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THE POTENTIAL OF SHORT FIBERS RECYCLING

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SUMMARY

This work presents the potential for recyclability of different short hardwood fibers, the major component of current office and graphic papers, simulating at laboratory scale the papermaking processes with major impact, pulp refining and paper drying conditions, using more realistic conditions.

The study involved 3 of the most typical hardwoods used worldwide for the production of office and graphic papers; *Eucalyptus globulus* bleached Kraft pulp, median short fiber with median cell wall thickness and a high Runkel ratio; a Nordic birch bleached Kraft pulp, the higher short fiber length (of the 3 tested samples), higher cell wall thickness and lower Runkel ratio and finally an Acacia *mangium* bleached Kraft pulp with the lowest fiber length, lowest cell wall thickness and lowest Runkel ratio. The *E. globulus*, when compared to the remaining hardwoods, presented a less pronounced evolution of resistance to water drainage - ºSR, higher bulk levels, the lowest level of Gurley (air resistance) and reasonable levels of mechanical resistance to bursting and traction.

Keywords: Hardwood, Papermaking, Pulp and Paper, Short fibers recyclability

INTRODUCTION

Recycling papermaking fibers is a well-established industrial reality especially in Europe. According to the Monitoring Report published by the European Recovered Paper Council, 2014, “In 2014, 71.7% of all paper consumed in Europe was recycled, totaling 58 million tons. Europe continues to be the world leader in paper recycling, followed by North America. In Europe paper fibers have 3.5 loops on average, far above the global average of 2.4. The paper fiber loop offers in the current EU-level discussions on the circular economy, a clear and workable model to be followed”.

Some published works has been dealing with the recyclability and the impact of the number of loops in the final papermaking properties. However, most of them lack for a consistent laboratorial study or are based on severe conditions, far away from those applied on industrial recycling process. For example, for the recyclability potential evaluation of eucalyptus kraft fibers, refining with 7500 PFI rotations and drying for 24 hours at 80ºC was previous reported [1].

In the present work the adopted methodology is closer to the industrial practice, considering a greater number of recyclability cycles and less severe conditions (Figure 1).

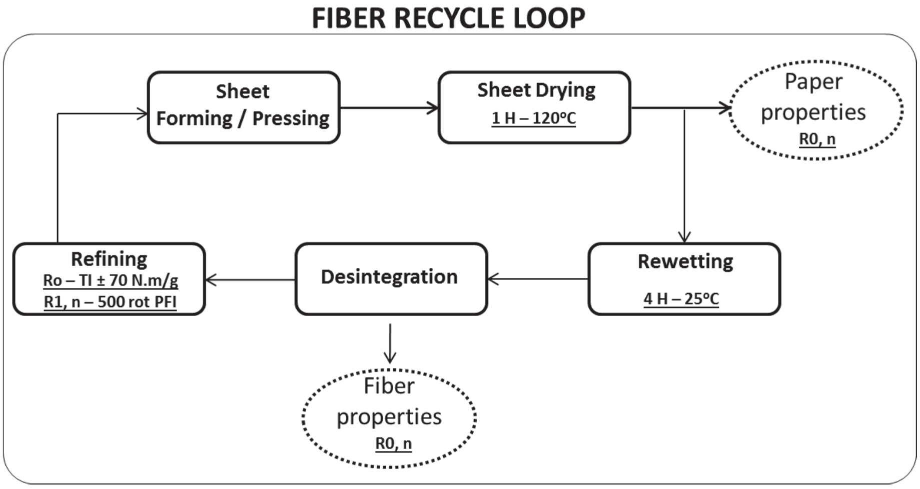

Figure 1 – Fiber Recycle methodology

EXPERIMENTAL

The initial treatment of the fiber, cycle R0, involved the specific refining treatment for each fiber, about 1800 PFI rotations for E. globulus, 1000 rotations for the birch and 2800 rotations for the acacia, aiming a mechanical web strength of about 70 N.m/g of tensile strength. This approach aims to simulate the first use of virgin fiber in paper production. In the 10 subsequent recycling cycles, R1 to R10, the refining treatment was constant and uniform for the 3 pulp samples, with a slight refining with about 500 PFI rotations, in order to enhance some reinforcement capacity of these recycled fibers in the formation recycled papers. Drying conditions of paper-like structures were adjusted to 120ºC during 1 hour, the same condition were used in the subsequent loops.

RESULTS AND DISCUSSION

The 10 recycling loops had an impact on the bio morphologic parameters of the tested fibers, reduction of external fiber diameters, reduction of cell wall thickness, minor decrease of coarseness with impact on the reduction of Runkel ratios (Figure 2), a significant increase of the number of fibers per gram due to the reduction of fiber lengths and consequent large impact in the level of fines generated.

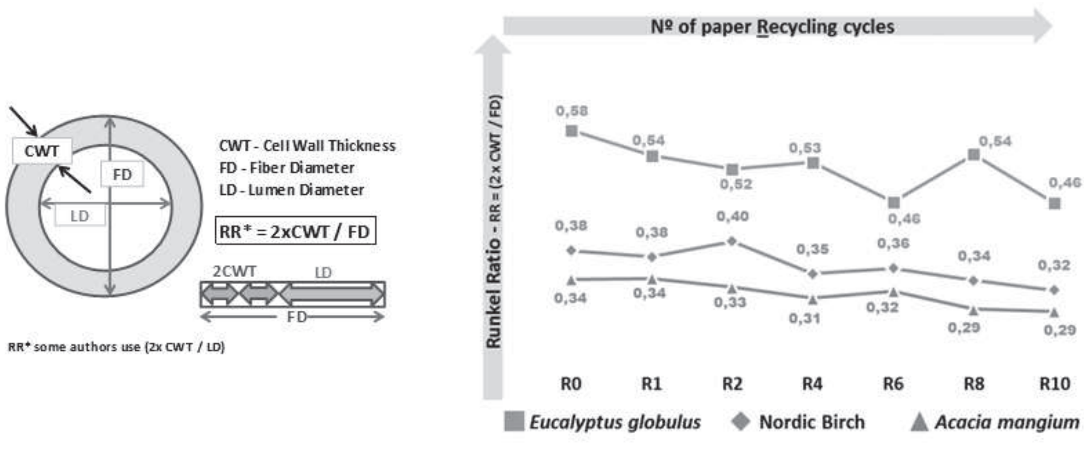

Figure 2 - Evolution of the Runkel ratio of *Eucalyptus globulus*, Nordic birch and Acacia *mangium* fibers throughout the 10 recycling cycles .

The drying effects of cellulose hornification and consequent loss of fiber flexibility contributed to the cutting effects in the refining stage, generating fines and the increase of fibers rigidity.
The generated fines played an important role in the increase of water drainage resistance (ºSR) reaching impractical levels for industrial papermaking for the 2 hardwood samples with lower Runkel ratio. The higher fibers rigidity had a positive impact on the papermaking bulk (Figure 3) of the web structures during the first 4 recycling loops, before the generation of fines started its influence.

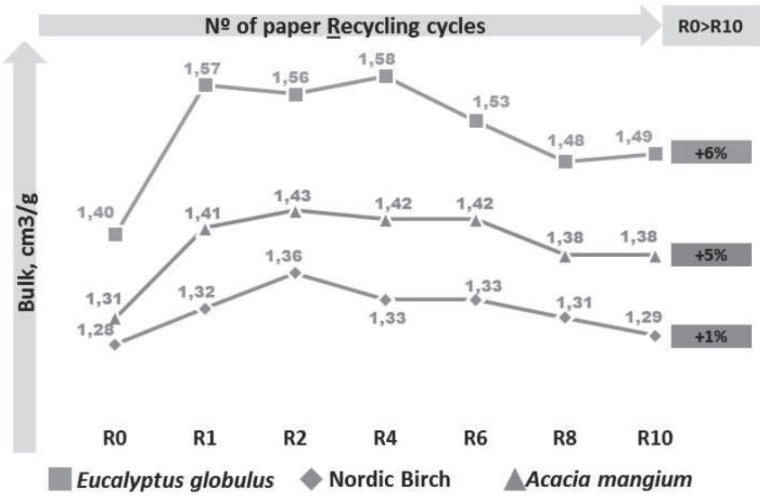

Figure 3 - Evolution of the bulk of the fibrous structure, for pulps of *Eucalyptus globulus*, Nordic birch and Acacia *mangium* throughout the 10 recycling cycles.

The reaction of the *E. globulus* fibers in the first recycling cycle - R1, with the associated drying process causing a very significant increase in the bulk value (from 1.40 to 1.57 cm 3 / g) was noted. The phenomenon continues for another 3 cycles (R1 to R4), decreasing the bulk from R6 due to the production and accumulation of fines.
However the air resistance (Gurley) started to increase in the last 6 loops, reaching impractical levels for industrial papermaking for the 2 hardwood samples with lower Runkel ratio. A positive impact was also observed on the web structure opacity. Negative impact was reported for the general mechanical strength properties (burst, tensile, tear and internal bond), mainly in the intrinsic fiber strength (wet zero span tensile).
The potential of the tested hardwood short fibers recyclability will be dependent on the impact of these affected properties on the industrial papermaking process. Increase of water drainage resistance (ºSR) and air resistance (Gurley) has been selected for the recyclability ranking (Figure 4).

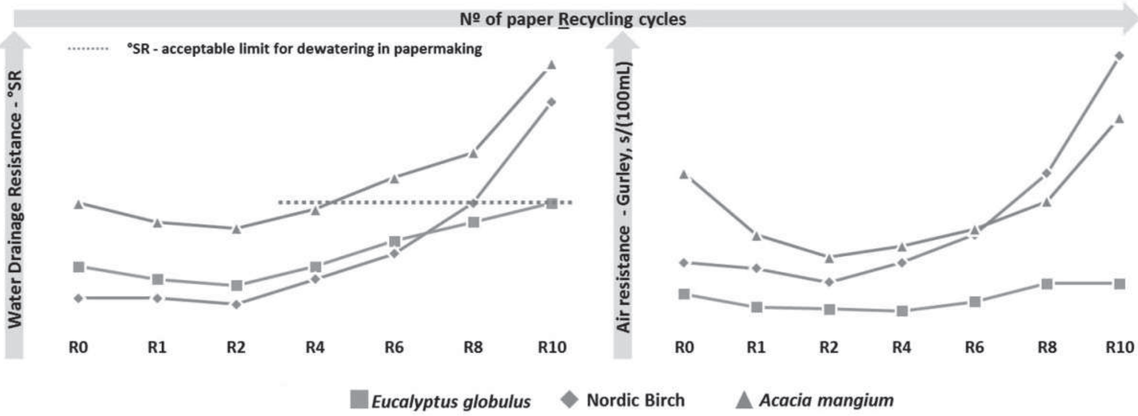

Figure 4 - Evolution of water drainage Resistance - ºSR and Air resistance – Gurley for *Eucalyptus globulus*, Nordic birch and Acacia *mangium* pastes during 10 recycling cycles.

CONCLUSIONS

The *E. globulus* pulp presented a favorable paper behavior in relation to the remaining hardwoods, of which:

- the less pronounced evolution of resistance to water drainage, ºSR, which will have a significant impact on the speed of the paper machine in the water flow in the formation web;
- a higher level of the specific volume, bulk;
- a reasonable level of opacity;
- the lowest level of Gurley air resistance, with significant impact on the speed of the paper machine in operation;
- reasonable level of mechanical resistance to bursting and traction.

In the study of recyclability, it is important to define a criteria for limiting the recycling cycles. It was found that the wall thickness of the fibers and despite some reduction in their value for the 3 pulp samples, the fiber wall was not "extinguished" at the end of the 10 recycling cycles tested. The main occurrence with impact on several paper mill production operations, thus limiting the use of pastes, occurred with the production of fines with a significant impact on the resistance to water drainage - ºSR.

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REFERENCES

1. Okayama, Takayuki; Kawana, Jun-Suke; Ishikura, Yukiko; Kojima, Yasuo and Ona, Toshihiro, Effect of recycling on handsheet properties of Eucalyptus globulus kraft pulps; APPITA Annual General Conference; 1; 481-486, (2001).