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Effect of different types of fines on the properties of recycled chemical pulp

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ABSTRACT

The effect of fine content and quality on the recycled chemical pulps was studied. As fine content increased, the apparent sheet density linearly increased. The effect of fines from DIP (deinked pulp) on the apparent density of the sheets was the most prominent especially with the secondary fines. The addition of secondary fines obtained from HW-BKP (hardwood-bleached kraft pulp) and DIP, and primary fines from DIP increased the tensile strength but decreased the light scattering coefficient after a critical point. The improvement of strength by secondary fines was caused by the different quality of fines, relatively larger specific area and higher WRVs (water retention values). While the primary fines of HW-BKP increased the light scattering coefficient but had little effects on the tensile strength. Porosity was rapidly decreased with the addition of secondary fines more than 30% regardless types of pulps.

1. Introduction

The fundamental properties of papers are influenced by a numbers of factors. Among the factors, the fine fractions have an effect on the physical properties of the papers to a large extent. Generally the fines are defined as small fractures which can pass through 200 mesh screen (75 μm diameter). They are classified as primary fines (flaks or flour stuffs) and secondary fines (fibrils or slime stuffs) depending on their shapes [1–3]. While the primary fines are small fractures mainly from short fibers, vessel, ray cell, and parenchyma, the secondary fines are cell wall fractures of fibers [2,4,5]. The main studies have been focused on mechanical pulps related to the behavior of these fines. The role of fines on the chemical pulps especially on the recycled pulps has been rarely reported [6].

In mechanical pulps, there is general agreement that the addition of fines into fibers (long-fiber fractions) improved the strength, optical properties and printability of paper [7–9]. It has been believed that the increased strength due to the fines is originated from the bridging fibers, high bonding area, and increased surface area [10–13]. Generally fines increase apparent surface area resulting in the increased light scattering coefficient and opacity. High lignin content in the fines is another factor to contribute to the increased light absorption and light scattering [14].

The effects of fines on the paper properties vary depending on fine contents and quality. Although the fine content is considered a more important factor on paper properties, the quality of fines is another important one to have effect on paper properties, where the quality of fines is decided by the pulping process, fractionation method, and raw materials [14–16]. While the secondary fines work as a filling and bridging agent between the fibers resulting in increasing the density, tensile strength and decreasing the light scattering coefficient, the primary fines work as non-favorable stiff structure, a network between fibers, and filling agent, which result in increasing the density slightly but show no effect on the strength. However the primary fines have positive effect on the light scattering [12,17].

For a while, the effects of the fines on the fundamental properties of chemical pulps have been considered little important compared to the mechanical pulps because the chemical pulps are flexible and contain high level of the fines [18]. However the fines play an important role also in the fundamental properties of chemical pulps. The fines have a significant effect on the mechanical, optical and dewatering properties of the chemical pulp [19]. The fines from the chemical pulp contain more hemicellulose and lignin than the fibers, thus with higher specific surface area as they are easily swollen up. Therefore, the fines from the kraft pulps increase the sheet consolidation and strength, but generate a negative effect on the freeness and porosity [20].

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On the other hand, the effects of fines on the properties of the recycled pulps have been rarely reported. Generally, it is considered that the fines (primary and secondary fines) of the recycled pulps are undesirable for the strength properties, because the fines are produced from dried fibers. The recycled fines serve only to fill the empty space of the fibers and do not work in improving the bonding of the fibers. While Hawes and Doshi [21] reported that both primary and secondary fines contribute to the improvement of strength, some researchers affirmed that the increase of strength properties is not dependent on primary fines but only on secondary fines [22]. The effects of different types of fines on the physical properties of the recycled pulps are controversial up to now.

We fractionated long fibers from recycled copy paper (chemical pulp), and fines from two different kinds of pulps (chemical pulp and recycled pulp), then analyzed the physical and optical properties for each handsheet prepared by the different fibers and fine mixing ratio.

2. Experimental

2.1. Materials

Long fibers and two different kinds of fines were prepared. The long fibers were fractionated by removing the fines from an unprinted recycled copy paper which was consisted of 90% HW-BKP (hardwood-bleached kraft pulp) from oak, gum, and poplar, 5% SW-BKP (softwood-bleached kraft pulp), and 5% CTMP (chemi-thermomechanical pulp) from aspen. As sources of fines, two types of pulps were chosen; the HW-BKP from oak-gum-poplar and DIP (deinked pulp). The DIP was acquired by de-inking waste paper printed on the same copy paper as stated above.

The primary fines were obtained by disintegrating the copy paper for 10 min, and in the case of HW-BKP and DIP for 5 min in a standard disintegrator, followed by passing through a 200 mesh screen with water jet under high pressure. The secondary fines were acquired by refining the pulps without the primary fines in a Valley beater for 40 min with loading according to TAPPI Standard T200 os-70. The removal of secondary fines was also accomplished by the same method as stated above. The free fractions of the fines were used as the long fibers which primary and secondary fines were removed.

2.2. Handsheets preparation

The pulps for handsheets were prepared by recombining the long fibers and fines (primary and secondary) in various proportions (fine ratio: 0, 20, 30, 50 and 100%). The handsheets were prepared according to TAPPI Standard, and recycled white water was used to avoid losing the fines through the screen. The basis weights of the handsheets were ranged from 62 to 65 g/m^2 except handsheets with the 100% fines which ranged from 40 to 42 g/m^2 due to difficulty in dewatering. The handsheets with the 100% fines were prepared using a Bűchner funnel with a filter paper with 185 mm diameter (Whatman no. 2) [12].

2.3. Fines characterization

The length and coarseness of the fines were measured using a FQA (Fiber Quality Analyzer, Optest Co. model no. LDA96029). WRV (water retention value) was determined according to the method of Jayme [23]. Specific surface area of the fines was measured by BET (Brunauer, Emmett, and Teller) nitrogen absorption method. Average size and distribution of fines were measured using a Seishin Laser micron sizer (Model: LMS-24).

2.4. Physical testing of handsheets

The handsheets were conditioned according to TAPPI Standard T400 and T402M-83, then the following items were tested; density (T200 om-83), tensile strength (T494 om-81), tear strength (T494 om-82), burst strength (T403 om-85), porosity (T251 pm-75), and light-scattering coefficient (T425 om-91).

3. Results and discussion

3.1. Properties of the fines

Table 1 shows the fundamental properties of the long fiber and fines. As shown in Table 1, the secondary fines were longer than the primary fines. However there was no significant difference among the secondary fines.

For the HW-BKP and DIP, the coarseness of the secondary fines was higher than that of the primary fines. The coarseness of the fines depends on the cell wall thickness and fiber diameter at the same thickness [24], therefore the greater coarseness of the secondary fines maybe indicates the combined effects of the factors.

The average fine size was 24.1 μm, and ranged from 22.0 to 25.9 μm not dependent on the pulp type, primary or secondary fines, because these fines were collected by passing through 200 mesh screen.

The WRV of the fines was higher than that of a long-fiber fraction. The WRV of the secondary fines were higher than that of the primary fines. However, there was little difference in WRV between primary and secondary fines at the HW-BKP. The WRV of primary fines from DIP is noticeably lower than that of the secondary fines because of hornification during recycling.

The specific surface area of the secondary fines was much higher than that of the primary fines. The specific surface area of the primary fines from the DIP was similar to the primary fine from the HW-BKP. The specific surface area of secondary fines from the DIP showed the highest value among all the fines.

3.2. Handsheet properties of 100% fines

Table 2 shows the physical and optical properties of the handsheets made from the 100% fines. Handsheets composed of the secondary fines showed the higher density and physical properties than those of the primary fines. The fines of DIP were superior to HW-BKP in terms of density and physical properties. These differences were more prominent with the secondary fines

Table 1
The properties of the long fiber and fines.

Fiber type			Length (mm)	Coarseness (mg/m)	Particle size (avg.) (μm)	WRV	Spec. surface area (m^2/g)
Fines-free long fiber			0.943	0.119	–	162.8	3.38
Fines fraction	HW-BKP	Primary	0.103	0.224	25.85	323.8	6.41
		Secondary	0.113	0.293	25.28	342.5	9.58
	DIP	Primary	0.114	0.249	22.00	196.7	6.59
		Secondary	0.129	0.352	23.52	313.5	18.08