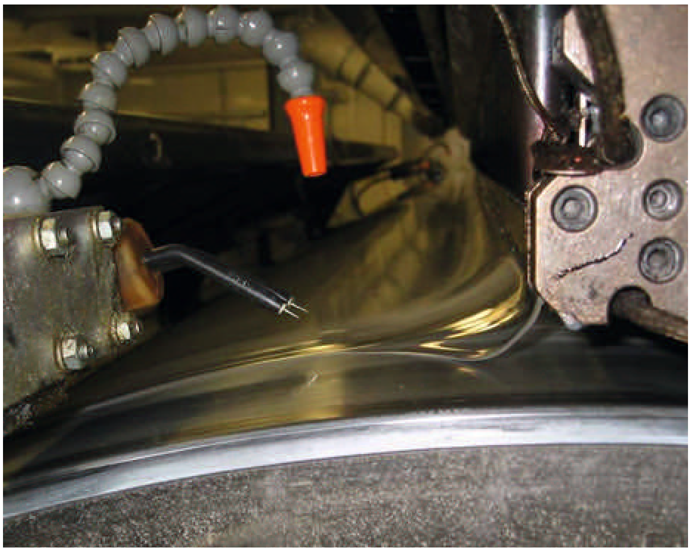
Thin Gauge Films Secure Heavy Loads

Logistics. In November 2012, Windmöller & Hölscher KG (W&H), Lengerich, Germany held a symposium on "Load Stability" for a diverse global audience consisting of film converters, multinational packaging end users, polymer suppliers and logistics companies, as well as responsible members of the traffic police. One of the symposium's key messages was that the whole process chain from the resin up to the wrapping machine needs to be considered. A case study was introduced showing that even in a bulk commodity market such as stretch films there is the opportunity to develop "value added" products.



Melt curtain length and melt temperature are crucial factors to quality consistency (figure: W&H)

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In the majority of applications, stretch wrap film is the most economic solution for achieving proper palett load stability. However, stretch film in Europe is a pure commodity product – predominantly driven by price per kg – and the whole industry faces severe price pressure. While multinationals are ever more driven to reduce the carbon footprint of their products and legislation in Europe is strongly focussing on the security aspect of transportation and logistics, there is a huge opportunity for converters to introduce "added value" stretch films to the market. To develop such products successfully, it takes the combination of resin, machinery, process, wrapping and testing know-how, as described in the following case study.

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The Consignor is Responsible

During the symposium, Professor Marc Juwet from KU Leuven outlined current EU and IMO directives and their impact on responsibilities of the consignor, shipper and haulier. According to the directives, the consignor is responsible that packages and unit loads are suitable to withstand the stresses expected under normal transport conditions, be it road, train or ship. From a legal standpoint, the securing system should prevent all movements of all parts of the cargo. According to the current understanding, this means that all load units should behave as a rigid block.

This being said, a palett transported on the road must withstand a brake acceleration of 0.5 g while remaining completely rigid. Besides "real life" – but very expensive – truck braking tests, wrapped paletts can also be tested on a so-called acceleration test (**Fig. 1**). In this test, a palett is accelerated and the behaviour of the load is documented with a high speed camera. During approximately 2,500 acceleration tests done within the last years, roughly 70 % of the paletts were not rigid, 20 % were rigid but too expensive, and only 10 % of the paletts were optimized. Keeping in mind that an estimated 4 % of all transported goods in Europe are damaged upon arrival, there is clearly a huge potential for improvement along the complete process chain [1, 2, 3].

The key factors influencing load stability, using stretch film, are

- shape and friction coefficient of secondary packaging units,
- stacking pattern on the palett,
- application of tie sheets,
- bottom roping for a good connection between load and palett,
- wrapping pattern,
- selection of suitable stretch film and
- appropriate wrapper settings.

Stretch Film and Wrapper

This case study will focus on the combination of the latter two items and describe

Fig. 1. Acceleration test at ESTL nv, Deerlijk, Belgium (figure: ESTL)

the development of stretch film used to achieve reliable load stability, while being a more economic solution than many other currently available films.

Beginning of 2012, W&H installed a Filmex cast stretch extrusion line at Ergis-Eurofilms S. A. in Olawa, Poland. The primary focus of this line was to produce high performance machine film that would primarily be used in high-speed wrappers that can go beyond 300 % prestretch. The line is equipped with a Cloeren 33-Nanolayer feedblock and a total of seven extruders **(Fig. 2)**. Based on the know-how W&H gained over the last five years through Nanolayer trials in their pilot line, this setup was aimed at giving the highest potential for developing such added-value products [4, 5, 6].

Advances in Load Stability

Before commissioning the line in Eurofilms, first trials were done on a Cloeren 17-Nanolayer feedblock in the W&H pilot line together with ExxonMobil Chemical. These trials showed significant improvements in puncture resistance when resins with different density and polymer structure were combined in the Nanolayer section **(Figs. 3 and 4)**.

Further joint trials conducted on the W&H pilot line and production tests performed on the Filmex line in Olawa led to the development of a wide range of high-performance films, for example the nanoErgis SPPV type presented in this study. In this development, there was a strong focus on the extrusion process parameters and their effect on the product properties [7].

The qualification process for this film involved the standard laboratory and "Highlight tester" film quality tests, as well as performance tests on a high speed wrapper and subsequent acceleration tests. During the development period, it became obvious to the whole team that an understanding of the complete process chain from the resin to the wrapped palett is required to achieve good results – as the following examples underline:

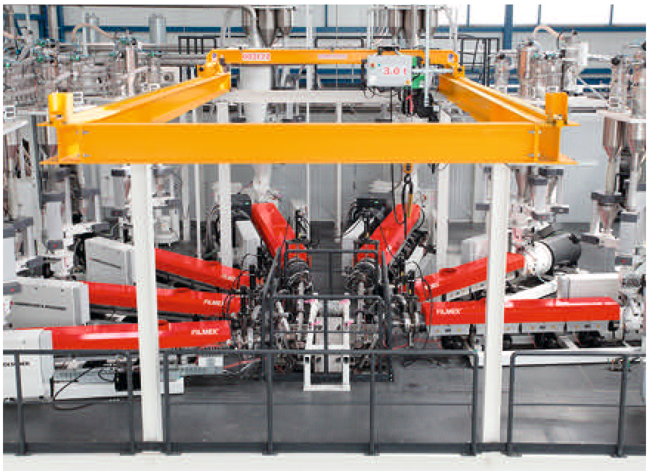

Fig. 2. Filmex Cast Stretch film line with seven extruders and 33-Nanolayer Feedblock (figure: Eurofilms)

In a first test, a 22 µm nanoErgis SPPV film was applied to a rather heavy test palett holding 60 carton secondary packages, each containing 10 PET water bottles of 1 litre, in an interlocked stacking pattern. When applied at the standard wrapper settings of 250 % prestretch / 40 % post stretch and without reinforcement bands, the load behaved unstable. By increasing the prestretch level to 350 % and at the same time introducing three reinforcement bands at 570 mm height, the load became stable with only a 10 g film weight increase. The stress/strain curve of this film shows that with the "practical stretch" achieved on the palett in Test A, there was too much potential for elongation left in the film **(Fig. 5)**. This explains why even a rather thick film with high holding force can fail in the application if the wrapping parameters are set incorrectly.

In the next test (C), the development team wanted to quantify the downgauging potential of this wrapping application. Therefore, a 15 µm nanoErgis SPPV film was used with the same wrapping parameters as in the test before. One can see that even with a much lower level of holding force of the film, the palett behaved stably. The weight of the film used to stabilize the palett was thus reduced by 35 % **(Fig. 6)**.

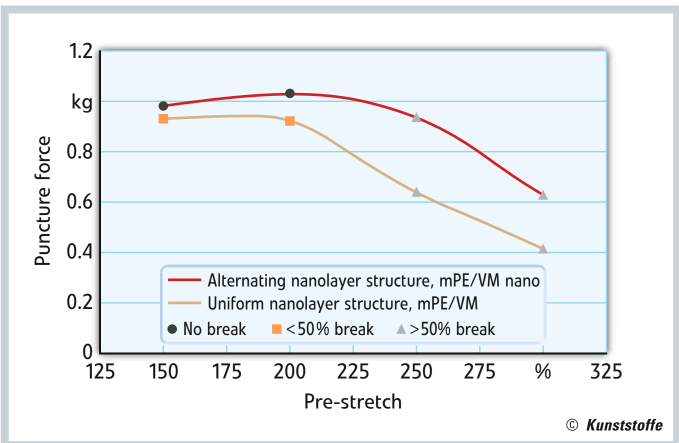

Fig. 3. Film structures with and without different metallocene resins in the Nanolayer (figure: W&H / ExxonMobil Chemical)

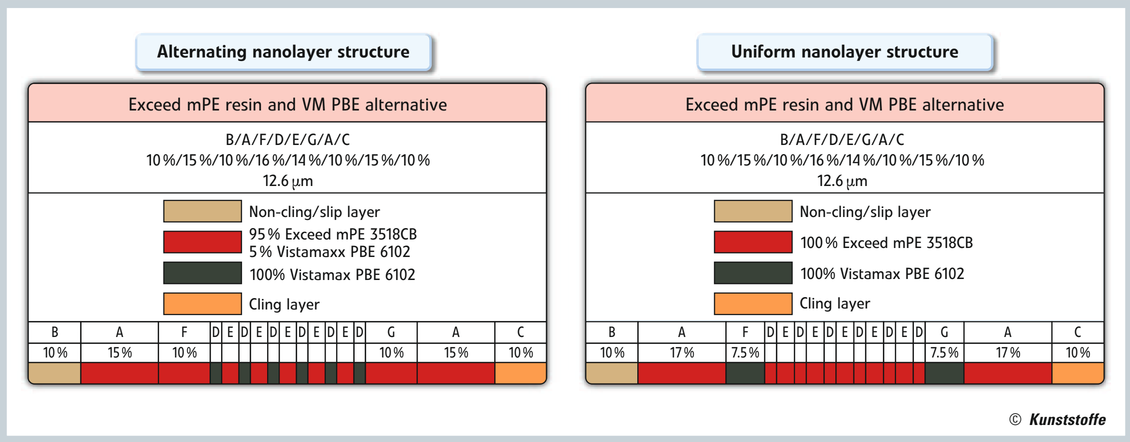

Fig. 4. Improvement in puncture resistance through use of Nanolayer film structures (figure: ExxonMobil Chemical)

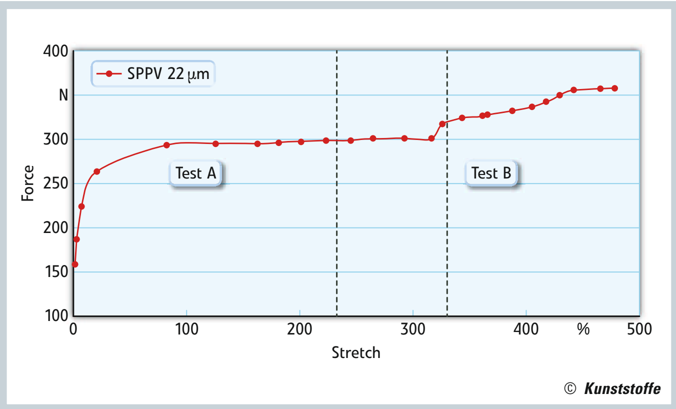

Fig. 5. Impact of wrapping pattern and wrapper settings on load stability (figure: W&H)

Test D with a 12 µm nanoErgis SPPV film then showed that a further reduction of film weight will not be possible due to insufficient holding force exerted on this heavy load. Hence, the 15 µm nanoErgis SPPV film applied with 350 % stretch is the most cost efficient solution for this wrapping application.

From the tests, the following main conclusions can be drawn:

- The holding force of the film is characterized by the tensile plateau of the stress/strain curve, as generated by a Highlight tester "Ultimate Test". It is important to choose a stretch film according to the holding force requirements of the individual load. If the holding force is not sufficient, the load will be unstable during transportation.
- If a film with sufficiently high holding force is chosen, it needs to be applied with the correct prestretch settings. The practical stretch on the palett must be at the end of the tensile plateau and just into the region of strain hardening of the film. Thus, when acceleration forces start to shift the load, a resulting increase in holding force will hold the load in place. However, there must be sufficient stretchability left in the film so that it does not break.
- In many applications, there is a huge downgauging and cost saving potential when the right film is applied in the right way. Therefore, the cost of stretch film should not be calculated in "price per kg", but "price per stable load" should be considered, including additional packaging materials, labour and machine cost.

Throughout the joint development project and the "added-value" approach described here, it became very clear to all parties that the quality demands for tomorrow´s stretch film are rapidly increasing. Once a packaging solution for a certain application has been developed and qualified, it is absolutely critical for the converter to maintain and monitor a high level of quality consistency in his film portfolio.

To prove the quality consistency of the nanoErgis SPPV product, films of different thickness were produced on the Filmex line at different production dates. As an example, **Figure 7** shows stress-strain curves for these films. As one can see from the specific stress given in N/µm, the properties of all the films are kept consistent through the whole thickness range. This can only be achieved by monitoring all the relevant process and production parameters and keeping them within a very narrow and repeatable process window (**Fig. 8**). The proof of quality consistency is vital, because this type of film is intended to run at higher elongation levels and wrapping speeds without increasing the risk of film breaks in the packaging lines.

Based on the above described laboratory results and after the proof of quali-

Type of load	Type of wrapper	Reference film thickness	NanoErgisSPPV film thickness	Holding forces	Savings in price per stable load (%)
Customer A: 800 kg heavy load: bottles or cans	Ring wrap	23 µm	20 µm	Increased both on top and bottom of the palette	23 %
Customer B: 500 kg medium load: mixed goods	Rotating table	17 µm	12 µm	Increased both on top and bottom of the palette	37 %
Customer C: 100 kg light load: carton boxes	Rotating arm	17 µm	15 µm	Increased both on top and bottom of the palette	16 %

Table 1. Results of wrapping tests at customer facilities (source: Eurofilms)

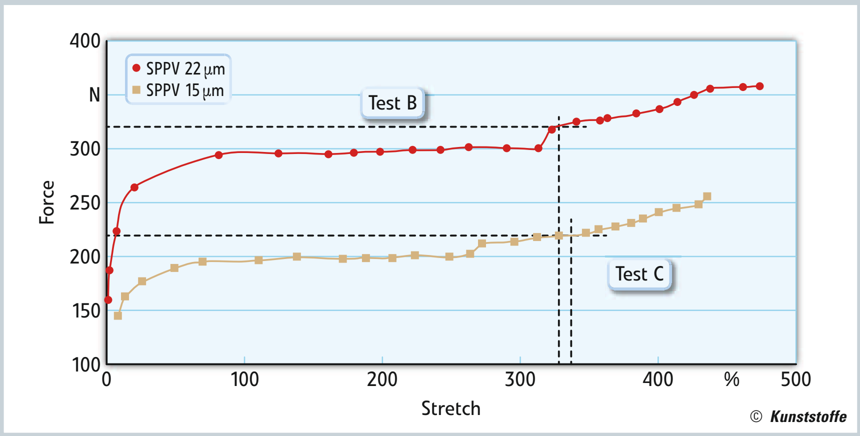

Fig. 6. Downgauging potential in wrapping application (figure: W&H)

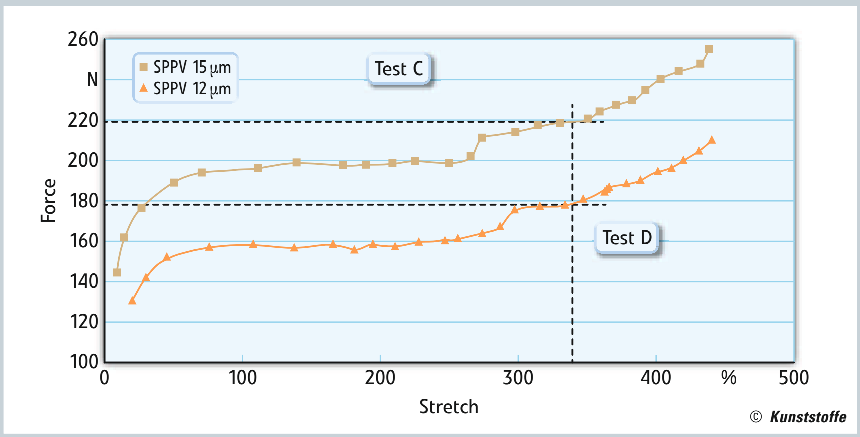

Fig. 7. The 12 µm SPPV does not exert sufficient holding force for this type of load (figure: W&H)

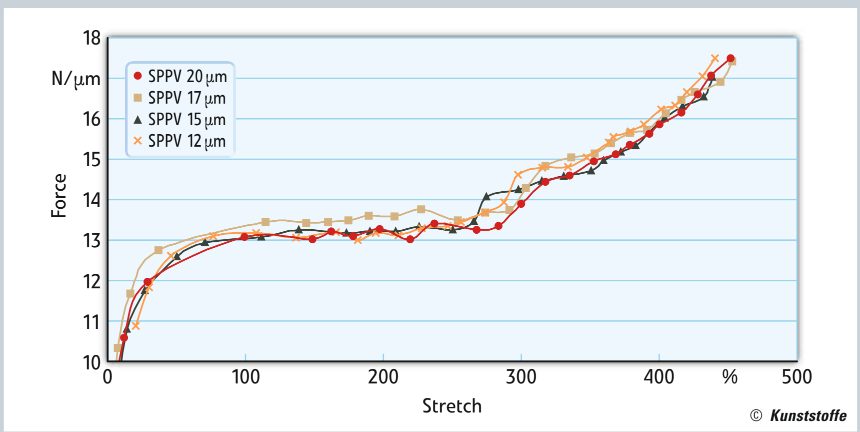

Fig. 8. Films of different thickness show a constant quality level (figure: W&H)

ty consistency, the next step was to qualify the nanoErgis films together with end-customers on their specific applications and wrapping machines. Based on the experience of the Ergis Eurofilms technical consulting team, the wrapping process within the different facilities was reviewed together with the customers and the optimum film thickness for the different load types was chosen. In order to tap the full potential of the nanoErgis films, the pre-stretch of the wrappers was increased. The resulting higher holding force both on top and bottom end of the palett gave further cost saving potential by eliminating additional packaging material like anti-slip interlayers. In total, replacing the film and adjusting the wrapper parameters gave way to significant savings in the total "price per stable load" as proven in case studies for three different customers **(Table 1)**.

Besides the savings on the film itself, sometimes the wrapping cycle time plays a significant role in the end application. In another case study for a client in the beverage industry, a conventional 20 µm film was replaced by nanoErgis SPPV 35 µm film. By changing the prestretch level to 300 %, the number of wraps was reduced from 26 to 19 and thus the number of wrapped paletts was increased from 55 to 67 per hour. Using the film at this high prestretch level also increased the load holding force by 34 %.

Conclusion

In the presented case study it was shown that even in commodity markets like stretch film there is still the chance to create added-value products with benefits for the end-user of the film. By tailoring both the film and the wrapper setup to the specific load, there is potential to save packaging cost, increase the output of packaging lines and achieve higher load stability. EU legislation and carbon footprint discussions are additional drivers of this approach. However, a deep understanding of the complete process chain as well as a trusted partnership approach between resin supplier, OEM, converter, testing facilities and end-customer are vital to develop successful packaging solutions. ■

REFERENCES

1 Juwet, M,; Bruggeman, K.: Dekra-VDI symposium "Securing of cargo on road vehicles", Klettwitz, Germany (2009)

2 Juwet,M.; Bruggeman, K.: "On optimization of 2D behavior or stretch film", PMI conference 2012, Gent (2012)

3 Juwet, M.: Legal and economical requirements for palettized goods. W&H Load Stability Symposium, Münster (2012)

4 Schmitz, T.: Wafer-Thin Layers for Giant Tasks. Kunststoffe international 5 (2011)

5 Schut, H.: Stretching Film´s Limits. Plastics Technology (2008)

6 Smith, C.: Stretching the benefits of multiplication. European Plastics News 4 (2011)

7 Degroot, J. A.; Doughty, A. T.; Stewart, K. B.; Patel, R. M.: Effects of Cast Film Fabrication Variable on Structure Development and Key Stretch Film Properties. Journal of Applied Polymer Science, Vol. 52, 365-376 (1994)

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