Extrusion of blown film

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R&D manager

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TERMOPLASTI – PLAMA d.o.o.

- Production of PO flexible packaging films and bags
- Private company
- Annual turnover: 24,300,000 €
- Produced in 2013: 9,300 tons
- N. of employees: 115
- Certified according int. standard ISO 9001 / 14001
- www.ter-plama.si
MANUFACTURING PROGRAM

- Production steps: extrusion, printing, embossing, welding, recycling
- Products: films and bag
  - film for industrial packaging
  - thermoshrinkable film
  - cover and protective film
  - embossed film
  - film for lamination
  - shopper bags: patch handle, flexi loop handle, T shirt bag
  - safety bags
  - bags for industrial packaging
  - bio degradable bags: oxo and compostable
  - recycled plastic materials in pellets form
RECYCLING

- Technological film waste
- Lumps
- Packaging waste from our clients
- Used solvent distillation
Extrusion process

- Plastic melt is extruded through an annular slit die, vertically to form thin walled tube
- Air is introduced in the centre of the die to blow up the tube like a balloon (IBC)
- Air ring blows onto the hot film to cool it (outside and inside the tube)
- The tube passes through nip rolls where is flattened
- Collapsed tube is taken back down the extrusion tower via more idler rollers
- On winder the tube or film is wound into rolls
Elements of blown film

- Film thickness: 6 – 250 microns
- Layflat width: 600 – 4000mm
- Die diameter: 100 – 600mm
- Die gap: 0.8 – 2.8 mm
- Bubble diameter
- BUR (blow up ratio): 2 – 4.5
- DDR (draw down ratio) = gap width/thickness x BuR
- MD (machine direction)
- TD (transverse direction)
- L/D ratio of screw: 24, 30, 32
Blow-up Ratio (BUR)

**short neck**
- MD: 400x3.14=1256
- TD: 11.748

**long neck**
- MD: 250x3.14=785
- TD: 9.843

**Blow-up Ratios**
- short neck: BUR = 2.5:1
- long neck: BUR = 3.82:1

**Dimensions**
- short neck: Width 61.81"
- long neck: Width 59.03"
Coextrusion is the extrusion of multiple layers of material simultaneously. This type of extrusion utilizes two or more extruders to melt and deliver a steady volumetric throughput of different viscous plastics to a single extrusion head (die) which extrude the materials in the desired form. The layer thicknesses are controlled by the relative speeds and sizes of the individual extruders delivering the materials.
Raw materials for blown film

POLYOLEFINS, BARRIER MATERIALS, PLASTOMERS, Ionomers, BIO MATERIALS

- LDPE
- LLDPE
- MDPE
- HDPE
- mLLDPE
- EVA
- COC
- HIPS
- Ionomer
- PP Copolymer
- PA6, CoPA
- EVOH
- PETG
- BIO materials (PLA, PHA...)
Additives for blown film

- Antioxidant
- Slip agent
- Antiblock
- UV stabilizer
- IR absorber
- Antistatic agent
- Processing aids
- Flame retardant
- Cleaning compound
- Antislip agent
- Blowing agent
- Oxo – degradable additive
- Colour masterbatches
Design of blown film line

Extruders
Blown film die head
Cooling ring
Calibration cage
Collapsing frame
Take-off
Turner bar system
Edge guiding unit
Corona treatment
Secondary nip roll assembly
Film winder
Thickness measurement
Suction, dosing unit
Blown film die head
Extruders
Edge guiding unit
Corona treatment
Secondary nip roll assembly
Film winder
Thickness measurement
Suction, dosing unit
Blown film die head
Extruders
Suction and conveying unit

Gravimetric dosing unit
Dosing system Octagon GDS

Combining the well-proven throughput measurement and screw feeder units, the GDS system offers highest performance in gravimetric dosing and extruder control.

Continuous dosing of additives directly at the material intake of the extruder ensuring:
- no loss of blend of components
- evenly distributed coloring
- highest blending accuracy
Dosing page example

<table>
<thead>
<tr>
<th>Prop.</th>
<th>Act.</th>
<th>MC</th>
<th>Ad1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td></td>
<td>0.945</td>
<td>0.935</td>
</tr>
<tr>
<td>Throughput</td>
<td></td>
<td>31.7</td>
<td>0.0</td>
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<tr>
<td>Tolerance</td>
<td>Act.</td>
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<td>0.0</td>
</tr>
<tr>
<td>%</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>%</td>
<td>Exterior on</td>
<td>g/ccm</td>
<td>kg/h</td>
</tr>
<tr>
<td>%</td>
<td>Centre on</td>
<td>g/ccm</td>
<td>kg/h</td>
</tr>
<tr>
<td>%</td>
<td>Inside on</td>
<td>g/ccm</td>
<td>kg/h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prop.</th>
<th>Act.</th>
<th>MC</th>
<th>Ad1</th>
<th>Ad2</th>
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<tbody>
<tr>
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<td>0.935</td>
<td>0.000</td>
</tr>
<tr>
<td>Throughput</td>
<td></td>
<td>35.5</td>
<td>0.0</td>
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<tr>
<td>Tolerance</td>
<td>Act.</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>%</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>%</td>
<td>Exterior on</td>
<td>g/ccm</td>
<td>kg/h</td>
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<tr>
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<td>kg/h</td>
</tr>
<tr>
<td>%</td>
<td>Inside on</td>
<td>g/ccm</td>
<td>kg/h</td>
<td>kg/h</td>
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</table>

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<th>Act.</th>
<th>MC</th>
<th>Ad1</th>
<th>Ad2</th>
<th>Ad3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td></td>
<td>0.945</td>
<td>0.935</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Throughput</td>
<td></td>
<td>16.8</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Tolerance</td>
<td>Act.</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>%</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
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<td>Exterior on</td>
<td>g/ccm</td>
<td>kg/h</td>
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<td>kg/h</td>
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<tr>
<td>%</td>
<td>Inside on</td>
<td>g/ccm</td>
<td>kg/h</td>
<td>kg/h</td>
<td>kg/h</td>
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Components of the extruder

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Screw drive motor</td>
</tr>
<tr>
<td>2</td>
<td>Screw drive gear reducer</td>
</tr>
<tr>
<td>3</td>
<td>Granule feed throat</td>
</tr>
<tr>
<td>4</td>
<td>Extrusion screw</td>
</tr>
<tr>
<td>5</td>
<td>Extrusion barrel</td>
</tr>
<tr>
<td>6</td>
<td>Thermoregulation insulating zones</td>
</tr>
<tr>
<td>7</td>
<td>Cooling fans</td>
</tr>
<tr>
<td>8</td>
<td>Connection flange to the screen changer</td>
</tr>
<tr>
<td>9</td>
<td>Screen changer assembly</td>
</tr>
</tbody>
</table>
Extruders, head and operator panel on 3-layer coex line

Frequency controlled AC motors as standard extruder drive
Components of blowing head

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trolley with wheels</td>
</tr>
<tr>
<td>2</td>
<td>Die body (head)</td>
</tr>
<tr>
<td>3</td>
<td>Die</td>
</tr>
<tr>
<td>4</td>
<td>Cooling ring</td>
</tr>
<tr>
<td>5</td>
<td>IBC system</td>
</tr>
<tr>
<td>6</td>
<td>Plenum</td>
</tr>
<tr>
<td>7</td>
<td>Circular heating elements</td>
</tr>
</tbody>
</table>
3-layer coextrusion head with cooling ring
Film bubble cooling
Double lip cooling ring including thickness control
Film thickness measurement unit - capacitive sensor reversing around the bubble
Heat exchangers for air cooling

IBC equipment

IBC fans controlled via frequency converters
Calibration cage

- Ultrasonic sensor for IBC control
Combined layflat device with CFK (and felt) + wooden slats and side gusseting tools up to the centre, all movements are motorized
Reversing haul off system

Horizontal take off system

Turner Bar
Corona treatment device
Film edge guiding device
Operator panel

Processing data
Profile page example

<table>
<thead>
<tr>
<th>Set gauge</th>
<th>150.0 μm</th>
<th>3.2%</th>
<th>-5.2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aver. gauge</td>
<td>147.8 μm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. gauge</td>
<td>142.2 μm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. gauge</td>
<td>154.8 μm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tolerance</td>
<td>3.3 (2-S)%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Last profile

Measure 277

Set gauge
150.0 μm

-10 μm

0° 90° 180° 270° 360°

Prol. before last

Measure 276

Set gauge
150.0 μm

-10 μm

0° 90° 180° 270° 360°
Blowing film control concept
Film cutting

Lateral cutter

Central knives
Principles of film winding
Versions of winders

1. Device for main longitudinal cut
2. Device for side cut
3. Spreader roll before cut (optional)
4. Control board
5. Grooved secondary nip roll for air evacuation
6. Device for secondary longitudinal cut
7. Film tension control using load cells
8. Spreader roll before cut (optional)
9. Shaft loading system
10. Easy Load basic (optional)
11. "Banana" spreader roller
12. Hydraulic supports for roll unload system and optional weighing system
Automatic contact surface winder
Central – contact winder

- Nip roller in the winder with dancer
- Lay on roller STS spiral grooved
- 5 knifes with oscillation
- Driven cord spreader roller
- WWH winding shaft handling / gripper
- Winding shaft pre-acceleration
Blown Film Applications

Focused key application areas:
- General Packaging films
- Lamination films
- Surface Protection films
- Barrier films for food packaging
- Agricultural films
  - Greenhouse films
  - Mulch
  - Silage sheeting
  - Silage stretch
- FFS – Heavy Duty Shipping Sacks
Blown film requirements

- **Thickness tolerances**
  → influenced by temperature profile during production process

- **Width tolerances**
  → influenced by air volume stability

- **Mechanical properties**
  → influenced by orientation of molecular structure during production process (blow-up ratio of film bubble) and raw material type / material combination

- **Optical properties**
  → influenced by raw material type and melt quality in extruder

- **Film planarity / free of wrinkles**
  → influenced by collapsing process → change from round to flat shape
How to achieve film requirements?

• **Thickness tolerances**
  → profile control system

• **Width tolerances**
  → precise and fast ultra sonic bubble control system (USB)

• **Mechanical properties**
  → smart recipe design
  → selection of blow-up ratio

**Optical properties**
  → smart recipe design
  → homogeneous melt quality trough optimized screw design

• **Film planarity / free of wrinkles**
  → smooth collapsing process trough film haul-off
  → constant winding tension/pressure
Smart lip maximizer long neck for enhanced mechanical properties = down gauging
Screw and cylinder design

- L/D ratio (24, 30, 32)
- Screw design for processing all PE types, PP, mLLDPE, and PA, EVOH, K-resin, PETG without screw-change
- Low temperature screws, high efficiency mixer
- Grooved feed section with unique heating / cooling section
Collation shrink film structure

Development target: down gauging from 45 µm to 35 µm with same properties

Application: 6-pack packaging for 2L bottles without handle
Stretch hood film structure

Development target: reduction of EVA content with same properties

Application: stretch hood for Euro-Pallets

<table>
<thead>
<tr>
<th>Polymers</th>
<th>Layer ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>mLLDPE</td>
<td>10%</td>
</tr>
<tr>
<td>mPP</td>
<td>20%</td>
</tr>
<tr>
<td>EVA</td>
<td>40%</td>
</tr>
<tr>
<td>mPP</td>
<td>20%</td>
</tr>
<tr>
<td>mLLDPE + Anitblock</td>
<td>10%</td>
</tr>
</tbody>
</table>
New products and new possibilities

Asymmetric structures

COC rich structures

PET outer layer
Extruder K 60-24D with melt pumps for a perfect melt quality and no pressure variation!
Blown film line - Recent Trends

- Increasing number of multi-layer lines
  → 5-, 7-, 9- and 11-layers

- Transfer of traditional 3-layer films to 5-layer structures

- Increasing number of films with barrier properties

- Increasing number of high quality / technical films
THANK YOU FOR YOUR ATTENTION!