A Practical Guide to Solving Gauge Variation Problems

Presented at Resin to Revenue Conference
January 24-26, 2006
Ft. Lauderdale, Florida

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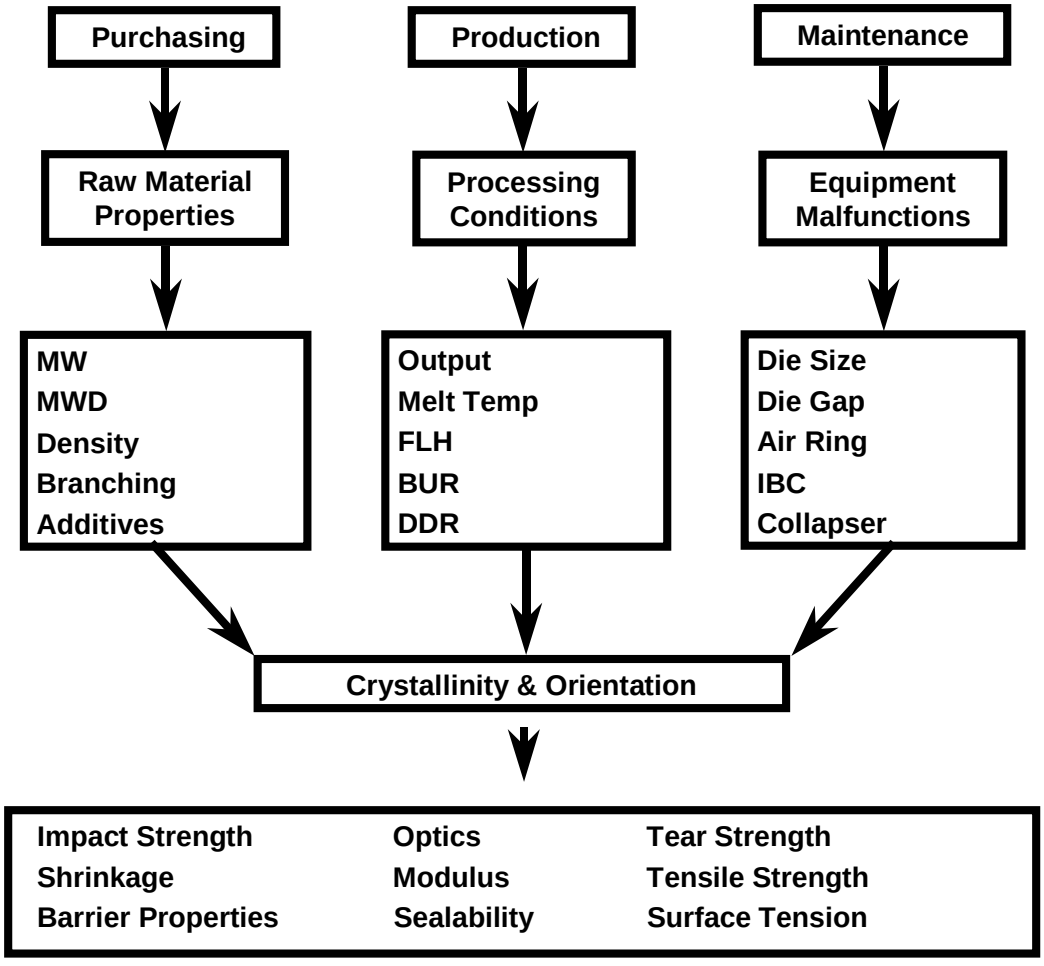
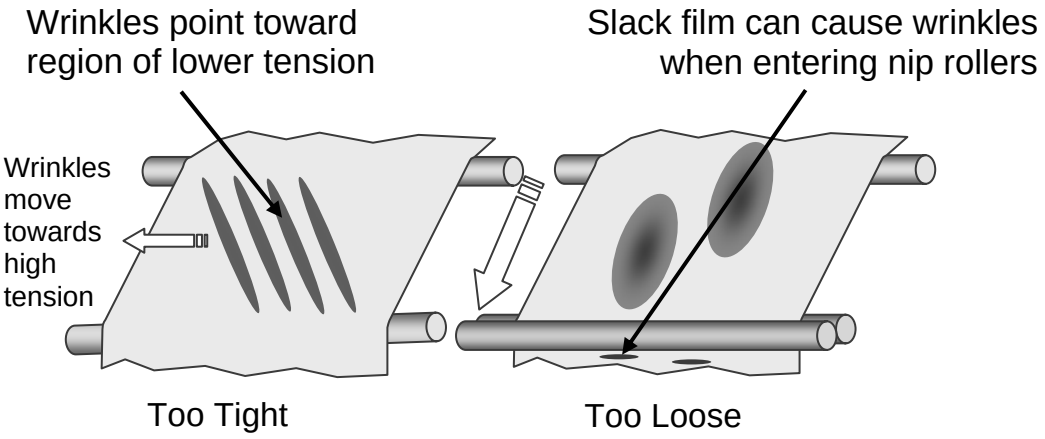
Despite our best efforts, film is never exactly the same thickness everywhere. Contributing factors can be classified under raw material, processing condition or equipment malfunction problems. An overview of these factors is shown in the diagram below.

Blown Film Properties



Web tension variation can be detected at a distance by noting a cyclical change in the reflection of light as film travels down the tower towards the winder. Although it cannot always be used to diagnose problems, it does indicate when significant problems exist.



A quick inspection of the wound up roll can be useful to diagnose problems. Look for non-symmetrical roll patterns first. Then look at the edges of the roll.

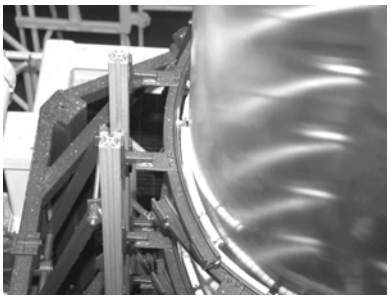
Machine Direction (MD) gauge variation is usually about ±3% unless severe problems occur. The most common causes include the following:

Causes of MD Direction Gauge Variation

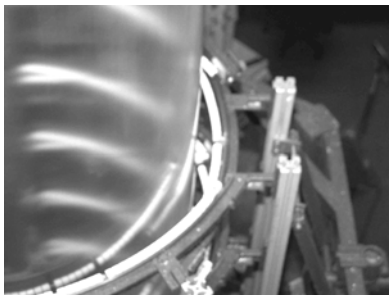
Raw Material	Wrong resin for screw design
Processing Conditions	Bubble not locked into air ring Melt temperature too hot
Equipment	Screw surging Unstable haul-off Uneven feed rate

Bubble Misalignment

Bubble touches cage



Bubble does not touch cage

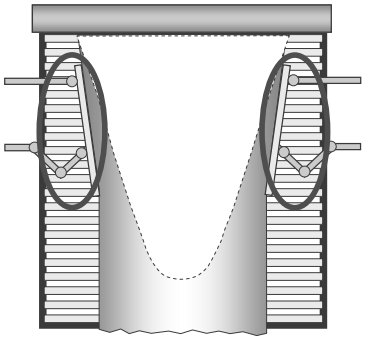


Moves with oscillating nip?
Yes Realign collapsing frame and side stabilizers
No Problem caused below collapsing frame

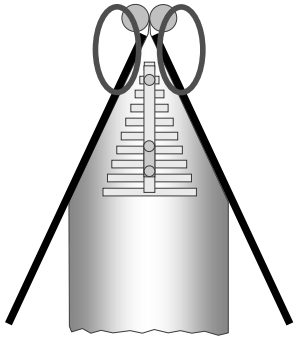
Alignment of all the collapsing surfaces is a critical when trying to minimize TD gauge variation.

Collapsing Surface Adjustment

Angle must be the same on opposite sides to prevent wrinkles, gauge variation and poor quality rolls



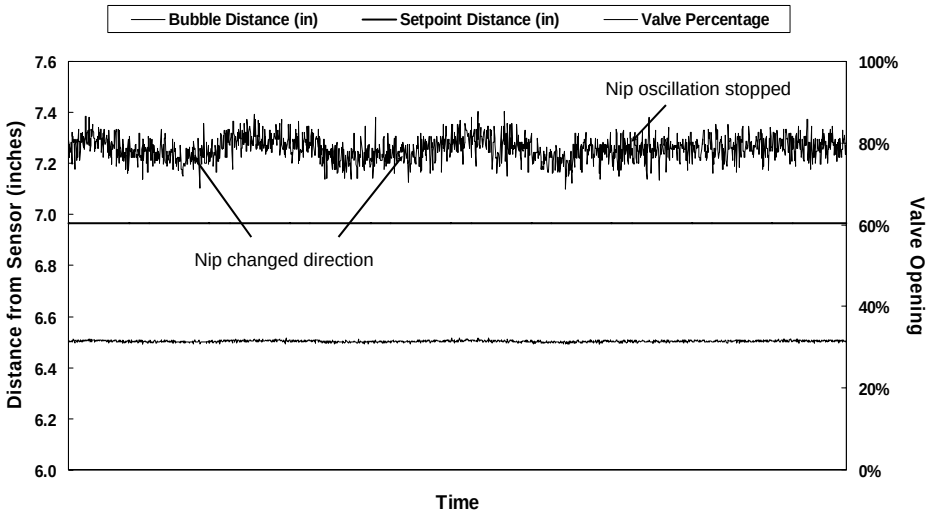
Side Stabilizers



Collapsing Frame

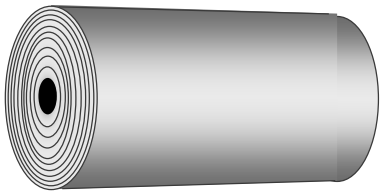
Misalignment problems can cause large layflat (MD) gauge variation in IBC systems with only one sensor. An oscillating nip with only a slight misalignment will result in the bubble moving towards and away from the sensor as it rotates. The IBC system will compensate, assuming the bubble diameter is becoming gradually larger and then smaller.

Evidence of Misaligned Collapsing Frame



Some common edge patterns on rolls indicate specific pr

Edge Variation

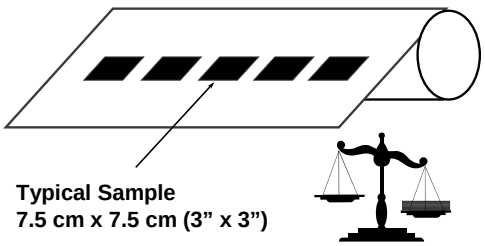


Sawtooth
- slippage in nip
- tension variation at slitters

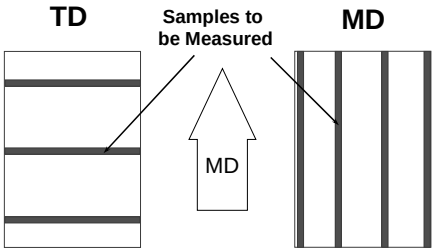
Oscillation from side to side
- misaligned die, cage, collapsing frame

Average gauge is often measured using the “Basis Weight” technique. This technique involves measuring a standard area and making an assumption about the average density of the film. Measuring gauge variation is a much more time consuming process. It involves measuring the thickness in patterns as shown below.

Basis Weight Measurement
ASTM E252-84(1999)



Measuring Gauge Variation



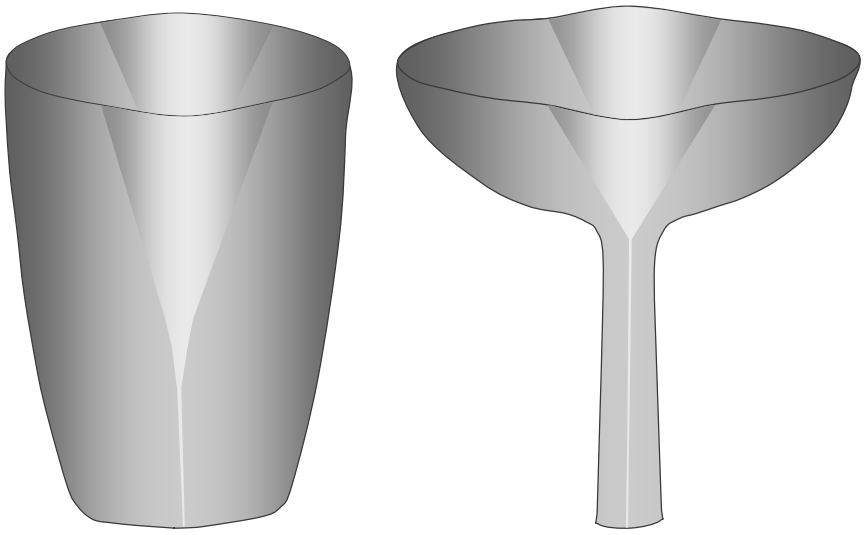
Transverse Direction gauge variation is typically in the range of ±8 to 12%. Automatic gauge control systems can reduce this by half. Common causes include:

Causes of TD Direction Gauge Variation

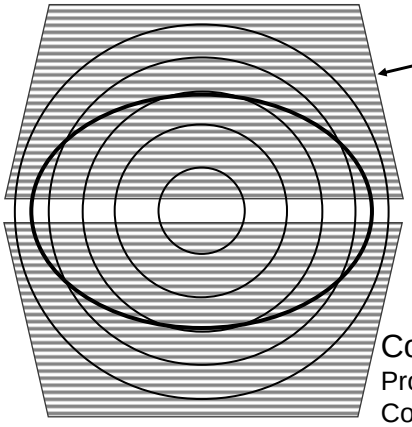
Raw Material	Wrong resin for die design
Processing Conditions	Bottom of die too cold Uneven bubble cooling Too much drag resistance in collapsing frame
Equipment	Die is dirty or misaligned Misaligned heaters Air ring is dirty or misaligned

The most important technique in diagnosing causes of gauge variation is to look for patterns. Some examples include the following.

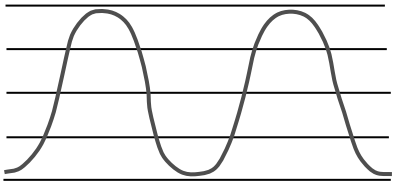
TD Gauge Variation
Oval Bubble with Thin Bands



TD Gauge Variation
Double Peak Gauge Profile



Collapsing Frame



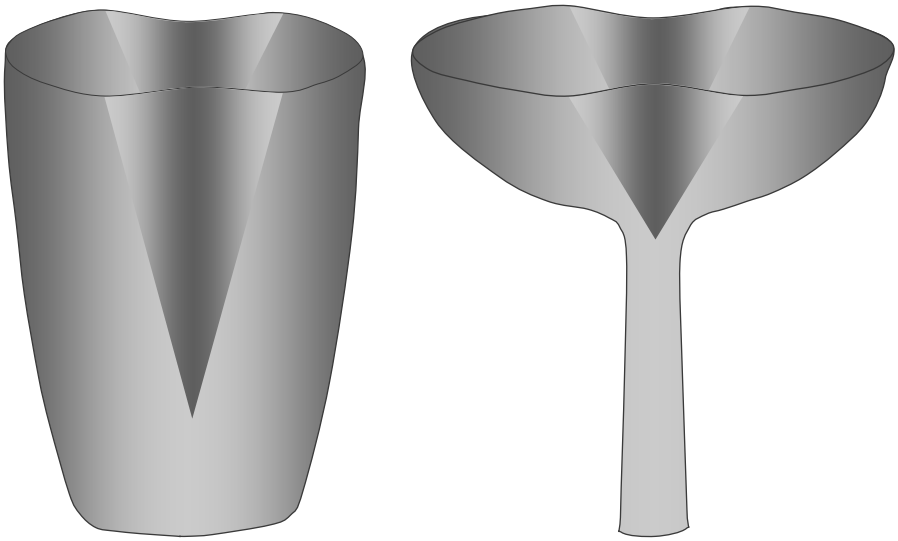
Linear Plot

Polar Plot

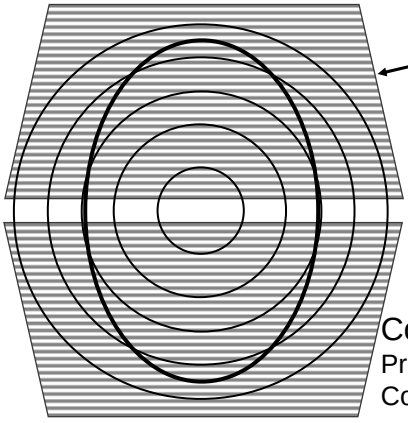
Common Causes

Processing Conditions	Die too cold by 10-20ºC/20-40ºF
	Back pressure too high
Equipment	Dirty screens
	Plugged air ring or IBC stack
	Too much drag in collapsing frame

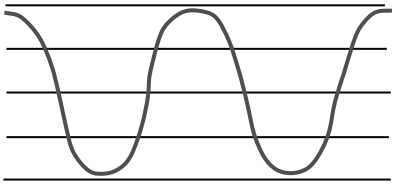
TD Gauge Variation
Oval Bubble with Thick Bands



TD Gauge Variation
Double Peak Gauge Profile



Collapsing Frame



Linear Plot

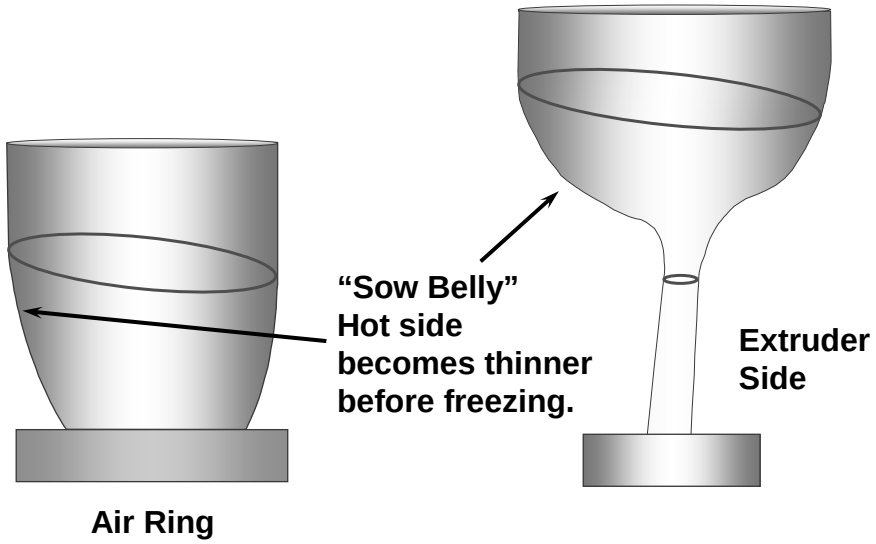
Polar Plot

Common Causes

Processing Conditions	Die too cold by 10-20ºC/20-40ºF
	Back pressure too high
Equipment	Dirty screens
	Plugged air ring or IBC stack

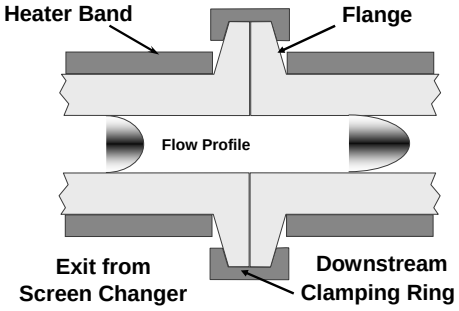
Melt channeling is one example of a single peak TD gauge variation profile. Bubbles exhibiting this problem for both low stalk (LDPE, LLDPE etc.) and high stalk (HDPE) are illustrated below.

Affect of Melt Channeling

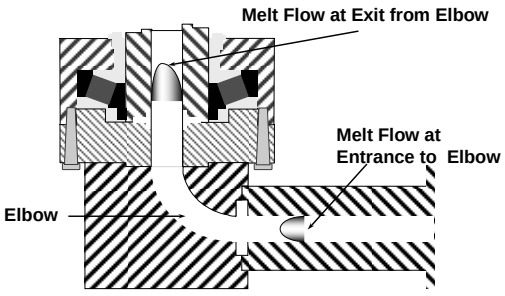


The melt remains hotter in the middle of the adaptor as it travel towards the elbow and die block. The variation in flow will increase with melt temperature variation. Although the flow may be symmetrical as it enters the elbow, it often is not at the exit. The result is that one side of the die is fed with hotter melt than the opposite side. Dies cannot turn fast enough to randomize this melt temperature variation. In many cases, warm air rising from the extruders masks this phenomenon. The velocity profile and resulting melt channeling is shown in the following illustration.

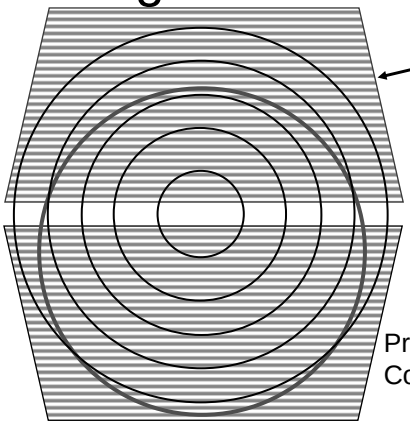
Affect of Transfer Pipes on Flow Profiles



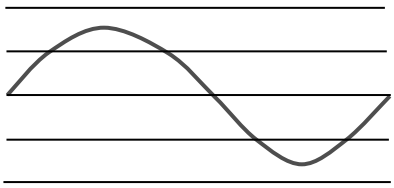
Melt Channeling
Side Opposite Extruder is Hotter



Single Peak TD Gauge Variation



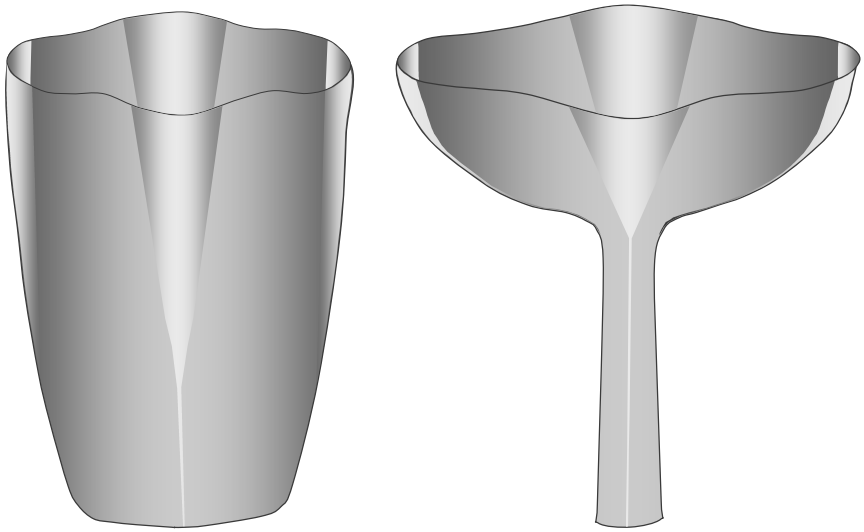
Polar Plot



Linear Plot

Processing Conditions	Uneven melt flow inside die (melt channeling) Hot air rising from extruder or other air currents inside the factory
Equipment	Die lip not centered Air ring or IBC stack not centered Tilted die ,air ring or IBC stack

TD Gauge Variation
Equal Number of Thick and Thin Bands



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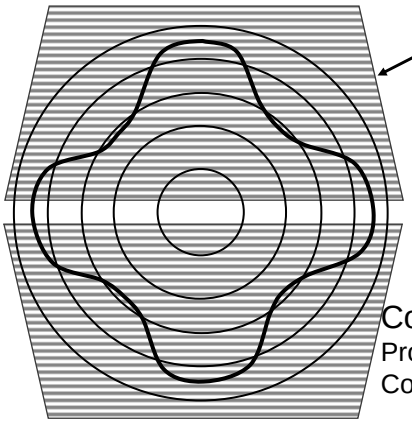
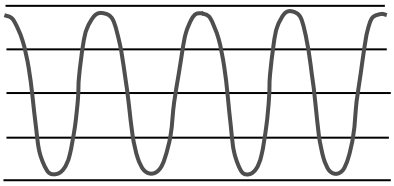


Polar Plot



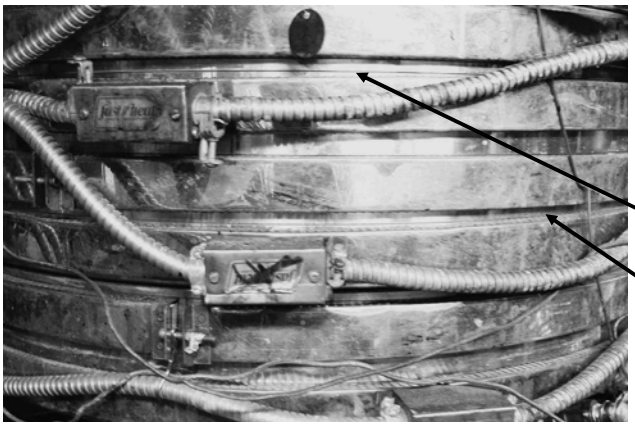
Linear Plot

Common Causes

Processing Conditions	Die too hot by 10-20ºC/20-40ºF
	Back pressure too low
	Too much output
Equipment	Dirty screens
	Melt temperature variation too large (worn screw)
	Plugged air ring or IBC stack

Bottom of Die is Too Cold

Loose Die Heater Bands

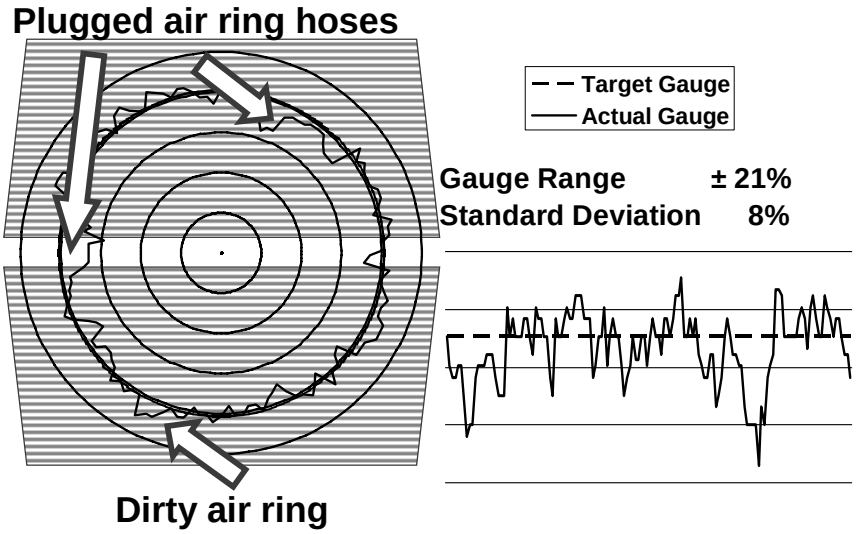


Compare heater position to:

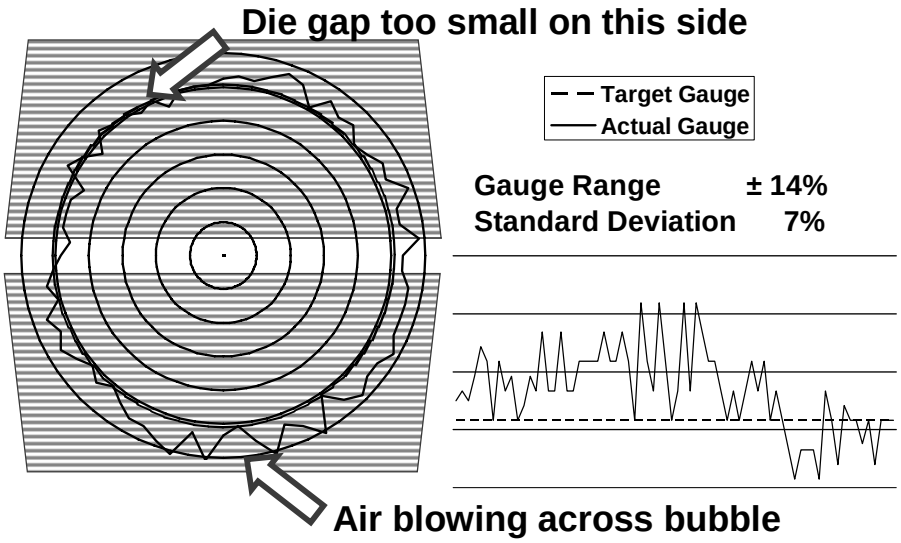
parting line

other heater bands

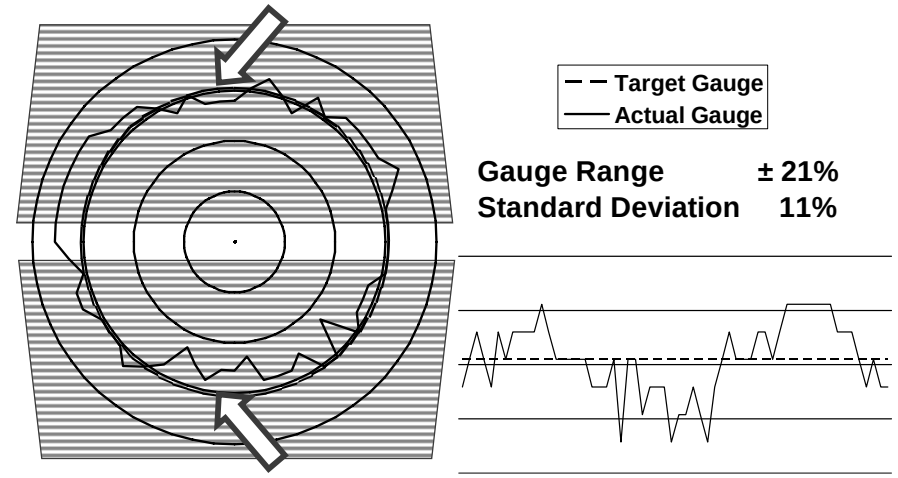
Transverse Direction Gauge Variation Example 1



Transverse Direction Gauge Variation Example 2

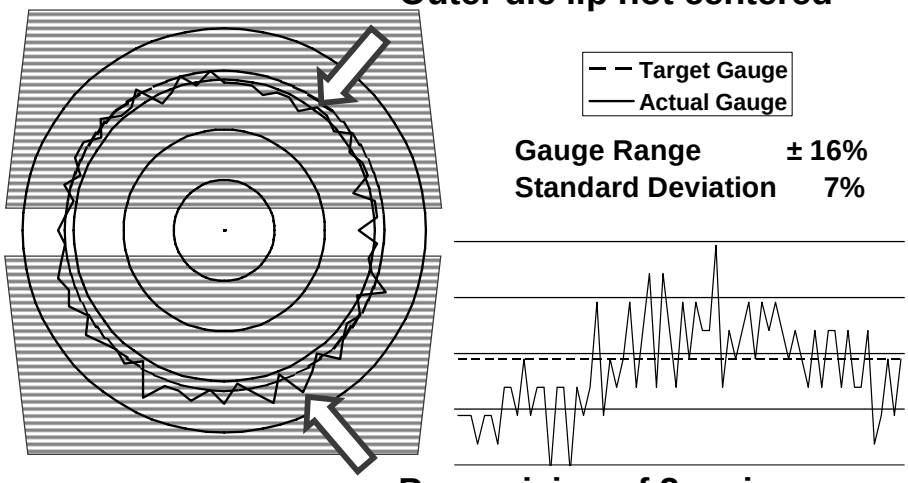


Transverse Direction Gauge Variation Example 3



Transverse Direction Gauge Variation Example 4

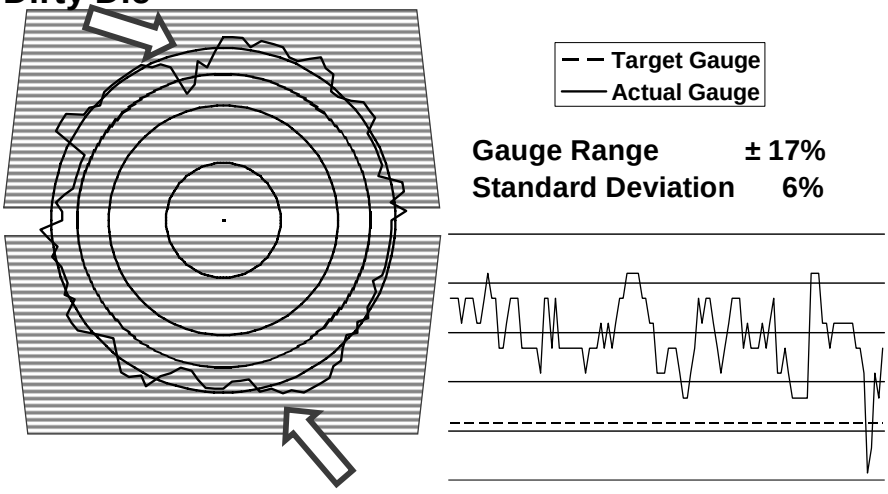
Outer die lip not centered



Poor mixing of 2 resins

Transverse Direction Gauge Variation Example 5

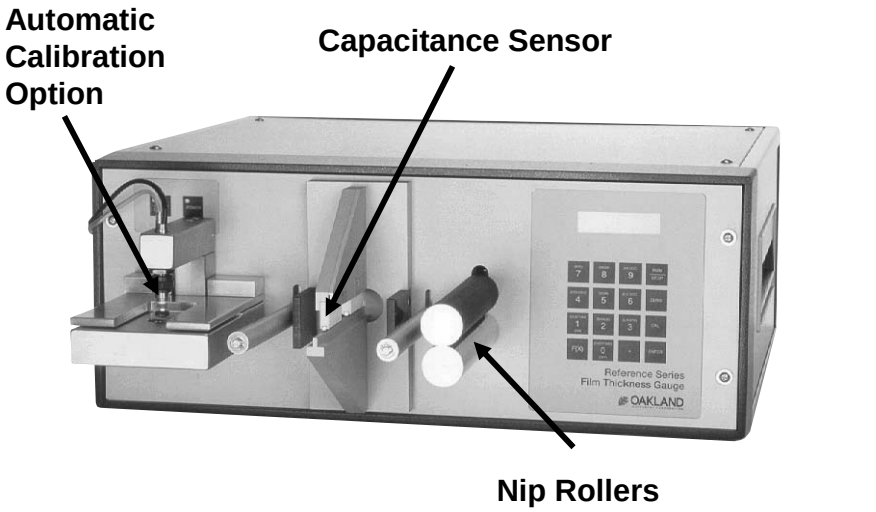
Dirty Die



Bubble not locked into air ring

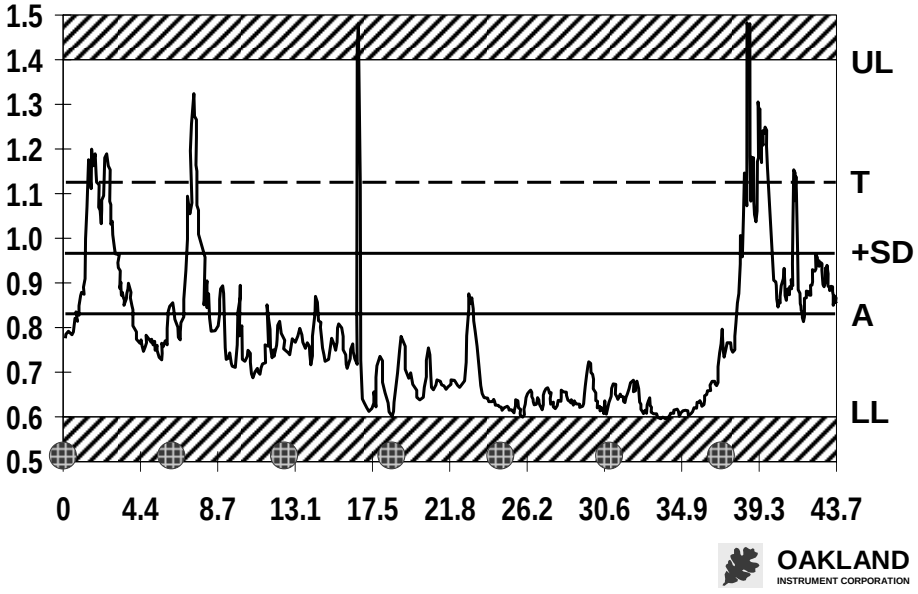
Efficient analysis of gauge variation requires a gauge profiler. Most bench top units are mechanical caliper or use capacitance technology. Capacitance systems require calibration whenever the formulation is changed. This unit has both, so it can automatically calibrate the sample.

Capacitance Type Gauge Profiler



Gauge variation can be plotted in linear or polar mode. There are several techniques to suppress unwanted noise due to wrinkles etc. Less sophisticated ones use simple cut-off techniques. This one uses a rate of change benchmark that can be adjusted as needed.

Thickness vs Length



Analysis of trends can be useful. Using Fourier series analysis, the strength of specific frequencies can be analyzed. Frequencies that do not fit the asymptotic curve are a strong source of gauge variation. This information can be used to identify problems in the manufacturing process.

Fourier Analysis