Increased screening efficiency with belt dilution

By B. Fredriksson

Abstract: A new screen basket for conversion of existing screens into two or three stage units has been developed. By dividing the screen basket into several stages with inter stage dilution and a new control algorithm for determination of the required amount of dilution flow the negative effects of thickening are minimized. Slot width can be reduced as well as screen RPM and the debris removal efficiency will be significantly improved.

A TYPICAL screening system for paper stock consists of several screening stages. Multiple stages are used because most pressure screens can not sufficiently concentrate the debris in one screening stage only, while maintaining acceptable removal efficiency, due to thickening. The concentration of fibers and debris increases along the length of the screening zone as the probability for acceptance, passage through the screen basket, always is higher for water than it is fiber and debris. Reject consistency will be higher than feed consistency (1, 2).

In many pressure screens the lower part of the screen baskets is often blocked by pulp at increased consistency and is not available for efficient screening (3). Large and high screen baskets suffer most from the negative effects of thickening. To counteract thickening often screens are operated at too high speed, have screen basket with too large profile depth and are fed at unnecessarily low feed consistency. All these measures taken to counteract the thickening will reduce the debris removal efficiency of the screen.

Mobility of individual particles at the screen plate surface is a requirement for the separation process. The flocks of fibers and debris in the boundary layer have to be broken up in order to select and separate individual particles according to their properties. The energy required to deflocculate the boundary layer increases exponentially with increased consistency (4). Thus thickening limits the ability to operate a screen at low reject rates and to efficiently utilize the full length of the screen basket.

THICKENING AND ITS CONSEQUENCES

The interaction between the surface geometry of the screen plate and the tangential velocity of the boundary layer results in micro turbulence which can, providing the energy intensity is high enough, disperse — deflocculate — the thickened stock on the screen plate surface. Most screen baskets have the same profile depth along the length of the screening zone. A more aggressive screen plate surface with larger profile depth can deflocculate a fiber mat of higher consistency (5). However, in a typical case variation of the profile depth is not enough to compensate for the increased fiber network strength caused by the thickening. When the pulp is moving along the screening zone not only the consistency — the concentration of fibers and debris — increases; average fiber length and freeness is also increasing. This makes the resistance against deflocculation even greater than predicted by the consistency increase alone.

To be efficient a screen basket has to remove the large fraction of debris, which in one dimension is smaller than the slot width. These particles can pass through the slot providing they get in a position for passage. If the intensity of the micro turbulence at the screen plate surface is too high the removal efficiency of the screen will be reduced. The energy intensity in the boundary layer should be as close as possible to that required for disintegration of the flocks, as any excess mobility of the debris particles will reduce the separation efficiency of the screening process.

To describe the varying conditions in a screen it is convenient to divide the screening zone from feed to reject side of the basket in three parts with different conditions:

• In the upper part, where the consistency is too low to be in balance with the energy intensity in the boundary layer, is where most of the pulp is accepted. In this section the pulp is exposed to a higher energy intensity than required by its resistance to deflocculation — consistency. The result is excessive turbulence and reduced separation efficiency.

• In the middle part the consistency has increased due to thickening, and there is a better balance between the energy intensity and fiber network strength. The separation efficiency is high as the conditions are close to optimal.

• In the lower part of the basket, the consistency is too high and there is not energy enough to break up the fiber network. Addition thickening takes place, energy is wasted and no or very little screening takes place. High network strength results in increased friction between the thickened stock and the rotor. The relative velocity between the rotor and the stock is reduced and as a consequence the pulsation from the rotor is reduced. The function of the lower part of the basket is further deteriorated.
Screen suppliers have developed a number of different ways to add dilution liquid to the screening zone to overcome or reduce the operational limitations caused by thickening. Some of these concepts are quite complicated and prone to different operational problems. The required amount of dilution water is not determined according to a measured need. It is adjusted arbitrary, and in many cases the dilution water flow is not measured at all.

To maintain capacity in large screens it is common to: increase slot width, increase rotor RPM, increase profile depth and lower feed consistency. All of these measures will reduce the screening efficiency.

Objectives for the new dilution concept:
• Eliminate the reduction of capacity and efficiency caused by large screen baskets by dividing the basket in two or three stages with intermediate dilution.
• The screen basket and the dilution arrangement shall be one integrated unit.
• The flow of dilution water shall be controlled by the actual need based on the thickening propensity of the pulp, feed flow and the mass reject rate. All of these measures will reduce the screening efficiency.

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THE NEW SCREEN BASKET AND THE CONTROL ALGORITHM.

The new basket is called Nimax-db and the dilution arrangement is called Belt Dilution. Nimax’ is the name of a new screen panel and db stands for dilution belt, divided basket or double basket. The db screen basket is divided in a primary and a secondary stage separated by the dilution belt. Before the reject from the primary stage enters the secondary stage it is diluted to the same consistency as the primary stage feed flow. The accept from the two screening stages are mixed in the accepts compartment of the screen. With the new basket the old screen has been converted to a two stage feed forward system and the available screen plate surface area is better utilized than before. Due to the increased debris content in the feed to the secondary stage it is often advantageous to use finer slots in the secondary section.

To get the most from this type of basket we need to know how much dilution water is needed. A control algorithm has been developed which makes it possible to calculate the required dilution water flow without knowledge of the accept flows and the reject flow from the primary stage. Only the flow rates and consistencies of the initial feed and the final reject are required.

We assume that the two stages in the basket have:
• Equal mass reject rate \((R_{m1} = R_{m2})\)
• Equal feed consistency \((C_{f1} = C_{f2})\)
• The same thickening propensity \((T_1 = T_2)\)

On these assumptions the new control algorithm for the required amount of dilution water \(Q_d\) is derived.

\[
Q_d = \sqrt{Q_f \cdot Q_r} \left( \frac{C_r}{C_f} - \sqrt{\frac{C_r}{C_f}} \right) \tag{1}
\]

\(Q_d\) denotes flows and \(C\) the consistencies of the feed \(f\) to the screen (the primary stage) and the reject \(r\) from the screen (the secondary stage of the db basket).

The ratio between the rejects and the feed consistencies is the reject thickening ratio \(T\), a most important parameter in any screening process. Now the equation can be written:

\[
Q_d = \sqrt{Q_f \cdot Q_r} \left( \sqrt{T} - \sqrt{T} \right) \tag{2}
\]

For a three-stage unit it is possible to derive a similar equation for the amount of dilution water required in the first \(Q_d\)
and the second Qd2 dilution belt. The derivation of the formulas is similar to the case with two stages. The flow requirement to the first dilution belt is given by the following formula:

\[ Q_{d1} = Q_{d2} \frac{\sqrt{T - \frac{T}{Rv}}} {\frac{Rv}{H20906} - \frac{T}{H20920} - \frac{T}{H20906}} \]  

(3)

Using the same assumptions the required amount to the second dilution belt in a three stage screen basket is given by:

\[ Q_{d2} = Q_{d1} \frac{\sqrt{Rm}} {\frac{Rm}{H20906} - \frac{T}{H20920} - \frac{T}{H20906}} \]  

(4)

Where \((Rm)\) is the total mass reject rate over the whole screen, after the three stages.

Equation (3) and (2) are similar and a general formula for two and three stage applications can written as:

\[ Q_{d1} = Q_{d2} \frac{\sqrt{T - \frac{T}{Rm}}} {\frac{Rm}{H20906} - \frac{T}{H20920} - \frac{T}{H20906}} \]  

(5)

Where the number of screening stages is \((n)\).

**INSTALLATION OF THE NEW SCREEN BASKET**

It is possible to install Nimax-db baskets in most screens without any modifications to the screen housing. The accepts outlet can be used to feed dilution water to the belt. Figure 3 shows how the dilution water pipe is inserted through an outer pipe welded to the first elbow of the accept pipe. To guide the pipe towards the hole in the dilution belt a hanger is mounted between the flanges of the screen and the accept pipe.

Figure 4. The dilution liquid pipe is guided by the hanger inserted in the flange between the screen and the accept pipe.

Figure 5. The dilution pipe is held by the flange between the water feed pipe and the outer support pipe.

**EXPERIENCES FROM THE FIRST INSTALLATION**

The first Nimax-db basket with Belt Dilution technology was designed for screening aspen GWD at Utansjö Bruk AB, a member of the Rottneros group in Sweden. The screen is a D12 from Metso with 3.6 m² screen plate surface area. The rotor is speed controlled and it operates in P2 position after Centrisorter screens fitted with 1.2 mm drilled baskets. Feed consistency is in the 0.8 to 1.0 % range.

The objective with this installation was to substantially reduce the shive content in the aspen pulp. Belt Dilution technology gave us the opportunity to use finer slots and lower profile depth than was possible earlier. The baskets were built of two Nimax panels both with 2.5 mm wide bars and 0.6 mm profile depth. The slot width was 0.12mm and 0.10 mm for the primary and the secondary stage respectively. We did not expect this basket to give sufficient capacity for production of spruce GWD.

However, at the initial start up of the new basket we were forced to start with spruce wood as the grinders and conveyors were filled with spruce logs. Much to our surprise the Nimax-db basket did handle the spruce pulp without any extraordinary measures. When on aspen pulp it was easy to reach the desired production level of 250 T/D. The good runnability of the screen made it possible to reduce the rotor speed.

After many aspen campaigns and several months of operation it can be concluded that accept shive content has turned out even lower than expected. The new basket with its belt dilution technology reduced the accept shive content after the screen to 20 - 40% of earlier levels. It was possible to reach target production levels also with spruce wood and with this raw material even larger reductions of accept shive content were achieved. In this case shive contents were reduced to about 20% of earlier levels.

As the mill wanted to achieve the best possible results in the shortest possible time the new db basket was improved in several ways compared to the old baskets. Besides introducing a two stage process with different slot widths in the primary and the secondary stage, both slot widths

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**TABLE 1. Aspen GWD, evaluation of Nimax-db.**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Nimax-db</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slot width mm</td>
<td>0.15</td>
</tr>
<tr>
<td>Bar width mm</td>
<td>3.2</td>
</tr>
<tr>
<td>Open Area %</td>
<td>4.48</td>
</tr>
<tr>
<td>Passing Speed</td>
<td>1.50</td>
</tr>
<tr>
<td>Accept shives Somerville %</td>
<td>0.012</td>
</tr>
<tr>
<td>Accept shives Pulpmac 0.10%</td>
<td>0.26</td>
</tr>
<tr>
<td>SRE Somerville</td>
<td>0.62</td>
</tr>
</tbody>
</table>

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**TABLE 2. Spruce GWD, evaluation of Nimax-db.**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Nimax-db</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slot width mm</td>
<td>0.18</td>
</tr>
<tr>
<td>Bar width mm</td>
<td>3.2</td>
</tr>
<tr>
<td>Open Area %</td>
<td>5.33</td>
</tr>
<tr>
<td>Accept shives Somerville %</td>
<td>0.091</td>
</tr>
<tr>
<td>Accept shives Pulpmac 0.10%</td>
<td>0.82</td>
</tr>
</tbody>
</table>

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*FIG. 5. The dilution pipe is held by the flange between the water feed pipe and the outer support pipe.*

*FIG. 6. Final pulp shive content before and after the installation of Nimax-db at Utansjö Bruk AB.*
and profile depths were reduced compared to the reference baskets. These baskets had wider slots than the Nimax-db (0.15 for aspen and 0.18 mm for spruce).

Table 1 and 2 shows a comparison between the old baskets and the new db basket when the same pulp quality was produced.

Figure 6 shows shive content data of final pulp as measured by the mill laboratory. The average shive content was earlier 0.014%, and with the new basket in the P2 screen was reduced to 0.004%.

**OTHER APPLICATIONS FOR THIS NEW TECHNOLOGY**

**Fiber Recovery**

The function of the final stage, the tail screen, in a screening system is to recover fiber without putting debris back into the system. This is an interesting application for Nimax-db as one more screening stage is added to the system.

**Quality Control**

Thickening propensity of the stock is continuously monitored by the new control concept. Changes in calculated dilution water requirement can serve as an indicator of variations in stock quality for pulp types where CSF and fiber lengths are important.

**SUMMARY**

The new Nimax-db, with its integrated Belt Dilution concept, has in this first installation given excellent results. The shive removal efficiency has been reduced to levels earlier unobtainable in this mill. By adding the correct amount of dilution water in the correct position lower rotor speed could be used. Energy was saved and screen basket life will be increased due to reduced wear.

The mill has received spontaneous positive comments on its improved pulp quality obtained with this new screen basket technology.

**REFERENCES**


**Résumé**

Un nouveau panier de classage pour convertir les classeurs existants en appareils à deux ou trois étages a été développé, le Belt Dilution. En divisant le panier de classage en plusieurs étages avec un étage intermédiaire de dilution, et un nouvel algorithme de contrôle pour la détermination du débit de dilution requis, nous avons réduit les effets négatifs de l’épaississage. On peut réduire la largeur des fentes ainsi que le nombre de tours/minute du classeur et amplifier ainsi l’efficacité de l’élimination des débris.

**Référence**


**Keywords**: SCREENING, BASKETS, SLOTS, GROUNDWOOD, ASPEN, SPRUCE.