

Mechanical treatment of eucalyptus fiber using refiner plates with higher bar edge crossing length

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SUMMARY

Paper manufacturing companies in Brazil have throughout their history acquired the expertise to work with a furnish composed of 100% hardwood of eucalyptus kraft pulp, an unique feature compared to worldwide common practice. In absence of softwood to enhance physical properties inherent to long fibers, Brazilian manufacturers are always in search of alternatives to handle eucalyptus fiber in such a way to achieve the best balance between physical strength development and minimum loss of structural properties, such as bulk.

Physical and structural changes in eucalyptus fibers happen during refining operation. Physical strength, opacity, porosity, bulk, water retention and drainage are the essential parameters for manufacturing of printing and writing papers. They are directly responsible for paper machine runnability, paper quality and its performance at the end-user.

For reprographic use, dimensional stability is extremely important due to its contribution to visual aspect of the blank and the printed material and the runnability in copiers and printers. Dimensional stability is strongly affected by the quality of the refined fiber and is inversely proportional to the amount of refining.

Recent advances in the technology of new materials and production of refiner plates made it possible to build plates with higher bar edge crossing length. Hence low intensity refining turned into reality and created opportunities to achieve a new referential for the quality of refined eucalyptus pulp.

INTRODUCTION

Votorantim Celulose e Papel – Luiz Antonio Plant located 300 km from São Paulo city is a manufacturer of Printing and Writing and Xerographic paper grades obtained from a furnish of eucalyptus pulp produced at the same site. Our products are exported mostly to NA and European markets and so far, eucalyptus hardwood is the key

point to have a superior paper in formation, opacity and bulk with low cost. Due to the condition of using always the same furnish we are continuously dedicated to developing processes most suitable to achieve at the same time high wet web tensile strength, high drainage capacity and a final product with high porosity and good dimensional stability. This paper describes our recent experience with mechanical treatment of eucalyptus fiber using refiner plates with higher bar edge crossing length.

1.1. Basic concepts in refining

Refining process is a key operation for fiber treatment in paper manufacturing. Through refining it is possible to give the required strength to the fiber enough for the web to stand the tension forces applied throughout the paper machine. Nevertheless there is a certain limitation for refining given by the negative influence on drainage, bulk and dimensional stability. The quality of refined fiber depends on the operating parameters of refining process.

Author's References:

- 1 - Votorantim Celulose e Papel S.A. – Luiz Antônio (SP) – Brazil
- 2 - Votorantim Celulose e Papel S.A. – Jacareí (SP) – Brazil

The degree of refining can be measured through the following parameters:

- a) Refining energy, kWh/t
- b) Refining intensity, Ws/m

The Specific Edge Load (SEL) empirical theory has good acceptability as a way to measure refining intensity, and represents in a simple way the intensity of impacts that fibers undergo in a refiner. It is defined by the ratio between net energy and the length of bar edge crossing length in time unit:

$$SEL = E_{net} / (km/s), \text{ in Ws/m, where:}$$

E_{net} : net energy, kW

Km/s: bar edge crossing length

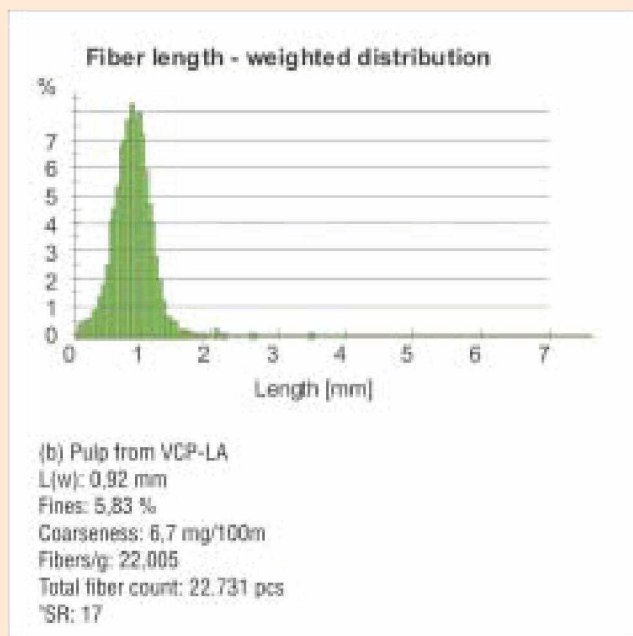
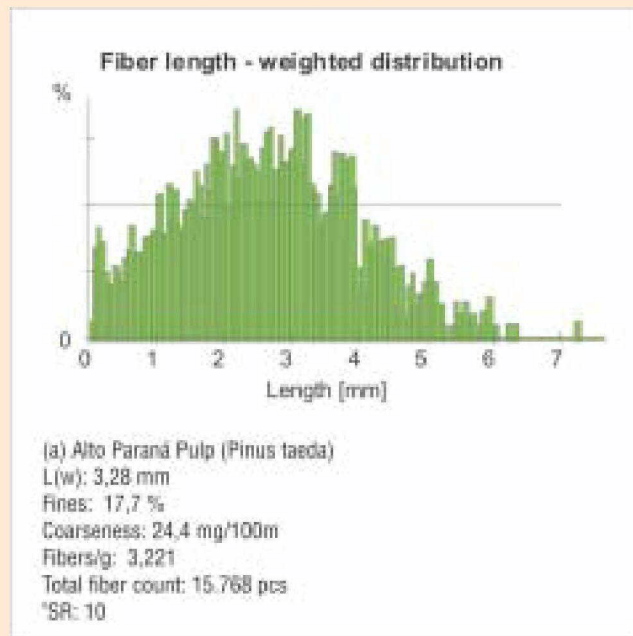


Figure 1 – Morphological analysis (Kajaani) of unrefined pulp: (a) Alto Paraná and (b) VCP-LA

Recommended refining intensity for hardwood is less than 1.0 Ws/m.

1.2. Refiner plates with higher bar edge crossing length

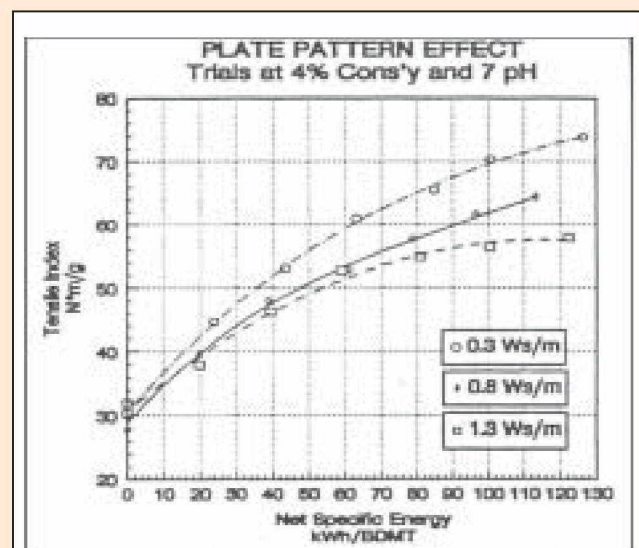
Eucalyptus hardwood fiber has very distinct dimensions compared to softwood (Figure 1), and its extensive use in different grades of paper demanded the development of refiner plates specific for its treatment.

A new patented technology that consists in manufacturing plates using precision laser cut, assembling and diffusion bonding made it possible to build refiner plates with an unique design and patterns of very fine bar patterns and high volumetric capacity.

Figure 3 illustrates the difference of design between a standard refiner plate used for hardwood refining and the plate built by the new concept, which will be referred as “Test”.

The possibility of working with extremely low SEL added to the material employed in the manufacturing of plates creates new opportunities for:

- Increasing the life of plates, by combination of lower SEL, plate design and manufacturing material;
- Reduction in energy consumption of energy due to the effect of higher bar edge crossing length;
- Improving the quality of refined pulp, by minimizing the negative effect on fiber structure with application of lower SEL in refining;
- Improving the quality of final product, increasing strength and bulk for the same refining degree.



The pattern of the plate has direct influence on refining intensity (SEL) and according to a study (Figure 2) the lower the intensity, the higher is the gain in net energy. On the other hand, higher tensile strength is obtained at the same energy (Demler e Ratnieks, 1991).

Figure 2 – Influence of SEL on refining net specific energy.

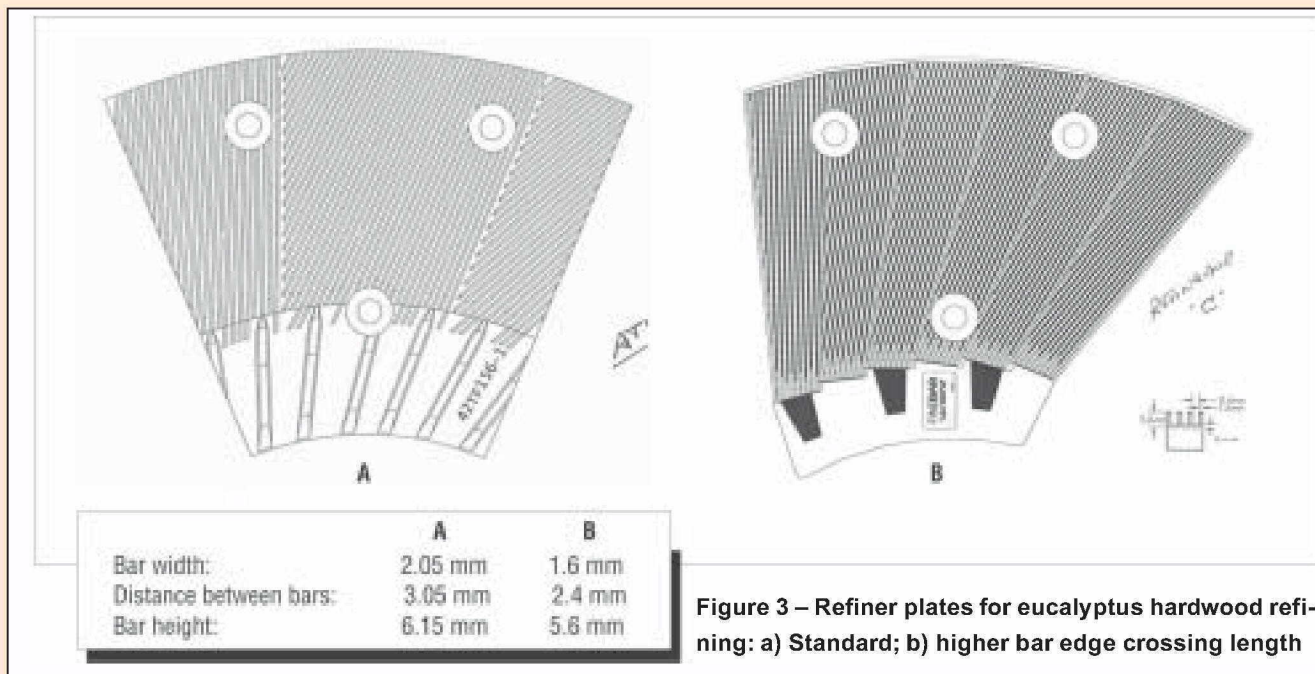
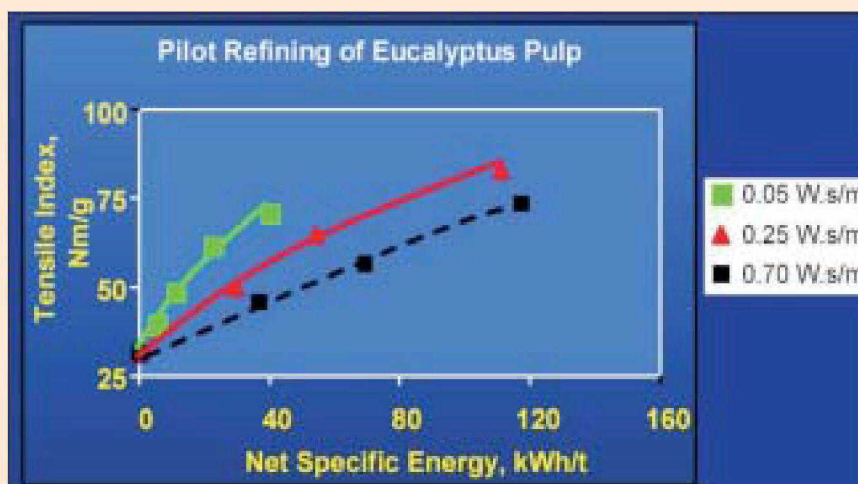


Figure 3 – Refiner plates for eucalyptus hardwood refining: a) Standard; b) higher bar edge crossing length



In a recent work, Demuner et. al (2005) presented results of SEL much lower than standard levels, with benefits for the quality of refined pulp (Figure 4).

Figure 4 –Low refining intensity for eucalyptus pulp (Demuner et. al, 2005)

The main difference between standard plates for eucalyptus pulp and the new generation of plates is the higher bar edge crossing length:

- Standard: 96,72 km/rev
- New technology: 152 km/rev

With this new plate, there is opportunity of running the refiner with 36% lower SEL for a given net specific energy.

RESULTS OF A PRACTICAL APPLICATION

Results presented in this work were obtained during the life period of the refiner plates with higher bar edge crossing length compared to the standard plates.

In our mill the paper machine has four Voith 42" diameter disk refiners, able to run either in series or parallel configuration. For this experiment, two refiners were maintained in parallel with standard plates and

two remained refiners were kept in parallel with new plates.

2.1. Specific energy consumption

In the first experimental situation, applied energy was kept constant to both plates condition. As a result, with the Test plates, SEL decreased from 0.96 to 0.61 Ws/m, but Schopper-Riegler (°SR) of refined pulp increased from 36 to 45 °SR.

In order to maintain the same quality of refined pulp in 37 °SR, in a second step, applied energy was adjusted to 88.7 kWh/t in the refiner with standard plates and 70.2 kWh/t in the refiner with the new plate.

The new refiner plate made it possible to achieve a reduction in 19% in total energy applied in refining, what can be directly measured by economy in energy (Figure 7). Moreover, there was also a reduction in 43% in the specific energy consumption by Schopper-Riegler, from 4.9 to 3.4 kWh/t/°SR.

Achieving required refined pulp became easier with the new plate, allowing operating the refiner with higher flow levels maintaining the same configuration of

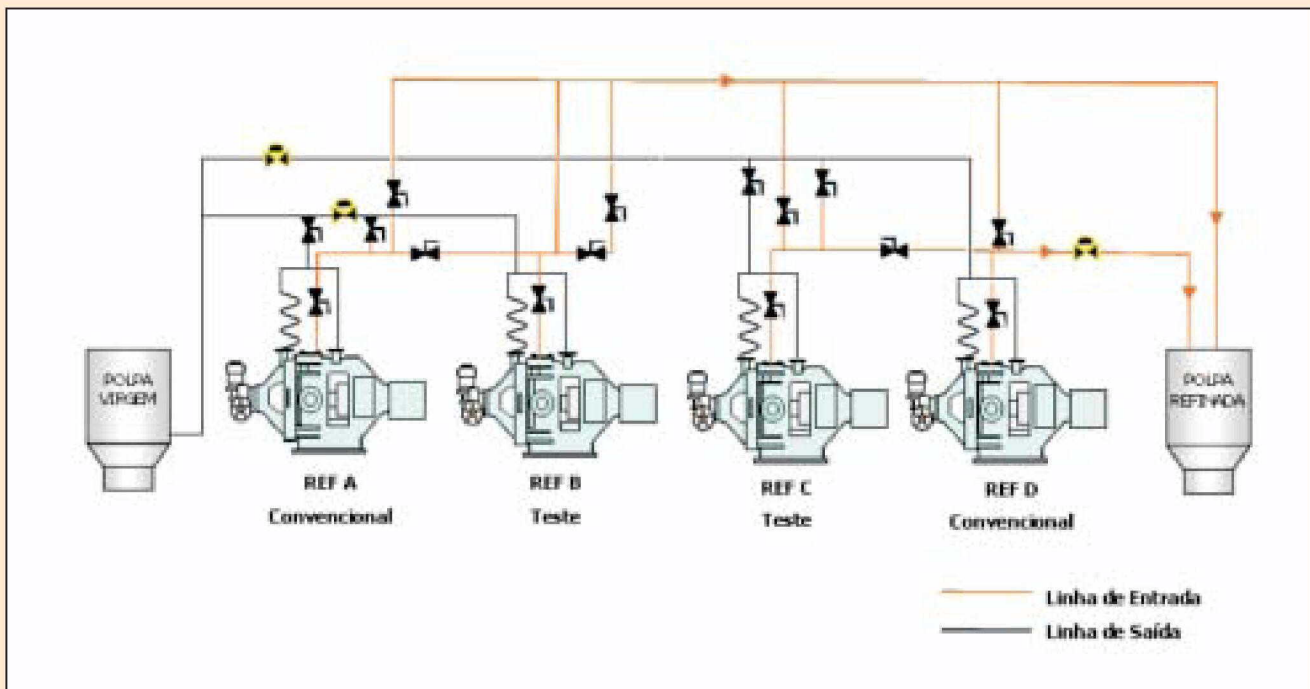


Figure. 5 – Schematic of refiners configuration during test.

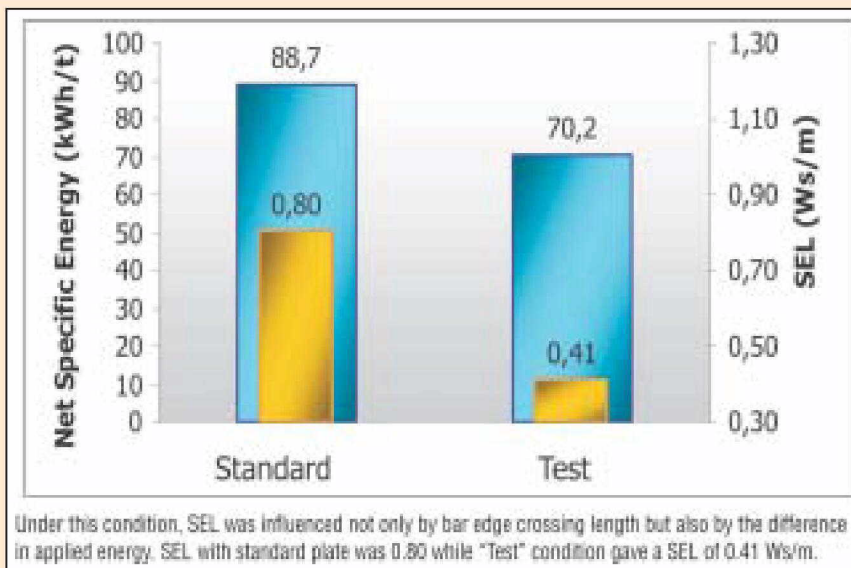


Figure 6 – Net energy and SEL for the trial conditions.

refiners. After optimizing process parameters, the new refiner plate made it possible to work with less one refiner, resulting in more gains in energy consumption and maintenance cost reduction.

2.2. Lifetime of refiner plates

Life of plates was determined by comparison to the amount of furnish refined during the period of life of the standard plate.

Pictures of standard and test plates before and after life can be seen next. It is possible to see that the width of bar from the new plate has not changed after end of life, however this do not happen with the standard plate. This feature can be explained by the pattern and the material used in the new plate, and, not less important, by the lower SEL applied in these plates during the trial.

2.3. Quality of refined pulp

Pulp refined with the new plate shows a smaller tendency of impacting Water Retention Value (WRV), reaching 20 points in difference comparing pulps with same °SR.

2.3.1. Morphological properties

There was no significant difference in morphological properties from fibers refined with standard or test plates (Table 1).

2.3.2. Microscopy

Microscopy of lab handsheets shows a difference between pulps refined with standard and test plates. By visual comparison, the standard refiner plate produces a more closed fiber mat and fibers present more degradation while the pulp refined with the test plate seems to be more intact.

2.4. Final paper quality

Lab handsheets and industrial paper samples from both conditions of plates were submitted to paper testing (Table 2).

The new test plates showed an improvement in Bulk in handsheets

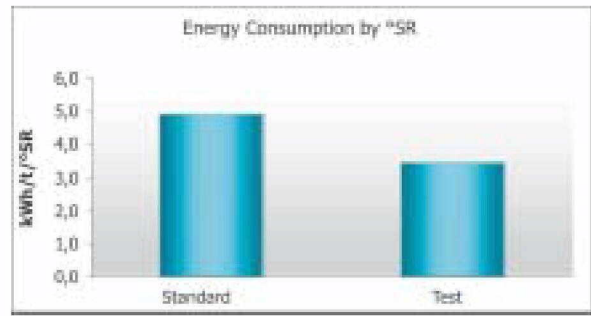
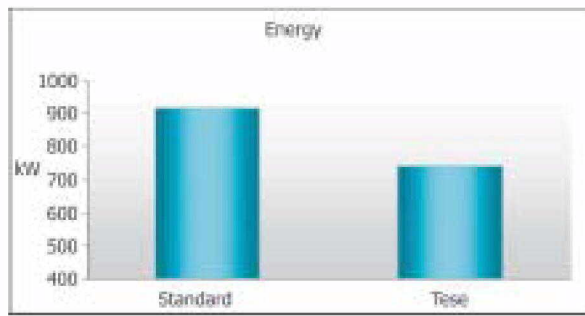


Figure 7 – Reduction in total energy and in specific energy consumption by schopper-riegler.



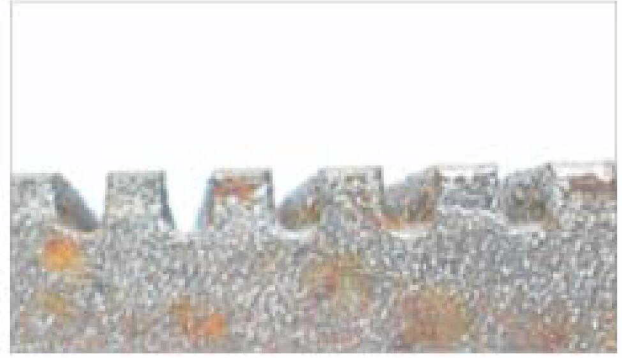
"Test" plate before use



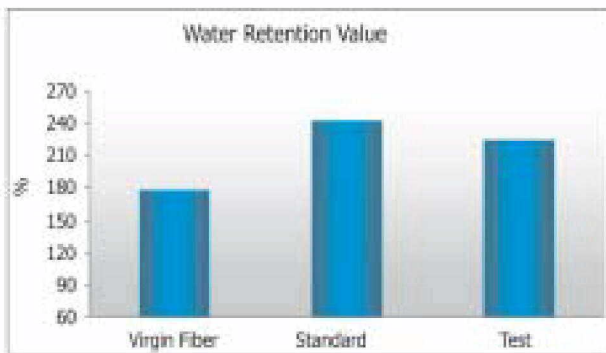
"Test" plate after use



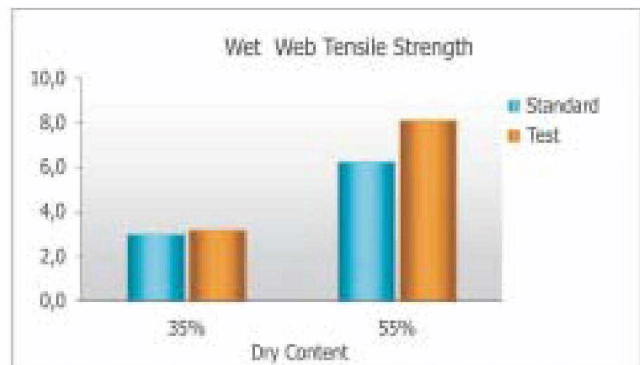
Standard Plate before use



Standard Plate after use



Lower WRV means better drainage capacity of pulp, benefiting paper machine runnability, allowing increasing process-operating alternatives, for instance, work with higher °SR in order to get higher web tensile strength without damaging drainage.



Wet web tensile strength (WWTS) showed significant gain when 55% dry, what is a positive result for runnability of paper machine.

	Virgin Fiber	Standard Plate	Test Plate
Fiber length, μm	17.2	17.3	17.3
Wall thickness, μm	2.75	2.62	2.71
Wall fraction	32.0	30.3	31.4
Lumen diameter, μm	11.7	12.1	11.8
Flexibility Index, %	68.0	70.0	68.6
Feltment Index	47.3	45.9	47.6
Runkel Index	0.47	0.43	0.44
Coarseness, mg/100m	6.4	5.8	6.0
Number Fibers/gram, $n^\circ \times 10^6$	23.3	27.3	25.1
Weigthed Average Length, mm	0.81	0.79	0.82
Fines (n) < 0.2mm - Lc,%	9.9	11.6	10.8

Table 1 -Results of morphological analysis of fibers.

	Standard	Test
Bulk - Lab, cm^3/g	1.32	1.35
Bulk - Paper, cm^3/g	1.31	1.32
Porosity, s/100 mL air	17.6	16.8
Tearing Strength - CD, mN	489	535
Tensile Strength - MD, kN/m	5.43	5.47
Elongation - CD, %	5.7	5.0
Stiffness - CD, gf.cm	0.90	0.90

Table 2 - Lab Handsheets and Paper Samples from papermachine



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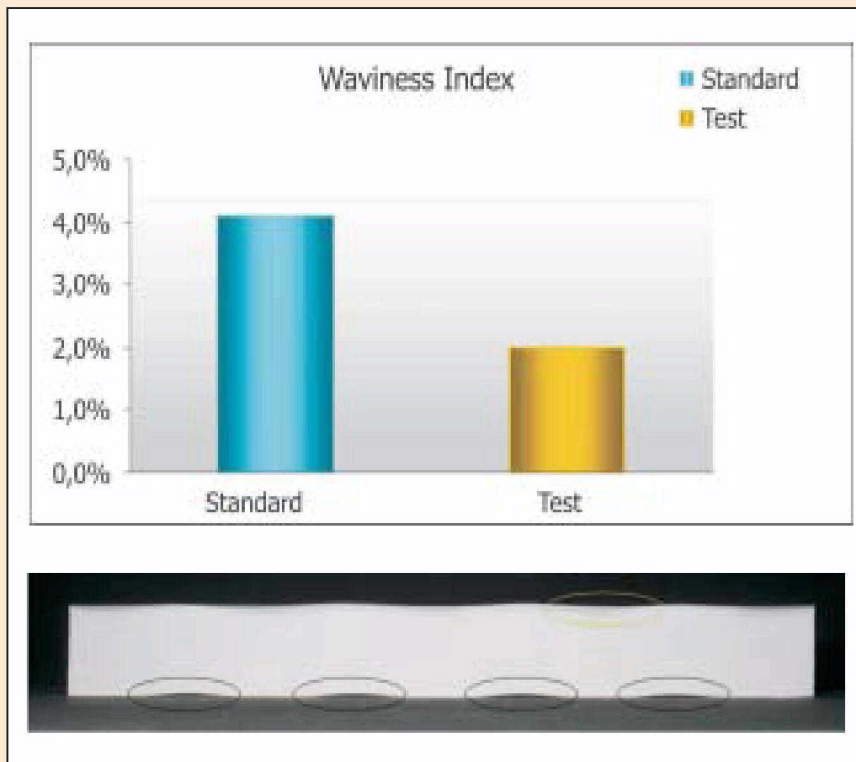
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from 1.32 to 1.35 cm³/g, only partially reproduced in machine sample, possibly due to mechanical action on fibers during passage through extended nip press. There was a positive impact on tearing strength – about

10% on machine sample - and loss in Elongation, benefiting dimensional stability and performance in copying/printing operation. There was no significant change in Porosity, Tensile Strength and Stiffness.

2.4.1 Dimensional Stability



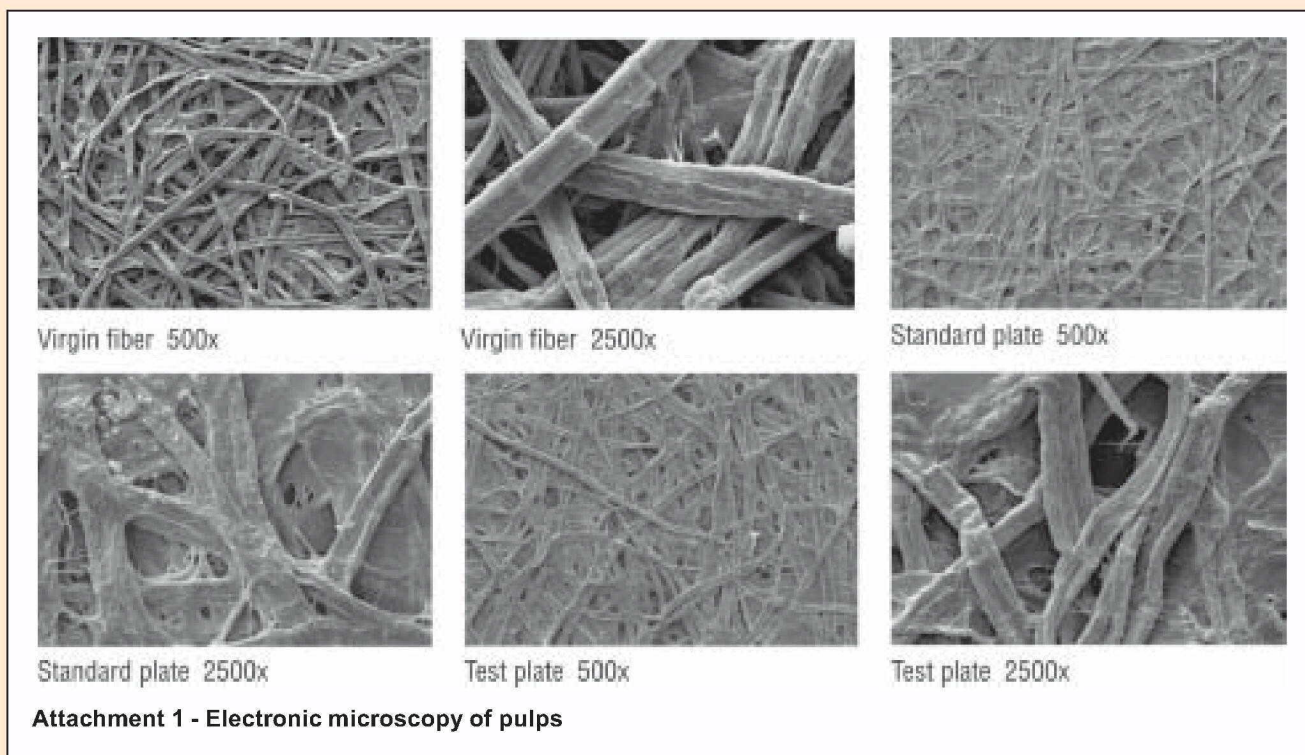
CONCLUSION

Refiner plates with higher bar edge crossing length made it possible to establish new operating parameters for eucalyptus kraft pulp refining, resulting in significant advantages to the paper-making process and the final product.

With lower energy consumption it was possible to spare refiners and work with a SEL of 0.41 Ws/m, with superior quality of refined pulp, higher tearing strength and a more intact fiber. Bulk and dimensional stability had a positive impact as well.

LITERATURE

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Attachment 1 - Electronic microscopy of pulps