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Fibril angle measurement using confocal microscopy

Prepared Contribution by Ian Parker, Australian Pulp and Paper Institute

The Australian Pulp and Paper Institute has developed a technique[1] which is an advance on the polarisation method used by Page[2] for the determination of fibril angle (δ). The technique uses the high resolution of a confocal microscope to confine the volume from which scattered light is detected to the S2 layer of a fibre.

The S2 layer of a fibre is a structure of helically wound microfibrils. The angle of this helix with respect to the fibre axis is defined as the fibril angle or microfibril angle (Fig 1). The fibril angle is an important fibre parameter as it has a major influence on the mechanical properties.

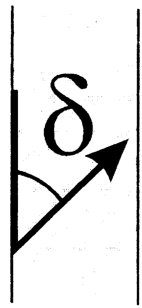

Figure 1. Schematic representation of t fibril angle (δ) in the S2 layer of a fibre.

Traditional crossed-Polarisation techniques can only be used if a single fibre wall is isolated as the second wall reverses the effect of the first. Page achieves this by impregnating the lumen with mercury (Fig 2a).

The beauty of the confocal microscope is the 'spatial filtering' achieved through 'pinhole optics' that allows only scattered light from a restricted volume to be detected (Fig 2b).

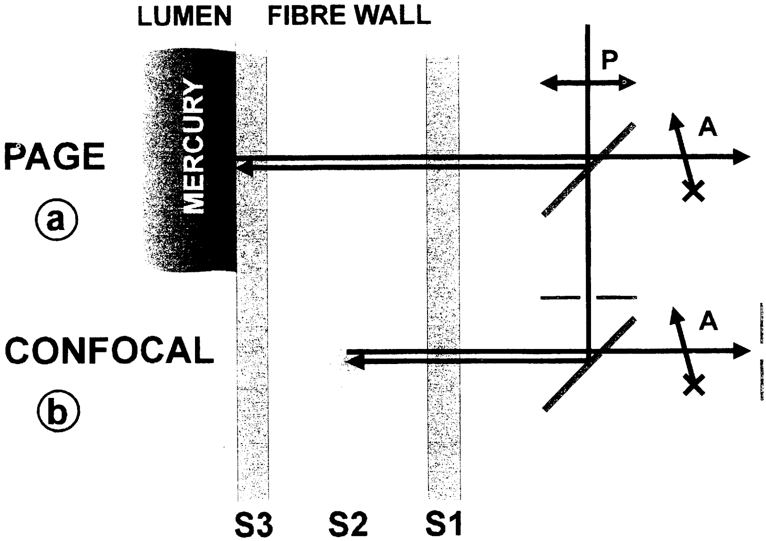

Figure 2. A comparison of the Polarised microscopy techniques (a) Page and (b) the confocal.

Fibril angle measurement using an Optiscan F900e confocal microscope has been achieved by capturing reflected light images of the S2 layer with the fibre axis at various orientations to the polarisation axis. Extinction occurs when the fibrils are aligned with either the polarisation axis of the incident laser light (P) or an analyser (A) placed prior to the detector. This extinction angle and thus the fibril angle can be calculated by analysing the images for intensity and by using curve fitting techniques (Fig 3).

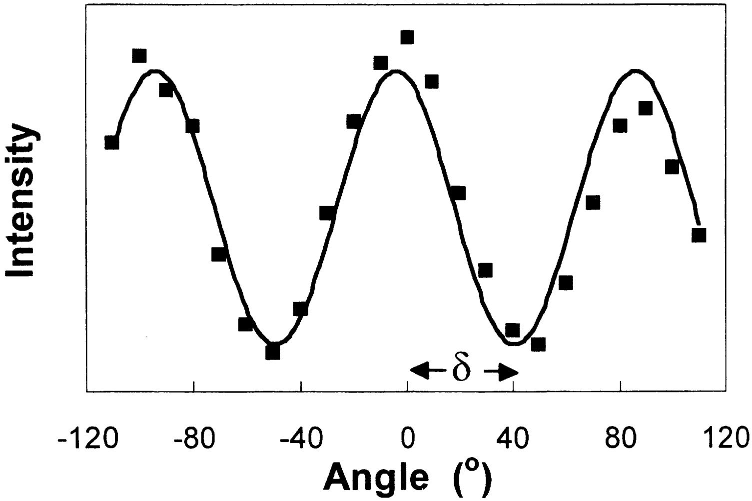

Figure 3. Intensity variation with the angle between the fibre axis and the polarisation axis for a radiata pine compression wood fibre.

Fibril angle measurement using confocal microscopy has a number of advantages over previous techniques including it's simplicity, speed, absence of a need for sample preparation and applicability to single fibres, paper or solid wood.

References

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Dr R Seth, Paprican, Canada

Since I mentioned fibril angle measurement on Monday, I wish to add that we have been successfully using the confocal microscope for these measurements for over 2 years and will publish our work in due course.

NB. Further comments made by me at this time may have been misconstrued. I wish to make it clear that the reflectance confocal microscopy approach to measuring fibril angle is distinctly different from our approach. If an impression was left that the APPI method was based on prior knowledge of our technique, this is regretted.

Prepared Contribution

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In preceding discussions and presentations on drainage and retention, speakers have referred to paper with basis weights of 50 grams per square meter, and above. I wish to remind the Symposium attendees that there is another form of paper which has much lower grammage, but still displays all the characteristics of "typical' papers. This, is, of course, tissue.

A typical bathroom (toilet) tissue has grammage of 14-15 grams per square meter, and is formed at more than 1000 meters per minute from a headbox concentration substantially below 0.5%. Cross sections of such papers show a thickness of 4 to 8 fibers at a scan line. It had long been held that such thin papers cannot act as depth filters and thus are not amenable to the use of flocculating type retention aids to improve the papermaking operation. During the last few years, however, particularly with the introduction of recycling and the use of mechanical pulps, it has become apparent that "something" must be done to prevent cellulosic fines and mineral particles from building up in the paper machine headbox and white water system. Practical experience has shown these papers to be as responsive to drainage/retention aids as their heavier counterparts. For example, in one extended machine run on 15 gsm single ply bathroom tissue, the following rounded off results were obtained, using a two-component (high charge cationic promoter, followed by a high molecular weight anionic flocculant) chemical retention aid system:

Parameter	Standard	With Retention Aid
Headbox consistency, %	0.22	0.11
Tray consistency, %	0.13	0.02
First Pass Retention, %	41	81
Headbox ash, %	4	2
Headbox drainage, arbitrary units	170	450
Tray Turbidity, NTU	710	200
Former speed, fpm	3425	3530
Yankee steam pressure, psi	129	116

My point is that <u>everything</u> we have been hearing applies to <u>all</u> papers. I also caution us to apply fundamental principals of retention chemistry and filtration when considering what happens during manufacture. We cannot assume that either very light or very heavy papers are different from "typical" papers, except where specific differences are dictated by the chemistry, physics or hydrodynamics of the system.