Carbon Busters, Part 3: How and Why rPET Could Lead to Significant Progress in Recycling

# The Packaging Material of the Future

To produce high-quality packaging for the European food industry, processors, besides having efficient means of production, must more than ever be prepared to break new ground. The requirements of the EU Plastics Pact are ambitious: By 2030, all plastic packaging must be 100 % recyclable and contain at least 30 % recycled material. "rPET" is the highly promising response to this challenge, which the partner companies Engel, Alpla, Brink, IPB Printing and Intopack have tried and tested in practice.

The European Food Safety Authority (EFSA) is serious about the Plastics Pact. In any case, for packaging made entirely of virgin material – so-called "single-use" products – some countries already levy taxes (plastic tax). It is irrelevant in which country the packaging manufacturer is based. As soon as the products are brought into circulation in the EU and do not contain at least 30% recyclate, taxes of up to EUR 450 per ton of virgin material will have to be paid in Spain, and soon in Italy, too.


To establish not only a bottle-to-bottle and bottle-to-cup, but also a cup-to-cup and cup-to-bottle cycle, separate material streams are needed for food and non-food packaging. © Engel

## *The Only Plastic that Can Be Recycled into Food Packaging*

With typical materials for packaging foods in thin-wall containers, such as polypropylene (PP) or polystyrene (PS), packaging manufacturers face a difficult hurdle. These materials lack favorable assessments by EFSA. Even if they were to be issued at short notice, a sufficient amount of pure recyclates will not be available rapidly enough. Recycled PET – so-called rPET – offers a solution here. EFSA has approved numerous recycling processes for PET, making rPET available in large quantities in Europe.

PET has so far been the only packaging plastic that, as a recycled material, can be processed back into food packaging on an industrial scale. As early as K 2022, a development cooperation comprising Engel, Alpla, Brink and IPB Printing presented a mass production-ready production cell for manufacturing thin-wall packaging from up to 100% rPET by injection molding. At its heart was an Engel e-speed 280/50 injection molding machine **(Fig. 1)**, combined with the mold and an automation solution from Brink **(Fig. 2)**. The hybrid machine with electrical clamping and hydraulic injection unit was developed specifically for the high performance requirements in thin-wall injection molding. For processing rPET, Engel combined the injection unit with a plasticizing unit developed and produced in-house specifically for recyclate processing.

## *Special Features of (r)PET Processing*

The changeover to PET or rPET brings with it new issues for thin-wall packaging producers who process PP or PS. For example, with material drying, an additional process step upstream of the actual injection molding process is necessary. PET is hydrophilic, which means it absorbs moisture from the surroundings. Since moist or residually moist materials result in cracked, brittle parts, PET – and therefore also rPET – is continually dried at 160 °C for six to seven hours before it is fed to the injection molding process.

PET is processed at 280 to 300 °C, and is therefore above PP or PS with a pro-

**Fig. 1.** The Engel e-speed injection molding machine can produce thin-wall containers from PET and rPET. © Engel

cessing temperature of 220 to a maximum of 280 °C. A homogeneous and gentle material melting becomes all the more important with increasing temperatures. PET also tends to degrade chemically and form deposits in the screw flights. The good self-cleaning properties of the plasticizing components from Engel, which are tailored to PET processing, counteract this.

Another special feature is the necessary isolation of the mold. The ideal mold temperature for PET or rPET is 12 °C. To prevent condensation water from forming on the mold, particularly in the summer months, air drying and isolation of the mold are of great importance. Condensation water on the mold surface would limit the reproducibility of the manufacturing process.

The extreme flow path/wall thickness ratio for thin-wall injection molding naturally makes strict demands on the injection molding machine. The dynamics, controllability and, most of all, the high reproducibility of Engel injection units permit very stable production even at the limits. Specifically, this means injection velocities of up to 1400 mm/s at maximum injection pressures of up to 2600 bar. For example, a 125 ml-rPET cup with a wall thickness of 0.32 mm (**Fig. 3**) could be injection molded in significantly less than 100 ms. With the development of the e-speed injection molding machine series, Engel makes it possible to produce thin-wall PET packaging directly by injection molding – with all the freedom of design that is not available by thermoforming.

In addition, in the conversion of production of thin-wall packaging to PET or rPET, the significantly lower shrinkage of the material must also be taken into account. To achieve identical part geometries, new molds may be required.

## *rPET Enters the Field of Thin-Wall Packaging*

How these special features can be taken into account in the conversion of PP to rPET processing can be illustrated by the example of the Dutch packaging manufacturer Intopack (**Fig. 4**). Since its foundation in 1969, the company has specialized in the development, manufacture and sales of high-quality packaging for the European food industry. For retailers, packaging materials have long been an important building block in the sustainability strategy – together with the aim of gaining consumer confidence. Intopack customers report that supermarkets are already asking specifically for rPET as packaging material.

In the changeover to PET, the packaging manufacturer benefited from the experience gained by the development consortium around Engel with the »

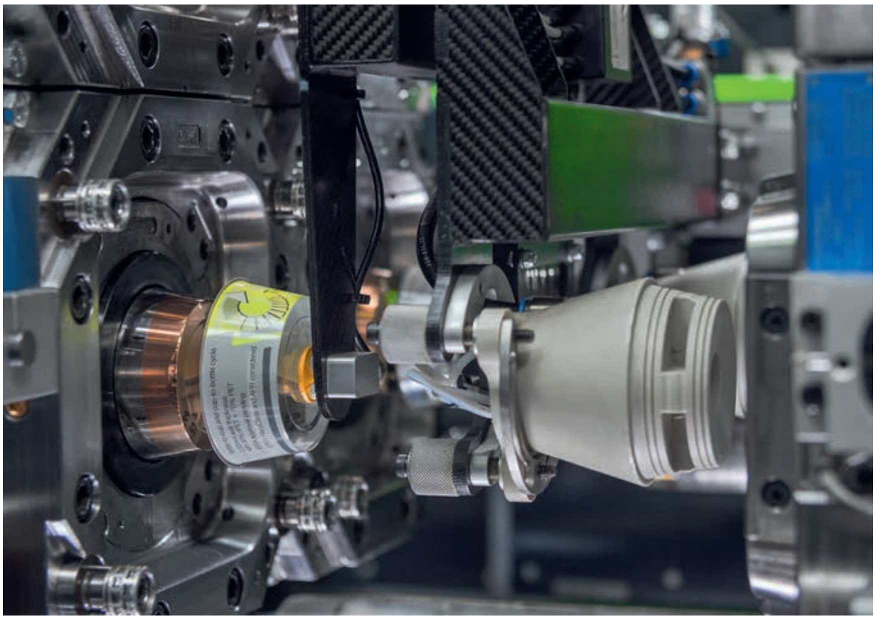

**Fig. 2.** In combination with IML, ready-to-fill thin-wall packaging can be injection molded in one operation from rPET. © Engel


**Fig. 3.** This cup of 70 % PET and 30 % rPET was used for the material tests from Alpla. © Engel


**Fig. 4.** Strong commitment to sustainable food packaging: Jeroen Langenberg (left) and Peter Langenberg, CEO of Intopack. © Engel

joint exhibit at K2022. They include the Austrian packaging and recycling specialist Alpla, as well as the mold maker and automation supplier Brink and the IML label manufacturer IPB Printing, both based in the Netherlands, and, like Engel, longstanding suppliers of Intopack. PP has so far made up the lion's share of processed materials in Intopack's production plant. The fact that PET did not play a role for a long time is the result of the processing technology. It was not economically feasible to produce thin-walled PET packaging. With conventional injection molding machines, PET can only be processed into thick-walled parts, such as bottle preforms.

Since the investment in an e-speed machine, Intopack now also manufactures rPET thin-wall packaging. Moreover, developments in PET recycling are paving the way for the use of rPET in thin-wall injection molding. Alpla has developed a technology for this. The modified rPET processed at Intopack comes from beverage bottles that were treated in Alpla's recycling factories. With nine recycling factories producing about 200,000 t of rPET per year, Alpla is one of the world's biggest manufacturers of recycled PET.

## *Deformation-Free up to 675 Newton*

Material tests from Alpla impressively show the advantages of thin-walled PET or rPET packaging. In a three-part series of experiments, the properties and behavior of a PET thin-walled cup (**Fig. 3**) were compared with a geometrically identical cup of PP. The PET cup consisted of 30 % recyclate and 70% virgin material. The polypropylene cup was 100 % virgin material, since, as mentioned above, EFSA has not approved PP recyclates.

For the mechanical inspection of the cup, Alpla performed a drop test according to an in-house specification. The base was, so to speak, "pulled away from under the feet" of the cup. In this manner, the PET and PP cups passed through five test series with a drop height of 90cm – this corresponds to an average table height – and five further series with a drop height of 120cm. The results show a clear trend in terms of product safety: After being dropped from a height of 90cm, the PET cup did not show any damage. After dropping from a height of 120cm, only a small crack could be seen in each of the five trials. The PP cup, on the other hand, exploded on impact – even from a height of only 90cm.

In a second trial, the top-load test, the filled cup was subjected to stress until it deformed. Over four test cycles, the PET cup withstands a force of 675N

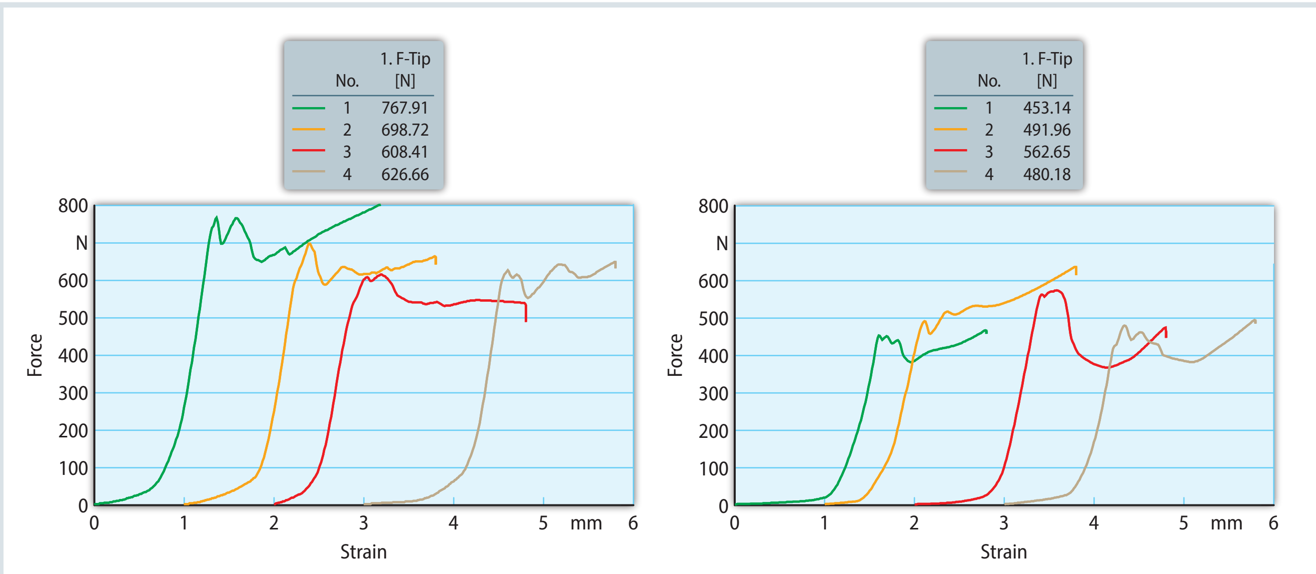


**Fig. 5.** If the curve profiles in the top load test are compared, it can be seen that the PET cup (left) withstands an almost 30% higher load than that of PP (right). Source: Alpla; graphic: © Hanser

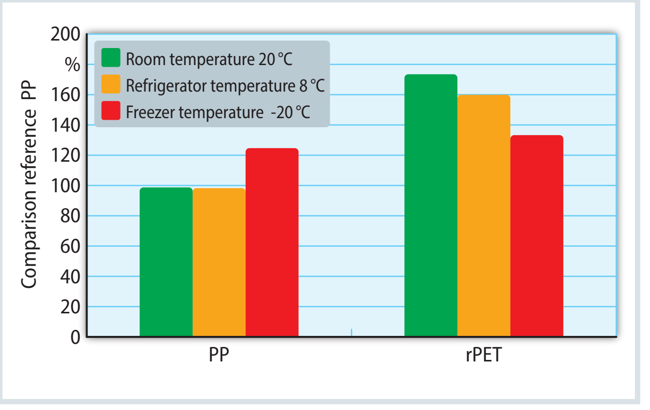


**Fig. 6.** The PET cup withstood significantly higher pressures in the breaking test than the comparison cup of PP. The superiority at refrigerator temperature underscores the suitability of PET packaging for cold-fill foods. Source: Alpla; graphic: © Hanser

on average, i.e. 68 kg. The PP cup was already shattered at an average force of 497 N. The PET cup thus withstood an almost 30 % higher load – an important finding, particularly for the transport and storage of thin-wall packaging (**Fig. 5**).

### *Stable Even at Extreme Temperatures*

In the final fracture test, the material behavior was investigated at different temperatures. Here, the head of a needle pressed onto the empty cup next to the gating point. In two of three tests, part failure occurred at a room temperature of 20 °C for the PP cup. The PET cup, on the other hand, resisted an average of 70 % higher pressure – without any impairment.

At 8 °C, which corresponds to refrigerator temperature, the PET cup in turn withstood a pressure that was on average 60 % above that of the PP cup. Once again, no damage to the material could be identified. From the freezer, at –20 °C, both the PP and PET cups withstood the pressure. The applied pressure was adjusted (**Fig. 6**).

The material tests from Alpla show impressively that thin-walled packaging of rPET is suitable for cold-fill foods, such as salads, spreads and dairy products.

Besides the above-described properties, the new packaging polymer also offers further material-specific advantages over PP. Thus, the barrier effect against oxygen is 20-times higher, which contributes to a longer shelf life of the foods. For an even better barrier effect, the packaging manufacturer Intopack is testing the combination of rPET with an EVOH layer. IPB Printing already offers all-round labels with EVOH layer, which reliably withstand the high injection pressures during rPET processing.

### *Exploiting the Full Potential of rPET*

All the aforementioned partner companies are committed to exploiting the full potential of the recycled material. To establish not only the bottle-to-bottle and bottle-to-cup, but also a cup-to-cup and cup-to-bottle cycle, separate material streams for food and non-food packaging are necessary. On the question of how to ensure the food quality of the recycled materials in the long term, Intopack, for example, is in contact with local recycling companies.

rPET is currently the only way for packaging manufacturers to offer customers a truly circular food packaging. Above all, however, it is the developments on the raw materials markets and political decisions that will determine the speed with which rPET becomes established in the field of thin-wall packaging. If the prices for virgin material fall, no one works with a higher proportion of recyclate than is legally required. Another challenge is the purity of the recycled materials. If Europe wants to be 100 % circular by 2050, then there must be no more downcycling. ■

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## End of the Series

The third part concludes the series about sustainability in injection molding. The series has the motto: **"Carbon Busters"** and describes the industry's commitment to reducing its carbon footprint. Part 1 of the series (Fit for the Circular Economy) was published in edition 5/2023, part 2 (Transparency as Basis for Energy Efficiency) in edition 6/23.