Fully-Automatic Melt Filtration System: New Possibilities in Plastics Recycling

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1. Introduction

Plastics recycling, in the context of this paper, means the transformation of a pure type of plastic waste into a clean, high-quality, new product. In most applications, a new, clean material (e.g. pellet) is manufactured for further processing in order to obtain the new final product. To achieve this, first of all, diverse cleaning operations (sorting, washing etc.) have to be carried out. Then, an extruder has to be supplied with the recycled material (as constant as possible). The material is molten and homogenized and should be well vented. After the extruder a filtration step takes place, usually followed by the pelletizing step or, in direct recycling, followed by the final product processing, e.g. film casting or fiber spinning.

The filtration step holds a key position in plastics recycling as it is decisive with regard to the quality of the pellets or the final product and its constant level and, therefore, with regard to the added value. If the quality is bad and varying, the market value achieved is lower.

Ideally, the filtration step should ensure the following aspects:

1. Consistent and high melt purity
2. High cost efficiency through minimization of melt losses, screen costs and operator work.
3. High availability of the line, i.e. a permanent and stable production process without interruptions and without disturbances.

Gneuss Kunststofftechnik GmbH, Bad Oeynhausen/Germany has developed a filtration system that meets these requirements. This system offers new possibilities in the field of plastics recycling. In pellet production a better and constant pellet quality can be achieved with a high availability of the line. Thanks to its mode of operation, direct recycling is also possible; the costs for pellet production are thus saved.

In the following, the fully-automatic filtration system RSF*genius* will be presented and examples of the successful installation of this system in PET recycling lines will be given and the new possibilities that arose will be presented.

2. The fully-automatic filtration system RSF*genius*

Gneuss has been manufacturing process-constant and continuous filtration systems for the cleaning of plastic melts for many years. With these, a constant melt quality as well as a reduction in costs can be achieved. The main characteristic of Gneuss filtration systems is the patented Rotary Technology, which is based on a filter disk rotating between two filter blocks. The special filter media are located on the filter disk in a ring pattern. Screen changes are actuated by a pressure and/or time controller. The filter disk is indexed in small increments, replacing a partial area of the screen at a time. Contaminated screenpacks are automatically indexed out of the melt channel where they are accessible from the outside. With this an automatic exchange of contaminated screens without any influence on the process is guaranteed. The filtration system is sealed by very hard and flat contact surfaces, without sealing elements. This makes the system operate practically wear-free. Dependent on the size of the system, it is laid out for pressures of up to 10,000 psi.

The filtration system that will be presented in more detail is the model RSF*genius*. This is a continuous, process-constant, pressure-constant and fully-automatic filtration system.

The technical layout of this filtration system is shown in fig. 1.

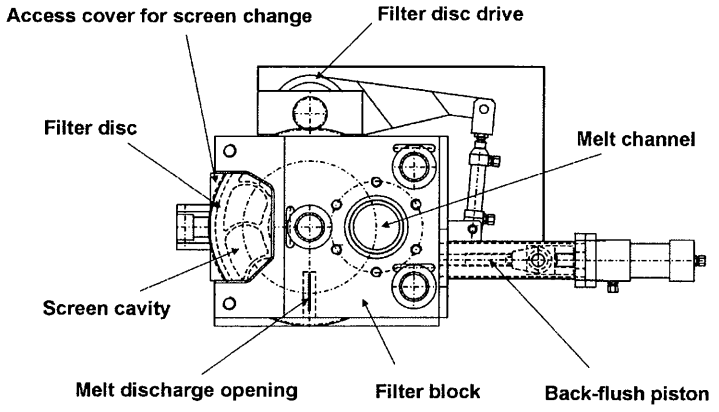

Fig. 1: The technical layout of the RSF*genius*

The filter disk – on which the screen cavities are located in a ring pattern – is completely encapsulated by the two filter blocks (this makes this system well suitable for sensitive melts like PET or PA). Screens can be inserted into the cavities by opening a small cover giving access to the cavities (see fig. 2). The production process is not disturbed by a screen change. With a certain pressure increase upstream of the filtration system, the filter disk is rotated (or "indexed") in steps of < 1° by means of a hydraulic drive. It is thus guaranteed that the free screen surface area is always kept constant. By indexing in very small steps a pressure constant operation (+/- 2 bar i.e. +/- 30 psi) is achieved.

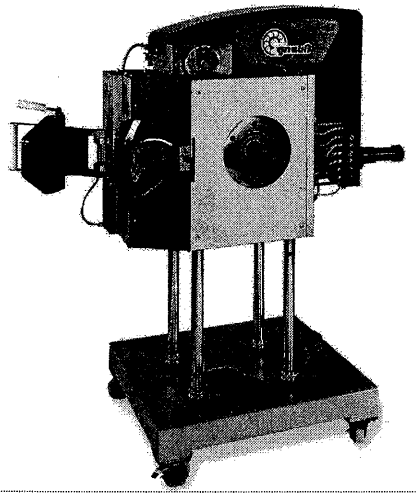

Fig 2: A photo of an RSF*genius*

The screens are cleaned by a patented, integrated back-flush piston system just before the contaminated screen is re-introduced into the melt channel. Filtered melt is diverted inside the outlet block from the main melt flow and it is transported to the back-flush piston. After every indexing step, this piston presses the diverted melt by high-pressure impulses through a small opening across the contaminated screen. The material quantity necessary for this process is freely adjustable and ranges in practice between 0.01 % and 1 % of the throughput rate. The speed for the melt to be pressed through the screen is adjusted, so that the back-flush pressure is higher than the pressure consumption across the screen. This guarantees an optimum screen cleaning.

3. RSF*genius* in direct recycling

For the manufacturers of PET fiber and sheet, major cost benefits can be made by substituting virgin material with bottle flake, now that this is available in adequate quantities.

To recycle bottle flakes into pellets is relatively easy as the pelletizing process can accept quite large processing variations. The challenge today is to recycle direct from flakes to a quality final product. In this case it must be possible to filter fine enough to provide a good quality product, the filtration system must not cause quality variations or disturbances, the amount of operator attention and skill must be kept to a minimum, the filtration system must operate cost efficiently and it must be able to handle varying contamination loads.

Thanks to its process constant operation and its ability to exchange filtration area rapidly, the RSF*genius* is perfectly suited to direct recycling operations.

In the following examples PET bottle flakes with an IV in the range of 0.72 to 0.78 are used to directly manufacture high quality products:

3.1 Application example 1: Staple fibers from bottle scrap

In staple fiber production it is important to filter as fine as possible to keep the life of the spinpacks as long as possible and to filter process-constantly to keep yarn breaks to a minimum.

In this example an RSF*genius* 200 replaced a conventional piston backflushing screenchanger in a staple fiber line with a throughput of 1,000 kg/h (2,200 lbs/h). This unit provides an active filtration area of 650 cm2 (100 in2) and a filtration area capacity of 9,000 cm2/h (1395 in2/h).

The quality of the flakes is reasonable. On average, a screen area of 6.3 m2/day (68 ft2/day) is used. Still, a rapid exchange of filtration area during contamination surges is important. As explained earlier, the rotation (or indexing) of the RSF*genius* is controlled by differential pressure. In case of contamination surges, the filter just indexes more often, without any influence on the process, until the selected pressure value is reached again.

- As a filter change does not cause any disturbances, the filtration fineness could be reduced to 40 um without compromising the process stability. The spin pack life was increased by 300 %.

- Due to the pressure stable operation, the number of yarn breaks could be reduced by 50 %.

- The filter elements can be cleaned and re-used 180 times through back-flushing. This means that the yearly filter element costs are only approx. US$ 4,800.

- The material lost through backflushing is approx. 1.2 %.

3.2 Application example 2: Spunbond nonwoven fiber

The manufacture of nonwoven fiber can in some respect be classified as more sensitive and critical than staple fiber since any flow disturbances in the spin pack are noticed immediately. In this example, spun bond fiber using different levels of bottle flakes reclaim depending on the end use of the fiber is processed. An RSF*genius* 175 replaced again a piston backflushing screenchanger. The throughput of the line is 700 kg/h (1,540 lbs/h). This model provides an active filtration area of 420 cm2 (65 in2) and a filtration area capacity of 6,800 cm2/h (1,054 in2/h).

- On average, a screen area of 4.8 m2/day (52 ft2/day) is used. Again, a rapid exchange of filtration area during contamination surges is important and ensured by the mode of operation of the RSF*genius*.

- The pressure-stable operation (+/- 2 bar i.e. 30 psi) enables the customer to operate the extruder with its sensitive pressure-dependent extruder screw speed control.

- It was possible to reduce the filtration fineness to 40 um.

- Depending on the proportion of bottle flake material used, the lifetime of the 75 um spinpack filter was increased by 200 to 300 %.

- The material loss through backflushing is 0.2 to 0.4 %.

- The filter elements are cleaned and re-used 140 times through backflushing. This leads here to yearly filter element costs of approx. US$ 4,200.

However, the biggest benefit is the stable operation of the extrusion line which makes the manufacture of spunbond fiber possible using bottle reclaim.

3.3 Application example 3: Thermoforming sheet

The case of PET sheet from bottle flake is interesting, because although the filtration fineness requirements for sheet are generally not quite as fine as for fibers, there is in the case of a sheet extrusion line only one filter – there is no second chance of catching contamination in the spin pack filter, contamination can be seen immediately in the finished product.

In this example, an RSF*genius* 150 replaced a piston screenchanger (without backflushing). The throughput of the line is 850 kg/h (1,870 lbs/h). This model provides an active filtration area of 300 cm2 (46.5 in2) and a filtration area capacity of 4,600 cm2/h (713 in2/h). On average, a screen area of 3.2 m2/day (34 ft2/day) is used.

With the RSF*genius*, the experience is as follows:

- As the RSF*genius* is rheologically optimized (there are no dead spots) there is no need to scrap any production due to black spots, therefore the production yield was increased. Further, it is possible to use finer filter elements in order to produce a sheet with such excellent optical properties, that it can compete with sheet made from virgin material. The amount of operator attention is reduced, since with the RSF*genius*, the filter elements only need to be changed roughly every 2 weeks (screens are re-used approx. 140 times, yearly screen costs approx. US$ 2,100), and of course a screen change does not cause any production disturbances.

- The constant pressure operation of the RSF*genius* helps the customer to manufacture sheet with a consistent quality since the melt temperature remains more stable as a result.

- Operation with a filtration fineness of in some cases as fine as 40 µm is possible. This is considerably finer than most thermoform sheet manufacturers use for filtration of virgin material.

- The more uniform melt properties make it possible to save some material through tighter gauge control.

4. Summary

The RSF*genius* is a process – constant and fully-automatic melt filtration system with highly efficient operation which opens new possibilities in the area of plastics recycling.

Through its efficient and process – constant operation, it is possible to reprocess PET bottle flake to products with a quality level that can compete with similar products made from virgin material. In order for the price advantage of bottle flakes to be used, the recycling process must be as cost efficient as possible.

The key to achieving this is the melt filtration system.

The above examples demonstrate how, with the Gneuss RSF*genius* Rotary Filtration System, bottle flake can be processed economically *direct* into a high quality finished product, without the cost intensive and processing technically disadvantageous stage of pelletizing.

Although the examples given focus on PET recycling, this system is suitable and successfully in use for the recycling of all kinds of different plastics, e.g. PP, PE, PS etc. and in a wide range of processes.