Profile Extrusion

PL ET 370

Modified 505

Extrusion Screw

Extrusion

- Screw Terminology
  - L/D - Ratio of Screw Length to Screw Diameter
  - Compression Ratio - Ratio of the volume in the first flight to the volume in the last flight
  - Mixing Section - Area of Screw that Mixes the Polymer
Extrusion

- Flow Mechanisms
  - Feed Hopper
    - Gravity
  - Screw
    - Drag - Conveyed by Screw Rotation
    - Pressure Flow

Extrusion

- Gravity Flow
  - Properties of the Material
    - Bulk Density
    - Particle Size & Distribution
    - Particle Shape & Distribution
    - Compressability
    - Internal/External Coefficient of Friction

Extrusion

- Movement by Screw
  - By Friction between Screw & Polymer
  - By Friction between Barrel & Polymer
Extrusion

- Movement by Screw
  - By Friction between Barrel & Polymer

Extrusion

- Frictionless
  - Polymer & Screw

- Friction
  - Polymer & Barrel

Extrusion

- Viscous Heat Generation
  - Mechanical Energy is turned into Heat
  - In Extrusion 80-90%
  - Cooling of the Barrel may be needed
Extrusion

- Methods to Achieve a Higher Barrel Friction
  - Change Barrel Temps (weak)
  - Use Grooved Barrel (strong)

Extrusion

- Methods to Reduce Screw Friction
  - Single Flighted Screw
  - Large Flank Radius
  - Large Helix Angle (pitch)
  - Use Screw Coatings
  - Internal Screw Heating
Extrusion

- Extrusion Rate
  - Determined by:
    - Screw Geometry
    - Depth
    - Width
    - Pitch
    - Diameter

- Extrusion Rate
  - Determined by:
    - Pressure Development
    - Coefficient of Friction - Screw & Barrel
    - Density of the Solid Bed

- Polymer Melt in Transition Section
Extrusion

- Extrusion Types
  - Film
  - Sheet
  - Fiber Spinning
  - Wire Coating
  - Profile

Film/Sheet

- Sheet
  - Cannot be rolled without permanent deformation
  - > .25 mm
- Film
  - Rolled without permanent deformation
  - < .5 mm
  - Biaxially Orientated

Extrusion

- Extrusion Line
Profile Extrusion

- **Advantages**
  - Low Tooling Cost
  - Low Part Cost

Profile Extrusion

- **Disadvantages**
  - Secondary Operations
  - Difficult to Control Dimensions
  - Long Lead Time to Debug Die

Profile Extrusion

- **Disadvantages (cont)**
  - Output Limited
  - Balanced Die
  - Drag Marks
  - Other Miscellaneous Surface Defects
Profile Extrusion

- Common Problems Associated with Processing
  - Surface Finish (Drag Marks, Shark Skin, Icebergs, etc...)
  - Difficult to Control Dimensions

Profile Extrusion

- Co-Extrusion
  - Ability to use two different materials in the same product.
  - Usually an Elastomer with a Rigid Material
  - Also used as a Coating

Extrusion

- Schematic of Extruder
Extrusion
- Breaker Plate
- Screen Pack

Extrusion
- Breaker Plate
  - Support Screen Pack
  - Stop Spiraling Action of the Melt
  - Static Mixing Device

Extrusion
- Screen Packs
  - Filter Contaminates
  - Increases Pressure for Better Mixing
Extrusion

- Mesh Screens
  - Weave
    - # is the number of Wires per Inch
    - High # means Smaller Openings
    - Low # means Bigger Openings

Extrusion

- Typical Screen Pack
  - 20 - 40 - 60 - 80 - 20

Extrusion

- Contamination in Screen Packs
  - Reduces Openings
  - Increases Pressure
  - Reduces Output

Changes Product Dimensions
Extrusion

- Screen Changers
  - Slide
  - Rotary - Continuous

Extrusion

- Gear Pumps
  - Advantages
    - Good Output Stability
    - Good Pressure Generating Capacity
  - Disadvantages
    - Poor Mixing Capability
    - Wear
    - Expensive

Extrusion

- Gear Pump
  - When to Use
    - Extruder with Poor Pressure Generating Capabilities
    - Output Variation must be kept below 1%
  - When NOT to Use
    - With Abrasive Components in Polymer
    - When Degradation could Occur
      - Polymers could be in Gear Pump for 10-20 mins
Extrusion

Grooved Feed Throats

Advantages
- Higher Output
- Output is Less Pressure Sensitive
- Better Stability
- Higher Molecular Weight Polymers can be Extruded

Disadvantages
- Cooling Required
- High Load on Screw Motor
- Higher Wear
- Higher Pressures
- Changes for Screw
  - Lower Compression Ratio (less pressure)

Double Flighted Screws

Less Efficient
- Larger Contact Area with Screw
- Less Contact Area with the Barrel
Extrusion

- Screw Beat

Profile Extrusion

- Die Swell

Profile Extrusion

- Flow Balancing in the Die
Profile Extrusion
- Extrusion Die

Profile Extrusion
- Corners

Profile Extrusion
- Dead Spots in the Die
Sheet Extrusion

- Thickness
  - 0.250 mm – 15 mm

- Widths
  - Up to 4 m

Sheet Extrusion

- Coathanger Die
  - Choker Bar
- 3 Roll Calender
- Winder
  - No Tension

Film Extrusion

- Thickness
  - < 0.5 mm
Flat Film Extrusion
- Coathanger Die
- Flexible Lip
- 3 Roll Calender
- Winder
  - Tension – Orientation

Blown Film Extrusion
- Biaxial Orientation