BHS AUTOPRESS COMPARISONS WITH NUTSCHE FILTER-DRYERS & CENTRIFUGES

A. PROCESS BENEFITS

1. Thin-Cake Filtration

The Autopress operates at an initial cake thickness of maximum 20 mm. At this thickness, higher filtration pressures are possible up to 8 bar without reducing the permeability of the cake. A nutsche filterdryer operates with deeper cakes greater than 50 mm up to 250 mm. Cake compression can occur resulting in much lower flux rates to reduce filtration efficiencies. Centrifuges operate based upon g-forces. For compressible cakes, higher g-forces will lead to compressed cakes, lower flux rates and reduced filtration efficiencies.

As the filtration time is related in a square root equation to the cake thickness, thinner filter cakes allow for a higher product throughput. A deeper cake as on a nutsch filter dryer therefore results in a much lower specific filtration capacity even without cake compression. In practise, the compression adds up further delays.

2. Slurry Feeding

The Autopress allows for even slurry filling and cake build-up. Normally, slurry feeding is from the bottom up, which is different from nutsche filter-dryers and centrifuges. For heavy, fast settling solids, the Autopress can be filled from the top as well as from the bottom for equal distribution and optimum cake formation. Centrifuges and nutsch filterdryers might lead to disintegration of the particle size distribution in the filter cake with the bigger parts at the cloth and a fine layer on top of the filter cake. This has a negative impact on the filtration rate and washing effects.

3. Maximum Wash Efficiency With Low Wash Ratios

The cake thickness on the Autopress is reproducible due to the elastomeric spacers between each plate. On a centrifuge or nutsche filter-dryer, the cake thickness is variable.

Secondly, the plates are sealed, plate-to-plate, by the spacers and then in the annular space by the inflatable membrane. Therefore, liquid by-pass is eliminated. In addition, the thin filter cake allows for a perfect positive displacement wash. With the sealed thin cake the risk of unwashed pockets is reduced to almost zero.

On a nutsch filterdryer, the high cakes tend to crack during washing resulting in a bad wash performance. Due to possible inhomogeneous particle size distribution over the cake height channelling occurs which reduces the washing efficiency. High cakes are hardly possible to be washed in a positive displacement wash due to unwanted pockets in the cake. For this reason, mainly reslurry washing is effected resulting in a higher consumption of wash liquid.

Finally, due to the construction of the filter plates on the Autopress, cake washing can be in the forward or reverse direction, which further enhances the washing efficiency. Therefore, based upon reproducible cake thickness, filter plate design and elimination of by-pass, the washing on the Autopress is much more efficient (lower wash ratio) than on a centrifuge or nutsche filter-dryer.

4. Cake Pressing

Some cakes tend to crack. On nutsche filter-dryers, the reverse action and slowly lowering of the agitator can smooth the cake; this is normally a manual/visual operation. However, smoothing of the cake is only closing surface cracks but it cannot completely seal the cracks through the whole filter cake. Therefore the effect on the overall structure of the filter cake is marginal. Smoothing of a cake on a centrifuge is not possible.

On the Autopress, the main Ram cylinder can compress the cake automatically up to 30% (from 20 mm to 16 mm) to eliminate cake cracking. A linear displacement transducer determines the exact location of the ram in relation to the plates.

5. Filter media:

The Autopress can use synthetic or metal (stainless steel or alloy) media. The media is welded to the filter plate (synthetic to polypropylene plates or metal to metal plates) and can be in the 2-5 micron range and tighter. On a centrifuge, synthetic media must be manually installed and on a nutsche filter-dryer clamping bars or rings hold the media in-place.

As there are no moving parts on the Autopress and the possibility of mechanical damage is eliminated, the media generally has a much longer life and in the case of metal media, lifetimes of five (5) years are common.

For metal media, on a nutsche filter-dryer, the design is a 5-layered sintered metal (protective layer, media layer, two drainage layers and a support screen). This can result in blinding of the media between the layers. The Autopress, due to the cake discharge scraper, uses only a 3-layer design (media, drainage and support) which allows for easier cake discharge and minimized blinding potential.

6. Cake discharge:

For cake discharge, the Autopress has a fully automatic, scraper assisted cake discharge. The scrappers are operated sequentially and can be run over several cycles. Mechanical damaging of the filter media by the scraper is eliminated because of a special scraper design. The cake discharge is heel-free. On an inverting centrifuge, cake discharge is also heel-free. On a nutsche filter-dryer, there is normally always a residual heel as the agitator cannot scrap the filter media and move the entire product cake out of the side discharge valve.

For sticky products, the Autopress has a further benefit such that gas-assist can be used to help remove the cake from the media prior to scraping. This is possible due to the design of the filter plates, which allow for forward and reverse flow of liquids and gases. A liquid assist is also possible. Sticky products will be very difficult to discharge from a nutsche filter-dryer or a centrifuge.

For overly wet or not-formed cake, the Autopress will be able to discharge it completely. This may not be the case on a nutsche filter-dryer where the agitator may not be able to move the entire wet mass of cake. The centrifuge would have similar difficulties.

Cake discharge is through a cone, which is the length of the plate stack to a 12-inch flange. This flange can be piped to a clean room dryer, pack-out or other containment device. Inerting can be through all components. The knives come down sequentially in pairs to eliminate any bridging in the discharge cone. The cone can be polished or lined to aid in discharge.

In summary, higher filtration pressures with thin-cakes and very fine pore filter media can be used for absolutely clear filtrates and increased production rates in the Autopress compared with centrifuges and nutsche filter-dryers.

B. MECHANICAL DESIGN BENEFITS:

1. No rotating parts. The Autopress filter plates are fixed in place, which eliminates any rotating seals and potential particulate contamination as found in centrifuges or nutsche filterdryers.

2. Maintenance: The Autopress is extremely low-maintenance. There are no bearings, gaskets, etc. to be replaced or balanced.

3. Installation: There are no vibration forces on the building structure. The installation is simply securing the four legs to pads or directly to the floor. Installation costs are therefore much less than those of nutsche filter-dryers or centrifuges.

4. Electrical & Controls: The Autopress is ATEX complaint for Europe as well as Class 1, Division 2 (or Division 1), Groups C & D for installation in the US. The PLC systems are all FDA-approved and validated, per ANSI/ISA 88 batch process control standards

5. Solvents: In terms of solvent compatibility, the Autopress normally uses EPDM, Viton, Teflon, Gylon, Kalrez or similar materials. These are all FDA-approved materials. The wetted parts will be the spacers, membrane and several housing o-rings.

6. Inerting & Monitoring: The inerting process on the Autopress consists of a slow-purge on the enclosure and a one-time fast purge of the housing/plate stack. Normally, O2 monitoring is not required. For all centrifuges, O2 monitoring is required. For nutsche filter-dryers, O2 monitoring is normally not needed.

7. Materials of Construction: As for material of construction, the Autopress has major benefits compared to centrifuges and nutsche filter-dryers. The Autopress is as a standard 316L stainless steel. If a Hastelloy unit is required, for example, the centrifuge and nutsche filter-dryer must be completely Hastelloy at a significant price adder. The Autopress would only require Hastelloy head and footplates. The middle filter plates can be polypropylene or Hastelloy. The enclosure would remain stainless steel, as it is not exposed to the wet slurry.
The price adder for a Hastelloy Autopress is a fraction of the cost compared with centrifuges and nutsche filter-dryers.

8. Turndown Ratio: The Autopress is designed as a standard to include 14 filter plates.
However, the unit can operate with one plate up to 14 plates. BHS would include a spacer cylinder to make up the space of the “not-used” plates. This spacer cylinder can either be made of plastic (polypropylene, PVDF, PTFE) or metal.

A nutsche filterdryer for example must operate at a minimum of 1-2 inches of cake thickness. As the batch gets smaller, the percentage of the residual heel will increase; therefore, in actuality, the turndown ration may be only 30%. Centrifuges have a higher turndown ratio than the nutsche filter-dryer as both the speed and batch size can be adjusted.

C. CLEAN-IN-PLACE (CIP) & GOOD MANUFACTURING PRACTICE (GMP):

1. **The Autopress cleaning has been validated with Riboflavin tests and swabbing.**

2. **CIP is subdivided into two categories: Housing/Plate Stack and Enclosure**

3. **Housing/Plate Stack**
    a. The filter plates, spacers and membrane are cleaned via circulation. The flow can be in the forward and reserve directions. Both liquids and gases can be introduced and circulated for CIP operation. Grab samples of the liquids can be tested to ensure no residual cross-contamination.
    b. As the housing/plate stack is a pressurized design, soaking of the plates can also be conducted and then followed by liquid/gas circulation.
    c. In operation, customers have reported less than 1 ppm residuals after the CIP operation.

4. **Enclosure**
    a. The enclosure consists of scraper knives, discharge cone and the enclosure itself.
    b. All surfaces are rounded, are polished for easy cleaning, and are free-draining.
    c. The discharge cone can also be coated.
    d. Cleaning is conducted via spray nozzles, spray lances, etc. Sequences, times, pressures, solvent selections, etc. are conducted with BHS and the client.

5. **Steaming (SIP) and Other Techniques**
    The free-draining design of the standard Autopress allows for steaming, SIP and other steps. Centrifuges and nutsche filter-dryers must be designed specifically for these operations at a significant higher cost.

D. SUMMARY:

As described, the Autopress is very flexible process filter. The filter can be equipped with different components such as plate materials (one plate stack in stainless steel, Hastelloy and polypropylene), spacers and membrane, filter media, etc. It can be set for different cake thickness or adjusted via the pressing option and has many modes of operation. These modes include filtration, cake washing (forward and reverse), pressure or vacuum drying (forward or reverse), cake pressing in filtration, washing or drying, and cake discharge (with gas assist). Finally, it is easy to clean with validated procedures either automatically or in a manual mode.

The installation is much simpler than a centrifuge or nutsche filter-dryer as there is no vibration forces and with no moving parts, maintenance and spare parts costs are low. Therefore, in summary, the Autopress is well suited as a multipurpose technology for potent compounds, active pharmaceutical ingredient (API's) facilities as well as for specialty chemical applications.