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Improving Process Operations with a Rotary Pressure Filter

Could a rotary pressure filter improve product quality, increase production rates and ensure environmental compliance at your facility?

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Improving Process Operations with a Rotary Pressure Filter

A rotary pressure filter can increase filtration rates, washing and drying efficiencies and eliminate organic solvent emissions

By Barry A. Perlmutter, Managing Director

A plant was experiencing high solvent usage and excessive volatile organic compound (VOC) emissions in the manufacture of a specialty chemical. In addition, off-specification product quality resulted from poor cake washing because the original solvent could not be displaced efficiently. Long drying times and production bottlenecks were typical because of the extremely high final solvent content of the wet cake discharged from the conventional open-vacuum filter equipment.

Plant engineering and development personnel evaluated the feasibility of using a rotary pressure filter[1] to improve product quality and increase production rates while adhering to environmental regulations.

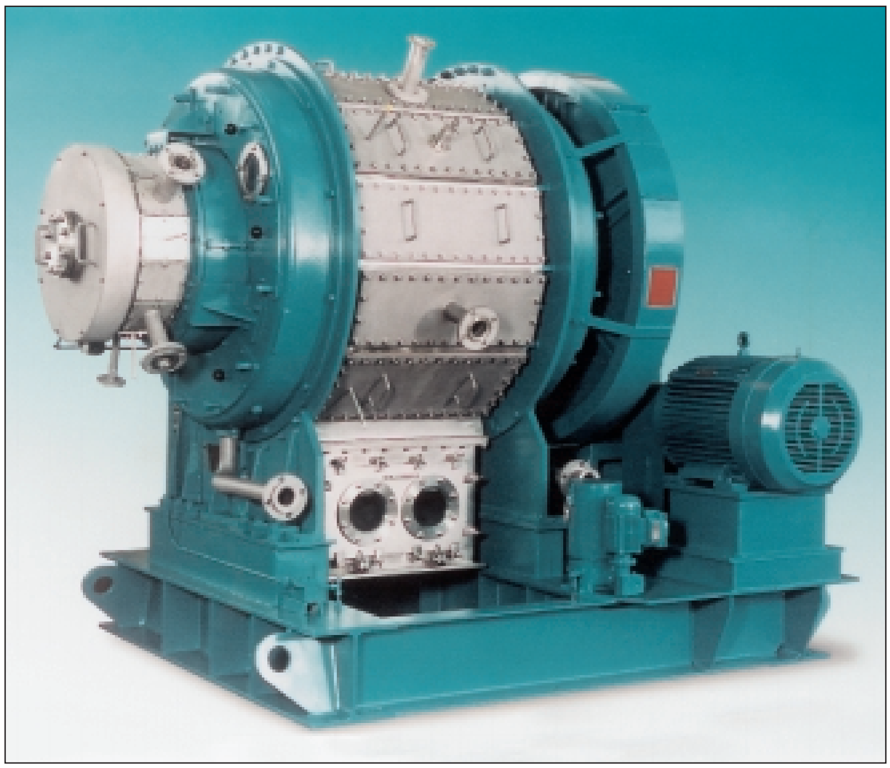

Figure 1. A rotary filter with an enclosed and pressurized control head.

Rotary pressure filter

The rotary pressure filter discussed in this article is a continuous-pressure filter for thin-cake filtration with cake depths from 6 millimeters (mm) to 150 mm (Fig. 1). The slowly rotating drum – 6 revolutions per hour (rph) to 60 rph – is divided into segments, called cells, each with its own filter media (synthetic cloth or a single- or multilayer metal) and an outlet for filtrate or gas. The outlet is manifolded internally to a service/control head, allowing each stream to be directed to a specific plant piping scheme or a collection tank. The mother liquor can remain separate from the subsequent washing liquids.

The feed suspension enters each cell under constant pressure to form a filter cake (Fig. 2). Internal divisions of the housing permit cake processing in separate zones. Each zone can operate under different pressures, depending upon the cake compressibility at each stage.

1. The filter tested at the specialty chemical plant was the FEST rotary pressure filter.

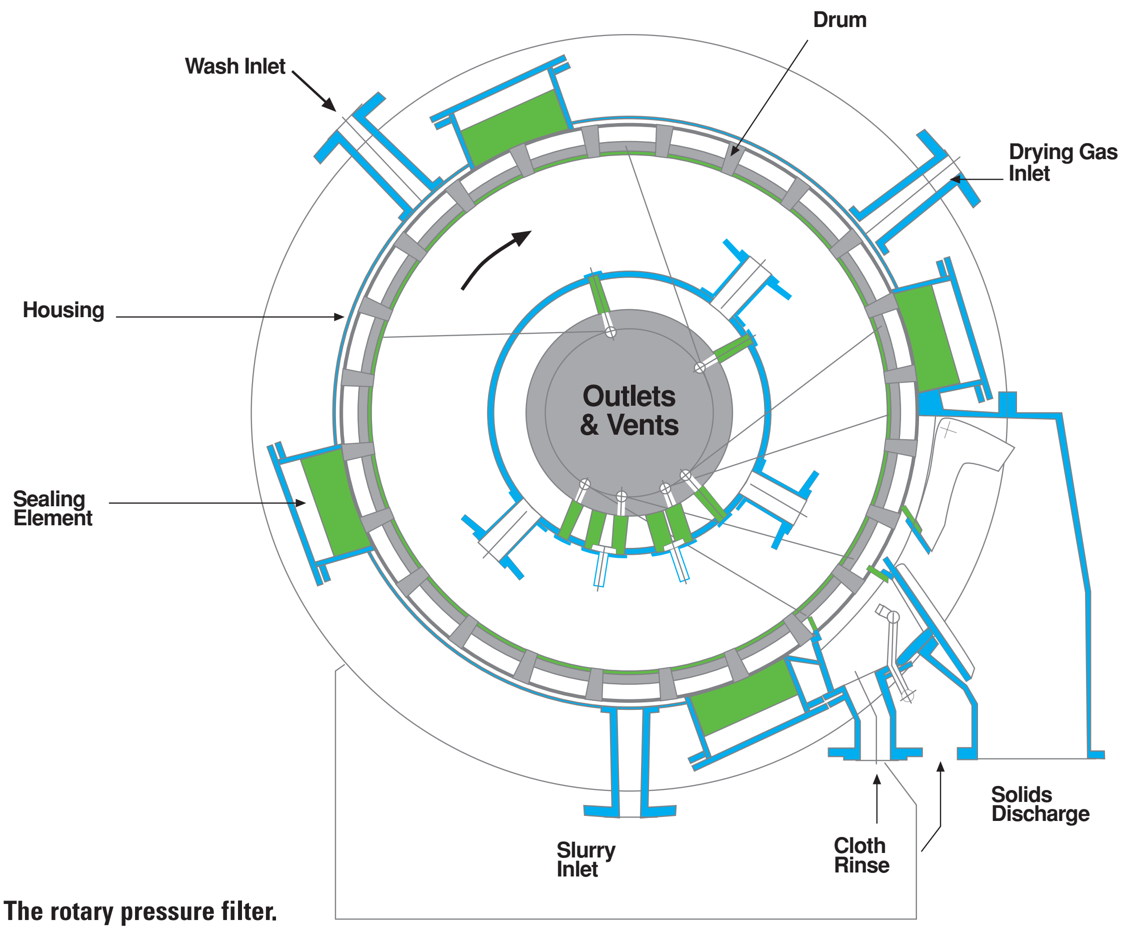

Figure 2. The rotary pressure filter.

For example, pressure filtration is conducted up to a maximum differential pressure of 6 bar. When a process solvent is prone to flashing under vacuum filtration, pressure filtration eliminates post-precipitation of the solids.

Positive displacement washing or countercurrent washing follows filtration. By ensuring the pressure cells have no free space and are completely filled, cake cracking or bypass is eliminated, providing maximum washing efficiency. This is important for the specialty chemical application previously mentioned, because the original solvent must be completely displaced to allow a purity specification of less than 0.04 percent. Multiple washing steps can be accomplished along with solvent exchanges and extraction.
Gas at elevated or ambient temperatures then is applied through the cake to dry it. The control of this drying step is influenced by gas flow, pressure and temperature, as well as by the cake's depth and residence time.

For the specialty chemical application, the dryness specification was less than 18 percent of the final moisture of the cake. At this moisture content, the downstream dryer efficiency would be maximized so the drying bottleneck would be eliminated.

The predried cake is discharged continuously into the downstream dryer. The cake is at atmospheric discharge, which allows it to be fed directly into the dryer without the need for vacuum locks or venting tanks. The cake discharge is assisted by a gas blowback, either pulse or continuous, and a mechanical scraper. In some cases, gas jet nozzles can be used for maximum discharge with sticky products.

The next step, cloth rinse, is controllable, depending upon the product discharge, filter media and cloth-binding potential. Several options are available for this step, including spray jets, rotating nozzles and gas blowback. The cloth wash can be performed after each discharge or on an intermittent basis. With the drum rotating, after cloth rinse, the cells are ready to be filled for filtration. A typical process is shown in Fig. 3.

On-site testwork

Filtration, washing and drying testing was conducted simultaneously in the laboratory and in the field at the crystallizer. The challenge was to conduct representative batch testing to simulate a continuous operation. Continuous pilot units were available at 1,000 liters per hour (lph), however, in this case, batch testing was used. The lab testing used a pressurized pocket-leaf filter with 20 sq. cm of filter area, as shown in Fig. 4. The fieldwork was conducted on a similarly configured test cell with a filter area of 400 sq. cm.

The pocket-leaf filter gathered the basic filtration, washing and drying date. Once these operations were optimized, the test were repeated in the field using the actual slurry with the test cell. The data collection form is illustrated in Fig. 5.

Test results

Filtration. The first optimization concerns cake depth vs. filtration rate. Filtration is conducted via pressure. A premeasured amount of slurry is added from the top, and the unit is pressurized. When filtration begins, the filtrate amount vs. time is recorded at constant pressure. Other parameters that are varied sequentially include cake depth, filtration pressure and filter media.

In this application, four different cake depths were analyzed, based upon the current operation: 50 mm, 60 mm, 75 mm and 90 mm. Filtration pressure and time were optimized for each cake depth.

During filtration testing, the slurry showed drastic changes in its filterability, depending upon the length of time from when the slurry was removed from the crystallizer to when testing began. This led to a change in the slurry collection methodology.

Washing. Displacement washing test also are performed in the pocket-leaf filter. For accurate testing, it is necessary to smooth out any cracks in the cake. This can be accomplished from the top with a long spatula or by carefully removing the bottom part of the pocket-leaf filter. Wash liquid is added in a predetermined wash ratio. Pressure and time again are measured.

In this application, multiple washing steps and countercurrent washing were used to determine which combination of washing techniques would meet the specification of 0.04 percent. After multiple tests with different combinations, it was found that a 90-mm cake using both displacement and countercurrent washing could not meet the specification each time.

The cake depth was reduced to 60 mm and the test were repeated. With this approach, only two displacement washes were needed to meet the purity limit. Because the 60-mm cake achieved the purity specification with low solvent usage, it then was decided to repeat the first set of filtration and drying tests at 60 mm.

During the washing tests, another phenomenon was observed that would have an impact on the full-scale production unit. As stated earlier, batch testing was used to simulate continuous operations; therefore, testing was conducted without cleaning between each batch. After several batches, the results showed an increase in the level of contaminants – cloth blinding was occurring. To solve this problem during the testing, a warm solvent wash of the cloth was initiated after several batches. This process step then was incorporated into the final design.

Drying. Product drying in the pocket-leaf filter was tested by

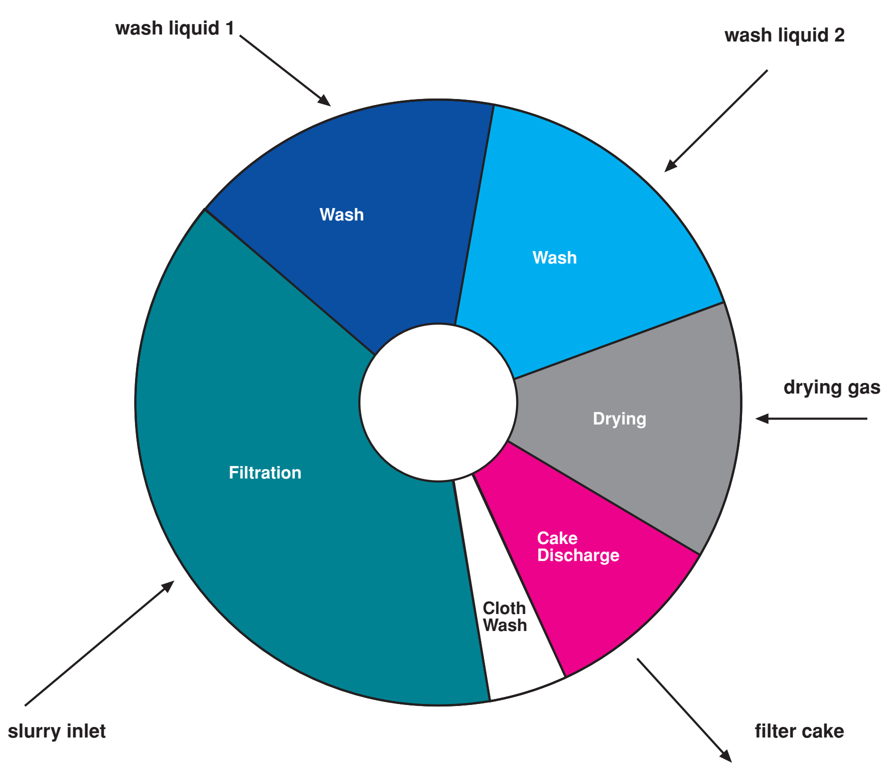

Figure 3. Typical flow showing process zones for a filter with 8 m^2 of filter area.

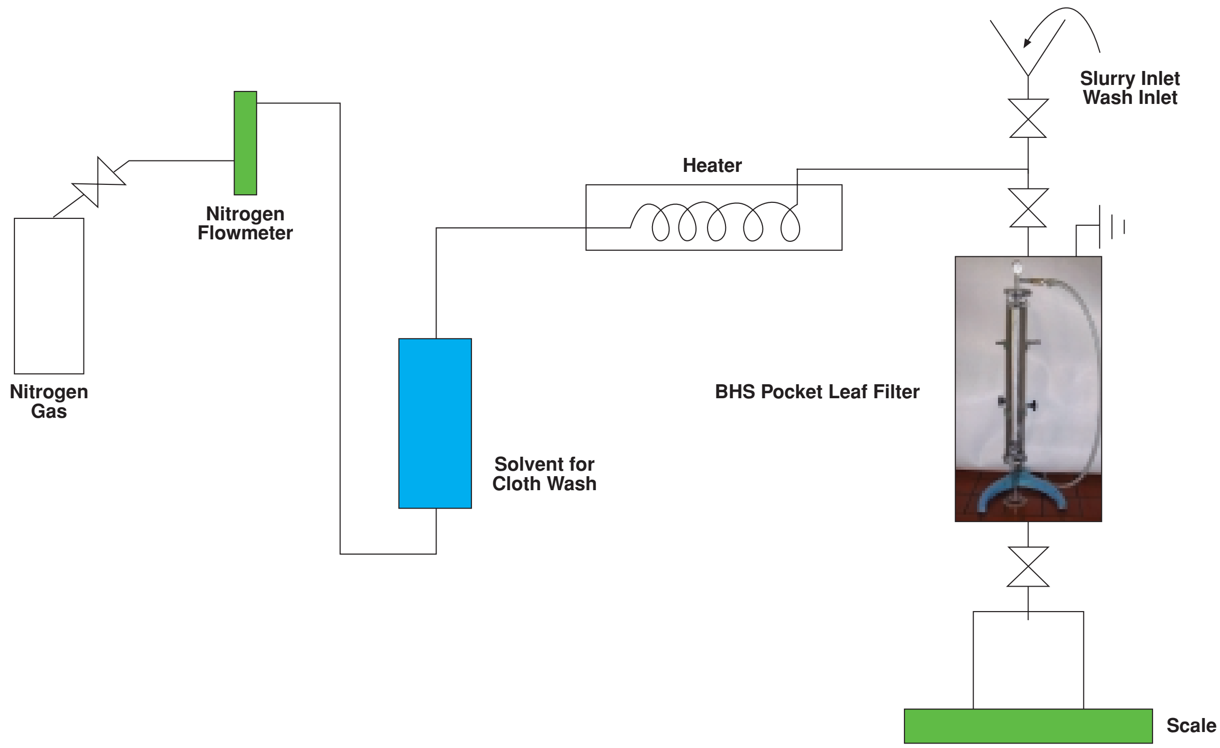

Figure 4. BHS Pocket-Leaf Filter Setup in Laboratory. (Test cell is not shown but similarly configured in the field at the crystallizer)

blowing ambient-temperature gas or hot gas through the cake. The pressure was kept constant and gas throughput was measured vs. time. After a preselected drying time, the cake was removed from the pocket-leaf filter. Cake depth was determined, and then the cake was weighed and analyzed for moisture content. After several iterations, the drying times were optimized along with the gas pressure and flowrate to achieve a better-than 18 percent final solvent content in the cake.

Test cell. Throughout the pocket-leaf testing, simultaneous testing was conducted in the field on the test cell. The results were generally in agreement. However, the test cell provided two additional observations that were critical for the final design.

The first observation concerned product discharge. The test cell was on a movable stand so product discharge efficiency could be checked. The product was sticky upon drying. Various techniques of gas use from behind the cake (pulse-blowback) or from the front of the cake were investigated to maximize the product discharge.

> The filter design includes two recycle modes to help meet VOC regulations

The second observation concerned back-mixing. In some cases, back-mixing occurred between the original solvent and the fresh solvent for washing if the cell was not completely filled with cake. The final design ensured the cells were filled with cake with no free space and the original process solvent was eliminated before the washing step.

Process scale-up

With testing complete, the process scale-up could be finalized. Scale-up involved a combination of filtration theory and company experience, as well as averaging the testing times and selected cake depth to meet the production requirements.

Design considerations

The testing led to a design of a rotary pressure filter to meet a purity specification, as well as to a final solvent content of the cake for improved drying. Special design details were incorporated

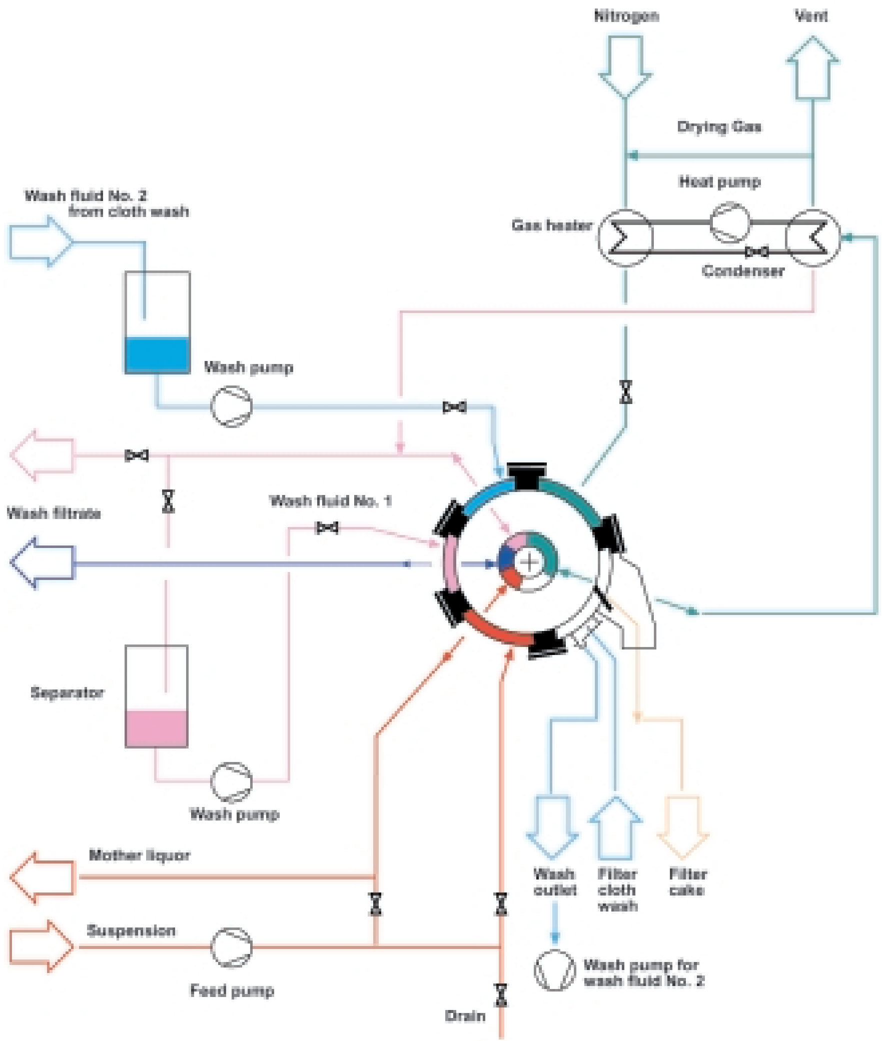

Figure 6. FEST Filter P & ID Showing Process Flow with Solvent and Nitrogen Recovery & Reuse.

to eliminate back-mixing of the solvents and to maximize product discharge. Finally, because of the changing nature of the slurry, specific start-up procedures and feed controls were included.

The third objective of the testing was to minimize and/or eliminate VOC emissions. The conventional filtration equipment used was the single largest VOC emitter at the plant. The enclosed nature of the rotary pressure filter reduces VOC emissions. However, three additional design features allow the filter to approach zero VOC emissions.

First, as shown in Fig. 1, the filter has an enclosed pressurized control head and bearing shields. This ensures containment of any potential solvent leakage through the control head packing. In addition, a uniquely designed gearbox and bearing assembly ensures a stable rotating drum with little or no changes in drum tolerances.

The filter design also incorporates two recycle modes to further meet environmental VOC regulations, as shown in Fig. 6. The cloth rinse solvent is used for the first wash, which minimizes solvent usage and solvent emissions. Finally, a gas compressor/condenser/reheater/solvent recovery system is incorporated to reuse the nitrogen for cake drying and to condense and recover the solvent from the nitrogen recirculation stream.

The process testwork demonstrated that the use of a rotary pressure filter would significantly improve the process operations in several ways. First, product quality is improved through more efficient washing. Second, the drying bottleneck is eliminated, as the initial solvent content of the wet cake is much lower than the current filter, allowing the dryer to operate more efficiently. A side benefit to this is the significant amount of energy savings.

Third, VOC emissions are eliminated based on the filter design along with the other process improvements of gas and solvent reuse. Finally, compared to conventional solid-liquid separation equipment, the filter has a high operating reliability as a result of its slow rotation (6 rph-60 rph), absence of hydraulic components, a system-matched motor and variable-frequency drive. Installation of the new filter will meet the plant's technical, environmental, maintenance, production and economic objectives.

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Figure 5: Data Collection Form for Trials with the BHS Pocket Leaf Filter

Suspension:	Date:
Washing liquid:	
Requirements:	Name:

	units	Trial 1	Trial 2	Trial 3	Trial 4
1.) Filling					
time for filling	min' sec"				
2.) Filtration					
pressure	psi				
temperature	°C				
weight of mother filtrate	g				
time for filtration	min' sec"				
3.) Washing					
pressure	psi				
temperature	°C				
weight of washing liquid	g				
time for washing	min' sec"				
washing result	quality				
4.) Drying					
pressure	psi				
temperature	°C				
flow rate	scfm				
time for drying	min' sec"				
5.) Cake discharge*					
pressure for the blow back	psi				
6.) Cake					
weight	g				
thickness	mm				
residual moisture	%				
discharge ok?	y/n				
cake rests on filter cloth?	y/n				

Notes:

* For test cell only

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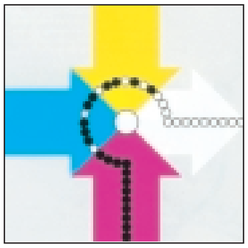
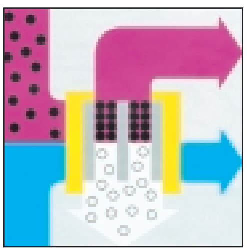
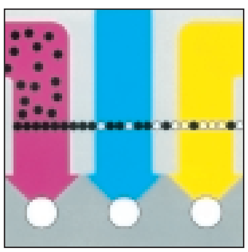


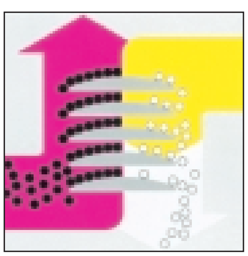
BHS FEST Rotary Pressure Filter
Continuous, gastight, pressure filter. Ideally suited for medium to high solids concentrations, poor filtering materials, and high production rate applications.



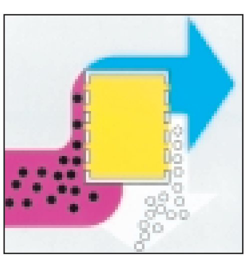
BHS-Autopress
Fully automatic, gastight filter press. Designed for solvent wet or hazardous applications. CIP/SIP options available. Well suited for pharmaceutical and fine chemical batch processes. Pressures of up to 210 bar g ensures excellent dewatering.



BHS Belt Filter
Continuous vacuum belt filter. Used for relatively high solids concentrations, medium to high production rates, and where excellent washing results are required. Gastight and polypropylene designs are available.



BHS Pressure Plate Filter
Fully automatic, gastight polishing filter for low solids concentration applications. Offers very dry solids content on waste streams or secondary filtration applications. Features unique oscillatory solids discharge.



BHS Candle Filter
Fully automatic, gastight lower cost polishing filter. Features BHS' "falling film filtration" technology for cake washing and heel filtration. Used mainly on waste stream applications.

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