# Recent Trends In Screening in The Paper Machine Approach System

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## INTRODUCTION

From the papermaker's point of view, the main objective of screening is that the stock components are screened as well as possible in order that the stock to the paper machine is free from any contraries, which would otherwise compromise the runability of the paper machine.

Targets for equipment used for screening pulp stock in the paper machine approach are generally similar whether for headbox, broke or thick stock screening,i.e.

- Increasing screening consistency
- Single equipment; i.e. one screen instead of two or more
- Multi-purpose equipment; i.e. the same equipment solution has multiple functions
- Increasing screening efficiency by decreasing hole/slot size

## HEADBOX SCREENING

Historically, machine screens were fitted with perforated baskets of hole sizes 1.6 - 2.4 mm and have been operating for decades. Today paper mills are in the process of changing from holes to slots.

For headbox screens, thickening factors are generally between 1.1 - 1.3 and reject rates range typically between 5-8% on the primary stage and 6-8% on the secondary stage.

### Process design

Screening generally takes place in 2 or 3 stages and at low consistency, i.e. <1.2%. The last stage has traditionally been a vibrating screen, because it has a low fibre reject rate, and operators are able to observe what debris is being rejected.

The accepts from the 2nd stage screen are normally returned through the white water silo to the 1st stage of the cleaner plant, or in some cases to the DECULATOR. The rejects from the 2nd stage usually flow to the 3rd stage screen. If the paper machine is fed with virgin wood fibre or is equipped with broke slotted screening, the 3rd stage screen can be excluded and instead the rejects of the 2nd stage screen directed to the broke screening. Occasionally, the rejects are also taken to the latter stages of the cleaner plant on the short circulation, as a cost saving measure.

If the machine production is low, a two-stage headbox screening system is sufficient. It is normally recommendable in this case to continuously reject from the 2nd stage screen. A reject collection tank is necessary between every screening stage so that pressure pulsations or consistency disturbances cannot travel up stream back to the headbox.

### Machine screening with one screen

Higher paper machine speeds and higher production figures require bigger machine screens.

Machine or headbox screening was earlier accomplished by several parallel working devices, however the trend of the last couple of decades has been to achieve the primary machine screening with just one unit.

The first who designed the "one-screen concept" was Messrs. Bird in the US, developer of the machine screens with the foil rotor in the middle of the 1970's. Headbox screens have seen many improvements since then and now typically look like **Figure 1.**

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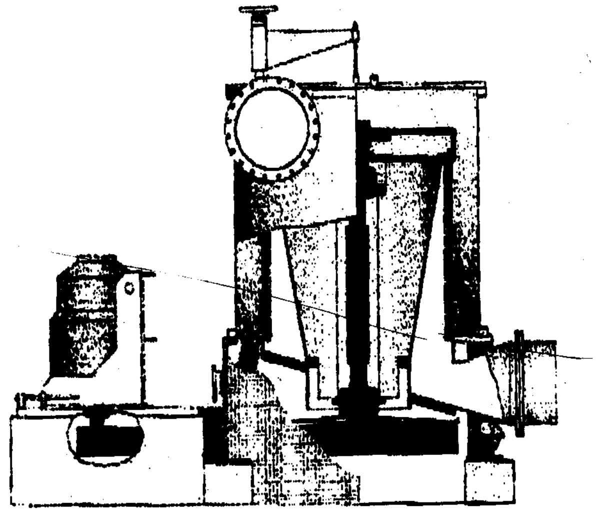


**Figure 1. Headbox Screen MODUSCREEN HB**

The development of the foil rotor was in fact the incentive, which enabled designers to develop bigger machine screens, however this solution also has it's advantages and disadvantages.

For the runability of the machine, the main advantage of a single screen is a simpler and cheaper installation, (less piping and floor space requirement, which leads to less dirt pockets and edges whereupon fibre could hang up and subsequently harden or string). The single screen concept has resulted in a more stable process. It is difficult to make several parallel units operate in a similar fashion. The purchase price is lower as are the operating costs.

Of course the disadvantage is that the paper-making is at the mercy of one single screen, although preventative maintenance can significantly reduce the chance of any unforeseen breakdown. On the other hand, with machines making a number of grades with multiple screens. it would be possible to service one of the screens while keeping the remainder in operation.

Machine screens have been developed so much in recent years that they have now become so reliable that the risk of breakdown is anyway minimal and single screens are universally accepted.

**Vertical or horizontal screens?**

The sizes of screens have increased with the single screen concept.

Limited floor elevations, particularly in older mills and bigger equipment sizes are factors causing conflicting requirments. Big screens such as required today could be pre-planned in a new mill, but cause problems in existing older mills. One solution has been to make a service batch in the machine room floor, through which the screen can be opened and serviced.

Another solution has been the introduction of the horizontal screen, but the cantilevered design of the screen basket, especially with large screens, can cause a bending in the screen basket, which reduces the runability of the screen and increases pulsations.

Thirdly, mills who have had space limitations around the headbox and in the basement, have resorted to thick stock screening. This concept allows the retaining of the original holed headbox screens and includes the installation of a fine slotted screen between the blend and machine chests, where space doesn't normally present a problem.

**Centrifugal or centripetal design?**

The flow direction passing the screen surface of the pressure screen is said to have an importance to the screening efficiency. Both types of screen are manufactured these days, partly due to historical reasons.

There are some advantages to the centripetal design including the fact that heavier objects are directed to the screen wall rather than the screen cylinder, thus saving the sensitive headbox screen cylinder from damage. There is also less likelihood that material will wrap itself around the foils and become entangled between foil and basket as can happen with outflow or centrifugal screens.

Regarding screening efficiency however, there is little proof that centripetal screens have higher screening efficiency than centrifugal screens as the overriding factor is the screen basket design.

### Hole or Slotted screening in machine screens?

Profiled screen cylinders were introduced at the beginning of the 1980's, which enabled the use of slotted screen for machine screening for higher productions and also resulted in smaller screen sizes.

The reason for using slotted screens for the machine screening can be seen from the comparison in **figure 2,** which shows the effect different types of screen basket have in removing dirt particles.

| SCREENING...... Holes vs Slots | | | | | |
|---|---|---|---|---|---|
| **Dirt Classes** | | | | | |
| I | II | III | IV | V | VI |
| >5.00mm | 1.00-5.00mm | 0.10-1.00mm | 0.15-0.40mm | 0.04-0.15mm | <0.04mm |
| 5.00mm | 1.00mm | 0.40mm | 0.15mm | 0.04mm | 0.04mm |
| D=2.5mm | D=1.13mm | D=0.70mm | D=0.44mm | D=.23mm | D=0.18mm |
| #1.5 | #1.6 | #1.5 | #1.5 | #1.5 | #1.5 |
| #0.45 | #0.45 | #0.45 | #0.45 | #0.45 | #0.45 |
| #0.25 | #0.25 | #0.25 | #0.25 | #0.25 | #0.25 |
| #0.20 | #0.20 | #0.20 | #0.20 | #0.20 | #0.20 |
| #0.15 | #0.15 | #0.15 | #0.15 | #0.15 | #0.15 |

**Figure 2. Screening...holes vs slots**

For example, the perforated cylinder of diameter 1.6 mm, which was common in older screens, at worst passes all particles which are smaller than 1.6 mm, whereas a slotted 0.45 mm basket separates all particles of dirt group III or larger.

Today, slotted screen cylinders with a typical slot size of 0.35 mm are generally used for most grades in machine screens. On some of the newest machines, even slot sizes of 0.25 -0.3 mm have been employed, but infrequently.

Due to the narrow slot and its structure and also the manufacturing method employed for the conventional milled slotted cylinder, the open area will be small, as low as 4-5%. It has not been possible to increase the open area with smaller pitches (the area between slots) as the slot pitch has to be chosen according to the fibre length in the fibre suspension to prevent plugging due to stapling or even in extreme cases, stringing.

The small share of the open area results in increasing the total basket area to pass the required flow. This leads to either very big screens or else possibly two screens. (when two screens are used, the foil frequencies are designed so that there is over 2Hz difference to avoid resonance). The screen surfaces of the biggest screens today are about 11-12 $m^2$ so that the number of screens required is kept to a minimum to achieve the required capacity.

The small share of the open area is due not only to the fact that the slot width is small, but also in part to the manufacturing method and construction of the slotted cylinder. Because of the manufacturing methods and for retaining the strength of the screen cylinder, the slot can only be of a certain length and the area between the slots must be unbroken.

It can be concluded from mill experiences that the use of slotted screens for the paper machine approach improves the purity of the paper and decreases linting and breaks on paper and printing machines.

Development of milled cylinders has concentrated on decreasing the slot size and on increasing the open area. In practice, the smallest possible slot size is 0.15 mm, but even 0.1 mm slots are conceivable.

Smaller slot sizes however increase the "sensitivity" of the screens, which is why slot sizes of less than 0.35 mm are infrequently used. The risk of blinding the screen basket increases, as does the risk of stringing (due to the more difficult manufacturing of the screen cylinder).

In recent years however there has been a new development with the introduction of water cut screen cylinders and wedge wire screen cylinders, the net effect being to increase the open area.

### Pressure pulsations

In the machine screen, the pulse suppression can be either passive or active. Passive pulse suppression, for instance the design of the accept opening and the control of the flow, has the following advantages:

- It prevents the direct propagation of the pulsation activated by the rotor into the inlet piping
- It suppresses the pulsation, including that caused by the pump, by obstructing its progress without obstructing the flow.

The active suppression of pulses means reducing the pulse pressure produced by the foil, which also involves reducing the capacity of the screen. The means of active suppression are

- Enlarging the foil clearance (typically 3-6 mm)
- Reducing the foil speed
- Improving foil design

In order to avoid barring of the sheet, the pulses generated by the screen must be lower than 400 Pa Peak-to-Peak.

As a foil rotates within the screen basket, a positive pressure wave is generated in front of the foil, and a negative pressure wave is produced behind it. Both the screen basket and the screen shell (through the basket perforations) reflect the two waves. Screen body openings such as the accept outlet, provide zones of "release". As a foil passes areas of reflection and areas of release, additional pulsations may be generated.

It therefore follows that a low-amplitude pulsation is achieved by installing the rotor above the accept outlet of the screen.

Unfortunately both enlarging the foil clearance and reducing the foil speed reduce capacity. Variations of foil design are available, including vertical foils, angled foils and even multiple foils, with each manufacturer claiming that their design is superior. The bottom line however is to produce a screen which should be able to give the required capacity at low pulsations of less than 400 Pa amplitude.

**Reject stage in machine screening**

For effective screening of the paper machine approach, rejects from the primary stage should be properly treated. Slotted screening either in one or two stages ensures a good cleaning result.

In all screening stages, the consistency should be kept as close to the headbox consistency as possible to minimize possible consistency variations. Unnecessary dilution should be avoided as this leads to bigger equipment.

The vibrating screen earlier used as a reject screen is today seldom accepted for modern machine requirements. Vibrating screens have a tendency to blind over, string and require constant attention. Large hole sizes are used else the stock will thicken. These large hole sizes will accept the particles that the efficient primary/secondary screens have just rejected and re-enter the circuit, creating a build-up of dirt in the process.

Vibrating screens have now been superseded by closed pressure screens, (see Figure 3), in which the perforation of the screen cylinder can be the same as in the primary screen. Thus rejecting of impurities is ensured.

The reject screen can be provided with periodic reject removal by means of a junk trap, which may be emptied via a timer, thus reducing fibre loss to a minimum.

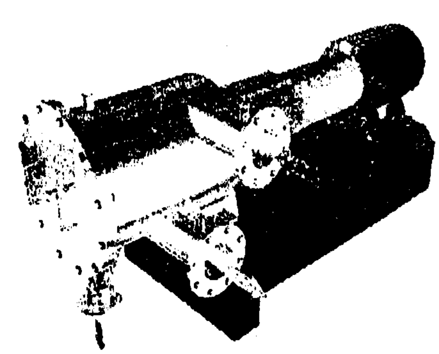


**Figure 3. Reject Screen MODUSCREEN FO**

## BROKE SCREENING

Necessity and process design of broke screening greatly depends on the paper grade being manufactured.

Some screens have now been developed to operate at consistencies reaching and even exceeding 3%, which makes screening broke possible. Machines making end products with low processing degree such as sack kraft, liner, fluting and newsprint have not traditionally been equipped with broke screening.

Broke screening on fine paper machine has been usually designed as protective screening ahead of thickening and proportioning through the defiberizers to the blend chest and webbing. The protection has been mainly to reduce wearing of broke deflakers. In addition to screens, HD cleaners have been in operation but are generally inefficient especially as the consistency increases over 3-4%.

Several solutions can be found to broke screening on SC-paper machines. The protective screens have been provided in some cases without broke defiberizing, to protect equipment in the paper machine approach such as cleaners and headbox screens. Some SC-machines have been provided with defiberizers for broke without thickening or screening. In such cases, the consistency shall be higher in the broke tower than at proportioning.

The process design of broke screening for paper and board machines manufacturing coated grades, has depended upon the thickness of coating. However, today it is not uncommon to find screens on all types of coated paper, including lightly coated"improved newsprint". If coated and uncoated broke are stored separately, the coated broke is often screened separately before being mixed.

**Targets for development of broke screening**

One target for the development of broke screens is to increase the screening consistency and thus decrease equipment size.

The higher the quality of the end product made on the paper machine, the more effectively the broke fractions must be screened before proportioning to prevent contraries from passing through which reduce quality.

Demands for increased machine availability as well as higher productivity, efficiency and longer running life of felts and wires, require the process. The installation of broke screens is an effective method of achieving these.

**Recent examples of broke screening**

Various solutions are open for broke screening.

**Figure- 4** shows a simple application as found for example on newsprint machines. The screen is replacing a HD cleaner, which has been used for the same application, but which is not as effective as a screen. The screen hole size is typically 2-3 mm. i.e. smaller than the gap between the plates in the deflaker.

**Figure-5** and **Figure 6** show how recently started fine paper machines, screen their broke. The first is a classic way of screening, with first coarse

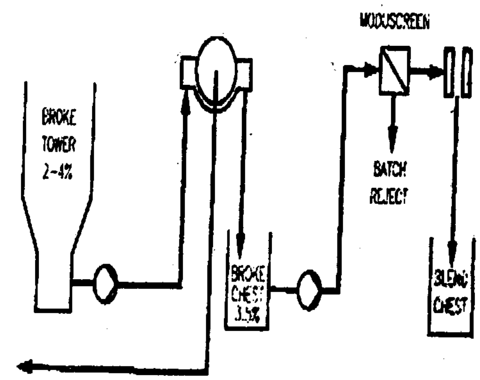



**Figure 4. Newsprint Broke Screening**

screens with holes followed by fine screening and defiberizing. In some cases, the screening had been so effective so as to make the defiberizer redundant. In the second installation, the process layout is similar, apart from the deflaker being used on the coarse screen and primary fine screen rejects. The coarse screens and fine screens efficiently remove any flakes, which can then be treated more effectively in concentrated form by a smaller defiberizer.

With the advent of screening at even higher consistencies, it is possible to thicken the broke before screening. This gives an advantage of using smaller screening equipment than if the screening was before the broke thickener.

## THICK STOCK SCREENING

Thick stock screening related to the paper machine approach, is employed between the mixing

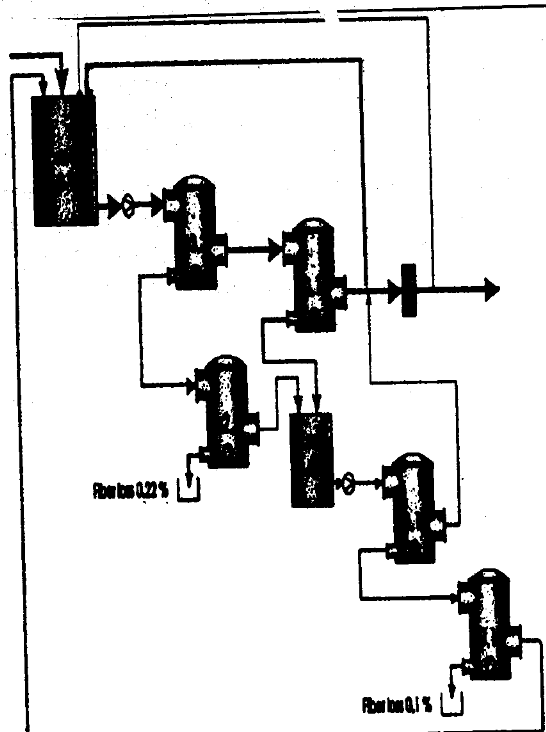


**Figure 5. Fine Paper 400 t/d Broke Screening.**

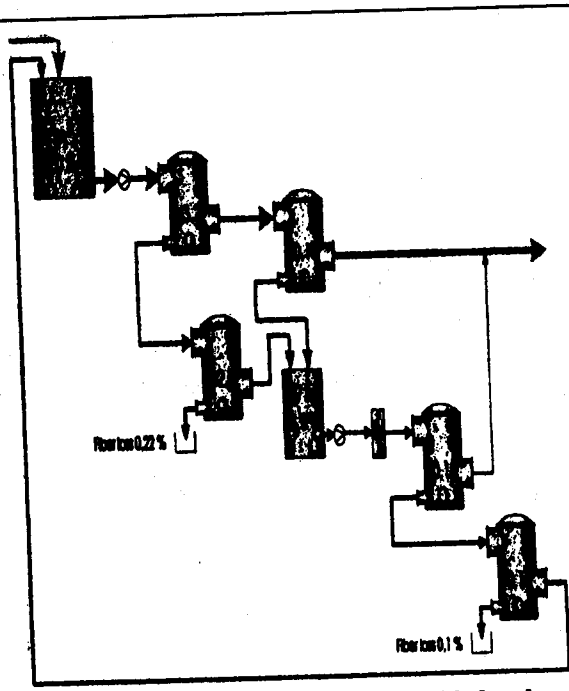


**Figure 6. Fine Paper 375 t/d broke Screening.**

chest and machine chest. Until now, this concept has hardly been seen on modern day paper machines in Europe or Asia.

It has been more of a feature on North America. The runability of the paper machines have been greatly improved, because web breaks and broke decrease.

The main advantages of thick stock screening are:

- It can compensate for poor screening in the pulp mill. Older pulp mills may still be screening their pulp with screens fitted with holes. To improve the paper quality, instead of adding slotted screens in the pulp mill, it is possible to install thick stock screens which would simultaneously screen all the pulp fractions, including broke, coming to the paper machine.

- It is more effective than just broke screening. For the reasons just outlined, it makes more sense to screen all the pulp coming to the paper machine. If baled pulp is used, this could eliminate the need for a HD cleaner.

- It is cost effective alternative to slotted headbox screens. Particularly if a paper machine has existing holed screens and it is necessary to improve the screening, a thick stock screening system can be easily installed instead of going to the trouble of replacing the existing screens and altering the expensive headbox piping layout. The papermaker has the peace of mind knowing that should the thick stock screen have to be bypassed for maintenance for example, he still has the back up of his existing screens.

- Better screening alternative to slotted headbox screens. Because thick stock screens do not have the same limitations on pulsations, they can be fitted with coarser rotors allowing screening up to over 4% consistency, which in turn reduces the equipment size. This also allows smaller slot sizes to be utilized, typically from 0.15 mm to 0.25 mm, with little risk of blinding.

**Recent examples of thick stock screening**

**Figure-7** shows a 3-stage thick stock screening system on a 1300 tpd coated board machine. The primary and secondary stages are fitted with 0.3 mm slots and screening efficiency is over 90%. The secondary headbox screen rejects are directed to the tertiary thick stock screen thus eliminating the need for a tertiary headbox screen.

**Figure-8** shows a similar 3-stage stock screening system for SC paper, however in this case the secondary screen accepts are combined with the primary screen accepts, thus reducing the primary screen size. The effect on cleanliness compared with a fully cascade system has been negligible.

**Separation of plastics and other light fractions**

Plastics and other impurities lighter than water are removed from fibre suspension by slotted

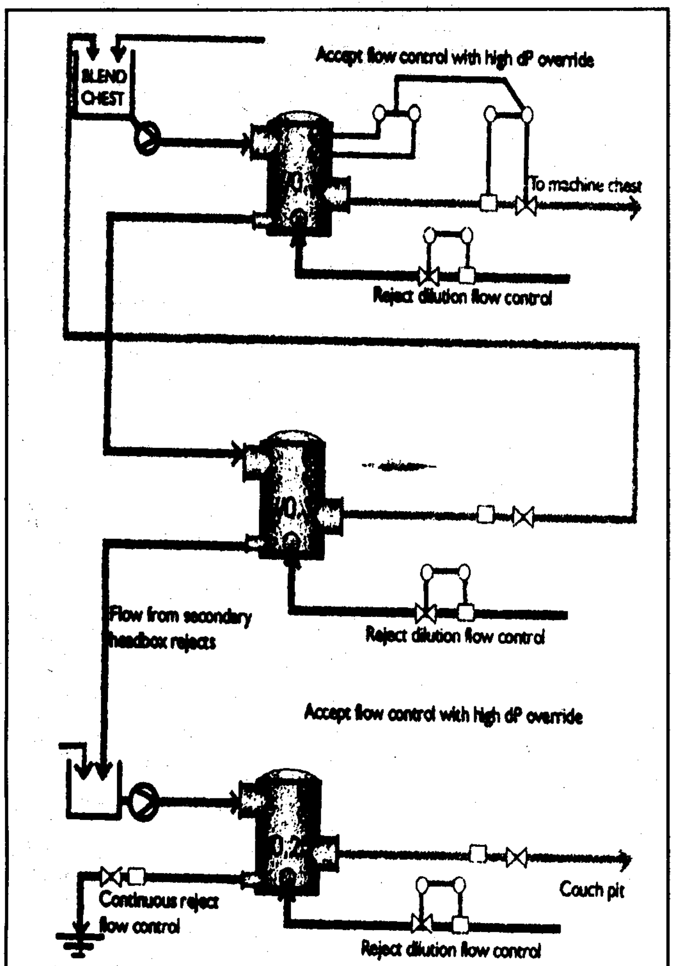



**Figure 7. Coated board 1300 t/d thick stock screening.**

pressure screens much more effectively than by reverse-type centrifugal cleaners.

It has been shown that plastic fractions lighter than water collect inside the screen rotor. If the screen is equipped with an extra reject pipe running from inside the rotor and flush water is fed into the inner side of the rotor, the plastic fraction which concentrates there can be effectively removed from the process.

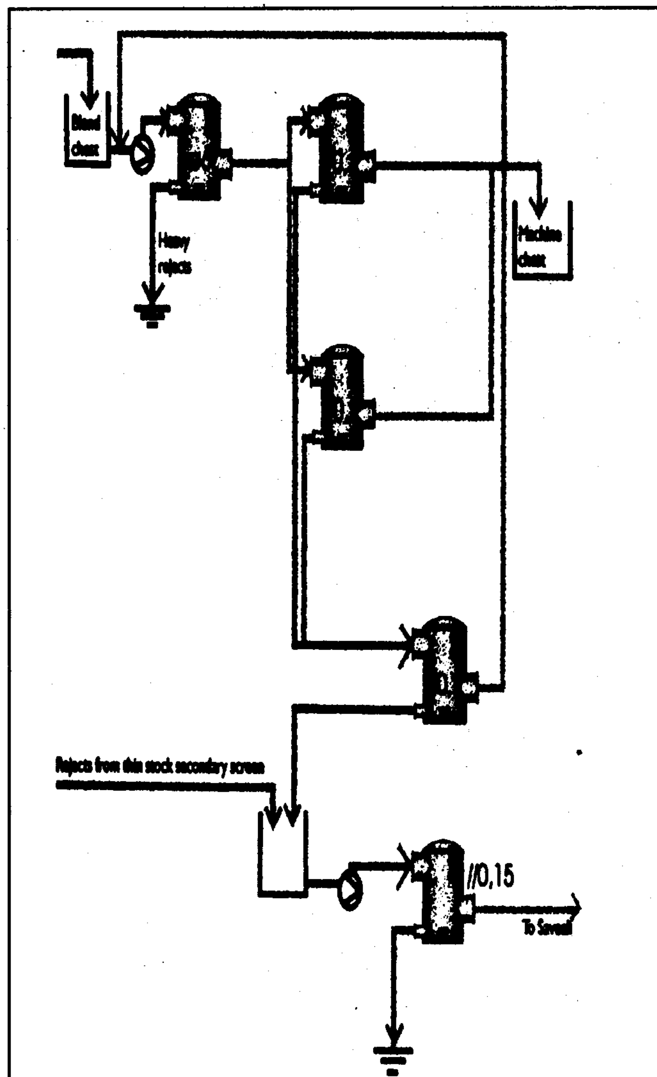



**Figure 8. SC Paper 1000 t/d Thick Stock Screening.**

## COARSE SCREENS

On machines requiring low processing such as newsprint and tissue, it is common nowadays to install a coarse screen with holes. See **Figure-9.**

Such a screen, is equipped with a rotating profiled screen cylinder and static foils located in the accept side which cause a pressure pulse on the feed side through the holes in the rotating cylinder. This pulse loosens fractions felted or attached to the screen surface and thus keeps the screen surface clean. Because of the rotating cylinder and tangential feed to the rotation direction of the screen cylinder, the screen partly operates in a similar way to centrifugal cleaners whereupon heavier impurities are hurled to the outer rim and do not travel to the screen surface. Coarse screens are typically fitted with holes from 2 mm to 6 mm and commonly operate with batch rejects to minimize fibre loss.

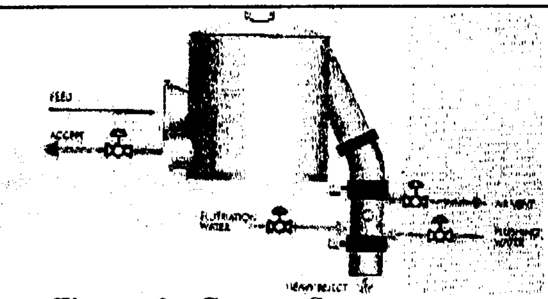


Figure 9. Coarse Screen type MODUSCREEN C

## FINE SCREENS

To increase the consistency in fine screens, new rotors have been developed such as the LR rotor, see Figure 10, which has been developed for consistencies of up to 4-5%.

The pulse generators or elements on the LR rotor produce forward downwards pressure pulses in the upper part, neutral pulses in the middle and upward pulses opposed to the flow in the lower section. The whole screening surface is taken into active screening use by means of this rotor construction.

Owing to more effective cleaning pulsation, the screen surface operates more effectively and without plugging at higher screening consistencies.

**Figure-11** shows the principle of the LR rotor. The rotor surface is divided into four zones. This allows the entire screen zone to be utilized at optimum energy intensity.

**Figure-12** shows the velocity profiles of a conventional bump rotor and the LR rotor. The LR rotor gives a more uniform flow over the screen cylinder in comparison to a bump rotor, allowing optimum conditions to be maintained during the whole screening process.

In zones I and II of the LR rotor, the elements on the rotor feed pulp suspension effectively to the middle of the screening space in order to distribute

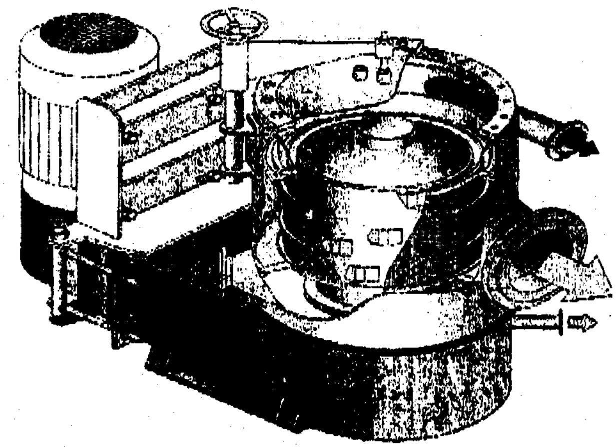
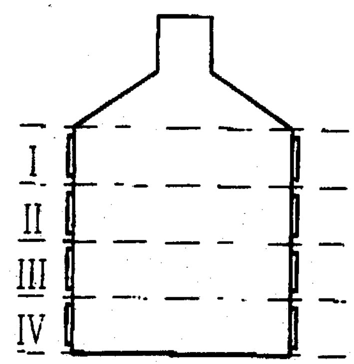


Figure 10. Fine Screen with LR rotor. MODUSCREEN F.

evenly the load of the screen cylinder and to increase capacity. The mixing effect increases from the upper to the lower part of the rotor, making it easier for fibres to penetrate the screen cylinder and thus reduce the reject rate but still maintaining screening



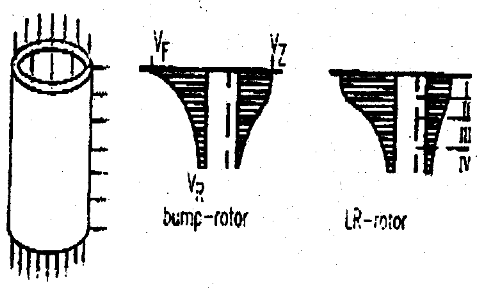

DIFFERENT ZONES OF THE AHLSTROM LR ROTOR
I FEEDING ZONE
II FEEDING AND MIXING ZONE
III MIXING ZONE
IV EFFICIENT MIXING ZONE

Figure 11. LR Rotor design

efficiencies of up to over and 90%. The small gap of 2-4 mm and the smooth curved edge of the element generate turbulence and result in efficient cleaning of the screen plate, which also helps to achieve a high capacity and consistency at low power (typically 8-15 kWhr/t).

### Fine screen for removing light impurities

The common concept of having lightweight or plastic removal at the top of the screen only works with the lightest of plastics, such as expanded polystyrene, where the separation is not based on centrifugal force but purely buoyant force.




Vf - axial velocity of equipment to screening
Vz - velocity of suspension through screen plate
Vr - axial velocity of suspension from reject end

**Figure 12. LR vs Conventional bump rotor**

Plastics tend to move toward the centre of the rotor, and also down to the reject chamber, from where approximately 50% are rejected. The remaining 50% of the plastics gather inside the rotor from where they can be removed by flushing to a separate light reject treatment system(see Figure-13). The debris is discharged intermittently, with the time being a function of the amount of debris in the pulp, thereby minimizing fibre loss.

The time between dumping can vary from every 10 minutes to once every 4 hours.

## COMBINATION SCREENS

Combination screens are starting to become available on the market. They offer the possibility of consolidating power consumption by undertaking coarse and fine screening in one unit. Mill experiences so far however, have indicated that they are unable as yet to operate effectively at consistencies of over 3%.

## SCREEN CYLINDERS

### Profile

The profile height of a slotted screen cylinder can greatly affect the runability and screening efficiency. The profile height is defined as shown in

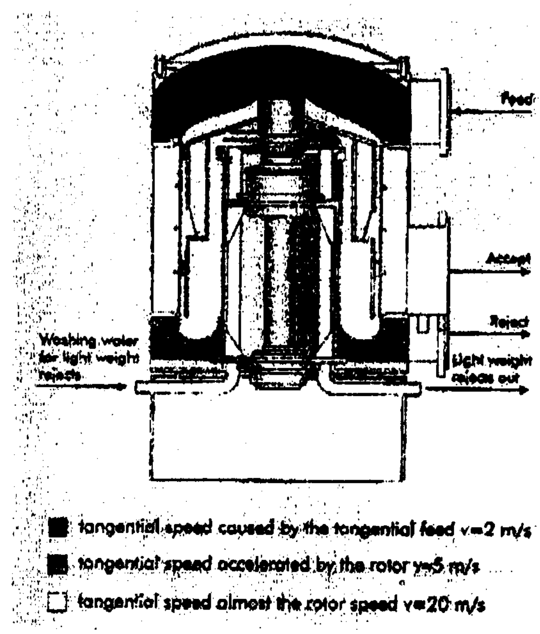



**Figure 13. Light weight reject removal in fine screen**

**Figure-14** The most common profile height used in headbox screens is 0.6 mm. For coarse screening with higher screening consistencies, higher profiles are used. With increasing profile height screening capacity increases and screening efficiency falls. When selecting the screen, slot size is just one criterion and quite often the profile type is overlooked. The advantages of a small slot size can be easily wasted if the wrong profile is selected.

### Slot/hole pitch

The distance between slots/holes is determined by the stock to be treated. A thumb rule is that the straight distance between the slots/holes should be more than 90% of the longest fibre length. If the distance is too small, the fibre can staple between two holes/slots. Stapled fibres easily collect new fibres and cause stringing or plug the cylinder.

### Wedge wire screens cylinders

Wedge wire screens used in the chemical and mining industry for decades, were accepted by the paper industry at the turn of the 1990's. They have

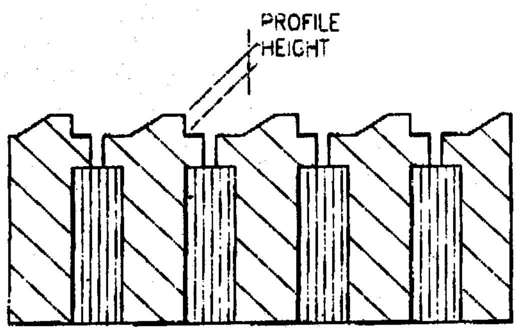



**Figure 14. Screen Basket Profile Height**

been successfully used e.g. for mechanical pulp and broke screening. The larger open area (approx. 40% more than conventional slotted cylinders) can be utilized either for increasing capacity or improving separation efficiency by using smaller slots. Modern manufacturing methods enable slots to be manufactured down to slot sizes of 0.1 mm.

The introduction of wedge wire screens has not been troublefree. The first cylinders were not mechanically strong enough. Ahlstrom delivered a reinforced wire screen, which has been proven to be reliable in operation. This has been used for broke and thick stock screening and also chemical/ mechanical pulp screening.

Potential mechanical damage to screen cylinders and problems with manufacturing methods has limited their use so that they are seldom employed in headbox screens.

With the progress of manufacturing methods, these problems may be eliminated in the new generation of wedge wire cylinders.

**Water cut screen cylinders**

New, milled cylinders with long slots yield a larger open area and accordingly a higher capacity.

A new SF (Super Flow) cylinder has been launched as an alternative to milled cylinders. The SF cylinder is manufactured by water cutting with additives at a pressure of 3000 hg/cm$^2$. The manufacturing technique enables slot lengths and shorter land areas between the slot rows, in which case the open area of the cylinder increases by approximately 20%. The structure is mechanically very strong with very fine tolerances being achieved.

**Passing velocity**

The optimum flow velocity through the screen basket has been calculated by some equipment manufacturers as being approx. 1m/s. the argument being that the screening efficiency drops when the velocity rises above this value.

This is certainly true with some paper grades as the higher stock velocity breaks brittle impurities smaller and hence make screening more difficult. This is the case with recycled fibre where fibre bundles are dyed with ink.

With machine screens, these flow rates are not applicable because the consistency is low and the volumes large, which make it impracticable to use low velocities and such big equipment, and both broke and thick stock screens have been found to operate optimally with a passing velocity of upto 1.5 m/s.

## CONCLUSION

With the advent of higher consistency screening with narrower slots, approach flow screening has taken on a multitude of new opportunities. Depending upon the source and nature of impurities to be removed, either broke or thick stock screening offer viable alternatives to enahance the total approach flow screening to the paper machine. Recent trends in Scandinavia have been to improve broke screening on most grades, and the introduction of thick stock screening, the benefits of which have been to raise total paper machine efficiency, availability and to increase longevity of wires and felts.