Analysis of pulp fibers and fines and their contribution to paper properties.

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Abstract:

Characterization of pulp fibers and fines in terms of their chemical and morphological character is of utmost importance for a better understanding of their contribution to strength, absorption and optical properties of paper and board. The focus in this article is on the morphological characterization of fiber fines. Two optical methods for the morphological characterization where compared. It was concluded that these methods provide complementary information about the morphology of fines.

Introduction:

Fines can be classified due to their size, shape and origin and are commonly defined as particles with a length below 200 µm (Kangas 2004), or particles which are able to pass a 200 mesh screen (Luukko 1998). They further can be subdivided by their shape into fibrillar and flake like particles for chemical pulps (Luukko et al. 1997; Mosbye 1999) or “Mehlstoff” (“flour stuff”) and “Schleimstoff“ (“slime stuff”) for mechanical pulps (Brecht & Klemm 1952). A differentiation is also made in where fines are generated. Primary fines are those particles which are present as a result of the pulping process and originate predominantly from the primary wall of the fiber. They also can be ray cells, vessel cells or parenchyma cells. Secondary fines are produced in the further mechanical treatment of the pulps, especially in refining (Ferreira et al. 2000). They are bundles of fibrils from the S1 - and S2 - wall. Additionally to these differentiations, fines as well as fiber properties are dependent of the wood species and influenced by various chemical, mechanical and thermal treatments in the process (Luukko 1999). The fines fractions were characterized using two image analytical methods. One method uses a flow cell based fiber analyzer. The other method is a microscopy based imaging method with subsequent image processing based on a method by Luuko (Luukko et al. 1997). Besides the determination of particle size distribution the microscopy method is able to distinguish between fibrillar and flake like fines.

Materials and Methods

Four different pulps were fractionated using a lab-scale pressure screen. The pressure screen is equipped with a perforated plate (hole diameter 100 µm). The material passing this plate was then defined as fines fraction. Three fines fractions were prepared from chemical pulps (F1, F2, F4)

and one from PGW (F3). The fractions were used to compare two methods for the evaluation of their morphological properties. The L&W Fibertester^{+} is a conventional flow cell based fiber analyzer, with a resolution (3.3 µm/pixel). The raw data can be exported which allowes further post processing using a MATLAB routine. This was necessary for the determination of particle size distribution (PSD) of pulp fines. The microscope method was used for the determination of the fibrillar content of fines and for the determination of PSD. Therefore a suspension of fines in water (0.1 - 0.3 g/L) was stained with methylene blue (1 wt. % in water), pipetted on a microscope slide and fixed with a cover glass. A light microscope equipped with a standard CCD camera and an automated stage control was used to take images (1600x1200 pixels; image area: 1380x1035 µm^2). For each sample 700 to 800 images were taken. An image analysis software which is able to distinguish between flake like and fibrillar material, due to gray level differences as well as a tool for the determination of PSD, was implemented in MATLAB.

Results

Four samples of different primary fines (F1, F2, F3 and F4) were measured with the automated analyzer (L&W Fibertester^{+}) and the microscope method. In Figure 1 an image of F4 fines taken with the microscope (Figure 1 left) and with the automated analyzer (Figure 1 right) is depicted. On the upper right corner of the microscope image fibrillar material is located and on the left side flake like material. These two kinds of fines are also visible in the right image taken with the automated analyzer. The fibrils are swollen and can be hardly distinguished from the background (Figure 1 right). Thus they cannot be detected quantitatively with the automated analyzer. Also the particle size distributions showed that the detection of fibrillar material is not quantitative with the automated analyzer. In Figure 2 the particle size distributions (PSD) of the four different fines are depicted. The left diagram shows the PSD calculated from the microscope images and the right diagram from the automated analyzer. The horizontal axis shows the equivalent circular diameter (x_c) and the vertical axis the fines area. The equivalent circular diameter (x_c) is the diameter of a circle that has the same area as the projection area of the particle. This representation is convenient working with irregular shaped particles as flake like fines are, because neither length nor width can describe the particles precisely. In the left diagram only the size distribution of flake like material is shown, whereas the right diagram shows the distribution of all fines, which are detected by the automated analyzer. Both diagrams show the same particle size range and a similar distribution for F1, F2, F4. These are fines from chemical pulps. The fibrils of chemical pulps swell in water to a higher extent and thus were not recognized by the analyzer. F3 fines originate from pressurized ground wood. Due to their higher lignin content they do not swell as much as chemical pulp fines. They can partly be detected by the analyzer.

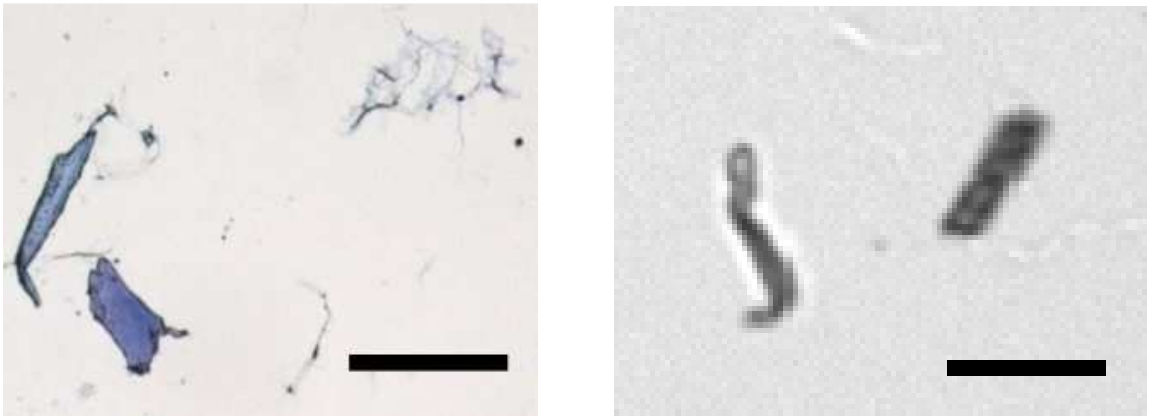

Figure 1: Images (microscope: left; fibertester: right) of F4 fines; black bar: 100µm

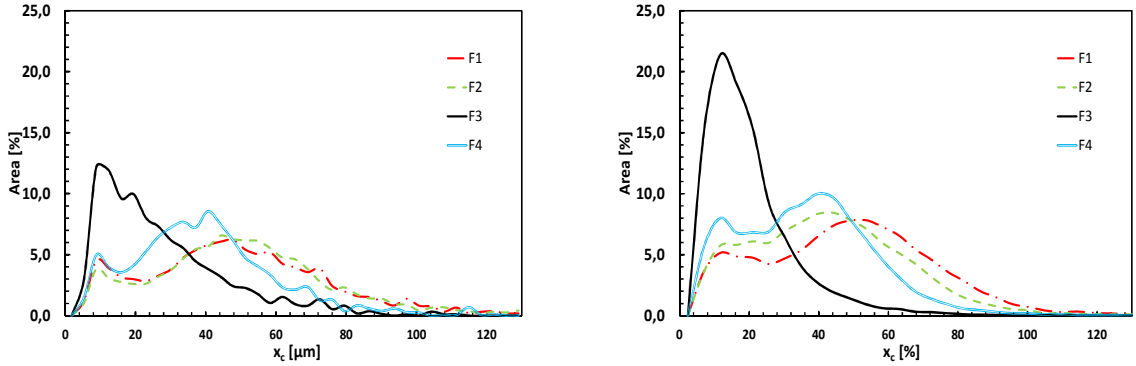

Figure 2: Particle size distribution; microscope (left diagram): only flake like material is measured; automated analyser: (right diagram): all material (flakes + fibrils) is measured

Conclusions

Two optical methods for the morphological characterization of fines were compared. The advantage of the conventional analyzer is the rather easy sample preparation and the fast measurement. Limitations occur regarding resolution and transparency of fine material. Furthermore the device is not able to distinguish between flake-like and fibrillar material. The microscopy based imaging method is able to determine the fibrillar content and the size distribution of a fines fraction. It was concluded that these methods provide complementary information about the morphology of fines.

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Literature:

Brecht, W. & Klemm, K., 1952. Das Struckturgemisch eines Holzschliffs als Schlüssel für die Kenntnis seiner technologischen Eigenschaften. *Wochenblatt für Papierfabrikation*, 11, pp.364–370.

Ferreira, P.J., Martins, A. & Figueiredo, M., 2000. Primary and secondary fines from Eucalyptus globulus kraft pulps - Characterization and influence. *Paperi Ja Puu-Paper and Timber*, 82(6), pp.403–408.

Kangas, 2004. Surface chemical and morphological properties of mechanical pulp fines. *Nordic Pulp and Paper Research Journal*, 19(2), pp.191–199.

Luukko, K., 1999. Fines Quantity and Quality in Controlling Pulp and Paper Quality. In *Tappi International mechanical pulping conference*. Houston, pp. 67 – 75.

Luukko, K., 1998. On the characterization of mechanical pulp fines.pdf. *Paperi Ja Puu-Paper and Timber*, 80(6), pp.441–448.

Luukko, K., Kemppainen-Kajola, P. & Paulapuro, H., 1997. Characterization of mechanical pulp fines by image analysis. *Appita*, 50(5), pp.387–392.

Mosbye, J., 1999. Fractionation and chemical analysis of fines. In *27th EUCEPA conference - Crossing the millennium frontier*. N-7491 Trondheim, Norway, pp. 317–321.