Glycolic Depolymerization versus Mechanical Bottle-to-Bottle Recycling

Glycol Turns the Extruder into a Turbo

Conventional PET recycling lines are based on single-screw extruders with maximum output rates of two and a half tons per hour. Since 2004, KraussMaffei has been researching a process to significantly increase these quantities with the help of glycol and the use of a twin-screw extruder. Given the current high demand for rPET materials, this technology is becoming increasingly important.

The recycling and new production of PET bottles is probably the best-known process in the field of plastics recycling. This process, in which sorted PET plastic bottles are washed, melted, filtered and pelletized before they are used as base material for new PET bottles, has for many years been one of the very few established recycling technologies. In general, a PET reuse rate of over 30 % is currently achieved worldwide.

In view of the growing demand for recycled plastics, the requirements in terms of material quantity and quality have also increased substantially. The established processes applied in this field are based on single-screw systems and achieve throughput rates of up to 2.5 t per hour and machine. Against this background and in view of the fact that polymer structures can be rebuilt to achieve the quality level of virgin material, glycolytic decomposition of PET materials is gaining increasing attention. As early as in 2004, KraussMaffei put into operation the first lines designed for this type of process, the interest in which has grown significantly in recent years.

Sustainability Takes Center Stage – Less Focus on Prices

In the past few years, this trend has been further fueled by declining prices for PET virgin material, so that only the use of large-scale machines ensures profitability. While the price for PET virgin material was rising before 2010 and already minor quantities of rPET were considered competitive from a purely economic point of view, the situation has changed drastically since.

Today, PET polymer producers are focusing on the use of rPET also for reasons of sustainability. In PET production, several metric tons of rPET are now added during glycolytic decomposition in the same process, so that twin-screw extruders are further gaining ground.

Melt Viscosity under Control

The process offered by KraussMaffei starts with the feeding system, which then transfers the material to the twin-screw extruder. Here, the washed and dried flakes are melted and homogenized while any adhering moisture and low-boiling contamination are removed via the vacuum degassing dome. Liquid glycol is then injected into the processing section and homogeneously mixed. The chemical reaction thus triggered decomposes and shortens the polymer chains, which results in the formation of oligomers. The PET bottle fraction with an intrinsic viscosity of 0.7 to 0.8 dl/g is thus converted into a low-viscosity melt. The viscosity can be decreased in a controlled manner, with an IV value between 0.5 and 0.2 dl/g being generally required for the subsequent process steps. This is where the exceptional strength of the process becomes apparent: the lower the viscosity, the finer the filters that can be used in the following process step.

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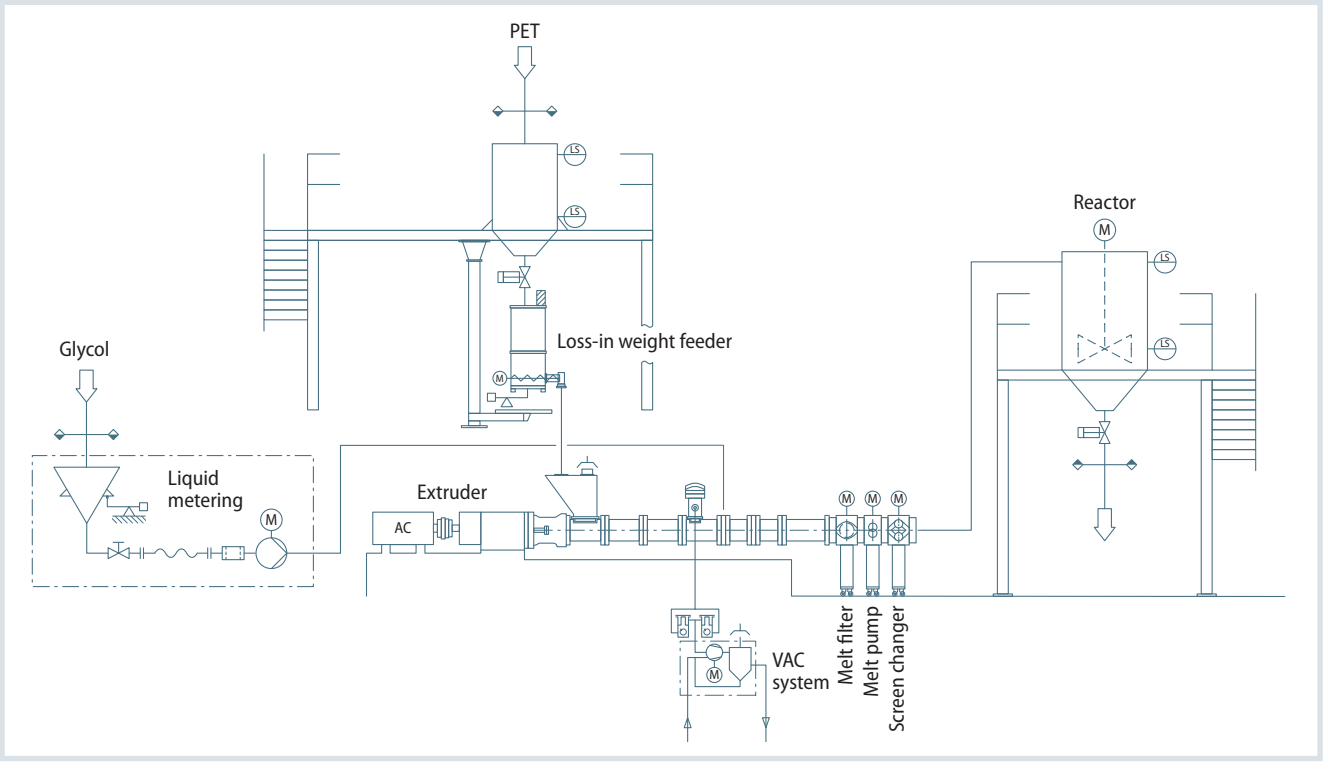

The above diagram illustrates the operation of the twin-screw extruder during rPET production, where exact metering, extrusion and filtering of the glycol mixture are essential. Source: KraussMaffei, © Hanser

Filters with a filter grade of 60 µm or better ensure that even extremely small contaminants are reliably removed from the melt. With the PET production process used in the large-scale petrochemical industry, the recycled low-viscosity melt is subsequently fed into the final reactor together with the material flow coming from the reactor for virgin material. Here, this input material is repolymerized into long-chain polymers with the desired intrinsic viscosity value.

Achieving an IV value of 0.2 dl/g places high demands on the machine and process. The seals and the tolerance values of extruder, melt pumps and filters must be perfectly adapted for this purpose. KraussMaffei achieves this goal through extremely tight manufacturing tolerances and "quality made in Germany".

In view of the market demand for the use of the finest filter stages, numerous tests were carried out in KraussMaffei's process laboratories in order to achieve an IV value of 0.2 dl/g and lower. In addition to the lowest possible viscosity, the objective was not to use any additives in order to obtain a high melt quality without any foreign substance. The addition of high amounts of glycol was a major challenge, as there were no downstream reactors available in the process laboratory to repolymerize the material and repelletization was therefore not possible. A viscosity of 0.15 dl/g was achieved in the trials and the melt was discharged by means of a gear pump. The tests confirmed that this viscosity value could be obtained by using 2 to 3 % of glycol and that it is not increased or decreased by adding a higher amount of glycol.

During all these tests involving the handling of ethylene and glycol quantities, special attention must be paid to protective measures in accordance with the Atex directive due to the flash and boiling point. On the one hand, any leaks in the glycol feeding system may cause ignition or deflagration when glycol ignites on hot surfaces of the extruder or vaporizes and subsequently catches fire. On the other hand, the glycol vapors escaping from the melt can also ignite or trigger deflagration. Such a vapor formation is particularly noticeable in the case of higher proportions of glycol (> 5 %).

Thanks to the low viscosity, filters with an even finer mesh width can be used. The melt quality is thus additionally improved, which allows the share of recycled material in the final product to be increased. A further reduction in viscosity is conceivable through the incorporation of additives or the use of new processes in order to install even finer filters, which could possibly remove even coarse color pigments. It is obvious that the twin-screw extruder for this type of process is an excellent alternative to conventional methods. The high output rates and the unparalleled quality achieved by KraussMaffei will further fuel this development. ■

Info

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