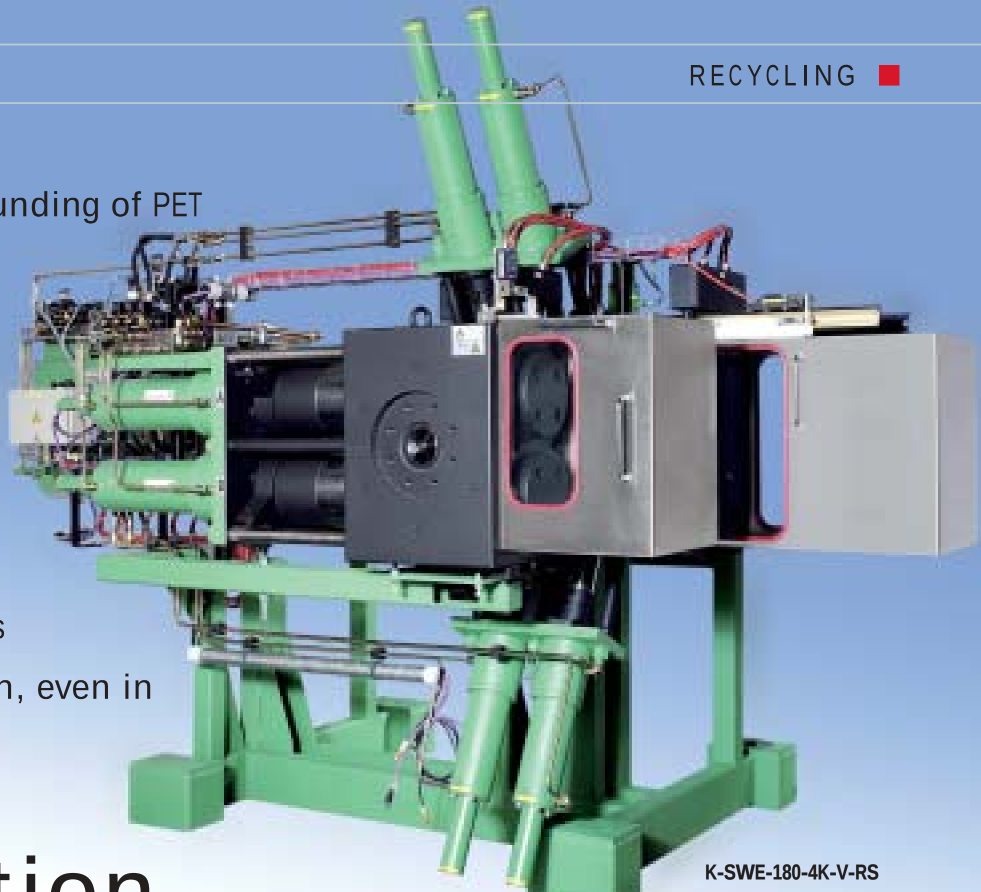
PET Recycling. Inline compounding of PET bottle flakes on twin-screw extruders is imposing ever greater demands on melt filtration. A newly developed piston-screen changer allows highly effective back-flushing of the filter elements with little pressure fluctuation, even in sensitive applications.



K-SWE-180-4K-V-RS screen changer

(photos: Kreyenborg)

Melt Filtration at Constant Pressure

STEFAN WÖSTMANN

The longstanding trend of substituting PET bottles for glass bottles continues unabated. Consequently, rising amounts of PET recyclate, or bottle flakes, are being generated. This presents makers of machines for processing plastics with the problem of devising new machine designs capable of inline compounding of bottle flakes to yield high-quality products. Recycled beverage bottles primarily serve as raw material for the production of flat film, fibres, monofilaments, nonwovens and packaging tape.

In particular, owing to the wide fluctuations in quality of bottle flakes on the market, these processes impose high demands on the mechanical engineering and the process technology. Table 1 illustrates the specification for bottle flakes for processing in a fibre-spinning machine. The level of contaminants can fluctuate considerably in accordance with the quality of the material, the intended application and the supplier of the bottle flakes. The contaminants in the polymer melt interfere in the extrusion process to an extent depending on the size and quantity of the particles. They can also cause the extruded material to tear when the above-mentioned products are being produced.

Lately, co-rotating twin-screw extruders with modified screw geometry and an appropriate multi-stage venting design have become the established machines for processing bottle flakes. The greater surface/volume ratio of this design, relative to that of the single screw, can produce results similar to those for pre-dried PET flakes, provided that the starting material is homogeneous. In other words, melt degassing in this extruder design offers an alternative, or where the bottle flakes have a higher moisture content, a useful complement to pre-drying.

Melt degassing allows volatile components in the melt to be removed. In this connection, the water content absorbed from the flakes must be effectively vented in order that the molecular weight of the melt (called the intrinsic viscosity in practice) may be kept at a uniformly high level. The goal is to minimise the hydrolytically induced reduction in melt viscosity.

The high surface moisture of the flakes (up to 20 000 ppm equates to 2 %) makes it necessary to remove the moisture from them prior to processing on the twin screw. This drying process lowers the

Specification for PET bottle flakes	
Material	PET bottle flakes
Physical state	crystalline
Source	Post-consumer PET beverage bottles
Intrinsic viscosity	0.7 – 0.9 dl/g
Size of flakes	1 – 20 mm
Residual moisture after pre-drying	500 ppm
Contaminants PE PVC Metal Paper Other polymers	 ≤ 6% ≤ 300 ppm ≤ 100 ppm ≤ 100 ppm PE, PP, PVC

Table 1. Specification for PET bottle flakes for spun-fibre production

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moisture content to 1000 to 3000 ppm (0.1–0.3%). In practice, this is accomplished by means of dry-air processes and infrared rotary tube driers.

Patented Filtration Concept

Starting with the proven basic design of bolt screen changers, Kreyenborg GmbH has developed a novel, patented filtration design that effectively filters even highly contaminated melts at constant pressure in sensitive extrusion processes [1]. This novelty makes it possible during ongoing production to back-flush filter elements with only minor pressure fluctuations and to replace the filter packages.

Since extrusion imposes high demands on consistency of pressure and volume flow, combinations of conventional back-flush bolt-screen changers and twin-screw extruders suffer from design-related disadvantages. Cleaning of the screen area by back-flushing entails removing melt from the process (as flushed compound). The resultant pressure drop behind the screen changer cannot always be compensated by incorporating gravimetric feeding and a melt pump to act as a regulating system. In particular, when highly contaminated polymer melts require large filter areas, the ratio of the quantity of required flushed compound to the machine's overall throughput is unfavourable. The filtration concept described below combines a large filter area, controllability of material removal from the extrusion process and effective back-flushing, with the result that the demands of processing bottle flakes are met.

Figure 1 shows a cross-section of the K-SWE-4K-V-RS screen changer in which the melt passes through four screen areas. The heated steel housing accommodates two movable screen support pistons at right angles to the mass flow, each of which is fitted with two filter units. On the material inlet side, the melt flow is split into four streams, each of which passes to a screen cavity. After filtration in the support piston, the streams are recombined in the housing. The outlet channel of each screen area is assigned a back-flush rod which, in the production position, is flush with the flow channel in the end position.

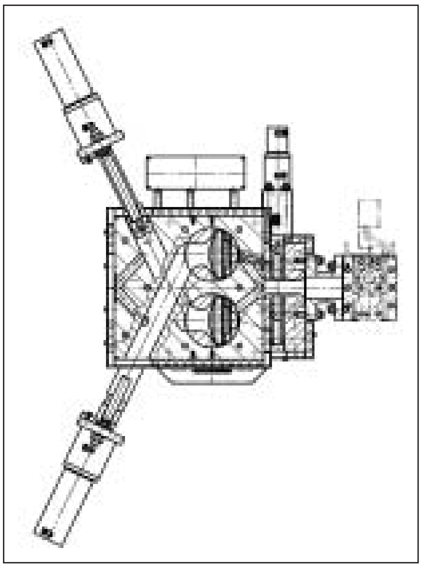

Fig. 1. Cross-sectional view of a K-SWE-4K-V-RS screen changer

The preferred filter material for extrusion is stainless steel. These screens are arranged in several layers along the flow channel of the extrusion line to form a screen package and are buttressed against bending by a perforated plate (screen support plate) in the direction of extrusion.

The contaminants removed from the melt increase the pressure in front of the screen area on account of the greater flow-through resistance of the filter cake. When a defined, process-related threshold value is reached, the filter elements need to be back-flushed. Figure 2 is a schematic drawing of back-flushing in a screen area.

Technology Implemented in a Machine

First, the support piston moves the screen into the flushing position so as to block the filter area from the material-inlet channel. Then, the back-flush rod slowly advances into the exit channel of this screen to compress the melt. The positive locking of the back-flush rod with the exit channel prevents pressure surges on the

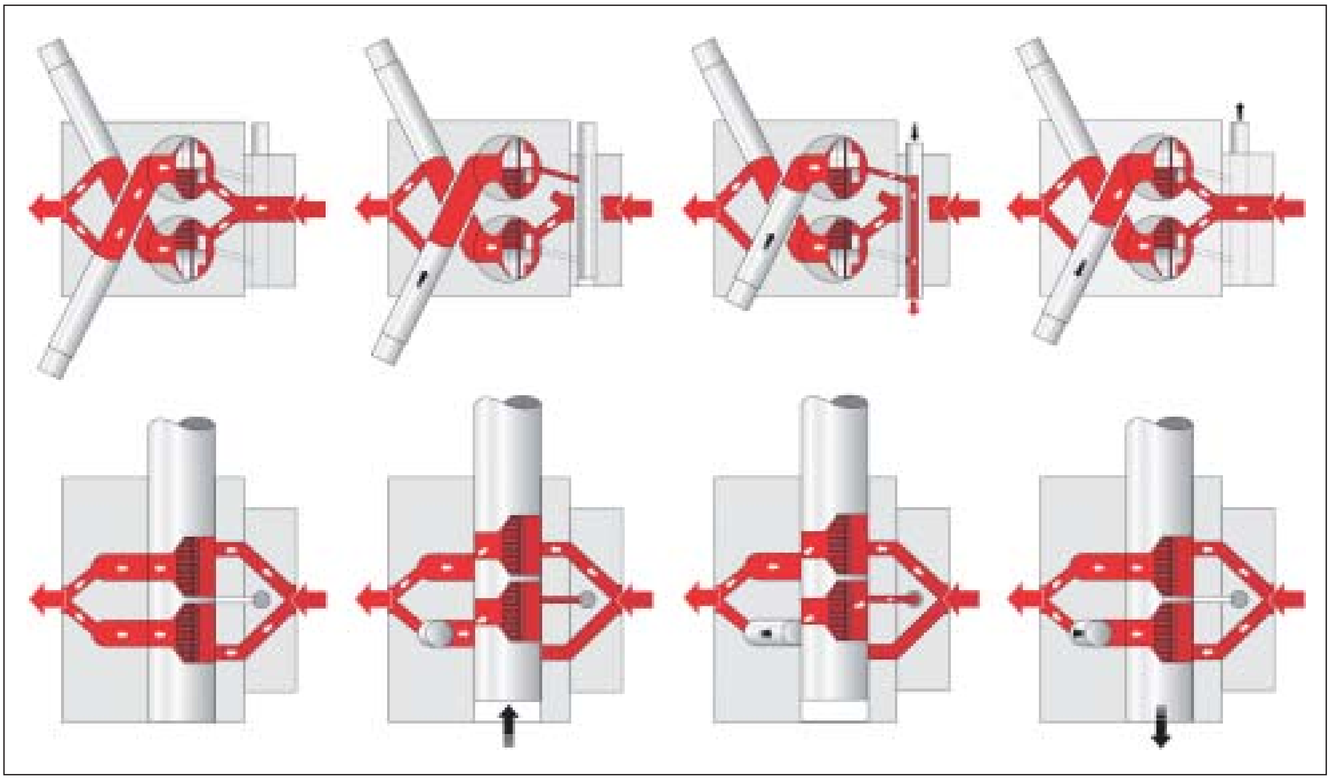

Fig. 2. Schematic representation of how a K-SWE-4K-V-RS screen changer works

Fig. 3. Organic contaminants and aluminium particles in the flushed compound generated in the process of PET bottle flakes

side of the material outlet. Now, the back-flush valve is opened in order that the sudden depressurisation of the compressed melt may effectively remove the contaminants from the filter element. At the same time, the back-flush rod is moved hydraulically at an adjustable rate into the foremost end position to divert the contaminants through the flushing channel and flushing valve into the open. An ever-constant flushing quantity ensures that the contaminants are discharged from the screen area. Figure 3 illustrates the contaminants flushed from a screen area. Aluminium particles and combusted foreign organic material in the PET melt may be clearly seen.

After flushing, the screen support piston is retracted to the production position and the back-flush rod is moved into the rearmost end position under the pressure of the melt and aided by the hydraulics. Removal of material from the process that is the source of the pressure fluctuations is thus stretched out over a longer, adjustable period. Provision is made in the control chain for an intervention threshold that enables the plant operator to define a maximum deviation from the pressure to be maintained at constant level. In other words, material removal for the purpose of filling the exit channel is reduced when the intervention threshold is reached.

Building on the above-mentioned theory and the subsequent design, trials were performed in the pilot plant of Reimotech GmbH, Ober-Abtsteinach/Germany, to implement the new filters in a real plant. Table 2 lists the boundary conditions of a filtration trial in which the maximum deviation from process pressure (inlet pressure of the spinning pump) is set at 5 bar. Reduction of the boundary condition to ± 1 bar is possible by increasing the retraction time for the back-flush rod.

A K-SWE 180-4K-V-RS (title picture) machine was built for the pilot test. This bolt screen changer is fitted out with four screen areas for filter discs with a diameter of 176 mm. The resultant screen area of 976 cm^2 is matched to a throughput of 600 kg/h of highly contaminated melt. An optional ultra-fine filtration stage was added downstream of this filter and is shown at the front of the title picture.

Upstream of the trial filter were a twin-screw extruder (manufacturer: Reifenhäuser) and a melt pump. A further bolt screen changer for ultra-fine filtration, and a spinning pump, were attached to the screen changer. Figure 4 shows the pressure curves for the back-flushing period of all four screens in the experimental machine. The imposed pressure boundary requirement is reflected in the amplitudes of the pressure charts shown.

Of particular interest in this regard is the blue pressure curve, which represents the inlet pressure of the spinning pump. In the trial, the aim was to keep this process pressure at 65 bar ±5 bar and at the same time to minimise the time needed for flushing all four screens. Pressure fluctuations of ±3 bar occurred in normal production on account of fluctuations in the bulk density of the PET flakes to be metered.

The maximum deviation from the default value during back-flushing is 7 bar for a period of 1 second at most. This short time period cannot be realistically shown on a chart. A further boundary condition for the trial was the provision of a melt of homogeneous viscosity, temperature and coloration. A necessary consequence of this was that the extruder speed (violet speed line) could not be increased during back-flushing as a means of briefly increasing the throughput to offset the discharged flushed melt.

After four days of hourly flushing of the contaminated screens, the filter ele-

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Filtration trial on K-SWE 180-4K-V-RS	
Material	PET bottle flakes
Intrinsic viscosity	0.74 dl/g
Processing temperature	290 °C
Throughput	600 kg/h
Filter area	4×244 cm^2 = 976 cm^2
Filtration quality	80 µm
Initial pressure loss with clean screens	15 bar
Pre-set pressure loss for back-flushing	40 bar
Material removal for flushing a screen area	1,3 kg
Pre-set maximum deviation from process pressure	5 bar
Time needed for flushing all four screens	12 – 15 min
Pre-set process pressure	65 bar

Table 2. Boundary conditions from filtration trials on the K-SWE 180-4K-V-RS

Fig. 4. Pressure curves for back-flushing of all four screen areas of a K-SWE 180-4K-V-RS screen changer

ments of the experimental machine showed a very good level of cleaning, with the result that there was no need to replace the screen packages. For a production machine, therefore, a filter change is indicated during weekly machine downtime for maintenance and refitting work.

As for current further development of the filtration concept, more has to be done as regards controlling the individual components of the extrusion unit – metering system, extruder, melt pump – with a view to reducing the time needed for conducting a flushing process.

Summary

In the back-flushing concept for bolt-screen changers presented here, the melt stream is split into four screen areas with continuous melt flows. Removal of the back-flush compound via an adjustable and controllable time enables pressure fluctuations in the process to be regulated over a narrow tolerance range.

Further advantages arise in the rugged design of the components, the large active filter surface, the ease of operation and the high economics of the novel concept. The use of four screen areas allows the active filter areas of K-SWE-4K-V-RS bolt screen changers to be extended such that, given the same constant pressure, they offer an economical alternative to screen-wheel technology. ■

REFERENCE

1 Wöstmann, S.: Stable and Cost-effective Filtration. Kunststoffe plast europe 95 (2005) 2, pp. 80–82

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