ISSN: 0379-5462
IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association
Vol. 36, E2, 2024, p. 103-107

Fiber Analysis and Freeness online Measurements help Recycled Paper Mill Achieve Uniform Product Quality and Eliminate Overrefining

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Abstract:

All papermakers producing paper from recycled fibers know that raw material variations significantly affect process stability and final product performance. To remain competitive in the global market it is imperative to look for solutions and technologies that will help in their goal - Deliver high quality paper at optimum price! With this objective, paper mills look for means to quickly adapt their process to the changes or variations of the incoming fibers, thereby increase runnability and stabilize final product quality. Specifically, to adapt the fiber refining process, which is key to maximize the performance of the fiber in the papermak-ing process. Basically, to refine just as much as each fiber needs.

Before fibers reach the paper machine, it is vital that refining generates enough fibrillation and fine material to enable proper bonding. Too much refining generates extra energy costs (power to refiners, drives and vacuum pumps) and slows down the production speed. Too little refining cause lower strength that doesn't meet market requirements and web breaks at the paper machine or converting plant. The strength may need to be increased by other expensive means such as using chemical additives or virgin kraft as a reinforcing pulp.

Image analysis based Fiber morphology measurements and Digitally enabled online freeness analyzers aid in monitoring fiber properties and freeness more often and optimize refining, leading to reductions in production costs, web breaks, culled paper and customer claims.

Keywords: *Refining, Fibrillation, Fiber Morphology, Online Freeness, Specific energy.*

Introduction

As recycled paper is increasingly used in paper making, developing fibers to achieve strength properties is a critical process. Promoting strong fiber network requires refining. Recycled fibers must be treated gently because the fiber has been previously refined. Optimum refining of recycled fiber can increase bulk retention, increase sheet strength, lower energy usage and increase paper machine speed.

The amount of times a fiber can be recycled is typically five to seven times before the fiber is too weak to offer any support. For recycled paper producers, gentle treatment of fibers must be conducted to minimize fines generation and fiber cutting, both of which affect drainage as well as strength of the paper.

This paper describes how improvement and uniformity in paper quality was achieved at Forestal y Papelera Concepción S.A (FPC Papeles) Chile paper mill by optimizing refining operations through continual monitoring of freeness and fiber quality utilizing On-line freeness analysis and Fiber morphology measurements. FPC produces testliner and fluting from 100% recycled fibers.

Challenges

The mill mainly use OCC (Old Corrugated Container) collected from 27 cities along the country and DLK (Double-Lined Kraft) from corrugating plants. This resulted in large variations on the properties of the incoming fibers, which is a big challenge to their objective of producing high quality paper.

The requirement was to control the amount of refining of the incoming pulp to meet strength specifications. They wanted to improve their ability to adapt their process for the variability of incoming fibers, to both stabilize product quality and reduce costs. It was quite clear the present procedure of checking freeness one or twice a shift was not good enough to know about how the fibers behaved.

BY ON-LINE FREENESS MEASUREMENT

Preliminary actions

Their first step in the journey was by responding to variations in incoming fiber quality by manually modifying the refining load based on lab measurements of pre and post-refiner freeness taken every two hours. If the strength of the paper, measured once per reel (about every 45 minutes) was insufficient, the refining energy was increased. If that was not successful, other methods were tried, such as adding chemicals, using more pre-consumer double-lined kraft (DLK) or finally, downgrading it to a lower-strength product. The long delay between lab measurements was masking fiber variation, making it impossible to respond to changes in a timely fashion. (Figure 1.)

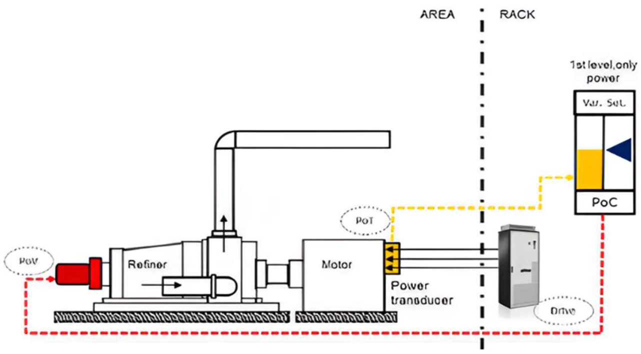

Figure 1. Refiner run solely by power control

Next steps:

Next step was to adapt the refining process to the real needs of the incoming fiber quantity, to provide, as stable as possible, fiber quality to the papermaking process. With this goal in mind, the refiners were upgraded to enable specific load control, meaning that refiners' disk gap are automatically modified as a function of the fiber mass flow, thereby to open and close the gap to provide uniform fiber refinement load, to stabilize the outgoing fiber properties. Online measurements of mass flow and consistency were used to calculate Specific Energy (SE). (Figure 2.)

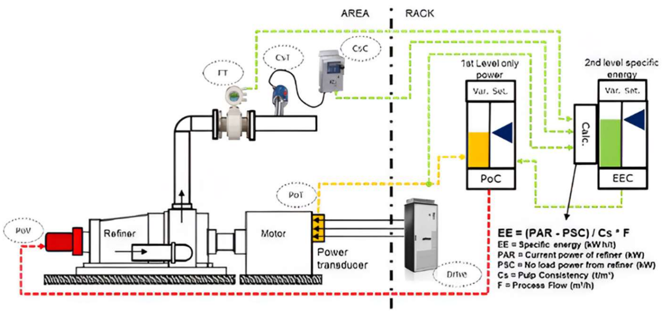

Figure 2. Refiner control by Specific Energy

It became rapidly clear that the long delay between lab freeness measurements was masking fiber variations making it impossible to implement the Fiber to Fiber refining strategy. So, an on-line freeness measurement system was very much needed. To internally validate and justify the need for on-line freeness measurements, samples of the incoming and outgoing pulp to the refiner were taken every 5 minutes to the lab and freeness measurements were made for several hours. Based on the findings, it was understood that there was indeed frequent fiber variations and need for an on-line freeness measurement system was justified.

In the beginning of 2018 the ABB/Lorentzen & Wettre Freeness On Line (FOL) system equipped with two samplers was installed. This would measure freeness at the output of the two refining circuits in the stock preparation area. After installation, the first step was to validate the FOL. Therefore, for 2 months validation process was performed by routinely comparing and correlation of FOL with lab readings. (Figure 3.)

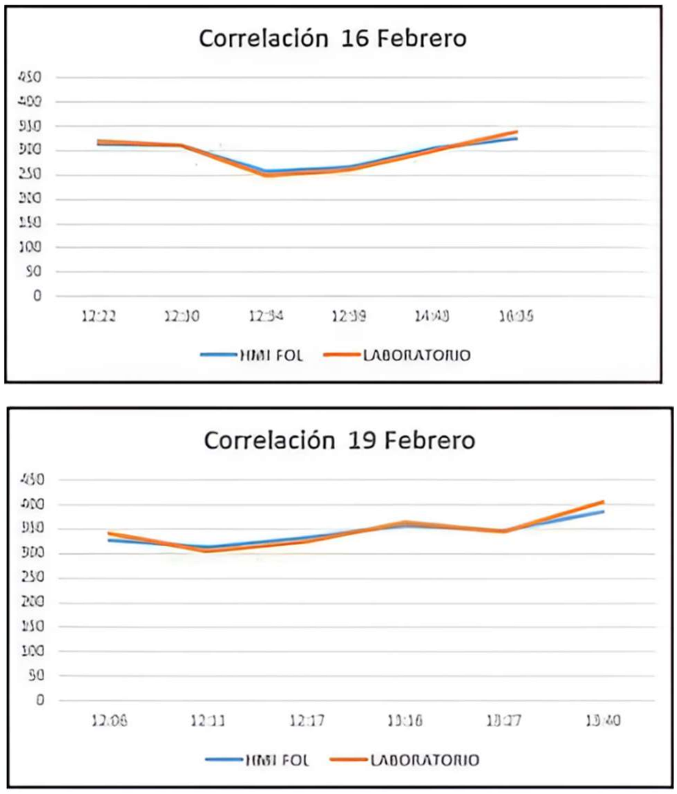

Figure 3. Correlation FOL vs Lab

After the validation period the process operators started to trust the system, and they started to manually adjust the refiner`s load based on freeness change tendencies; hence, adapting to incoming fiber changes contributing to stabilize the overall process.

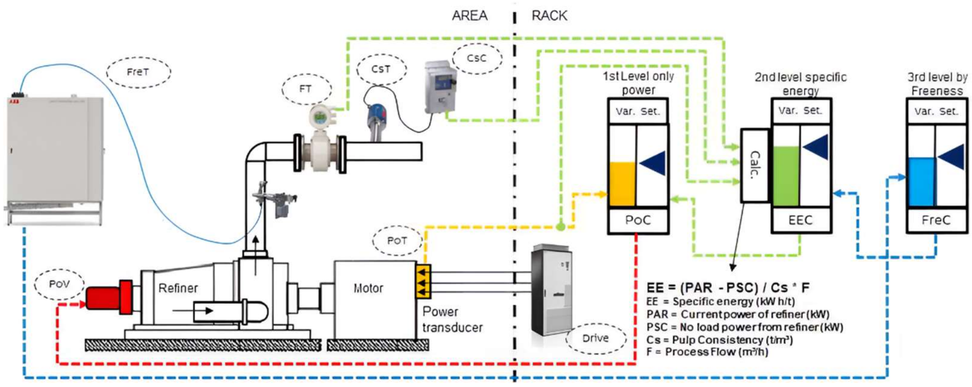

Figure 4. Refiner control by Freeness

With this a new level of process stability was reached. Subsequent to installation of FOL and other improvements in the mill, the monthly production record was broken twice during 2019 and for the first time production record of more than 100000 tons in a year was reached. At this stage automatic refining load control using Freeness Online (FOL) has been implemented. (Figure 4.)

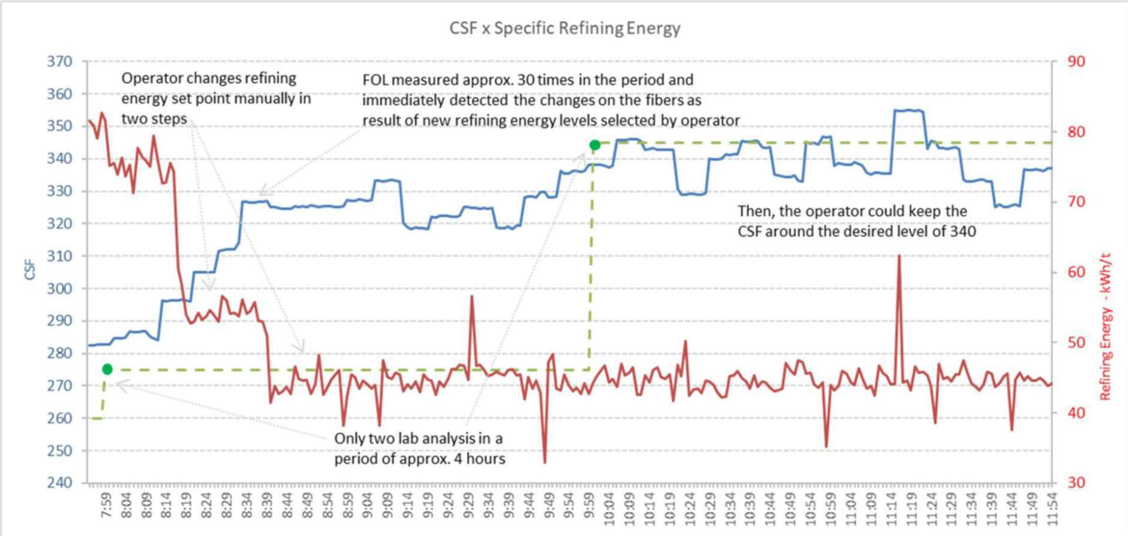

Figure 5. Freeness and Refining energy

Freeness measurements in lab can be a nuisance to measure manually, and it is common to skip a measurement or just copy the previous result. It is not due to laziness but a consequence of prioritizing, there is not enough time to do everything. The result may differ considerably between operators, and it also takes a long time to receive the correct compensated result. There are large savings to be made by moving from manual to automatic measurements, not only in operator resource and reliability but also in refining energy. On top of that an uniform furnish is an ultimate condition to the papermaker. Thus, the use of online freeness to control refining can lead to reductions in production costs, web breaks, culled paper and customer claims

BY FIBER MORPHOLOGY CONTROL

Before the fibers reach the paper machine, it is vital that refining generates enough fibrillation and fine material to create proper bonding surfaces between the fibers as they are dried in the process. Too much refining generates extra energy costs (electricity to refiners, drives and vacuum pumps) and slows down the production speed (lost profit). Too little refining generates lower strength paper that could lead to web breaks at the paper machine or the converting plant. The strength may need to be increased by other means such as using chemical additives or virgin kraft as a reinforcing pulp, which are more expensive than the cost of refining.

Initial studies

The FPC Papeles mill had a goal of using recycled material rich in long fibers for their production of high-performance fluting paper. High Performance fluting is characterized by having a high flat compression strength, which is measured through the CMT laboratory test.

The first step was to arrive at the ideal mix of fibers from their four raw material sources: Domestic double-lined kraft corrugated cuttings (DLK), Imported DLK, Old Corrugated Carton (OCC) pulp, and Kraft Liner Board (KLB) pulp. Raw material from various suppliers for these grades were evaluated using the L&W Fiber tester™ and classified according to fiber length.

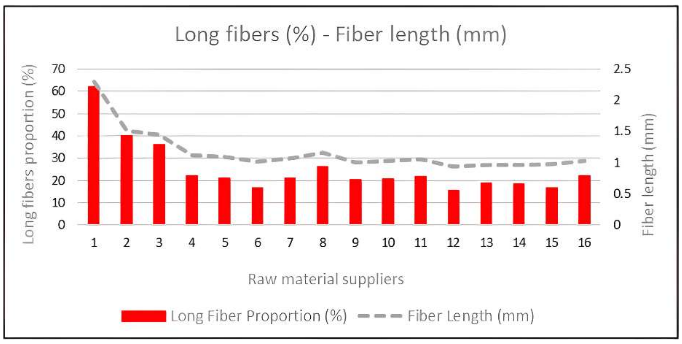

Figure 6. Raw material classification

The mill analyzed the following fiber morphological characteristics:

• Fiber length (mm)

• Proportion of long fibers (%)

• Coarseness (μg/m)

These properties play a fundamental role on refining requirements as they are directly proportional variables, meaning the greater fiber length, the greater the proportion of long fibers and the greater the coarseness of the fibers. A fiber with high coarseness needs a higher refining intensity to be collapsed and thus achieve much more resistant interfibrillar links in order to increase the paper strength. Using the image analysis based Fiber Tester Plus helped to find optimal fiber classification to determine refining intensities for each type of recycled material without damaging the fiber.

With the ability to accurately classify the fibers, the raw material yard was segregated with the aim of using the best quality raw materials for manufacturing best paper quality ever. The Fiber Tester also made it possible to test the combination of different types of raw materials using the blend module. This supported the mill's goal of optimizing the load of the pulper and fiber properties in accordance with the corresponding manufacturing recipe.

The recipes were adjusted based on the ideal blend of local and imported raw materials, the loading of bales was opti-mized to feed the pulper for a specific grade, and the amount of DLK was balanced with OCC.

Refining

The development of high-performance paper led the mill to seek optimal refining points for each type of

recycled material with the objectives of:

- Not damaging the fiber
- Making fewer unwanted cuts in the fiber
- Generating good fibrillation
- Obtaining more resistant interfibrillar connections
- Increasing paper strength
- Saving energy
- Improving the paper machine productivity

Refining curves were created, defining and keeping the refiner's operational parameters constant while only modifying the specific energy consumption (kWh/ton). The refiners were optimized in accordance with the requirements of the grade manufactured and the state of the refining discs. The main morphological properties from the Fiber Tester Plus that were used for creating the refining curves are: Fiber Length, Fibril Area and Perimeter, and Courseness. The following graphs show the effect of refining energy on each of these properties (Figure 7.)

It was possible to know the real behavior of the fiber at different refining intensities, leading to find the optimal refining points to meet the specifications of each grade produced. It became clear that fiber Length decreased with greater refining intensity. This means the higher the specific energy, the greater the fiber cutting. Also fiber Perimeter and Area of fibrils (%) increased when applying more refining energy. This means, the higher the specific energy, the greater the fibrillation.

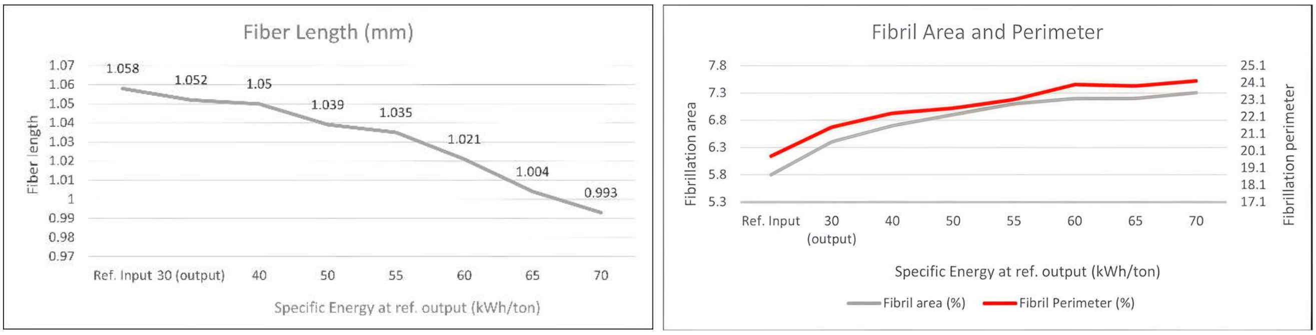

Figure 7. Effect of refining load on fiber properties

Thanks to the analysis carried out using the L&W Fiber tester™, very conclusive results were obtained to define a com-plete and integrated refining curve. It was possible to know the real behavior of the fiber at different refining intensities, helping to find the optimal refining points that met the specifications of each grade produced

Performance and life of refiner discs:

The mill wanted to see how they could improve the performance of the physical refiner asset. Performance tests on the refining discs were carried out at the beginning, half-life and end of their normal lifecycle.

The L&W Fiber tester™ was also used to validate these results. Fibrillation area and perimeter were monitored on how it develops according to the refining segment life cycle to find an optimum timing for replace it. The same was done monitoring the CMT and Tensile from the finished paper. It showed the area and perimeter of fibrils and the strength for CMT (Corrugating Medium Test) and tensile decreases with longer usage of the refining discs.

With these results, strategic decisions were made regarding the purchase and use of refining segments to meet the quality requirements of both the pulp and finished product. This included how to manage and optimize the disc performance. (Figure 8)

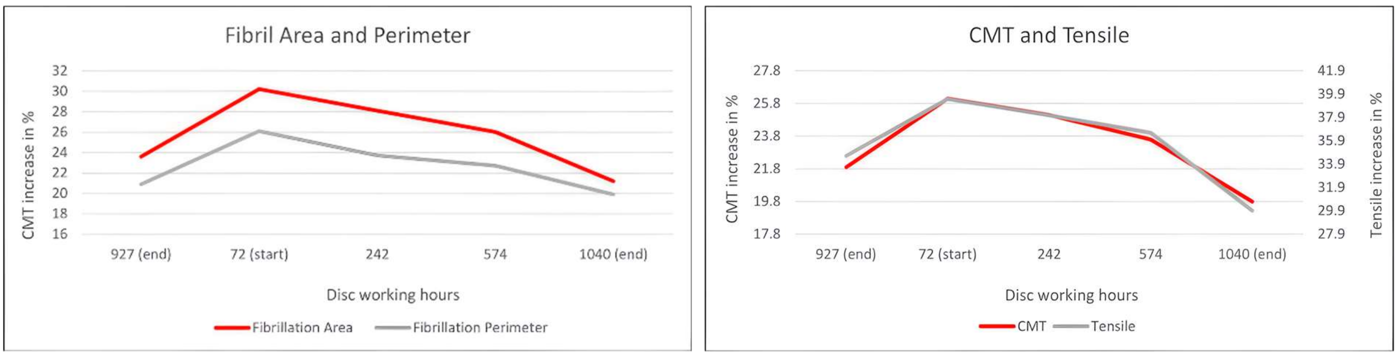

Figure 8. Refining efficiency vs life of discs

Special studies were conducted at the half life of the discs to find the optimum specific energy which provided maximum quality parameters. Below graph shows that when more than 60 kwh/ton of energy is applied, the fibrillation is maintained but the CMT and Tensile declines.

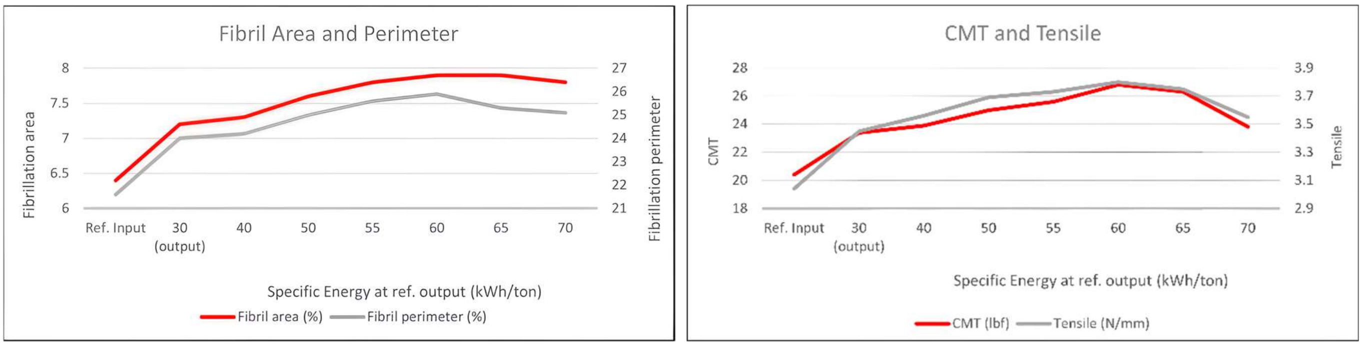

Figure 9. Refining efficiency at disc half life

With the data and characteristics of the fibers that was provided by fiber analysis, an excellent classification of the raw materials could be made, at the same time also determine the optimal refining points for them. Then, by complementing the morphology of the fiber with refiner parameters and lab results it was possible to obtain conclusive results.

Conclusions:

Implementing an effective refining strategy can enhance pulp processing efficiency even before deploying automatic CSF or SR measurements. This strategy typically includes several levels of control, with power control and specific energy control being the most prevalent initial stages. Specific energy control necessitates reliable signals from a refiner flow and precise consistency transmitter. The subsequent level integrates freeness control, which relies on inputs from automatic CSF readings.

Transitioning from power control to specific energy control can reduce refining energy consumption by 22%, while progressing to freeness control can yield an additional 19% reduction. The highest tier involves advanced process con-trol, which hinges on soft sensor technology. These sensors continually model and compute CSF values between auto-matic measurements, promptly updating freeness models.

Recent advancements in fiber morphology analysis, both in laboratory settings and online, offer significant advantages to the industry. Modern analyzers can swiftly assess thousands of fiber suspensions, detailing properties such as length, width, shape factor, fines content, and more. Although these measurements are cost-effective and deepen understanding of pulp characteristics, their full potential emerges when integrated with comprehensive mill data—both online and offline. Leveraging big-data solutions and sophisticated control strategies empowers paper manufacturers to enhance quality, reduce variability, and lower production costs effectively

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