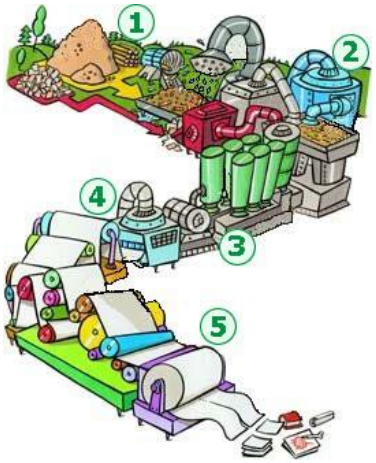
UNIVERSIDADE FEDERAL DE VIÇOÇA
CENTRO DE CIÊNCIAS AGRÁRIAS
DEPARTAMENTO DE ENGENHARIA FLORESTAL


Laboratório de Celulose
e Papel LCP/UFV

# EMERGING TECHNOLOGIES TO IMPROVE EUCALYPTUS FIBERS QUALITY FOR PAPER

## That means: Trials to innovate technologies




**Rubens Chaves de Oliveira**

Vitória, June 29, 2015

# *THE MAIN TOPICS*

## INTRODUCTION

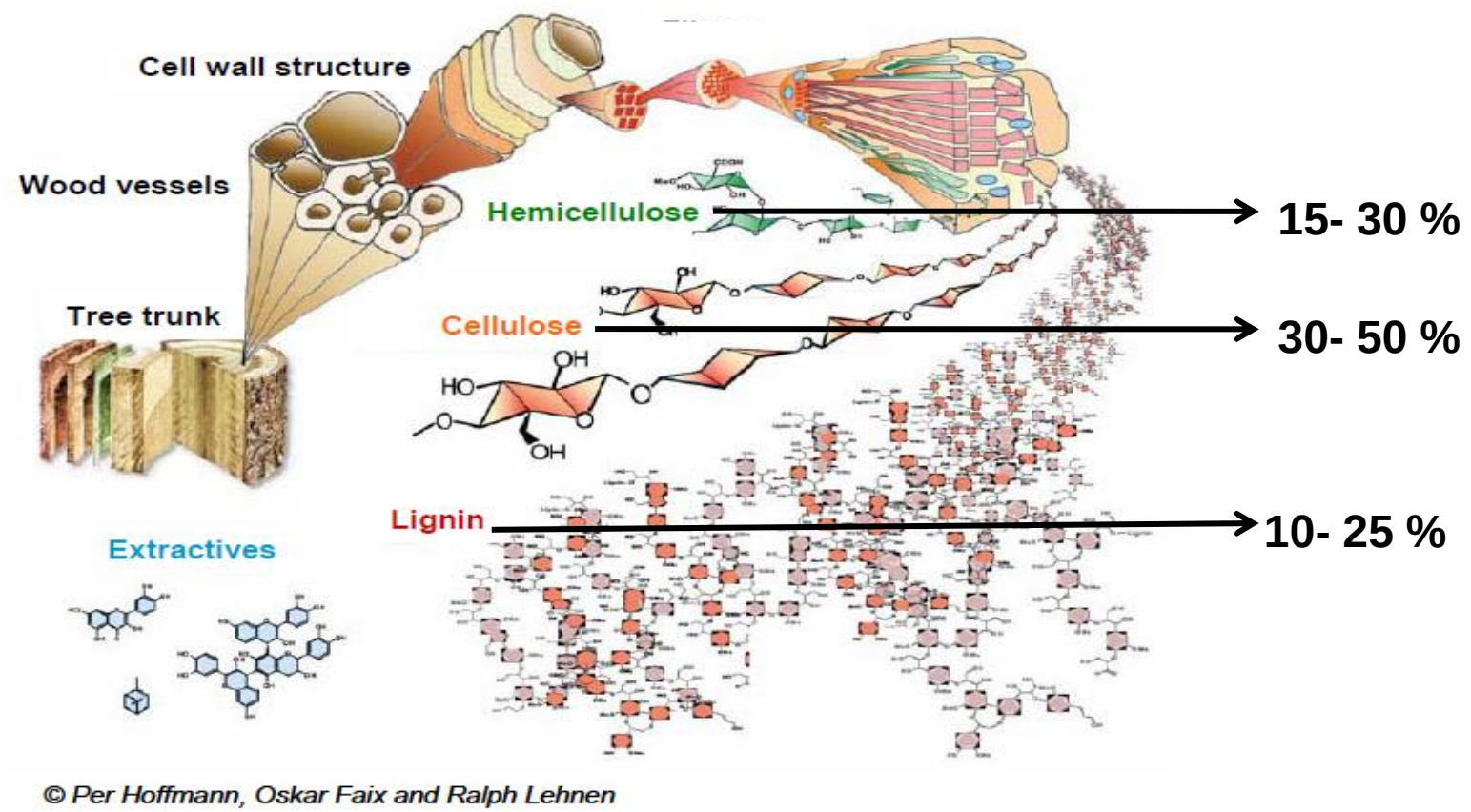
- THE NATURAL BEAUTY OF THE WOOD AND FIBER STRUCTURES
- THE PAPER STRUCTURE
- THE PAPERMAKING INDUSTRY

## EMERGING TECHNOLOGIES TO IMPROVE PAPER QUALITY

- ULTRASONIC TECHNIQUE TO REFINE THE PULP FIBERS
- MICROWAVES TECHNIQUE TO DRY PAPER

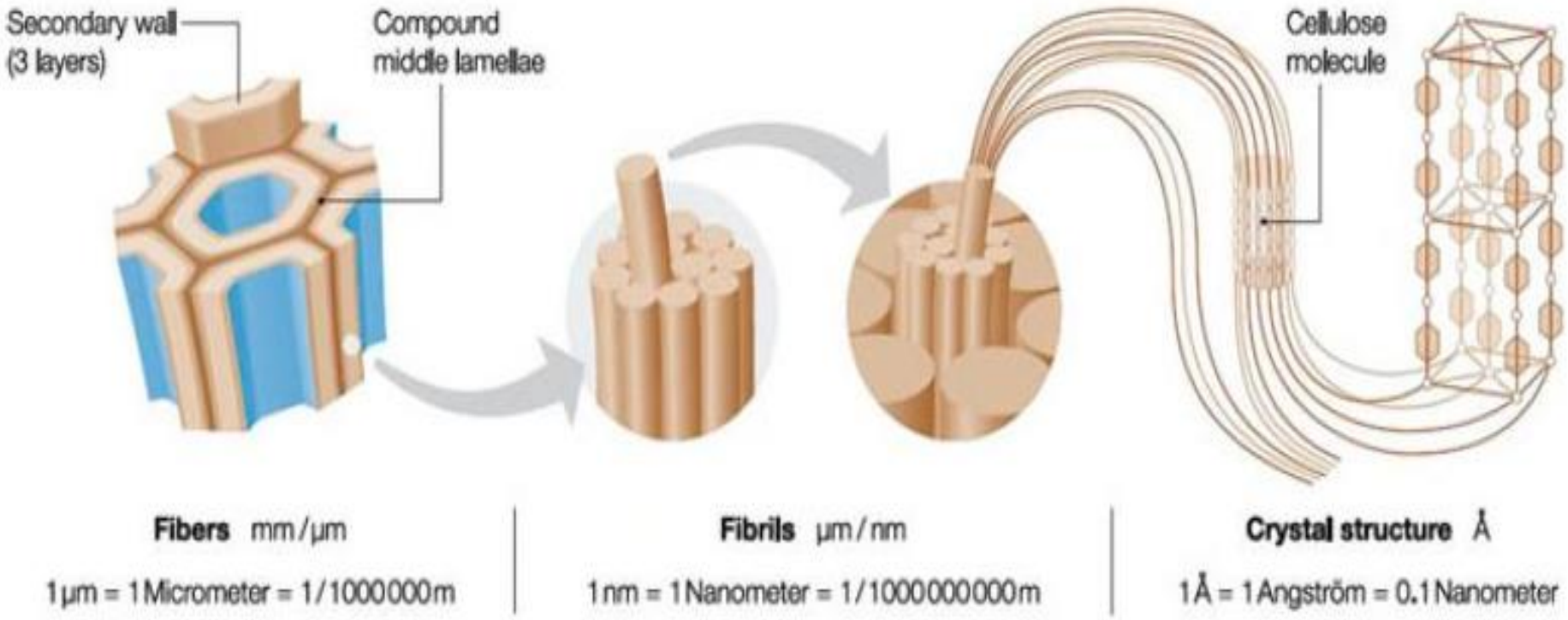
## FINAL REMARKS

# THE WOOD CELL WALL STRUCTURE




**The wood structure is a complex and sustainable raw materials that the nature takes many years to construct it and I believe we are going to use it for so many years to make papers.**

# THE FIBER CELL WALL STRUCTURE



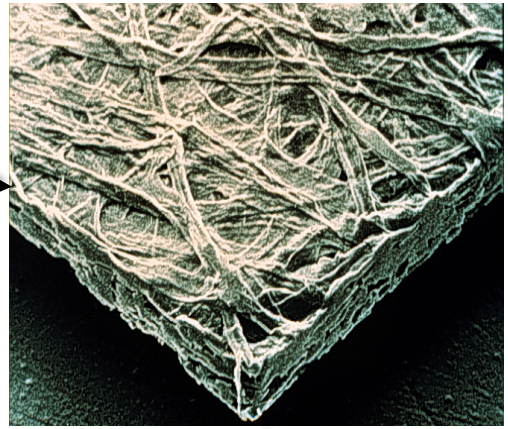

**Source:Zimmermann et. al. (2005).**

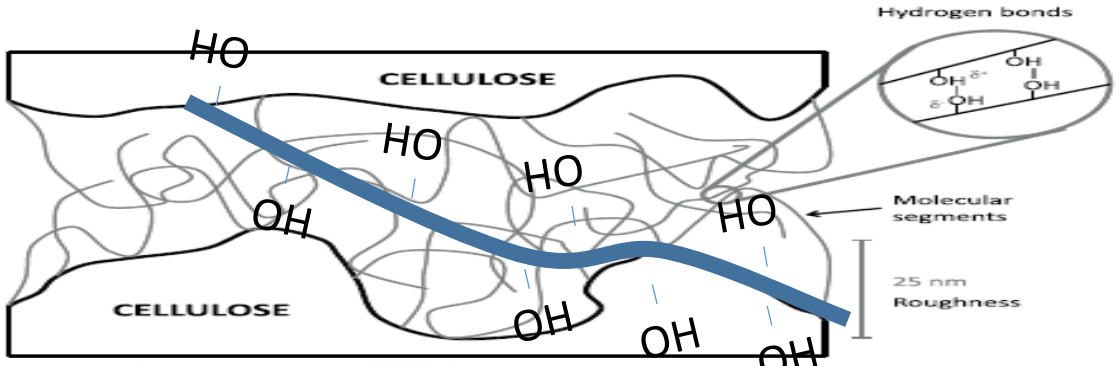
**The fibers cell wall are very important composite materials. They are the main elements on the paper structure. We should be able to find a technology to cause less damage to the fibers during the papermaking process.**

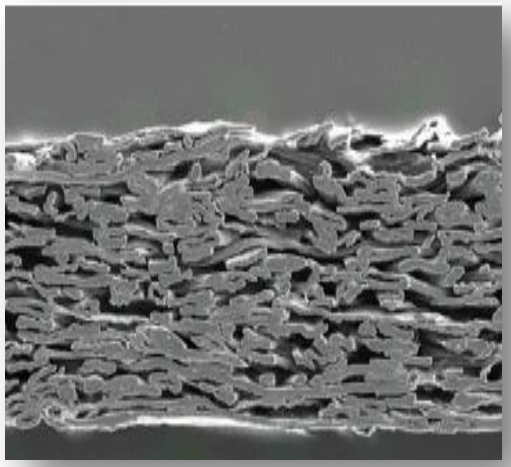
# THE PAPER STRUCTURE AND STRENGTH

**BASICALLY DEPENDS ON:**

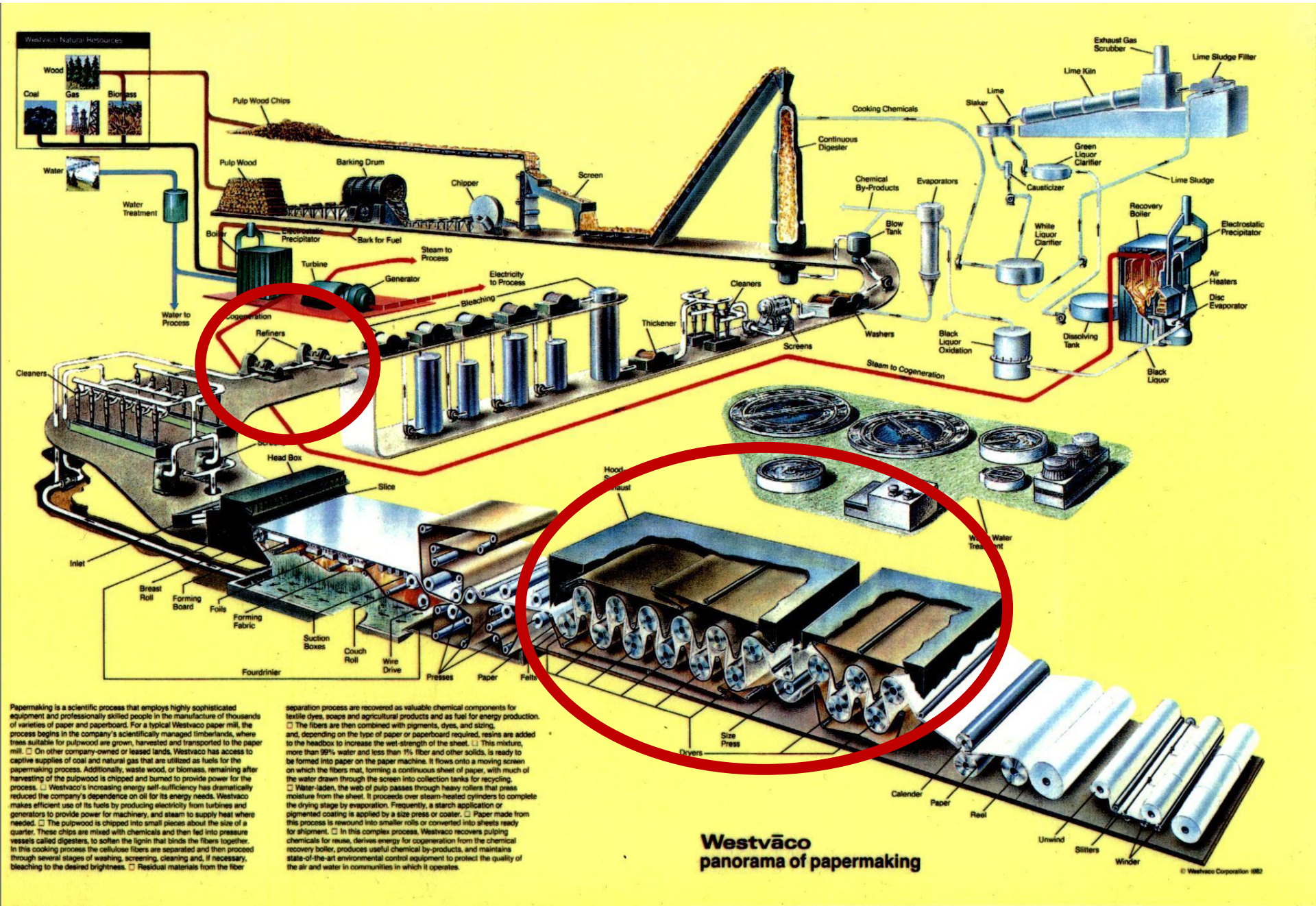
- The fiber properties
- The number of fiber bonds
- The bond resistances





# THE INDUSTRY FROM WOOD TO PAPER




Papermaking is a scientific process that employs highly sophisticated equipment and professionally skilled people in the manufacture of thousands of varieties of paper and paperboard. For a typical Westvaco paper mill, the process begins in the company's scientifically managed timberlands, where trees suitable for pulpwood are grown, harvested and transported to the paper mill. ☐ On other company-owned or leased lands, Westvaco has access to captive supplies of coal and natural gas that are utilized as fuels for the papermaking process. Additionally, waste wood, or biomass, remaining after harvesting of the pulpwood is chipped and burned to provide power for the process. ☐ Westvaco's increasing energy self-sufficiency has dramatically reduced the company's dependence on oil for its energy needs. Westvaco makes efficient use of its fuels by producing electricity from turbines and generators to provide power for machinery, and steam to supply heat where needed. ☐ The pulpwood is chipped into small pieces about the size of a quarter. These chips are mixed with chemicals and then fed into pressure vessels called digesters, to soften the lignin that binds the fibers together. In this cooking process the cellulose fibers are separated and then proceed through several stages of washing, screening, cleaning and, if necessary, bleaching to the desired brightness. ☐ Residual materials from the fiber separation process are recovered as valuable chemical components for textile dyes, soaps and agricultural products and as fuel for energy production. ☐ The fibers are then combined with pigments, dyes, and sizing, and, depending on the type of paper or paperboard required, resins are added to the headbox to increase the wet-strength of the sheet. ☐ This mixture, more than 99% water and less than 1% fiber and other solids, is ready to be formed into paper on the paper machine. It flows onto a moving screen on which the fibers mat, forming a continuous sheet of paper, with much of the water drawn through the screen into collection tanks for recycling. ☐ Water-laden, the web of pulp passes through heavy rollers that press moisture from the sheet. It proceeds over steam-heated cylinders to complete the drying stage by evaporation. Frequently, a starch application or pigmented coating is applied by a size press or coater. ☐ Paper made from this process is rewound into smaller rolls or converted into sheets ready for shipment. ☐ In this complex process, Westvaco recovers pulping chemicals for reuse, derives energy for cogeneration from the chemical recovery boiler, produces useful chemical by-products, and maintains state-of-the-art environmental control equipment to protect the quality of the air and water in communities in which it operates.

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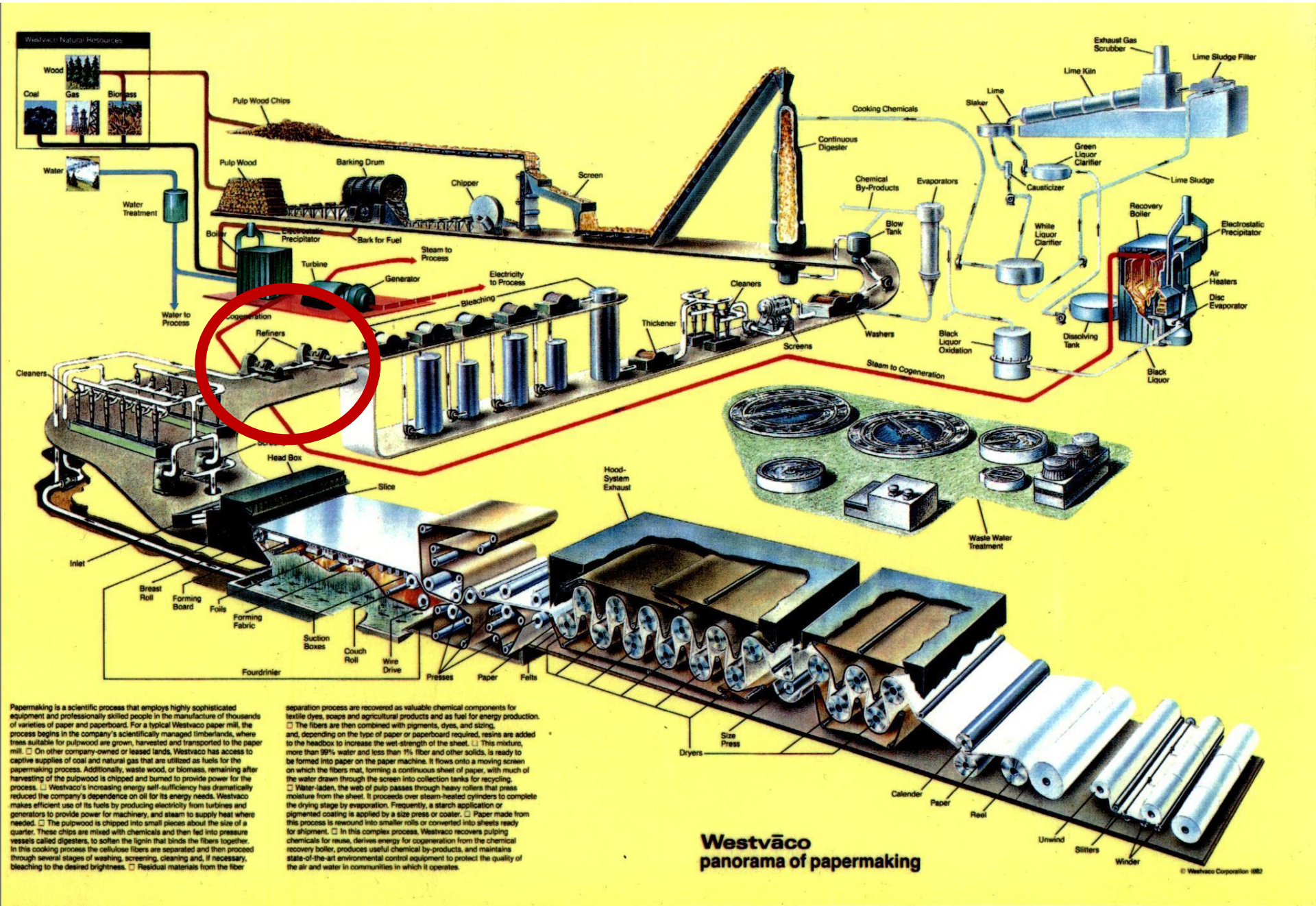


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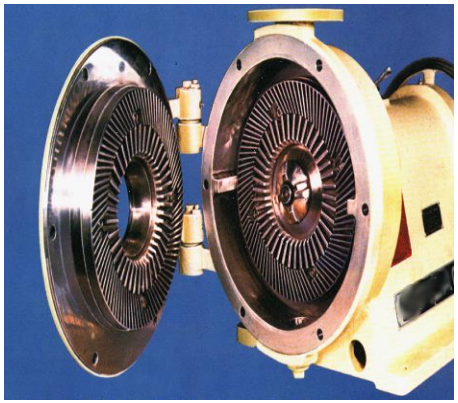
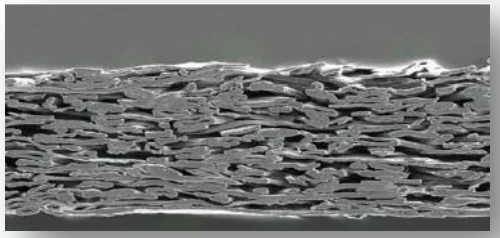
**Westvāco**
**panorama of papermaking**

# PAPER MANUFACTURE: FROM WET END TO DRY END

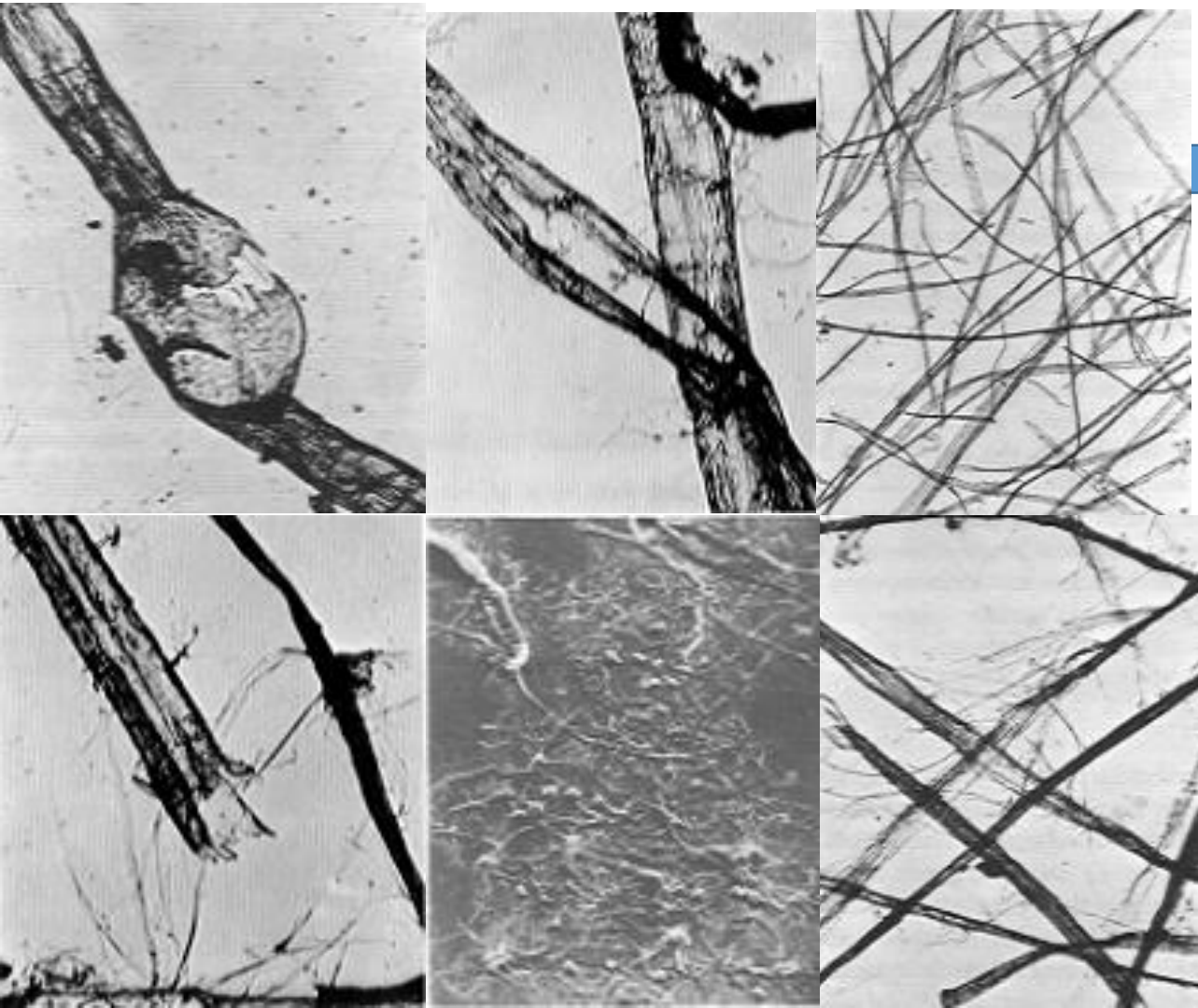
- STOCK PREPARATION
- PAPER FORMATION
- PRESSING SECTION
- DRY SECTION
- REELING

**THE MECHANICAL REFINING TECHNIQUE**





# MECHANICAL REFINING TECHNIQUE



- Intra-Fiber Bond Break
- Fiber Cut
- Fines Generation
- Fiber Defibrillations

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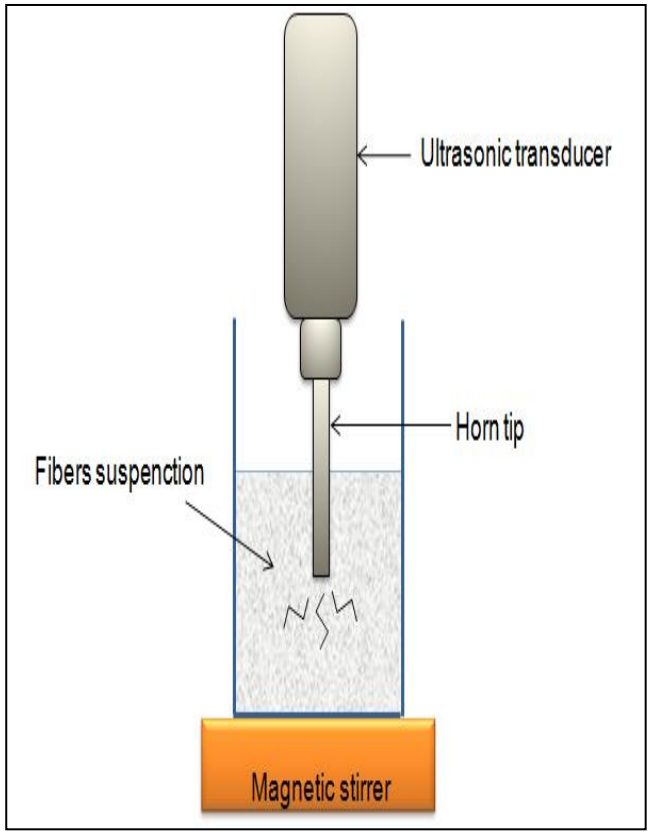
# ULTRASONIC VIBRATIONS OF PULP FIBERS TO IMPROVE PAPER STRENGHT




Virsonic 475

(190 Watts; 20 kHz)

Variables:

Eucalyptus pulp

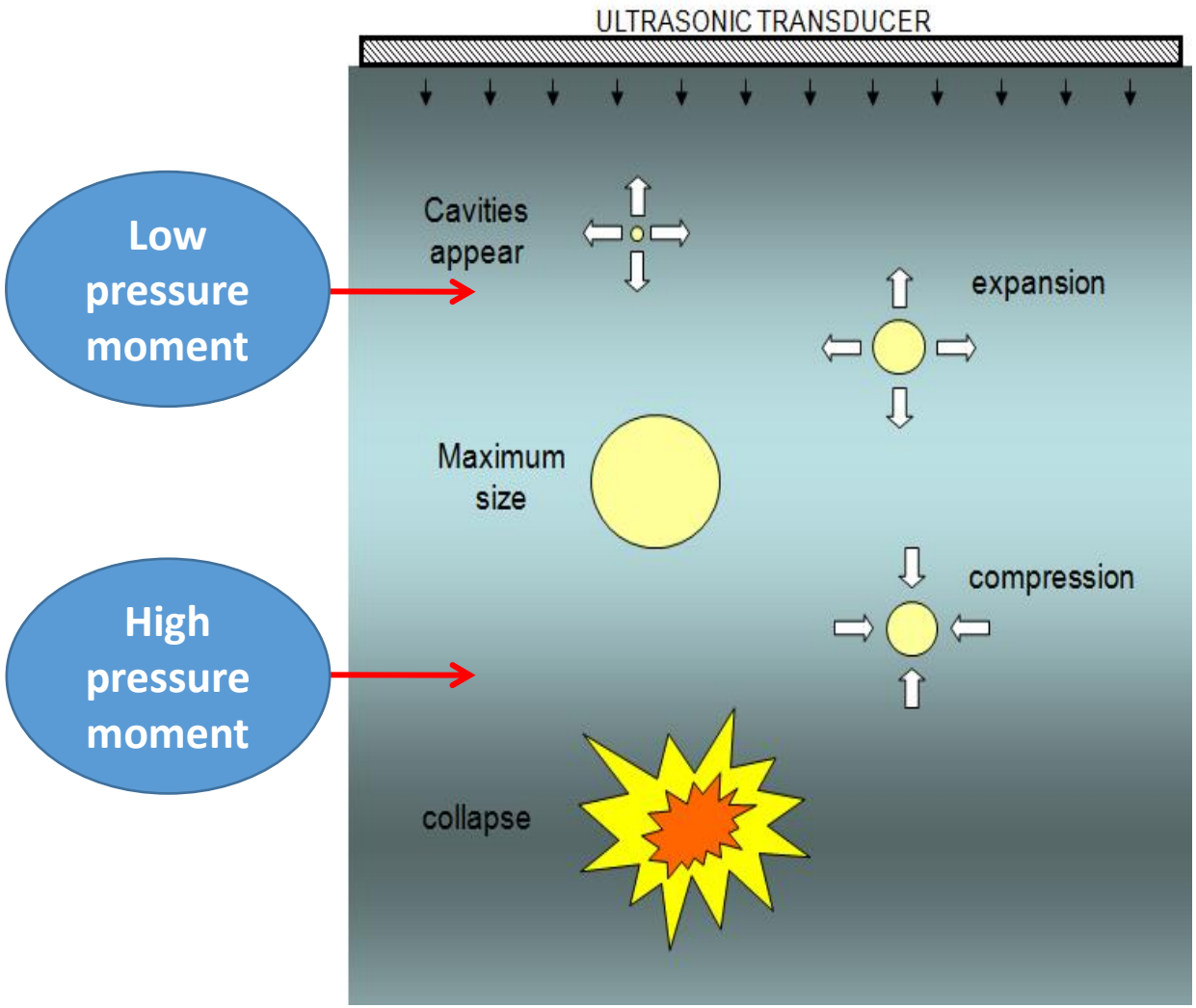
pH: 7,0 and 10,0

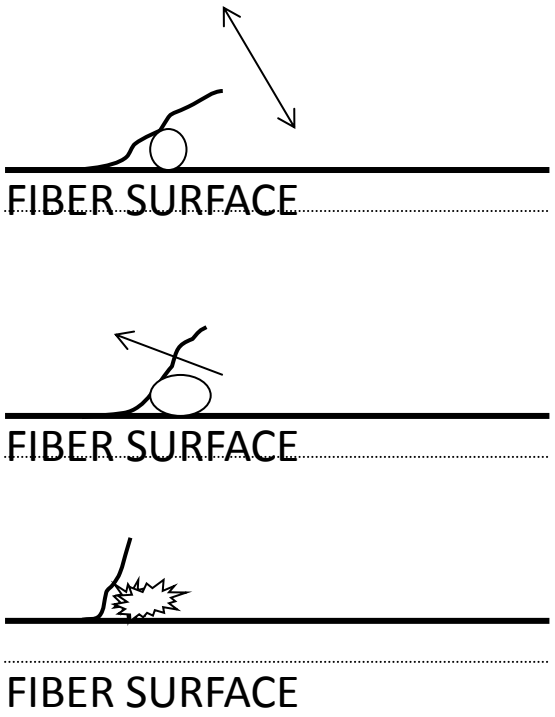
Pulp Consistency:
0,5%, 1%, 2% and 4%

Time: 5 min, 10 min
and 20 min

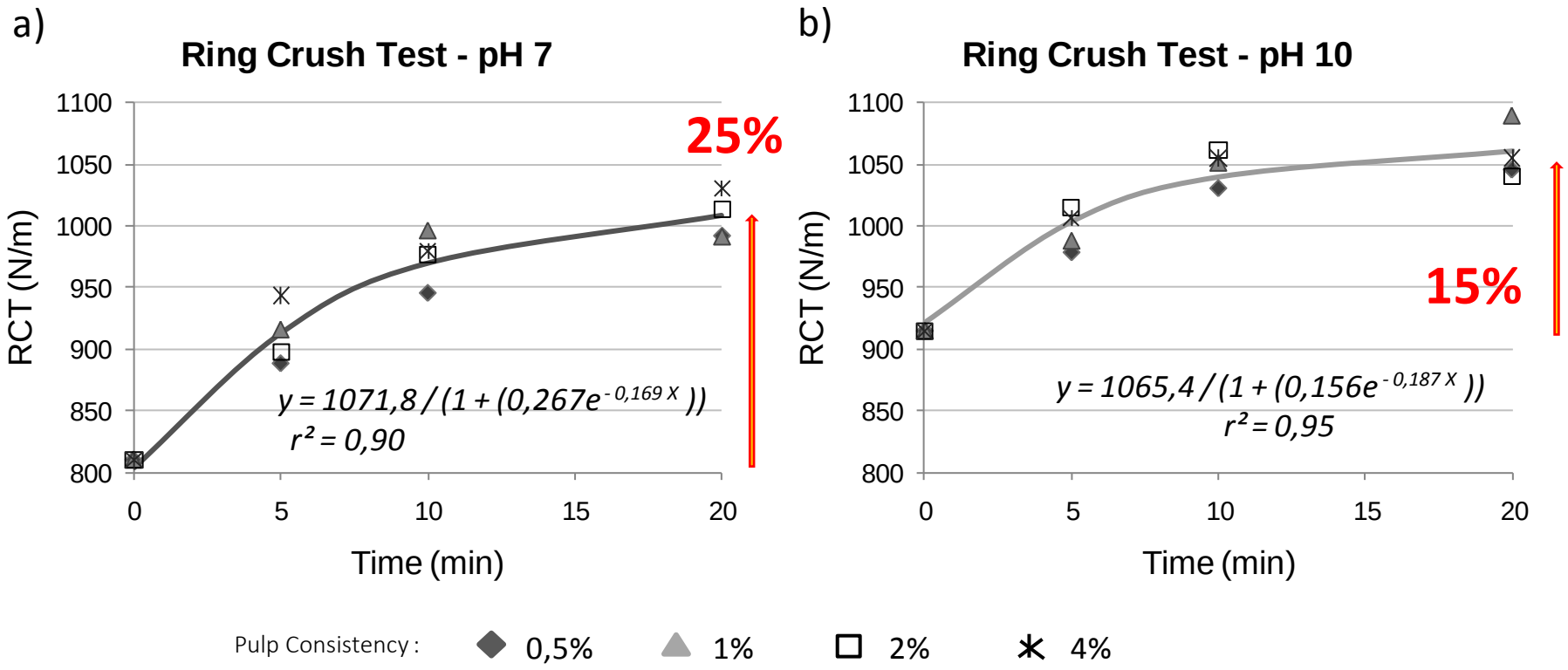
# ULTRASOUND PHENOMENON

When mechanical longitudinal waves with frequency higher than 20 kHz propagate in a liquid occur the cavitations' phenomenon



# ULTRASOUND TECHINIQUE RESULTS



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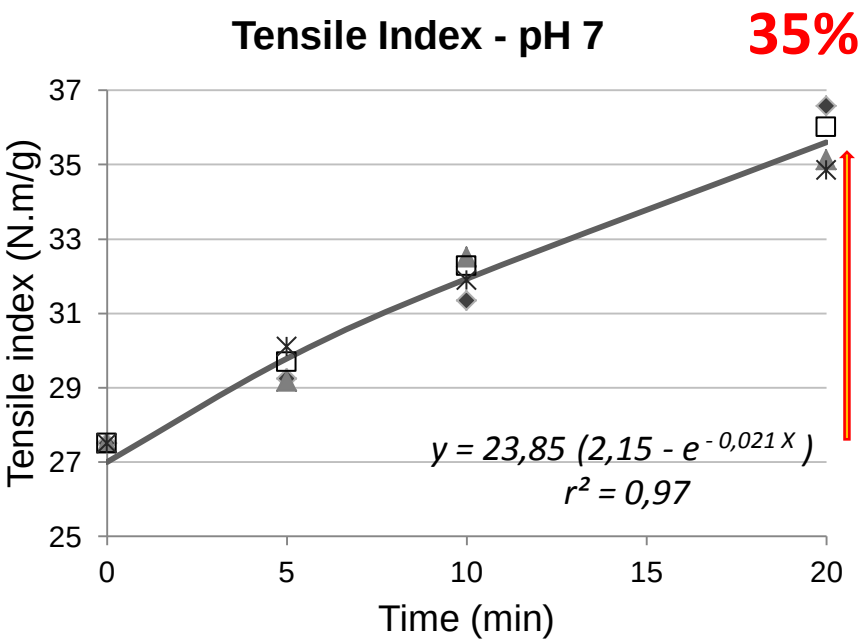


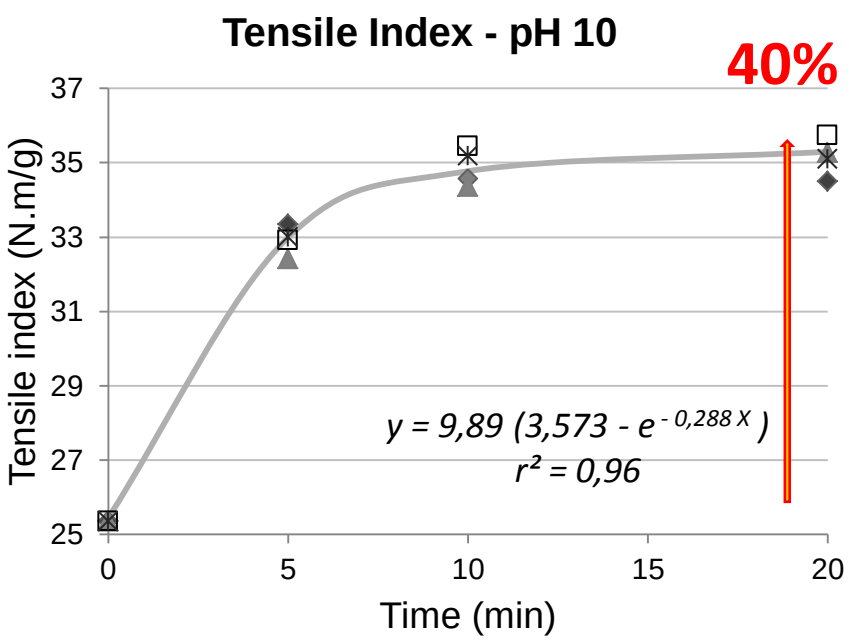


Pulp Consistency : ◆ 0,5% ▲ 1% □ 2% ✱ 4%

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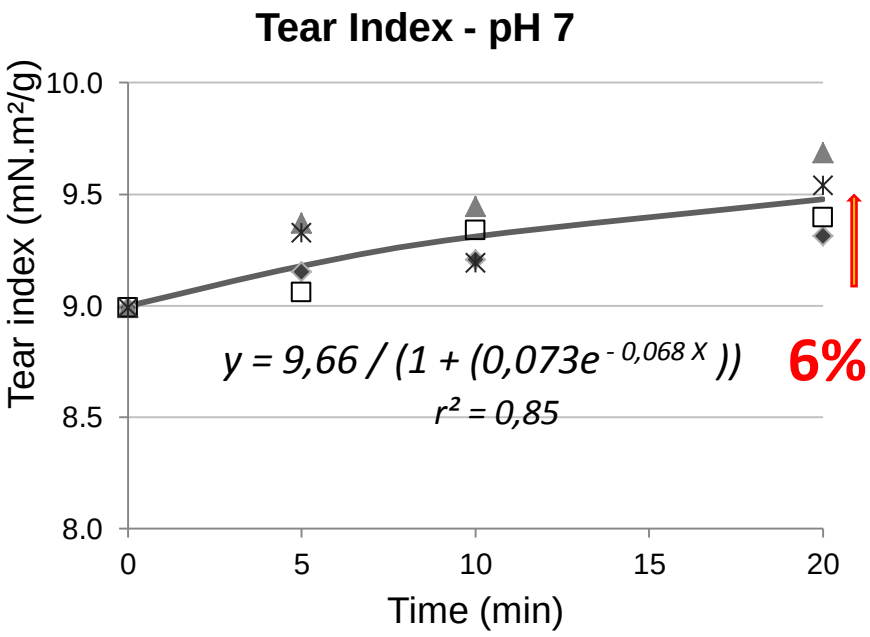


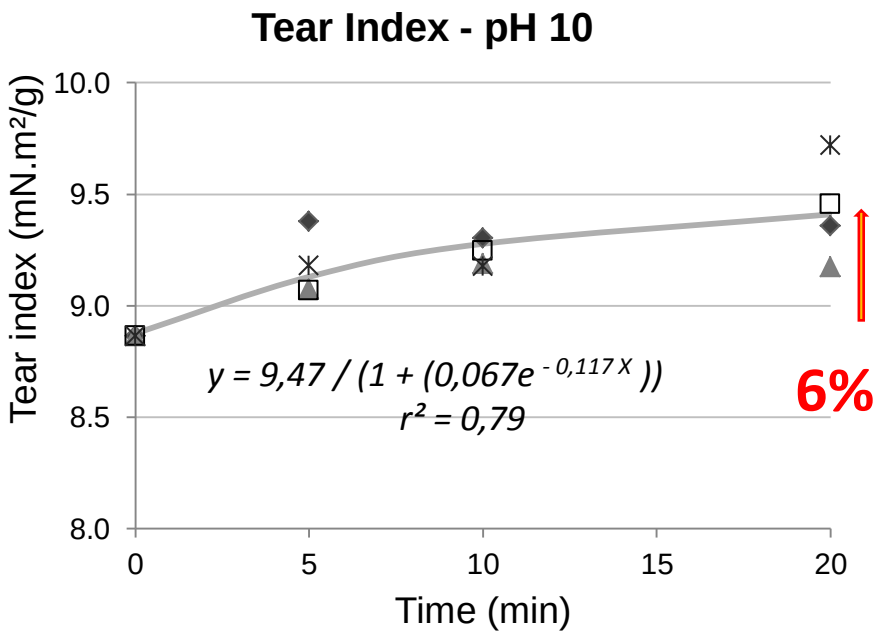


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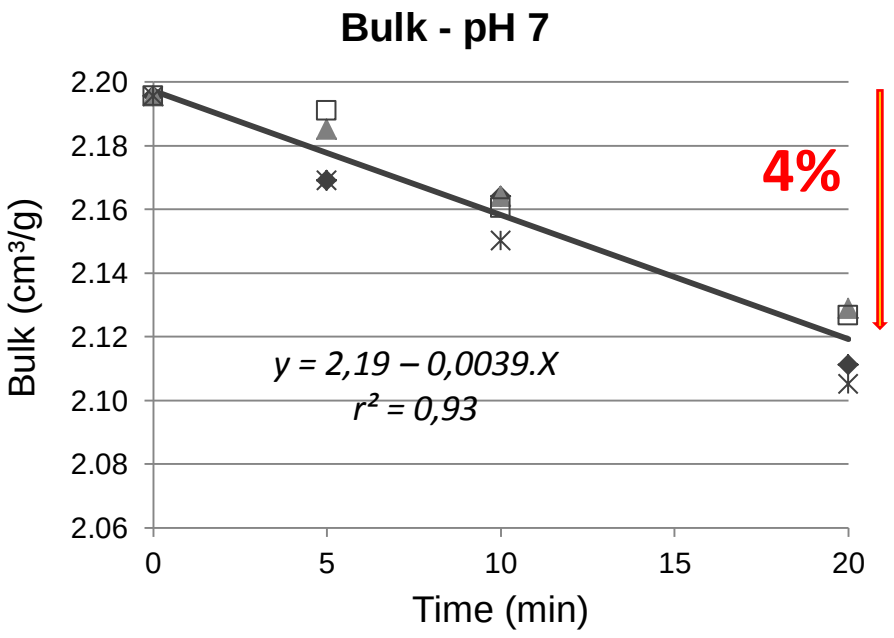


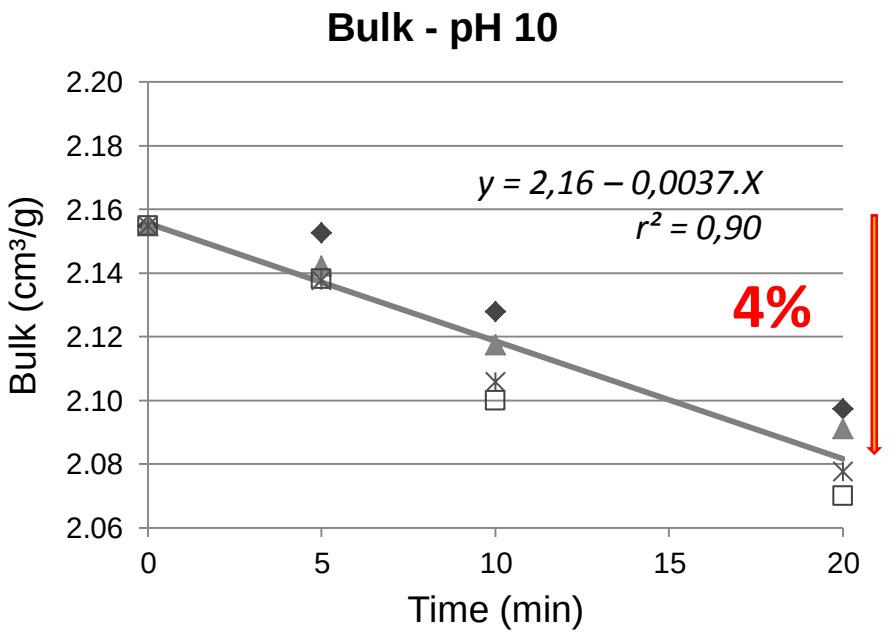


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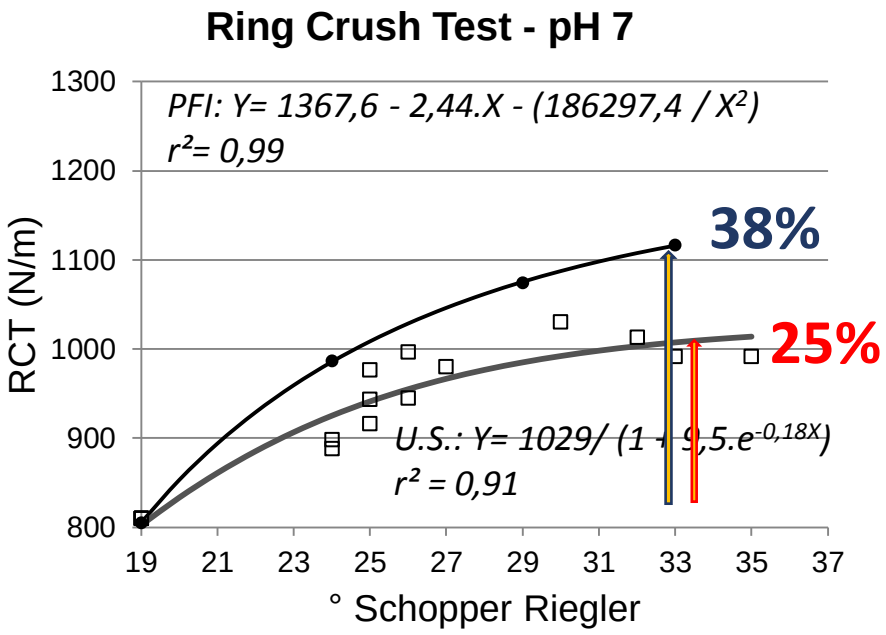
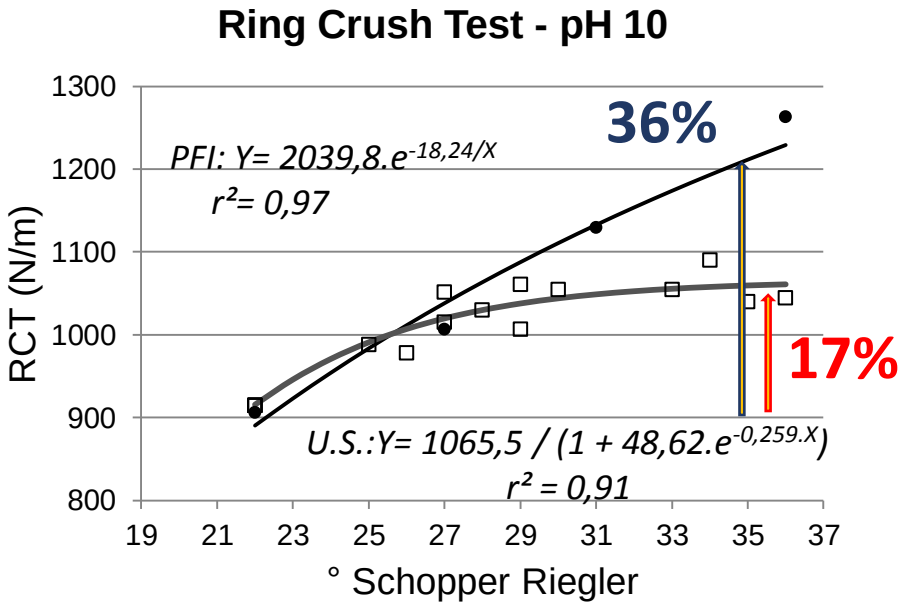
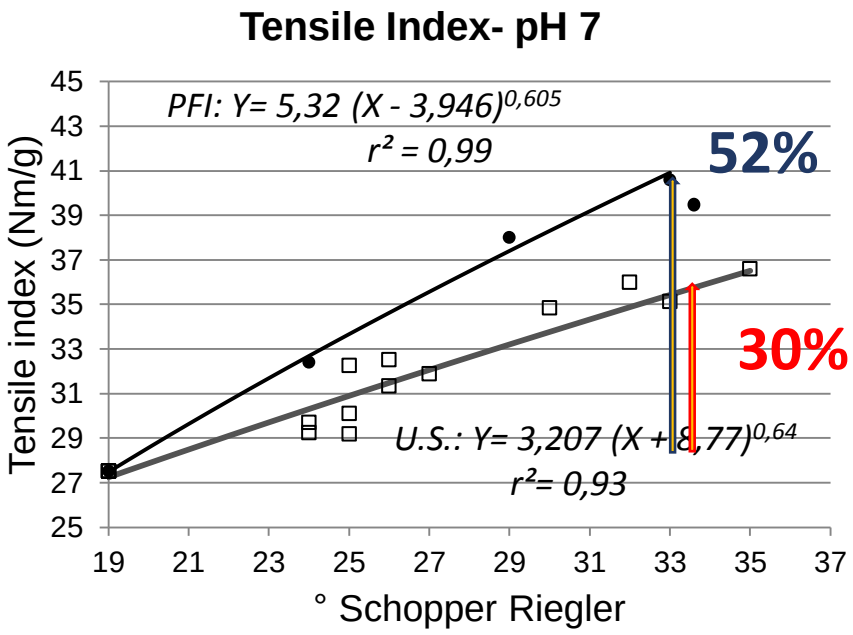
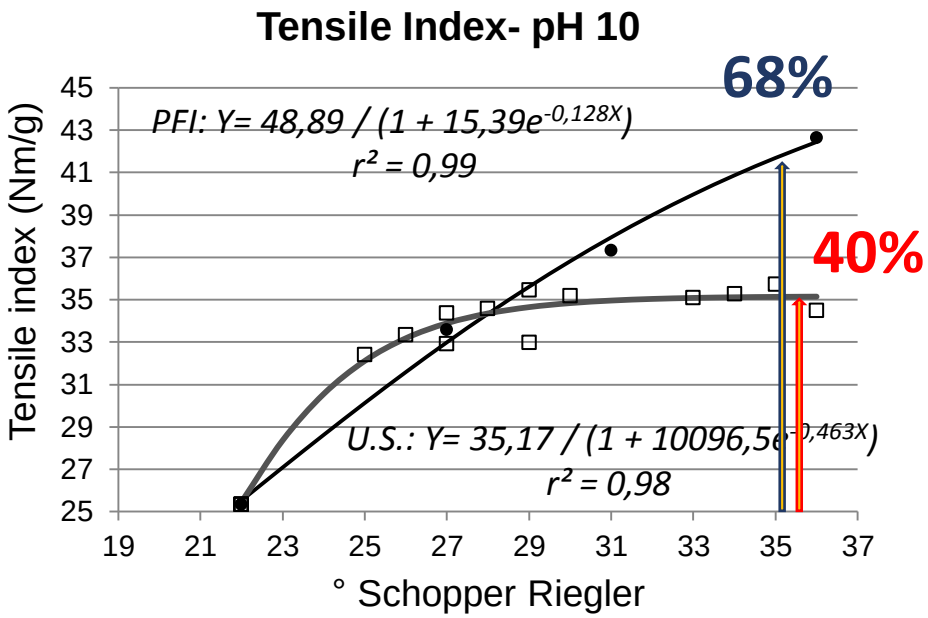



PFI  Ultrasound (U.S.)

# ULTRASOUND TECHINIQUE RESULTS

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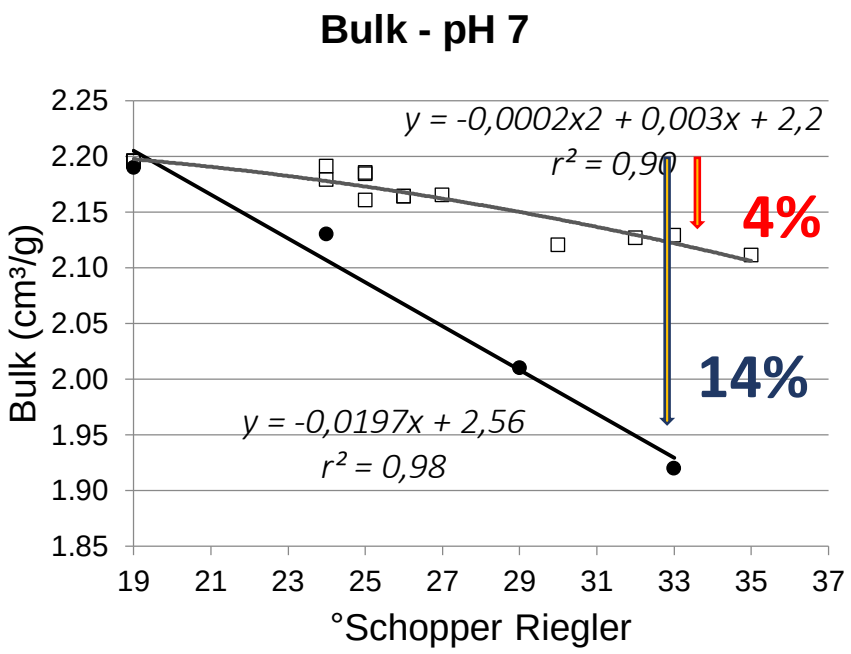
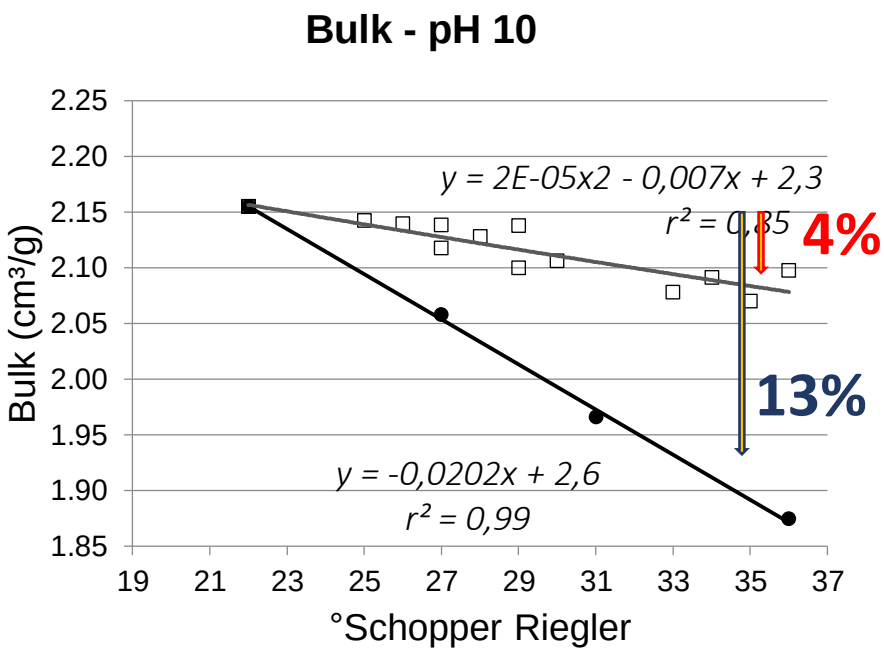


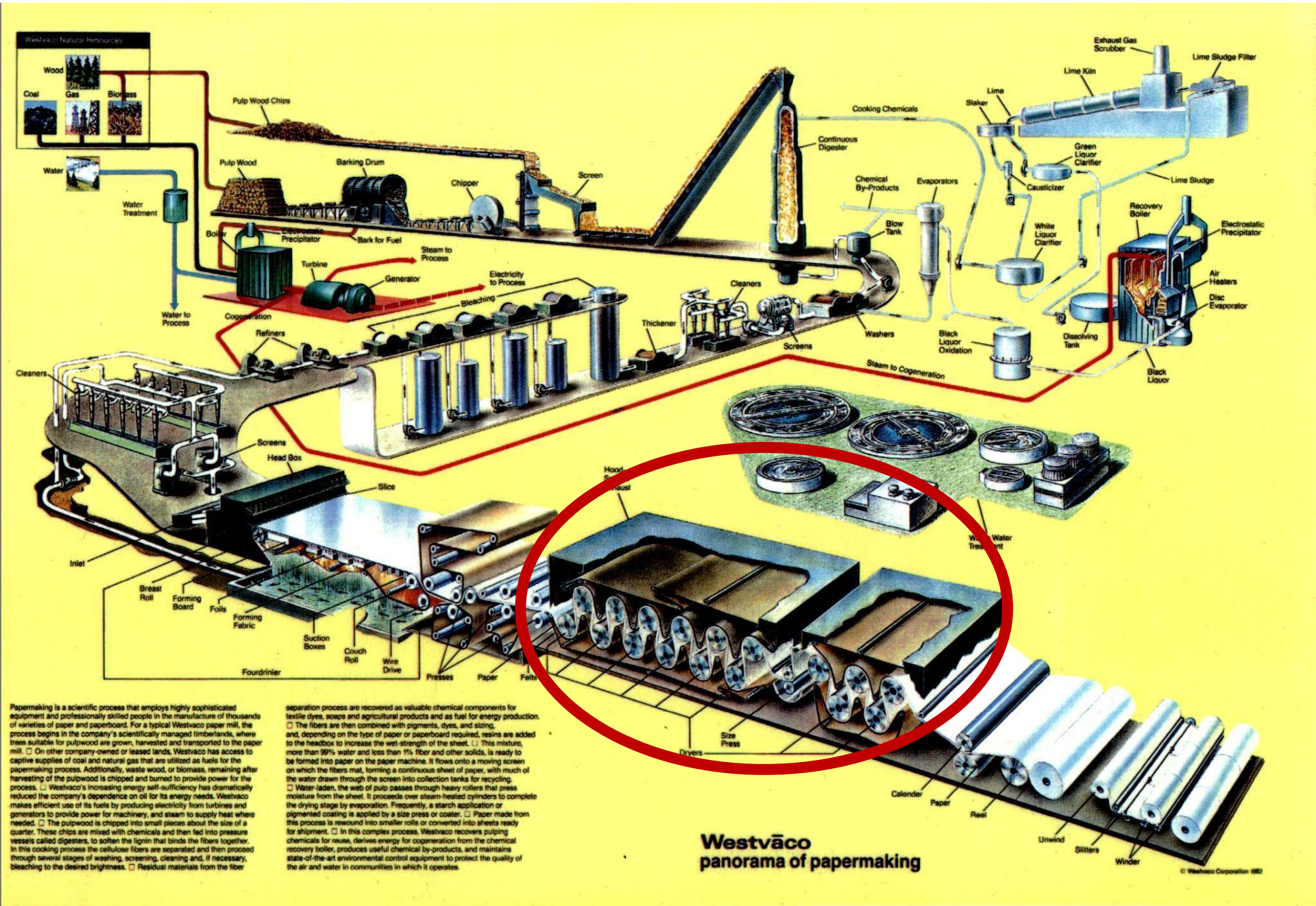

PFI

Ultrasound (U.S.)

# *CONCLUSIONS*

- ✓ The Ultrasonic technology can be successfully used to improve the paper strength. Our hypothesis: Ultrasonic treatment acts mainly on fiber surface leading external fiber defibrillation with less impact on *bulk* than PFI refine;
- ✓Pulp consistency in the range (0.5%-4%) didn't affects the results;
- ✓Increasing the pH makes the treatment more efficient for some specific properties;
- ✓Efficient to increase the paper strength with less fiber damages;
- ✓Little impact on Bulk; very much recommended to tissue word
- ✓Less fiber cut and fines production than refine in PFI, to the same °SR increasing;
- ✓New studies are need using more powerful ultrasound device, but with saving energy.

# THE INDUSTRY FROM WOOD TO PAPER

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# PAPER MANUFACTURE: FROM WET END TO DRY END

STOCK PREPARATION

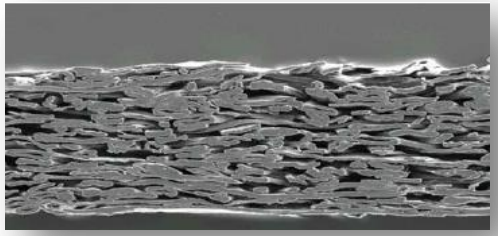
PAPER FORMATION

PRESSING SECTION

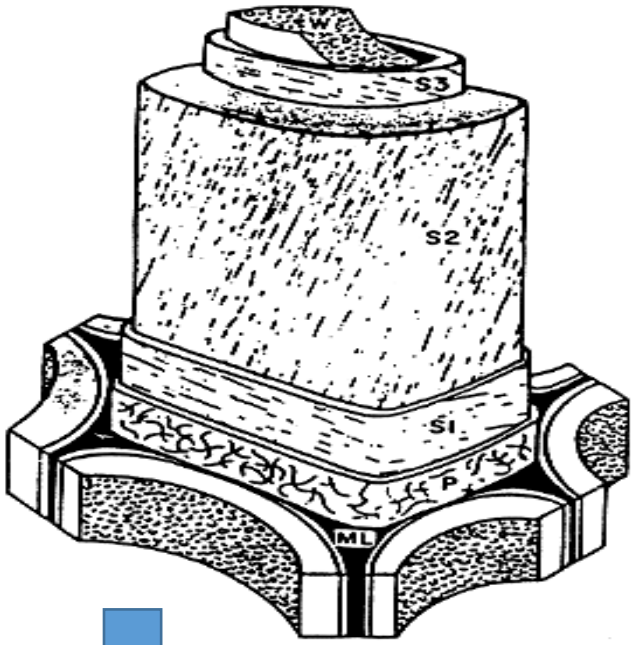
DRY SECTION

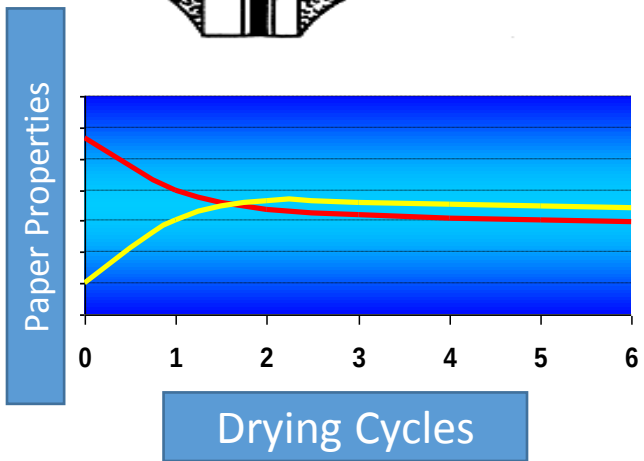
REELING

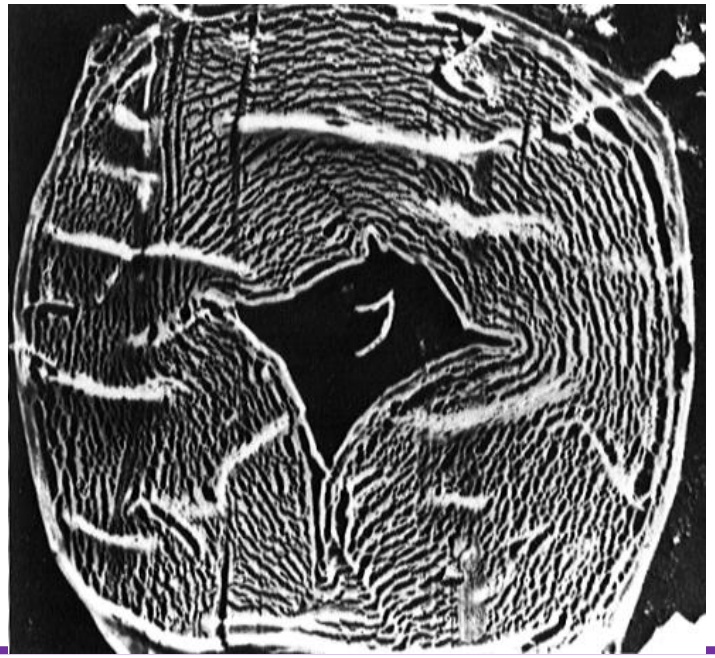
DRYIER CYLINDERS



# DRYING PAPER BY HEAT CONDUCTION

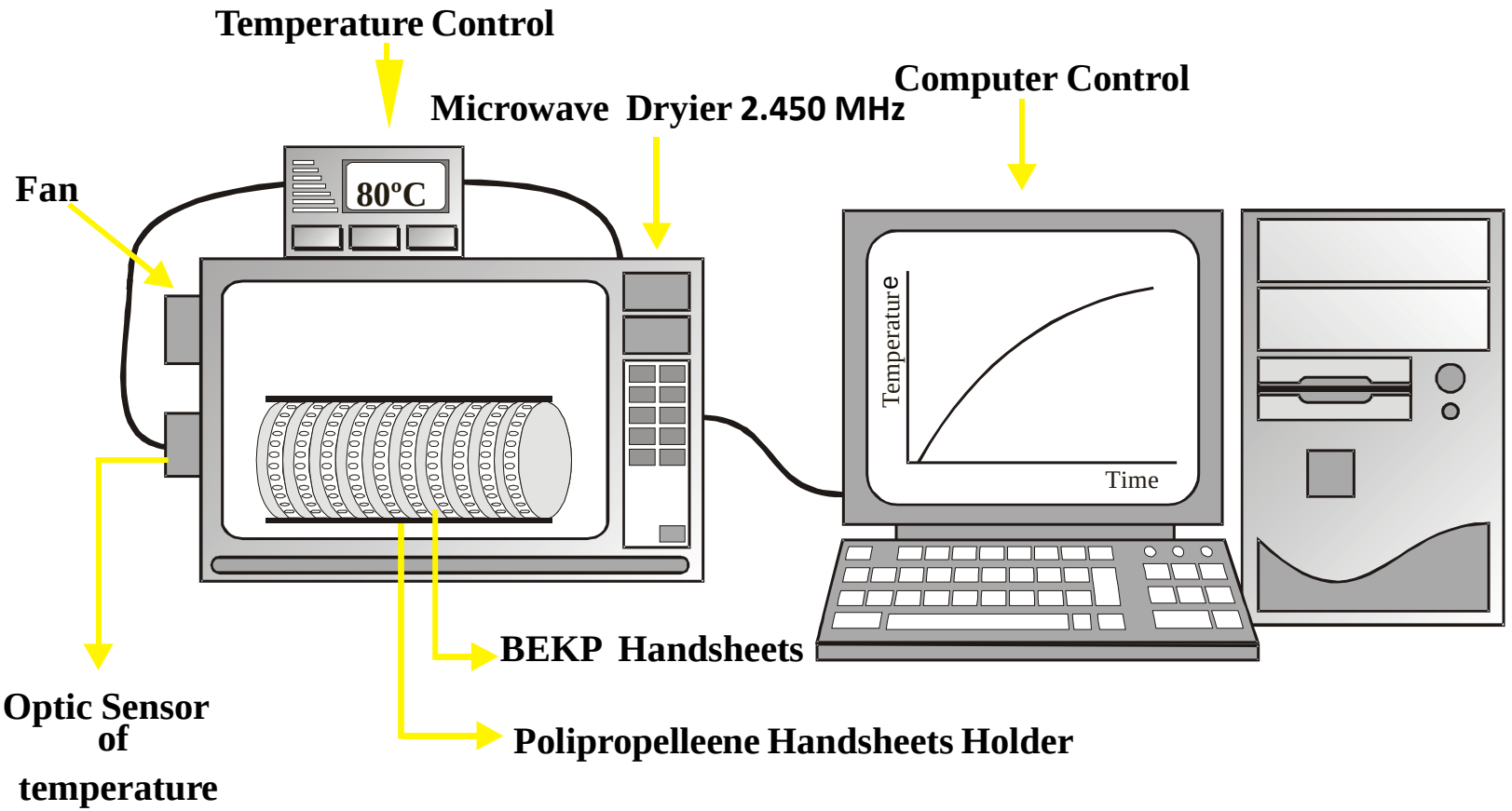


Fiber Cell Wall Delaminations.
Increase fiber stiffness and hornification
Intra-Fiber Bond Break.
Intrinsic fiber strength reduction.
Decrease inter-fiber bonds potential.
Quality decreasing due to new production cycle.

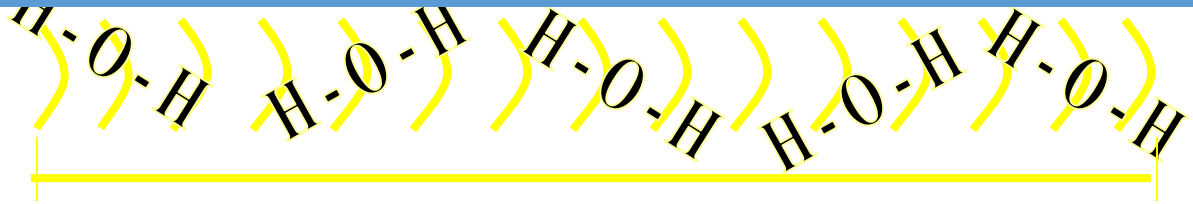
# LABORATORY MICROWAVE EXPERIMENT




**MICROWAVE DRYER:Temperature:80 ºC; Final Handsheet consistency:95 %**
**Cylinder Dryer: Temperature: 100 ºC; Final Handsheet Consistency: 95 %**

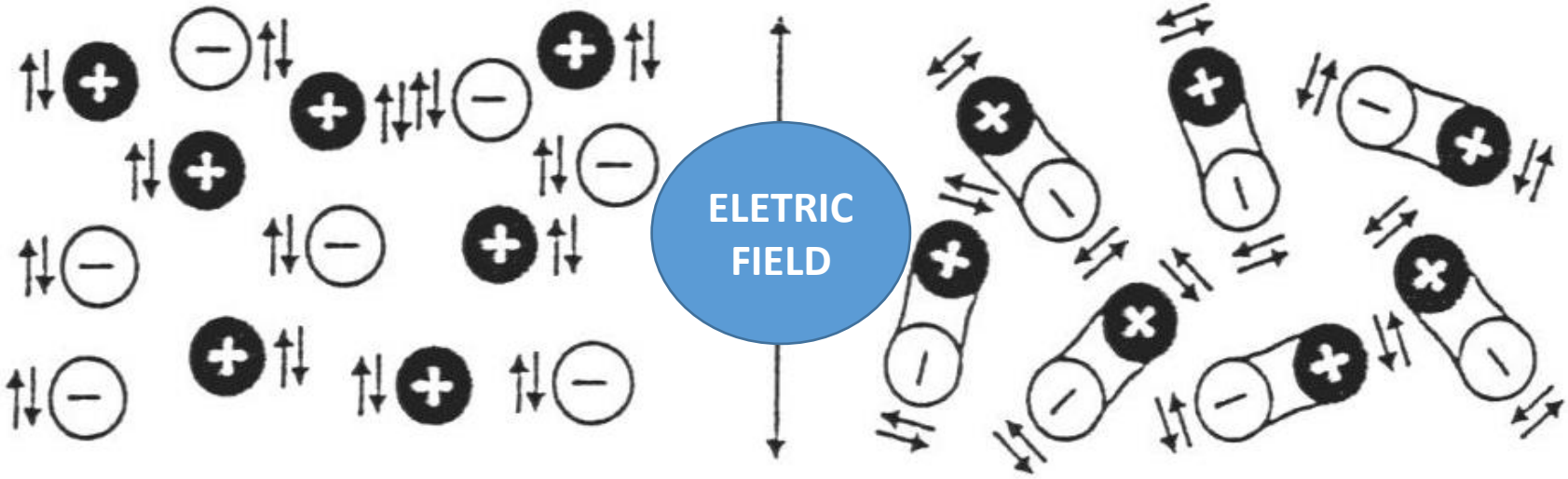
# MICROWAVES PHENOMENON

**When Microwaves with frequency between 400 to 20.000 MHz propagate in liquid or solid medium occur the friction phenomenon**




**400 a 20.000 MHz**

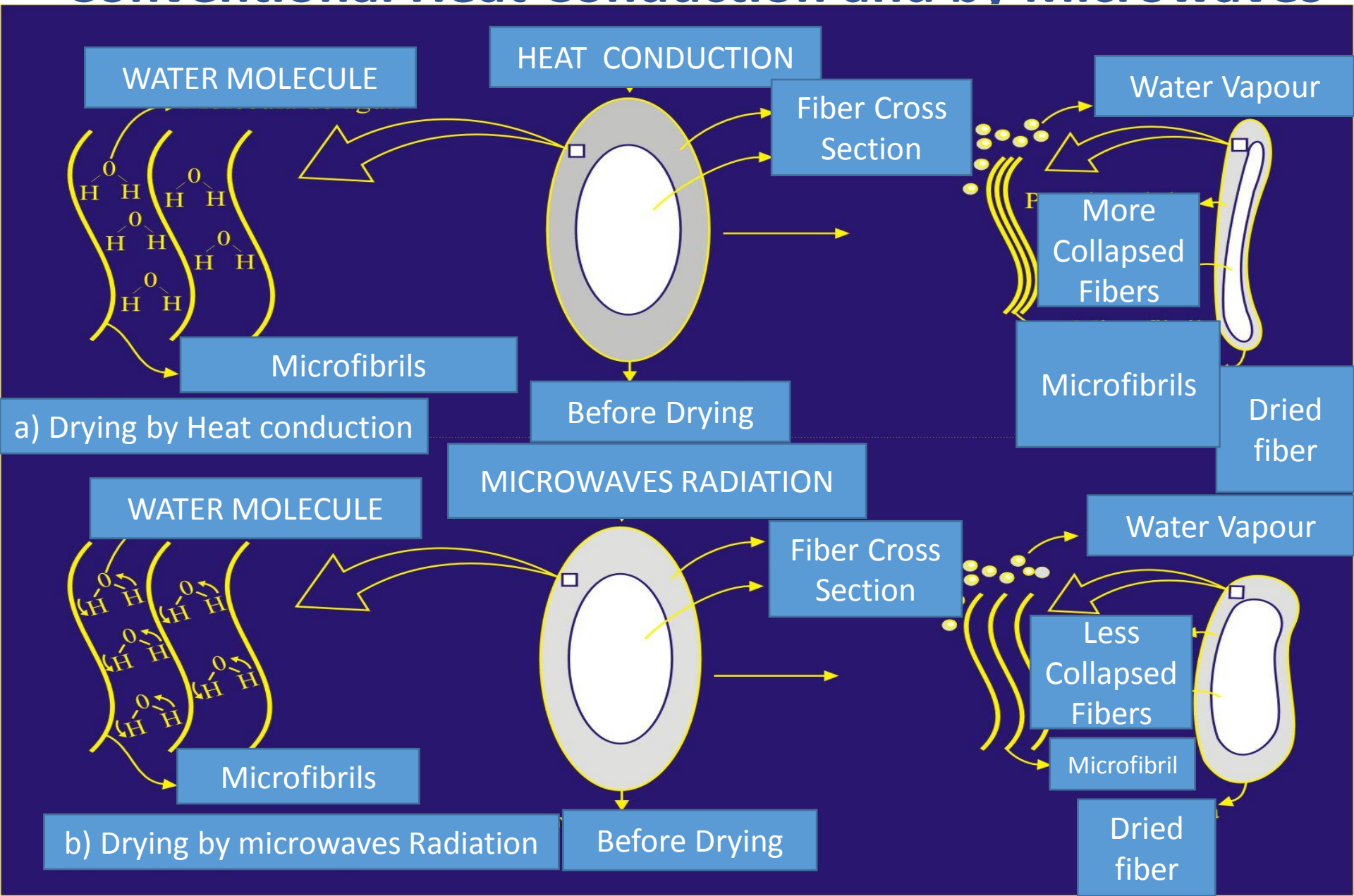
Source: GOULD (1995).




**Ionic Orientation**

**Molecular Orientation**

# Suggestion mechanisms for Drying Fibers by Conventional Heat Conduction and by Microwaves

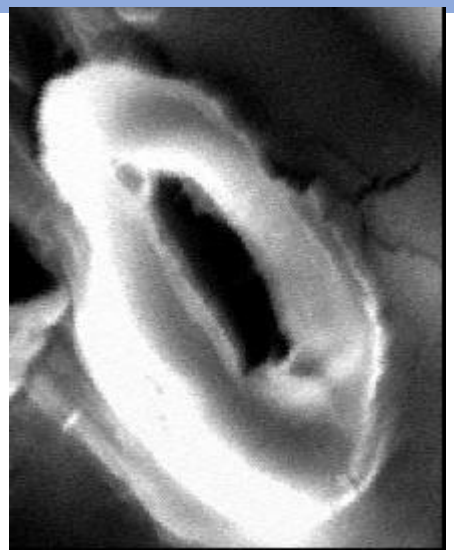


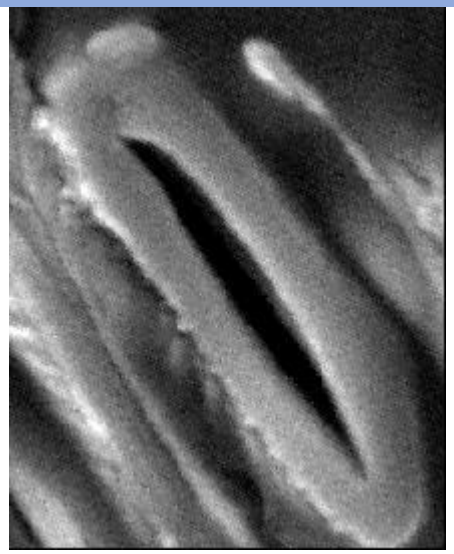
# CROSS SECTION OF FIBERS WALL

## A)Drying by microwaves

## B) Drying by Heat Conduction

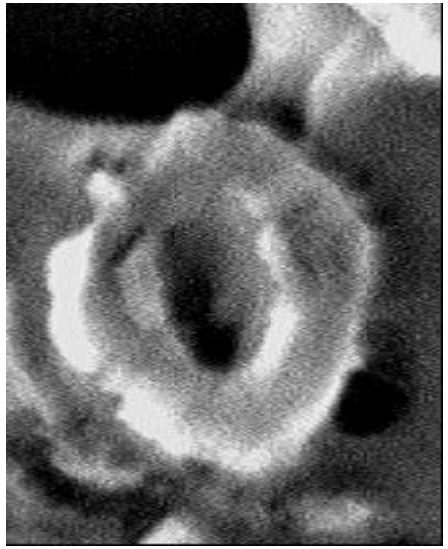
Virgin fiber





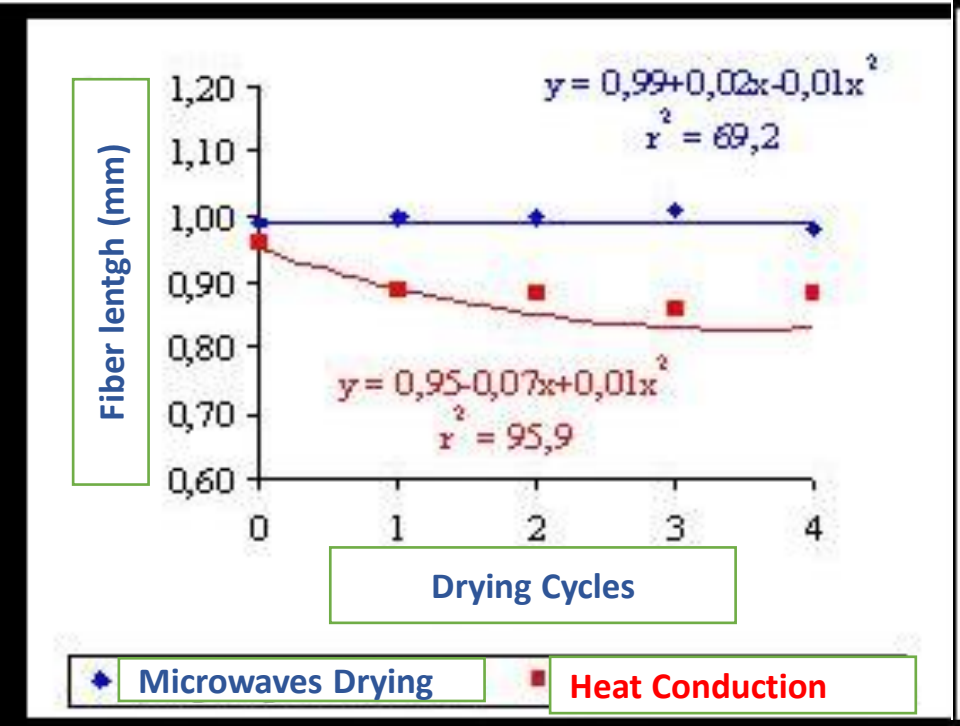
Virgin fiber

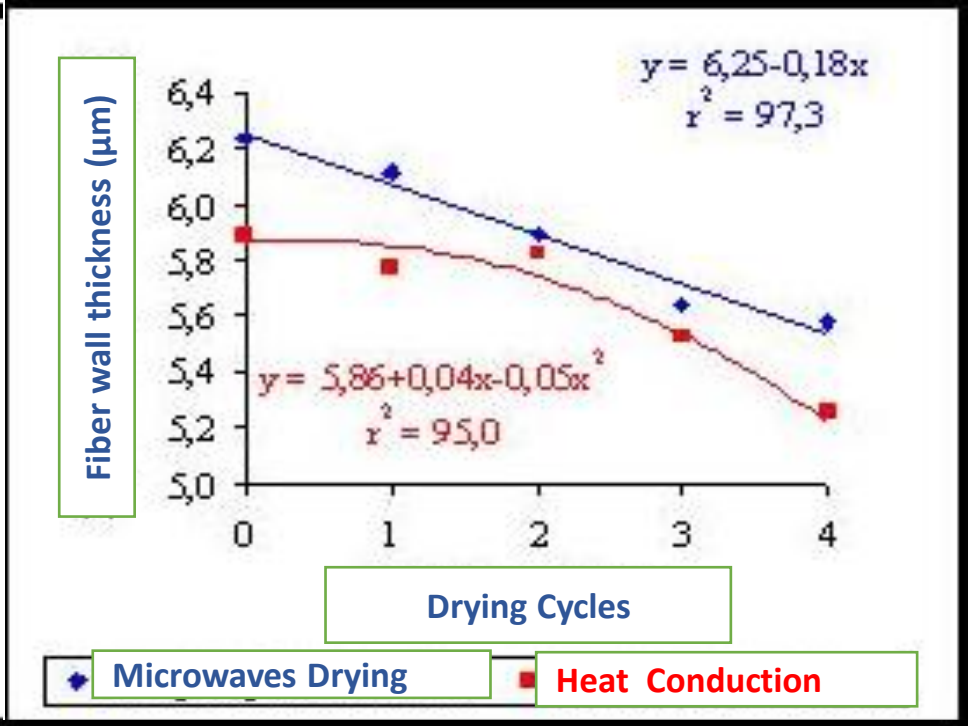
4 th Cycle of Drying

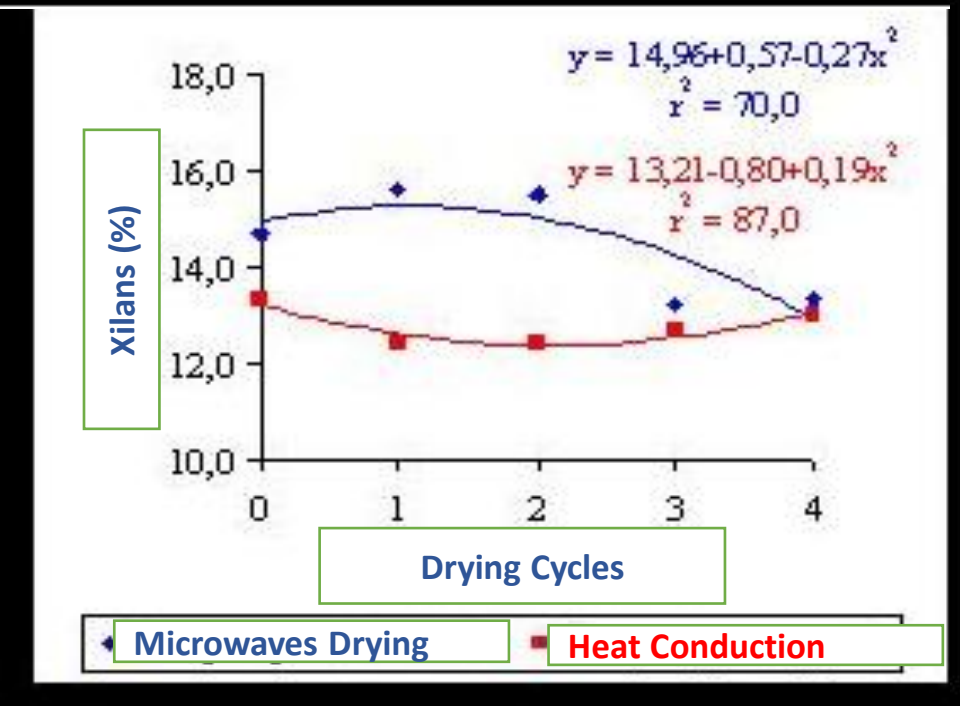


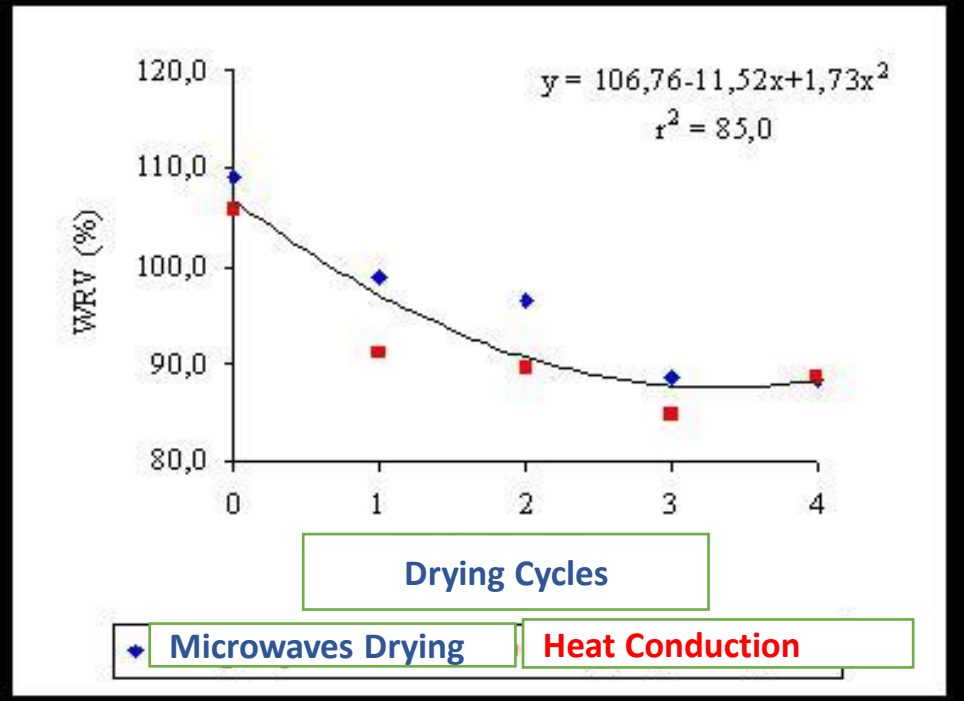
4 Th Cycle of Drying

SEM Picture: 3000 x


Fiber lentgh (mm)
1,20
1,10
1,00
0,90
0,80
0,70
0,60
y = 0,99+0,02x-0,01x²
r² = 69,2
y = 0,95-0,07x+0,01x²
r² = 95,9
0
1
2
3
4
Drying Cycles
Microwaves Drying
Heat Conduction


Fiber wall thickness (µm)
6,4
6,2
6,0
5,8
5,6
5,4
5,2
5,0
y = 6,25-0,18x
r² = 97,3
y = 5,86+0,04x-0,05x²
r² = 95,0
0
1
2
3
4
Drying Cycles
Microwaves Drying
Heat Conduction


Xilans (%)
18,0
16,0
14,0
12,0
10,0
y = 14,96+0,57-0,27x²
r² = 70,0
y = 13,21-0,80+0,19x²
r² = 87,0
0
1
2
3
4
Drying Cycles
Microwaves Drying
Heat Conduction


WRV (%)
120,0
110,0
100,0
90,0
80,0
y = 106,76-11,52x+1,73x²
r² = 85,0
0
1
2
3
4
Drying Cycles
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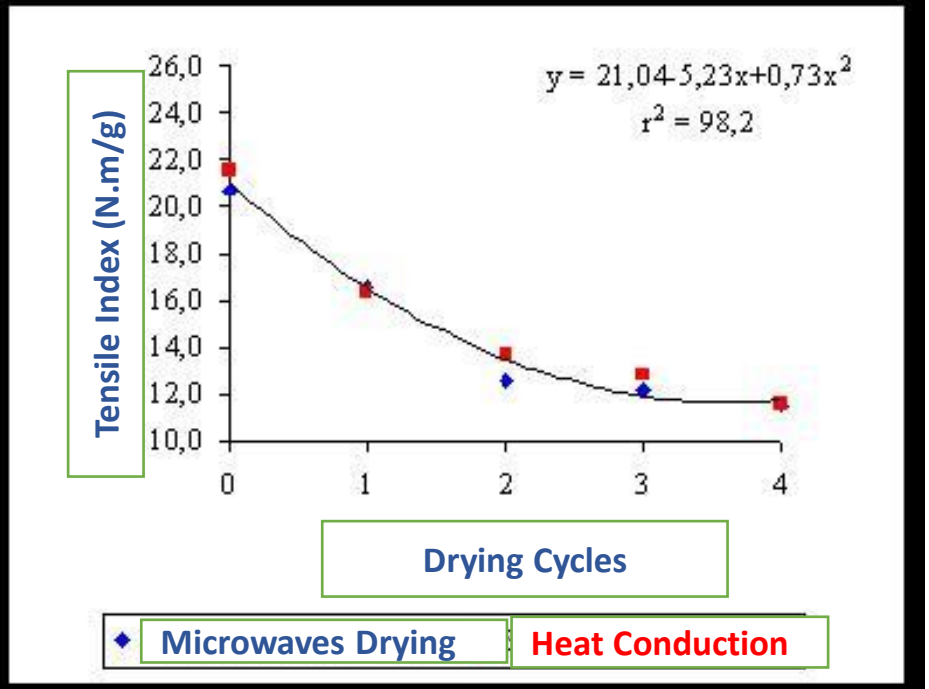
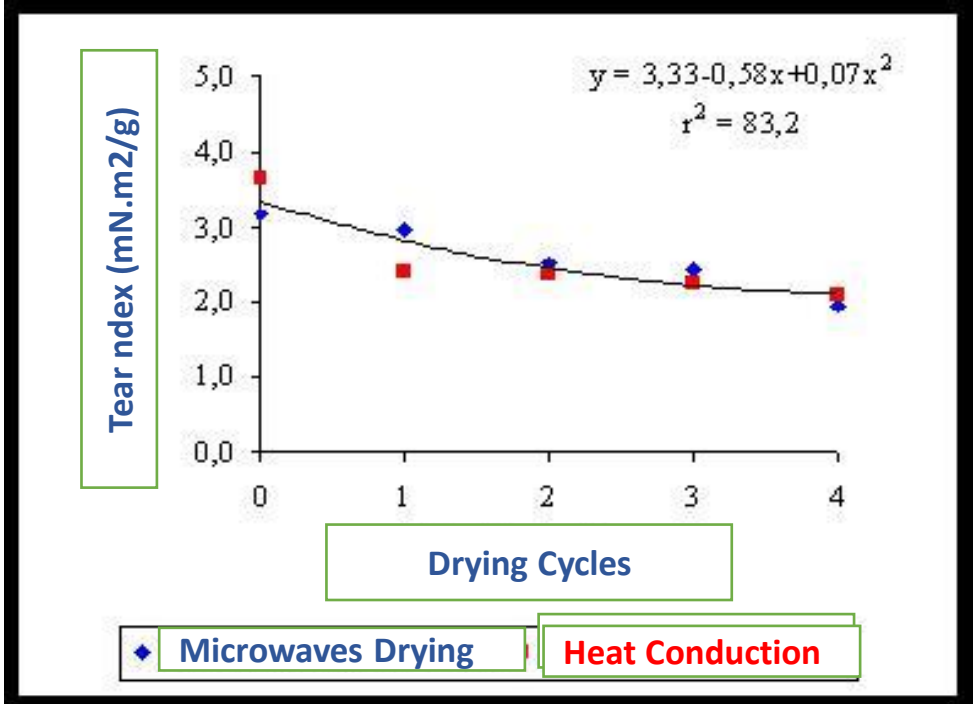
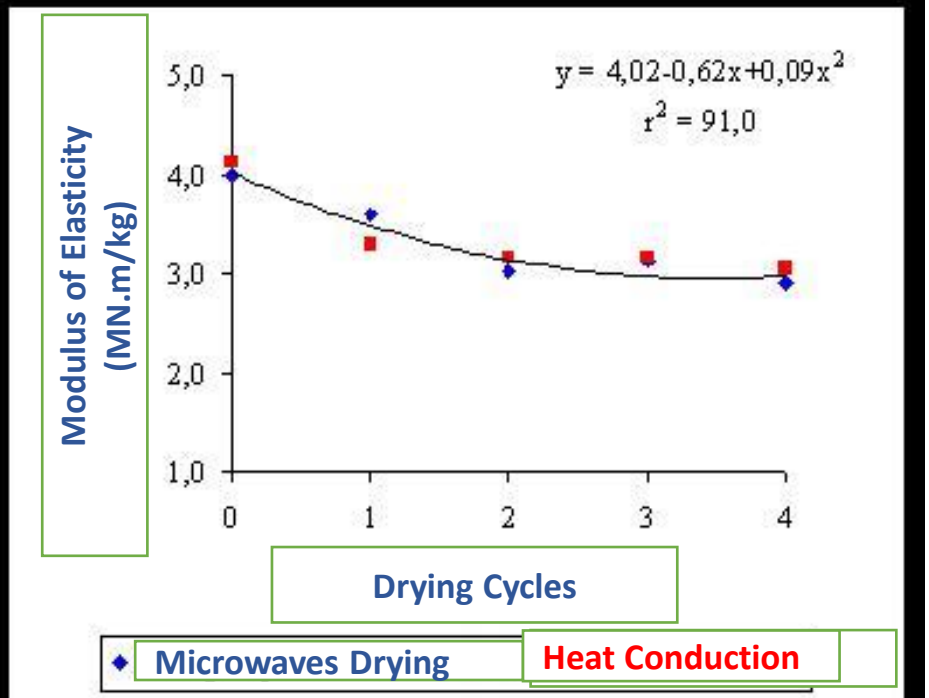

Tensile Index (N.m/g)
26,0
24,0
22,0
20,0
18,0
16,0
14,0
12,0
10,0
y = 21,04-5,23x+0,73x²
r² = 98,2
0
1
2
3
4
Drying Cycles
Microwaves Drying
Heat Conduction


Tear ndex (mN.m2/g)
5,0
4,0
3,0
2,0
1,0
0,0
y = 3,33-0,58x+0,07x²
r² = 83,2
0
1
2
3
4
Drying Cycles
Microwaves Drying
Heat Conduction


Modulus of Elasticity (MN.m/kg)
5,0
4,0
3,0
2,0
1,0
y = 4,02-0,62x+0,09x²
r² = 91,0
0
1
2
3
4
Drying Cycles
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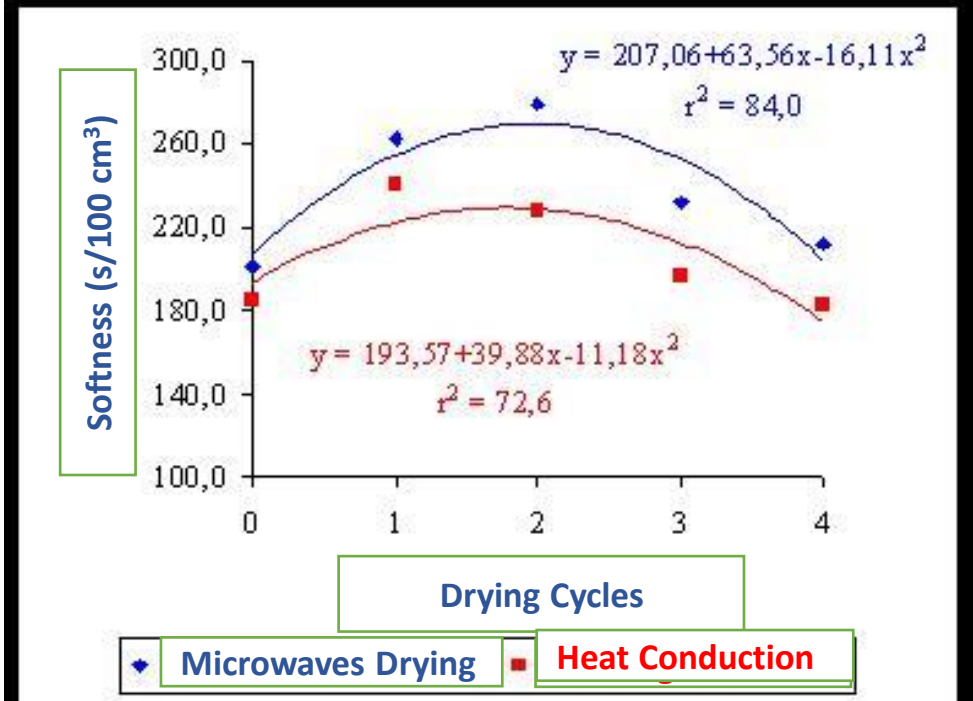
Heat Conduction


Softness (s/100 cm³)
300,0
260,0
220,0
180,0
140,0
100,0
y = 207,06+63,56x-16,11x²
r² = 84,0
y = 193,57+39,88x-11,18x²
r² = 72,6
0
1
2
3
4
Drying Cycles
Microwaves Drying
Heat Conduction

# CONCLUSIONS

- The results of laboratory studies show that the application of microwave radiation is a drying feasible alternative to dry paper.
- The drying by microwave radiation provided a better preservation of the structural properties related to the fiber length and cell wall thickness when compared to conventional heat conduction.
- The fibers of dried papers by microwave radiation had higher content of xylan, but this preservation was not reflected in better mechanical properties.
- The dried papers by microwave radiation behaved similarly for all drying cycles in relation to the mechanical and optical properties compared to paper dried to conventional heat conduction. Except for the smoothness property, where the microwave drying tend to produce papers with higher values.
- The previous conclusion reinforces that this technology presents itself as a possible alternative to the industries of paper, mainly from the tissue segment. However, requiring more studies with respect to its economic viability and how dangerous it may be to papermaker.

# THANK YOU

*Dr. Carolina M. Jardim*
*Mauro Manfredi*
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*Rogerio Peixoto Silva*

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DEPARTAMENTO DE ENGENHARIA FLORESTAL

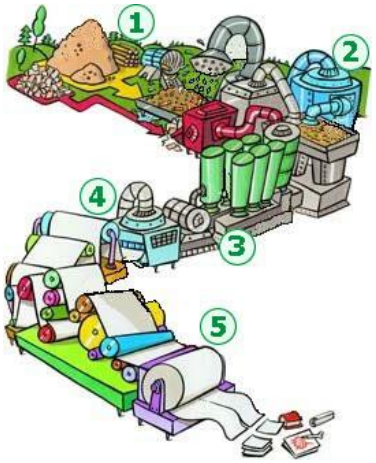

Laboratório de Celulose
e Papel LCP/UFV

# EMERGING TECHNOLOGIES TO IMPROVE EUCALYPTUS FIBERS QUALITY FOR PAPER

## *FOR THE NEXT ICEP!!!!*

## *Enhance of Eucalyptus Fiber Properties Using Dielectric-Barrier Discharge*

**PLASMA TECHNIQUE TO IMPROVE INTERFIBERS BOND SURFACES**




**Rubens Chaves de Oliveira**

Vitória, June 29, 2015