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OFFICE PAPER RECYCLABILITY: FIBROUS CHARACTERISTICS

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The aim of this work was to verify the recyclability of three printing and writing papers, from the characteristics of their fibers after two recycles. To do this, we examined the microscopic characteristics of recycled pulps and the physical properties of the sheets, trying to relate both characteristics.

INTRODUCTION

Recycling is the ability of a material to re-obtain the same property that it originally had. Knowledge of the recyclability of commercial papers is a tool for companies, when making decisions on expansions or process modifications.

The paper industry frequently discusses fiber length in terms of length weighted average. It is possible to calculate several kinds of average (or mean) fiber lengths, the most popular being the Arithmetic average fiber length L(n) (Equation 1), the L-weighted average fiber length L(l) (Equation 2), and the W-weighted average fiber length L(w) (Equation 3).

$$L(n) = \sum_i n_i L_i / \sum_i n_i \qquad \text{Eq. 1}$$

$$L(l) = \sum_i n_i L_i^2 / \sum_i n_i L_i \qquad \text{Eq. 2}$$

$$L(w) = \sum_i n_i L_i^3 / \sum_i n_i L_i^2 \qquad \text{Eq. 3}$$

Where: n_i = number of fibers in the specified length class l_i

Fiber coarseness is defined as weight per fiber length and is normally expressed in units of mg/m or g/m. Coarseness depends on fiber diameter, cell wall thickness, cell wall density and fiber cross section. The coarseness value has a great influence for the paper structure. coarseness Co is obtained as shown in Equation 4.

$$Co = m / n\,L(n) \qquad \text{Eq. 4}$$

Where: m = very small ovendry mass of fibers (supplied to the analyzer); L(n) = arithmetic mean length of the fibers; n = total number of fibers in the mass m.

Pulp fibers are seldom straight, and contain many deformations along their length.
The deformations are produced largely by axial compressive failure of the fiber wall during pulp processing.
Characterizing the average fiber shape in a suspension the most commonly used are Curl Index (Equation 5) and Kink Index (Equation 6).

$$CI(n) = (L/e) - 1 \qquad \text{Eq. 5}$$

$$KI = N(10°-20) + 2N(21°-45) + 3N(46°-90) + 4N(91°-180) \qquad \text{Eq. 6}$$

Where: e = end-to-end distance; L= fiber contour (backbone) length; N(α-β)= average number of sharp bends per fiber with angles between α and β.

METHODOLOGY

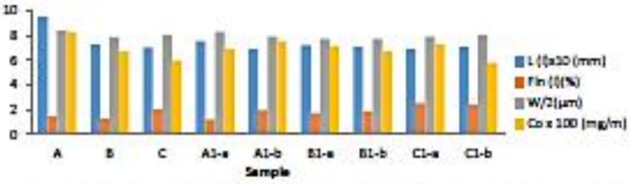
Three different commercial bond papers from Argentina and Brazil, made of Eucalyptus grandis ECF bleached kraft pulp (A, B, C) were studied (nominal grammage of 75 g/m²).
The original sheets were re-pulped and refined applying two energy levels and two different intensities, measured by the number of PFI revolutions and PFI load, (first recycling). The detailed methodology is presented in a previous paper. In all cases, moderate energy and low intensity of refining gave the best properties in the 1st recycle. Handsheets were prepared with those pulps, and they were re-pulped and refined again (second recycle) following the same methodology of the 1st recycle.

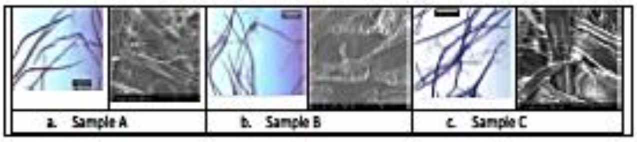
Refining conditions in the 1st and 2nd recycling (PFI load: 1.77 N/mm)

Paper	1st recycle			2nd recycle		
	Sample code	PFI Rev.	°SR	Sample code	PFI Rev.	°SR
A	A1-a	1500	34	A2	--	29
				A2-a	1300	36
				A2-b	2000	42
	A1-b	2500	40	-	-	-
B	B1-a	2000	32	B2	--	28
				B2-a	800	34
				B2-b	1500	41
	B1-b	3000	40	-	-	-
C	C1-a	500	35	C2	--	31
				C2-a	500	35
				C2-b	1400	43
	C1-b	1000	40	-	-	-

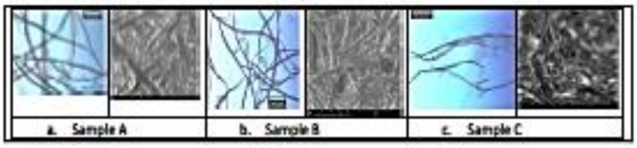
RESULTS

Microscopic properties of the repulped original papers and of pulps from the first recycling (FiberLab F-100)



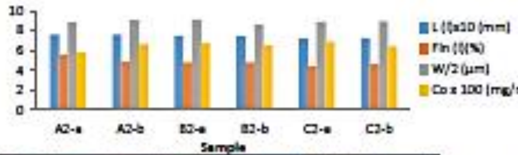


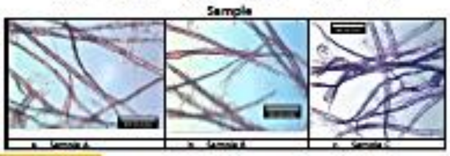
Optical photomicrographs of pulp fibers and electronic photomicrographs of pulp sheets of repulped papers A, B and C without refining



Optical photomicrographs of pulp fibers and electronic photomicrographs of pulp sheets, of samples A, B and C from the 1st recycle (refined with PFI load 1.77 N/mm)

Microscopic properties of pulps from the second recycling (L&W)





Photomicrographs (optical: 100 µm) of samples A, B and C from the 2nd recycle (refined with PFI load 1.77 N/mm to ≈40°SR)

CONCLUSIONS

- ✓ Differences found in the behavior of the different samples can be explained by fiber parameters. The fiber length was significantly different in the three papers (A> B> C) and globally decreased with recycling and refining.
- ✓ Sample A had the highest initial fiber length, but it largely declined with refining conditions in the 1st recycle (L(w) fall about 40%], falling in a lesser extent between the 1st and 2nd recycle (about 9%), whereas it did not change with refining conditions in the 2nd recycle.
- ✓ Sample B fall by 5% with refining conditions in the 1st recycle, and 9% between the 1st and the 2nd recycle, but suffered few alteration in the second recycle.
- ✓ Fiber length of sample C was unaffected by refining conditions and only decreased slightly between the 1st and 2nd recycles. This behavior may be the cause of the constant increase of physical properties of sample C under all refining conditions.
- ✓ In all cases, the generated fines increased slightly with refining in the first recycle, but were much higher in the second recycle than in the first one.
- ✓ The fiber coarseness of the 3 samples did not show consistent variations.