ABSTRACT

Super Film, one of the leading producers of flexible packaging, is developing strongly in flexible packaging sector. To increase the product and service range, Super Film has invested in a new coating line. The paper focuses on the role of a new coating technology in enhancing the film properties and in developing innovative flexible packaging.

The paper shows how the coater has been designed for the utmost flexibility, to make it extremely versatile and complete with the most technically advanced features, in order to bring added values to the standard BOPP and PET films. Mention is made of the latest technologies and of the new different films that can be produced by this line. In particular, the paper considers a PET having sealable, peelable and antifog properties with in-depth analysis of the enhanced seal performances as well as of the optical and antifog properties. Some examples are given about the growing market for these grades due to consumers’ inclination to fresh produces, from ready meals, packaged and refrigerated, to fruit platters and salad bowls.

1.0 INTRODUCTION

Film producers are constantly innovating to keep up with the changing demands and requirements of the market and of consumers habits, as well as to stand out in an increasingly competitive environment. SUPER FILM, one of the leading producers of flexible packaging, is developing strongly in flexible packaging sector and, in order to increase the product and service range, Super Film has invested in a new coating line.

The paper will deal with the role of this new coating technology in enhancing the film properties and in developing innovative flexible packaging with a specific focus on a new family of sealable/peelable PET film useful for a different range of applications within the growing market of fresh and ready produces.

2.0 THE COATING MACHINE

The coating machine has been designed for the utmost flexibility, to make it extremely versatile and complete with the most technically advanced features, in order to bring added values to the standard BOPP and PET films.
The coater max. web width is 2,500 mm and the process can be run up to 500 m/min through 2 coating stations for primer and main coating applications. It is worth mentioning the two long drying ovens, 10,5 meters and 20,5 meters respectively, which allow to adjust a gradual temperature profile in order to improve some critical properties of the different coatings.

The coater is equipped with two different mass supply systems, one for standard products and the other one for products with high foaming tendency. Furthermore a pressure chamber with fixed doctor blade enables a large variance in coating weight with one anilox roll, a wide variance for different compound viscosities as well as an utmost precision in the distribution of the compound, metering and flushing; all this resulting in a better and homogeneous coating ability in particular for wider rolls.

Thanks to these latest and versatile technologies several different coated films can be produced by this line: Just as examples we mention here:

- SILICON COATED BOPET FILM
- PVOH COATED BOPP FILM
- PVDC COATED BOPP&BOPET FILM
- BOPP FILMS FOR DIGITAL PRINT
- ACRYLIC COATED BOPP FILM
- SEEABLE/PEELABLE PET FILM

In particular the present paper wants to consider in more details the PET films having sealable, peelable and antifog properties with in-depth analysis of the enhanced seal performances as well as of the unique optical and antifog features. In the following description the films will be named as SUPCOAT which is their commercial code.

### 3.0 SEALABLE/PEELABLE PET FILMS

#### 3.1 The Market

The consumers’ inclination has been changing in these last years with an increasing trend to fresh produces, from ready meals, packaged and refrigerated, to fruits platters and salad bowls.

The trend is driven by the new “lifestyle”, in particular of young people, single households, vegetarians, and, more in general, by the eating habits for fast-food like ready meals and snacking, the relevant market growing by approximately 10% per year. Typically fresh and cut fruits, salads, ready meals are packed in trays made of PET (A-PET, C-PET, R-PET), PP but even PVC and PS.

In addition to punnets with rigid lids or fully ready kits, heat sealable containers with a lid made of a flexible film represent a significant share of this market.

The main requirements for a successful usage of plastic film as lidding are a proper seal onto the tray as well as a clean and easy peel without shredding and without causing excessive frustration to the user for the inability to open or hard-to-open packaging. The film must guarantee a smooth peel at ambient conditions but even at chilled ones and from the freezer. At the same time the film must withstand high temperature processes in order to be suitable for ovenable containers either microwave or conventional oven.
3.2 Seal / Peel Mechanism

There are two main mechanisms for seal/peel properties of coatings (fig.1):

- Adhesive failure, when the coating totally delaminates from its substrate and is transferred to the other material (tray) surface
- Cohesive failure, when the bulk strength of the coating is far less than the seal strength between the substrate surface and the coating

Supcoat film BT 7010 MPC owns seal/peel properties based on cohesive failure.

The mechanism is based on two or more ingredients which are not miscible and/or low adhesion forces in between which cause weak points within the coating. These ingredients can normally cause a reduction in clarity so that the coated film cannot achieve good haze and clarity as standard PET films which have about 2% haze whereas Supcoat films have about 9-12% haze (measured according to ASTM D 1003). On the other hand, the strong adhesion of the coating on the film surface and the high seal strength onto the tray and container substrate ensure good performances during stocking and handling unless a force is applied to separate the lidding film from the substrate.

The heat seal properties of Supcoat BT 7010 MPC are shown in fig. 2 wherein some graphs related to other commercial films from different sources are also reported for comparison reasons.

It can be seen that the sealing strength at higher temperatures (between 140 and 180 °C) has a very smooth curve, the seal strength remaining stable with increasing temperatures. From the practical point of view it results in “smooth peel” properties that is the user can peel the film from the surface by applying a regular and consistent force without any sudden resistance.

3.3 Antifog Properties

The food must have an inviting appearance and to be presented in such a way to take the consumer's interest. Consequently the “see-through” properties are also mandatory which is particularly critical in the applications where mist can be formed. Standard solutions to prevent misting are based on perforation of the film or application of an antifog coating by the converter or even films having a direct antifog effect.

The Supcoat films are also designed to guarantee a proper antifog effect to keep the film transparency by uniformly spreading the moisture droplets on the inner surface of the coating and providing an attractive appearance as well as preventing food deterioration.

It is well know that the fog in the package is formed when the enclosed air in the package is cooled and the excess water vapour is condensed.
### Antifog Properties

<table>
<thead>
<tr>
<th>Description</th>
<th>Performance</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>An opaque layer of small fog droplets</td>
<td>Very poor</td>
<td>A</td>
<td>Zero visibility, poor light transmission</td>
</tr>
<tr>
<td>An opaque or transparent layer of large droplets</td>
<td>Poor</td>
<td>B</td>
<td>Zero visibility, poor light transmission</td>
</tr>
<tr>
<td>A complete layer of large transparent drops</td>
<td>Poor</td>
<td>C</td>
<td>Poor visibility, lens effect, dripping</td>
</tr>
<tr>
<td>Randomly scattered or large transparent drops</td>
<td>Good</td>
<td>D</td>
<td>Discontinuous film of water</td>
</tr>
<tr>
<td>A transparent film displaying no visible water</td>
<td>Excellent</td>
<td>E</td>
<td>Completely transparent</td>
</tr>
</tbody>
</table>

**Figure 2. Seal/Peel properties of Supcoat vs. competitors**

**Figure 3. Antifog Properties**
on the inner surface of the lidding film in the form of water droplets. The droplets occur because of the difference in surface tension between the film surface and the water which has a very high surface tension (around 70 dynes/cm).

Specific antifog additives are added into the coating of Supcoat which are able to migrate to the coating surface, to increase the surface tension of the coating itself and to let water vapour wet the coating surface as a continuous layer instead of droplets. It results in a transparent and “see-through” film.

The antifog additive is an organic chemical which is mixed within the polymer matrix of the coating material, being EC and FDA approved and having a very limited impact on the optical properties of the coating itself and on the heat seal properties. It has been proved that the best performances come out in the range 4-10 °C.

In order to measure the antifog performances we have used a cold fog test with a 250 ml beaker having 200 ml of tap water inside. We have covered the top of the beaker with a sample of the test film being sure that the coated, antifog, side of the film is directed to the inside of the beaker.

Then we have placed the beaker in a temperature controlled cabinet (refrigerator) at 4°C and checked the film surface at regular time intervals recording the antifog performances according to a rating table from A to E, wherein A means an opaque layer of small fog droplets (with zero visibility and poor light transmission) while E means a transparent film displaying no visible water (complete transparency).

Total performance rating for antifog quality depends on specific customers’ requirements. Nevertheless it is an industrial practice that the target is to have D-E level after 1 day.

The fig. 3 shows the results obtained by the Supcoat antifog film (BT 7011 MAC) when compared with Supcoat standard grade (BT 7011 MPC) as well as with the plain, uncoated, PET film.

It clearly stands out the MAC grade ensures an E level already after 10 minutes, the level being kept for up to 7 days with no further modifications.

This outstanding result makes the MAC grade an excellent solution for most of practical usage and applications. However it is worth mentioning that the effectiveness of antifog coatings and films is guaranteed only for medium humidity levels in the packages since, when the moisture content related with the packed goods is very high, the antifog surface could not be enough and certain macro or micro perforations should be applied.

3.4 Seal / Peel Properties

Coming back to the seal/peel performances, fig. 4-6 show the heat seal graphs of Supcoat BT 7010 MPC and BT 7011 MAC when applied on different substrates. All the samples have been sealed on a Brugger Sealing Machine at 1 mPa for 1 sec and then tested on a Lloyd tensile tester. The results are given as N/15 mm at different temperatures.

Supcoat films provide an excellent performance on PET containers either Amorphous PET or Crystalline PET which represent the biggest share of this specific market; it is also worth mentioning that the same performances are obtained with R-PET (Recycled PET) whose volumes are growing fast due to the benefits for the environment and to the increasing approach to sustainability.

It also turns out that, while the Supcoat has poor seal/peel properties onto PP, it owns a unique feature based on the ability to seal and peel onto PS surfaces. As a matter of fact the all range of currently available PET films which seal on PET surfaces cannot be used for PS trays and this limit their usage, being the user forced to buy different flexible films for lidding depending on the containers to be closed.

On the contrary the new coating of Supcoat provides a wide range of adhesion and peelability on different substrates being able to be used on APET, CPET, RPET, PVC and PS.
Figure 4. Seal/peel properties on APET/CPET and PVC

Figure 5. Seal/peel properties on cardboard
3.5 Haze and Clarity

As already mentioned above, some market may find that haze (clarity) level of Supcoat MPC and MAC films are higher (9-12%) than required. Consequently we have designed a new product with improved haze in order to get as close as possible to standard PET films.

The new product is based on a different formulation and on a different process. As far as the formulation is concerned, we have changed especially silica and wax types with finer particle size as well as we have used some PET ingredients with lower monomer and lower molecular weight. At the same time we have worked on the process by selecting the best coating techniques and the optimum drying conditions to improve clarity of the final film. Out of the possible different techniques (direct gravure, reverse gravure, offset, mayer bar, etc...) the direct gravure turned out to be the best one and the usage of an up-to-date pressure chamber with fixed doctor blade provides better and homogeneous application of the coating.

In addition, since the coating is a kind of adhesive system which is very sensitive to temperature changes it needs a very narrow operating window.

Thanks to the up-to-date drying system and its dimensions, we took advantages of the two drying ovens with 10 and 20 meters respectively to adjust the drying temperature profile and to keep the temperatures as lower as possible in 10 meters oven whereas higher in 20 meters oven. This allows to regulate and control any possible reaction between the different ingredients before they get fully dried (minimum solvent residue) in the second oven. Thanks to these modifications we have got two new grades: standard peelable (Supcoat BT 7010 MSC) and peelable antifog (Supcoat BT 7011 ASC) having better haze (7%) while keeping excellent seal/peel properties (see fig. 7 related to APET/CPET and PVC as substrates).
2.6 Applications and Migration Tests

As we already mentioned, the film can be used for different applications with different substrates and in very different conditions. In particular, as far as the temperature is considered, the film can be used for fresh food packaging, directly from chilled and freezer conditions, as well as for ovenable containers, either microwave or conventional oven etc.

And, as any other coating which may come into contact with foodstuff, even the Supcoat family has to be carefully checked in terms of possible components’ migration into the food and in terms of conformity with EC and FDA regulations. A lot of efforts have been then made to define and identify any possible contamination problem.

Migration test has been carried out according to Commission Regulation EU 10/2011 on plastic materials and articles intended to come into contact with food using the following simulants:

- Simulant A: distilled water/ethanol 10%
- Simulant B: acetic acid (3%)
- Simulant D2: olive oil

And the following conditions:

- OM2 (10 days, 40°C): any long term storage at room temperature or below
- OM4 (1 hrs, 100°C): applications for all food simulants at temperature up to 100°C
- OM5 (2 hrs, 100°C): high temperature applications
- OM6 (4 hrs, 100°C): any conditions with simulants A, B and C, at temp. exceeding 40°C
- OM7 (2 hrs, 175°C): high temperature applications with fatty foods

Fig. 8 shows the results of the migration tests carried out on the different Supcoat products according to OM7 conditions (and simulant D2) which,
being the most critical ones, cover also food contact conditions of OM2, OM4, OM5 and OM6 and represents the worst case.

In general the best practice is to have migration results which are lower than 10 mg/dm² although correction factors can be applied related to the food type which is intended to pack. For example, if the user will pack fatty biscuits and cakes a correction factor of X/3 can be applied.

The table shows that only Supcoat BT 7011 MAC overcomes 10 mg/dm² so that its usage is restricted to the foods where a correction factor can be applied. Althought they represent a wide part of the food type’s range, nevertheless we have modified the formulation of MAC grade by using a different version of antifog additive and producing the new grade Supcoat BT 7011 ASC which is able to pass the OM7 test for any kind of foodstuff wherein antifog properties can be necessary.

In conclusion the Supcoat BT 7010 MSC and BT 7010 ASC represents the optimum solutions for PET films respectively as seal/peel lid and as seal/peel/antifog lid for a wide range of containers, for different applications and in all the possible conditions of use.

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>TEST</th>
<th>SIMULANT</th>
<th>RESULTS</th>
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<tbody>
<tr>
<td>SUPCOAT BT 7010 MPC</td>
<td>OM7 (2 hrs, 175 °C)</td>
<td>D2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>SUPCOAT BT 7011 MAC</td>
<td>OM7 (2 hrs, 175 °C)</td>
<td>D2</td>
<td>16,3</td>
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<tr>
<td>SUPCOAT BT 7010 MSC</td>
<td>OM7 (2 hrs, 175 °C)</td>
<td>D2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>SUPCOAT BT 7011 ASC</td>
<td>OM7 (2 hrs, 175 °C)</td>
<td>D2</td>
<td>&lt; 2</td>
</tr>
</tbody>
</table>

Fig. 8 results of migration tests