Journal of Korea TAPPI
Vol. 43. No. 5, 2011
Printed in Korea

An Alternative Fiber Processing Method

Yung Bum Seo[1†] and Chun Han Lee[2]

(Received December 2, 2011: Accepted December 26, 2011)

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 fibers, followed by 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 Hobart mixer were effective on increasing tensile and tear strength at fast drainage, but there were no further increase by 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.

KeyWords : *Mechanical impact, Fiber curl, Hobartmixer, Kadymill, Fiberstraightening, Breakinglength, Fiberlength, Tearstrength, WRV, Drainagetime.*

1. 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 mentioning a few different fiber processing methods tried by others that showed some potential1-3). Researchers applied gentle, mechanical impacts on virgin and recycled fibers, or on mechanical and chemical pulp fibers, respectively, and found different effects from conventional refining4-8). 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 refining 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 WRVs at the

1 Corresponding author, Dept. of Bio-based materials, Chungnam National University, Gung-Dong,Yousung-Gu, Daejun, Republic of Korea.
2 Research Associate, Pegasus Research Co.
† 교신저자(corresponding author) :E-mail; ybseo@cnu.ac.kr

same freeness levels than the fibers treated by valley beater only, and gave higher tensile and tear strengths simultaneously as reported in the literature5-9).

Kady mill (Model LB Kady mill. Kady International Co.) was used at 0.5% consistency and 12,000 RPM in room temperature to apply hyration and decurling of highly curled fibers without losing fiber length in the experiment. We assumed the shear force generated by the Kady mill in the fiber–water mixture could lower the fiber curl index without significant loss of fiber length. Actually, Kim had used the same kady mill for mechanical treatment of recycled fibers at the same consistency and RPM as we did, and found out almost no decrease of fiber lengths10). If the kady mill, we used, decurls the curled fibers without decreasing fiber lengths and furnish freeness, we could design a series of system, which consists of a repetitive, gentle, mechanical impact process using Hobart mixer and ensued decurling 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.

2. Materials & Methods

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 the same time, increased fiber curl indices as byproducts. So we called the mechanically pretreated furnishes as curled fiber furnishes. We refined curled

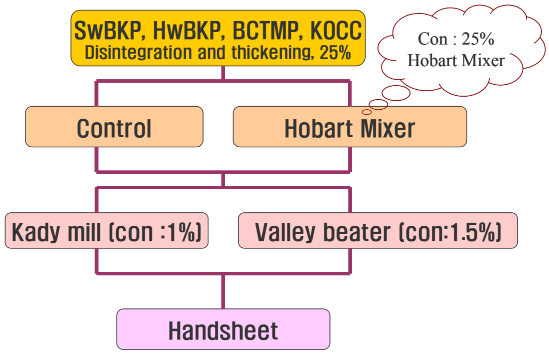

Fig. 1. Schematics of the fiber furnish treatments

and control furnishes (control has no treatment with Hobart mixer), after lowering consistency from 25% to 1.5%, to four levels of refining by using valley beater in laboratory. Refining by valley beater at low consistency always lowered fiber curl indices as well as fiber lengths. The capacity of the valley beater we used was 0.35kg of AD pulp, and we used a 5.5kg weight during the refining process. To remove fiber curls only without lowering fiber lengths, we applied the kady mill to the fiber furnishes at 1% consistency. In the experiment, kady mill actually did not lower the fiber length, but decreased fiber curl indices of fiber furnishes. Fig. 1 shows the 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 analyzed.

3. Results & Discussion

3. 1 Fiber length analysis

We expected Hobart mixer treatment would make extensive fiber wall delamination, and increase fiber curl indices from our previous studies5-8), 11). If there are WRV increases 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 at low consistency would lower the fiber curl indices and fiber lengths. We applied Kady mill treatment on curled fibers to lower the fiber curl indices, but not to change the fiber lengths.

Fig. 2 showed significant changes of fiber lengths (length weighted) by the application of valley beater refining, but little differences between curled and control samples (no curl) in all four furnishes at equivalent freeness levels, respectively. For Kady mill treated samples, there were no changes in fiber lengths, but changes of freenesses for all furnishes. Fig. 3 showed less generation of fines by the curled fiber furnishes than the control furnishes (no curl) at the same freeness levels. 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, compared to the control furnishes (no curl). 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 publication11). The Kady mill treatment showed much less increase in WRVs than the valley beater refining at the same freeness levels12). 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 as shown in Fig. 5. In BCTMP case, the scale of curl index axis was so small that the curl index differences by Kady mill and valley beater were less than 0.4% in total, which could be considered as measurement

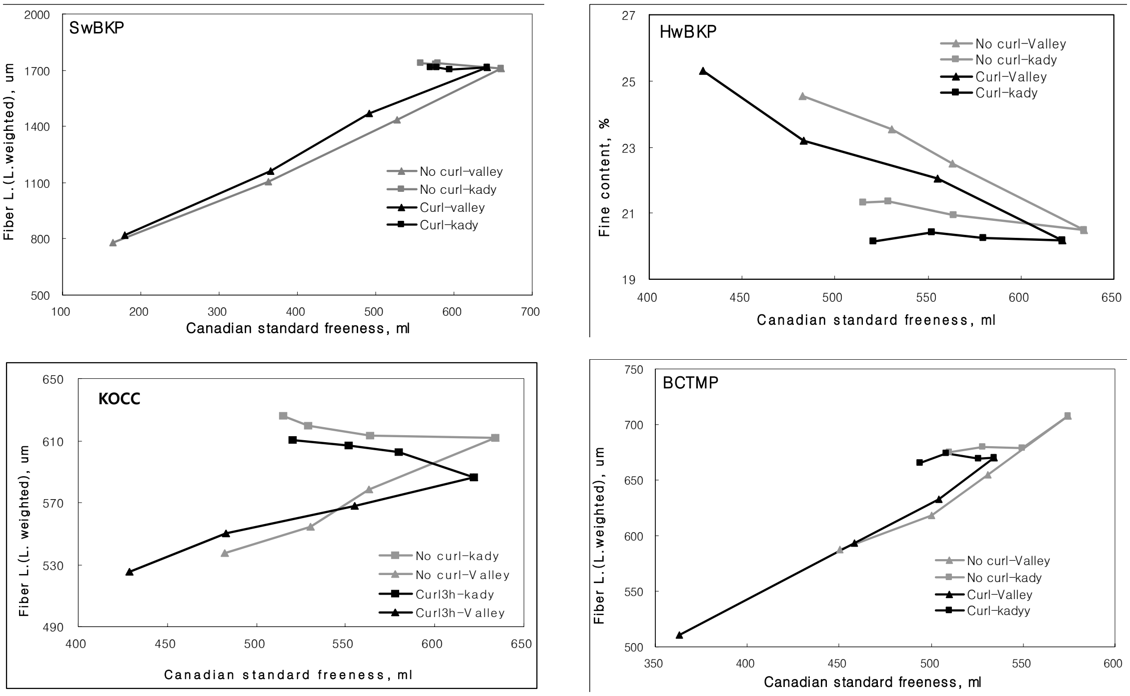

Fig. 2. Changes of fiber length for four furnishes by valley beater and kady mill treatment

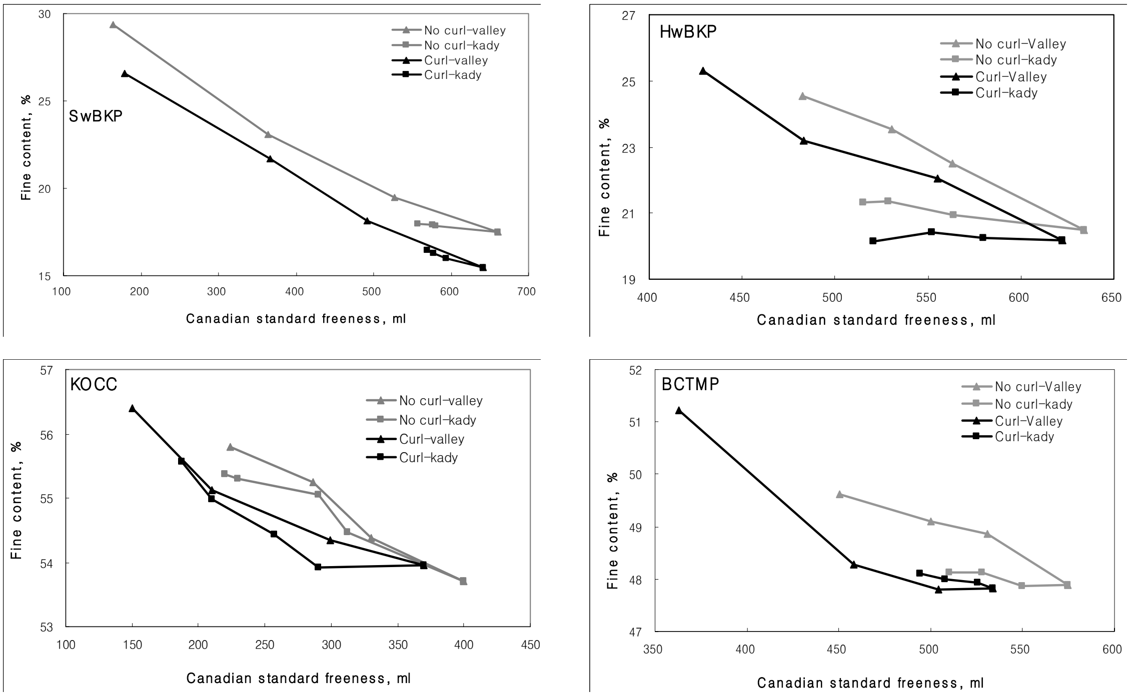

Fig. 3. Changes of fine contents for four furnishes by valley beater and kady mill treatment

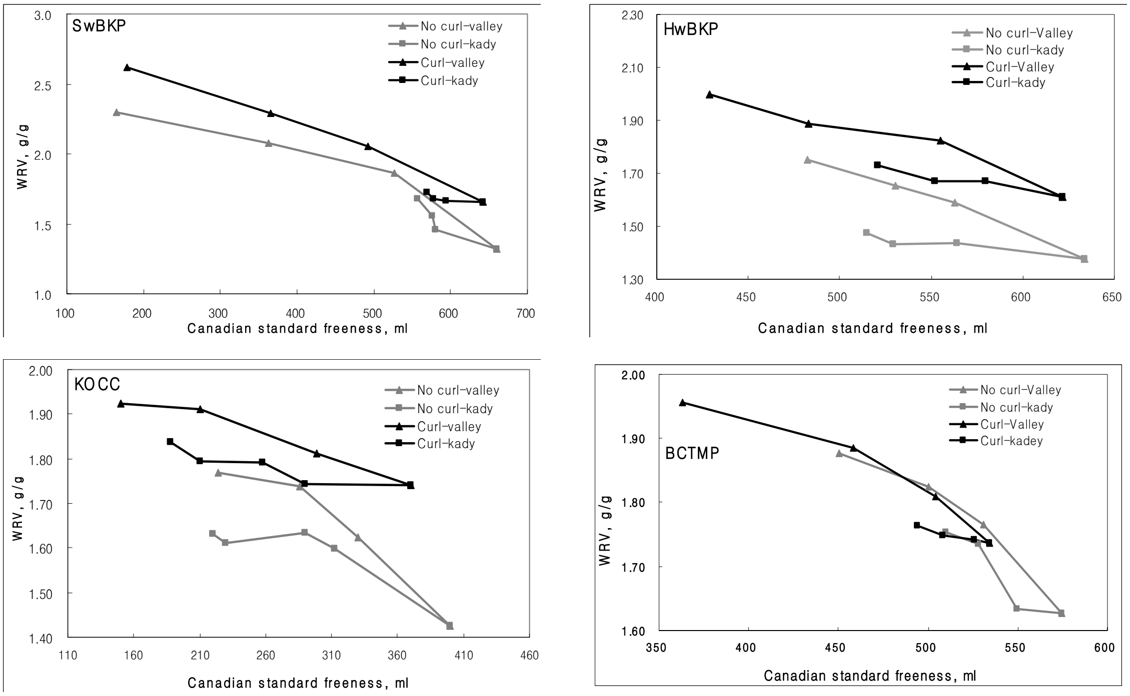

Fig. 4. WRV changes of four furnishes by valley beater and kady mill treatment

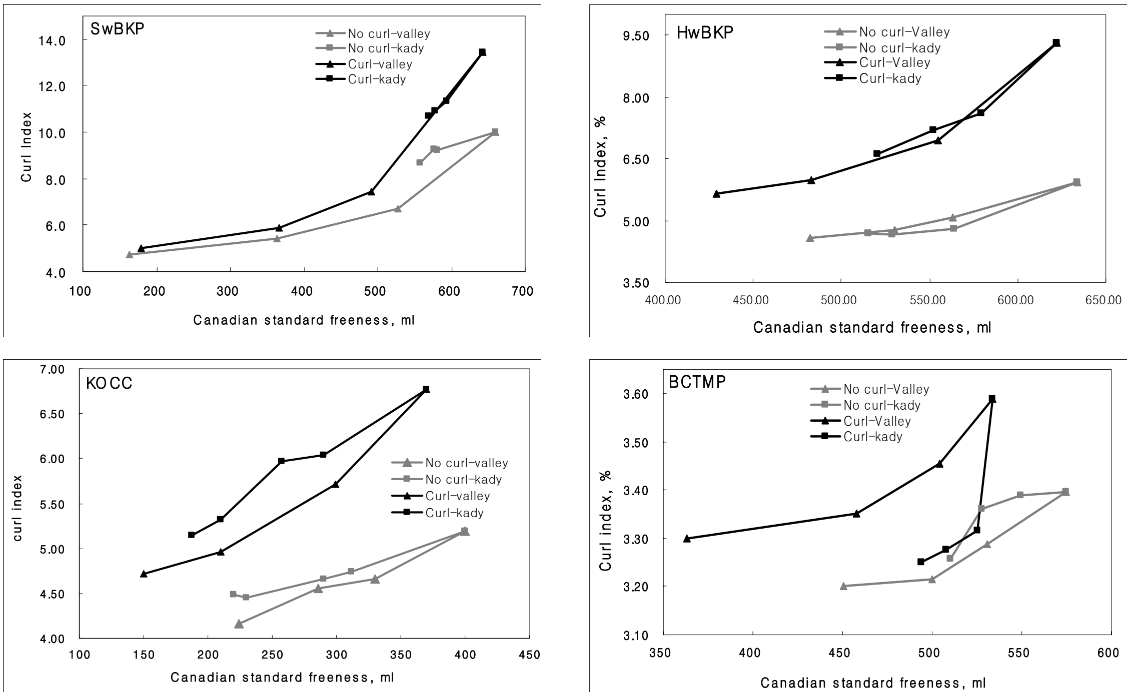

Fig. 5. Curl index changes of four furnishes by valley beater and kady mill treatment

errors. We can make another observation, which is that the curl index of the curled fiber furnishes were always higher than those of the controls even at low freeness levels. Curled fibers usually increase stretch, but decrease tensile and burst strength13).

3.2 Furnish drainage

At the equivalent freeness levels, the curled fiber furnishes gave equivalent fiber lengths and less fine contents to the control furnishes (no curl), but gave higher WRVs. 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 better drainage than straight fibers13).

3.3 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. 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. For BCTMP and KOCC, Kady mill treatment showed higher increases in tear indices than valley beater treatment did. We believe that's because Kady mill kept their fiber lengths from shortening. 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. The figure of HwBKP means the curled fiber furnish gave the same tear strength at the same breaking length

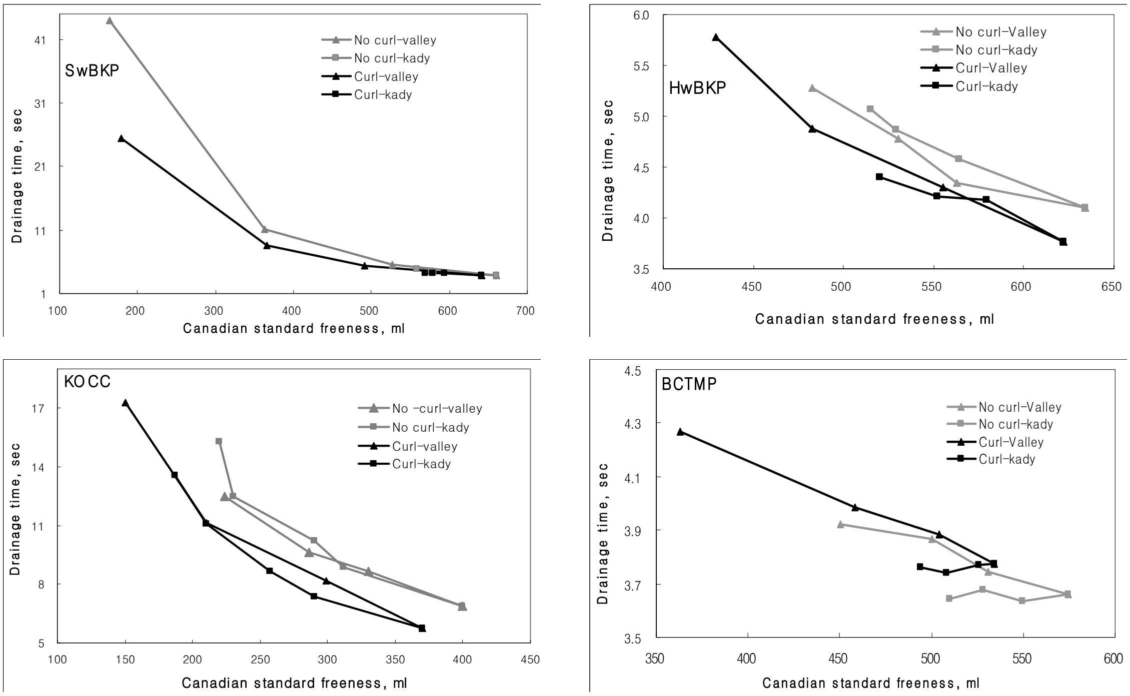

Fig. 6. Drainage time changes of four furnishes by valley beater and kady mill treatment

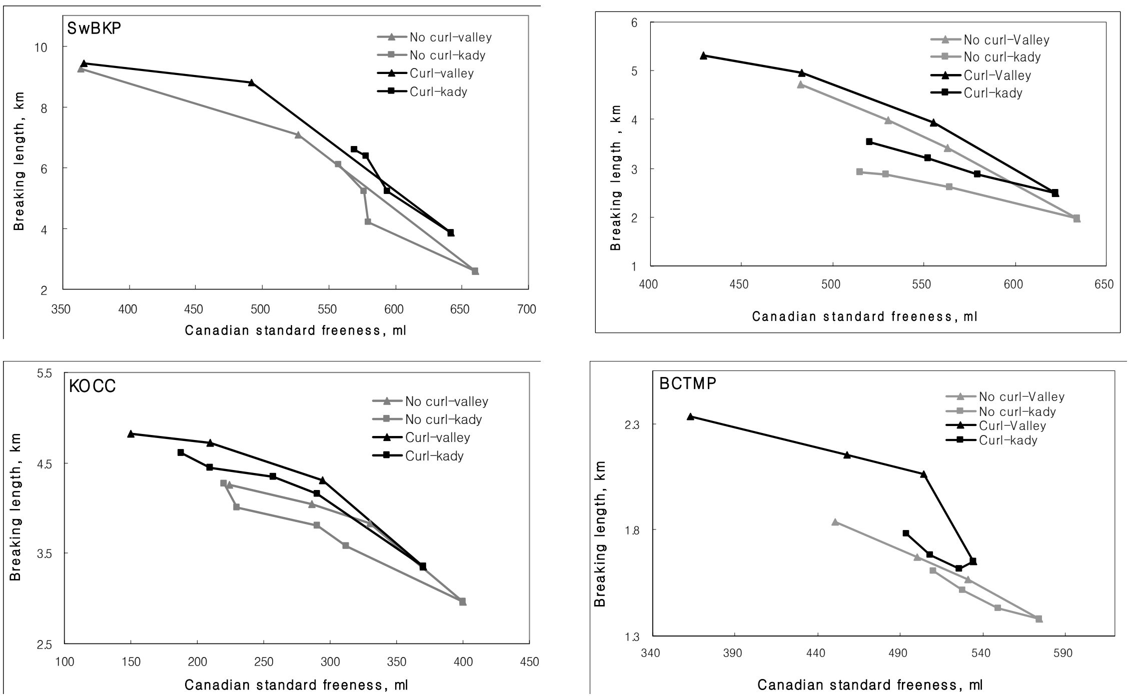

Fig. 7. Breaking length changes of four furnishes by valley beater and kady mill treatment

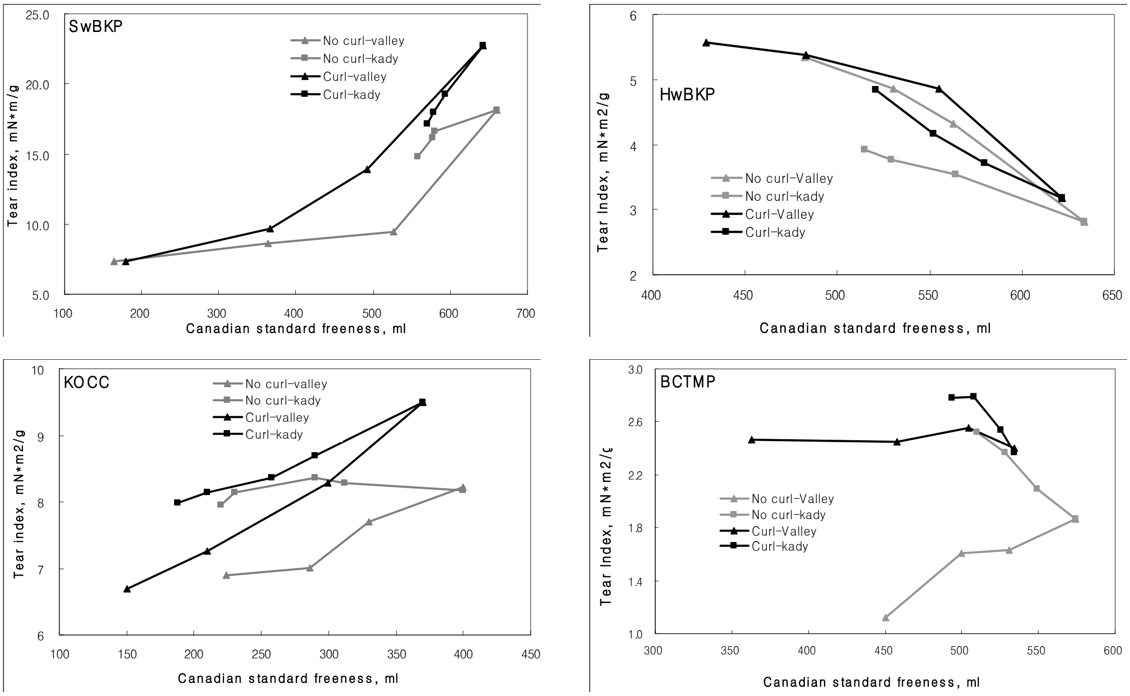

Fig. 8. Tear index changes of four furnishes by valley beater and kady mill treatment

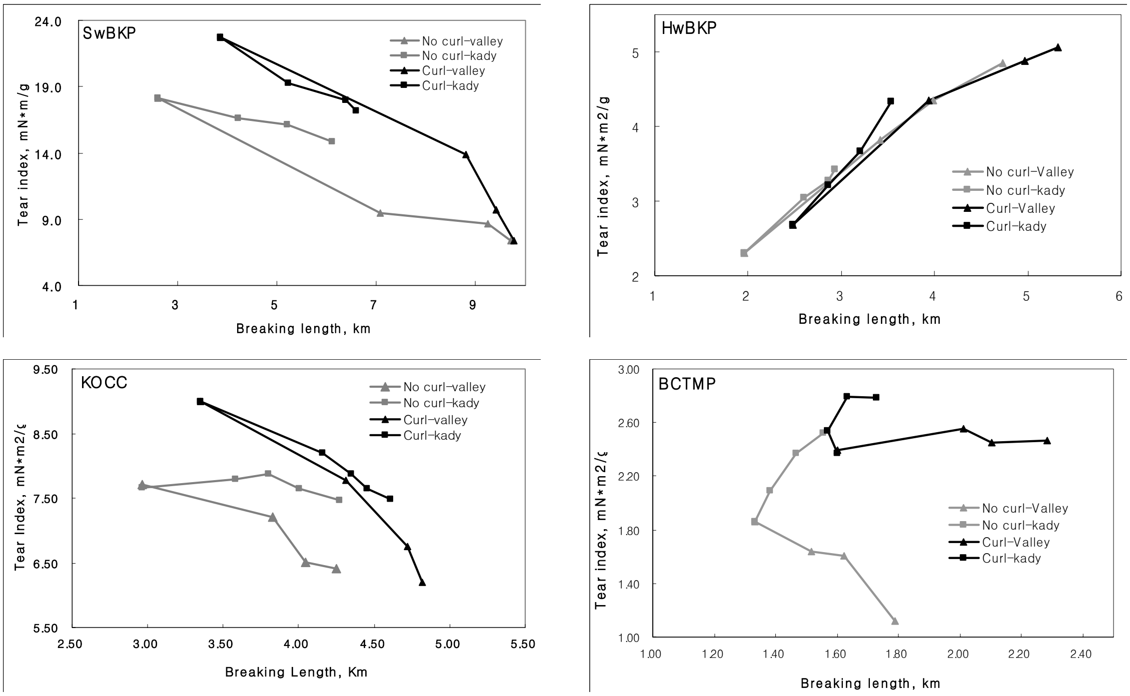

Fig. 9. Tear index vs. breaking length changes of four furnishes by valley beater and kady mill treatment

level. Important thing to remember is that the curled fiber furnish of HwBKP gave much higher breaking lengths already than the control by the Hobart mixer treatment.

The BCTMP was the exceptional case of tear index increase in Fig. 9, where large improvement of breaking lengths and tear indices were shown simultaneously by the Hobart mixer treatment followed by either the valley beater or the kady mill treatment. We may explain this in this way. In BCTMP, small increase of breaking length needed large decrease of fiber length (Figs. 2 and 7) for the control furnish (no curl furnish). But by the application of Hobart mixer and Kady mill treatment, the fiber lengths of BCTMP were kept effectively, and breaking lengths were increased very much (Fig. 7). It is known that at low breaking length level, which is the case of BCTMP, small increase of bonding increases tear index a lot. For the control samples (no curl) of KOCC in Fig. 9, it demonstrates the superiority of the Kady mill type treatment to the valley beater refining when improvement of tear index is needed without lowering breaking length. Sack paper made with recycled fibers may need high tear.

Conclusions

An alternative new fiber processing method was introduced, which consists of fiber mechanical pretreatment using Hobart mixer and ensued Kady mill treatments for decurling the 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 increased tear strengths 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 untreated controls.

For KOCC, application of Kady mill type refining 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 treatment 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.

Literature Cited

1. Tasman, J.E., The mechanical modification of paper-making fibres, Pulp Pap. Can. 67(12):T554 (1966).
2. Seo, Y.B., Shin, Y.C., and Jeon, Y., Enzymatic and Mechanical Treatment on Chemical Pulp, Tappi J, Nov., pp.1-9 (2000).
3. Seo, Y.B., Jeon, Y., Shin, Y.C., and Kim, D.K., Effect of mechanical impact treatment on fiber morphology and handsheet properties, Appta J., 55(6):475-479 (2002).

4. Omholt, I., The effects of curl and microcompressions on the combination of sheet properties, 1999 TAPPI International Paper Physics Conf. Proceedings, pp.499-515 (1999).

5. Lee, J.H., Seo, Y.B., and Jeon Y., J., Strength property improvement of OCC-based paper by chemical and mechanical treatment (I), J. Korea TAPPI, 32(1): 10-18 (2000).

6. Lee, J.H., Seo, Y.B., Jeon Y., Lee,H.L, and Shin, J.H., Strength Property Improvement of OCC-based Paper by Chemical and Mechanical Treatments(II), J. Korea TAPPI, 32(2):1-7 (2000).

7. Lee, J.H., Seo, Y.B., and Jeon Y., Strength Property Improvement of OCC-based Paper by Chemical and Mechanical Treatments (III), J. Korea TAPPI, 32(2): 8-15 (2000).

8. Seo, Y.B., Choi, C.H., Seo, S.W., Lee, H.L., and Shin, J.H., Fiber property modification by mechanical pretreatment, Tappi J., 1(1):8-13 (2002).

9. Seo, Y.B., Lee, M.G., Ha, I.H., and Cho, W.Y., Effect of Papermaking Additives on Fiber Mechanical Pretreatment, J. Korea TAPPI, 35(4):1-7 (2003).

10. Kim, D.K., MS thesis, Physical properties of recycled fibers treated with different refining methods, Chungnam National Univ., Replblic of Korea (1997).

11. Seo, Y.B., Choi, C.H., and Jeon, Y., Effect of mechanical pretreatment on fibre properties, Appita J., 56(5):371-375 (2003).

12. Cowan, W.F, High shear laboratory beating and fiber testing offer new insights into pulp quality, Tappi J., 78(3):133 (1995).

13. Page, D.H., Seth, R.S., Jordan, B.D., and Barbe, M.C., Papermaking Raw Materials, Vol. 1, Mechanical Engineering Publications Ltd., London, p.183 (1985).