Processing of Post-Consumer Waste with Omni

New Perspectives for Polystyrene

The performance of the Omni recycling systems from Gneuss makes it possible to close new recycling loops. Performance parameters that were previously only conceivable when recycling PET bottles are now also possible with other materials such as polystyrene. This opens up new recycling possibilities for plastic packaging.

The Omni series is based on a Gneuss extruder, a robust vacuum system and an RSFgenius high performance filter. As an option, material can be fed into the extruder via a 3C Rotary Feeder. © Gneuss

Polystyrene (PS) has a large share in the packaging industry, both as a foamed product for trays and as an unfoamed product for the production of cups – and until recently it has been considered a "single-use plastic", i.e. a plastic that cannot be recycled or is very difficult to recycle. This is partly due to the collection system and partly due to the sorting systems used to date. In Germany, PS packaging (yogurt cups, meat trays, plant pots, etc.) is collected in the yellow bag and sent for recycling. Due to impurities and cross-contamination with other household waste, the cycle back into food packaging could not be closed.

An example from East Asia shows how things can be done differently: in Japan, the market leader decided several years ago to tackle the problem and collect the PS packaging directly from the supermarket, which consumers return after use. At the same time, this manufacturer became aware of the Gneuss "Super Clean Technology" for polyethylene terephthalate (PET), which was successfully registered with the U.S. Food and Drug Administration (FDA) in 2009 and received a Letter of Non-Objection (LNO). Compared to other processes, this Gneuss technology does not require any upstream or downstream process steps. This is very important for polystyrene because, unlike polyester, it does not need to be dried prior to processing and molding.

Super Clean in One Process Step

The "Gneuss Super Clean Process" has been adapted to the processing of polystyrene and new successful challenge tests have been carried out. In these tests, a mixture of different model substances is added to the original polymer and allowed to diffuse into the polymer over a certain storage time and at a certain temperature. The contaminated polymer is then subjected to the decontamination step and the resulting regranulate is analyzed for the model substances.

The substances are selected in such a way that they represent a large cross section of possible contaminants during the recycling process:

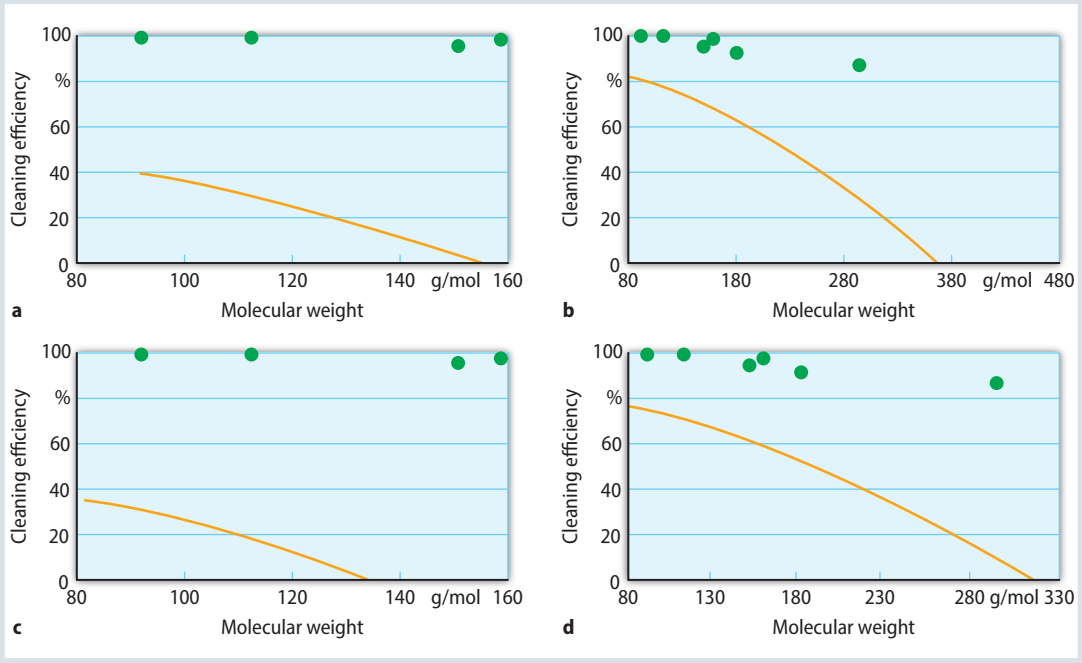

Fig. 1. Results of the challenge tests a) 250 g yogurt per day for a toddler, 2 h 70 °C, followed by 40 days at 6 °C (hot filled yogurt), b) 500 g fruit or vegetables per day for a toddler, 30 d at 25 °C, c) 750 ml cold drinks per day for a toddler, 1 d at 25 °C (cold drinks), d)750 ml hot drinks per day for a toddler, 2 h at 70 °C (hot drinks) Source: Gneuss; graphic: © Hanser

- highly volatile,
- lowly volatile,
- polar,
- non-polar,
- etc.

A before/after comparison can be used to calculate the cleaning efficiency, which must not fall below prescribed limits depending on the end product. challenge tests were so successful that a petition was written to the FDA, which responded with an LNO for this process. In addition to the highly efficient superclean process, the tests also include the collection, sorting and washing of post-consumer products, which have been used to produce plastics for food packaging again since 2016.

In the fall of 2022, the European Food Safety Authority (EFSA) published a new guideline that considers all mechanical recycling processes (except PET) as new technologies that need to be assessed and applied for separately. As a result of this new requirement, further tests were successfully carried out (**Fig. 1**). The results of the cleaning efficiency achieved in the challenge tests (green dots) are shown here, as well as the results of the comparison with the minimum cleaning efficiency for various applications (yellow line). It can be seen that the efficiency achieved by the Gneuss Super Clean Process is well above the requirements. Using this process, it is therefore possible to produce products from 100 % post-consumer waste that are safe even under different storage conditions.

This outstanding performance is achieved by using a Gneuss Omni recycling system (**Titel figure**). This line purifies the polymer by subjecting it to a highly efficient degassing process using an MRS extruder (**Fig. 2**) to remove volatile impurities. Hard impurities are then removed by ultra-fine filtration using the RSFgenius filtration system (**Fig. 3**). Various other regional approvals and brand owner approvals, such as Anvisa and Invima, have since confirmed the decontamination efficiency.

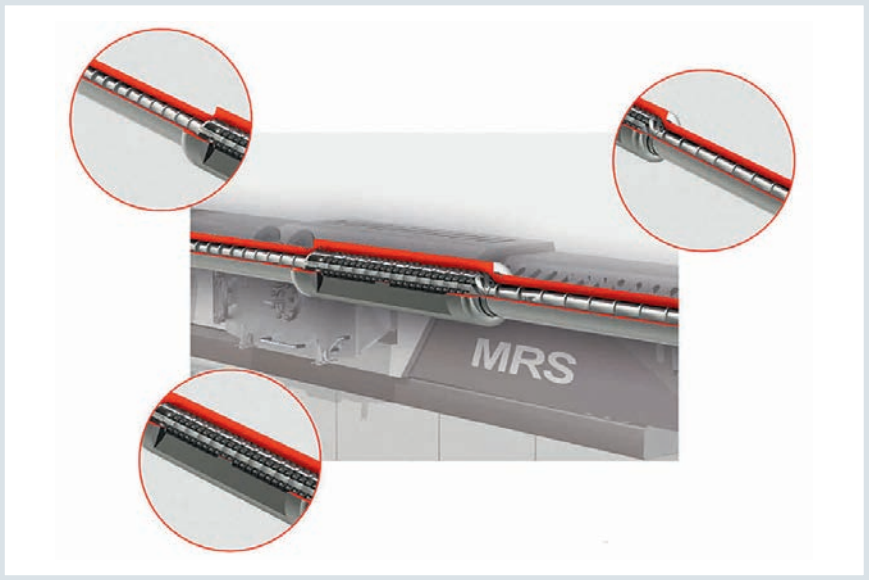

Fig. 2. The MRS extruder is based on a conventional single-screw extruder. It is equipped with a multi-screw element in the middle section for optimum degassing. © Gneuss

Features of the Omni Series

In addition to a wide range of input materials such as PS, polypropylene (PP), polytethylene (PE), PET, polylactide (PLA), etc., typical applications for the Omni include the processing of PET bottle flakes into thermoformed film (suitable for food contact), staple fiber, POY, FDY, BCF or strapping tapes. The Omni series is also used in the decontamination of post-consumer waste for the produc- »

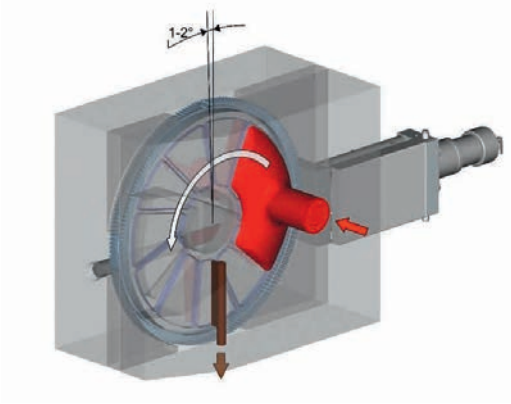

Fig. 3. The RSFgenius filtration system is fully automatic and guarantees 100 % system availability. The screens are changed approximately every 1–16 weeks depending on usage (takes about 20–30 minutes) and have no impact on the production process or product quality.

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tion of direct food contact products such as bottle caps, coffee caps and for odor reduction and degassing of PA, SAN or other polymers.

In addition to its compact design, which requires very little space and can therefore usually be easily integrated into existing premises, the Omni scores highly in terms of flexibility. The fully automated control of vacuum, extruder, dosing, degassing dwell time and filter exchange ensures a consistently high quality of the recyclate and also allows the operator to use cost-effective input materials. It is becoming increasingly important to be able to produce regardless of the properties of the input materials, especially in the case of varying and uncertain input qualities in the future.

The compact design also results in very low energy consumption. Any energy used in the extrusion process is designed to be used in the next process step. This not only has a noticeable effect on electricity and gas consumption, but also significantly reduces the CO_2 footprint of the recycling process.

The cleaning efficiency of the MRS extrusion process and Rotary Filtration Systems is unique in the world. In a single, simple extrusion step, harmful contaminants can be removed so thoroughly that the resulting recycled pellets are safe for use in food contact applications. The short residence time in the system largely eliminates thermal damage, so the chemical properties of the recycled material are virtually identical to virgin material. As a result, products can be manufactured that are equivalent to those made from virgin material. Material changes, e.g. for batch changes, are possible within minutes due to the short residence time, so that the flexibility requirements of a new recycling plant are fully met and production interruptions can be kept to a minimum (**Fig. 4**).

Omni recycling technologies can be easily integrated into existing production lines. Further energy savings and CO_2 reductions can be achieved by ensuring online recycling of recyclates.

Application Example from Colombia

The Colombian company Carvajal purchased an Omni90 line a few years ago with a throughput of about 300 to 400 kg/h (**Fig. 5**). Carvajal uses this line to produce alternating thermoforming sheet of PET and PS, each with a thickness of about 400 µm. From non-crystallized and non-pre-dried bottle flakes, a transparent thermoforming sheet is produced in which cereal is packaged.

The line also processes post-consumer PS waste without pre-treatment into a thermoforming sheet that is used to make yogurt containers (**Fig. 6**). These cups are filled by Alpina, one of the country's largest manufacturers of dairy products. In both cases, the flakes are first melted in the extruder and decontaminated in the degassing stage, so that

Key Components of Omni

3C Rotary Feeder: This is a cutter/compactor specially adapted to the extruder, which shreds and compacts loose bulk material in a single step with a short residence time, introduces thermal energy and continuously feeds it to the extruder. In this way, a very wide range of materials can be processed on the machine, as the combination of shredding, compacting and conditioning as a pre-stage to the extrusion process creates a very wide process window.

Extruder: The patented Gneuss MRS multi-screw extruder is used for PS recycling. Based on the robust single screw concept, the extruder is equipped with a Multi Rotation System (MRS) in the middle section. This system ensures a very large polymer surface area, by means of satellite screws that rotate in the opposite direction to the extruder drum on their circular path. In addition, this whole section is under vacuum. The surface created in the MRS section allows highly efficient decontamination, mixing and viscosity control of the PS. The use of multiple screws provides unique degassing and homogenization of the melt. To ensure unhindered degassing of the medium, the cylinder in the multi-screw section is open along its entire length. As a result, the melt in this area is completely under vacuum.

Vacuum systems : Gneuss has developed its own vacuum systems for the extraction of volatile impurities, some of which have patented separation systems. Due to the large melt surface in the MRS extruder, the suction capacity is considerably higher than in conventional systems, so that large quantities of volatile impurities can be extracted from the polymer and separated from the vacuum flow by means of separator systems. In addition to a water ring pump vacuum system, Gneuss also offers deep vacuum systems with appropriate separators.

Rotary filtration system: Recycling applications always use the patented Gneuss RSFgenius filtration system, which features fully automatic screen cleaning with guaranteed pressure and process consistency. A high-pressure segment backflush system cleans the contaminated screens directly before they re-enter the melt channel, allowing automatic screen re-uses up to 400 times and filter finenesses of less than 10 µm.

Online Viscometer VIS: If required, Omni recycling systems can be equipped with the innovative VIS online viscosity measurement system. Using a high-precision, rigid gear pump, a small partial flow of polymer melt is diverted from the main melt channel and forced through a precisely manufactured slotted capillary. The data measured there can be used to improve quality assurance using the viscometer.

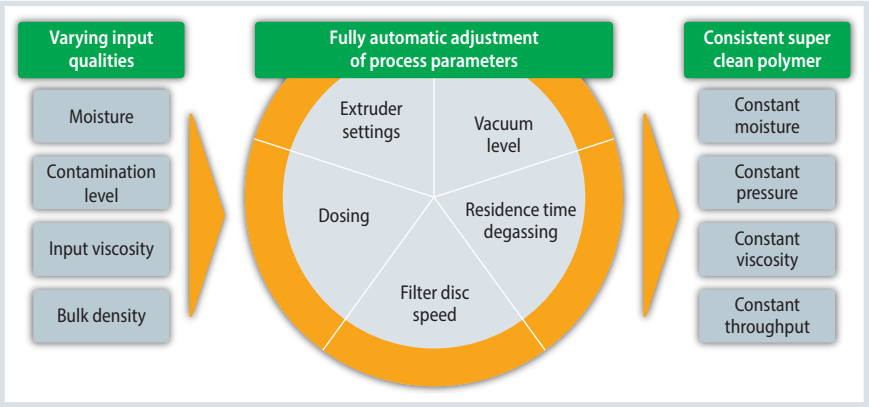

Fig. 4. Features of the Omni recycling system: high flexibility thanks to fully automatic process parameters. © Gneuss

the melt exiting the extruder, which is then filtered at 160 µm by the RSFgenius90, is 100 % food-contact compliant even before it exits the die into the calender. The approval of the new post-consumer PET and PS products for direct food contact was first confirmed by the FDA and finally by the local Colombian food authority Invima.

Fig. 6. Application example from Alpina: yoghurt cups made from rPET and rPS. © Gneuss

Conclusion

The Omni recycling plant, based on Gneuss technologies, enables the efficient purification of polymers such as polystyrene, which is widely used in packaging but has long been considered difficult to recycle. The flexibility of the system makes it possible for the first time to process post-consumer waste from different collection systems to the point where it can be used to make products that can come into direct contact with food. This is achieved in a single extrusion step without the need for complex pre- or post-treatment. This helps to expand recycling opportunities and secure economic benefits. ■

Info

Text

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Company Profile

Since its foundation in 1983, **Gneuss** has positioned itself worldwide as a technology leader in the extrusion and recycling of plastics and plastic waste of all kinds. While in the past the focus was primarily on the development, manufacture and sale of machines and system components, Gneuss now concentrates on complete turnkey systems with the Omni recycling systems.

www.gneuss.com/en

Fig. 5. Omni90 plant at Carvajal: The Colombian company employs more than 17,000 employees. © Gneuss