

Refining: Recycled Fiber for Tissue Production

Dylan Schnese Local Product Manager – Fiber Treatment
Voith Paper
Appleton, WI USA

ABSTRACT

As recycled paper is increasingly used in papermaking, developing fibers to achieve sheet strength is a critical process. Promoting a strong fiber network for tissue production requires refining which is the process of changing the geometric structure of fibers. The process is accomplished by pumping fiber and water through refiner plates mounted on a rotor and stator, which fibrillate (external and internal fibrillation) the cell wall of fibers. The result is increased bonding area and improved sheet strength. The technological result of refining is determined by both the applied energy and intensity. Recycled fibers must be treated more gently by utilizing a refiner filling with low intensity because the fiber has been previously refined. A patented-technology known as Pluralis was released in 2006 offering low intensity refining in a plurality of recycled paper manufacturing applications.

Refining has a major impact on fiber development affecting paper properties and process conditions. Optimum refining of recycled fiber can increase bulk retention, increase sheet strength, lower energy usage and increase paper machine speed. The key is choosing the correct refiner filling design for the application. By understanding the challenging refining process, operational success can be achieved.

INTRODUCTION

The amount of times a fiber can be recycled is typically five to seven times before the fiber is too weak to produce paper¹. For tissue makers to effectively use recycled fiber, gentle treatment of the fibers must be conducted to minimize fines generation and fiber cutting, both of which can affect drainage. Thus, low intensity refining which creates the necessary surface area for tissue production while not damaging the fiber is important. This paper will describe the refining process for those who are unfamiliar with the technology, the importance of choosing the correct refiner filling type, and some examples of optimized refining systems with low intensity refiner fillings.

REFINING PROCESS

Wood pulp fibers in their natural, cylindrical form are not capable of forming a matrix due to the lack of surface area. The shape of the fibers must be physically altered to promote the strong, intermolecular bonds needed for papermaking. This process is known as refining. In the case of tissue production, the fibers must undergo refining to develop tensile strength so the pulp suspension forms into paper without breaking. Thus, the task of refining is to break and disrupt the levels of the cell wall (figure 1). There are many mechanisms that occur during refining (figure 2). External fibrillation is when the outside of the fiber is scuffed and produces high surface area bonding surfaces. Internal fibrillation is when the inside of the fiber is cracked allowing water to enter, making the fiber more flexible. Also, the fibers can be cut into smaller fractions which is called fiber cutting and is undesirable in tissue production. Fiber cutting can lead to an increase in fines content which can decrease pulp drainage.

Fiber Wall Sublayers

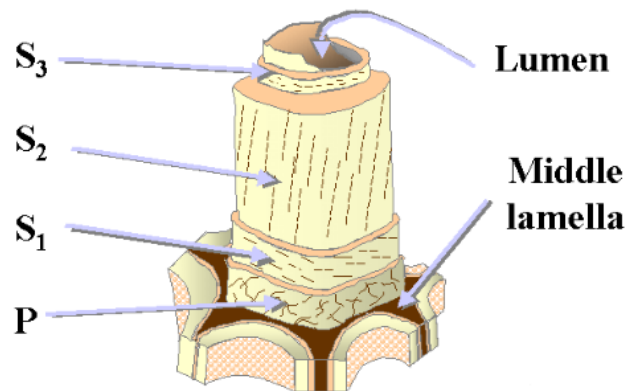


Figure 1 The cellular structure of a wood fiber

In the refiner, the fiber suspension is passed through refiner fillings which are fastened to a rotating element, known as the rotor, and to two stationary surfaces, known as the stator, adjacent to the rotor. The refiner fillings are brought together by an adjusting mechanism on the door side of the refiner to form a narrow gap (0.5 mm) between the rotor and stator. First, a bundle of fibers is gathered between the bars of the fillings. Then as the bars pass each other, water is expelled from the fibers and mechanical energy is transferred to the bundle of fibers. Concluding the energy transfer is a dispersion of the floc of fibers.

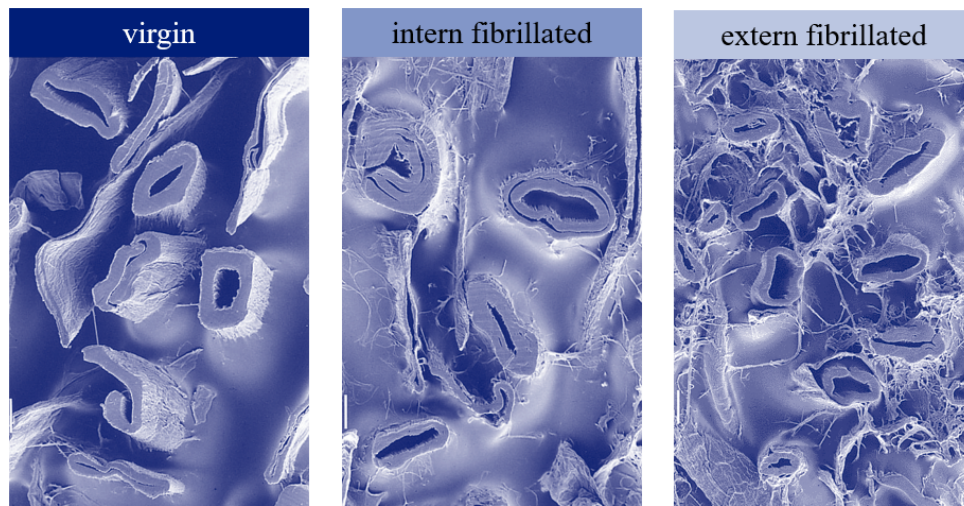


Figure 2 The mechanisms of refining

Multiple factors determine the technological result of refining, but the two most important are the specific refining energy (SRE) and the specific edge load (SEL). The specific energy is defined as the total amount of energy applied to the pulp expressed in power as a function of throughput (hpd/t or kWh/t). The amount of energy applied to the pulp differs depending on the cell wall thickness of the furnish. Recycled fiber typically requires less energy than virgin fibers because they have been previously refined². The SEL is defined as the intensity of refining action on the pulp. Different fiber types require varying levels of intensity to be treated properly. Applying too little intensity to a fiber will not change the geometric structure. Conversely, too high intensity will cause unnecessary damage to the fiber resulting in the generation of fines and destroyed tensile development. A function of the intensity is how much surface length is available. This value is called the cutting edge length (CEL) and is defined as the distance of bar per revolution (km/rev). The higher the CEL, the lower the intensity will be. The intersecting angle of the filling bars also affects strength development. A low cutting angle produces a small amount of intersection points resulting in greater fines content compared to a larger cutting angle which distributes the energy over more points thus delivering lower local intensity and providing more fibrillation.

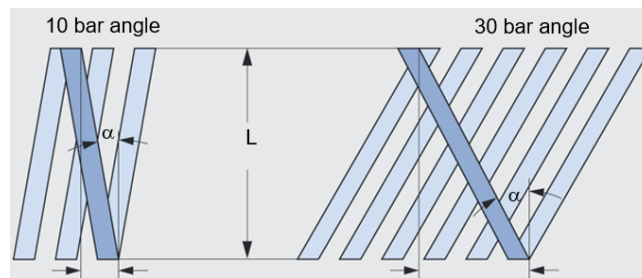


Figure 1 Bar angle influences the intensity of refining

REFINER FILLINGS

Selection of refiner fillings is imperative to optimizing the tissue making process. Refiner fillings vary in geometry, material of construction, and the resulting properties of the paper. Standard refiner filling technology which have been available for the last fifty years are comprised of parallel, straight vanned bars divided into sectors by channels. For the tissue maker, these fillings offer some disadvantages. First, the intersecting angle the parallel bars create decrease from the inner diameter to the outer diameter resulting in fiber cutting and fines generation. Second, there are a limited amount of sectors creating a lack of homogeneity, which limits strength development. Generally the more sectors there are, the better the technological outcome will be. The channel dividing the sectors allow unrefined stock to flow through.

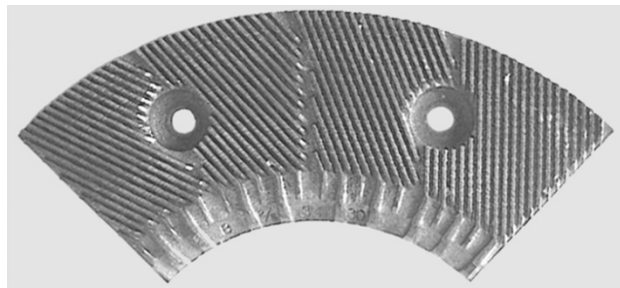


Figure 2 Standard straight-vanned refiner filling

In 2006, patented low intensity refining technology became available to optimize refining operations in a plurality of fiber types. Curved, continuous bars guide fibers from the center to outward ensuring that all fibers are treated. There are no channels for the stock to flow through the filling unrefined. The fillings have a larger intersecting

angle which leads to improved fiber development and fibrillation. The filling is also highly sectorized resulting in a more homogenous fiber treatment.



Figure 3 Curved-bar low intensity refiner filling

APPLICATION

MILL TRIAL A

A mill in Wisconsin produces lightweight bath grades from carrier stock (#17 RISI guideline), mixed flyleaf shavings (#22 RISI guideline) and other pre-consumer recovered papers. The stock is prepared by means of deinking with a starting freeness of 350 CSF.

Operating conditions were the following:

- Connected motor power and speed: 800 hp / 514 rpm
- Inlet consistency: 4.5%
- Amperage range: 62-92 amps

A baseline of the customer situation utilizing standard fillings was collected by taking samples and recording process conditions. Sample collection was repeated using the low intensity fillings for comparison.

The following figure 6 shows that at 82 amps, the customer's usual set point, tensile index increased from 46 to 56.5 N·m/g, a 22% increase in strength. The customer stated the fillings performed without deviation for the entirety of the lifetime. The low intensity plates lasted 8 months in this application.

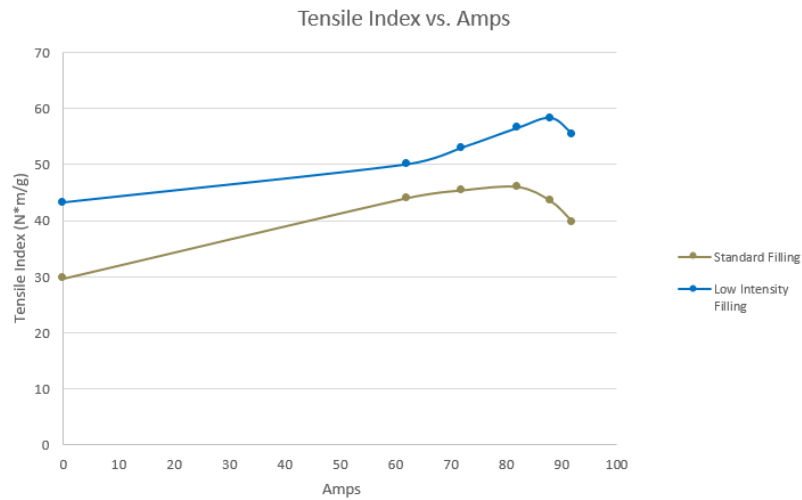


Figure 6. Tensile index vs. Applied amps

In this case, the SEL was decreased from 0.90 Ws/m (figure 7a) to 0.58 Ws/m (figure 7b) because of an increase in the cutting length due to the optimum geometry of the low intensity refiner filling.

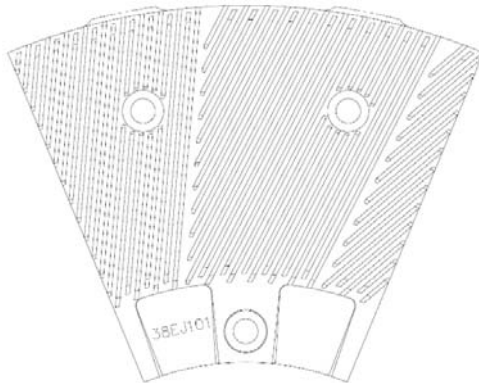


Figure 7a Cutting edge length: 38.7 km/rev

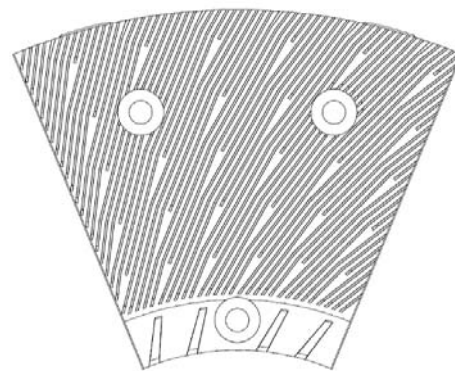


Figure 7b Cutting edge length: 60.48 km/rev

MILL TRIAL B

In another trial, a mill in the Southern US, albeit producing tissue from virgin fiber, utilized low intensity fillings to save energy. The increase in refining efficiency can be used either to increase strength at a constant energy value or to decrease energy usage while maintaining the same strength. Furthermore, bulk retention can be improved by lowering the energy applied to the pulp.

Operating conditions were the following:

- Connected motor power and speed: 600 hp / 580 rpm
- Inlet consistency: 3.8%
- SRE: 1.5-2.5 nhpd/t

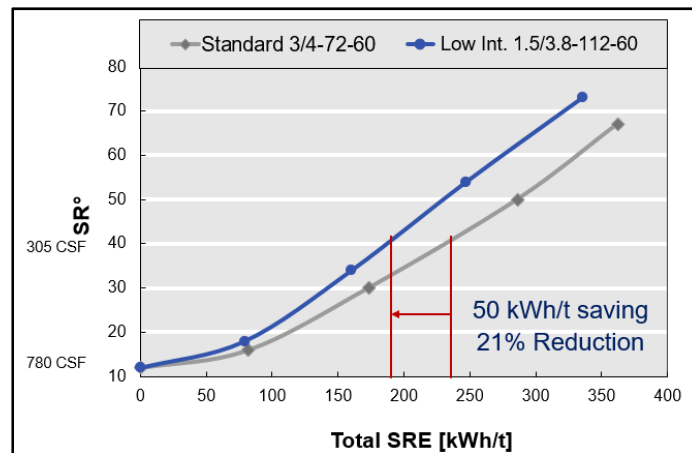


Figure 8 Graph of freeness vs. energy

An increase of the CEL by 305% (9.18 km/rev vs. 37.2 km/rev) provides an increase in efficiency of refining. The figures below show the differences in bar geometry. The straight vanned refiner filling (figure 9a) has a lower CEL versus the curved bar filling (figure 9b) which has a higher CEL. On certain grades, the mill can turn one refiner off saving 150 hp.

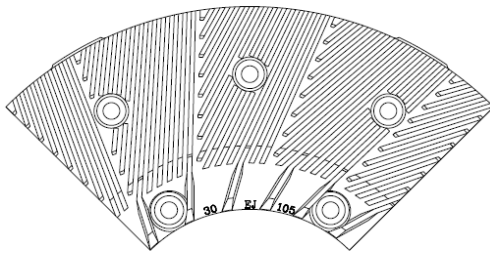


Figure 9a Cutting edge length: 9.18 km/rev

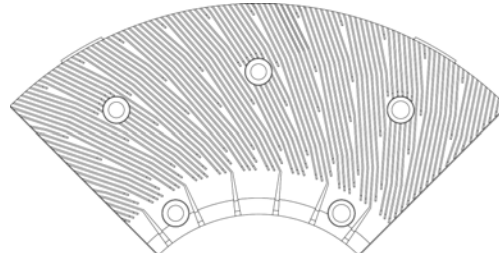


Figure 9b Cutting edge length: 37.2 km/rev

CONCLUSION

Increased recycling rates require papermakers to challenge their approach to treating the fiber. By understanding the mechanisms of refining and the result on papermaking, tissue production can be optimized. Low intensity refining when conducted at the same energy is shown to increase the strength of the pulp. Alternatively, energy can be saved while maintaining the same strength specification.

SOURCES

¹Baker C F (1999) Refining recycled fibres. In: Doshi M R & Dyer J M (eds) Paper recycling challenge, Volume IV, Process control & mensuration. 1st edition, Appleton WI, Doshi & Associates Inc:134–152

²Bajpai P (2014) Recycling and deinking of recovered paper. 1st edition, Elsevier, London pp 181–197.

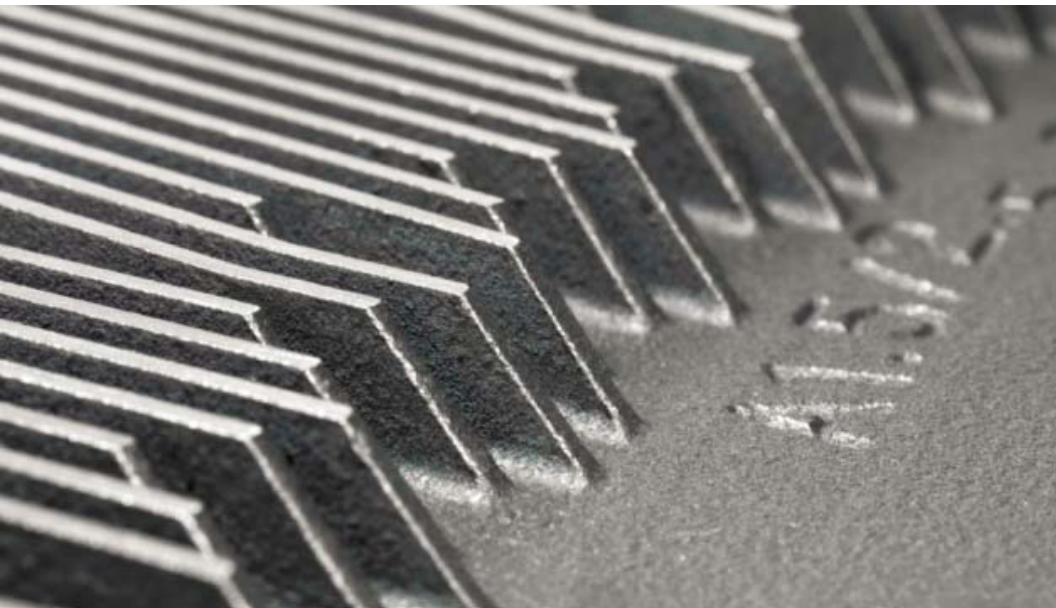
SOURCES FOR FIGURES

- ¹ Hubbe, Martin. *Mini-Encyclopedia of Papermaking Wet-EndChemistry*, NCSU, www.projects.ncsu.edu/project/hubbepaperchem/FIBR.htm
- ² Voith micrograph
- ⁴ Göthhsching, Lothar. *Refiner plate*. 2000. *Recycled Fiber and Deinking*. Jyväskylä: Gummerus Printing, 2000. 197. Print.
- ⁵ Pluralis. 2014. www.stories.voith.com/en/refiner-fillings-for-nearly-every-raw-material-44983

Gateway to
the Future

Refining: Recycled Fiber for Tissue Production

Dylan Schnese | PEERS 2019 St. Louis, MO | 2019-10-29



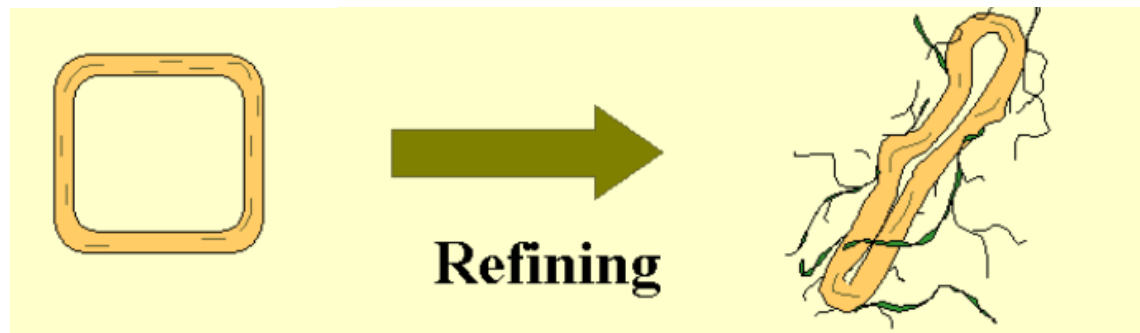
Dylan Schnese

- UW Stevens Point-Chemistry with ACS certification
- Appvion, Chemist, 3 yrs
- Voith, Product Manager – Screening and Fiber Treatment, 1 y

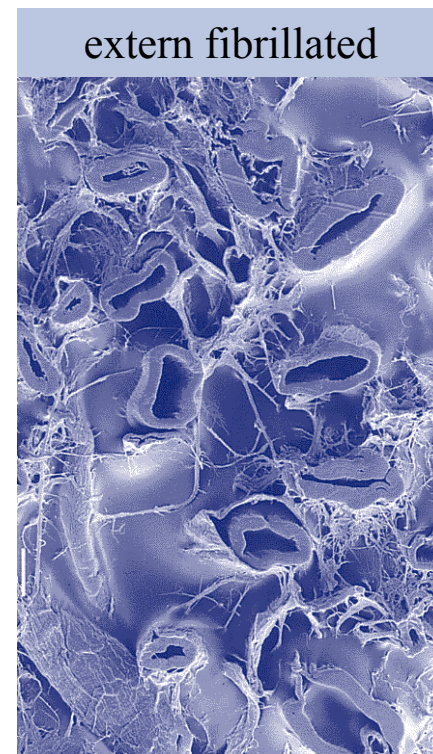
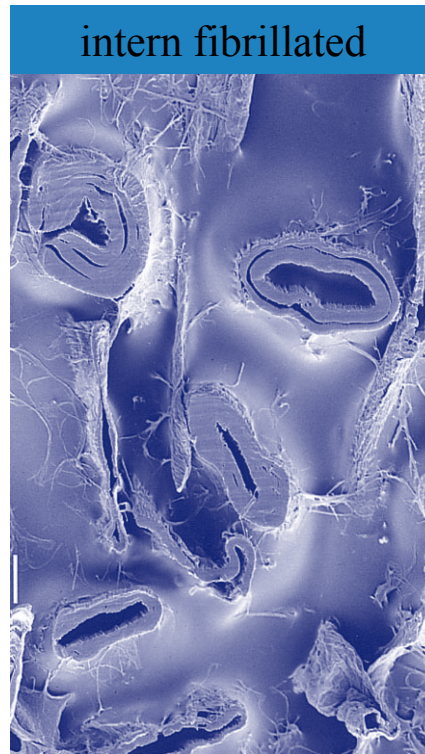
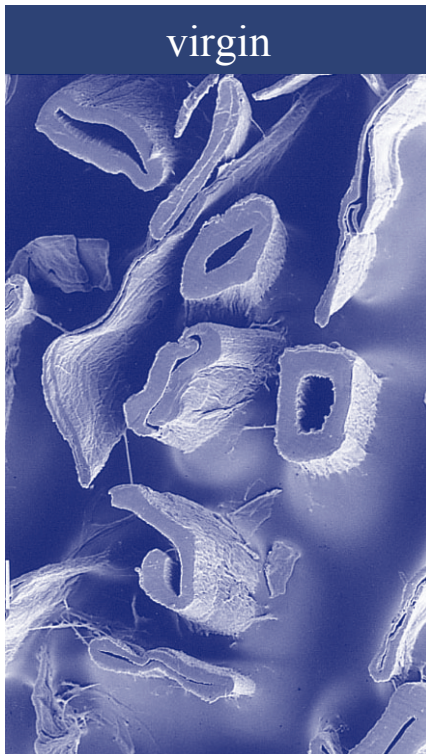


What is refining?

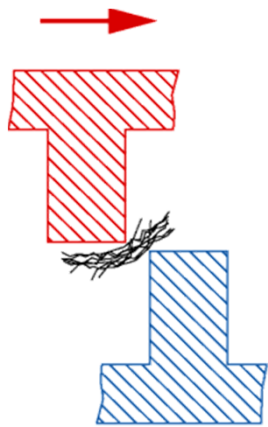
- Change structure of fiber to develop properties suitable for papermaking



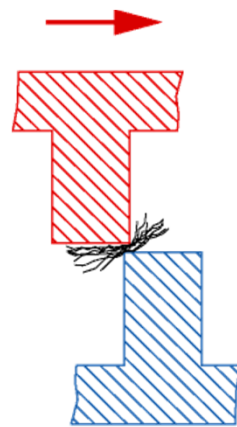
Goals of Refining



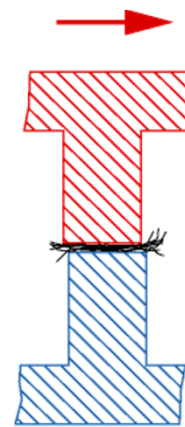
Mechanism of Refining



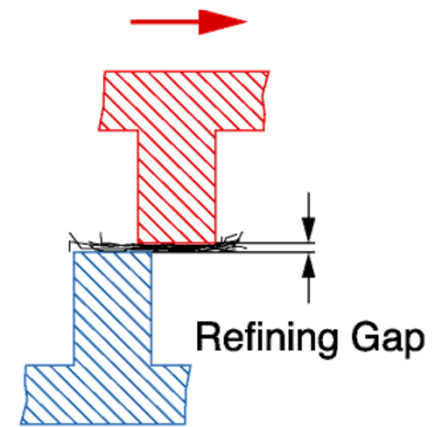
First Step:
Wad gathering and
preliminary localized
dewatering



Second Step:
Mechanical pressure
and water expulsion



Third Step:
Sliding wads
under pressure



Fourth Step:
Mechanical release
and water reabsorption,
then dispersion of flocs

Refining energy

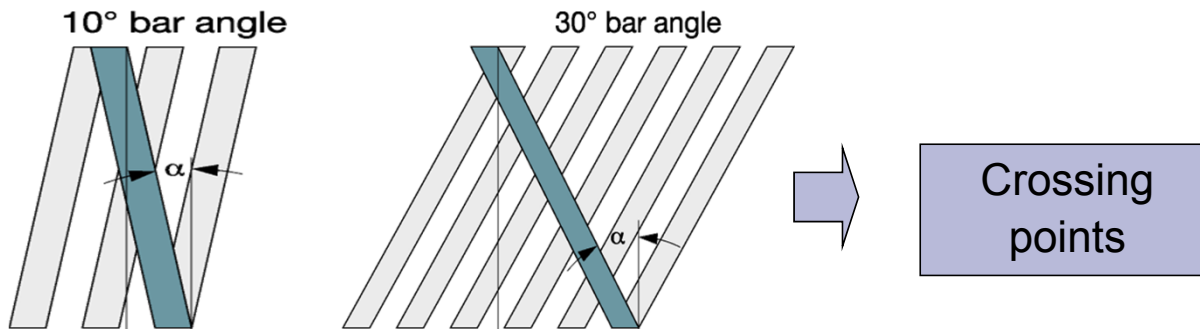
$$\text{Net Specific energy} \quad [\text{kWh/t}] = \frac{\text{Net refining power [kW]}}{\text{Throughput [t/h]}}$$

Refining intensity

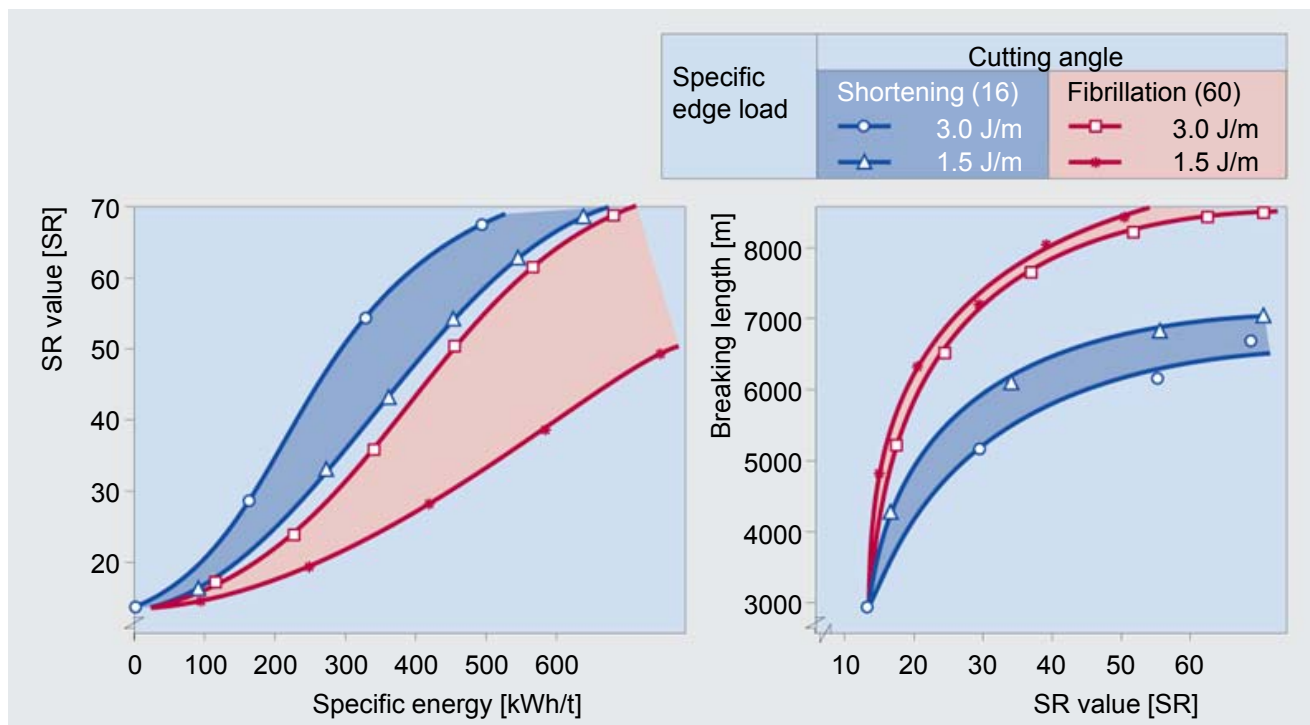
$$\text{Specific edge load} \quad [\text{J/m}] = \frac{\text{Net refining power [kW]}}{\text{Cutting edge length [km/s]}}$$

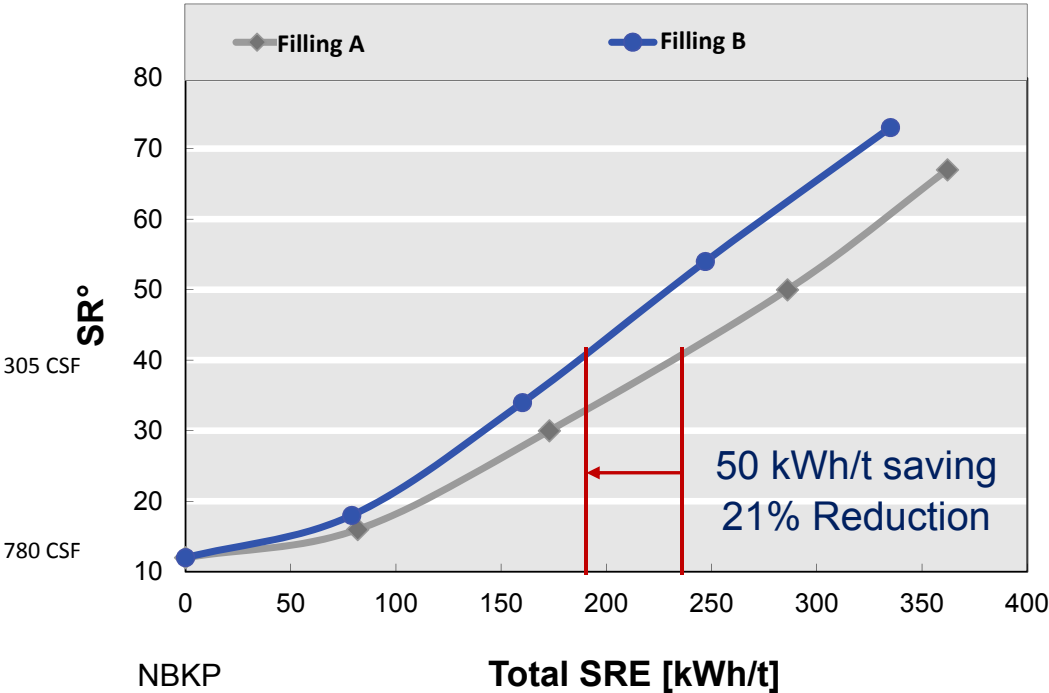
Other influences

- pH
- Recirculation
- Direction of rotation
- Mechanical condition

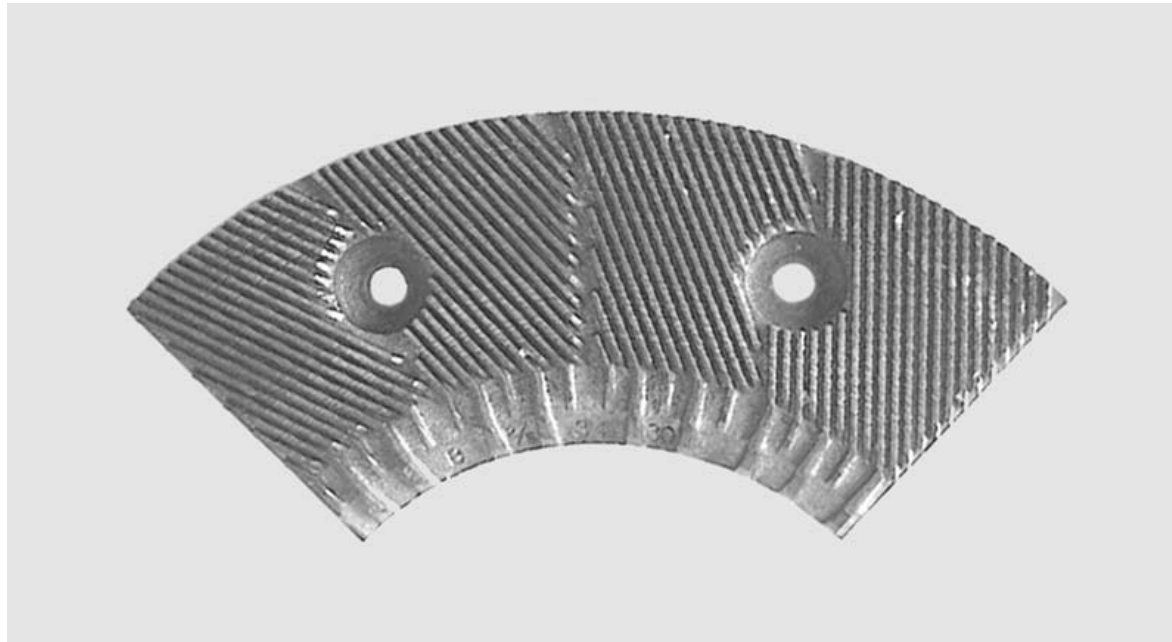


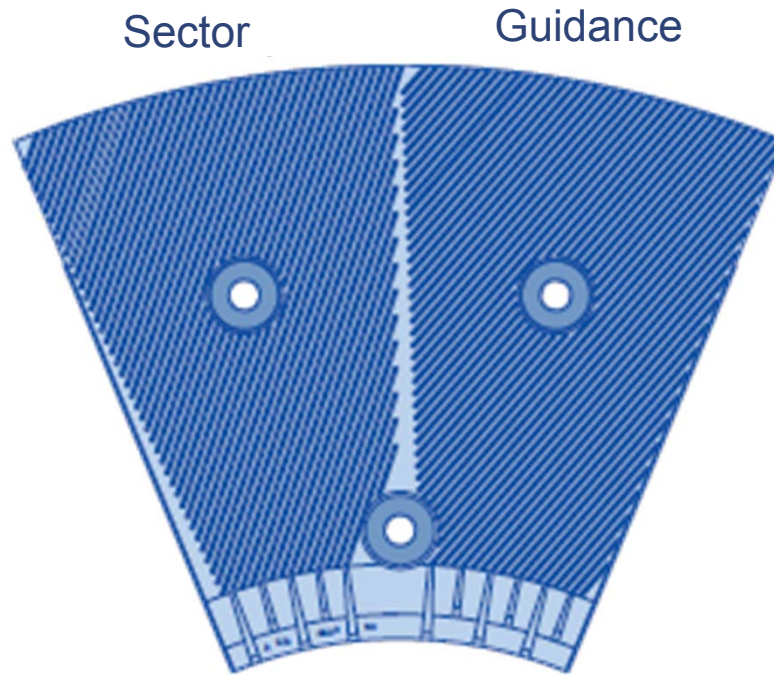
Effect of Cutting Angle





Gateway to
the Future

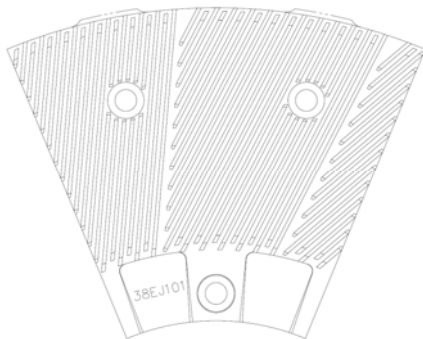




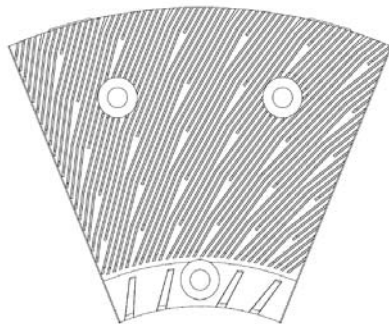
- Highly **sectored design** means uniform treatment from ID to OD
- A controlled **fiber guidance** enables more fibers to be treated
- **Constant groove** opening from ID to OD reduces chances of collecting contaminants compared to grooves which narrow from ID to OD

Tissue Mill A – North America Strength Development

Before: 38" LF (xxx/xxx-645-xx)



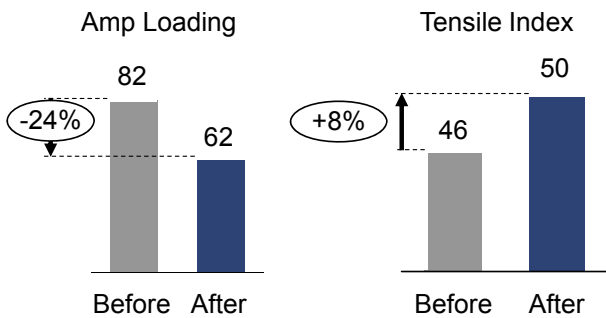
After: 38" LF (1,5/3,8-1008-60)



Customer technical data: 100% DIP

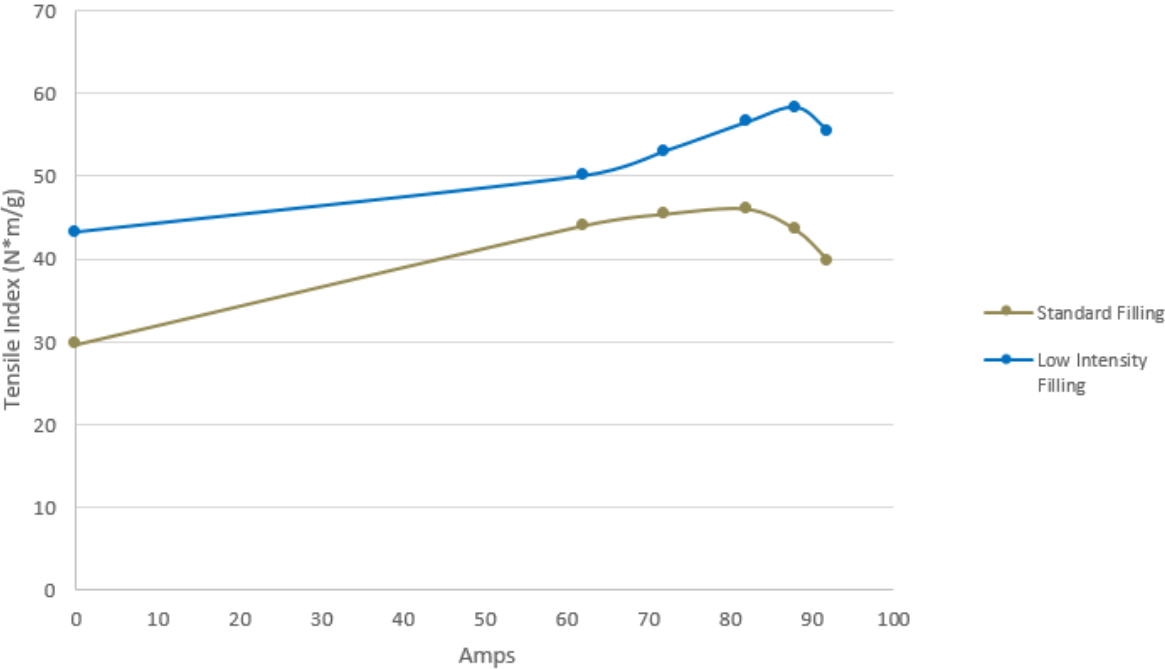
Parameters	Old situation	New situation
Amps applied	82	62-65
SEL [J/m]	0.90	0.58
Flow (gpm)	650	
Consistency	4.8	
Production	190	
Freeness (CSF)	260	

Results and benefits



- Lower Amp loading with increase in strength
- Similar freeness

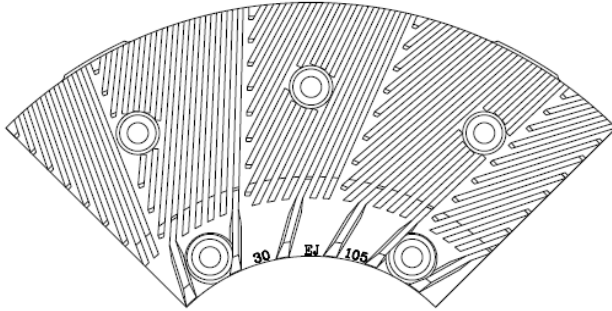
Tensile Index vs. Amps



Tissue Mill B - Southern US Energy Savings

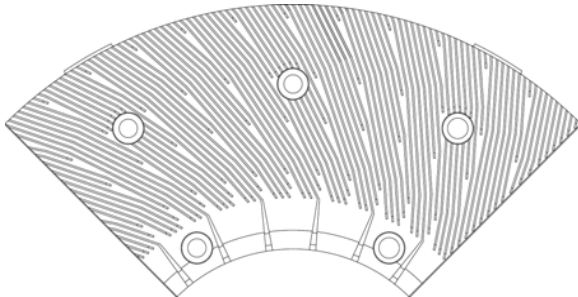
Filling A

30"EJ105/106 (4/5.3-153-42.5)



Filling B

30" LF (1.5/3.8-620-60)

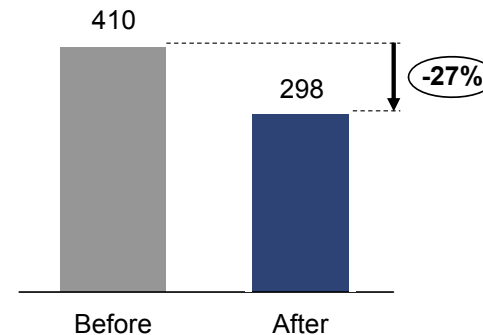


Comparison of Technical Data

25%NBKP/75%LBKP Blend

	Before	After
Filling	Filling A	Filling B
CLF	153	620
No. of refiners	2	1-2
Power saved	0	112kW(150 HP)

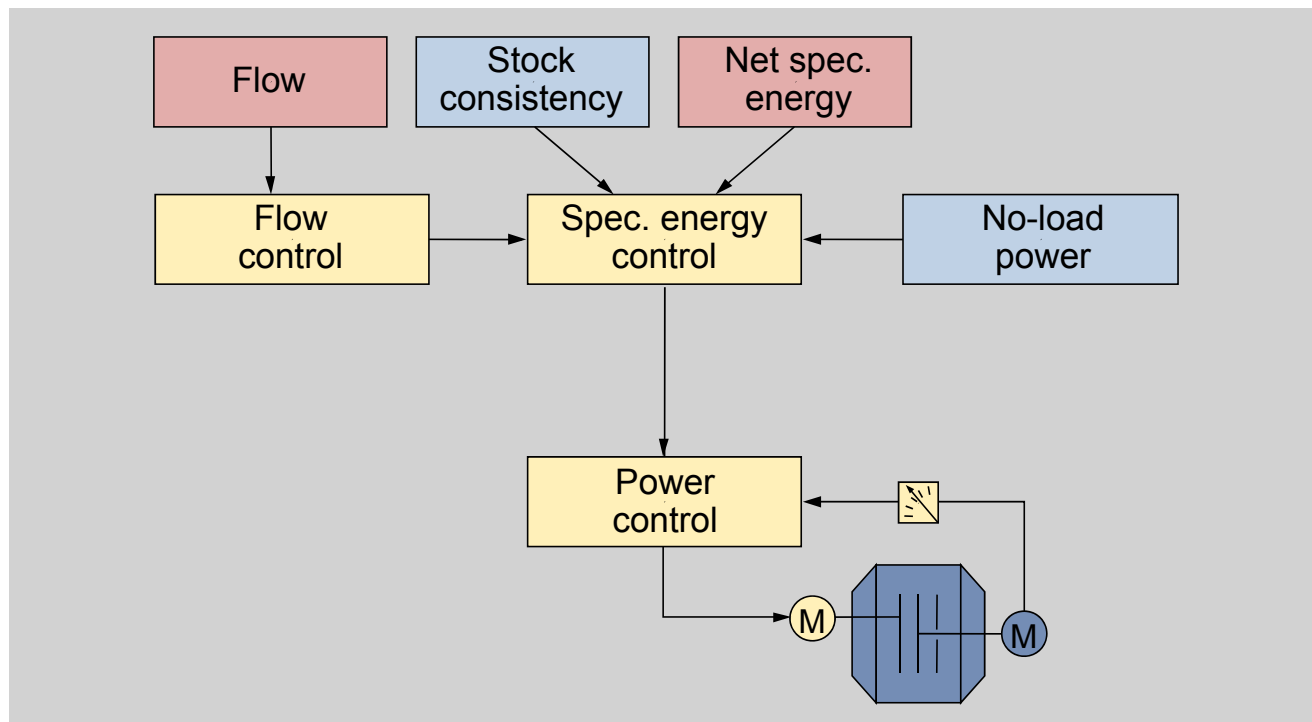
Results and Benefits (kW)



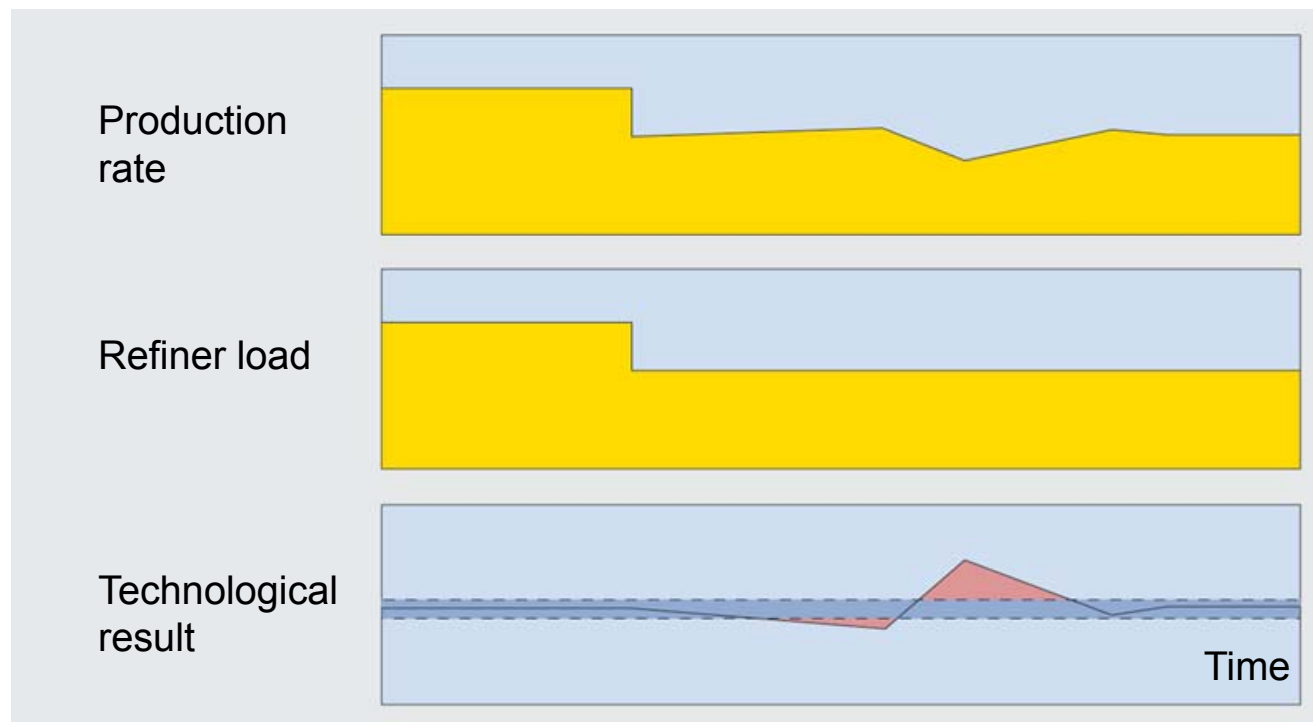
Value Added Savings

+ Higher bulk retention and increased softness

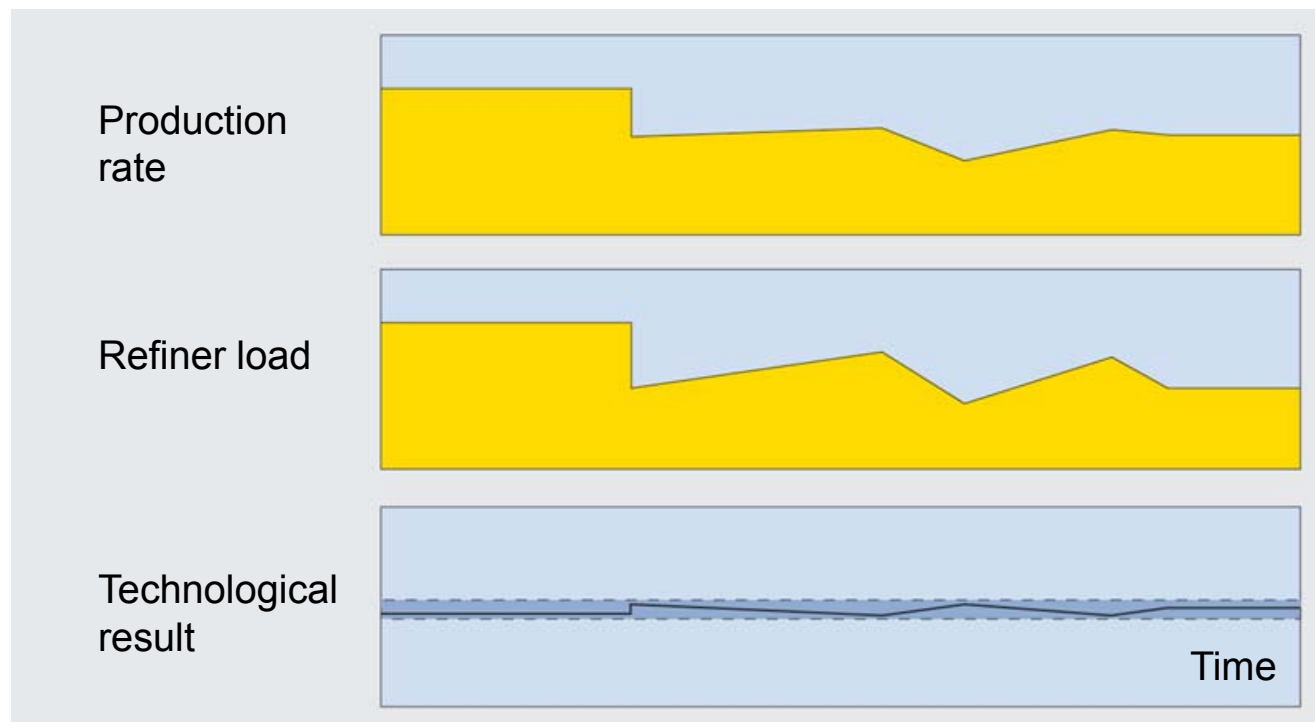
Refiner specific energy control



Refiner operation without automatic control



Refiner operation with specific energy control



Gateway to
the Future

Questions?



Gateway to
the Future

Contact:

Dylan Schnese

Local Product Manager – Screening and Fiber Treatment

Phone 920-358-2445



VOITH

Inspiring Technology
for Generations