



## **A REVIEW OF FILTER PRESS BASICS AND ISSUES VERSUS ALTERNATIVE BATCH OR CONTINUOUS REPLACEMENT TECHNOLOGIES <sup>(1)</sup>**

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### **INTRODUCTION**

Filtration experts, over the years, have discussed and debated filter presses and have indicated that soon they would be a thing of the past; the last filter press would be replaced by more modern equipment. Given that filter presses were amongst the oldest mechanical dewatering devices, this was a fairly plausible suggestion. However, now, almost half a century later, any chemical engineering exhibition shows that filter presses are alive and well and are going to be around for years to come. True, they look different from the ones in the 1950's, but essentially they are still the same device. Their continued presence is a tribute to the filter press manufacturers who embraced new materials and upgraded the mechanics and configurations. However, the basics are still the same and much of the issues surrounding filter presses remain valid.

This article discusses the perceived shortcomings of the filter press as well as batch or continuous filtration alternatives to them based upon the process conditions and requirements of the chemical operation.

### **HISTORICAL PROBLEMS WITH FILTER PRESSES**

- The cake has to be scraped manually out of the frames
- The frames cannot be too thin otherwise the feed ports block. This point applies to the plate and frame presses. For the rest, almost all filter presses now have recessed or chamber plates.
- If the plates are too large or there are too many of them, the weight is excessive. Almost every plate nowadays is made out of a plastic material, usually polypropylene which also solves many chemical resistance problems, although this does pose limitations on temperatures of the feed, the wash liquids and the cleaning liquids.

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<sup>(1)</sup> *Acknowledgement: The author would like to thank Mr. Wim Pierson, minority owner and Director of BHS-Filtration Inc. for his help and assistance with this article.*



- If the cake sticks to the cloth, there is no discharge. The much better filter cloths have reduced this problem considerably; in addition most manufacturers offer a range of cloth scrapers, plate “bumpers”, plate shakers or any other mechanical devices to induce the cake to drop away.
- If some of the cake does, in fact, stick to the cloth, especially the edges, the next cycle may result in leaks and the plates may distort when closing the plate pack. Many manufacturers offer cloth-washing systems with trays to channel the water away, whereas others offer compensators to allow for misalignment.
- If the filter cycle is a bit too short, sloppy cakes with wet centers may result. However, advanced electronics allow for a fairly accurate interplay between time, pressure, backpressure, filtrate clarity etc. so that this risk is reduced.
- Opening and closing the filter press is time consuming. However, almost all modern presses are equipped with automatic plate moving systems, which select one or several plates, allowing them to discharge the cake.
- If there is only a partial batch remaining in the reactor, the chambers cannot be filled and the result is a partially filtered mess, which cannot be washed or dried. If the press is designed with a membrane compression device, this can be overcome. Admittedly this may come at the cost of reduced filtration area and definitely at the cost of reduced chemical resistance, higher capital cost and more maintenance, but it does resolve the problem.

### **THE PRESENT DAY FILTER PRESS**

Some chemical plants have the philosophy that the filter press is the most universal filter that can be used. In spite of the many mechanical improvements, there are still inherent potential problems with its operation and since the basic principle of the press has not changed neither have its inherent limitations.

The mechanical improvements are not always completely effective and certainly they add cost to the operation. The traditional concept of a filter press of being a simple, compact unit, offering large filter areas at a low cost is only true if one has extremely easy material to filter. If not, the difference between the basic press and the one, which is ultimately installed, may be quite large. The mechanical “solutions” which are offered are designs for solving the issues previously discussed such as cake discharge, cloth washing, sticky cakes, bad positioning etc.

### **THE ORIGIN OF THE FILTER PRESS FOR FILTRATION**

The origins of many if not most filter presses are in the areas where clay fields were exploited, i.e. places where semi-colloidal, plastic, or poor draining material had to be dewatered and brought to as low a moisture content as was feasible. With the filter cloths, which were available at the time, the only practical solution was to subject the suspension to as much pressure as could be generated. But herein lies a conflict.



Fine and evenly dispersed solids in suspension will inevitably form a tightly packed filter cake, and the more pressure one puts on the cake, the tighter it gets packed until one arrives at a stage where the cake becomes almost impervious and further drainage is barely possible. Obviously the thicker the layer of solids, the worse it gets and one arrives soon at the situation where any extra pressure on the cake creates a resistance to draining which is almost equal to the extra pressure. The logical thing to do would be to stop at this point, open the press, remove the cake and start all over again.

This is fine if the press holds a reasonable amount of solids, but if all this effort yields only a thin sheet of cake, then it is hardly worth the trouble. In addition, the thinner and thus lighter the cakes are, the greater is the tendency for cakes to stick to the cloth. Conversely, the thicker the cake, the better the chance that it will drop free by its own weight leaving a moderately clean filter cloth. The accepted practice therefore is to work with thick (normally 25 – 50 mm) cakes and to keep the pressure up, and, if possible to increase it (although this in itself reduces the drainage capacity) and keep squeezing droplet by droplet until the cake is “dewatered”.

Fairly thick cakes are almost inevitable with filter presses and that may mean that a press has to cycle for quite a long period of time before it can suddenly drop a whole load of cakes which have to be handled as a separate operation. For continuous operations, this clearly creates a bottleneck and it does little for any meaningful quality control, as the cakes can vary, plate to plate as well as within the plate themselves.

### **FILTER CAKE WASHING**

Filter press operators frequently claim “extremely well washed” filter cakes, often giving the impression that no other filter would be an equal to this. In some special cases this can be true, but in general, whereas the washing can be good, it is rarely very efficient, in terms of time cycle nor usage of the wash fluid.

First, it is almost impossible to visualize a filter press operating a counter current washing system. This immediately increases the potential volume of wash fluid by a factor of probably 3 or 4 times.

It is axiomatic that a filter cake which has been dewatered to its maximum, i.e. out of which no more liquid can be expelled with mechanical means, is also a cake through which one can squeeze a washing liquid. This means that the dewatering cycle has to be stopped well short of its maximum; and by default, leaving a poorly dewatered cake, as shown in Figure 1. This applies to all filters, but obviously, the thicker the overall cake, the greater the residual Mother Liquor, the greater the risk of “back-mixing” and the greater the resistance. All of which translates into a tendency for long washing cycles.



The typical filter press produces not only thick cakes but also “two sided” cakes with a compacted layer on either side and a softer and better draining matter in the middle, as shown in Figure 3. The wash liquor therefore has to be forced (in the opposite direction of the earlier dewatering) through the compacted outer layer into the softer material and then again be forced through the second compacted layer at the other side. The pressure required to force the wash liquid through is therefore at least twice that for a single sided cake and it is no surprise that the slightest pin hole, fissure or shrinkage in the cake will cause by-passing of the wash liquid, quite apart from a tendency for the wash liquid to back mix instead of doing a displacement wash.

Filters, which filter on one side only, have it much easier. Not only is the cake thickness normally much less than half that of a Filter Press, the wash fluid travels in the same direction of the earlier Mother Liquor and once it has broken through the final cake layer it emerges as wash filtrate without risk of back-mixing, as shown in Figure 2.

Since most filter presses have vertically mounted plates there is further a greater chance of not presenting a homogeneous cake for washing (due to settlement) than would be the case with non-vertical plates. (The much more expensive membrane chamber plates can overcome this problem to an extent by pre-squeezing the cake.)

Taking all these factors together, the normal practice is to “over wash”; just to be on the safe side. For difficult or critical products, it is not uncommon to find dewatering cycles of 3 – 4 hours being followed by 8 hours or more of washing.

### **OVERALL EFFECT OF THICKER FILTER CAKES**

Figure 4 shows how increases in cake thickness extend the overall filtration and washing time, how the necessity for high (er) pressures increases and how the cake moisture content increases in the final cake.

These principles apply to any filter, not just Filter Presses. However, since the Filter Press is a batch filter, an increase in filtration time also means much larger periods between cake discharge and, sometimes even more troublesome, a widely varying stream of filtrate, varying from maximum to nothing during each cycle of often many hours. Obviously continuously operating filters have a constant cake and filtrate discharge, regardless of the filter cycle.

Each suspension has its own characteristics and, as such, only exact and professional laboratory tests or pilot tests can give accurate comparable figures. However, the tendencies, as per Figure 4, will remain and their criticality can only be judged by the end-user.



## **THE PERCEIVED ADVANTAGE OF A LARGE FILTER AREA: BATCH FILTER PRESS VERSUS A CONTINUOUS VACUUM BELT FILTER**

One of the main attractions of the Filter Press is still its ability to offer quite large filter areas in a relatively small footprint. Of course they do offer much area, but given the normally long cycles, a large area is a must.

For example, a small vacuum belt filter of 1.5 meters wide and 10 meters long has a filter area of 15 m<sup>2</sup>. The filter dewateres and washes a 4 mm cake in 4 minutes which results in a per hour rate of 0.9 m<sup>3</sup> (60/4 x 15m<sup>2</sup> x 4/1000m) of cake per hour.

A Filter Press can handle the same material, producing 25 mm cakes. Its overall filtration and washing time is a very reasonable 2 hours, which with the opening, cloth washing and closing will probably extend to about 3 hours cycle time on average. This means that it has to produce 3 x 0.9 = 2.7 m<sup>3</sup> per discharge. If the plates are an average 1.5 x 1.5 meter, then each plate will carry 1.5 x 1.5 x 25/1000mm = 0.056 m<sup>2</sup> of cake. The number of plates therefore has to be 2.7 m<sup>3</sup> / 0.056m<sup>3</sup> = 48 plates.

Clearly, the first impression is that the Filter Press offers much more filter area at 216 m<sup>2</sup> than the small belt filter with only 15 m<sup>2</sup>. However, the output is identical, and the assumed advantage of more filter area is of no consequence. Similar comparisons with continuous pressure filters can give even more startling figures.

## **ENVIRONMENTAL AND CONTAINMENT CONCERNS**

Given the origin of the Filter Press (harmless clay dewatering, etc.) and the working conditions at the time, it is not surprising that there was no concern about leaks and the occasional spurt of slurry. However, the present day environment and the large process/chemical- industrial complexes cannot accept solids, liquids or gaseous leaks.

With the present cloth and plate washing systems, one can be reasonably certain that the sealing edges of the plates are normally clean and provided that the cloths are properly doped the high hydraulic closing pressures should ensure that there is only a small risk of serious leaking or spurting. However, that presupposes optimum conditions. After all, a press as in the previous example will have 48 x (4 x 1.5) x 2 faces = 576 meters length of sealing which is a lot of meters to seal. One cannot guarantee therefore that there never will be a leak or even a spurt.

However, if the slurry to be filtered is not obnoxious or dangerous, a simple shroud is sufficient to contain any occasional leaks; although it must be said that this shroud costs extra money and takes extra time opening and closing. But, for any material that is at all hazardous, the containment can only be guaranteed if a gas tight housing is created around the filter. This, however, creates maintenance issues and not to mention the extra capital cost involved.



In addition the press will have to be re-clothed from time to time. This means generally two (2) operators for an average of 15 minutes per plate for an open press. For an enclosed filter press, this would further entail having to be “space suited” to carry out the work within the enclosure. This is a great deal of time and cost including cooling, cleaning and preparation time.

## **ALTERNATIVE BATCH OR CONTINUOUS REPLACEMENT TECHNOLOGIES**

There are without doubt many applications where the characteristics of the modern filter press make it the right choice and in that case one obtains a basically simple, well-tryed and proven piece of equipment. However, there are also many applications where a filter press could do the job, but so could other filters, and perhaps even better. In such cases it is essential to compare performances. A brief description of four (4) types of filtration technologies is presented below based upon general operating conditions at the plant.

### **High-Solids Slurries: Continuous Pressure Operation**

The Rotary Pressure Filter technology provides for thin-cake, continuous production in a single unit. Filtration is conducted via pressure of up to 45 – 90 psig. Positive displacement washing or counter-current washing follows filtration. Of course, multiple washing steps as well as solvent exchanges, steaming and extraction can also be accomplished. Finally, the cake is dried by blowing hot or ambient-temperature gas through the cake. The Filter has a uniquely designed discharge system, which provides for atmospheric discharge from pressure filtration. After automatic cake discharge, the filter cloth is washed; the clean filter cloth re-enters the feeding / filtration zone thereby continuing the process. All solvent and gas streams can be recovered separately and reused in the process to minimize their consumption.

As for the operation, each process zone (typically 5 - 7 zones) is isolated by a separating element. The pressure in the specific zone can be adjusted to meet the process parameters. The separating elements are sealed to the rotating drum via a gas membrane pressure seal. This drum is sealed to the outer housing by drum packing. The drive system with self-sealed roller bearings, which provides for high stability and low stress on the drive.

### **High-Solids Slurries: Continuous Vacuum Operation**

High-solids slurries can be defined as up to 50 – 55% solids in the slurry feed. In some cases, for high solids applications, the slurries can be better handled using vacuum filtration rather than pressure filtration. An example of a continuous, thin-cake technology is a Continuous – Indexing Vacuum Belt Filter. This technology consists of fixed vacuum trays, continuously feeding slurry system and indexing or step-wise movement of the filter media. The filter media is indexed by pneumatic cylinders located on the exterior of the unit. The pneumatic operation and fixed trays eliminates a motor and variable speed drive, there are no rails/rollers, and no rubber carrier belt. In one case, for example, a 12 m<sup>2</sup> continuous vacuum belt filter replaced a 440 m<sup>2</sup> batch filter press.



### **Low-Solids Slurries for Clarification & Recovery: Batch Pressure Operation**

Candle Filters and Pressure Plate Filters are installed for clarification and recovery applications from liquids with low solids content, as alternatives for filter presses. These units offer full containment, fines removal in the 1 micron and finer range, and can be fully automated. The candle filters are vertical candles while the pressure plate filters are horizontal plates. The major difference between the two units depends on the cake structure that is formed. Some cakes are better handled in the horizontal and some in the vertical. Cake discharge is automatic either by gentle gas expansion for the candle filter sock or via plate vibration with gas-assist for the pressure plate filter.

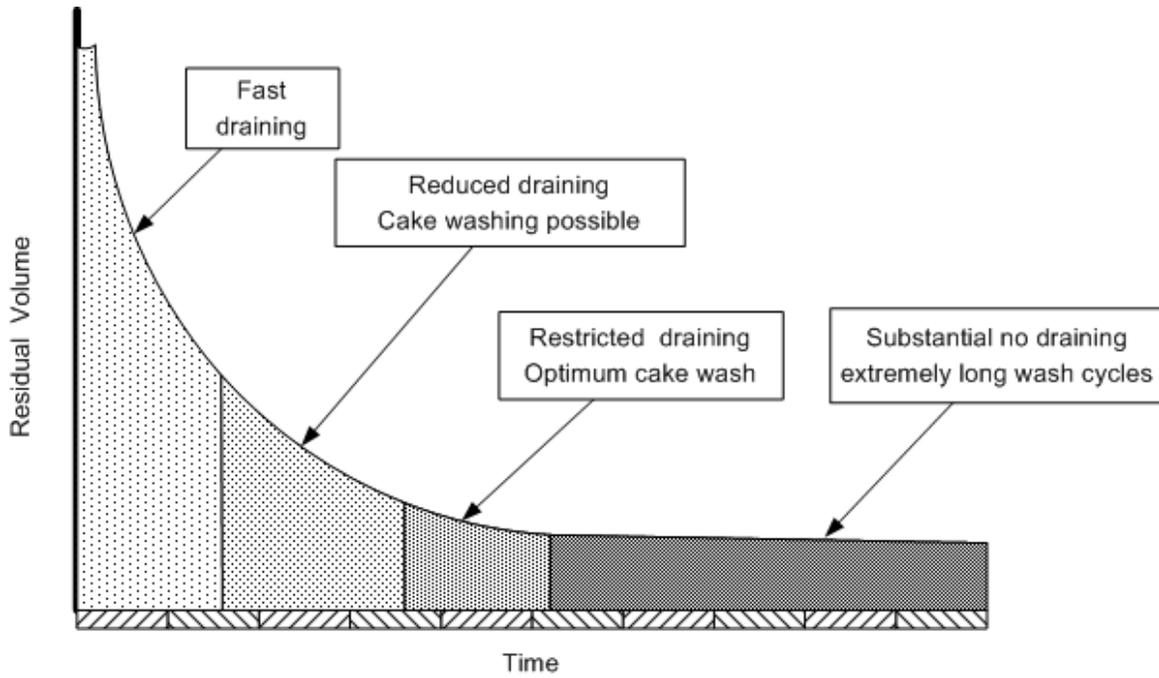
### **SUMMARY**

Unfortunately, filters are very unpredictable and even minor differences in feedstock or washing or cake moisture requirements can turn a filter, which would appear to be ideal into a definite non-choice. Ultimately, there is no substitute for accurate and professional test work under realistic conditions. This almost certainly means that tests have to be done by the technical staff of the filter manufacturer, either in their laboratory or at the client's site, since they will have the right test equipment, the expertise of doing the test and the expertise to interpret the results.

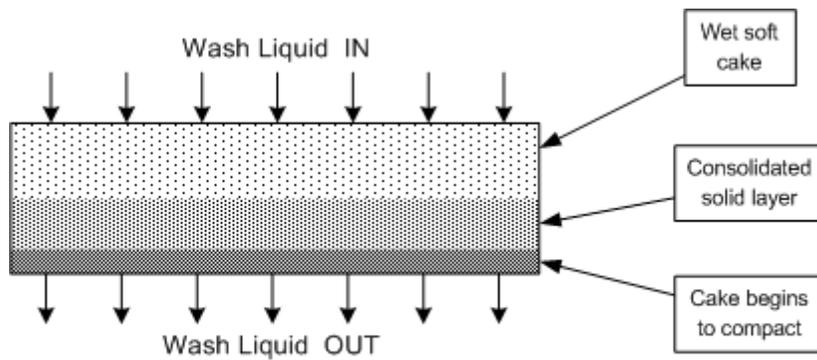
In all cases, however, it is the combined overall efficiency, total installed capital cost, operating cost, space requirements, ancillary equipment and above all convenience and reliability which will result in the optimum filter selection. For this, close cooperation between the plant operations and engineering staff and the filtration vendor is necessary along with detailed and professional laboratory and pilot plant tests.



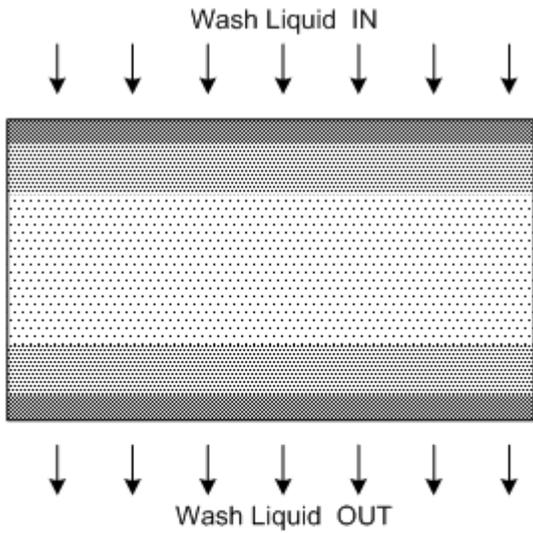
**Barry A. Perlmutter** is currently President and Managing Director of BHS-Filtration Inc., a subsidiary of BHS-Sonthofen GmbH. BHS is a manufacturer of thin-cake filtration, washing and drying technologies. Barry has over 25 years of engineering and technical business marketing experience in the field of solid-liquid separation including filtration and centrifugation and process drying. He has published and lectured extensively worldwide on the theory and applications for the chemical, pharmaceutical and energy / environmental industries and has been responsible for introducing and creating growth for many European companies and technologies into the marketplace. He received a BS degree in Chemistry (Albany State, (NY) University), MS degree from the School of Engineering, Washington University, St. Louis and an MBA from the University of Illinois. Barry served on the Board of Directors of the American Filtration and Separations Society (AFS) and is a member of several internationally recognized societies.



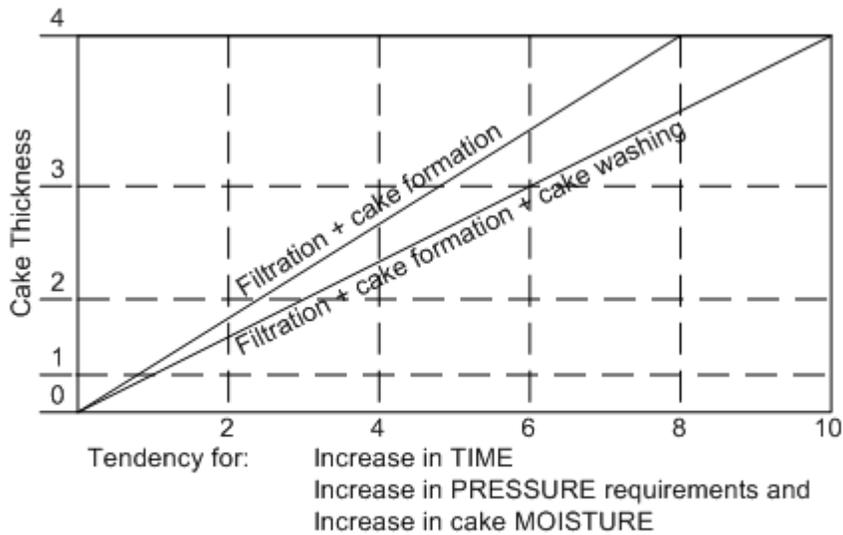
**Figure 1: Residual Volume Versus Time**



**Figure 2: Typical Horizontal Cake Structure During Cake Washing**



**Figure 3: Filter Press Cake During Washing**



**Figure 4: Cake Thickness Comparisons**



## **BHS Thin-Cake Pressure and Vacuum Filtration Technologies For Batch/Continuous Operations From High Solids to Clarification Applications**

BHS-Sonthofen GmbH, founded in 1563, is a leader in technology and innovation. BHS specializes in thin-cake (3 mm - 180 mm) filtration, cake washing and drying technologies.

### **BHS serves three major market segments as follows:**

- Chemical: Fine, Specialty, Agricultural, and Others
- Pharmaceutical: Bulk and Final Products
- Energy / Environmental: Refinery, Power Plants, Wastewater and Others

### **Specialized Applications & Centres of Excellence:**

BHS is organized both locally and globally. BHS-Filtration Inc., a subsidiary of BHS-Sonthofen GmbH is responsible for North America and Mexico.

For specialized applications, BHS is organized globally with centres of excellence. For example, for terephthalic acid, power plant and the dewatering and drying of gypsum applications, this expertise resides at BHS-Sonthofen GmbH. For refinery and bio-energy applications, the expertise for process engineering, etc. resides at BHS-Filtration Inc.

### **Product Technologies & Capabilities**

The BHS technologies and expertise are thin-cake (3 mm – 180 mm) filtration, cake washing and drying. The five-patented BHS technologies are as follows:

- Rotary Pressure Filter
- Continuous-Indexing Vacuum Belt Filter
- Candle Filter
- Pressure Plate Filters
- Autopress, an Automated/Contained Specialized Filter Press

These technologies are installed for pressure or vacuum filtration, for batch or continuous operations from high solids slurries (up to 60% solids) to clarification applications with solids to less than 1% and trace amounts.

### **Process Lab Testing & On-Site Pilot Testing**

BHS conducts preliminary tests in our worldwide laboratories or at your facility. On-site tests with pilot rental units continue the process. Finally, BHS completes the project with a complete technical solution and performance guarantees. Contact us today.

#### **BHS Rotary Pressure Filter**



#### **BHS Duplex Candle Filter**



#### **BHS Vacuum Belt Filter**

