Distinctive features of approach-flow screening

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The screens in the approach-flow system must remove debris and help stabilize the flow to the headbox.

Approach-flow screening is designed to prevent unsuitable fibrous components from passing to the paper machine. These include fiber flocs as well as deposits that break free from the walls of white-water tanks and chests, assuming that nonfibrous contaminants are screened out during the preceding stock-preparation process.

The approach-flow screens also must satisfy a range of other requirements if they are to ensure a uniform flow of stock to the paper machine. This article examines the effects of screen parameters on system performance. Among the parameters discussed are screen hydraulics, screen surface characteristics, system configuration, screen operating principles, and the intensity and frequency of pulsations within the approach-flow system.

Purpose of approach-flow screens

The approach-flow screens have several objectives:

- Remove stock buildups
- Dampen pulsations
- Deflocculate stock
- Deaerate stock
- Protect headbox system.

The primary objective is removal of debris and agglomerations. However, the screen's hydraulic performance is also important, since optimum paper machine performance depends on the supply of a well-dispersed stock under stable and controllable conditions to the headbox. A most important aspect here is the dampening of pulsations from the screen and other sources. Pulses occur in machines with rotating elements such as pumps, screens, cleaners, or by turbulent flows caused by valves. The frequency and amplitude of these pulses depend on the operating conditions of the various pieces of equipment. Engineers strive to maintain pulsation at a low level and within appropriate frequency ranges, thus avoiding overlapping and signal addition. Screens can help reduce such disturbances by creating microturbulence and by dampening absorbed and reflected pulses.

Pulp suspensions tend to flocculate during their flow through pipework. The approach-flow screens, positioned in front of the headbox, provide the last opportunity to deflocculate the stock by the action of the screen foils.

Removal of air entrained in the incoming thick stock ahead of the fan pump is another important feature. Screens remove the larger air bubbles from the incoming suspension through the action of the centrifugal force created by their rotors. Of course this is not a replacement for vacuum systems, but for many paper machines it is sufficient.

Finally, the approach-flow screens also protect the headbox system from heavy tramp material.

Criteria for selecting approach-flow screens

The functional demands of screens can be split into "general criteria" valid for all screens and "specific criteria" valid for approach-flow application. General concerns include screening efficiency, stability of operation, specific energy consumption, and ease of maintenance. Specific approach-flow criteria include:

- Pulsation dampening
- Foil frequency level
- Surface finish requirements
- Roundness of baskets
- Space requirements
- Operating principle.

Pulsation dampening

Figure 1 shows pulsation before and after a screen as measured in a paper mill. The charts on the left depict pulsation amplitude as a real-time signal, while those on the right show pulsation in the frequency domain. The screen's influence on pulsation cannot be detected in the real-time measurements. When the pulsation is converted to the frequency domain, however, it is apparent that the screen reduces the amplitude of the pulsations, especially at higher frequencies above 50 Hz. The foil frequency of

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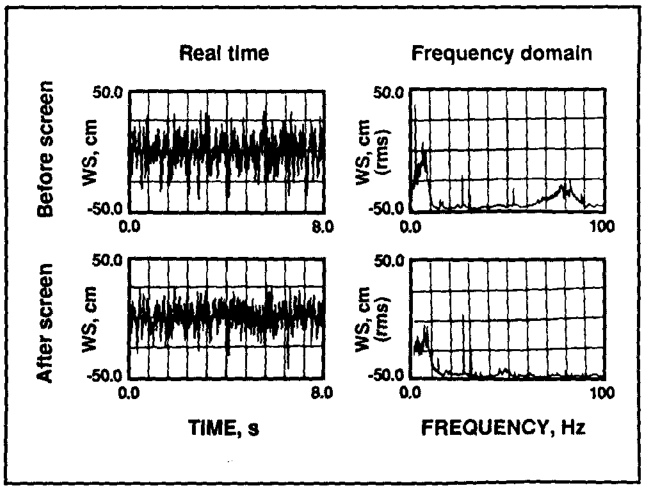
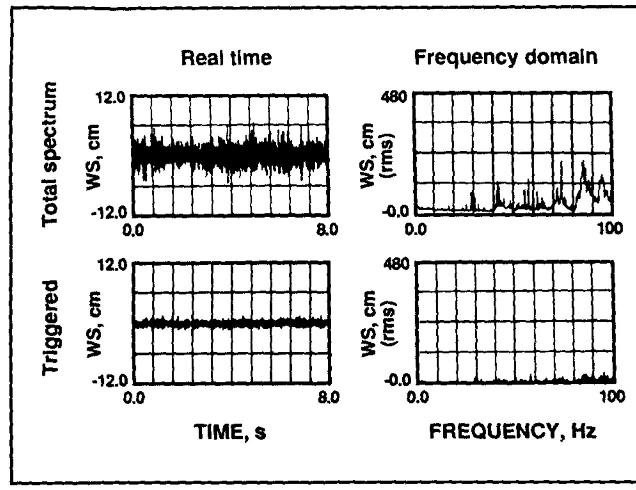
1. Pulsation before and after a screen as depicted in real time and in the frequency domain. Foil frequency of screen is 30 Hz. WS = water column



2. Total pulsation and pulsation triggered by screen as depicted in real time and in the frequency domain. WS = water column



the screen in this case was 30 Hz. The observed dampening by the screen can be attributed to screen-basket reflection and absorption of pulses originating from other sources in the screening system.

Pulsation inherent within the approach-flow system

Figure 2 shows the total pulses of an approach-flow system and the pulses triggered to the shaft frequency of the screen. The triggered data emphasize screen performance by adding all pressure amplitudes relating to a certain rotor position in the screen and then dividing the result by the number of measurements. Nonscreen-related pulses of various frequencies are thus mathematically decreased, and screen-related pulses are emphasized. As in Fig. 1, the charts on the left side represent real-time signals, while those on the right depict the frequency domain.

Comparison of the total spectrum of the untriggered pulses with the triggered pulses in real time shows that the screen pulses are of minor importance. Less than one-third of the total is related to the screen. As regards the frequency domain, the system has significant peaks, especially above 50 Hz. The triggered results, however, show that other sources are responsible for these peaks.

These results also stress the importance of the foil frequency level, which must always be far enough apart from the frequency level of other sources to avoid signal additions. In general, foil frequencies greater than 25 Hz are recommended for approach-flow screens.

Surface-finish qualities

Smooth surfaces in the approach-flow system are essential. Surface imperfections are likely to capture fibers or other stock components, which can then break free and contaminate the system. The most economic screen surface finish is equivalent to that of headbox surfaces in contact with stock. The screen should not be better or worse.

Figure 3 shows the surface of a raw plate used for screens and the case manufactured from it after rough grinding. The profiles were measured with a profilometer, and all peaks larger than 1 μm/cm were counted. Figure 3 shows that while the raw plate has a coarser profile, it has less peaks per centimeter than the plate subjected to rough grinding. Grinding simultaneously smoothes the surface and creates more small peaks. Therefore, the number of peaks must be carefully interpreted in relation to the profilometer value.

5. Photographs of four plates depicted in Figs. 3 and 4

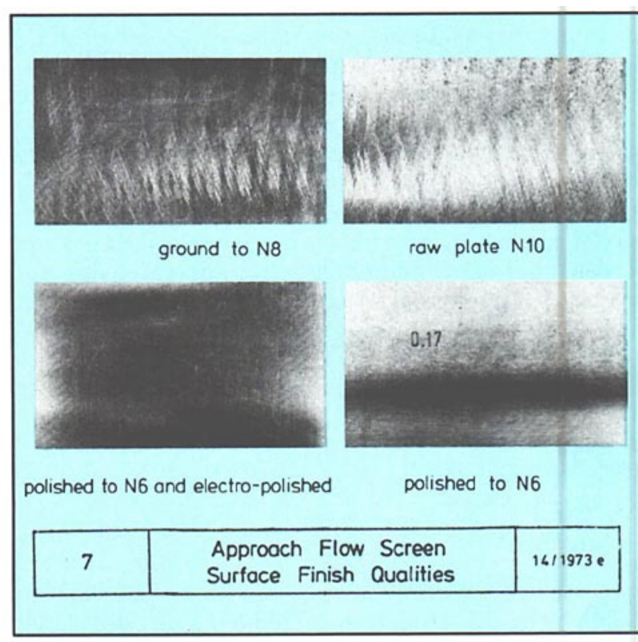
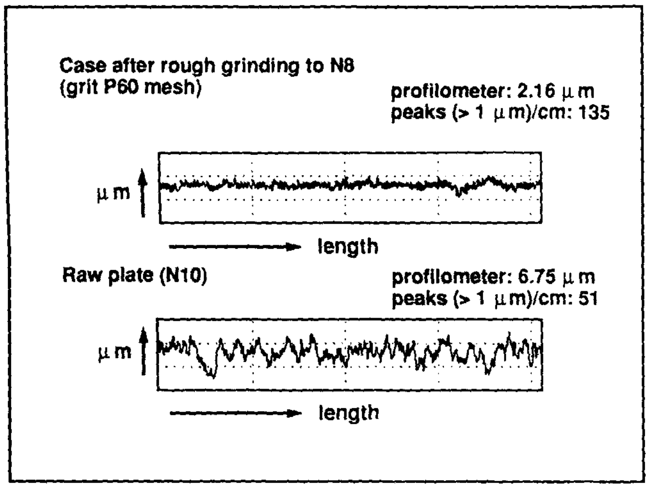


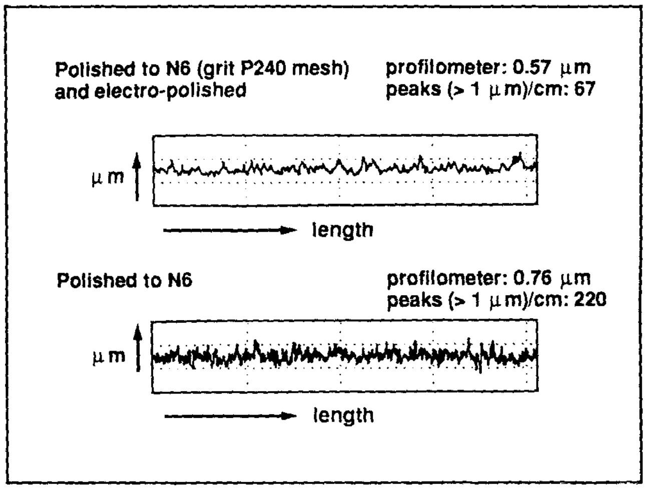
Figure 4 shows the profiles for a polished and a polished-plus-electropolished screen surface. The improvement for the polished-plus-electropolished surface is apparent. The profilometer value is somewhat smaller, and the number of peaks has been reduced significantly. Grinding, on the other hand, steadily increased the number of peaks. **Figure 5** shows photographs of the four surfaces depicted in Figs. 3 and 4.

Electropolishing has the additional advantage of improving the structural surface of the screen body. During the screen-manufacturing process, the mechanical forces applied to the metal change its surface structure. These material layers are removed during electropolish-

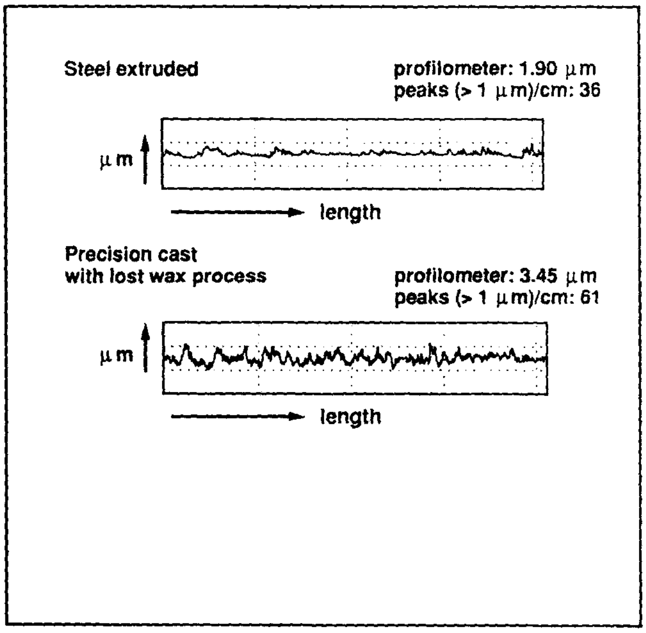
3. Surface finish of raw plate and the same plate after rough grinding



4. Surface finish of two plates polished to N6. The electropolished surface has fewer peaks per centimeter



6. Surface finish of extruded and precision-cast screen foils



ing, leaving the original material on the surface. In addition, the oxygen freed during the electropolishing process helps enrich the surface layers with chromium, making the surface more resistant to corrosion. This also improves the cleanliness of the wetted parts.

The situation around the foils, which are cast or extruded, is somewhat different. Given their complicated shapes, polishing is not economic. The upper profile in **Fig. 6** is typical of an extruded foil, while the lower profile is typical of a precision-cast foil. The quality of extruded foils is generally better, with profilometer values and the number of peaks about half those of precision-cast foils. Therefore, extruded foils should be given preference for approach-flow screen applications.

Screen-basket quality

Screen baskets are rolled and welded into shape. Because of this, the roundness of the basket is not as exact in the area of the welded seam as it is in other areas. Post-machining in the welded area is done in different ways. **Figure 7** shows baskets manufactured using two different methods: with seams through the openings and with seams welded in the land between the openings.

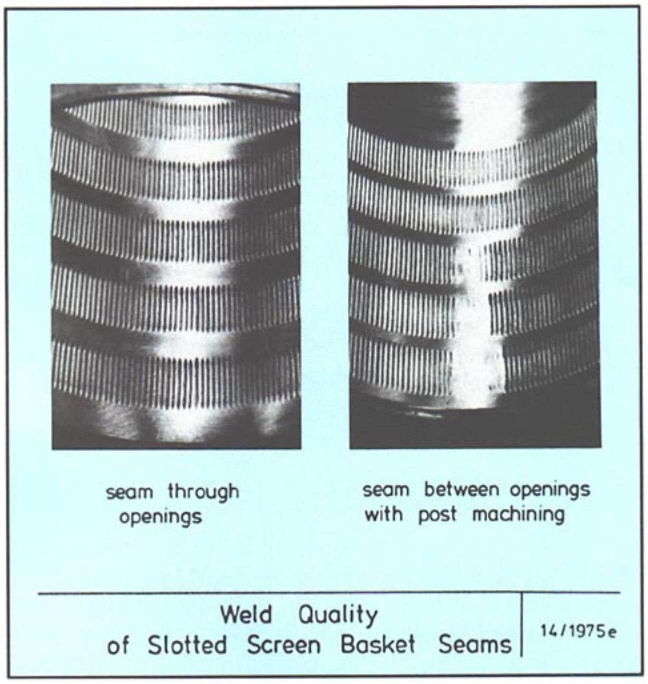
Despite efforts to machine these areas, nonuniform operating conditions can cause uneven flow. It is therefore essential to select high-quality screen baskets and install them so that the welded seam does not face the accept outlet of the screen. Reflection and absorption can then dampen any remaining abnormalities.

Ease of maintenance

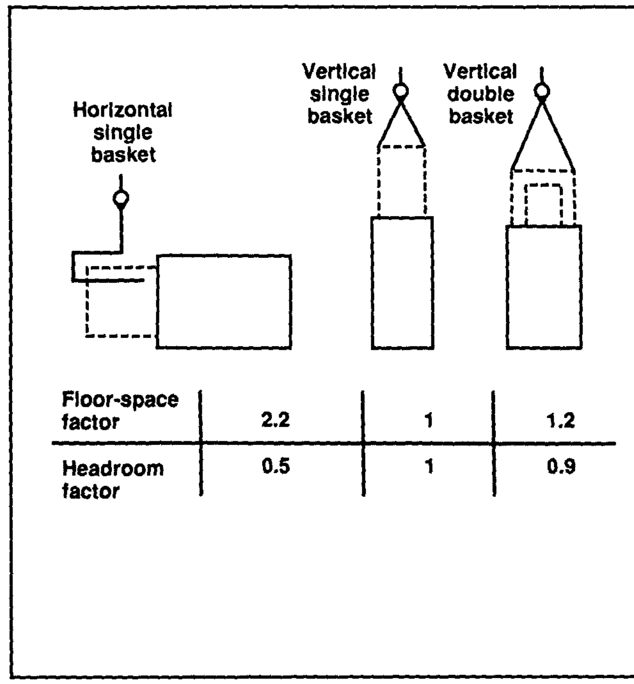
Downtime of the approach-flow screen can mean equivalent downtime on the paper machine. Obviously, ease and speed of maintenance are crucial factors.

Approach-flow screens are usually placed in the basement of the paper machine building. This provides sufficient counter-pressure on the accept side without any throttling elements. Unfortunately, there is not much extra space in this area because of the concentration of white-water tanks, fan pumps, and piping beneath the wet end of the paper machine. Maintenance of approach-flow screens in cramped and difficult local conditions is common.

To ease the problem, three different designs can be considered: a horizontal single basket, a vertical single basket, and a vertical double basket. These are illustrated in **Fig. 8**, which shows relative floor space and headroom requirements for screen configuration sized to handle the same level of production. The horizontal-shaft arrangement has the lowest headroom needs. However, because the baskets are removed horizontally, the demand for spare floor space is greater. The single-basket design of the vertical shaft needs the least floor space. In this case, however, the need to extract the basket through the top places a premium on head room. There also must be sufficient space to exchange the bearing housings. The double-basket design needs less head room, since the height of the baskets for the same screening area is reduced by about 40%. In addition, the floor-space requirement for



7. Welded areas in slotted-screen baskets. Left: seam welded in the land between openings. Right: seam welded through the openings.



8. Relative floor-space and head-room requirements for three screen-basket arrangements

the vertical double basket is considerably less than for the horizontal-shaft arrangement. For large production rates requiring large screening areas, the double-basket design seems to be the most economic solution.

Operating principles

The main variations in the operating principles of approach-flow screens are in the direction of flow and the location of the rotor. Most screens have either centrifugal, centripetal, or combined centrifugal/centripetal flow directions. The rotor is located either on the inlet side or the accept side. **Figure 9** illustrates the most common screen configurations. **Table I** lists the performance characteristics of these designs in decreasing order of importance.

The most important characteristic is prevention of stringing. Only the screens with the rotor on the inlet side perform this task effectively. Ease of maintenance, the second important characteristic, is determined by the accessibility of the screen basket. Screens that provide access to the screen basket without removing the rotor have an advantage in this area.

The tendency of long-fiber fractionation (equivalent to fiber losses) is largely determined by flow direction. Centrifugal forces react opposite to the hydraulic forces. Centripetal-flow screens minimize the buildup of fiber matting and thus have the advantage in this area.

The specific energy consumption depends on the circumferential speed of the rotor and the position of the rotor in relation to the flow. In general, rotors on the inlet side need less energy. Energy consumption also depends on the hydraulic losses (turbulence and friction) in the screen housing. Here, the double-basket design with a low volume on the inlet side, a high amount of active screening surface, and a low amount of housing surface is superior to the other designs.

In general, the high-efficiency screening that takes place during stock preparation reduces the efficiency requirements in the approach-flow system. The approach-flow screen needs only to protect the headbox and remove fiber buildups that have re-formed following screening in the stock preparation. The double-basket design has the advantage because of the higher speed and tangential direction of the flow.

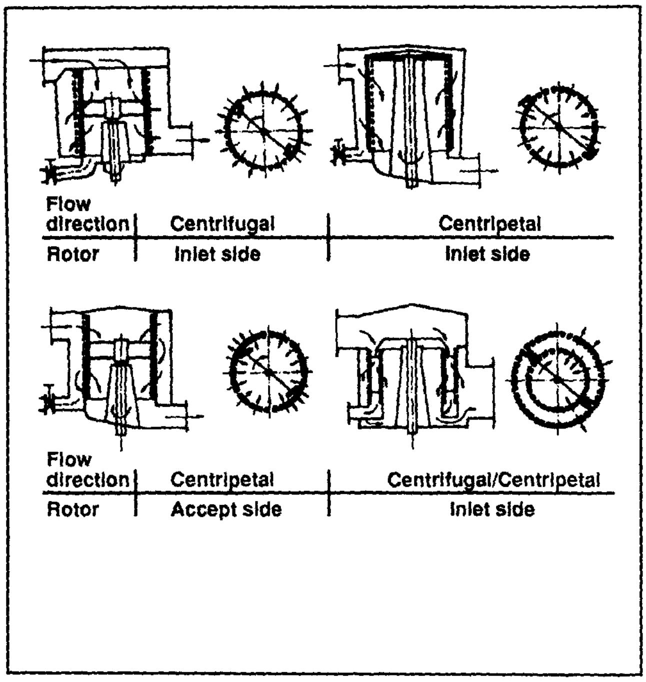
Finally, protection against heavies, although of minor importance, is a further point for consideration. Screens with centripetal flow have an advantage, since any heavies in the stock are forced to the outer housing and not the screen basket.

Approach-flow systems

While screen design is a primary consideration, the placement of the screen within the approach-flow system is of utmost importance. **Figure 10** shows a typical system with two fan pumps. The incoming stock passes through the first fan pump into the cleaner system. From there, it passes through a second fan pump to the primary screen and then on to the headbox. Screen rejects are fed to a secondary stage and from there to the tail-end screen. Stock dilution of the rejects is only undertaken between the secondary stage and the tail-end screen. Thus, the system is open between these two screens.

Pulsation sources in this system are: the fan pumps, the cleaners, the screens, and the control valves for the overflows of the screens and the headbox. The frequency levels for these components must be differentiated against each other to avoid signal addition. The engineer also must ensure that the pressure is maintained at a low level and that the control valve is in the optimum position to reduce turbulence during operation. If, for some reason, larger pulses are to be expected from a certain source (e.g., from

9. Common screen configurations

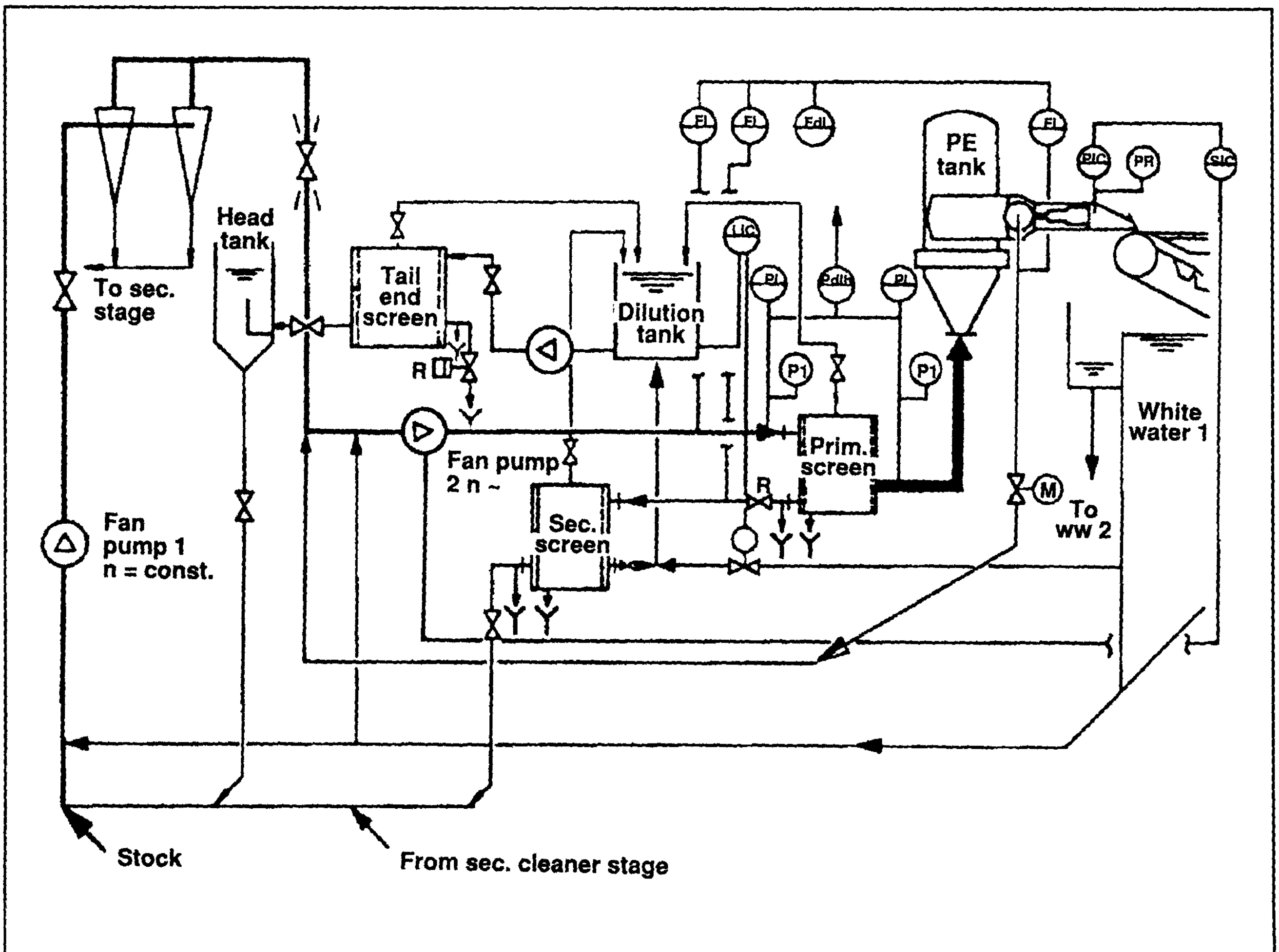


I. Performance characteristics* of common screen configurations

Flow:	*Centrifugal*	*Centripetal*	*Centripetal*	*Centrifugal/ centripetal*
Rotor:	*Inlet side*	*Inlet side*	*Accept side*	*Inlet side*
Protection against stringing	++	++	. . .	++
Ease of maintenance	++	. . .	++	. . .
Fractionation tendency	. . .	+	++	. . .
Specific energy consumption	+	+	. . .	++
Screening efficiency	+	+	. . .	++
Heavies protection	. . .	+	++	. . .

*++ = very effective; + = effective.

10. Typical arrangement of primary, secondary, and tail-end screens in an approach-flow system



the intermittently working valve of the tail-end screen), this element must be separated from the rest of the system by open vessels. In the system shown in Fig. 10, the tail-end screen is preceded by a dilution tank and followed by a head tank.

Figure 10 also shows the process controls and the static head requirements of the system. The speed of the second fan pump must be controlled to prevent regulating valves after the screen from creating turbulence in the approach flow. For the same reason, there are no intermittent operating valves for reject control within the loops of the primary and secondary screens. The first control valve in the loop is the dilution water valve before the dilution tank. Thus, pulsations created here are compensated. The screen operation is followed up by differential pressure indicators, which are shown only for the primary-stage screen. The same would apply to the secondary and tail-end screens as well. These were not included in the figure for the sake of simplicity.

An important element is the head pressure between the primary screen (located in the basement) and the headbox. The screen needs a certain counter-pressure to overcome the central air core created by centrifugal forces. On the other hand, the pressure of the headbox is determined by the production rate. Thus, the counter-pressure must be in balance with both needs to eliminate the need for a throttling valve, which would create additional turbulence. If the pressure needs of the headbox are lower than those of the screen, throttling can only be accepted as an exception to the rule.

Finally, Fig. 10 also shows the deaeration and system drainage. Careful design of system drainage is essential, since the presence of dead-end pipes in the main flow line will lead to stock buildups. Special valves must be used to drain the screens.

Summary

Debris removal is but one of the performance requirements for approach-flow screens. These screens also are called upon to stabilize and homogenize the flow to the headbox. The design of the approach-flow system, including the placement of screens, is a crucial aspect in controlling pulsation and turbulence.

Fiber buildup in the approach flow is reduced by using components with smooth, polished surfaces. The cost-effective approach is to match the surface finish in the approach flow with the headbox finish.

The choice of centrifugal, centripetal, or combined-flow screens depends on performance requirements and maintenance considerations. Because screen downtime is directly related to downtime on the paper machine, ease of maintenance is a primary criterion. Several screen-basket configurations are available to accommodate the cramped quarters under the paper machine's wet end.□

The help of M. Pellhammer and N. Rhodes is gratefully acknowledged.

Received for review Jan. 18, 1990.

Accepted March 27, 1990.

Presented at the TAPPI 1990 Papermakers Conference.