

Influence of Chemical Pulp Fines' Origin on Fines Quality

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ABSTRACT

Fines play an important role in process control of wet end and affects greatly on paper properties. The fines from different origins were compared in this paper. Results demonstrated that fines quality were quite different from different origins, such as primary fines, secondary fines different beating degrees, fines from different pulps, and fines from different refining equipments. And fines properties could indicate the difference in type of fines quite well and explain the influence of fines on paper properties.

Keywords: chemical pulp fines' origin; fines quality; paper properties

Introduction

The terms “primary fines” and “secondary fines” are established to distinguish between the fines that are present already in the chemical pulp before refining and those that are created by mechanical actions during refining. Chemical pulp fines are in general the sum of primary fines and secondary fines. Primary fines are mainly ray cells and parenchyma cells, less than 2%, and associated with virgin pulps, for example, softwood kraft pulp have little primary fines and hardwood kraft pulp have the primary fines in the form of parenchyma cells, ray cells and vessel elements [1]. Secondary fines include lamellar and fibrillar parts of the fiber wall and colloidal material, which originate mainly from the S_1 and S_2 layers, and have increased specific surface area to increase the relative bonded area between fibers.

Secondary fines were reported to increase bonding strength but primary fines to decrease it [2]. Compared to primary fines, secondary fines have strong swelling ability, have clearly better bonding properties and are more advantageous to paper properties [3]. The crystallinity of wet primary fines is higher than that of wet secondary fines, while the crystallinity of dry secondary fines is higher [2]. The wood species affect the quality of the fines fraction. Hardwood chemical pulps contain larger proportions of primary fines than softwoods, but the difference in bonding ability between softwood and hardwood kraft fines, as well as between bleached and unbleached softwood kraft fines, are small [4]. In this paper, an integrated evaluation was applied to chemical pulp fines based on the available methods, in order to get more information on chemical pulp fines and select superior chemical pulp fines to improve paper properties.

Experimental

All the fines in this study were chemical pulp fines. The effect of primary fines and secondary fines, fines from different beating degree, fines from different chemical pulps, and fines from different refining equipment were evaluated in the experiment. Fibrils content of fines, dynamic water retention and surface charge were measured to explore the fines quality evaluation methods. Each type of fines was added to screened “fines free” eucalyptus pulp, which had been beaten 30 minutes by Valley Beater before screening, to make hand sheets and physical paper properties were measured. The relationship of fines quality and its effect on paper properties were discussed.

Experiments with Primary Fines and Secondary Fines from Pulps of Different Refining Degrees

This group of experiments evaluated fines collected from the virgin eucalyptus pulp (i.e., eucalyptus primary fines) and those from the pulps refined to different degrees (eucalyptus secondary fines). Three different eucalyptus pulps were obtained by refining to 29 SR, 49 SR and 68 SR in a Valley beater for 30, 60 and 90 minutes respectively with 5.5 kg load according to standard SCAN-C 25:76. The fines separated from these virgin and refined pulps by 200-mesh screen in Dynamic Drainage Jar (DDJ) were called as primary fines, 30 min. fines, 60 min. fines and 90 min. fines. The fiber fraction for this experiment was fibers from screened 29 SR eucalyptus pulp (named as SE30). Fines addition was fixed at 15% of pulp regardless of the source of the fines. Hand sheets as 60 ± 2 g/m² were made according to SCAN C 26:76. End-product properties were tested and analyzed.

Table 1

The experimental conditions of four kinds of eucalyptus pulp fines

No	Fiber fraction (eucalyptus pulp SE30) (%)	Fines type	Fines fraction (%)
1	100	–	0
2	85	Primary fines	15
3	85	30 min. fines	15
4	85	60 min. fines	15
5	85	90 min. fines	15

Experiments on Fines from Different Pulps

Pine (softwood), eucalyptus (hardwood) and reed (non-wood) pulps were selected to study the effect of pulp sources on fines quality. These pulps were refined to 68 SR in Valley beater with 5.5 kg load by adjusting beating time. All pulps were screened in DDJ to get the secondary fines for comparison. The fiber fraction still was the fibers from screened 29 SR eucalyptus pulp SE30. Fines addition was fixed at 15% based on pulp fraction to make hand sheets (Table 2). Pine fines generated from PFI mill was selected to compare the influence of beating equipment on fines quality with that from Valley beater. End-product properties were tested and analyzed.

Table 2

Experimental conditions of highly refined pine, eucalyptus and reed pulp fines

No	Fiber fraction (eucalyptus pulp SE30) (%)	Fines type	Fines fraction (%)
6	85	Pine fines	15
7	85	Eucalyptus fines	15
8	85	Reed fines	15
9	85	Pine fines (PFI)	15

Analysis and Testing Methods

The dewatering rate of a fines suspension (or water retention value of fines) was tested by AA-GWR water retention meter Model 250. A

membrane filter with a pore size of 5.0 μm (Kaltac Scientific, Inc., USA) was used for filtering fines suspension, and plenty of blotting papers (produced by Whatman) were used to absorb the water filtered from fines suspension. 10 mL of fines suspension at a consistency of 9 g/L was used for the measurement. The external pressure was 0.2 bar, and the pressurized time was from 10 seconds to 40 seconds at an increasing increment of 10 seconds. The difference in the weight of the blotting paper before and after water adsorption indicates the dewatering rate of the fines suspension, and was calculated in grams per square meter.

Apparent mass proportion of fibrillar material and ray-cells of fines were analyzed by image analysis method introduced by Kari Luukko [5].

The apparent viscosity of the fines suspension was measured using a Brookfield DV-E viscometer (Brookfield Engineering Labs., Inc. USA). Spindle No.2 and 100 rpm were used in the measurement. The temperature of all fines suspension was kept at 23°C.

100 mL 1.0 g/L fines suspension was used for hydrodynamic specific volume test. The fines suspension was allowed to settle in a 0.5 mg/L MgSO_4 aqueous solution for 24 hours in a 100 mL glass measuring cylinder at constant conditions (23°C). Additional air from fines suspension was removed by vacuum before settling. After the settling, the sediment volume was read, and the hydrodynamic specific volume was calculated in milliliters per gram.

Surface charge for pulp fines was measured by mutek PCD 03 pH. Tensile index was tested according to SCAN-P 11:73. Opacity of handsheets was measured by using Technidyne Color Touch PC and light scattering coefficient was calculated by using the equation available in the catalogue provided with the instrument.

Results and Discussion

Table 3 Apparent fibrillar and ray-cell content of fines samples

Fines Sample Description	Apparent mass proportion of fibrillar material of fines (%)	Apparent mass proportion of Ray-cells of fines (%)
Pine pulp fines gathered from 68 SR Valley beater refined pulp passing 200 mesh wire	66	5
Pine pulp fines gathered from 68 SR PFI refined pulp passing 200 mesh wire	76	2
Eucalyptus pulp primary fines	15	16
Eucalyptus pulp fines gathered from Valley beater refined 29 SR pulp passing 200 mesh wire	24	10
Eucalyptus pulp fines gathered from Valley beater refined 49 SR pulp passing 200 mesh wire	32	9
Eucalyptus pulp fines gathered from Valley beater refined 68 SR pulp passing 200 mesh wire	32	7
Reed pulp fines gathered from Valley beater refined 68 SR pulp passing 200 mesh wire	37	13

Table 3 shows apparent fibrillar content and ray-cell content of all the fines samples. The biggest difference in fibrillar content and ray-cell content is among the highly refined pulp fines.

Addition of fines affected paper properties regardless of the source of fines, however the addition of secondary fines affected paper properties more effectively than that of primary fines. In addition, the effect of secondary fines increased with increase of refining (Figs. 1 and 2). Primary fines in chemical

pulps consist mainly of a coarser fraction rich in ray-cells and a finer fraction containing fibrils and lamellas, while secondary fines consist of broken fiber fragments, fibrils and thin lamellas from the fiber surface [6]. Mosbye et al. showed that the fines from the second, third or fourth stages of refining are more fibril-like and originated from secondary wall (S_2 layer) [7]. The fragments from the secondary wall are more prone to bonding than the fines from primary layer (P layer). This fact may also explain better bonding of the fines from the highly refined

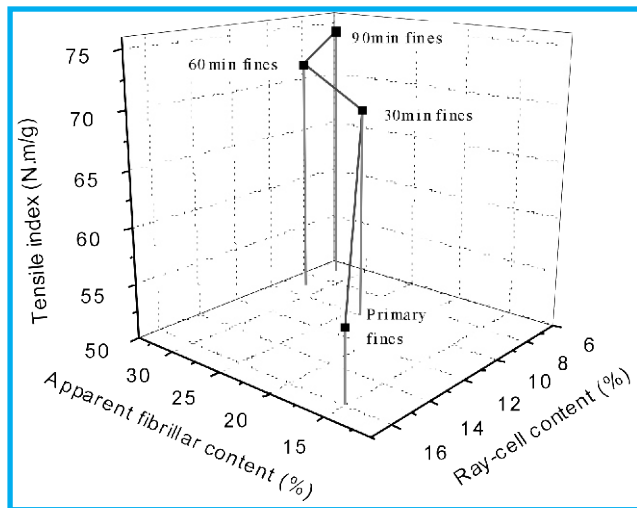


Figure 1 Influence of apparent fibrillar content and ray-cell content on tensile index with progress of refining. Hand sheets were made from furnishes having 15% fines.

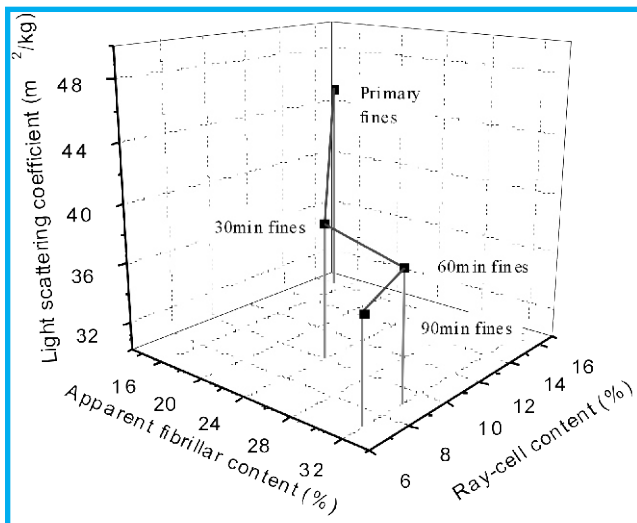


Figure 2 Influence of apparent fibrillar content and ray-cell content on light scattering coefficient with progress of refining. Hand sheets were made from furnish with 15% fines.

pulp. As refining went on, fibrillar content of eucalyptus pulp fines increased and ray-cell content decreased, tensile index increased and light scattering decreased. The fibrillar content and ray-cell content influence paper properties simultaneously. The fines with higher fibrillar content and lower ray-cell content affect paper properties more strongly.

Pictures of the three pulp fines obtained from optical microscopy show that the three chemical pulp fines contained heterogeneous particles: pine pulp fines had large amount of fibrils and a small quantity of fiber fragments and ray-cells (Fig. 3); eucalyptus pulp fines was a mixture of fibrils, vessels and fiber fragments (Fig. 4); reed pulp fines contained fibrils and various non-fibrous cells and their fragments (Fig. 5). The pines pulp fines had a fibrillar content of 66%, indicating the fines was mainly of fibrils, and reed pulp fines had 13% ray-cells which were twice as eucalyptus pulp fines. All these generally agreed with the observation by optical microscopy. The apparent fibrillar content and ray-cell content can be used to explain the effect of different fines on paper properties well.

Chemical pulp fines retard dewatering of the pulp suspension due to the high water holding capacity of fines. The suspension exhibits different rheological characteristics depending on the degree of interaction between fines particles and on their hydration. The higher is hydration of fines and interaction between the fines particles, the higher is the viscosity. Hydrodynamic specific volume indicates the swelling of

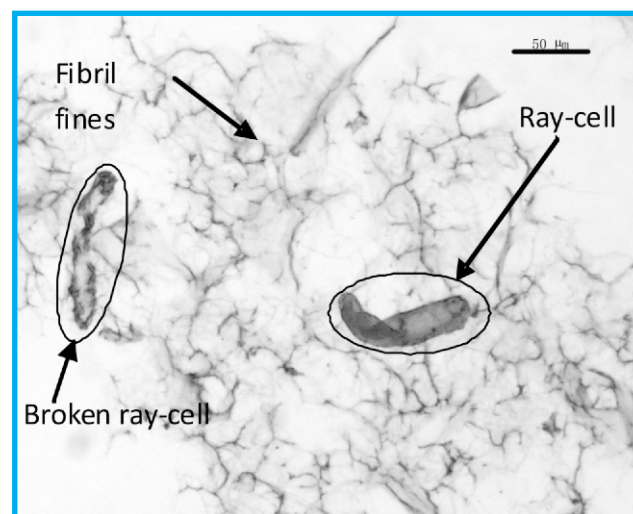


Figure 3 Fines from 68 SR pine pulp

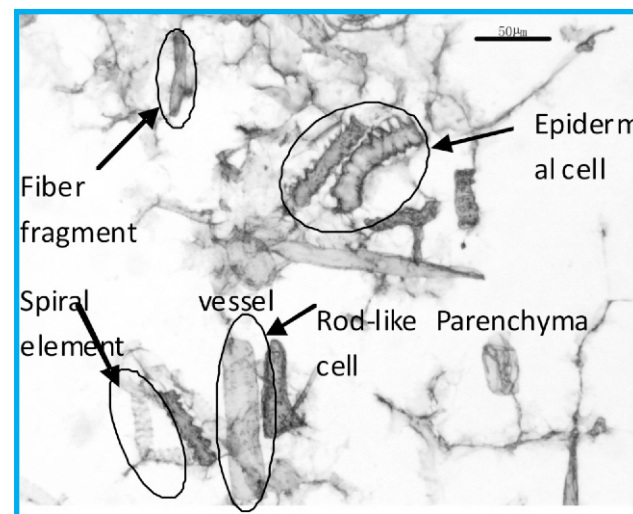


Figure 4 Fines from 68 SR eucalyptus pulp

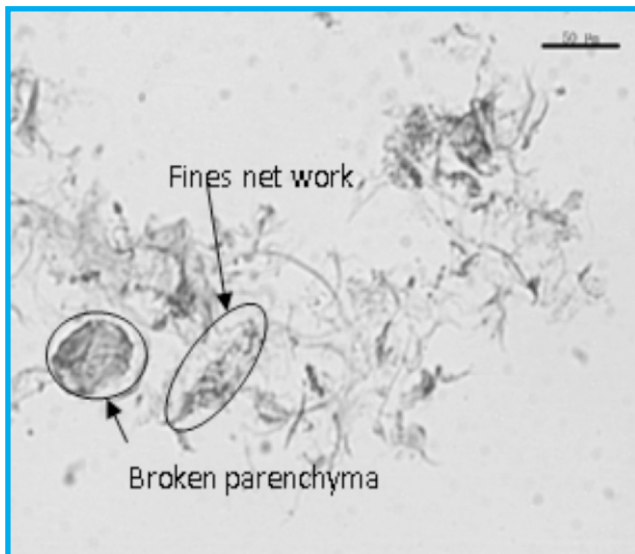


Figure 5 Fines from 68 SR reed pulp

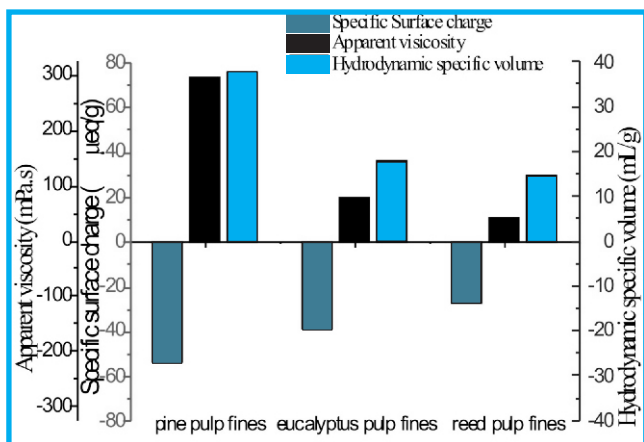


Figure 6 Apparent viscosity, hydrodynamic specific volume and specific surface charge of pine, eucalyptus and reed pulp fines

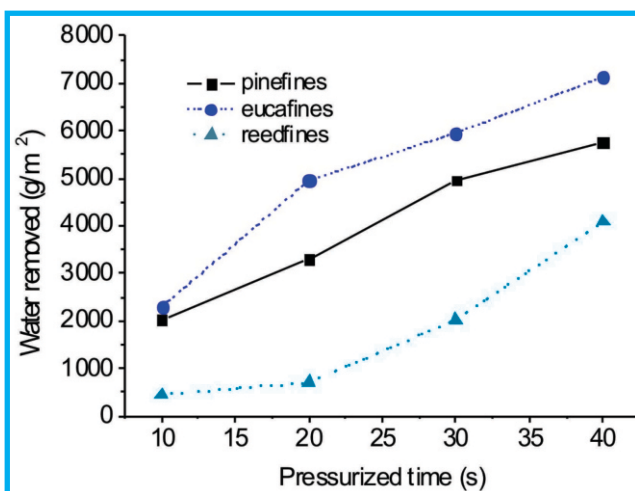


Figure 7 Dewatering rate of pine, eucalyptus and reed pulp fines. The external pressure was 0.2 bar

($4\pi \cdot \text{Area}$)), surface area, and swelling ability, resulting in higher bonding ability, compared to non-fibrillar particles. Higher fibrillar content in fines means higher specific sediment volume as well as higher viscosity (Fig. 6). The data on surface charge for the samples of three pulp fines (as measured by mutek PCD 03 pH) indicated that fines sample with higher fibrillar content had higher surface charge.

The water removal value by AA-GWR water retention meter can be used to indicate the amount of water drained from the fines suspension in a given time and at a given external pressure [9]. The higher is the dewatering rate of fines if more water is removed in certain pressurized

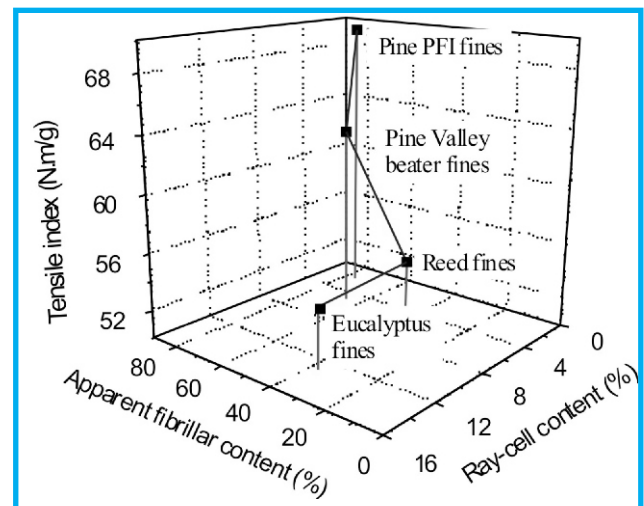


Figure 8 Influence of apparent fibrillar content and ray-cell content on tensile index for different types of fines. Hand sheets were made from furnishes having 15% fines.

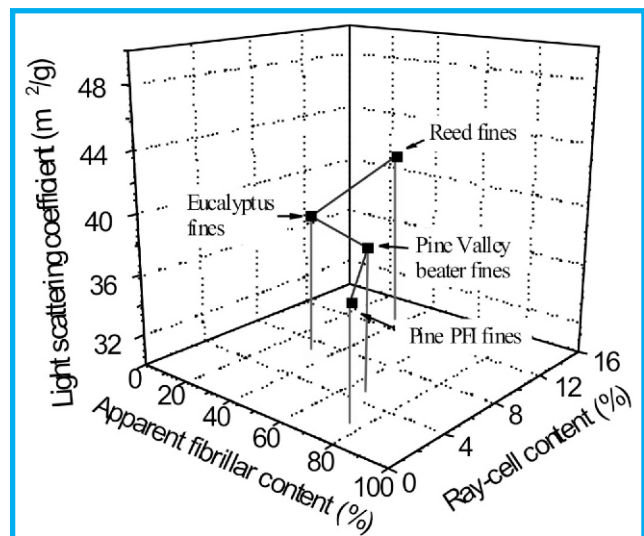


Figure 9 Influence of apparent fibrillar content and ray-cell content on light scattering coefficient for different types of fines. Hand sheets were made from furnishes having 15% fines.

time. The water removal value of pine fines is lower than that of eucalyptus fines (Fig. 7), which means longer drainage time of pine fines compared with eucalyptus fines. Reed fines have rather lower

water removal value than pine fines, probably due to its quite high ray-cells content, which blocked the holes of AA-GWR water retention meter.

Figs. 8 and 9 also show that fibrillar content and ray-cell content both have influence on tensile index and light scattering. The light scattering coefficients did not change considerably due to difference in ray-cell content of the fines.

Conclusions

Fines properties change with refining, wood species as well as refining equipment. The secondary fines (fines generated by refining) yield higher strength properties than primary fines (fines generated in pulping process). Fines from pulp after different refining amounts showed different properties. Higher strength properties were gained from highly refined pulp fines. Fines from pine pulp showed higher strength properties than the fines from eucalyptus or reed pulp. Fines produced by PFI mill had better bonding potential than the fines produced by Valley beater. Fines with higher refining amounts had higher bonding potential, higher surface charge, higher hydrodynamic specific volume, and higher fibrillar content but lower ray-cell content. Fines with high bonding potential retarded drainage and deteriorated sheet formation stronger than that with low bonding potential.

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References

- [1] Kibblewhite, R.P.. Interrelations Between Pulp Refining Treatments, Fiber and Fines Quality, and Pulp Freeness. *Paperi ja Puu*, 1975, 57 (8): 519-526.
- [2] Retulainen, E., Moss, P. and Nieminen, K.. Effect of Fines on the Properties of Fiber Networks. *Transactions of the 10th Fundamental Research Symposium held at Oxford*, 1993: 727-769.
- [3] Laivings, G.V. and Scallan, A.M.. The Influence of Drying and Beating on Swelling of Fines. *Journal of Pulp and Paper Science*, 1996, 22 (5): 178-184.
- [4] Retulainen, E., Luukko, K., Fagerholm, K., Pere, J., Laine, J. and Paulapuro, H.. Papermaking Quality of Fines from Different Pulp The Effect of Size, Shape and Chemical Composition. *Appita Journal*, 2002, 55 (6): 457-467.
- [5] Luukko K., Kemppainen-kajola P., Paulapuro H.. Characterization of mechanical pulp fines by image analysis. *Appita journal*, 1997, 50 (5): 387-392.
- [6] Krogerus, B., Eriksson, L., Sundberg, A., Mosbye, J., Ahlroth, A., Östlund, I., et al.. Fines in closed circuits-Final report (2002). From Nordisk Innovations Center Website: http://www.nordicinnovation.net/_img/fines_in_closed_circuits_final_report.pdf
- [7] Mosbye, J., Moe, S. and Laine, J.. The Charge and Chemical Composition of Fines in Mechanical pulp. *Nordic Pulp and Paper Research Journal*, 2002, 17 (3): 352-356.
- [8] Luukko, K. and Paulapuro, H.. Development of Fines Quality in the TMP Process. *Journal of Pulp and Paper Science*, 1999, 25 (8): 273-277.
- [9] Kang, T. and Paulapuro, H.. Characterization of Chemical Pulp Fines. *Tappi Journal*, 2006, 5 (2): 25-28.



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