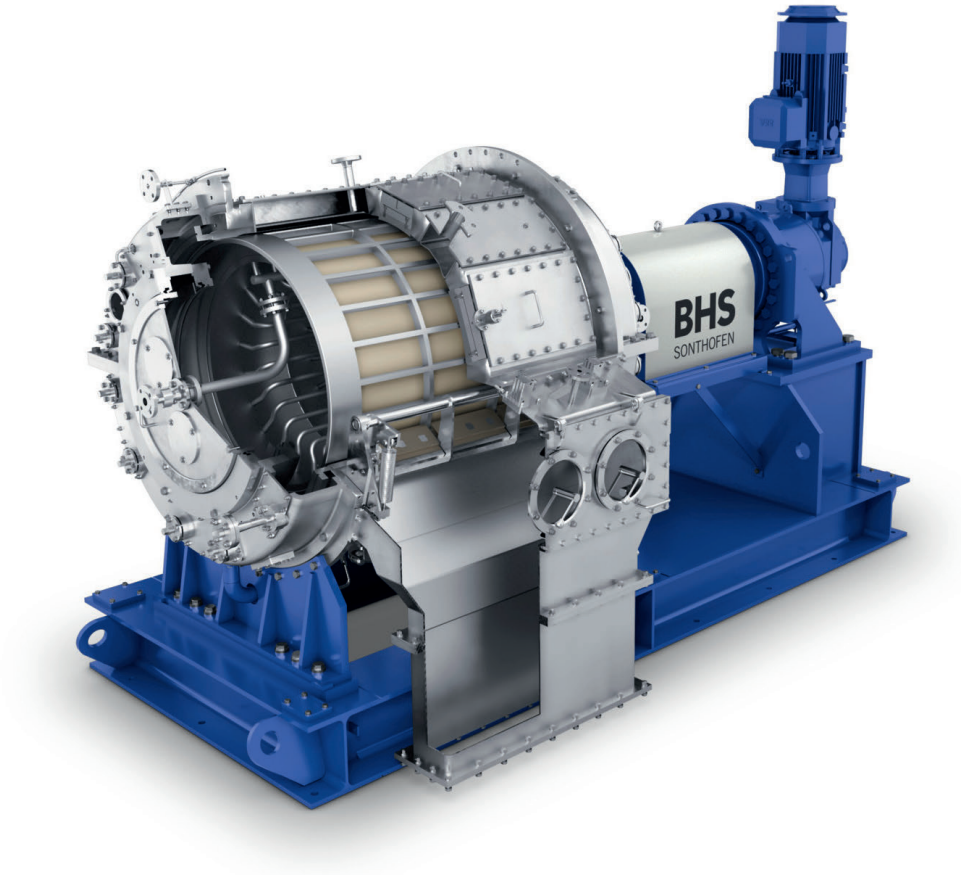
Efficient Filtration and Cake Washing for Improved Chemical Recycling of PET

Well Filtered is Better Recycled

Chemical recycling processes permit treatment of plastic waste – also if highly contaminated. The results are recyclates that have the same quality as virgin material. For example, newly developed processes enable used PET plastics to be returned to the material cycle. Hereby, the end products' quality is determined by the recycled material's purity. This can be significantly increased by means of efficient filtration and cake washing.



The RPF rotary pressure filter is a continuously operating device for pressure filtration, cake washing, and drying of suspensions. Cake washing plays an important role for improving the processing efficiency of chemical recycling.

Plastic waste causes severe environmental problems. However, suitable recycling processes permit waste plastic to be used as a valuable secondary raw material – a decisive step, which not only permits the huge amounts of waste to be reduced, but also counters the raw material shortage. The need for increased waste recycling has also been recognized by politicians, and corresponding regulatory frameworks have been launched. For example, in the EU from 2025 onwards, bottles made of polyethylene terephthalate (PET) must contain at least 25 percent of recycled plastic, and by 2030, all packaging must be recyclable.

But higher recycling rates also offer considerable economic potential, provided that the plastics industry introduces the right steps. According to the consulting firm McKinsey, reutilization and recycling of plastics could lead to increased earnings of up to USD 60 billion for industry [1].

However, mechanical recycling processes have limitations. For mechanical recycling, the plastic is melted and then converted to recyclate, whereby the material's quality suffers. Therefore, it is not possible e.g. to produce new bottles from 100 % recycled PET. Consequently, manufacturers are searching for alternative methods. Meanwhile, an increasing number of companies has successfully implemented chemical recycling.

Chemical Recycling: Products Achieve the Quality of Virgin Material

Chemical recycling includes all methods for the depolymerization of plastics. For this, waste plastic is first shredded mechanically, and then chemically decomposed into the basic constituents, frequently by using a catalyst or enzymes. The resulting recyclate exhibits the same properties as virgin materials produced from crude oil, and can be returned directly into the plastics manufacturing process. The decisive difference to mechanical recycling is: with the chemical method, very pure and high-quality materials from the recycling operation are available for plastic production. The quality of the end products is equal to that of virgin material.

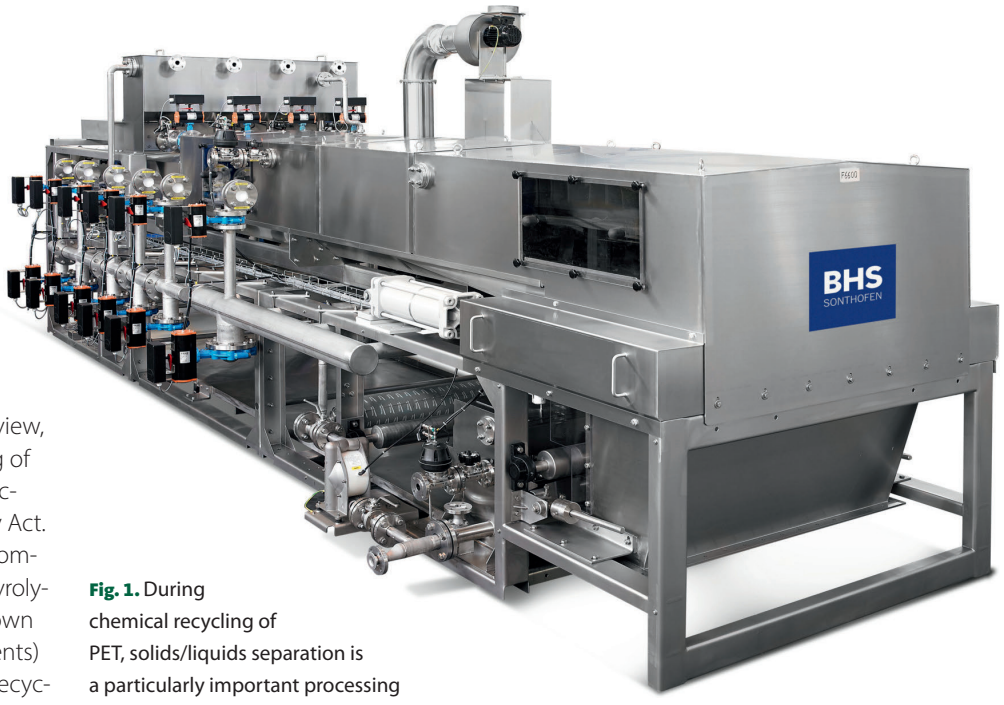


Fig. 1. During chemical recycling of PET, solids/liquids separation is a particularly important processing step. Corresponding systems from BHS-Sonthofen are already being used by several companies. © BHS-Sonthofen

In this way, for the first time, a closed raw materials loop for plastics has been created. Therefore, chemical recycling opens up new possibilities, and must presently be seen as the only way to achieve the targeted recycling rates. The German Federal Environmental Agency agrees with this view, and has classified chemical recycling of plastics as the preferred process in accordance with the Circular Economy Act.

Apart from thermochemical decomposition in the absence of oxygen (pyrolysis), and gasification, the process known as solvolysis (dissociation using solvents) has been discussed and tested as a recycling method in recent years. Under the influence of suitable agents, mainly thermoplastic materials such as PET are liquefied and then dissociated into their monomers. Because different solvents are used, solvolysis processes can be further distinguished: the most common methods include glycolysis, methanolysis, and hydrolysis, partially with enzymatic boosting [2]. All three processes are suitable for decomposing PET (**Info box**). Which process is used, depends on the quality of the input material.

High Monomer Purity

The processes named above produce monomers in the same quality as their petroleum-based pendants. The monomers are dissolved in the process liquids, and must be separated. As soon as depolymerization has been completed, the monomers are precipitated from the solution, and the suspension passed through a filter. Here, the solvents, catalysts, and other constituents are removed.

To a great extent, the quality of the produced PET virgin material depends on the monomer's purity, as contaminations clearly impair the transformation in polymers, and the reactions take a different course. The product purity required for successful recycling is decisively achieved by solids/liquids separation with efficient cake washing (**Fig. 1**). For this step, several international companies who employ one of the described recycling processes make use of the BHS-Sonthofen processing solutions.

Multi-Stage Counterflow Washing with Lower Consumption of Resources

For one of these customers, BHS-Sonthofen supplied two Type BF indexing belt filters (**Fig. 2**). The machines operate in parallel in the production line with a throughput of 2 t/h. The Type BF indexing belt filter is a continuously working horizontal vacuum filter that is used for efficient and gentle separation of sedimenting solids from suspensions.

A multi-stage counterflow washer with washing filtrates is used, which represents a highly efficient form of cake washing. Hereby, fresh, application-specific washing liquid is used in the last washing zone, which is then re-used in the previous zones. This procedure is especially suited to generate high purity – with a low consumption of washing liquid and energy.

Particularly in the context that processing efficiency will also decide how chemical plastic recycling will become established in the market in future, cake washing plays a very important role. Another advantage is that fresh liquid is used for washing the filter cloth, before it is used again for filtration and later cake washing. The solids washed off the cloth are returned to the process and recycled, which increases product yield.

BHS-Sonthofen has adapted its filtration process to the demands of chemical recycling. This permits high-purity monomers to be reclaimed efficiently, which can be used for the »

Solvolysis of PET

For **glycolysis**, various glycols are used to dissociate the polymers. The glycol diffuses into the polymer's structure. Hereby, a mixture of bis(hydroxyethyl)terephthalate (BHET) and short-chain oligomers is created, which is cleaned and can then be reused for the production of PET.
For **methanolysis**, the polyester structure is dissociated by methanol, mostly by means of catalysts. Hereby, monomers are recovered for renewed PET synthesis – in this case dimethyl terephthalate and ethylene glycol. Because special safety measures are required for methanolysis, the investment costs are higher than for glycolysis.
The energy input for **hydrolysis** is comparatively low. Hereby, PET is dissociated into terephthalic acid and ethylene glycol by adding e.g. sulfuric acid and sodium hydroxide [3]. If supported with special enzymes, hydrolysis is particularly time & energy saving, and conserves resources.

Fig. 2. The BHS indexing belt filter is made of stainless steel and supports multiple counterflow washing.

synthesis of new PET without additional processing steps. Hereby, the company was able to resort to the experience acquired from the use of their filters in numerous plastic applications.

Rotary Pressure Filter for Chemical Recycling

In addition, the Type RPF rotary pressure filter (**Fig. 3**) is suitable for chemical recycling of PET. It is a continuously operating device for pressure filtration, cake washing, and drying of suspensions. Experience values and comprehensive trials have shown that both technologies can be used successfully for chemical recycling of PET. BHS-Sonthofen's many years of experience in the production of virgin PET material proved to be advantageous during development of the filter.

Chemical plastic recycling offers several benefits: it prevents the combustion of plastics (thermal utilization), and the consumption of fossil raw materials is reduced. Highly contaminated plastic waste can also be recycled, and waste flows of materials that previously were out of the question can now be recycled. However, ecological and economic challenges must still be overcome. Regarding energy and consumption of resources, the processes must be designed so that they exhibit a positive ecological balance, and are also economically viable. Therefore – and apart from the quality of the reclaimed monomer – processing efficiency plays a major role when it comes to the application of the described processes on an industrial scale. For this, smart processing solutions are required, which ensure product quality and efficiency in equal measure.

High Monomer Yield with Suitable Solids/Liquids Separation

The use of efficient machines permits a high yield of monomers to be achieved, for a reduced consumption of energy and resources. A customized solution for solids/liquids separation for the respective customer application is a decisive contribution for introducing chemical plastics recycling on a large scale. If attempts are successful to establish technically functional and commercially viable solutions in the market, the industry will have made a large step towards the sustainable production of plastics. ■

Fig. 3. Pressure filtration can also be used in chemical recycling of PET, e.g. with the rotary pressure filter RPF.

Info

Text

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References & Digital Version

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