Ultra low intensity refining of eucalyptus pulp for papermaking

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Introduction

This study was undertaken jointly by Aracruz and Finebar due to a mutual interest in providing customers with premier service and providing the industry with advanced technology for eucalyptus pulp processing. Several research groups acknowledged the importance of proper intensity for each fiber furnish. For short fibers, the main constraint has been to establish the knowledge as an industry standard. Only some special refiners or arrangements of standard refiners did the job in an economical way in the past.

The term "ultra low intensity refining" was coined in the literature to describe this range of intensity /Cláudio-da-Silva et al, 1985; Demler and Ratnieks, 1991/, studying eucalyptus pulps in commercially sized refiners: "...This indicates that the ultra low intensity operation...begins to process fibers similarly to a medium consistency refiner...". At that time, it was thought that there was no practical reason to go below this intensity value. One possible explanation for the lack of work done on fibers below 0.2 Ws/m was that the mechanical refining action was not enough to produce useful deformations in the fibers, producing only elastic changes and heat. In other words, under the prevailing conditions, the refining gap between pairs of plates was too large to produce useful work.

The lessons learned from that time are extremely valid and seem to have revived interest in the early 2000´s. We all learned that short-fibered furnishes develop excellent qualities at ultra low intensity conditions. The generally accepted benefits are:

1. Significantly reduced energy consumption,
2. Significantly extended plate life,
3. Homogeneous fiber wall treatment without fiber cutting, and

4. Development of the full potential of fiber properties, similarly to lab beaters like the PFI.

From the process point-of-view, refiners operating at lower intensities are less sensitive to process variations and subsequently produce nearly equal quality regardless of variables such pH and consistency swings. The same swings would produce larger quality variation in higher intensity refiners which require much more energy that increases plate wear at smaller refining gaps.

The extended concept of ultra low intensity refining

By 1997, Finebar devised a breakthrough refiner plate manufacturing technology, which made it possible to retrofit existing refiners, either disks or conicals, to operate well below 0.5-0.7 Ws/m, the lowest intensity range commercially sustainable at that time. The first results of our joint work were presented /Demuner, Ratnieks, and Robinson, 2005/. Besides the confirmation of the benefits of ultra low intensity refining for eucalyptus pulp in papermaking, the new plate designs have provided an extension of the useful refining range, at least, down to 0.05 Ws/m and maybe lower.

It is the aim of our presentation to update our findings since our presentation in Barcelona, both from the pilot plant studies and from continued evaluation of the results from plates operating since then in one papermachine. Some comments from other papermachines benefiting from the ultra low intensity will be made and as possible, compared to our experience.

The pilot plant studies

Our pilot plant studies have indicated that the refiner efficiency increases, based on net energy consumption to increase a singular fiber property. Despite a smaller decrease rate below 0.1 Ws/m, a benefit still exists and this finding is rather new, because it can only be demonstrated by the new generation of plates tested.

As refiner efficiency increases the overall operation of the refiner improves, probably due to a more homogeneous distribution of fibers over the bars and grooves, and larger and more stable plate gaps. This situation provides the opportunity for fiber properties from distinct eucalyptus origins to be comparable, demonstrated with similar tensile strength development of market pulps from distinct suppliers. This is a feature that confirms earlier findings that ultra low intensity refining is a much more stable condition for the machine and provides fully developed fibers.

Pulp quality developed under these refiner conditions show that the fibers can develop their potential by extensive fiber wall treatment without fiber cutting, with removal of fiber kinks and curl, and low production of fines, probably only produced by fiber wall delamination /Demuner, Ratnieks, and Robinson, 2005/. Figure 1 shows that paper formation is much less based on secondary fines at the same drainability level, as intensity goes down /Almeida et al, 2005/.

To substantiate such findings and optimize pulp quality, a set of trial runs was run with distinct furnishes to investigate Gurley air resistance. This can be translated to the tensile air resistance relationship, especially with fully developed fibers. For fully developed fibers, the lower the intensity, the higher the tensile that can be achieved, keeping air resistance low (and saving energy).

The papermachine after two years

The papermachine in question has been operating refiners equipped with Finebar plates. It is our aim to update the findings from this industrial environment after two years of operation.

First, it is interesting to compare two distinct trials from two papermachines which operate in Brazil within the ultra low intensity concept. Figure 2 compares the papermachine's results, taking a known base case, a very similar situation to both machines, expressed in absolute figures for the main paper qualities and operational gains. The relative figures (in %) of the main features achieved after converting the refiners to lower intensities (not equal to each case), show that the paper qualities and gains are rather proportional to the reduction in intensity practiced in each case.

For the Aracruz Guaiba mill, each refiner plate pattern was studied in the pilot plant before the plate pattern scale-up to papermachine refiner. The aims were to find a pattern suitable for 100% eucalyptus furnish, with the lowest intensity possible and maximum gains in energy and paper quality. We concluded that for this case, a plate pattern of 1 mm bar width and 2 mm groove width was the best choice.

The refiner plates today easily achieve 1 year of operation, and depending on the position, being it the primary or secondary refiner, there is some expectation for the secondary plate to achieve 2 years of operation. The base-case for cast plates operating at 0.8 Ws/m was 4 months.

Depending on the paper grammage, mainly the lower ones, one refiner can be shut down because of the important energy economy achieved. The refining energy reduction at the mill is 15-25% of total power, mainly due to one-refiner shutdown (no load power spared), and secondarily because refiner loads were eased. An interesting finding is that operators tend to explore this extra energy to improve wet web strength and paper air resistance, for example. These actions consumed part of the energy gains of plates change. Many of the eucalyptus customers have been able to idle refiners with the combination of reduced energy and ability to increase applied motor load. Tensile increases are important, but getting the same tensile on lower water retention value and better dimensional stability are even more important to paper machine operation. Sheet breaks have been rare, which means the operators have to induce sheet breaks to clean up rolls, calender, etc.

The Aracruz Guaiba papermachine has been actively developing its capacity under the classical creeping conditions. The refiner section has been identified as a bottleneck twice during the last years. Keeping the same equipment, all piping and instrumentation setup was modernized during the first intervention in 2001. The second intervention was during December 2004 with a plate change to ultra low intensity mode. It is clear that the same refiners have been holding an important role in the capacity increase (+15%), not only maintaining paper quality but helping to improving it.

Ongoing industrial advancements

Ongoing efforts to further optimize industrial application of ultra low intensity refining at Finebar have been focused in several areas. While it is still possible to manufacture bars with lower thicknesses, the practical limit is being reached. Use of 0.8 mm bars and possibly 1.5 mm grooves could add as much as 50% more cutting edge length. As the grooves are reduced below 2.0 mm, however, there will be additional design modifications to the patterns to allow optimum flow into the plate.

Further optimization efforts must also be focused at a better understanding of some of the other parameters such as crossings angles and refiner types. Critical to being able to understand the impacts of changes to the patterns and type of refiner is the ability to know the refining gap resulting from these changes. Previous research /Joy, Matthew, and Robinson, 2001; Mohlin, 2005, and others/ has shown a characteristic relationship of motor load to plate gap. Using this relationship and estimating the initial gap at the no-load value (g_0), we see the following correlation for this relationship. This gap vs. power relationship will be unique for a given pattern with a constant furnish, consistency, and flow. It is this relationship that we want to understand more than the values of various edge load theories. Using this relationship, we can begin to understand some of the variables that are not readily addressed in edge load theories.

Final remarks

Pilot and commercial trials have confirmed that reducing specific edge load far below typical commercial values for short fibered furnishes has many benefits. A novel manufacturing technology for refiner fillings has made the application of this concept possible on a commercial basis.

As papermakers continue to strive to improve their operations and the increased global usage of eucalyptus and other short fibers, the identified benefits (reduced refining energy consumption, improved paper qualities and better papermachine runnability) are of great importance.

Since reductions in specific edge load have now been pushed to the limits of plate construction materials and constraints relative to the fibers and process, the future focus should be on the understanding of other variables in refiner plate design and operation with the goal of maximizing refiner plate gap.

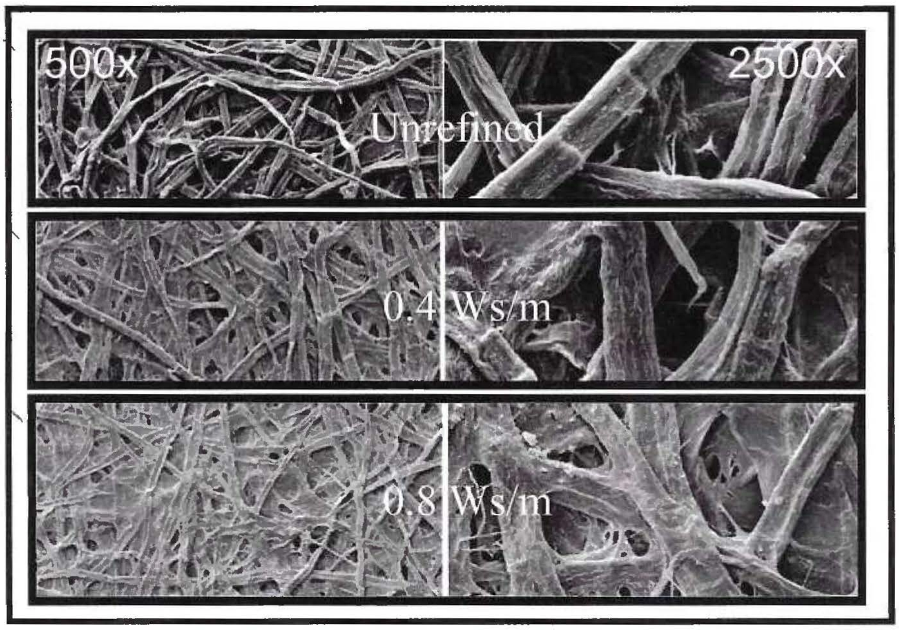

Figure 1. Effect of intensity on fiber mat topography showing distinct amounts of fines and pore structure, at 35 °SR /modified from Almeida et al, 2005/.

% change of properties compared to base case @ 0.8 Ws/m		Aracruz Guaiba Mill 0.1 Ws/m	VCP L Antonio Mill 0.4 Ws/m
Intensity	0.8 Ws/m	-80%	-50%
Total Specific Energy	80 kWh/t	-50%	-20%
Net Specific Energy/°SR	4.7 kWh/t.°SR	-60%	-30%
CD expansion (paper)	4%	-20%	-50%
Tear (paper)	8 mN.m/g	10%	10%
Bulk (lab sheets)	1.65 cm^3/g	3%	2%
Bulk (paper)	1.31cm^3/g	1%	1%
Stiffness (lab sheets)	0.19 mN.m	15%	not mentioned
Stiffness (paper)	0.07 mN.m	15%	no change
Wet Web Strength (55% Solids)	Nm/g	less PM breaks	30%
WRV	%	improved runnability	-10%

Figure 2. Two P&W papermachine trials in Brazil reported in the literature that the intensity reduction is proportional to the benefits achieved /Demuner, Ratnieks, Robinson, 2005; Almeida et al, 2005/.

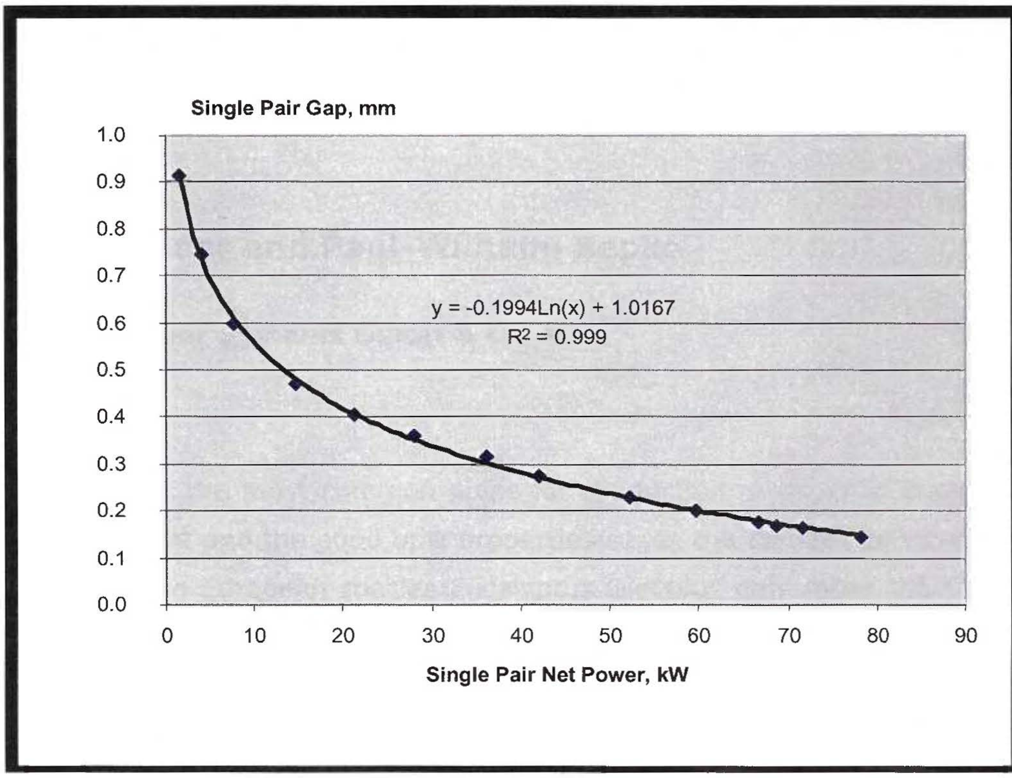

Figure 3. Gap-to-energy fingerprint of a specific pair of plates.

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