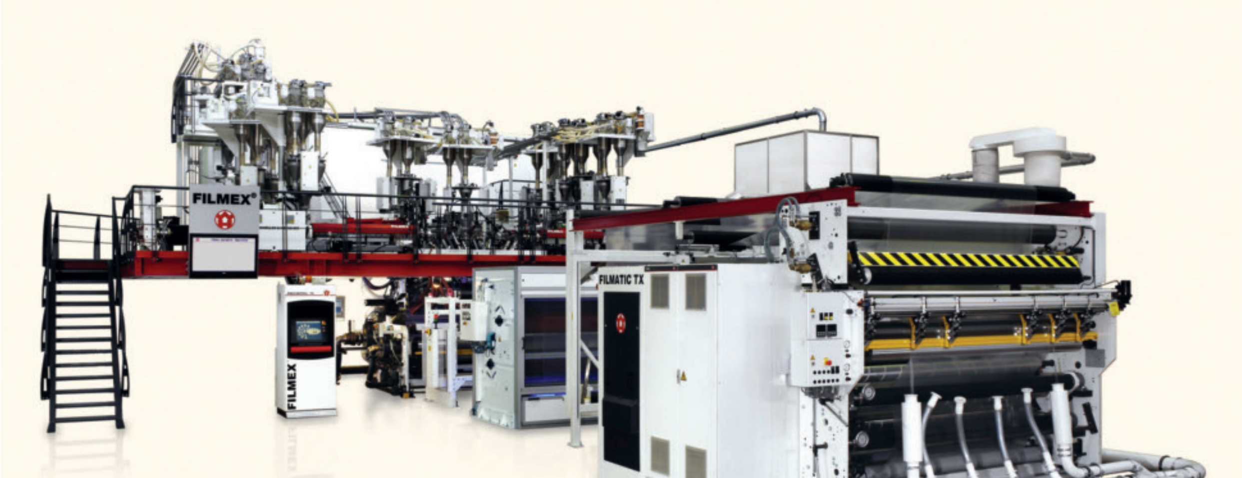

Filmex cast film extrusion line equipped with eight extruders, optionally with a 9-layer or 17-layer feed block, a 2.7 m flat film die, chill roll and various winders (photos: W&H)

Wafer-Thin Layers for Giant Tasks

Cast Film Extrusion. The cast film technology is frequently a cost-effective method for the production of high-quality films. The fields of application are gradually expanding also to areas previously served exclusively by other methods.

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If we limit the description of the cast film extrusion process to the essentials, then we see the different raw materials being melted in the respective extruders, being laid onto one another in a co-extrusion feed block, being spread over the width in a die, calibrated and cooled on a casting roll, then examined for thickness tolerances and finally wound onto a reel. All these process steps have to be analyzed individually and expanded, if necessary, when lines are configured to the production of stretch, CPP, barrier, surface protection or hygiene films. Particularly helpful during the configuration process – apart from the corresponding technology know-how – is extensive process engineering experience and the possibility of validating the customer's formulation on a flexible pilot plant **(Title photo)**.

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Cast Stretch

Stretch film is predominantly used to protect palletized commodities during transport and storage. This type of film has a "sticky" (cling) coating on the inside and a "non-sticky" (release or anti-cling) coating on the outside and consists predominantly of different LLDPE types. Depending on the product and local conditions, the pallets are wrapped either manually (hand stretch) or automatically (machine stretch).

Hand stretch is generally wound as a 3-layer film of 500 mm width and 300 m length with a thickness of between 8 and 30 µm onto 2″ reels. In order to minimize the raw material costs, butene grades are predominantly used. For in-line production of such reels, a winder with a correspondingly short reel changing cycle is required. At present, however, the production of hand stretch on "jumbo reels" with approx. 400 mm diameter with subsequent rewinding onto short reels is still a widespread practice.

Apart from a certain elasticity of up to 100 %, hand stretch also needs to have sufficient elastic recovery. It is important to consider here that the force used during packing can differ very widely, depending on the physical strength of the personnel, while the packed goods still have to be protected.

The grades and thicknesses available on the market in this segment could also hardly be more diverse. While in Japan, for example, hand reels with 10 or 12 µm thick film, perfect winding down to the last centimeter, an absolutely immaculate appearance and individual boxing are demanded, in many other countries batches of lower grade film are frequently rewound and sold as hand stretch. The quality of the films is dictated to a great extent by the distribution: While in many parts of the world stretch films are sold by weight through distributors, in the USA and in parts of Asia, for example, sale by area or performance is common.

That also explains why in some regions of the world, the production of hand stretch on thin reels is demanded **(Fig. 1)**, while in other regions the weight of the reels is increased without any technical necessity in order to maximize profit. Par- →

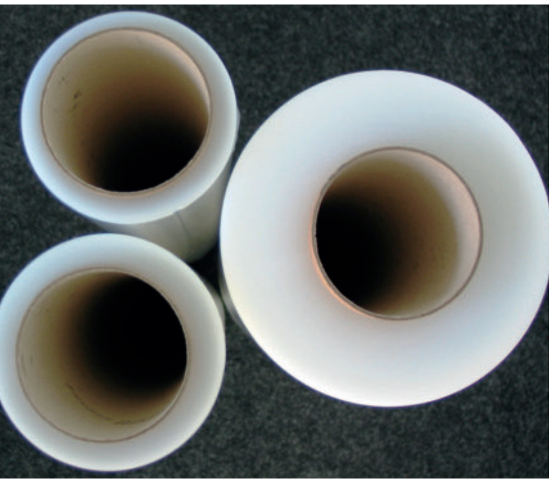

Fig. 1. Film rolls with 2 mm core thickness

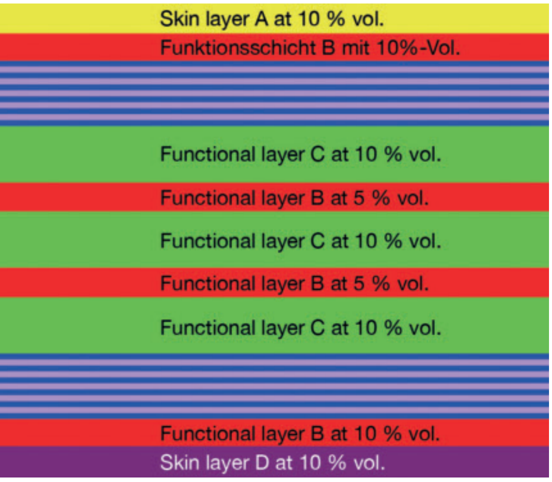

Fig. 2. Film composite with nanolayer technology (photo: Cloeren Inc.)

ticularly in the light of the efforts towards sustainability, however, the trend towards minimizing the reel weight will assert itself in the long term and the topic of thin reels will gain in importance. As far as the winding technology is concerned, the use of special winding shafts and a very low web winding tension are the keys to success.

Machine stretch is generally wound as 3-layer or 5-layer film in 500 mm width on 3″reels to form rolls of 250 mm diameter in a thickness range from 12 to 30 µm. Apart from the inexpensive butene grades, hexene and octene (in some cases metallocene catalyzed) as well as LDPE, VLDPE, ULDPE and their blends are also used as raw materials. During application, these rolls are processed on automated palletizing machines which wrap the film around the revolving pallet after a preliminary stretch of between 100 and 300 %. Elasticity, retention force, puncture resistance, unwinding speed and noise and the number of fatal breaks are the crucial quality criteria here.

Stretch films are an almost purely commodity product and the profit margins are low. Many manufacturers are therefore forced to keep the raw material price as low as possible by producing large quantities of film. This demand is consequently passed on to the machine manufacturer, so that line concepts in particular with high melting capacities using four extruders and a 5-layer feed block established themselves in the past. Today it is difficult to achieve any degree of differentiation compared with the competition using such lines. For this reason, a trend towards more and more layers has established itself, starting from the USA as a very highly developed stretch market. The first 7-layer line went into operation in 1995, followed in 2000 by a 9-layer plant and in 2005 by a 21-layer (nanolayer) line. With the "nanolayer" technology, an alternating arrangement of two layers is created at different points in the film structure (**Fig. 2**). Since 2008, the number of lines with nanolayer technology and more than 30 layers has increased steadily.

Patents and commercial applications show that on lines with large number of layers, individual raw materials can be used to selectively achieve defined functions in the film. This makes it possible to do partly or completely without raw material blends which are known to have a poorer property profile than the same individual components in separate layers. A particular effect can be observed when the borders of conventional formulations are transcended and raw materials such as polypropylene or propylene-ethylene-interpolymers are employed. In these cases it is indispensable, often together with the machine manufacturer and raw material producers, to selectively develop a formulation and to validate this on a corresponding pilot plant, as depicted by way of example in **Figure 3**.

Apart from the trend to ever more layers, the demand is also growing in certain markets – as already described above – for ever thinner films with the same performance. Large companies, in particular, try to reduce not only the costs but also the CO_2 footprint of their production, and are therefore interested in a lower film weight per packed pallet. This trend presents a special challenge in particular to those converters whose whole machine park is geared to the production of thicker films with very high melting rates, because in many cases efficient production of thin films is not possible on these lines for technological or economic/energy-related reasons. When planning new lines, the machine manufacturer is therefore repeatedly called upon to also contribute to the future viability of film production through appropriate advice and expedient dimensioning of tailor-made lines.

Barrier Films

The trends described so far of ever more layers, unconventional raw materials and thinner films have also been recognizable in the field of barrier films for many years. Co-extruded barrier films are indispensable today in the world of flexible packagings. They are used among other things as thermoforming, lidding or bag films and ensure the shelf life of the packed foodstuffs. While such films were more frequently produced in the past by laminating polyamide (PA) films with polyethylene (PE) films, the coextrusion of symmetrical or asymmetric PA/PE films has been a well-established process now for many years.

PA is responsible here for good heat resistance, thermoformability and barrier effect towards oxygen. The PE "body" provides a good water vapor barrier and the necessary sealing properties. If a higher barrier effect towards oxygen is demanded, ethylene-vinyl alcohol (EVOH) is also used in the co-extrusion composite. The films can be produced here using both the blown film and the cast film

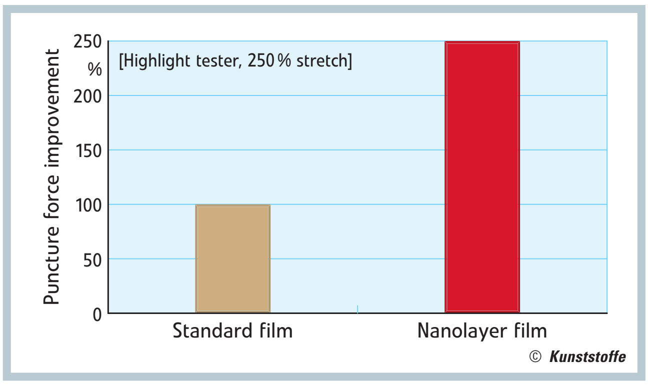

Fig. 3. Improvement in the puncture resistance through the use of raw materials of differing density in the nanolayer composite (source: W&H/The Dow Chemical Company)

Fig. 4. Thermoformed tray of coextruded PET/PE cast film

process, and a detailed and neutral comparison of the two methods with a clear focus on the production environment and the ultimate application is required. The cast film process has fundamental benefits in the higher output ranges (600 to 2,500 kg/h), for thicker films, thermoformability, film appearance and flexibility in the composite structure and raw materials. The flexibility in the composite structure is ensured by a corresponding design of the co-extrusion adapter. As far as the raw materials are concerned, modern cast film lines generally have universal screw geometries so that all common cast film raw materials can be processed on all extruders.

This notion of flexibility led at Windmöller & Hölscher (W&H) to the idea of extending the field of application of the Filmex cast film extrusion line to include the co-extrusion of polyethylene terephthalate (PET), as this raw material can also be easily processed on their smooth barrier (SMB) screws. PET is a versatile polymer which is of great importance in the packaging world due to its spectrum of properties and attractive price. Apart from its use for bottles, the raw material is also employed in very thin, biaxially oriented films (PET-BO) and in thick films between 150 and 1,000 µm. In packaging applications, these PET films are generally laminated with PE in order to achieve the necessary sealing properties. Laminating composites with thick PET films are normally further processed to produce rigid packaging trays, while PET-BO composites are employed as lidding or bag films.

In competition with PA, PET wins points with its better optical properties, perfect printability and outstanding thermoformability. Furthermore, the raw material is now also far less expensive than PA. PET does, however, make considerably higher demands on the processing than PA: For example, the polycondensate has to be predried elaborately and at high temperatures before processing, the extrusion demands higher melt temperatures, and the melt viscosity and the type of coupling agent have to be carefully matched to the composite.

Comprehensive tests prior to the K2010 plastics trade fair provided the necessary process know-how. Experience was gained with a film spectrum extending from simple PET/PE composites through to PET/PA/EVOH high barrier films. In order to visualize the potential of these innovative co-extrusion composites, W&H presented at the fair a thermoformed tray made from a 250 µm thick PET/PE film characterized by high transparency and rigidity **(Fig. 4)**.

A further important benefit of the co-extrusion process is that processors are no longer restricted to the limited range of available thicknesses of PET-BO and PET thick films for lamination purposes. Instead, co-extruded composites up to a total thickness of approx. 300 µm open →

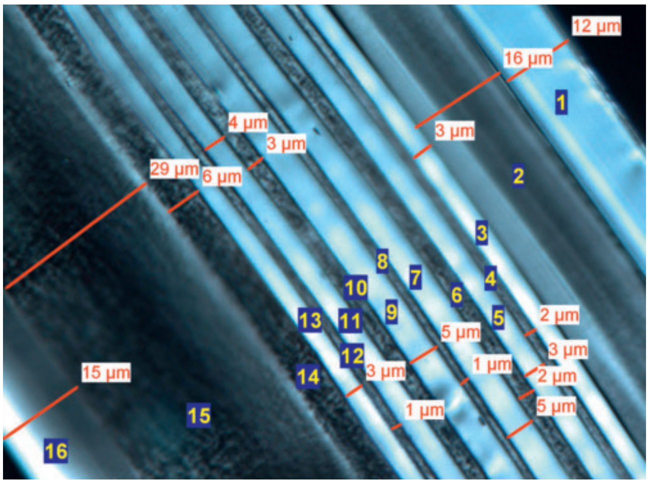

Fig. 5. Microtome section of a 17-layer PA/PE barrier film
(source: W&H/DSM Engineering Plastics)

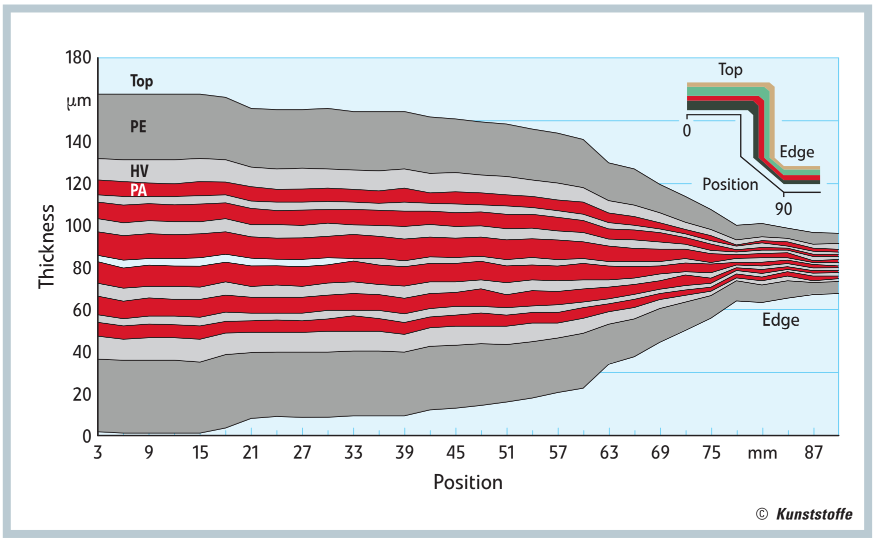

Fig. 6. Individual layer thickness distribution of a thermoformed PA/PE packaging film (source: W&H)

up new possibilities in packaging design and offer corresponding savings potentials.

In addition, W&H demonstrated the extrusion of a 17-layer PA/PE barrier film during its in-house exhibition parallel to the K 2010 **(Fig. 5)**. It was designed as a lidding film to the thermoformed tray described above and has outstanding transparency and perfect sealing properties. Similar composites have been produced of late also with polybutylene terephthalate (PBT) as outer layer. With its very good optical properties and very high heat resistance, PBT has advantages over PET in applications with high sealing temperatures.

As already explained at length on the subject of stretch film, the nanolayer technology offers potential for improving the film properties also in the barrier film segment. With appropriately developed formulations it is possible, for example, to optimize the rigidity, barrier effect or thermoforming properties. **Figure 6** shows a thermoformed packaging and the distribution of its individual layers gained from an analysis of microtome sections of individual areas of the packaging. The figure shows clearly that no layer rupture occurs during thermoforming. With a suitably developed formulation, the thermoformability and the distribution of the individual layers can be improved thanks to the large number of layers. To date it has not been possible, however, to clearly quantify the improvement potential compared with a conventional 11-layer film.

Fig. 7. Filmex cast film line for the production of surface protection films under cleanroom conditions

Surface Protection Film

While in the stretch and barrier film segments the trend to ever more layers and thinner films has been observed for some time now, the surface protection film segment is developing in a different direction. Here rising demands for very high film quality have been observed, driven in particular by the booming flat screen industry. Numerous protective polyolefin films of different grades and specifications are required for the production of the LCD panels. Common to all these films are the demands for excellent flatness, minimum residual shrinkage, a precisely defined low fish-eye level and an adhesiveness geared exactly to the substrate. The fish-eye level is important here because the fish eyes can damage the substrate or can cause faults during a visual analysis. The machine technology for such products generally consists of three extruders with the focus on a very gentle and good homogenization, very short melt channels without dead zones, special filtration, high-quality winding technology and cleanroom production conditions **(Fig. 7)**. Huge capacities are currently being built up in this special film segment, particularly in Korea, driven by the high demand from the local flat screen manufacturers.

Conclusion

In summary we can conclude that the cast film technology is frequently a cost-effective method for producing high-quality films. The fields of application are gradually expanding also to areas previously served exclusively by other methods. The key to success for film manufacturers in this context is a close analysis of the available production methods, allowing for the individual boundary conditions, and neutral advice from the equipment manufacturer. When a decision has been taken for a technology, the equipment must be tailored individually to the customer's needs during the project phase. Particularly helpful in this context is a relationship based on partnership between film, raw material and equipment manufacturer in order to achieve an optimum product development or adaption. Welcome assistance is often provided here by a corresponding pilot plant for validation of developments and finished products, for carrying out pilot production and last but not least for intensive training of the operating personnel. ■

! Company Profile

Windmöller & Hölscher KG is a leading international manufacturer of machines and equipment for the flexible packaging industry based in Lengerich, Germany. The product range includes blown film and cast film lines, flexographic and gravure printing presses, machines for the finishing and processing of paper, film and plastic fabrics as well as FFS (Form, Fill & Seal) packaging systems.
www.wuh-lengerich.de

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