Evaluating the performance of paper machine savealls

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ABSTRACT: Many items affect the performance of paper machine savealls. A systematic analysis is required to look at all the possible causes of poor results in order to improve saveall performance.

KEYWORDS: Disc filters, drum filters, filtrates, filtration, savealls, separation, siphons.

The saveall is one machine to which papermakers often pay little attention because most of the problems associated with its use are usually eliminated during the paper machine startup. Saveall problems arise when there is a production increase or a substantial change in furnish.

Disc versus drum savealls

The two most common types of savealls in use are rotary vacuum drum filters and disc filters. Rotary vacuum drum filters have greater flexibility and a wider capacity range.

The maintenance required on drum filters is much less than on disc filters. For example, drum filters with stainless steel wires can operate maintenance-free for many years. Shrunk-on sector covers require routine replacement. Drum filter cover cleaning showers are installed on one piece of pipe and require minimum attention. There are two individual knock-off showers for each disc, which must be individually positioned and adjusted periodically.

The disc filter is normally preferred for several reasons. The disc saveall can separate the cloudy and clear filtrates more efficiently because of the much smaller storage volume inside the filter; that is, the disc filter has less internal volume from the filter media to the filter outlet. The disc filter requires less space for the required filtration surface area. Furthermore, its compact design minimizes the typical washer feed distribution problem because of the high flow rate per foot of width. The biggest selling point, however, is the disc filter's installed cost. It is much less than the installed cost of a drum filter, which is the prime motivator for most users.

Drum filters are usually used for high freeness, long fiber pulp such as linerboard and kraft papers. The thick pulp mats on disc sectors are stiff and usually do not discharge cleanly. The stiff pulp falls on the next disc sector, and part of the pulp falls through the crenelations into the vat instead of being discharged to the repulper.

The problem of discharging very thick pulp pads from the sectors can be eliminated in two ways. One method involves significantly increasing the space between the discs. The other way is to use one of the newer designs that incorporate a central, wide open discharge.

Separation of cloudy and clear filtrates

Most of the white water fiber and filler enters the filter during the initial formation, when the vacuum is turned on. **Figure 1** illustrates this process. Within a few seconds, the thin pulp mat on the filter cloth filters the white water, capturing most of the fiber and filler. It stands to reason that, within reasonable mesh sizes, the filter cloth or wire has no influence on saveall performance.[1]

After a few more seconds, most of the flow from the initial formation is in the shaft, flowing toward the filter outlet, as shown in **Fig. 2.** The storage volume in the sectors and in the shaft is normally minimized by tapering, as shown in Figs. 1 and 2. Most of the air in the sectors is forced out by the water entering the sector before the vacuum is turned on. Most of the air in the shaft is pulled down the cloudy drop leg.

The filtrate flow down the disc filter shaft is shown in Fig. 2. After about a quarter of the filtration cycle, there should be very little fiber in the filtrate at the saveall outlet.

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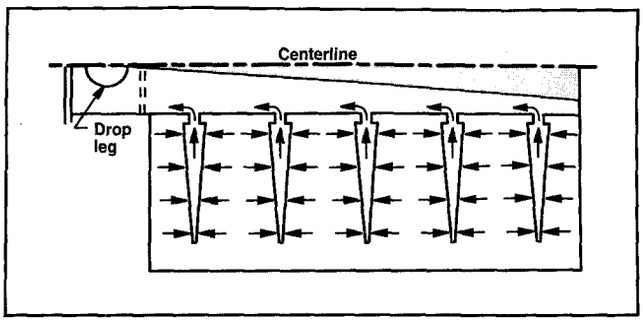
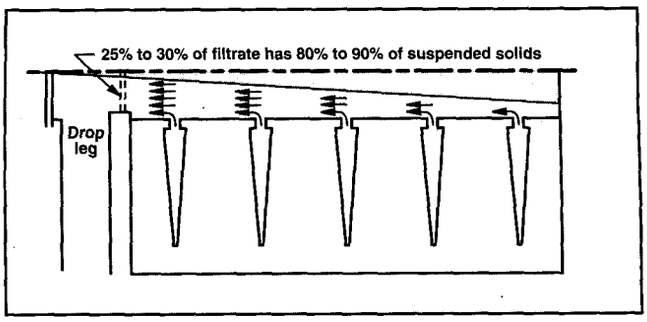
[1]Bellas, H. W., in *Chemical Engineers' Handbook* (R. H. Perry, Ed.) 3rd edn., McGraw-Hill, New York, 1950, p. 965.

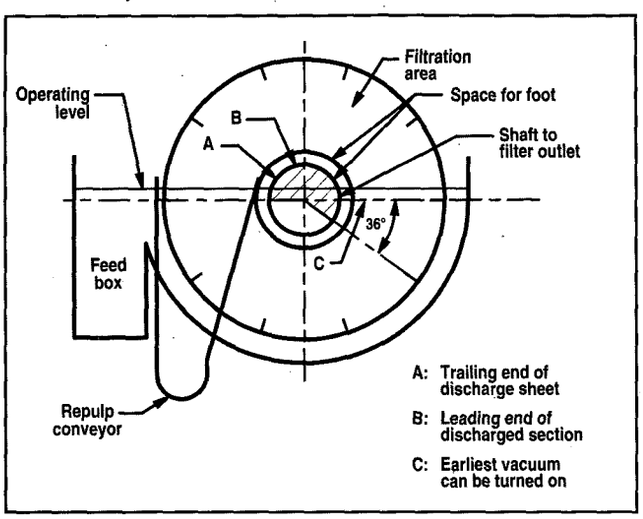
1. Suspended solids enter filter during initial formation



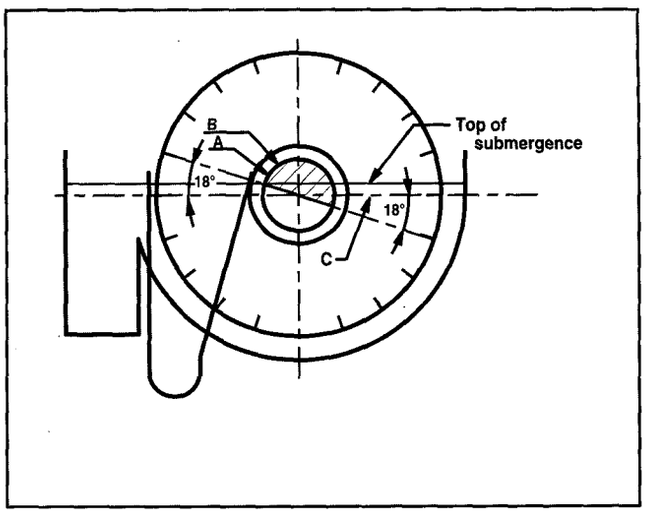
2. Suspended solids removal from inside the disc filter



3. Filtration cycle for saveall with 10 36° sections



4. Filtration cycle for saveall with 20 18° sections



As a result of this operation, the fibers in the clear filtrate have the same fiber size distribution as the fibers in the cloudy filtrate. If nozzles plug when cloudy filtrate is used (e.g., fourdrinier showers), then the clear filtrate will also plug the nozzles. A curved surface screen can be used to remove the long fibers. The fiber and filler concentration in the cloudy filtrate is normally six to eight times more than in the clear filtrate.

Items that affect saveall operation

There are many things that affect the performance of savealls, from installing it at the proper elevation to providing adequate filtration surface area.

One item which does not affect the rate of filtration but must be emphasized is the filter cloth, fabric, or wire. Within a very wide variety of weave patterns and mesh sizes, the pulp in the white water is the filtration media and filtration rate is essentially not influenced by the filter media.

If paper machine capacity has not significantly increased nor the pulp furnish changed, there are several methods to consider to improve saveall capacity. The first area to look at is water use around the paper machine wet end.

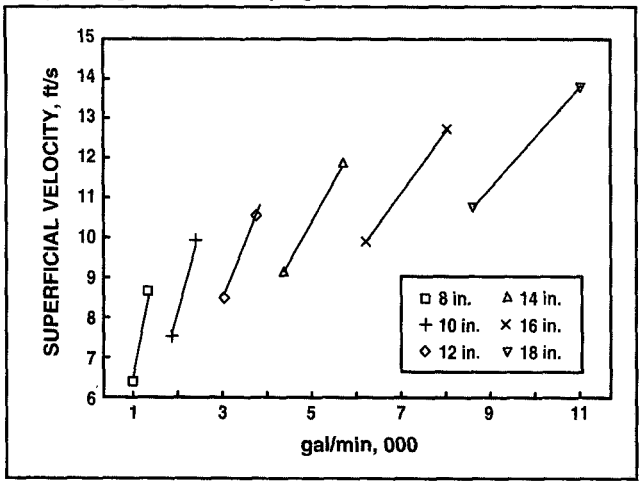
After years of operation, pumps and valves may begin to fail. While repairs are being made, backup mill water can be used temporarily. However, when shifts change, the work in progress is passed on to new operators, and the recirculated water or white water may not be turned back on after the repairs are made. A few of these occurrences over a period of years can result in a dramatic increase in flow to the saveall.

When broke is used as sweetener, the pulp may not discharge completely from the sectors. Usually, some long fiber pulp or sweetener is required for a clean discharge. Otherwise, the saveall must operate at a higher speed to make up for the "blinded" area.

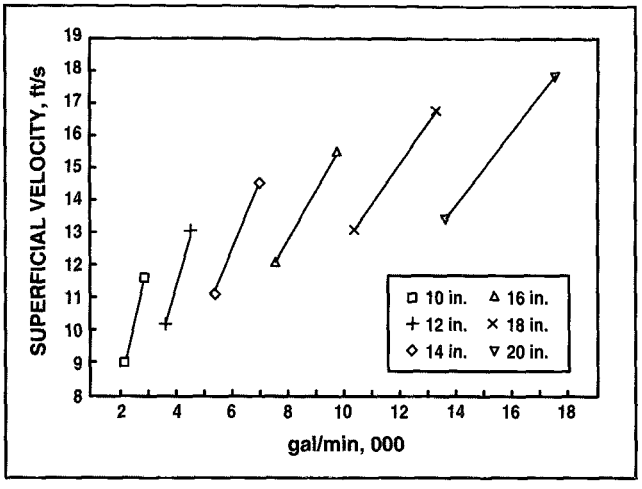
Feed temperature to the saveall will affect production rate. The influence of temperature is approximately the square root function of the viscosity of the white water at the two temperatures.

It is also possible that the original design conditions have changed considerably, and physical changes to the vacuum system may be required. Switching from acid to alkaline wet end and increasing the filler in the sheet will increase fines to the saveall. Filler gets into the voids in the pulp mat and reduces its permeability.

5. Siphon leg sizes for cloudy legs



6. Siphon leg sizes for cloudy legs



In general, the savealls that empty the shaft while the vacuum is turned off (e.g., super clear third leg) require about half of the filtrate flow to generate a good vacuum in the cloudy leg. About one third of the filtrate is required in the cloudy leg when the filtrate in the shaft is not drained and replaced with air.

In the late 1970s, a Canadian fabric cover manufacturer convinced several mills to install finer disc sector covers to reduce the suspended solids in the clear filtrate. The arguments sounded reasonable, and several mills started to use the fine mesh covers. The saveall manufacturers were called immediately when, for no apparent reason, saveall performance deteriorated.

A check of the time required for the air to exit the spare sectors with the new covers showed the air could not exit before the vacuum was turned on during normal operation. Too much air was pulled down the leg, resulting in a significant loss of vacuum and, consequently, production rate.

Filtration cycle analysis

The saveall filtration cycle is shown in **Figs. 3 and 4.** The bridge (timing, gate, or shoe) setting is provided for disc filters with 10 and 20 sectors per disc. Filtration starts after the complete sector is submerged in the vat and the air in the sector has been evacuated. One of the few examples where the filter fabric mesh size can affect the performance of disc filters occurs when the porosity is too low.

As soon as the leading edge of the sector clears the bridge, the vacuum is turned on in the sector. After completing the filtration cycle, the sector comes out of submergence, and the vacuum is kept on to allow the pulp on the trailing end of the sector to dry before it is discharged. Most savealls discharge the pulp before the top centerline, but one manufacturer discharges the pulp at the vertical centerline.

The filtration area per disc and the filtration time are two of the most important items that differ between manufacturers. Two 12-ft diameter disc filters do not necessarily have the same filtration area. The area that is not filtering must be subtracted from the total area. The inside diameter without the filtering surface equals the shaft diameter plus the foot (or transition from the sector outlet, bolted to the shaft, to the bottom of the filtration area) of each sector.

A 12-ft diameter disc, with an inner filtration diameter whose shaft and sector foot are 5 ft in diameter, has 187 ft^2 per disc compared to a disc with an inner diameter of 3 ft, which has 212 ft^2. The difference of void space in the middle of the disc is considerable and must be considered.

A saveall operating at 60% submergence with 10 sectors will have the leading edge of the bridge 36° after the horizontal centerline, compared to 18° with 20 sectors. The difference in filtration time per cycle is 12.5%. Since the filtration rate is essentially constant during the filtration cycle, for every eight discs the 10-sector machine will need an additional disc when all other features are identical.

The discharge consistency can vary considerably from the leading to the trailing edge of large angle sectors. For example, a disc filter with 10 sectors, equipped with a vacuum pump for thickening pulp to as high a consistency as possible for refining, can discharge the pulp at 17% at the leading edge and only 12% at the trailing edge.

Another item to consider on savealls is the knockoff and cover cleaning shower power consumption. Some savealls use high pressure, low volume while others use high volume, low pressure. Ten times the volume at one third the pressure results in about three times more energy consumption. On large disc filters, this difference can amount to US$ 20,000 per year.

Sizing the drop legs

There are only two requirements for sizing the drop leg. The first is to ensure that the air and filtrate are completely mixed at the bottom of the leg. In other words, there should be enough friction from the piping walls to prevent the air from accumulating in the middle of the pipe. The top of the float-

ing bubble becomes the effective length of the drop leg. The second requirement is to be certain the size is not too small to limit hydraulically the flow of air and filtrate.

These requirements are difficult to determine. The design specifications should allow for changes in the operation and future expansion. The exact flows are unknown until after the paper machine startup. There is also the difference between the flow down the cloudy and clear legs, determined by the location of the clear and cloudy separation and the air in the shaft. The air in the shaft will expand and be pulled down the cloudy leg, resulting in a considerably lower vacuum in the cloudy leg.

Charts in the TAPPI Technical Information Sheet for barometric leg sizing[2] are completely valid today for washers. They can be used for small, single leg washers requiring superficial velocities of 5–7 ft/s (Chart 1) and 7–9 ft/s (Chart 2). Somewhat higher velocities should be used for bleach plant washers. For savealls with two solution outlets, the superficial velocities versus flow rate in gal/min, for cloudy legs and clear legs, are shown in **Figs. 5 and 6,** respectively.

Because of the larger volume of air in the cloudy leg, the design velocity of the flow down the legs will be considerably lower than in clear legs. Estimating the volume of saturated air is difficult because the permeability of the pulp and the operating speed change. Estimations become even more difficult when the filtrate is at a high temperature. Therefore, a superficial velocity is used.

Velocity increases substantially as the pipe diameter increases, because there is proportionately less circumference length to area as the pipe size increases, and higher velocities are required to keep the air and filtrate thoroughly blended.

The only consideration at the bottom of the drop leg is the creation of a back pressure that will reduce the vacuum on the saveall. Using an elbow seal or submerging the bottom of the drop leg a few inches in a seal box is all right. There are hundreds of legs that operate open-ended at the bottom of the leg without any problems, as long as the leg is running full.

Summary

There are many items that affect the performance of paper machine savealls, and several are listed below. A systematic analysis is required to look at all of the possible causes of poor performance in a structured manner.

- Where possible, disc filters are commonly used as savealls because they have the lowest installed cost.
- Within reason, the filter cloth or wire does not influence the filtration rate. The pulp is responsible for filtration.
- Fiber size distribution and classification in clear and cloudy filtrates are about the same. The amount of fiber present in the cloudy filtrate ranges six to eight times higher than in the clear filtrate.
- The air in the sectors should be evacuated before the vacuum is turned on.
- Draining the shaft and replacing the filtrate with air results in more air being sent to the cloudy leg. As a result, a higher filtrate flow is required down the cloudy leg to achieve a reasonable vacuum.
- Adequate filtration area, with proper physical installation to include a proper drop leg length and pipe size, is required.
- Filtration time per disc per revolution is not dependent on the outside diameter of the discs.
- Superficial velocities in the cloudy legs are lower, but the actual flow rate is higher than in the clear leg.
- There is proportionately less circumference, length to cross-sectional area, in larger pipes than small pipes. Therefore, the velocity in the larger pipes is higher.
- If there have been no major furnish changes or paper machine configuration changes, the loss of saveall capacity is most likely from changes made at the wet end of the paper machine.
- Miscellaneous items that affect the performance of savealls include temperature, sweetener freeness, and the amount of filler and fines from the paper machine wet end. ▮

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[2]TAPPI TIS Data Sheet No. 010.02, "Barometric leg sizing."