Effect of Paper Recycling and Beating on Fiber Length Distribution of Softwood Kraft Pulp

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Abstract: Laboratory paper recycling or beating with a PFI mill alone did not affect the fiber length distribution, and their effects on the mean fiber length and fines fraction were minimal. On the other hand, beating in addition to recycling caused a decrease in the mean fiber length and an increase in the fines fraction, leading to a distinct change in the fiber length distribution, that is, an increase in the short fiber fraction and the appearance of a characteristic peak from the fines fraction.

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1. Introduction

Almost all paper is now recycled many times. Accompanying an increase in the recycle number, the fiber-fiber bonding area decreases due to fiber hornification and the bond strength per unit bonding area also reduces and thus, strength reduction of paper made from kraft pulp is marked[1,2]. Further, the average fiber length usually more or less decreases with paper recycling, depending on its various conditions, such as : original pulp type, recycle number, dispersing consistency, and beating[3,4], and further decrease in the fiber length could also be considered as a possible cause of the strength reduction [1]. Thus, the change in the fiber length distribution caused by laboratory recycling and beating is examined to clarify the shortening of fibers and increases in the fines fraction in this study.

2. Experimental

2.1 Materials

A fully bleached kraft softwood pulp, in the form of dry pulp sheet, was obtained from a paper mill. Softwood pulp (length weighted mean fiber length: 2.31 mm, fines fraction: 6.5%, CSF: 680 mL) has a 2.5 times wider distribution of fiber length (Fig. 1), compared with that of hardwood pulp[5], and thus was expected to show a more distinct change in the fiber distribution due to recycling and beating. Simple drying and rewetting cycle of pulp did not reduce the fines fraction, however, the fraction was remarkably decreased by usual recycling with additional reslushing and sheet molding[6]. Thus, the pulp was in advance screened using a classifier with 80 mesh screen in order to remove the fines fraction. The fiber length distribution of the classified pulp (length weighted mean fiber length: 2.39 mm, fines fraction: 0.9%, CSF: 723 mL) is given in Fig. 2, showing the disappearance of the characteristic peak of the fines fraction. Simple laboratory recycling[7] was conducted 20 times as follows: the fines free pulp without beating, which was molded using the standard laboratory handsheet former, was soaked for 12 h in water at room temperature and then re-
dispersed for 25 min with a standard laboratory disintegrator, the pulp was molded to thin pads, and then the pulp pads were wet-pressed and dried over night by air blowing at 45 °C. The fines free pulps before and after recycling were beaten with a PFI mill at 1000 rev.

2.2 Measurement

Pulp fiber analysis including length distribution, length weighted mean fiber length, and fines(less than 0.2 mm) content was conducted using fiber quality analyzer (Optest Equipment). Freeness of pulps was measured as Canadian standard freeness (CSF).

3. Results

3.1 Effect of laboratory recycling

The repeated disintegration on recycling could produce fines or external fibrils from fiber surface by friction action between fibers[8] and further shortening of fibers by the collision of rigid fibers could be expected, since rigidity of fibers should increase due to hornification with recycling[1,2]. On the other hand, repeated sheet molding could cause a loss of fines through opening of the mesh[6]. As the results after 20 times recycling in this study, CSF decreased from 723 to 628 mL, and fines fraction increased from 0.9% to 1.4%, while the mean fiber length less changed from 2.39 mm to 2.37 mm and distinguished change in fiber length distribution was not recognized as shown in Fig.3. Above results suggested the shortening of fiber didn’t happen in this study. There are also some examples in which fiber length hardly changed in a laboratory experiment[6,9]. Differing from laboratory recycling, the commercial paper recycling employs pulp which had been beaten and includes lots of non-fibrous material such as fillers, thus probably fiber length could a little decrease, however, the further experiment is expected on this point.

3.2 Effect of laboratory beating before and after recycling

The fiber length distribution of the beaten pulps before and after 20 times recycling was shown in Fig.4 and 5, respectively. Although beating degree was fairly heavy, laboratory beating with PFI mill before recycling did not affect on the distribution, and the mean fiber length did not change, further fines fraction a little increased to 1.5%, while CSF decreased from 723 mL to 328 mL. On the other hand, beating of recycled pulp gave a distinguished change in the length distribution, that is, an increase in short fiber fraction (0.2-0.5 mm) and appearance of characteristic peak from fines fraction. Accompanying with the change in the distribution, mean fiber length clearly decreased to 2.25 mm, and fines fraction increased to 3.3% and further CSF drastically decreased to 86 mL. The result arising from fiber hornification with recycling suggested that PFI mill beating of rigid fibers affected on the fiber length distribution while the beating of soft fibers did not. As explained above, independently recycling and

Fig. 2 Fiber length distribution of the classified pulp before recycling.

Fig. 3 Fiber length distribution of the classified pulp after recycling.

Fig. 4 Fiber length distribution of the beaten pulp before recycling.
Fig. 5 Fiber length distribution of the beaten pulp after recycling.

beating less affected on the fiber length distribution, while recycling with beating caused the increase in fines fraction and the decrease in mean fiber length.

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References