Feedblock & Die Technology for Co-Extrusion Coating

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Agenda

• Feedblock Coextrusion Coating
  • What & why coextrusion
  • Feedblock function
  • Coextrusion challenges
  • Feedblock designs

• Flat die basics
  • Manifolds and distribution
  • Deckles; width change and edge bead reduction
Feedblock Co-Extrusion – What & Why

• Combining together multiple different polymers from separate extruders into a stack of uniform layers to then flow through a single manifold die to form a useful composite flat web structure.

• ‘The whole is greater than the sum of the parts’ 
No individual polymer made in a single layer coating or film can provide all the performance properties of the multi-layer, multi-polymer composite at an equivalent total thickness and weight. Source reduced with improved function and performance. May often deliver performance at lower cost. May enhance operating efficiency through use of off spec or reprocessed materials buried in an inner layer or improved run ability with pure materials in contact with the die.
Combining Methods

• Multi-manifold dies
  • Separate die manifold for each polymer
    • Expensive
    • Massive
    • Complex to operate / clean

• Feedblock w/ single manifold die
  • Combine polymers before the die
    • Versatile
    • Dependent on polymer viscosities
    • Simple die operation
Multi-Manifold Die

Spreads the polymer before combining into a layered stack. Allows coextrusion with mis-matched viscosities.

Images courtesy Nordson EDI
FEEDBLOCK SYSTEMS

The most common method for slot die coextrusion is combining in a feedblock adaptor and delivering to a single manifold die. Requires attention to matching of polymer viscosities.

Images courtesy Nordson EDI
Feedblock Function

• Arrange the polymer streams in the desired order
  • ABCBD
  • DBCBA
• Reshape the polymer streams for combining
  • Uniform rectangular sandwich
  • Pre-shape for viscosity compensation
• Join the polymer streams for final forming
  • Minimize interfacial stresses
  • Reduce distorting opportunities - time / geometry
Layer Thicknesses Determined By Extruder Output
CHALLENGES IN COEX

- Viscosity matching
  - Rule of thumb - < 3:1 viscosity difference
- Interface Stability
  - Interface stress
  - Interface uniformity
- Temperature / Pressure Uniformity
  - Garbage In = Garbage Out
Flow Migration - Viscosity

If there is a viscosity difference the lower viscosity polymer will migrate to regions of high shear stress

Viscous Encapsulation
Co-Extrusion of Layer A and Layer B through a pipe, where $\eta_A < \eta_B$

The amount of distortion depends on the magnitude of viscosity difference, shear rate, and length of the flow path (time)
Compare Viscosities at running conditions - Not just Melt Index
Widely different rheologies will be challenging to co-extrude
Flow Migration - Elasticity

The elasticity of the polymer generates secondary flows in the channel due to an imbalance in normal forces.
The amount of distortion depends on the polymer elasticity, shear stress differential, and length of the flow path (time).
Dow Style Technology
Dow Style Technology

• Layer arrangement
  • Fixed by entrance channels
  • Rearranged by secondary plate

• Shape for combining
  • Lamellar stack – fixed by secondary or tertiary plate
  • Viscosity compensation by plate change

• Joining of polymers
  • Join then converge
  • Velocity match by balancing channel flows
    • May require change of arrangement plate
Velocities at Combining

Five Layer Coex

40% LDPE
5% Tie
10% EVOH
5% Tie
40% LDPE
Fixed Insert Style Technology

• Layer arrangement
  • Rearranged by selector pin

• Shape for combining
  • Combine in 3 layer blocks
  • Viscosity compensation by insert change

• Joining of polymers
  • Multi-plane combining of 3 layers
  • Velocity compensation through insert change
Fixed Insert Technology

Cloeren – One Piece Insert

NordsenEDI – Two Piece Insert
Vane Style Technology

• Layer arrangement
  • Rearranged by selector pin

• Shape for combining
  • Combine in 3 layer blocks
  • Viscosity compensation
    • Cloeren distribution pin
    • NordsonEDI replacement insert

• Joining of polymers
  • Multi-plane combining of 3 layers
  • Velocity compensation through vane adjust
Adjustable Vane Technology

Cloeren – 5 Layer VG™

NordsonEDI – Vane Inserts
Viscosity Compensation

Image courtesy Cloeren Inc
Compensation thru pre-shaped flows
Pre-shape by insert
Pre-shape by distribution pin

Image courtesy Cloeren Inc
Coextrusion IR Scan
IR Scan Showing Response To Feedblock Adjustment

Instantaneous Response
Interface Instability

Response due to critical stress at interface

- Velocity at combining
- Shear rate at interface
- Relative viscosities
  - Shear
  - Extensional
Interface Instability

- Applesauce
- Fuzzy Edges
- Sharkskin
- Zig-zag
- Orange peel
Velocity At Combining
Velocity Compensation – Vane Adjustment

Image courtesy Cloeren Inc
Velocity Compensation – Insert Design
Coat-Hanger Film Die
T-Slot Coating Die – w/ Internal Deckles
Edge profile control is provided by adjusting the relative positions of the internal deckle components.
Cloeren T-Slot Die w/ Internal Deckles
Relative Deckle Offset – Controls Edge Flow

Image courtesy Nordson EDI
0 – 0 Setting
Plug = 0
Blade = 0

Image courtesy Cloeren Inc
Melt Draw Down – No Deckle Offset

Die Exit

After Neck-in

Simulation courtesy Nordson EDI
½” – ½” Setting
Plug = ½”
Blade = ½”

Image courtesy Cloeren Inc
1” – 1” Setting
Plug = 1”
Blade = 1”
2” – 1” Setting
Plug = 2”
Blade = 1”

Image courtesy Cloeren Inc
Melt Draw Down – Optimized Deckle Offset

Profiled Edge

After Neck-in

Simulation courtesy Nordson EDI
2” – 1” Setting
Plug = 2”
Blade = 1”

Image courtesy Cloeren Inc
Bead Reduction

NA206 LDPE, 37.5 µm, 130 m/min, 307°C

Image courtesy Cloeren Inc
Internal / External Deckle

Images courtesy Nordson EDI
Summary

• Feedblock coextrusion is common in extrusion coating
• Feedblock coextrusion provides product enhancement and production efficiencies
• The benefits of feedblock coextrusion out weigh the challenges
• Understanding polymer viscosities and process effects on viscosity are key to optimizing the performance of feedblock coextrusion
• Don’t be afraid of coextrusion
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