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A Practical Guide to Blown Film Troubleshooting

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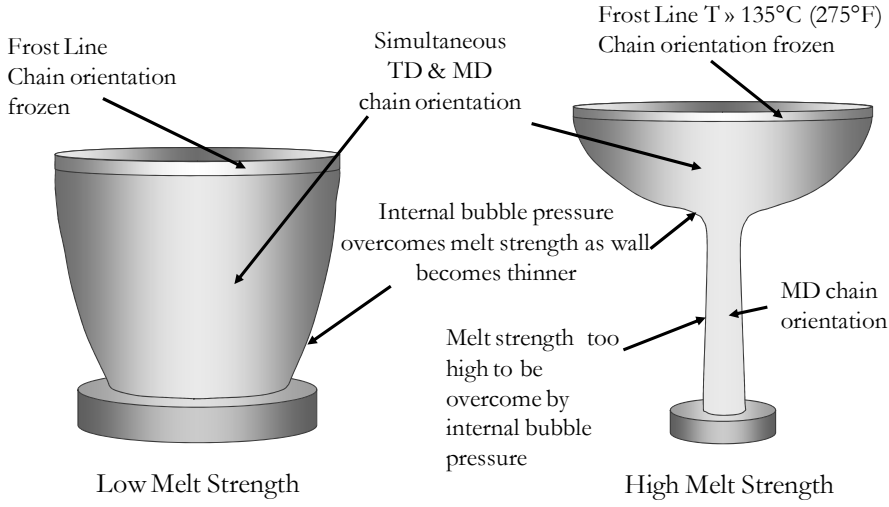
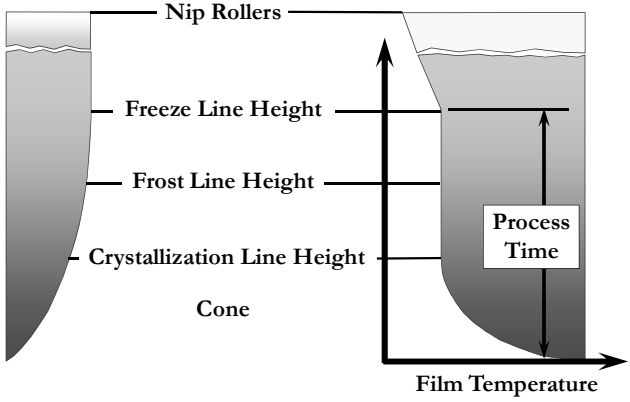
Melt Strength Affects Bubble Shape

The bubble shape affects the process of chain orientation. It depends of the melt strength of the polymer. High (strong) melt strength resins such as HDPE form a high stalk bubble as shown on the right. Low (weak) melt strength resins form low stalk bubbles as shown on the left.



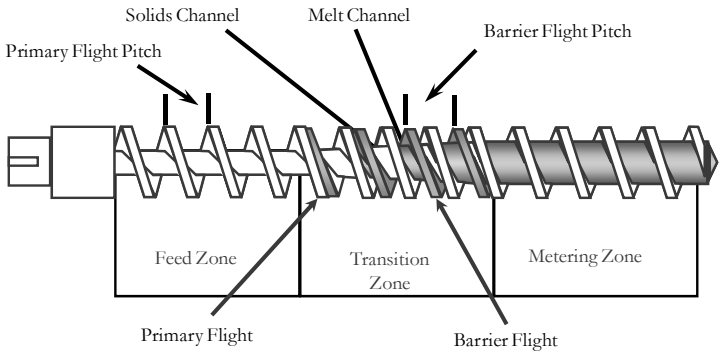
Process Time

The long molecular chains become oriented in the machine direction as they travel through the die opening. The onset of solidification begins at the *Crystallization Line*, and is completed at the *Freeze Line*. The *Frost Line* is often visible in transparent films and is located somewhere between these two lines. The primary processing condition factors that control film properties can be summarized by the *Process Time*.



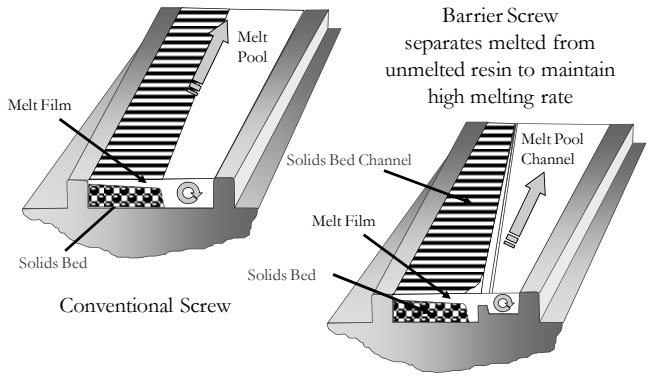
Barrier Screw Designs

There are two successful concepts for improving screw output capacity: The first is to delay the solid bed breakup until most of the pellets are melted. The screw for this is commonly referred to as a barrier flighted screw. The second uses repetitive solids and melt redistribution. Mixing pins in the metering zone are a common way of doing this. The limitation of both these concepts is that they narrow the processing window (range of operating conditions) under which acceptable quality product can be extruded. Higher output rates increase torque, requiring larger motors and gear reducers. It is often not practical to retrofit older extruders with modern barrier screw designs. Higher output rates reduce residence time inside the extruder, required faster melting rates. Melt overheating is a common problem with these high performance screws unless barrel temperature profiles are adjusted correctly. A generalized concept drawing for a smooth bore barrier screw is illustrated below.

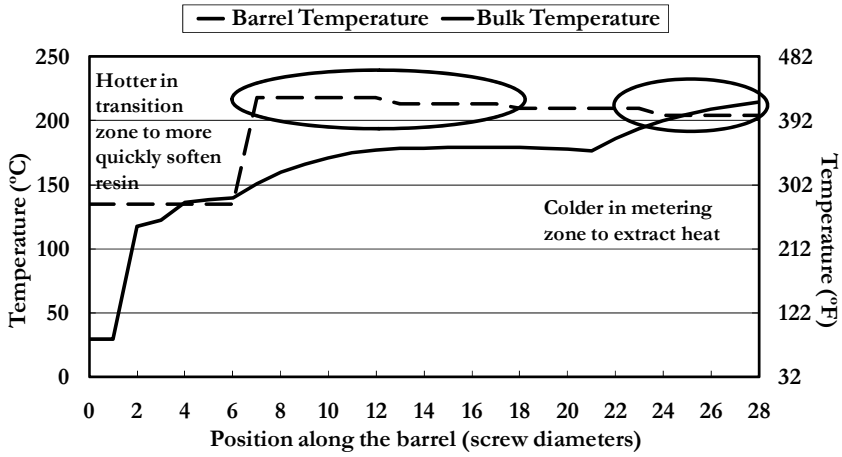


Comparison of Conventional versus Barrier Screws

Barrier screws separate melted from unmelted polymer. Friction between the pellets and barrel wall does not diminish because of premature solid bed breakup. An average barrier screw will increase melting efficiency by 30% when compared to conventional single flighted screws. A 3D comparison of the unwrapped screw channel is illustrated below.



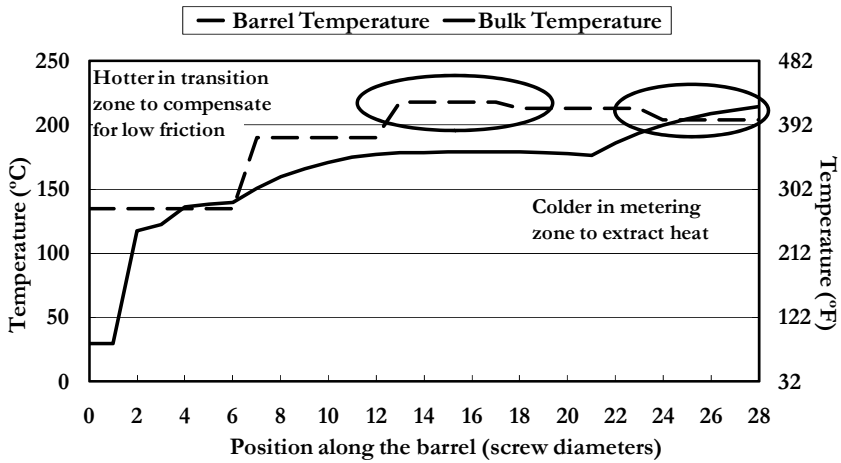
Reverse Temperature Profile Strategy
63.5 mm (2-½") 28:1 L/D Barrier Screw, 60 RPM, 1 MI LLDPE



3. Humped Temperature Profile

This strategy is common when compensating for unstable output, known as surging. See page 57 for details. Extra energy to melt the pellets is added to the transition zone. Melting too quickly may result in gels or unstable solid bed breakup. See page 60 for details.

Humped Temperature Profile Strategy
63.5 mm (2-½") 28:1 L/D Barrier Screw, 60 RPM, 1 MI LLDPE

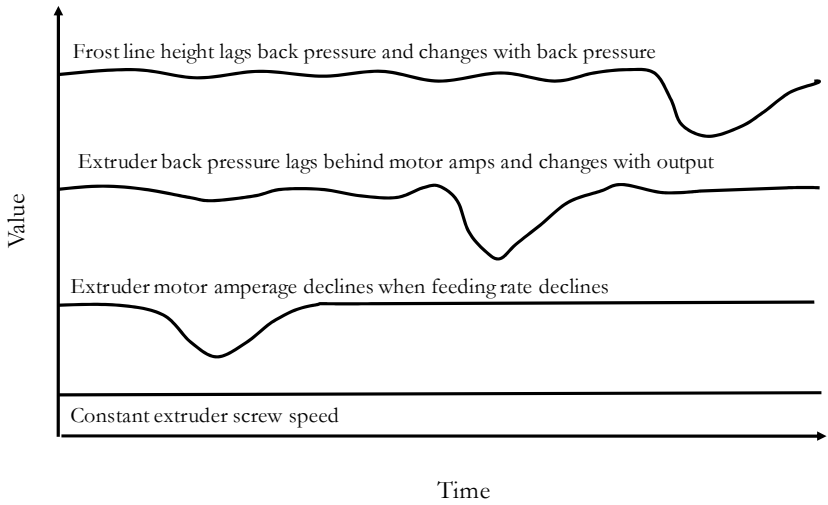


Assuming the extruder motor and drive are stable, surging can be analyzed by monitoring the following operating parameters.

Three parameters increase and decrease, just like in a chorus line of dancers:

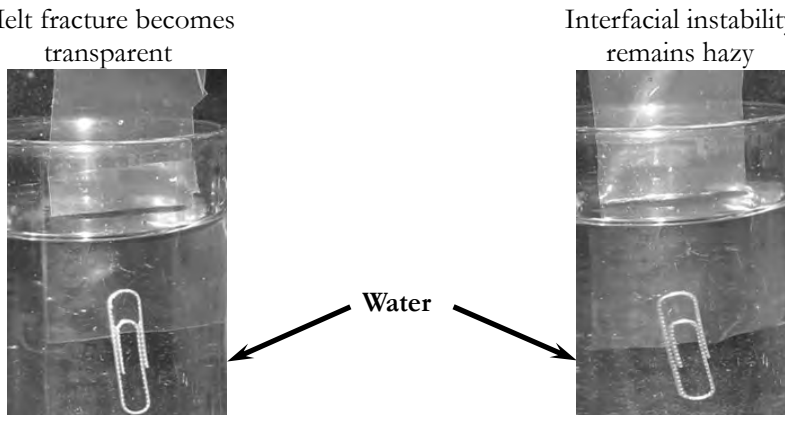
- Extruder motor amperage
- Extruder back pressure
- Frost line height
- All 3 parameters increase and decrease in cycles
- Cycles are not always synchronized

Symptoms of Solids Conveying Variations in Feed Zone



Strategies to Avoid Solids Conveying Variations in Feed Zone

Processing Conditions	• Keep feed throat cool • Use water cooling, if available, to cool screw in feed zone
Equipment	• Remove blockages from feed throat • Ensure that vacuum loaders can supply sufficient resin to feed hopper • Maintain at least 60 cm (2 ft) of resin in the hopper to avoid starving the screw



Gels

Gels are classified first by size and distribution pattern, and then by shape and color. They include pinpoint (very small), arrowhead, chevron, V or J, fisheye, platelet or disc, lens (hollow) and discolored gels. Gels that are evenly dispersed throughout the film are likely to come from the raw material or extruder. Gels that form lanes of gel and gel-free regions in the machine direction are likely to be created inside the die.

The size of the gel compared to the film gauge defines the severity of the problem. Gels that are smaller than 5 microns will affect appearance but are not likely to result in mechanical failure of the film. As gels become larger, they become more unappealing and may result in mechanical failure of the film. The standard test methods for reporting gels only report the quantity larger than specific sizes. These include ASTM D-3351 for gels greater than 400 microns and the TAPPI Dirt Chart T-437 for black specs. Automatic gel counters are available, but are very expensive.

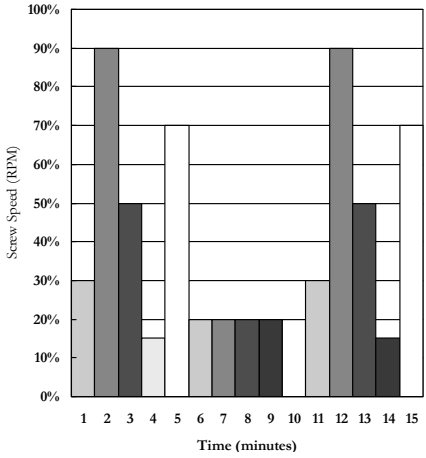
Unmelted Gels

Very small gels evenly dispersed throughout the film are often referred to as applesauce. Larger unmelts can deform enough to flow through screen packs and reform on the downstream side. The primary cause for unmelts is insufficient mixing in the extruder to complete the melting process.

Applesauce

Unmelt

Cyclical Scouring (Disco Purging) Technique Summary

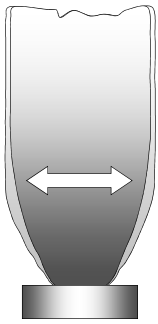


Minute	% of Maximum Screw RPM
1st	30%
2nd	90%
3rd	50%
4th	15%
5th	70%
6th - 10th	15% - 20%
11th	30%
12th	90%
13th	50%
14th	15%
15th	70%

3. Disassembly and Cleaning

If options 1 and 2 are not effective, it will be necessary to disassemble the die and pull the screw. This is the least preferred strategy because it takes many hours to complete the task. Purge the line with a low viscosity (high MI) stable polymer before beginning the procedure. This will make it easier to disassemble the die and pull the screw. Use only brass or copper tools that are not sharp enough to damage plating when cleaning the hot metal surfaces. Use polishing compound recommended by the equipment manufacturer to avoid stripping the plating off the metal. Remove as much polymer as possible while the steel is still hot. Polish the screw and die after the steel has cooled down to room temperature.

Slow Bubble Breathing



Raw Material
- Melt strength is too weak
  - Not enough LDPE in formulation
  - Melt index too high

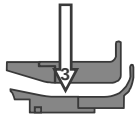
Processing Conditions
- Not enough air volume from air ring (frost line is too high)
- Melt temperature too hot
- Too much output for cooling system to control

Equipment
- IBC sensor(s) are too high
- IBC blowers or valves are not balanced
- Leaks in IBC ducts
- Leaking IBC plenum (oscillating dies only)

Air Ring and IBC Adjustments to Eliminate Slow Bubble Breathing

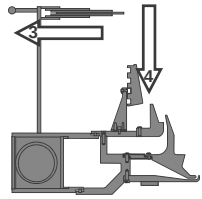
Increase the air velocity and adjust air volume (if required) from the air ring. Adjust the movable parts of the air ring, the air ring blower and IBC (if available) in the following sequence, depending on the type of air ring installed on the line.

Single lip

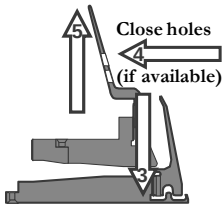


Dual lip with iris

1. Reduce Air Ring blower speed *to increase venturi affect and lower frost line height*

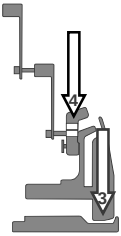


Dual lip with perforated ring



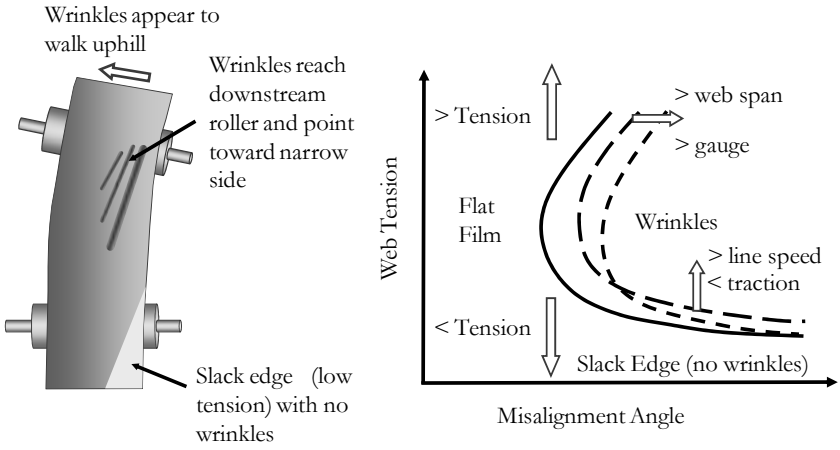
Dual lip with stabilizer rings

2. Reduce IBC cooling rate (if available) *to increase melt strength*

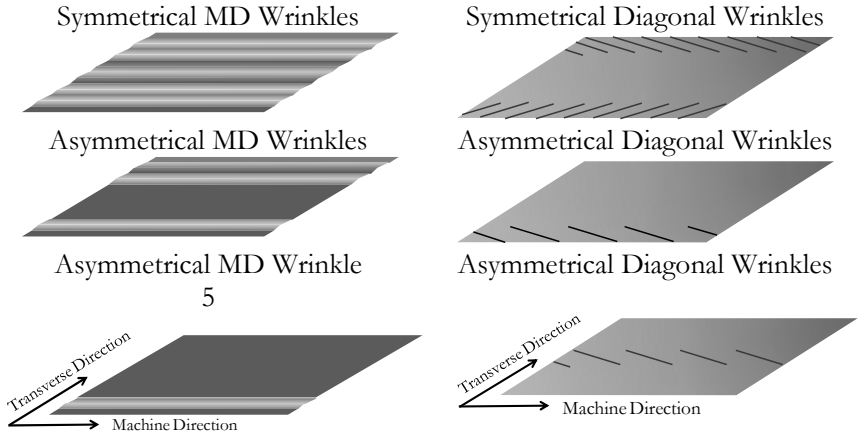


Wrinkles

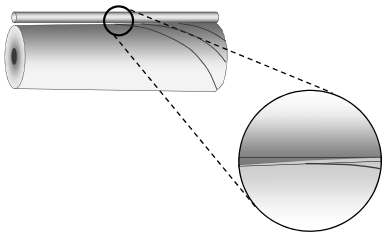
Edge guides, misaligned rollers and improper tension can result in many types of wrinkles. Roller misalignment patterns can be eliminated using the following strategies. The objective is to keep to the left of the solid curved line shown below by adjusting tension or shifting the boundary between the wrinkle and no wrinkle zones.



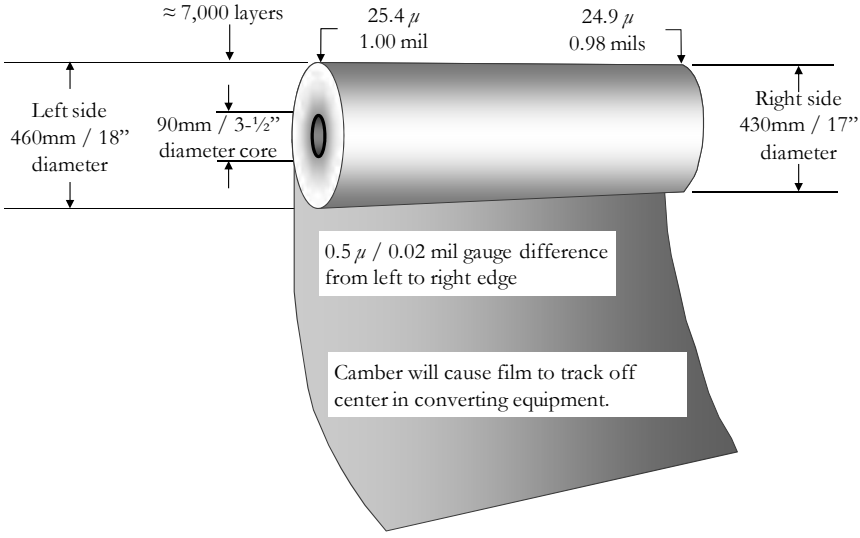
Wrinkles are an indication of gauge variation or unstable tension control. The patterns can be summarized as *machine direction* and *diagonal* wrinkles.



Tapered Rolls



These rolls are smaller in diameter at one end and gradually increase in diameter along the face of the roll. A gauge difference of 0.5 microns (0.02 mils) will result in large diameter differences as the roll builds up. The illustration below shows the affect of this difference across the roll face.



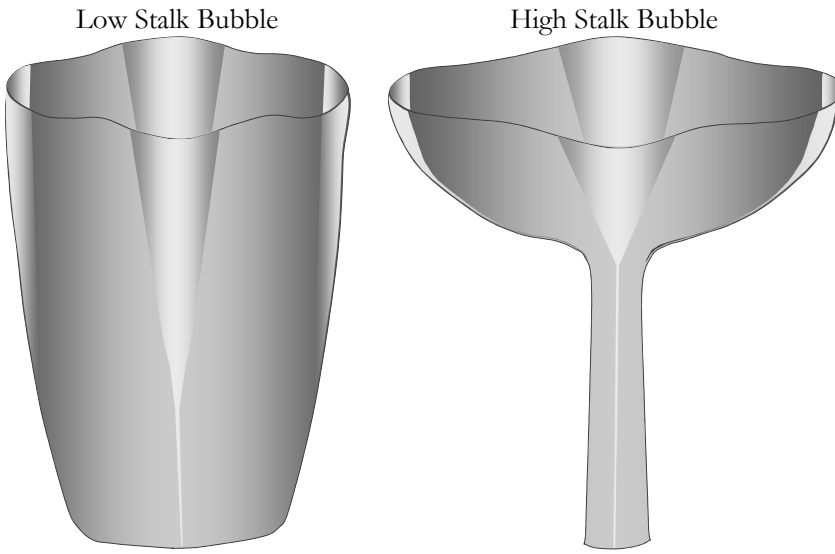
Solutions for Tapered Rolls

Processing Conditions

- Reduce melt temperature variation (melt channeling)
- Eliminate air drafts across the bubble

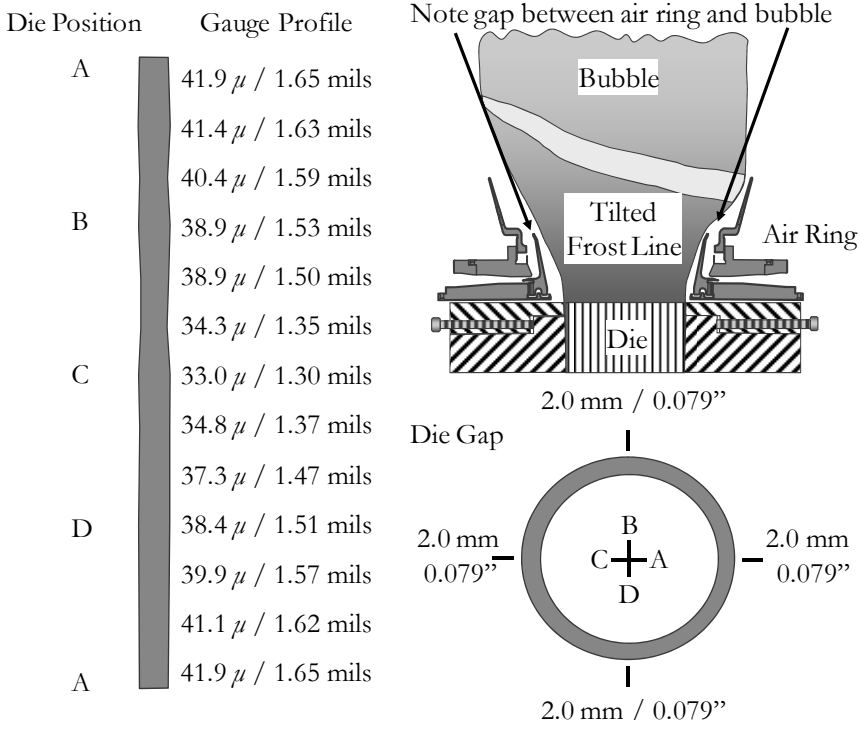
Equipment

- Realign or level
  - Die
  - Air ring
  - Cage
  - Collapsing frame
  - Haul-off nip
  - Lay-on roller



Some common equipment problems are illustrated in the following examples.

Effect of a Misaligned Air Ring



The following guide summarizes the troubleshooting tips described in the manual. The blown film line is split into several zones to remind operators which area of the line should be examined when problems occur. Each problem includes causes split into raw material, processing conditions and equipment. Recommendations for each cause are included.

Blown Film Troubleshooting Guide

Film Defects Troubleshooting Guide

Roll Defects Troubleshooting Guide

Published by:
Plastics Touchpoint Group, Inc.

Website:
www.plasticstouchpoint.com

This book is designed to help readers understand how the complex interaction of raw materials, equipment and processing conditions affects productivity and film characteristics.

Contents include:

- Polymer characteristics
- Equipment options and comparisons
- Troubleshooting guides for:
  - Extruder temperature profiles
  - Screw wear
  - Surging
  - Melt fracture
  - Interfacial instability
  - Gels
  - Bubble instability
  - Surface treatment
  - Wrinkles
  - Roll geometry
  - Heat sealing
  - Gauge variation

ISBN 978-0-9812474-1-0

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