HIGH-ENERGY, SELF-CLEANING FILTRATION SYSTEM

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A HIGH-ENERGY BACKWASH SYSTEM CAN INCREASE EFFICIENCY OF FILTER MEDIUM CLEANING

APPLICATIONS SUCH AS THE FILTRATION OF SAVEALL white water using 75 mm wedge wire filter screens, filtration of 12% starch to a size press using 50 mm wedge wire elements, and the filtration of recirculating vacuum pump seal water have one commonality. They are not typical self-cleaning pressure filter applications that anyone versed in filtration would normally consider. This paper presents a backwashing filter system that has had successful use in these applications. The system uses a short duration, high-energy pulse of water to dislodge contaminants from a filter element. This method of backwash has the following advantages:

- Up to 83% reduced backwash water use
- No minimum inlet pressure requirements for internal backwash
- No external water source necessary
- Use of filtered water with minimum downstream flow variation
- Use of fine filter screens with effective regeneration
- Efficient cleaning of filter screens that allows using filters on difficult applications.

PRESSURE FILTRATION

Pressure filtration can use manual clean pressure filters, internal back-washing filter systems, and external back-washing filter systems.

Manual clean filters

Figure 1 shows a typical single tube pressure filter. Liquid enters the vessel through an inlet on the left. It flows from the outside to the inside of the cylindrical filter screen. Clean liquid exits on the right. Debris and contaminants remain on the outside of the filter medium. As the filter cake accumulates, differential pressure measured from the inlet to the outlet of the filter increases. When the differential pressure reaches a predetermined value that is typically 10–20 psid, the filter medium nears its maximum dirt holding capacity. Cleaning is then necessary. The cleaning operation requires manual removal of the filter element from the housing.

Internal backwash filter systems

Back-washing filter systems clean filter screens while they remain in the filter housing. **Figure 2** shows a typical unit. Multiple filter housings mount on common inlet, outlet, and drain headers. Liquid enters the system through the bottom inlet header and distributes equally through each filter barrel. The clean pressure drop measured from the inlet to the outlet header is normally 1–7 psid. As the filter screen captures contaminants, the differential pressure increases. Back flushing typically occurs when the pressure drop reaches 10–20 psid. During back flushing, one filter barrel at a time is removed from service by closing the inlet and opening the drain valve. Clean filtrate flows from the outlet header through the filter barrel to drain. Each barrel undergoes back-washing for 4–8 s. After back-washing of all barrels, the system pressure drop will return to 1–7 psid.

External backwash filter systems

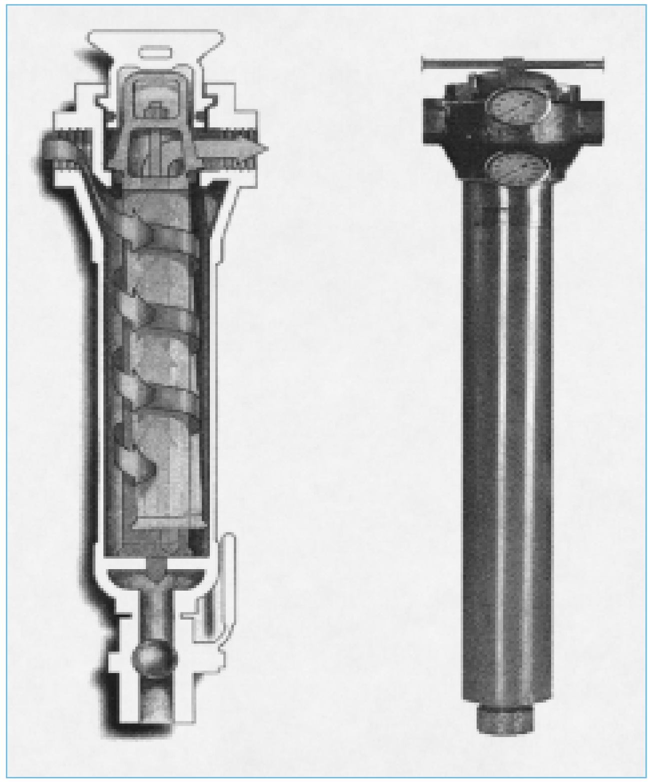
Figure 3 shows a typical system. In the filtration mode, the system operates in a manner identical to the internal backwash system. A fourth header at the top of the unit introduces a secondary source of clean backflush fluid. When the differential pressure reaches 10–20 psid, the filter system requires back-washing. This happens with closing of the inlet and outlet valves and opening of the drain and backwash supply header valves. The outside source of clean liquid flushes contaminants to a drain. Each barrel undergoes sequential back-washing for 4–8 s. After cleaning, the system returns to 1–7 psid.

HIGH-ENERGY, BACKWASH SYSTEM

Figure 4 shows a device that provides a high-energy backwash, and **Fig. 5** shows a back-washing cycle for the filter in Fig. 3. Piping that extends from the discharge of the water cylinder on the pulse unit to the backwash header on the filter bank connects the subsystems. The system works as follows:

1. Filtration mode: The filtration mode is identical to the internal and external back-washing filter systems. Flow is from the outside to the inside of the filter screen with debris retention on the exterior of the filter medium. When a predetermined pressure drop from the inlet to the outlet header occurs, the filter must be back-washed.
2. Fill the water piston: Beginning a backwash cycle requires supply of a system filtrate or a secondary source of clean liquid to the backwash header and water piston. The system pressure moves the piston inside the water cylinder as it fills with liquid. Adjusting the filling speed of the water cylinder can eliminate downstream flow variations.
3. Drain the barrel: Draining the filter housing before a backwash improves the filter medium cleaning efficiency. This requires closing the inlet and outlet valves and opening the drain valve to allow liquid to drain from the barrel.
4. Pressurize the hydraulic cylinder and water piston and backwash the barrel: With the backwash header valve closed, the backwash supply header fills with liquid and undergoes pressurization to the filter outlet pressure. Due to hydraulic forces, the backside of the water piston becomes pressurized. The backwash valve on the filter system is then opened. Fluid flows from the water cylinder back through the filter housing in approximately 1 s to dislodge debris from the filter medium and flushing it to the drain header. The filter barrel then returns to service.

Firing the piston in the water cylinder releases flow energy equivalent to a 150-hp pump delivering more than 800 gallons/min for 1 s. This high-energy, low water volume backwash is virtually impossible to duplicate economically with common system feed pumps. Calculations show the hydraulic backwash system releases 15 times more energy than a standard internal backflush.



1. Single filter

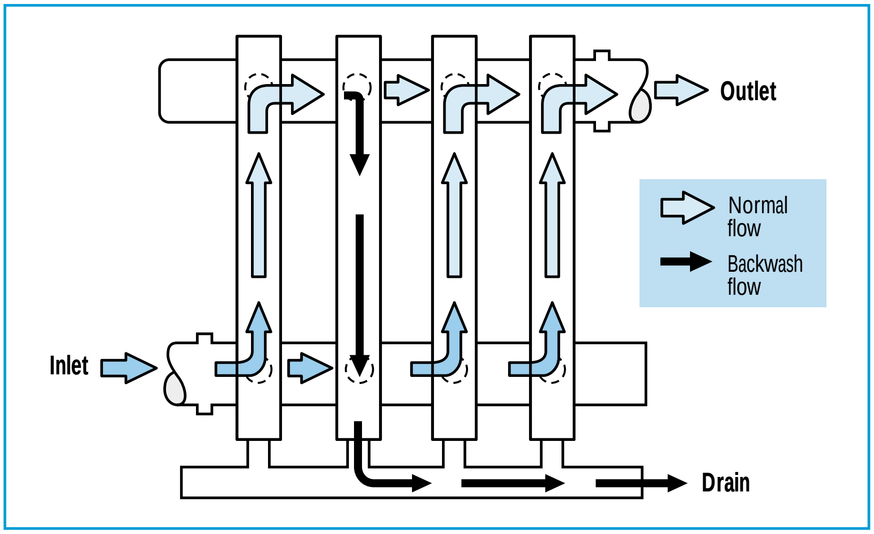
SYSTEM COMPARISON

The following discussion provides some typical questions and answers potential users ask about a high-energy back-washing filter system.

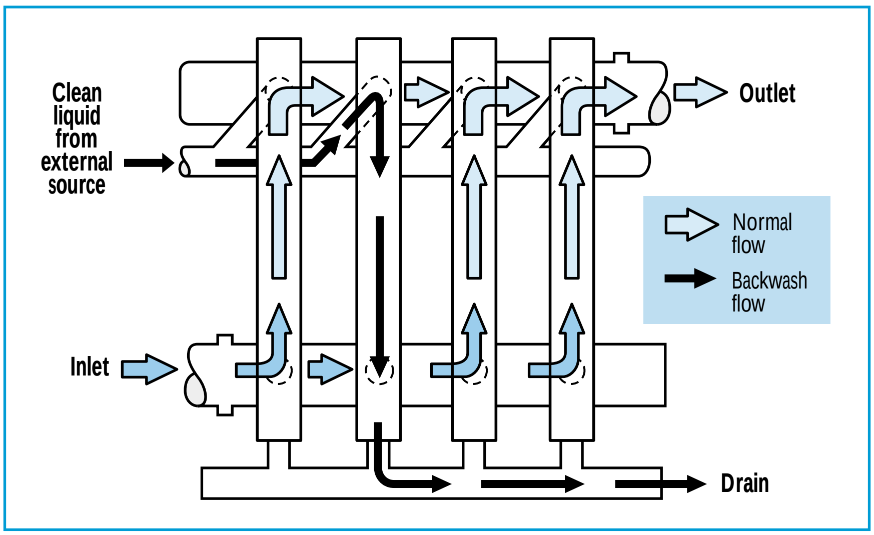
Can a pumping system provide sufficient energy to use internal backwash? To regenerate a filter medium effectively, sufficient energy must be available to dislodge contaminants from the filter screen. The pump that is supplying the backwash fluid must provide this energy. Inadequate backwash water supply pressure is a common reason for inefficient screen cleaning. Depending on the nature of the contaminants flushed from the element such as gelatinous or fibrous, providing sufficient energy to clean the screens effectively may be difficult. A high-energy backwash can free very stubborn contaminants from a filter medium while using a low volume of backwash water.

Can the process tolerate a loss of flow during the backwash cycle? Internal back-flushing filters require drain flows that are typically 50–150 gallons/min for 4–8 s per barrel. Depending on the pumping system, the process may loose all or part of the downstream flow. Adjustment of the water cylinder filling speed can eliminate most downstream flow fluctuations.

What type of pump feeds the filter system, and what happens during backwash? Failure to ask this question could mean the difference between success and failure of an installation. Centrifugal and positive displacement pumps have common use. When installing a standard



2. Internal backwash filter system



3. External backwash filter system

internal or external backwash filter system, the inlet, outlet, and drain flows require careful examination in three instances:

- When the filter elements are clean after a backwash cycle
- When the filter elements are dirty immediately before a backwash cycle starts
- During a backwash.

With a high-energy backwash system, the third and most difficult scenario to predict during a backwash cycle is not an issue.

How valuable is the liquid being filtered? For applications such as size press starch, coatings, additives, expensive polymers, or viscous liquids, an external back-washing filter is the most economical choice. An external back-washing filter system will minimize waste of valuable fluids and allow use of a more effective cleaning liquid such as hot water. A high-energy backwash system can use an external source of liquid for backwash or the process filtrate.

Is the system prone to upsets? If the filter medium in a back-washing filter system plugs due to a system upset, the filter may not recover and manual filter element cleaning will be necessary. A high-energy backwash filter system can recover from process upsets and provide uninterrupted flow to the process.

APPLICATIONS AND TEST RESULTS

White water filtration is a common application encountered in the paper industry. One mill installed a high-energy backwash system on a clear leg saveall white water application. Data collection occurred when the mill was manufacturing 23 lb corrugated medium producing a 100% recycled grade. The filter had 0.003-in. wedge wire filter elements. White water suspended solids were 311–511 ppm during the 12-h data collection period. This installation is significant because the filter screens are much finer and the solids level is much higher than generally accepted pressure filtration guidelines suggest. Typical "rules of thumb" state that white water should not contain more than 60 ppm of solids when using 0.006-in. slotted wedge wire filter screens.

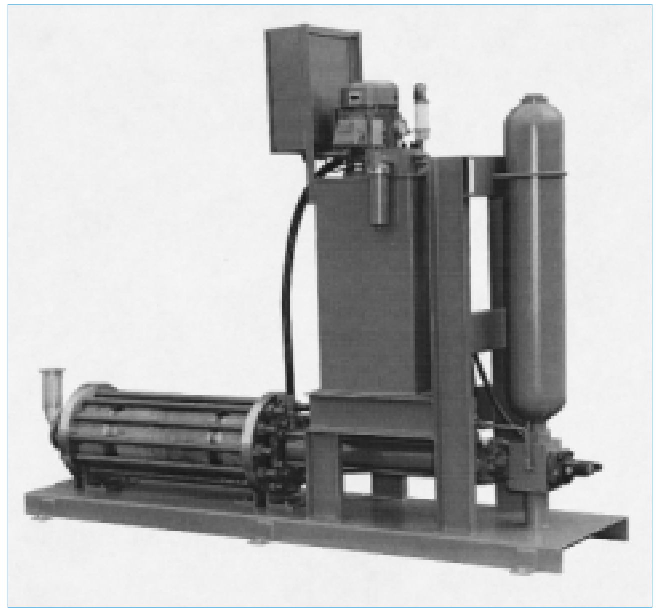
The objective of the examination was to compare the effectiveness of a high-energy backwash to a common internal backwash. The trial filter could operate in either mode. **Figure 6** shows that the filter system operated in a high-energy backwash mode for 7 h. During that time, the backflush intervals were 21–27 min. When the mode of backwash changed to internal, the backwash frequency increased immediately. After 69 min, the filter system underwent back-washing every 8.5 to 10.5 min.

After 2.5 h, the unit returned to a high-energy backwash mode. The backwash cycle times increased from 10.5 min to 18.4, 19.4, and 20.4 minutes for the next three cycles. These results indicate that the total number of daily internal backwash cycles will be 2.5 times greater than with a high-energy backwash system. An 8-s internal backwash uses 35 gal of water per barrel compared with 15 gal used by the 1-s high-energy backwash system. The data indicate that a high-energy system will use only 17% of the total water volume compared with the internal back-washing system.

This facility also installed a dissolved air floatation (DAF) clarifier with the clear leg pumped to a high-energy backwash system. The DAF clear liquid still contained 200 ppm consisting mostly of fines with trace quantities of long fiber. After operating for nine months, the filter systems have been trouble free. The filter elements never required removal from the filter housing for manual cleaning during that time.

Size press filtration is another common paper mill application. Typically, a 12% starch solution is cooked and pumped to the paper machine feed tank and to the size press. The excess amount of starch solution applied to the paper returns to the feed tank and mixes with fresh cooked starch. The paper machine feed tank contains contaminants such as felt hair and paper fiber introduced by the returned starch. Uncooked starch particles are also present. To prevent quality problems, the starch solution is filtered before pumping to the size press typically using 0.006-in. slotted wedge wire filter screens. Attempts to filter finer with standard back-washing filters have been unsuccessful. A 30-day trial testing a high-energy backwash filter system used the 0.002-in. and 0.003-in. slotted wedge wire filter elements.

The high-energy backwash system effectively regenerated both size filter elements. The 0.002-in. elements were in use for 21 days. During this time, the elements never required removal from the filter housing for manual cleaning. This method of backwash has demonstrated

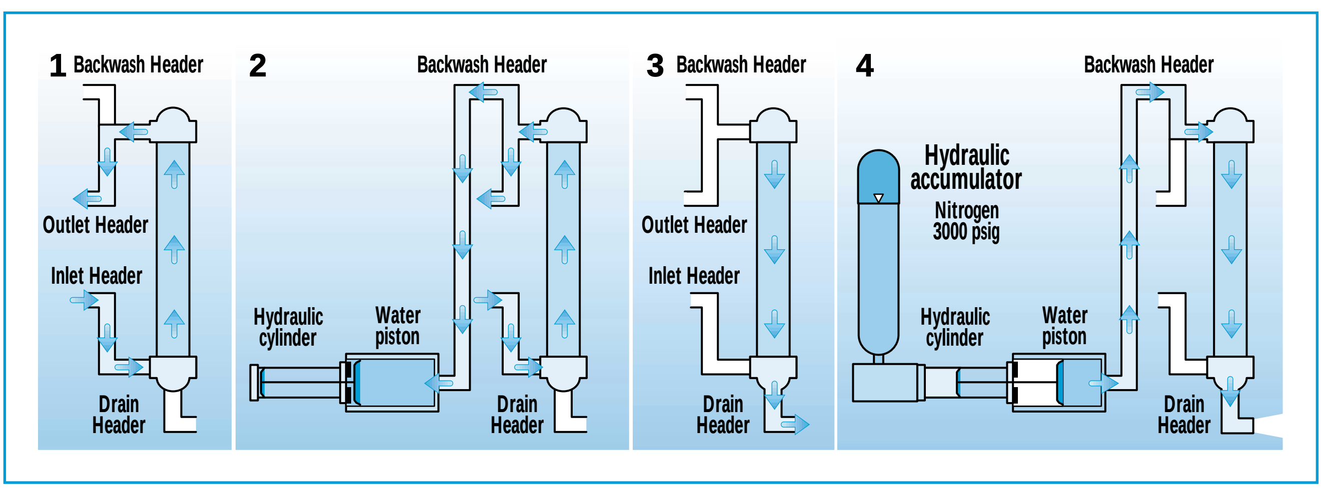


4. High-energy backwash device

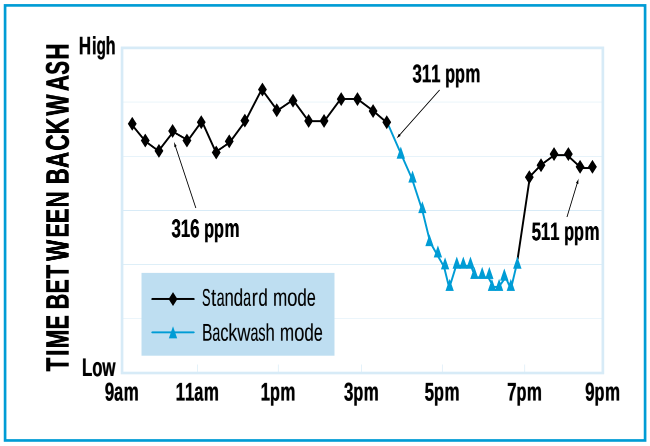
that a high-energy backwash filtration system can recover from process upsets when the feed tank solid levels increase such as during a sheet break.

Preliminary trial results indicate that the filtration of size with 0.002-in. elements can have positive benefits especially on lightweight paper grades. One mill using a high-energy backwash filter system claims they can justify the purchase using savings from machine operation.

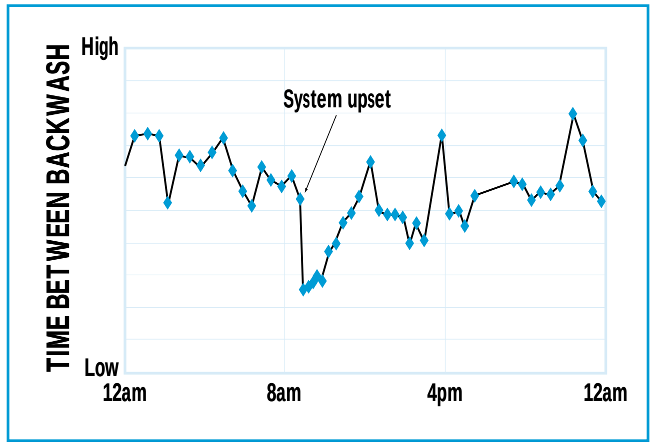
Recirculating vacuum pump seal water is another common paper mill application that normally contains fibrous contaminants and excessively high solids level for filtering with pressure filter technology. Vacuum pump sealing water discharges to a sump. It is then pumped through a filter to a cooling tower and back to the vacuum pumps. The water contains 300–500 ppm of paper fiber and suspended solids. A filter system equipped with 0.006-in. slotted wedge wire filter elements processed 1700 gallons/min of flow. Backwash cycle times were 24–69 minutes during two months. The filter screens did



5. High-energy backwash cycle



6. High-energy backwash in a white water application



7. High-energy backwash for river water

not require removal from the filter system for manual cleaning.

Figure 7 shows river water test data. The water goes to an undersized settling clarifier and then to a high-energy backwash filter system. During rainstorms, the clarity of the river water changed and backwash frequency increased. The graph shows that the hydraulic backwash system can recover from upset conditions. The high-energy backwash water use was 17% of the internal backwash—almost identical to the values calculated during white water trials.

An expensive polymer containing gel particles, dirt, and fiber was filtered with a 2-stage filtration system. The test was conducted to determine if a high-velocity backwash filter system could replace a plate and frame filter press. The first and second filter housing were piped in series and contained 0.004-in. and .002-in. slotted wedge wire elements, respectively. The polymer temperature was approximately 300°F. The contents of both filter housings underwent purging with nitrogen before backwashing. A solvent compatible with the polymer was pumped to the piston on a high-energy backwash system. Filter housings underwent back-washing individually. Before the backflush, the filter elements had a heavy coating of contaminants. The hydraulic system was a very effective method of cleaning the filter screens.

CONCLUSIONS

Accelerating a small volume of liquid backward through a filter housing using a high-energy backwash will increase filter medium cleaning efficiency. This allows use of finer filter screens, less backwash water, and pressure filters in applications where back-washing filters have not previously worked successfully. TJ

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