>Insufficient heat at die lip.</i>	6	<i>Check die lip heaters and thermocouples. Repair or replace if required.</i>