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Closing the Plastic Cycle

Highly Efficient Filtration for Chemical Recycling of PET

Plastics can be reused again and again, delivering recycled items of the same quality as new goods – thanks to chemical recycling processes. In the case of PET in particular, new, innovative processes are successfully breaking down used plastics into their chemical components and thus reintroducing them into the material cycle. All these approaches have one thing in common: The purity of the recovered components determines the quality of the end products. A closer look at the processes shows how efficient filtration and cake washing contribute to a technically functional and economically viable solution.

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Plastic waste is one of the key environmental problems of our time. But if suitable recycling processes are applied, used plastic can be turned into a valuable secondary raw material – and this represents a crucial step towards addressing the issues of raw material shortages and high waste volumes. The need for these processes is also reflected in the legal framework: in the EU from 2025 onwards, bottles made of polyethylene terephthalate (PET) must contain at least 25 percent recycled plastic, and by 2030 all packaging on the local market must be reusable and recyclable.

But higher recycling rates also offer considerable economic potential, provided that the plastic industry takes the right steps today. According to the consulting firm McKinsey, reutilization and recycling plastics could lead to increased earnings of up to $60 billion for the industry. [Cf. Mc Kinsey (2018): How plastics waste recycling could transform the chemical industry.]

The BHS indexing belt filter is made of stainless steel and supports multi-stage countercurrent washing

Chemical recycling of PET

Conventional recycling processes have limitations. For mechanical recycling, the plastic is melted and then converted to recyclate, whereby the material's quality suffers. The process reduces the quality of the plastic. Therefore, it is impossible to produce new bottles from 100 percent recycled PET, for instance. Consequently, manufacturers are looking for and evaluating alternative methods. In the meantime, an increasing number of companies are successfully using chemical recycling to achieve a recycling economy.

Chemical recycling is the term used to describe all processes used for the depolymerization of plastics. In more simple terms, plastic objects are first shredded mechanically and then broken down chemically into their basic chemical building blocks, often using a catalyst or enzyme. These have the same properties as raw materials produced from petroleum and are fed directly back into the plastics manufacturing process. The decisive difference to mechanical recycling is that high-quality, ultra-pure materials gained through recycling flow into the plastics production process. The quality of the end products is equal to that of virgin material.

In this way, for the first time, a closed raw materials loop for recycling has been created. Chemical recycling thus opens up new avenues and can at present be regarded as an alternative building block on the way to achieving the targeted recycling quotas. The German Federal Environment Agency

Solid-liquid separation is a particularly important process step in the chemical recycling of PET. Several companies rely on technology from BHS-Sonthofen

shares this assessment and classifies the chemical recycling of plastics as a preferred process under the Circular Economy Act.

In addition to thermochemical decomposition in the absence of oxygen (pyrolysis) and gasification, recycling technologies that have been discussed and tested in recent years include solvent decomposition, known as solvolysis. Under the action of suitable agents, thermoplastics in particular, such as PET, are liquefied and broken down into their monomers. Since different solvents are used, the solvolysis processes can be broken down into the common methods using glycolysis, methanolysis and hydrolysis (sometimes with enzymatic enhancement). [Cf. The next generation of recycling – giving plastic waste a new life: Angew. Chem. Int. Ed. (2020), 59, P. 15402-15423.] All three processes are suitable for degrading PET. The decision of which process is most suitable depends on the quality of the input material.

High monomer purity

The processes named above produce monomers of the same quality as their petroleum-based counterparts. These are present in the process liquids in a dissolved state and must be separated. In other words, once depolymerization is complete, the monomers are precipitated from the solution and the suspension is fed to a filter. This is where the separation of solvents, catalysts and other components takes place.

Pressure filtration is also suitable for use in chemical PET recycling

The BHS rotary pressure filter of type RPF is a continuously operating system for pressure filtration, cake washing and drying of suspensions

The quality of the virgin PET to be produced depends to a large extent on the purity of the monomer, since impurities significantly impair the conversion to polymers and the reactions take a different course. This product purity, which is necessary for a successful recycling process, is mainly achieved by solid-liquid separation with effective cake washing. Several international companies that apply one of the recycling processes described rely on the proven process engineering solutions of BHS-Sonthofen for this step.

Multi-stage counterflow washing with low resource consumption

BHS-Sonthofen supplied two indexing belt filters of type BF to one of these customers. Both machines operate in parallel in the production line with a throughput rate of 2 t/h. The indexing belt filter of type BF is a continuously operating, horizontal vacuum filter used for the efficient and gentle separation of sedimenting solids from suspensions.

The application involves multi-stage counterflow washing with washing filtrates, which is a highly efficient method of cake washing. In this process, fresh, application-specific washing liquid is used in the final washing zone, which is then reused in the preceding zones. This operating mode is particularly suitable for producing a high level of purity despite low washing liquid and energy consumption.

This is a particularly important feature of cake washing, especially in view of the fact that process efficiency is one of the factors that will determine how chemical plastics recycling develops on the market in the future. And, as an added benefit, the fresh liquid is used to wash the filter cloth before it is used again for filtration and then cake washing. The solid material washed off the cloth is returned to the cycle and reused as a product. This significantly increases the product yield.

BHS-Sonthofen has adapted its filtration process to the requirements of chemical recycling. This means that monomers can be efficiently recovered at high purity levels, allowing it to be used for the synthesis of new PET without requiring any further process steps. Here, the company was also able to draw on its experience from the use of its filters in numerous plastics applications.

Alternative pressure filtration

Another technology suitable for use in the chemical recycling of PET is the BHS rotary pressure filter of type RPF. This is a continuously operating device for pressure filtration, cake washing and drying of suspensions. BHS-Sonthofen has proven through empirical data and extensive trials that both technologies can be successfully used for the chemical recycling of PET. Customers also benefit from the company's many years of experience in the production of virgin PET.

Outlook: Product quality and process efficiency are decisive

In summary, chemical plastic recycling offers several advantages: The new processes avoid so-called "thermal recycling," which is nothing more than the incineration of plastics, and they also help to reduce the use of fossil raw materials. Even heavily contaminated plastic waste can be recycled, and waste streams that were previously ineligible for recycling can be used. However, there are challenges of an ecological and economic nature to be overcome. In terms of energy and resource consumption, the processes must be designed in such a way that they have a positive eco-balance and are also viable from an economic perspective.

Therefore, in addition to the quality of the recovered monomers, process efficiency is the most decisive factor when it comes to the industrial use of the processes described.

This calls for new, innovative process solutions that ensure product quality and efficiency in equal measure.

With the use of efficient machines, high yields of monomers are achieved in addition to reduced energy and resource consumption. A tailor-made solution for solid-liquid separation for the respective customer application thus contributes decisively to making the chemical recycling of plastics feasible on a large scale. If technically functional and commercially viable solutions can be established on the market, the industry will have made a decisive breakthrough in the sustainable production of plastics.

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