A New Fiber Processing Method

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ABSTRACT

A fiber processing method, which might be an alternative for conventional refining process, was introduced. The method consists of repetitive, gentle, mechanical impacts on fiber, and ensued fiber uncurling process. This method was very effective for OCC and BCTMP for increasing WRVs (water retention value) while keeping fiber lengths from shortening. For OCC and BCTMP, gentle mechanical impacts on fibers using Hobart mixer increased breaking lengths and tear strengths simultaneously at fast drainage level, and straightening fibers using kady mill increased those strength properties further. For SwBKP and HwBKP, only mechanical impacts using the mixer were effective on increasing tensile and tear strength at fast drainage, but not kady mill treatment. The strength increases of BCTMP by this alternative fiber processing method were exceptionally high. An extensive engineering development should be followed to actualize this fiber processing mechanism in an energy-effect way.

INTRODUCTION

Refining of wood fibers change the fiber morphologies, increase paper bonding properties, and improve papermachine runnability. Refining, which uses rotating metal plates and bars, has been the most effective fiber mechanical processing method of all until now, and therefore, attempts to replace it have not been very successful. It may be worthwhile to mension a few different fiber processing methods tried by others that showed some potentials (1-3). A few researchers applied gentle, mechanical impacts on virgin and recycled fibers, or on mechanical and chemical pulp fibers, respectively, and found different effects from conventional refining (4-8). The repetitive, gentle, mechanical impacts, which were imparted by Hobart mixer, made the fibers flexible and curled. The curls formed from the impacts can be removed by applying DDR reining in the mills or valley beater refining in the lab, but refining always lowers fiber length and freeness as well. The fibers treated by Hobart mixer and valley beater in series, gave higher WRV at the same freeness levels as the fibers treated by valley beater only, and made higher tensile and tear strengths simultaneously as reported in the literature (5-9).

Kady mill had been used at low consistency to give high mechanical shear on fibers (10). We may use it to straighten curled fibers without lowering fiber lengths or freeness. So, we could design a series of system, which consists of a repetitive, gentle, mechanical impact process using Hobart mixer and ensued uncurling process using kady mill instead of valley beater. We tried to compare this alternative fiber processing method to valley beater refining in respects of fiber furnish

properties and handsheet strength properties.

EXPERIMENT

We used four different furnishes in the experiment – bleached kraft softwood pulp from Canada (SwBKP, a mixture of Hemlock, Douglus fir, and Cedar), bleached kraft hardwood pulp from Canada (HwBKP, a mixture of Aspen and Poplar), BCTMP obtained from Hansol Paper Co. in Korea, and OCC collected in Korea (KOCC). The fiber furnishes were all disintegrated completely and were thickened to 25% consistency, which was the consistency used in Hobart mixer for mechanical pretreatment. The mechanical pretreatment for 3 hours by Hobart mixer made the fibers flexible and at no time, increased fiber curl indices as byproducts. So we called the mechanically pretreated furnishes as curled fiber furnishes. We refined curled and control furnishes (no Hobart mixer treatement), after lowering consistency from 25% to 1.5%, to four levels of refining by using valley beater in laboratory. Refining by valley beater always lowered fiber curl indices. To remove fiber curls only without lowering fiber lengths, we applied kady mill to the fiber furnishes at 1% consistency. In the experiment, kady mill actually did not lower the fiber lengths, but decreased fiber curl indices of fiber furnishes indeed. Fig. 1 shows the schematics of the fiber furnish treatments.

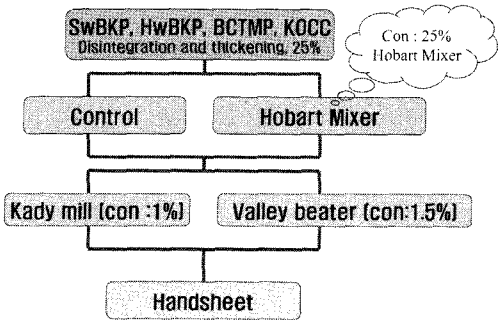


Figure 1. Schematics of the fiber furnish treatments

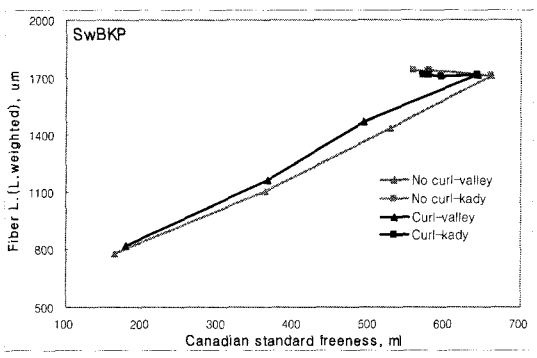
Morfi analyzer (Techpop, France) was used for fiber length analysis. Canadian standard freeness, WRV (water retention value, 900G), drainage time (Tappi T221), and handsheet strength properties were measured and analysized.

RESULTS AND DISCUSSIONS

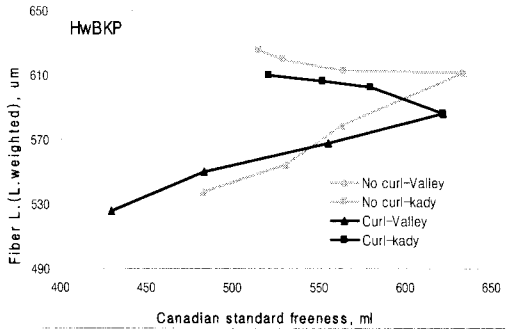
fiber length analysis

We expected Hobart mixer treatment would make extensive fiber wall delamination, and increase fiber curl indices from our previous studies (5-8, 11). If there are WRV increase by the Hobart mixer treatment without shortening fiber lengths and without increasing fine contents, we can believe there are extensive internal fibrillations or fiber wall delaminations in the furnishes. Extensive fiber wall delaminations will lead to the increase of fiber flexibility. We expected valley beater refining would lower the fiber curl indices and fiber lengths. We introduced Kady mill treatment on curled fibers to lower the fiber curl indices, but not to change the fiber lengths.

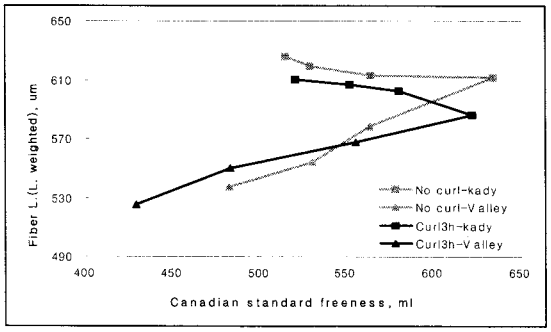
Fig. 2 showed no or very little, if any, changes of fiber lengths (length weighted) between curled and control samples (no curl) in all four furnishes by the valley beater refining at equivalent freeness levels, respectively. For kady mill treated samples, there were no changes in fiber lengths, but changes of freenesses for all furnishes.



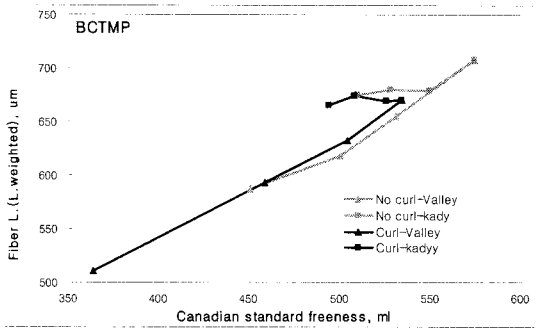
(2.A) SwBKP



(2.B) HwBKP



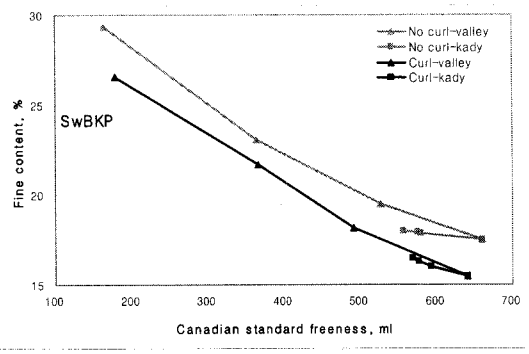
(2.C) OCC



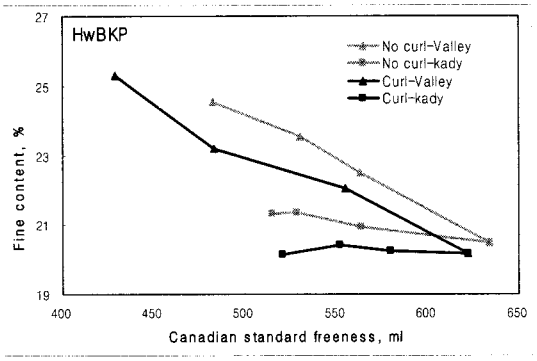
(2.D) BCTMP

Figure 2. Changes of fiber length for four furnishes by valley beater and kady mill treatment

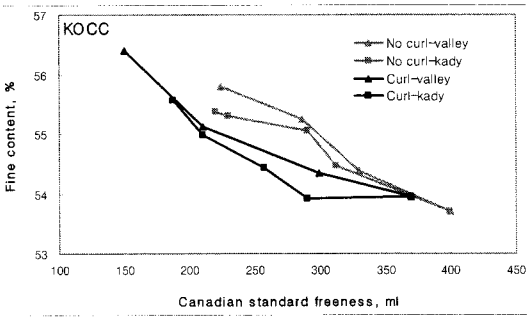
Fig. 3 showed less generation of fines generally by the curled fiber furnishes than the control furnishes at the same freeness levels.



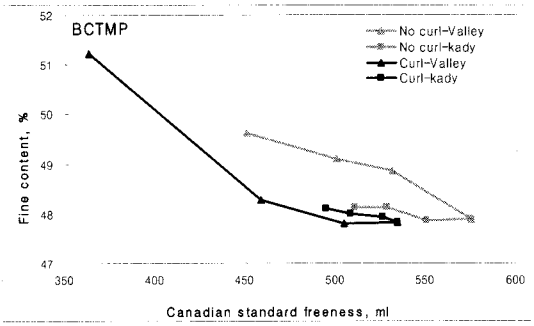
(3.A) SwBKP



(3.B) HwBKP



(3.C) KOCC

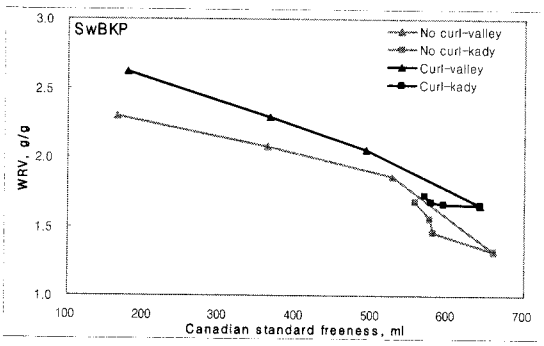


(3.D) BCTMP

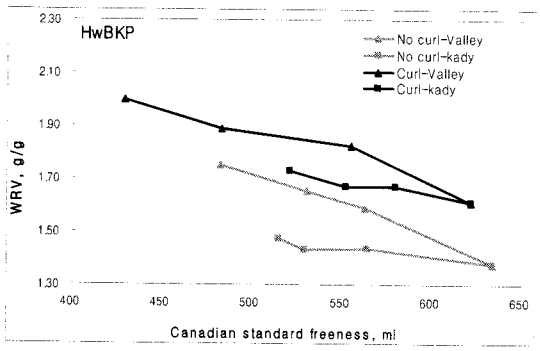
Figure 3. Changes of fine contents for four furnishes by valley beater and kady mill treatment.

Fig. 4 showed the increase WRVs of curled fiber furnishes when the fiber furnishes was subjected to either

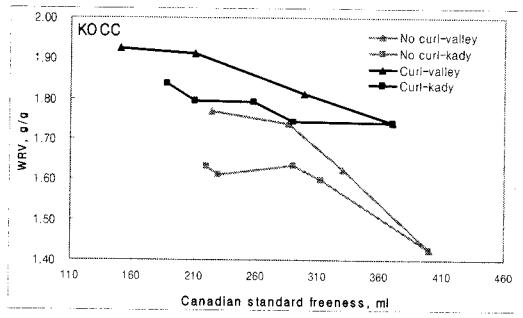
valley beater refining or kady mill treatment. In short, what we observed from the figures were that the curled fiber furnishes gave higher WRVs at less fine contents and at equivalent freeness as the control furnish. Presence of fines in fiber furnish usually increases WRVs, but not in our cases. Curled fibers had less fines, but higher WRVs than the control samples. From these results, extensive delaminations of the fiber walls were expected by the Hobart mixer treatment, as we showed their micrographs in previous publication (11).



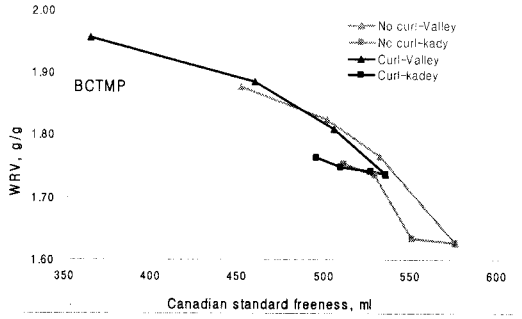
(4.A) SwBKP



(4.B) HwBKP



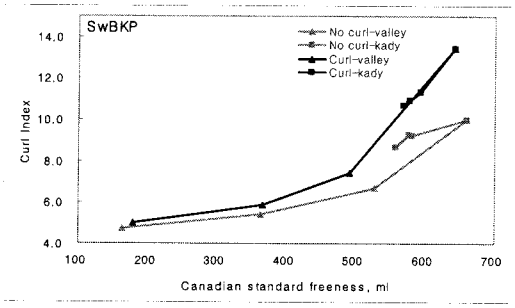
(4.C) KOCC



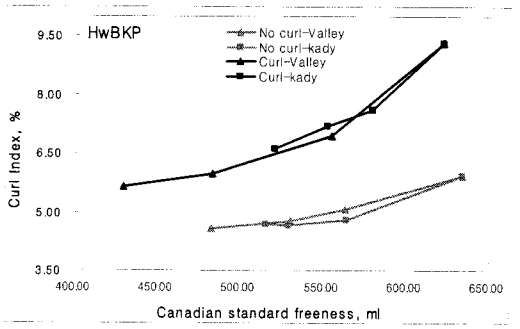
(4.D) BCTMP

Figure 4. WRV changes of four furnishes by valley beater and kady mill treatment

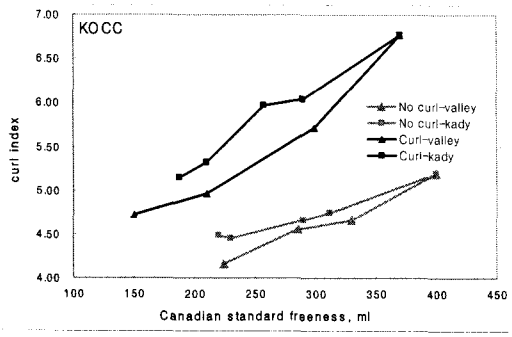
The kady mill treatment showed much less increase in WRVs than the valley beater refining at the same freeness levels. This means that continued kady mill treatment on fibers made no shortening of fiber length, little fiber wall delamination, but only lowered the fiber curls as much as valley beater treatment except BCTMP as shown in Fig. 5. In BCTMP case, the scale of curl index axis was so small that the curled fibers treated by kady mill showed up to only 0.4% drop of curl indices, which could be included in measurement errors. We can make another observation, which is that the curl indices of the curled fiber furnishes were always higher than those of the controls even at low freeness levels.



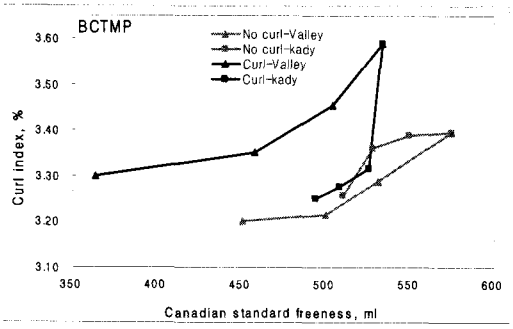
(5.A) SwBKP



(5.B) HwBKP



(5.C) KOCC



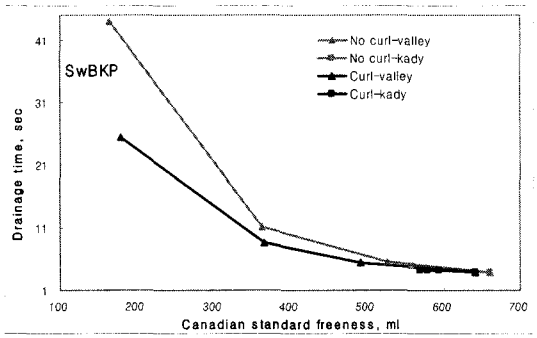
(5.D) BCTMP

Figure 5. Curl index changes of four furnishes by valley beater and kady mill treatment

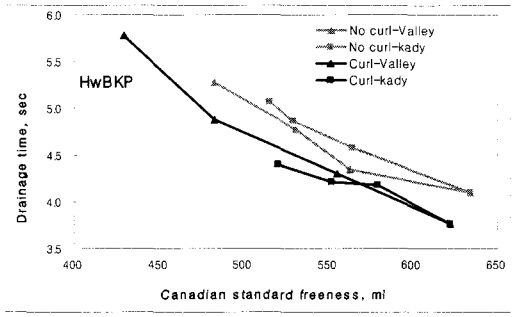
Curled fibers without further treatment such as valley beater refining, usually increase stretch, but decrease tensile and burst strength (12).

furnish drainage

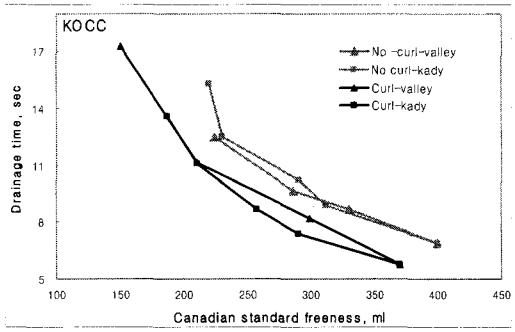
At the equivalent freeness levels, the curled fiber furnishes gave equivalent fiber lengths and less fine contents to the control furnishes, but gave higher WRVs when those fiber furnishes were under refining by valley beater. We may expect longer drainage times for the curled fiber furnishes due to higher WRVs at the same freeness levels. Fig. 6 showed our expectation was wrong. Three furnishes gave shorter drainage times than the controls except BCTMP, where the difference of the longest and the shortest drainage time was 0.8 second, which may be too small to make difference. Possible explanation of the shorter drainage time is that the curl indices of curled furnishes remained higher than the control furnish even at low freeness levels. Curled fibers usually give higher drainage than straight fibers (12).



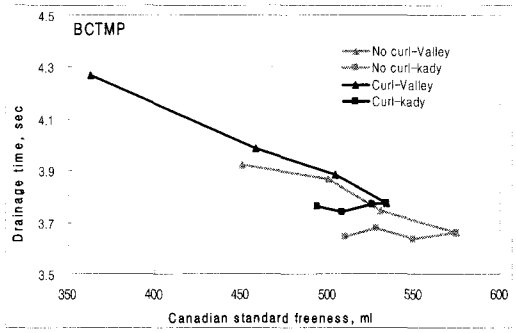
(6.A) SwBKP



(6.B) HwBKP



(6.C) KOCC

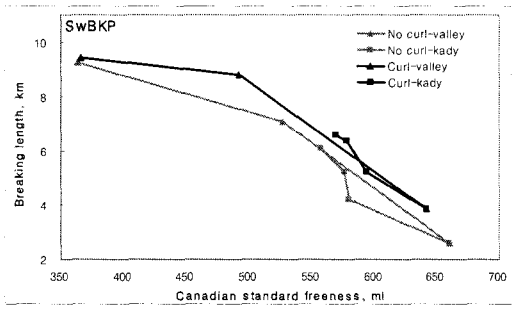


(6.D) BCTMP

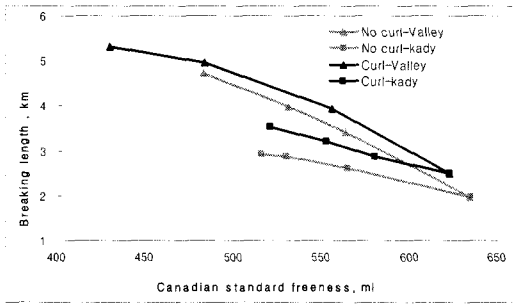
Figure 6. Drainage time changes of four furnishes by valley beater and kady mill treatment

strength properties

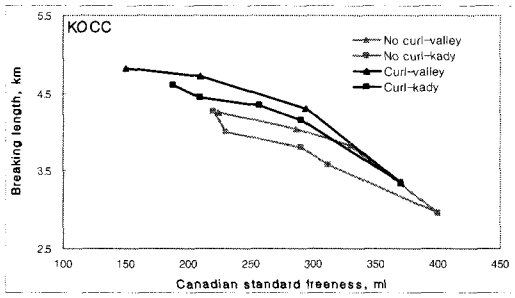
We could find the breaking length increases of curled fibers for all furnishes as shown in Fig. 7 at the same freeness levels. However, kady mill treatment gave the increase not as much as the valley beater treatment.



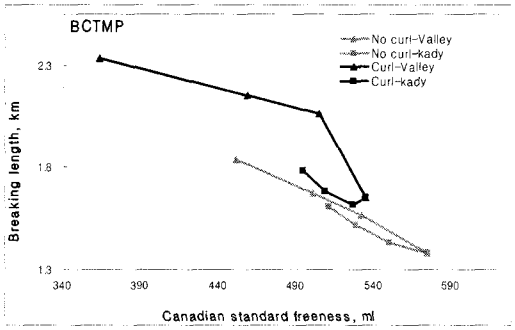
(7.A) SwBKP



(7.B) HwBKP



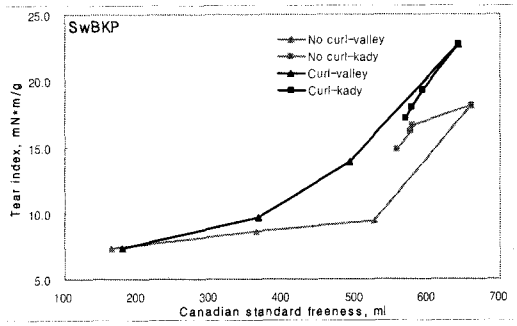
(7.C) KOCC



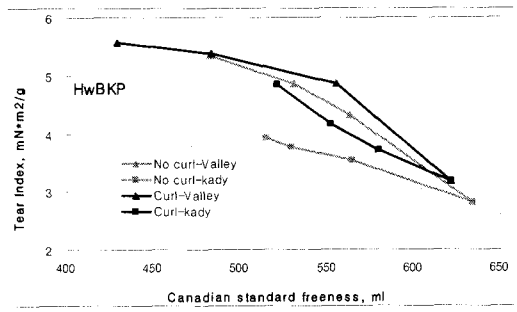
(7.D) BCTMP

Figure 7. Breaking length changes of four furnishes by valley beater and kady mill treatment.

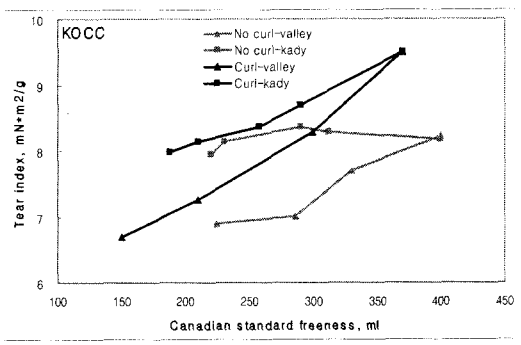
Tear indices of four furnishes of curled fibers were shown in Fig. 8. We could find the large increases of tear indices for four furnishes of the curled furnishes.



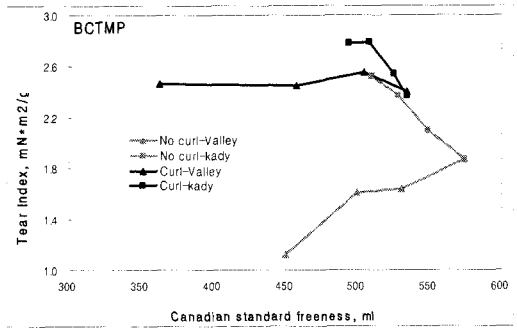
(8.A) SwBKP



(8.B) HwBKP



(8.C) KOCC

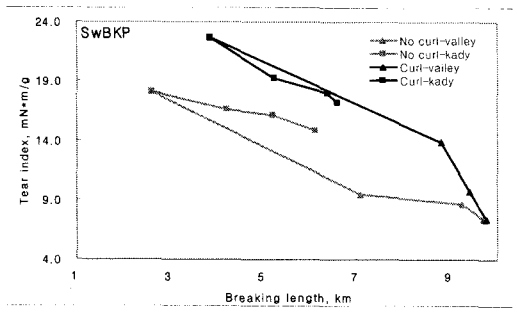


(8.D) BCTMP

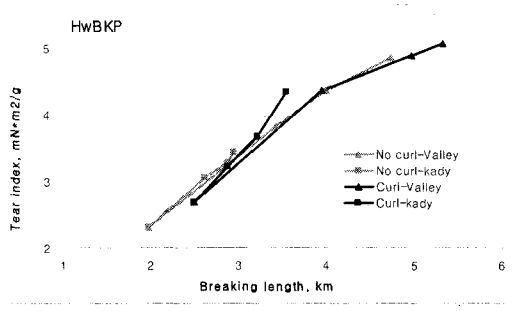
Figure 8. Tear index changes of four furnishes by valley

beater and kady mill treatment

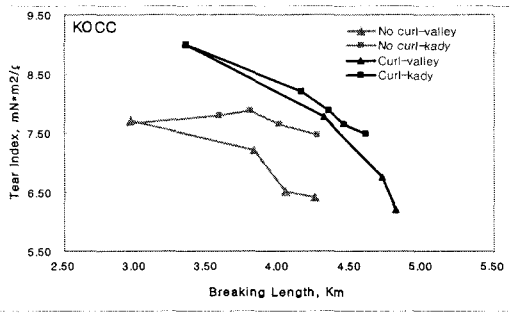
For BCTMP and KOCC, kady mill treatment showed higher increases in tear indices than valley beater treatment did. In tear index vs. breaking length graphs shown in Fig. 9, curled fibers gave large improvement of tear indices at the equivalent breaking length levels except HwBKP. However, even in HwBKP, the figure means the curled fiber furnish gave higher breaking length and higher tear strength at equivalent freeness levels. Kady mill treatments gave very little differences of tear strength from valley beater treatments for the curled fiber samples of SwBKP and HwBKP in the tear index vs. breaking length graphs. BCTMP and KOCC were the exceptional cases, where large improvement of breaking lengths and tear indices were shown simultaneously by the Hobart mixer treatment, and further dramatic improvement of tear indices by the kady mill treatment were shown. For the control samples of KOCC in Fig. 9, it demonstrates the possibility of changing the valley beater refining to kady mill type treatment, if improvement of tear index is needed without lowering breaking length. Sack paper made with recycled fibers may need high tear. More remarkable increase of tear was shown in BCTMP by the kady mill treatment.



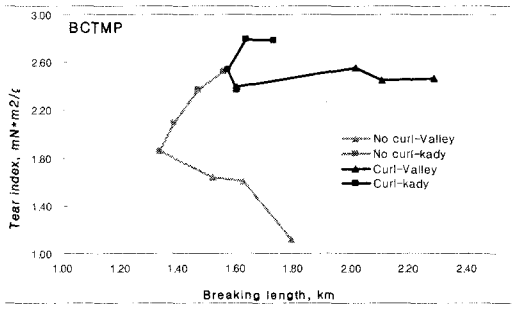
(9.A) SwBKP



(9.B) HwBKP



(9.C) KOCC



(9.D) BCTMP

Figure 9. Tear index vs. breaking length changes of four furnishes by valley beater and kady mill treatment

CONCLUSIONS

An alternative new fiber processing method was introduced, which consists of fiber mechanical pretreatment using Hobart mixer and ensued kady mill treatments for straightening curled fibers formed from Hobart mixer. The fiber curls formed by Hobart mixer are not the desired main effects of the mixer in our experiment, but byproducts. Main effects of the mixer we want, is the repetitive, gentle, mechanical impacts on

fibers. Valley beater was used to give refining effects as well as fiber straightening effects. Kady mill was introduced only to straighten fiber curls in this experiment. To actualize this fiber processing method in an energy-effective way, extensive engineering development should be followed. We used SwBKP, HwBKP, KOCC, and BCTMP as sample fiber furnishes in the experiment and following conclusions were made:

- Fiber mechanical pretreatment using Hobart mixer combined with fiber straightening process using valley beater or kady mill treatment increased WRVs of all fiber furnishes at the equivalent freeness levels as the sample furnishes without mechanical pretreatments.
- Kady mill treatment instead of valley beater refining kept the fibers from shortening and increased tear strengths remarkably further for KOCC and BCTMP.
- Tear strength and breaking length of BCTMP and KOCC were increased largely and simultaneously by the combined effects of mechanical pretreatment using Hobart mixer and kady mill straightening process.
- Drainage times for the mechanically pretreated samples were faster than the controls.
- For KOCC, application of kady mill type process instead of valley beater type refining could improve the tear indices without lowering breaking lengths.
- An alternative fiber processing method introduced in this study was most effective for BCTMP, and KOCC. For SwBKP and HwBKP, mechanical pretreatment of repetitive, gentle, mechanical impacts using Hobart mixer type treatment will be effective to increase tensile and tear strength properties simultaneously without loss of drainage. Kady mill treatment was not much effective to these virgin chemical pulps.

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