“Blending and Feeding Options for Extrusion”

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Types of Feeding & Blending Systems

- Volumetric Feeders
- Gravimetric Feeders
  - Auger, Vibratory, Belt
- Volumetric Blenders
- Batch Gravimetric Blenders
- Loss-in-Weight Blenders
  - Target Rate & Target Weight
- Special Fluff Feeders & Reclaim Systems

Volumetric Feeders - Strengths

- Low Cost
- Simple to use
- Easy to maintain
- Bolt direct to extruder throat

Volumetric Feeders - Weaknesses

- Poor Accuracy
- Calibrate for different materials
- No material usage information

Gravimetric Feeders - Strengths

- High Accuracy
- Adjust for changing bulk densities
- Material usage information

Gravimetric Feeders - Weaknesses

- High cost
- Maintenance intensive
- Difficult to install
- Sensitive to vibration
Volumetric Blenders - Strengths
- Low Cost
- Easy to use & maintain
- Immune to vibration
- Simple to install

Volumetric Blenders - Weaknesses
- Poor Accuracy
- Requires frequent calibration
- No inventory or extrusion control

Batch Gravimetric Blenders - Strengths
- Lowest cost gravimetric
- Easier to maintain
- Compact designs
- More accurate than volumetric
- Documents material usage

Batch Gravimetric Blenders - Weaknesses
- More expensive than volumetric
- Maintenance intensive
- Lower weighing resolution & difficult mixing
- Sensitive to machine vibration

Loss-in-Weight Blenders - Strengths
- Highest accuracy
- Load cell for each material
- Best for mixing
- High output
- 8 ingredients or more
- Extruder output control

Loss-in-Weight Blenders - Weaknesses
- Highest cost system
- Maintenance intensive
- Vibration sensitive
- Difficult to install
Fluff Reclaim Systems - Strengths

- Direct film recycling
- No additional heat history
- Less contamination
- Lower overall energy cost
- Saves personnel cost

Fluff Reclaim Systems - Weaknesses

- Limited reclaim percentages
- Dust around extrusion line
- Complicates blending and extrusion control
- Can make extruder more unstable

Blending for Sheet/Film/Profile

- Volumetric blending/feeding is rare
- Gravimetric systems are the norm
- Type, configuration and features
- System elements
  - Metering/proportioning
  - Blending/mixing

Gravimetric System Types

- Gain in weight – Batch
- Loss in weight – Target weight
- Loss in weight – Target rate
- Additive proportioning – Throat feeding
- Common elements
  - Weighing system
  - Material storage/surge
  - Feeding/metering devices

Basic Configurations

- Extruder throat mounted
- Mezzanine mounted
- Floor mounted
- In combination with online scrap systems

Weighing System Basics

- Strain gauge load cells
  - Shear beam load cell (below left)
  - “S” beam load cell (below right)
Scale Basic – Analog Signals
- Load cell output
  - 0 – 45 mV
  - 0 – 10 V DC
  - 4 – 20 mA
  - Digital (converted at the load cell)
- Converted close to the load cell
- Mechanical overload protection
- Minimize electronic ‘noise’ effects

Scale Basics – A/D Converters
- Digitizes Analog Signal from Load Cell
- Filters out electrical noise and vibration
- Resolution Rules Performance
  - 8 Bit is $2^8 = 256$ Divisions
  - 12 Bit is $2^{12} = 4,096$ Divisions
  - 16 Bit is $2^{16} = 65,536$ Divisions
  - 20 Bit is $2^{20} = 1,048,576$ Divisions
  - $65,536/4,096 = 16$ Times the Resolution

Metering Devices
- Gates and Valves
  - Free Flowing Materials
  - Lowest Cost & Maintenance
- Vibratory Pan Feeders
  - Simple and reasonably accurate
  - Moderate Cost & Maintenance
- Auger Feeders
  - High Stability & Control
  - Highest Cost & Maintenance

Blending/Mixing Options
- Passive – Static mixing (below left)
- Active – Dynamic mixing (below right)

Blending/Mixing Devices
- Passive (Static) Mixers
  - Require Gravity Flow
    - Cascade Baffle for Free Fall
    - Stream Splitting for Plug Flow
  - Difficult to Change Performance Characteristics
  - Simple to Use and Maintain
  - Requires proportional accuracy

Blending/Mixing Devices
- Active (Dynamic) Mixers
  - Does Not Require Gravity Flow
  - Easy to Change Performance Characteristics
    - Mixing Time
    - Mixing Speed
  - More Complicated to Use
  - Higher Cost & Maintenance
  - Blending of layered ingredients
Gain in Weight – Batch

- Single weigh hopper for multiple ingredients
- Second weigh hopper for ingredients < 5%
- Ramping/self adjusting feeders
- Layered ingredients into an active mixer
- Multiple batches for averaging inaccuracies
- Large batch size – slow to respond

Loss in Weight – Target Weight

- Load cell/weighing hopper for each ingredient
- High accuracy proportioning and ease of mixing
- Feeder coupled to the weight hopper
- Materials metered simultaneously to an active mixer
- During weigh hopper refill, feed cycle is paused
- Combination weigh hopper/vacuum receiver
- Compact arrangement requires minimum headroom

Loss in Weight – Target Rate

- Arguably most prominent method for extrusion
- Individual ingredients are continuously fed/proportioned
- Static or occasionally dynamic mixers
- Material flow rate is the target being controlled
- Match extruder rate for overall thickness/layer control
- During refill, proportioning system is in volumetric
- Responsive, cleanable, simple, extrusion control
Additive Proportioning – Throat Feed

- Used primarily in film and sheet extrusion
- Extruder acts as the primary material feeder
- Weigh hopper used to measure material consumption
- Minor ingredients metered proportionally by augers
- Weigh hoppers de-coupled from feeders/extruder
- Control extruder speed for accuracy/responsiveness
- Well suited for gravimetric extrusion control

Volumetric In-Line Scrap Recovery

- Gravimetric blending/control – volumetric scrap
- Scrap and pellets handled separate or as a mix
- At low levels of scrap (15 – 20%) assumed constant
- Typically edge trim only reclaim
- Most extruders can handle up to 25 – 30% scrap
- Melt pumps can reduce surging/increase rates
- Effective alternative to repelletizing scrap

Gravimetric In-Line Scrap Recovery

- Fluff loader to a fluff feeder
- Dual chamber re-feeder or crammer feeder
- Fluff loader to on demand fill fluff feeder
- Fluff metered continuously by weight
- Precise gravimetric extrusion control
- Systems are temperamental and expensive
Gravimetric Extrusion Control

System Prices – 4 component, 1000 PPH

- Large capacity, central volumetric - $18,000
- Extruder mounted, single loadcell batch - $12,500
- Central, dual loadcell batch - $29,500
- Loss in weight, target weight, w/ receivers - $43,000
- Loss in weight, target rate - $25,000 to $30,000
  - Add extrusion control, with line speed - $4,000 to $9,000
- Single component extrusion control - $16,500

Summary

- Gravimetric systems in extrusion
- Loss in weight feeders for twin screw extruders
- Batch and continuous blenders for single screw
- Integrated extrusion control for film/sheet/profile
- In-line scrap reclaim for light gauge film/sheet
- Gain in weight – batch most economical
- Loss weight – target weight most accurate
- Loss weight – target rate most versatile

Suppliers

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<tr>
<th>Company</th>
<th>Material Handling/Blending Products</th>
<th>Location</th>
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<td>The General Group, Inc.</td>
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<tr>
<td>Perfect Control Corporation</td>
<td>Conveying, Blending, Control, Scrap receivers</td>
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<td>JHM</td>
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<td>Sharp Peep Corporation</td>
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<td>Advanced Blending Equipment</td>
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