**IMPROVING EUCALYPTUS PULP REFINING THROUGH THE CONTROL OF PULP CONSISTENCY AND STOCK pH: Comparisons at given bulk and given tensile strength**

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## ABSTRACT

Eucalyptus pulps have short and numerous fibers. They are well-suited to the manufacture of printing & writing and tissue papers. Refining is a vital step in preparing the pulp to papermaking. Refining optimization may improve the eucalyptus pulp performance oriented to the end product. Papermakers are willing to achieve sheet specifications, such as bulk, tensile, tear, porosity, etc.

When optimum refining is searched, the comparisons among treatments may be performed at given bulk or tensile index, instead of given freeness or given net energy. This is a more realistic situation regarding the end product quality.

In this paper, the properties of handsheets were compared at given bulks and given tensile. When the purpose is to improve fiber bonding, mainly to the printing & writing papers, the pH and consistency are suggested to be higher (pH around 9, consistency around 5). Tissue papers require loosen sheet structure. In this case, it is advised to run beating at lower pH's (5-7) and lower consistencies (3-4%).

## INTRODUCTION

Stock preparation is a vital step in the way to develop the desirable paper properties.

Eucalyptus fibers are popular raw material to the manufacture of printing & writing and tissue papers. The pulp has numerous and short fibers. They impart special properties to the papers because some unique characteristics. Tissue papers require softness, bulk, fluffiness, tactility and absorption. Printing and writing papers demand formation, opacity, bulk, strength, porosity, smoothness, printability and dimensional stability. All these properties can be upgraded and optimized via an appropriate refining. Refining is a key operation in the stock preparation. One of the issues to be controlled is the specific consumption of energy to develop the required properties. Paper properties and refining energy are related to operational parameters, such as pulp consistency and stock pH.

This paper is intended to show the influence of pH and consistency on the refining performance of eucalyptus fibers.

A commercial bleached kraft eucalyptus pulp was submitted to the tests. Three levels of consistency (3%, 4%, 5%) and three of pH (5, 7, 9) were evaluated in a factorial type experiment, with one replication. The trials were performed using a commercially sized double disk refiner with 20 " disks, with duo-flow feed. The equipment was a DD 4000 Beloit refiner driven through a variable speed coupling by a 400 kW induction motor. Power measurements were made with a strain gauge torque sensor and appropriate signal conditioners. The refiner was outfitted with bar width = 3mm; groove width = 3mm; groove depth = 10mm; refining angle = 5º. Operating speed was kept constant at 1200 rpm during the trial. The refining strategy was single pass, straight-through refining. Speed and motor power were kept constant during all the trial, calculated to guarantee 0.6 Ws/m refining intensity, according to the specific edge load theory. Different levels of net specific energy applied to the pulp were achieved by varying the refiner throughput. This was obtained thanks to a variable speed feeding pump.

The pulp after each treatment was evaluated in laboratory according to TAPPI standard methods. The results were presented in ISO units. The samples were also studied using a Kajaani FS –100 fiber analyzer and a dynamic jar tester.

In general, when you evaluate pulp refining, there are several options to make comparisons of the results: constant freeness, constant applied energy, constant bulk, constant strength. In this paper, the results were compared under the view of the tissue and printing & writing manufacturers. Thus, the comparisons were performed under constant bulk and constant tensile strength. In other papers to be published, the comparisons based on freeness and net energy will be made available.

## *FIBER CHARACTERISTICS*

Fiber length was almost unaffected by the refining. The short eucalyptus fibers are so small that cutting is a phenomenon difficult to happen. A very slight decrease on fiber length can be noticed from the unbeaten pulp (~0,66mm) to the highly beaten pulp (~0,63mm). However, this is mainly due to the way the Kajaani analyzer perform the tests, counting small fragments of fibers as being single fibers. It was not possible to detect a pH or consistency influence on fiber length variations.

In the opposition, the amount of fines in the pulps was proved to vary with the refining development. Unbeaten pulps had lower fine contents as expected:

10,0 – 10,5% measured by Dynamic Jar Test
4,6 – 4,8% measured by Kajaani FS 100

After beating, the levels of fines reached the maximum at the highly beaten pulps:

13,5 – 14,5% measured by Dynamic Jar Test
5,8 – 6,7% measured by Kajaani FS 100

The generation of fines was affected by refining development and by the pulp consistency. At 5% consistency, the generation of fines (DJT) was 1 or 2% lower, independent of the pH.

Coarseness reduced with the refining development from 7,5 to 6,0 mg/100m. This is expected, since fibers are losing particles / debris from the walls. There was not a trend in function of pH or consistency.

As it is known, the number of fibers per gram of pulp raised with beating development. The Kajaani results showed about 5 million more particles per gram in the highly beaten pulps in relation to the unbeaten ones.

## *EFFECT OF CONSISTENCY AND pH UNDER GIVEN BULK COMPARISONS*

After tests and pulp evaluations, all the properties were plotted in graphs against bulk. For each treatment, the results were taken from the graphs in the following handsheets given bulks:

2,1 ; 2,0 ; 1,9 ; 1,8 $cm^3$ /g

Because of the matrix of results, which was created for each test, three trends could be easily observed: refining development, pH influence and consistency influence.

In order to avoid a boring report of many tables and discussions test by test, a summary of relevant findings is provided. Pulp evaluations were performed on 60 g/m2 handsheets.

Table 1 – Relevant findings for eucalyptus pulp refining (comparisons at given handsheet bulks)

| **Property** | **Objective** | **Best treatment** | |
|---|---|---|---|
| Brightness | Higher | Consistency 4% | pH 9 |
| Slowness ºSR | Lower | Consistency 5% | pH 5 |
| Net Energy | Lower | Consistency 5% | pH 9 |
| Tensile | Higher | Consistency 3% | pH 9 |
| Stretch | Higher | Consistency 3% | pH 5 |
| Burst | Higher | Consistency 3% | pH 5 |
| Tear | Higher | Consistency 3% | pH 5 |
| Opacity | Higher | Consistency 3% | pH 5 |
| Porosity | Higher | Consistency 4% | pH 5 |
| Water absorption | Higher | Consistency 3% | pH 7 |

When comparisons are made in a given bulk, pulps may have different levels of net applied energy and different freeness. However, if the purpose is to refine the pulp to promote the best possible bulks and associated properties at these given bulk levels, the beating conditions to enable this are consistencies 3-4% and pH 5-7.

The properties that are in disagreement with this trend are tensile and brightness. They better respond to pH 9 at refining. For tissue manufacturing, tensile and brightness are not critical. A high tensile is undesirable because it’s associated with brittle sheets.

In the case of beating eucalyptus pulps for tissue paper manufacturing, the most recommended conditions are lower consistencies (3-4%) and lower pH (5-7). For tissue, the perceived softness is a function of stiffness, bulk, surface texture and fiber quality. The basic strategy for high bulk tissues is to avoid compaction during sheet making process. Bonding due to compaction and fibrillation has to be minimized under a given bulk. This situation was proved to be better obtained at lower consistencies and lower pH’s. Considering the fact that the fiber cutting is not significant, the lower pulp consistency does not bring on associated damage of fibers. Although net energy required is higher under these circunstances, for tissue manufacturing, the refining is very gentle with low energy consumption.

## *EFFECT OF CONSISTENCY AND pH UNDER GIVEN TENSILE STRENGTH COMPARISONS*

Again, the pulps were evaluated and the final properties were related to tensile strength. For each treatment the results were taken from the graphs in the following handsheet given tensile index: 30, 40, 50 N.m / g.

In table 2, the most relevant findings were summarized. For each evaluated property, the best performing treatments were selected. As it is well-known, pulps refined under different pH and consistencies develop differently along the beating. This means that a pulp refined to 40 N.m/g under a given pH and consistency may have a different freeness or net applied energy in comparison to other pulp with the same tensile index, but refined under other pH / consistency condition.

Table 2 – Relevant findings for eucalyptus pulp refining (comparisons at given tensile strength levels)

| **Property** | **Objective** | **Best treatment** | |
|---|---|---|---|
| Brightness | Higher | Consistency 4% | pH 9 |
| Slowness ºSR | Lower | Consistency 4% | pH 9 |
| Net Energy | Lower | Consistency 5% | pH 9 |
| Tensile | Higher | Consistency 3% | pH 5 |
| Stretch | Higher | Consistency 5% | pH 5 |
| Burst | Higher | Consistency 5% | pH 9 |
| Tear | Higher | Consistency 5% | pH 9 |
| Opacity | Higher | Consistency 3% | pH 5 |
| Porosity | Higher | Consistency 5% | pH 5 |
| Water absorption | Higher | Consistency 3% | pH 5 |

The properties related to strength are affected by pH and consistency at significant extension. All properties requesting bonding perform better when the pulp is refined at higher pH (9) and higher consistency (5%). However, the properties that are associated with loosen sheet structure (bulk, water absorption, opacity, porosity), they were better developed with lower consistencies (3-4%) and lower pH (5). We shall not forget that comparisons are made at given tensile index and not given freeness.

## *CONCLUSIONS*

It is very important to properly select the stock consistency and pH when refining a pulp. Eucalyptus fibers are unique in the fact they are short and numerous. Fiber length is almost unaffected by refining, although coarseness is reduced and number of "fibers"/ gram is increased, as expected.

Pulp is refined to achieve the desired product properties and machine runability. Running performance depends on net applied energy and freeness after refining. However, when the papermaker manufactures the paper, he wishes to achieve paper sheet specifications and not freeness or net energy. Thus, comparisons at given bulk or given tensile index are becoming more interesting to the paper-maker. Conclusions may be somewhat different than in relation to comparisons at given freeness.

In this paper, at neutral pH, most of the properties are average, not extremes. In case the purpose is to improve fiber bonding, mainly to the printing & writing papers manufacture, the pH and consistency are suggested to be higher (9 and 5%, respectively). For the other properties, those not related to fiber bonding, fibrillation, or fiber collapsing, it is advised to run the refining at lower pH (5-7) and lower consistencies (3-4), simultaneously. In all situations, the net required energy is saved when the pH is 9 and consistency 5%.

## *REFERENCES*


1 Demler, C. and Ratnieks, E., Eucalyptus refining for the papermaker, 2º International PIRA Conference – "Current and future technologies of refining", 1991, Birmingham, UK

2 Ratnieks, E., The effect of refining consistency on Eucalyptus pulp strength, 26th Annual Congress of the Brazilian Pulp and Paper Technical Association, 1993, São Paulo, Brazil