EXECUTIVE SUMMARY

In 2009, Kadant published a study presenting the characterization and removal strategy of small stickies, referred to as ministickies in our study. One of the conclusions, based on mill surveys and several pilot plant trials, was that the screening efficiency of ministickies is low and some technologies were better than others for removing ministickies. Since that initial study, a 4th generation of screening cylinders has been introduced to the market. This 4th generation of screening cylinders features highly engineered wedge wire cylinders with a high degree of accuracy and consistency.

Kadant investigated the screening capabilities of 4th generation cylinders offered by major equipment suppliers and evaluated the screening performance of these screen cylinders, including the FibreWall™ screen cylinder. Initial field results of the 4th generation screening cylinders are promising and suggest that the generally accepted screening limits can be extended to smaller stickies sizes (i.e., ministickies Classes 1 to 4).

The FibreWall screen cylinder is a fabricated wedge wire cylinder made without structural welding or rolling processes. The wire clamping is made mechanically using an innovative process that eliminates welding and other processes that can permanently deform the cylinder shape. The cylinder is not rolled and offers excellent roundness with no distortion. This allows for a uniform gap between the cylinder and the rotor to achieve optimum screening performances. The cylinder also offers dimensional stability over time due to the absence of residual stress caused by welding and rolling processes.

Based on field trials and numerous installations, screening efficiencies achieved by FibreWall screen cylinders outperformed major competitive cylinders on removing debris and deformable contaminants (e.g., stickies). FibreWall screen cylinders have been shown to reduce the stickies level by two to four times compared to other wedge wire cylinders operating under similar conditions.
INTRODUCTION

When examining the efficiency of a screen, one of the first items to consider is the contaminant nature. Large, three-dimensional contaminants of approximately the same size, such as hot melt particles and shives, are readily removed by slotted screens if their size is larger than the slot size.

Flexible and flat contaminants, where one dimension is much smaller than the other two dimensions, are more complex as the smaller dimension is equal to the fiber thickness and easily subject to passing through slots, even those smaller than 0.15 mm, along with the fiber.

Stickies are generally classified into one of three categories: macrostickies detected by a laboratory screen, microstickies, and colloids not detected by the laboratory screen. The table below illustrates the stickies size range and effective equivalent diameter.

Macrostickies are generally evaluated using the INGEDE 4 method or TAPPI T277 method. Both of these methods utilize a sample in which the sticky material is coated with a white material that is easily distinguished from the base paper. During the counting of the white powdered adhesive particles, image analysis software makes the distinction between different particle sizes enabling the size distribution profile of the stickies population contained in a pulp sample.

<table>
<thead>
<tr>
<th>Stickies Class</th>
<th>Size (mm$^2$)</th>
<th>Size in Equivalent Diameter (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.01 - 0.04</td>
<td>113 - 226</td>
</tr>
<tr>
<td>2</td>
<td>0.04 - 0.15</td>
<td>226 - 437</td>
</tr>
<tr>
<td>3</td>
<td>0.15 - 0.26</td>
<td>437 - 575</td>
</tr>
<tr>
<td>4</td>
<td>0.26 - 0.80</td>
<td>575 - 1009</td>
</tr>
<tr>
<td>5</td>
<td>0.80 - 1.81</td>
<td>1009 - 1518</td>
</tr>
<tr>
<td>6</td>
<td>1.81 - 3.21</td>
<td>1518 - 2022</td>
</tr>
<tr>
<td>7</td>
<td>3.21 - 5.02</td>
<td>2022 - 2528</td>
</tr>
<tr>
<td>8</td>
<td>5.02 - 7.22</td>
<td>2528 - 3032</td>
</tr>
<tr>
<td>9</td>
<td>7.22 - 20.07</td>
<td>3032 - 5055</td>
</tr>
<tr>
<td>10</td>
<td>&gt; 20.07</td>
<td>&gt; 5055</td>
</tr>
</tbody>
</table>
When analyzing the results by class using samples from the field, limited data was available for Class 4 and smaller contaminants. Consequently, the Centre Technique du Papier (CTP) based in Grenoble (France), commissioned a study in 2008 to benchmark more than 20 deinking lines in Europe and Asia to better understand the impacts of stickies in and around Class 4.

Data was collected from deinking lines using various stock and equipment from major suppliers including Andritz, Kadant, Metso, and Voith. The benchmarking study results showed that particles larger than Class 4 were removed while smaller particles were not removed. Also, it was noted that Class 4 stickies are the primary stickies found in final DIP stock. Depending on the DIP line benchmarked by CTP, 80 to 90 percent of the total stickies were observed to be Class 4. In addition, it was found that stickies in the final DIP stock were mainly composed of PSA (pressure sensitive adhesive), and higher contamination was found in mills using wood-free raw material, most likely due to higher PSA content in the raw material.

At the 2008 PTS-CTP Deinking Symposium, Kadant introduced a new concept in analyzing stickies and at that time introduced the term ministickies. Ministickies was defined as the relatively small macrostickies that are not necessarily micro nor macro and are categorized as Class 4 and smaller stickies. Based on the findings from the CTP benchmarking study and Kadant's internal research conducted at its laboratory in Vitry (France), Kadant expanded its research initiatives to better understand the characteristics of ministickies and to identify how ministickies can be effectively removed from the stock.

### EVOLUTION OF SCREENING CYLINDER TECHNOLOGY

Pressure screens were introduced in the 1950’s and consisted of drilled cylinders with hole diameters greater than 1.5 mm. Milled slotted screens began to appear in the 1970’s. At that time, slotted cylinders offered better performance than drilled cylinders for contaminant removal, but the low capacity of slotted cylinders limited their application.

The introduction of contoured slotted slots in the 1980’s greatly enhanced the capacity of slotted screen contributing to the general acceptance of the slotted screening process as an efficient way to remove contaminants. At that time, slot width for fine screening typically ranged from 0.20 mm to 0.25 mm.

In the 1990’s, the first wedge wire cylinders were introduced to the market. Despite the larger open area, the construction using continuous wires resistant-welded to the support rings did not meet the runnability
and integrity expectations that the market demanded. This type of cylinder is what we refer to as 2nd generation screen cylinders.

Following the initial wedge wire cylinder design, a 3rd generation of mechanically-held wedge wire was introduced. The basic concept of 3rd generation cylinders was to bring increased resistance to the welded cylinder to avoid catastrophic failure. Efficiency on stickies removal were obtained by contour optimization and reducing the slot size. The 3rd generation of screen cylinders provided increased efficiency and reliability, yet efficiencies were still often below 70 percent and reliability and accuracy of the slot width was constrained by the traditional manufacturing processes and cylinder design.

Fine screening technology is relatively mature and is characterized by the common use of wedge wire cylinders with slots between 0.12 mm and 0.15 mm, low-profile contour wire, and a low-energy rotor. Considering this industry standard approach toward fine screening and the findings from the CTP benchmarking study, an important conclusion was that ministickies are not effectively removed using conventional screen cylinders.

To address these limitations, innovative work was underway to introduce a new wedge wire cylinder without structural welding or rolling processes—two aspects of the 2nd and 3rd generation screen cylinders that limited reliability, accuracy, and overall efficiency.

A 4th generation high selectivity, advanced engineered cylinder was introduced in 2006 by Filtration FibreWall Inc. This concept was developed over several years and then further refined when Kadant acquired the company in 2010.

The FibreWall screen cylinder is a fabricated wedge wire cylinder made without structural welding or rolling processes. The wire clamping is made mechanically using an innovative process that eliminates welding and other processes that can permanently deform the cylinder shape.
The cylinder is not rolled and offers excellent roundness with no distortion. This allows for a uniform gap between the cylinder and the rotor to achieve optimum screening performance. The cylinder also offers dimensional stability over time due to the absence of residual stress caused by welding and rolling processes.

Based on field trials and numerous installations, screening efficiencies achieved by FibreWall screen cylinders outperformed major competitive cylinders on removing debris and deformable contaminants, including stickies. FibreWall screen cylinders have been shown to reduce the stickies level by two to four times compared to other wedge wire cylinders operating under similar conditions.

Comparative studies have been done showing that FibreWall screen cylinders are capable of removing a large number of ministickies that most other cylinders are not capable to separate. The following section summarizes the field trials documenting these results.

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**FIBREWALL SCREEN CYLINDER FIELD TESTS**

As one of the first applications for FibreWall screen cylinders, Kadant targeted DIP fine screening systems for tissue production. After several tests in different mills, the following details summarize the tissue mill experiences.

Results have been compiled for stickies greater than Class 4 (i.e., macrostickies), and for stickies of Classes 1 to 4, referred to as ministickies. To evaluate fiber passage capacity, fine screening system fiber losses have also been reported. Fiber is considered as what is retained on a 100 mesh Bauer-McNett classifier.

The total fiber passage ratio is defined using the formula:

\[ P = \frac{\log(T)}{\log(R_v)} + 1 \]

Where P is the total fiber passage ratio, T is the thickening factor \((C_r/C_i)\), and \(R_v\) is volumetric reject rate \((Q_r/Q_f)\).

The fiber passage ratio has a direct influence on the total fine screening system fiber losses. In the following figures, we have reported the total fiber losses to evaluate the fiber passage approach.
Figure 1 represents efficiency gains in macrostickies, Figure 2 represents efficiency gains in ministickies, and Figure 3 represents fiber loss evolution. All FibreWall screen cylinders were low-profile contour wedge wire cylinders.
CONCLUSIONS

As presented in this paper, the 4th generation FibreWall screen cylinder is more efficient at removing smaller stickies than competitive offerings and has pushed the limit known on ministickies elimination with fine screening with slots.

FibreWall is a wedge wire cylinder designed to achieve high screening efficiency for deinked, brown recycled fiber, chemical, and mechanical pulp applications. Its patent-pending design combines a robust mechanical assembly with a high-precision wire positioning system ensuring the smallest slot width deviation on the market. As a result, the accuracy of the cylinder provides maximum efficiency in any application with any type of debris. The strength of the cylinder allows the installation of the FibreWall cylinder in any commercially available screen, even on those with demanding mechanical requirements.
For more than a century, Kadant has been delivering smart and efficient solutions to process industries. As a global leader in fiber processing, fluid handling, water management, and doctoring systems, we design and manufacture products used in industries ranging from paper to plastics and textiles to tires.

We are a leading supplier of technology-based systems for the global pulp and paper industry as well as other process industries. Our equipment plays a critical role in nearly every stage of paper making and paper recycling, enhancing process efficiency and product quality for our customers.

At Kadant, we are proud to offer innovative products and technologies that help reduce energy consumption, improve water management, and enhance efficiencies for long-term sustainability.

Our primary product lines are:
- Stock preparation systems for recovering recycled fibers and processing virgin fibers
- Fluid handling systems that transfer fluids, steam, or air between rotating cylinders and fixed piping
- Roll doctoring and scraping products that clean roll surfaces to keep machines running efficiently
- Water management systems that clean and condition fabrics and filter and recycle process water

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