Polypropylene cast film
About Borealis

Borealis is a leading, innovative provider of plastics solutions. Its technology shapes daily life products and forms the basis of next generation innovation and creative development in plastics.

With EUR 4 billion revenue in sales and 4,500 employees, Borealis has more than 40 years of experience as a reliable supplier of polyethylene (PE) and polypropylene (PP) products. Borealis today is a partner to its customers manufacturing and developing products such as food packaging, diapers, appliances, automotive parts, distribution pipes for water, gas and sewage, power cables, sporting equipment and medical devices.

Borealis is headquartered in Copenhagen, Denmark with innovation centres, customer service centres, and main production sites in Europe and the Middle East. Borealis has representative offices and operations in Asia, North and South America.

At its heart, the company’s four values of Responsible, Respect, Exceed and Nimblility™, define its way of doing business. For Borealis, success is driven by responsiveness, operational excellence and innovation.

Borstar® is the proprietary process technology supporting differentiated PE and PP products and is a registered trademark of Borealis A/S.

To learn more about Borealis visit www.borealisgroup.com.
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A commitment to cast film

Borealis is a leading polyolefins supplier to the cast film segment. We know that raw materials and their properties form just a part of a successful solution. Other key issues include defining and fulfilling consumer needs, correct design and cost competitive packaging production, responding to environmental requirements, and enabling problem-free, efficient production on the filling lines. Borealis views cast film as a strategically important market segment, and shows its commitment by supplying materials which fulfill the needs of the whole supply chain. This brochure presents our latest developments and the range of products we offer. A technical description of our PP products for cast film is also included.

Processing/technologies

Polypropylene is a partially crystalline material produced by polymerisation with catalysts, using suspension, gas phase and bulk polymerisation processes. Depending on the desired spectrum of properties, homopolymers, random copolymers (C2 is randomly incorporated into the i-PP chain), heterophase copolymers and random heterophase copolymers (Raheco) are polymerised.

Processing Borealis polypropylene

Borealis Polypropylene may be processed on all conventional equipment for manufacturing films with suitable tooling. Borealis PP film grades should be processed using screws which are suitable for PP (these differ according to the manufacturer) with shear and mixing part and a length of 25 - 33D. The temperature of the extruder should be so that the temperature of the melt, with normal dwell times, is between 220°C and 260°C and the structure of the film produced is as fine as possible. To obtain the best quality films, the filter packs recommended by the manufacturer for melt filtration should be used. Higher melt temperatures could cause thermal damage and impair material properties. The addition of processing aids or master batches can influence the properties of Borealis PP. Films made from Borealis PP may be processed with customary welding equipment if international and national regulations are followed. Again it should be ensured that there is adequate ventilation of the workplace.
**Chill roll process**

Nowadays, for economical and qualitative reasons, the majority of PP films produced for packaging applications are made using the chill roll process. In this process the melt emerging from the flat film die is poured onto either a chrome plated, highly polished or matt finish chill roll. With the latter, the most important factor is the rough surface.

Films produced using the chill roll process, where the restrictor bar and die lip are at an optimum setting, have a much more uniform thickness than blown films.

The following points should be noted for the chill roll process:

- The melt film should be placed at a tangent to the chill roll.
- The optical properties are achieved by optimising the chill roll temperature and by precision adjustment of the air knife and air flow rate. The clearance, draft angle and uniform distribution of air flow are crucial factors for this.
- The cooling air for the air knife must be filtered to prevent dust being blown onto the melt, which could cause particulate contamination.
- The installation of a vacuum extraction unit has proved an effective way of dealing with the vapours generated when the melt comes into contact with the chill roll.
- Where thicker films are to be produced, it is advantageous to install cleaning rollers for the chill roll. To ensure good reel winding quality, uniform film tension must be maintained across the width of the film web (due to the after-shrinkage, which occurs during post-crystallisation).
- The preferred thickness range for films extruded using the chill roll process is between 20 and 200 μm.
**Blown film process**

In addition to the chill roll process, the blown film process is also used for some applications where the dimension of the bubble plays an important role in the subsequent processing.

In the production of PP blown films, the melt emerges from a circular die and is led through a water contact cooling ring, which instantly cools it. It is now possible to produce PP films on traditional blown film equipment for polyethylene, which only works with air cooling.

This necessitates the use of special PP grades which are suitable for blown film technology.

**Quenching bath process**

In this process the melt is shock-cooled in a quenching bath immediately after emerging from the die. This technology is only used in special cases (mainly for producing film tapes, packaging tapes and monofilaments).
**Influence of processing on film properties**

Together with the choice of raw materials, the processing parameters have a high influence on film properties. The two most important influences on film properties are raw materials and processing parameters.

The following factors have the most decisive effect on film quality:

**Die temperatures**

Increasing the die temperature results in marginal improvements to the gloss and transparency.

**Chill roll temperature**

In general, the higher the chill roll temperature, the higher the degree of crystallinity. The lower the chill roll temperature, the finer the spherulitic structure becomes. This results in films with higher transparency, gloss and tenacity, but with reduced stiffness (Figure 4 - 7).

On the other hand, frictional properties as a function of time are improved with higher chill roll temperatures. The temperature of the second chill roll and the winding angle influence not only the slip properties, but also the winding behaviour and planarity of the film.

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**Figure 4:** Mechanical properties (DDI) with varying chill roll temperature.

**Figure 5:** Mechanical properties (stiffness) with varying chill roll temperature.

**Figure 6:** Optical properties (gloss) with varying chill roll temperature.

**Figure 7:** Optical properties (haze) with varying chill roll temperature.
Types of polypropylene

Polypropylene homopolymers (homo, nucleated or non-nucleated) are characterised by their high stiffness, excellent heat deflection temperatures, excellent H₂O barrier and good transparency, as well as high tensile strength for film applications. These properties are strengthened by the use of highly crystalline grades commercialised as Borealis Bormod™ generations.

Random copolymers (nucleated and non-nucleated) are propylenes with statistically incorporated C₂ monomers. These grades are very soft and have excellent heat sealing properties at low sealing initiation temperature, extremely low stress whitening and the best optical properties (gloss and haze) of all PP grades. By using special nucleation systems, films with superior optical properties can be produced in the blown film process.

Heterophasic copolymers (heco) have an ethylene propylene rubber as a separate phase incorporated in the polymerisation, which means that films are characterised by a matte surface and low transparency. The high toughness and good stiffness, as well as the extremely wide temperature range (from freezing to sterilising) are the dominant properties of this material.

The newly developed Rahecos are random heterophasic copolymers, a combination of both previously mentioned polymers, which also combine their properties. Films with extreme softness and toughness can be produced from Borealis Borsoft™. These polymers have much better optical, heat sealing and stress whitening properties than hecos.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Unit</th>
<th>PP homopolymers</th>
<th>PP random copolymers</th>
<th>PP heterophasic copolymers</th>
<th>PP random heterophasic copolymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile modulus ISO 527-3</td>
<td>MPa</td>
<td>600 - 900</td>
<td>300 - 500</td>
<td>450 - 600</td>
<td>180 - 450</td>
</tr>
<tr>
<td>Penetr. energy ISO 7765-2</td>
<td>J/mm</td>
<td>6/10</td>
<td>10/20</td>
<td>15/25</td>
<td>23/35</td>
</tr>
<tr>
<td>Haze ASTM D 1003</td>
<td>%</td>
<td>2 - 4</td>
<td>1 - 2</td>
<td>25 - 40</td>
<td>5 - 25</td>
</tr>
<tr>
<td>Gloss ISO 2813</td>
<td>%</td>
<td>90 - 100</td>
<td>100 - 125</td>
<td>10 - 30</td>
<td>15 - 80</td>
</tr>
<tr>
<td>Property temp. range</td>
<td>°C</td>
<td>4°C - 142°C</td>
<td>-8°C - 130°C</td>
<td>-35°C - 135°C</td>
<td>-35°C - 130°C</td>
</tr>
<tr>
<td>Water vapour transmission rate</td>
<td>g/m²·d</td>
<td>0.9 - 1.1</td>
<td>1.2 - 1.5</td>
<td>1.4 - 1.6</td>
<td>1.5 - 1.7</td>
</tr>
</tbody>
</table>

Figure 8: A = Propylene monomer  B = Ethylene comonomer

1) Due to nucleation, the spherulite construction of the film becomes finer and this increases the stiffness and improves the optical properties.
Molecular weight distribution (MWD)

The ever more demanding requirements on polymer raw materials have led to the development of controlled rheology PP or “CR-PP”. These polymers are produced by making selective changes to the molecular weight distribution (MWD).

Borealis began narrowing MWD 25 years ago in a special process known as “visc breaking” (Figure 9).

Thanks to their advantageous properties, these CR products have gained a strong market position. At higher shear rates, the viscosity of CR-PP grades decreases less than that of standard PP products (ST-PP) with broader distribution (Figure 10).

Due to their higher degree of crystallinity, products with a broad MWD (ST-PP) have a larger superstructure than the narrowly distributed CR-PPs. These structural differences mean that CR-PP grades have significant advantages over standard PP grades with comparable molecular weight (Figure 11).

These are particularly apparent when properties are measured as a function of film thickness. The differences in transparency between CR-PP and ST-PP increase sharply as film thickness increases (Figure 12).
Influence of C₂ content on film properties for random copolymers

Figure 12: Influence of C₂ content on stiffness. Borealis standard film with thickness 50μm.

Figure 13: Influence of C₂ content on tensile modulus (MPa). Borealis standard film with thickness 50μm.

Figure 14: Influence of C₂ content on tenacity. Borealis standard film with thickness 50μm.

Figure 15: Influence of C₂ content on transparency as f (film thickness). Film thickness (μm).

Figure 16: Influence of C₂ content on gloss as f (film thickness). Film thickness (μm).

Figure 17: Penetration energy at low temperatures as f (C₂ content). Penetration energy dynastest DIN 53373 (J/mm)

Figure 18: Influence of C₂ content on welding range. Borealis standard film with thickness 50μm.
Conversion

A decisive factor in achieving trouble free conversion of PP films is the coefficient of friction. This is influenced by the product and processing parameters, by the type of slip agent used (oleic or erucic acid amide) and above all by the storage conditions. Slip agent migration in PP is time-dependent.

Normally the frictional properties required for machining (minimum coefficient of friction: <0.30) are achieved after 7 - 14 days storage at room temperature (23°C), depending on the type of polymer and slip agent used. Experience has shown that oleic acid amide as slip agent migrates much faster than erucic acid amide (Figure 19).

The migration of the slip agent also depends on the storage temperatures: the higher these are, the sooner the slip agent will rise to the surface (Figure 20). At storage temperatures below +10°C, slip agent migration almost entirely ceases.

It is also detrimental to store films at cold temperatures during the post-crystallisation phase. Under unfavourable storage conditions (e.g. around 15°C) grades with 100% erucic acid amide can take several months to reach the minimum coefficient of friction which is required for machining.

![Figure 19: Frictional behaviour contingent on type of slip agent.](image1)

![Figure 20: Frictional behaviour as f (storage time and temperature).](image2)
Surface treatment

To ensure adequate adhesion of printing inks, lamination adhesive or metal (from metallisation), the surface energy or tension of CPP must be increased so that it achieves a minimum surface tension of 38 mN/m (dyne/cm). Corona treatment is the preferred method on cast film lines to achieve an increased surface tension.

Back treatment is a fairly common occurrence with cast film which arises from wrinkles and creases on the reverse face. This phenomenon can be avoided by the exclusion of air between the film and the surface of the dielectric roll. Back treatment may interfere with subsequent heat sealing and cause blocking, especially over print which results in unsightly marks (stripes).

Surface tension can be measured using a treatment pen or test solution immediately after extrusion. Surface tension will fall off with time by two points or more depending on the polymer additive levels. Excessive treatment may give rise to blocking, unacceptable odours or colouration. The treatment will usually cause some heating of the web. Steps must be undertaken to prevent this from causing creasing.

Figure 21: Effect of surface treatment – surface tension.
Coextrusion

When using the coextrusion procedure it is possible to combine different materials/properties in a sandwich construction. Coextrusion in general, and polyolefin coextrusion in particular, have gained a dominant position over the last few years.

In particular the 3-layer coextrusion in a layer combination ABA of ABC is a preferred version of PP for manufacturing the following sandwich constructions.

Figure 22: Transparent freezeable structures.

Figure 23: Peelable structures.

Figure 24: Very soft sterilisable structures with good weldability.

Figure 25: High stiffness structures with good sealing.

Figure 26: Tough films with heat resistance and excellent sealing properties.

Figure 27: Low temperature resistance and optical properties.
Standard applications

**Textile packaging**
PP random copolymers with high C₂-content for excellent sealing and optical properties.

**Flower packaging**
Mono- or 3-layer coex films with PP homopolymers (stiffness) and PP random copolymers (sealing, optics).

**Food packaging**
PP homopolymers, random copolymers, heterophasic copolymers, depending on required properties like good mechanics, excellent optics, low temperature resistance, good sealing properties.

**Stationery films**
PP homopolymers, filled PP homopolymers (stiffness), PP random copolymers (optics, sealing properties), PP heterophasic copolymers (mechanics, tenacity).

**Laminating films**
PP random copolymers and heterophasic copolymers for lamination with aluminium, other plastics films (PET, PA, PE).
New application trends

PP – Twist films

Development reason/substitution:
Substitution of cellophane, PVC or wax paper

Material: Cast coex film, 3-layers

<table>
<thead>
<tr>
<th>Transparent films:</th>
<th>PP Homo</th>
<th>PP Raco</th>
<th>Borclear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bormod</td>
<td>PP Homo</td>
<td>PP Raco</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Borclear</td>
<td></td>
</tr>
</tbody>
</table>

Applications: Packaging of sweets, metallised and non-metallised
Benefits: • Downgauging: from 34 μm to 25 μm
• Economic advantage – PP
• No restrictions in converting
Potential: Transparent: 20 kt ons in Western Europe
Matt: 25 – 30 kt ons in Western Europe

New FFS packaging films (BOPP substitution)

Development reason/substitution:
Substitution of laminates with BOPP structures or BOPP films typical:
PP cast or PE blown film/BOPP

Material: Cast coextrusion layers

<table>
<thead>
<tr>
<th>Typical construction:</th>
<th>Bormod</th>
<th>PP Homo or Bormod core</th>
<th>Terpolymer (Borseal™) or Raco sealing layer (Borclear, C2/C3 Copos)</th>
</tr>
</thead>
</table>

Applications: Bread packaging, pasta packaging, cake packaging, snack packaging
Benefit: • Saving of processing steps – no lamination
• Improved mechanical properties – tear resistance
• Reasonable stiffness/barrier – metallisation opportunity
Metallisable PP cast films

Development reason/substitution:
Alternative to BOPP and new applications

Material: Calcium stearate free PP polymers, partly with special antiblocking agent

<table>
<thead>
<tr>
<th>Grades</th>
<th>Borclear: RE736CF, RE718CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>C/C3 Racos:</td>
<td>RD204CF, RD208CF, RE216CF</td>
</tr>
<tr>
<td>Homo:</td>
<td>HD601CF, Bormod HD915CF</td>
</tr>
</tbody>
</table>

Applications: Tobacco films, twist films, food packaging (bread....)
Benefits: Special additivation, Smooth surface

Medical PP pouches

Step 1: Development of the primary packaging – the pouch with the liquid

Requirements: Highest softness, Excellent optics, Highest toughness, Tight sealing seam, Sterilisable up to 121°C

PP solution: cast coextrusion: 3-layers

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP Homo or high stiff</td>
<td>Blends of PP Raheco (Borsoft) or PP random with EPR, TPO, SEBS</td>
<td>PP sealing layer; blend or random copo or terpolymer</td>
</tr>
<tr>
<td>PP Bormod™ “heat resistant layer”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 2: Development of the tubing system

Requirements: Highest softness, Good optics, No whitening, High buckling resistance, Sterilisable up to 121°C

PP solution: PP Raheco Borsoft or Random modified with EPR, TPO or SBS
Step 3: Development of the secondary packaging

Requirements:
• Sterilisable up to 121°C
• Sealable between 160°C and 220°C
• Peelable against PP and itself
• High H₂O and (partly) O₂ barrier

PP solution: cast coextrusion: 3 – 5 layers

A
PP homo or random – heat resistant layer

B
C
D
E
glue
O₂ barrier
glue
PP peelable compound
Borealis Steripeel WD170CF

Label/display films

Development reason/substitution:
Substitution of existing materials (PVC, PE) or new applications

Material: Easy punchable grades: Bormod HD915CF
Homo – most probably additive and stearate free, often used in blends with special PE products, e.g. HD601 CF.
Typical are coex combinations with raco in the outside layer (gloss).

Applications:
• Detergent & cosmetics bottles
• In-line moulding/labelling
• Paper substitution

Benefit:
• Beneficial use of high stiffness/good optics of PP – down gauging
• Higher heat resistance
Stand up pouch lamination film

Development reason/substitution:
Substitution of aluminium, white tin and glass bottles, trays, cans, boxes by a polymeric stand up pouch concept

Typical structure for a stand up pouch:
SiOx coated PET/PA/PP laminates.
PP has mainly the function of a sealing layer. It provides the tenacity and body of the film.

Material used today:
- High molecular block copolymers, e.g. BB213CF, BA110CF.
- New development initiated.

Applications:
- All kinds of food packaging, e.g. soups, sauces, solid food, pet food…
- Detergent and cosmetics packaging.

Peelable films

Development reason:
Peelable structures/films based on PP sterilisable and non sterilisable

Typical structure:
Coex film, consisting of PP core (homo/raco/homo) and thin peelable layer (10μm)

Peel material used today:
- Steripeel WE150CF
- Steripeel WD170CF
- Borぺel WD255CF

Applications:
- All kinds of films for ready to eat meals, ice cream boxes, desserts, soft cheese, dairy products.
- Peelable flexible structures for food and detergents - peelable against itself.
- Sterilisable, peelable secondary packaging for medical pouches.

Benefit:
First PP concept, especially in the field of sterilisable packaging.
# Troubleshooting guide

## Extrusion problems

<table>
<thead>
<tr>
<th>Problem</th>
<th>Reason</th>
<th>Suggested cure or check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation in output (surging) accompanied by</td>
<td>Insufficient melting</td>
<td>Increase set temperatures</td>
</tr>
<tr>
<td>Variation in screw speed, melt temperature</td>
<td>Insufficient back pressure</td>
<td>Finer screen packs</td>
</tr>
<tr>
<td>or melt pressure</td>
<td>Too low screw speed</td>
<td>Reduce die gap</td>
</tr>
<tr>
<td></td>
<td>Poor screw design</td>
<td>Increase screw speed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace or modify screw</td>
</tr>
<tr>
<td>Variation in melt curtain width (at constant</td>
<td>Draw resonance</td>
<td>Reduce line speed</td>
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<tr>
<td>screw speed)</td>
<td></td>
<td>Increase melt temperature</td>
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<tr>
<td></td>
<td></td>
<td>Use higher MFR resin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase die gap</td>
</tr>
<tr>
<td>Bubbles in melt</td>
<td>Moist polymer</td>
<td>Dry before processing</td>
</tr>
<tr>
<td></td>
<td>Air in polymer</td>
<td>Decrease feed zone temperature</td>
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<tr>
<td></td>
<td></td>
<td>Increase back pressure</td>
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<tr>
<td></td>
<td></td>
<td>Pre-heat granules</td>
</tr>
<tr>
<td>Cloudy extrudate</td>
<td>Melt temperature too low or uneven</td>
<td>Increase temperature</td>
</tr>
<tr>
<td>Dull finish</td>
<td></td>
<td>Increase back pressure</td>
</tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rough or matt extrudate</td>
<td>Surface melt fracture</td>
<td>Increase die lip temperature and/or melt temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Streamline die entry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use higher MFR resin</td>
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<tr>
<td>Lumpy extrudate</td>
<td>Melt turbulence</td>
<td>Streamline die land entry</td>
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<tr>
<td></td>
<td></td>
<td>Use higher MFR resin</td>
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<tr>
<td></td>
<td></td>
<td>Increase melt temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase back pressure</td>
</tr>
<tr>
<td>Low output</td>
<td>Excessive shear or excessive back pressure</td>
<td>Use higher MFR</td>
</tr>
<tr>
<td>High power Amps</td>
<td></td>
<td>Raise feed zone temperatures</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Melt temperature over-riding</td>
<td>Excessive shear</td>
<td>Use coarser screen packs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open die gap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Change or modify screw</td>
</tr>
</tbody>
</table>
### Cast film problems

<table>
<thead>
<tr>
<th>Problem</th>
<th>Reason</th>
<th>Suggested cure or check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower than expected overall clarity</td>
<td>Cooling rate too low</td>
<td>Increase melt temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reposition air knife</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase air knife pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduce chill roll temperature</td>
</tr>
<tr>
<td></td>
<td>Coextrusion viscosity mismatch</td>
<td>Change polymers to better match viscosities</td>
</tr>
<tr>
<td>Non-uniform optical properties</td>
<td>Temperature gradient across chill roll</td>
<td>Check chill roll temperature and adjust if necessary</td>
</tr>
<tr>
<td>Plate-out</td>
<td>Poor chill roll contact</td>
<td>Use the lay on roll to remove air cushion between the film and chill roll</td>
</tr>
<tr>
<td></td>
<td>Air trapped between the chill roll and the film</td>
<td>Check pinning</td>
</tr>
<tr>
<td>Flow defects</td>
<td>Melt temperature too low</td>
<td>Increase die and adapter temperatures</td>
</tr>
<tr>
<td></td>
<td>Lack of recycle compatibility</td>
<td>Reduce recycle or adjust recycle MFR</td>
</tr>
<tr>
<td>Brittle or fibrous heat seals</td>
<td>Melt temperature too low</td>
<td>Increase die and adapter temperatures</td>
</tr>
<tr>
<td></td>
<td>Cooling rate too low</td>
<td>Reduce chill roll temperature</td>
</tr>
<tr>
<td>Poor pigment dispersion</td>
<td>Poor mixing</td>
<td>Increase back pressure</td>
</tr>
<tr>
<td></td>
<td>Uneven melting</td>
<td>Lower temperatures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add static mixer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Change or modify screw</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Better match of polymer and master batch MFR/polymer base resin</td>
</tr>
<tr>
<td>Film blocking</td>
<td>Too hard winding</td>
<td>Reduce winding tension</td>
</tr>
<tr>
<td></td>
<td>Too glossy</td>
<td>Increase chill roll temperature to increase haze</td>
</tr>
<tr>
<td></td>
<td>Treatment level too high</td>
<td>Add antiblock (via MB)</td>
</tr>
<tr>
<td></td>
<td>Back treatment</td>
<td>Reduce treatment power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remove air under film at dielectric roll</td>
</tr>
<tr>
<td>Gels content too high</td>
<td>Contamination</td>
<td>Check pellets and recycle stream</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace filter pack</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clean and purge machine</td>
</tr>
<tr>
<td>Gauge bands</td>
<td>Dirty die lips</td>
<td>Clean lips</td>
</tr>
<tr>
<td></td>
<td>Die adjustment</td>
<td>Reset die bolts</td>
</tr>
<tr>
<td></td>
<td>Flapping melt</td>
<td>Reset air knife/vacuum box/edge pinning</td>
</tr>
<tr>
<td>Too high COF</td>
<td>Insufficient additives for chosen film thickness</td>
<td>Add masterbatch</td>
</tr>
<tr>
<td></td>
<td>Film not annealed</td>
<td>Increase storage temperature</td>
</tr>
<tr>
<td>Die lines</td>
<td>Dirty die lips</td>
<td>Clean lips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace filter pack</td>
</tr>
<tr>
<td>Discolouration</td>
<td>Too high extrusion temperature</td>
<td>Lower extruder temperature</td>
</tr>
</tbody>
</table>
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**Borealis** specialises in supplying advanced polyolefin plastics for the manufacture of film, fibre, coating and thermoforming solutions. Through introduction of technologies and solutions such as Borstar®, Borclear™, Borflow™ and Borseal™, Borealis has over 40 years established a leading position on the film and fibre market across Europe.

Borealis believes that customer-driven innovation is the only way to achieve and sustain progress. In the film and fibre industry, Borealis has pioneered the development of innovative solutions. Borseal advanced biaxially oriented PP film with higher gloss and transparency has opened up new opportunities for film producers. For meltblown, nonwoven applications, Borflow has set a new standard in barrier performance in applications such as diapers. Through foresight and focus on customer needs, Borealis continues to provide innovative PP and PE solutions for the film and fibre industry that add real value throughout the value chain.

We also know the high value that our customers place on product consistency and processability. We pride ourselves on the performance of our products, and through ongoing investment in upgrades and new plant programmes, we continue to set new records for output efficiency and product reliability. Borealis believes that responsiveness is the foundation of fruitful customer partnerships. We ensure this through highly skilled and experienced technical, marketing and product development people, located in Borealis hubs across Europe: Central Europe, Belgium, Scandinavia and Finland. In addition we have a strong sales force around Europe and close cooperation with our joint venture Borouge in the Middle East and Asia.

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