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Application of WCT(Wet Compaction Test) for Fiber Evaluation

Yung B. Seo[†], In Ho Ha[*1], and Chun Han Lee[*2]

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ABSTRACT

Wet compaction test (WCT) is a fiber evaluation method where wet fibers are compressed at one side of a cylinder and water drains out from the other side. The consistency of the fiber furnishes and their pressures are recorded during the test. In the previous study we found that WCT results always gave better coefficients of determination in fiber furnish drainage, and paper properties (density, tensile, tear, and burst strength) than those of WRV (water retention value). Fiber freeness and fiber length correlated well with drainage and tear strength of the furnishes, respectively; however, their correlations were very much improved by combining the WCT results. In this study, we used the WCT test for fractionated fiber furnishes to see whether improvement of the WCT is possible. We found that strength properties such as breaking length and burst index were correlated better with the fractionated long fiber furnishes. Drainage was greatly affected by the presence of short fiber furnishes. We used bleached chemical pulps (SwBKP, HwBKP), recycled pulp (OCC), and mechanical pulp (BCTMP) as fiber furnishes in this study. Fiber fractionation can be performed on-line in these days by using multifractor and WCT can be used as an on-line test in papermachine in the future.

Keywords : wet compaction test, fiber evaluation, drainage, WRV, freeness, fiber fractioation

1. Introduction

The objective of this study is to improve the WCT(Wet Compaction Test) performance in the prediction of fiber furnish and paper properties by cooperating with fiber fractionation technology. For the experiment, we fractionated fibers with 150 and 400 mesh screens.

• Chungnam National Univ., Daejun, Republic of Korea
[*1] Tae-A Co., Daejun, Republic of Korea
[*2] Pegasus Research Inc., Daejun, Republic of Korea
[†] Corresponding Author: E-mail;ybseo@cnu.ac.kr

There are a few fiber evaluation methods such as fiber length measurement, WRV(water retention value), canadian standard freeness, specific surface area, and so on. These methods are useful to reveal parts of the fiber furnish properties, but have many limitations to predict fiber and paper quality overall. It is also true to say that there is no single universal factor that predicts most of paper properties. What we want to develop in this study was to find a factor to predict fiber furnish and paper quality together, and it also had a on-line measurement potential.

In WCT (1-4), a known amount of wet fiber pad is squeezed in a predetermined diamenter cylinder under the increasing pressure while water drains out through the screen in the opposite side of the cylinder. The ratio of compaction, the fiber pad thickness, and corresponding pressure were recorded for the analysis. The principle of the wet compaction test (WCT) was so simple that the device was designed to be attached to any on-line test machines. As long as the exact amount of fiber samples are collected on-line, WCT can be used to predict the fiber furnish quality.

2. Experimental

2.1 The wet compaction test device

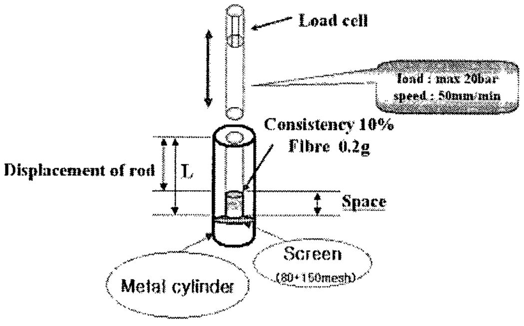
The schematics of WCT device were shown in Fig. 1.

2.2 Fiber furnish

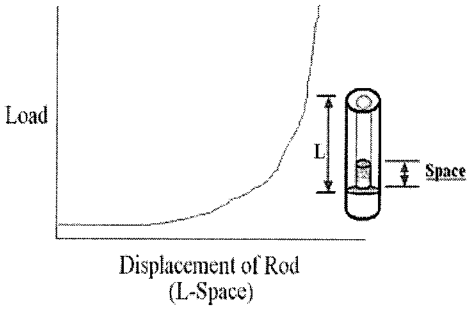
We used four different furnishes in the experiment such as bleached kraft softwood pulp from Canada (SwBKP, a mixture of Hemlock, Douglas fir, and Cedar), bleached kraft hardwood pulp from Canada (HwBKP, a mixture of Aspen and Poplar), BCTMP obtained from Hansol Paper Co. in Korea, and OCC collected in Korea (KOCC). Laboratory valley beater was used to refine those pulp fibers in 3-4 levels. After refining, part of pulp fibers were screened by 150 and 400 mesh screen to make 150 mesh-screened furnish and 400 mesh-screened furnish, respectively. Whole fibers, 150 mesh-screened furnish, and 400 mesh-screened furnish were used to make handsheets and were evaluated by WCT device.

2.3 Fiber furnish evaluation and data analysis

Morfi analyzer (TechPAP, France) was used for fiber length analysis. We used length weighted fiber length in length. Canadian standard



(a) Schematics of WCT sensing device



(b) Schematics of data collection for WCT

Fig. 1. Schematics of WCT device.

freeness, WRV (900G), drainage time (TAPPI T221), and handsheet strength properties were measured according to TAPPI standard method and analyzed. WCT gave a series of pressure vs. space data everytime, and we used the space data at 15 bars only in this study. In the regression analysis, we used multiple linear regression for the statistical analysis, and used the coefficients of determination from the analysis for the comparsion of how well the regression model fits data.

3. Results and Discussions

3.1 Comparison of WRV and WCT

WRV and WCT are similar in respect of applying wet pressure on wet fiber furnish. After applying very high pressure up to 900 kg/cm^2 to the fiber furnish, the weight of water remained in one gram of wood fibers is measured to read WRV. In WCT, high pressure up to 25 kg/cm^2 is applied to wet fiber furnish, and the volume or the height change of the fiber furnish is measured according to pressure increase. If fiber wall is very rigid in WCT, the height change will be minimal, and the volume of the furnish will be large regardless of how much hydrophilic the fibers are, while WRV only measures the hydrophilicity of exposed fiber surface (5).

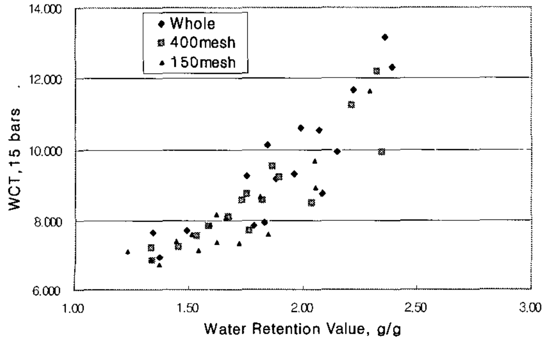


Fig. 2. Relationship of WCTs and WRVs.

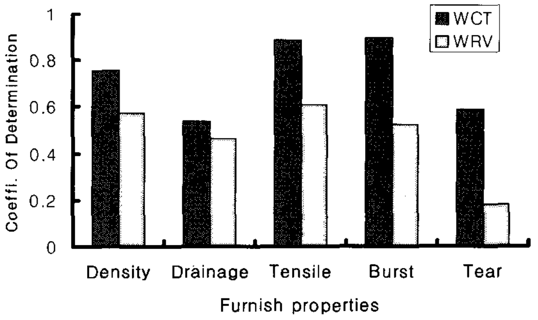


Fig. 3. Comparison of coefficients of determination of WCT and WRV. (Calculated from whole fiber furnishes)

We used four different furnishes and their refined furnishes altogether in the regression analysis. In Fig. 2, the relationship between WCTs and WRVs were shown. In different fiber furnishes and refining levels, WCT and WRV had high correlations. Measurement of WRV of fiber furnish usually takes long time. We may consider that WCT measurement can replace WRV in on-line test. However, when we compare the quality of two parameters in respect of coefficients of determination, Fig. 3 showed the results. In every respect, WCT makes regression models fit better than WRV. From Fig. 4, the furnish without fiber fines passing 150 mesh

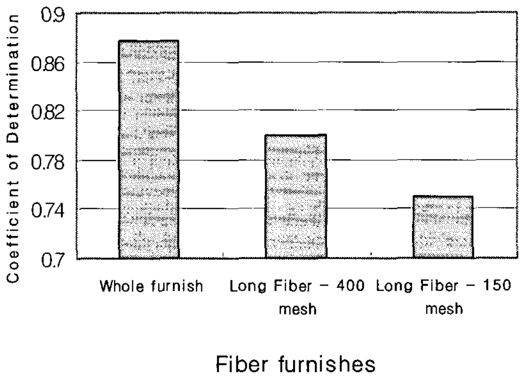


Fig. 4. Coeffcients of determination between WCTs of fractionated furnishes and WRVs of whole furnishes.

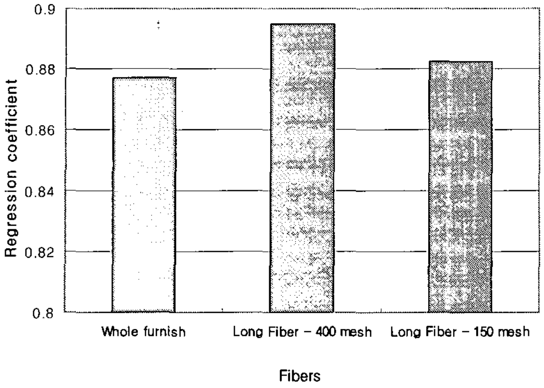


Fig. 5. Coeffcients of determination between WCTs of fractionated furnishes and WRVs of fractionated furnishes.

screen gave the lowest regression coefficient of all. This means that WCTs without fines may not predict WRVs of whole fiber furnishes correctly. However, if we correlates WCT results with the WRVs of each fractionated furnish (e.g. WRV of long fibers from 400 mesh and the WCT of the same furnish), the regression results are different as in Fig. 5, where whole fiber furnish gave the lowest regression coefficient.

3.2 Paper properties

Relationships of breaking lengths against WCT and WRV were shown in Figs. 6 and 7, respectively. We found WCTs and WRVs of whole furnishes did not show high correlation, but those of 400 mesh and 150 mesh passed furnishes did. Removal of WCTs of whole furnishes were shown in Fig. 8, and the relationship between WCTs and breaking lengths were improved greatly. We found the same trend for WRVs. Between two screened furnishes, 150 mesh-screened furnish always gave higher coefficient of determination.

In burst index, the relationship exactly follows breaking length case. WCTs and WRVs measured from the long fiber furnishes of 150 mesh screen

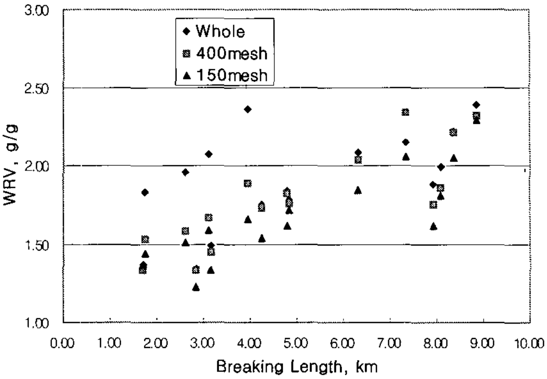


Fig. 7. Relationship between WRV and breaking length. (Fractionated WRVs to the breaking lengths of whole furnishes)

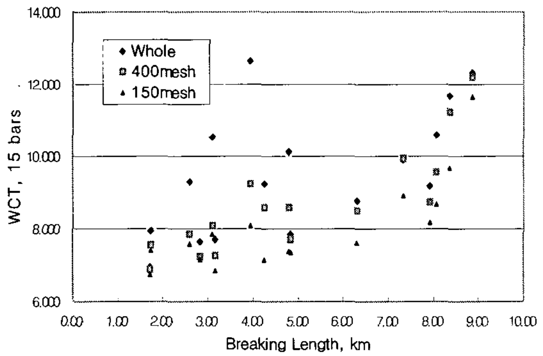


Fig. 6. Relationship between WCT at 15 bars and breaking length.
(Fractionated WCTs to the breaking lengths of whole furnishes)

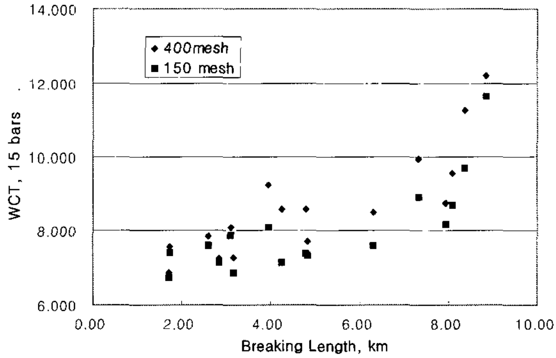


Fig. 8. Relationship between WCTs at 15 bars and breaking length.
(WCTs measured for fractionated furnishes only)

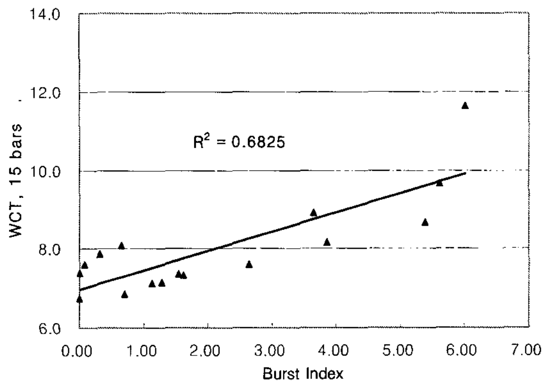


Fig. 9. Relationship between WCTs at 15 bars and burst index. (WCTs measured from long fiber furnish of 150 mesh screen)

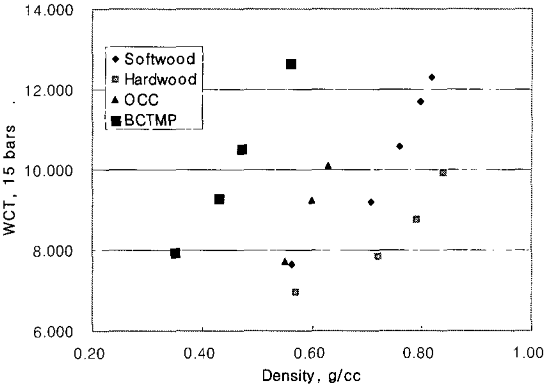


Fig. 10. Relationship between WCTs at 15 bars and density. (WCTs and densities measured for whole furnishes only)

gave the highest regression coefficient of all. We showed a WCT vs. burst index curve in Fig. 9.

In density, four different funishes showed four different curves for WCT and WRV, respectively, as shown in Figs. 10 and 11. In previous study, we showed that in case when these fibers are mixed in a certain propotion, the relationship between WCTs and densities were found to be an average of the corresponding curves (6).

3.3 Tear index, drainage, freeness, and fiber length

From Fig. 3, we knew drainage and tear strength of the fiber furnishes did not give high coefficients of determination with WCT or WRV. Those two properties were related to freeness and fiber length. Fiber length is a powerful predictor of tear strength of the furnish. Fig. 12 showed excellent relationship between tear index versus fiber lengths of whole, 400 mesh, and 150 mesh furnishes. Fiber lengths of any furnish (here, SwBKP, HwBKP, OCC, and BCTMP) at any refining levels can be a good predictor of tear

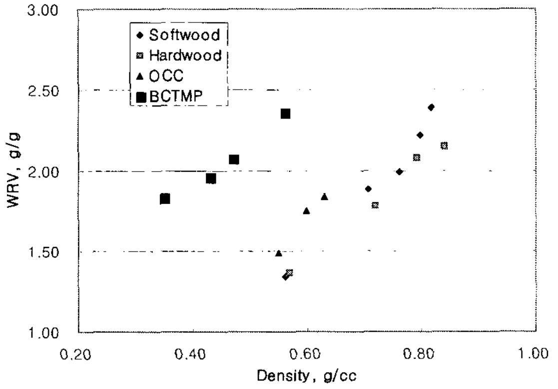


Fig. 11. Relationship between WRVs and density. (WRVs and densities measured for whole furnishes only)

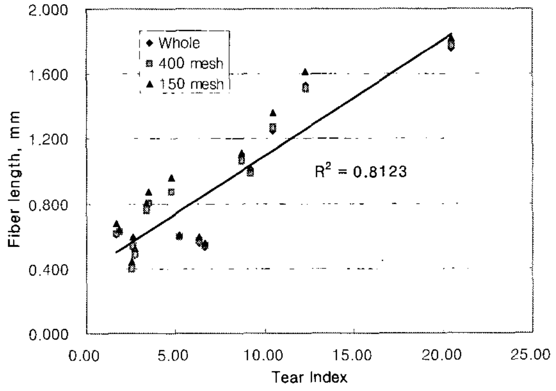


Fig. 12. Relationship between fiber lengths and tear index. (Tear index measured for whole furnishes only)

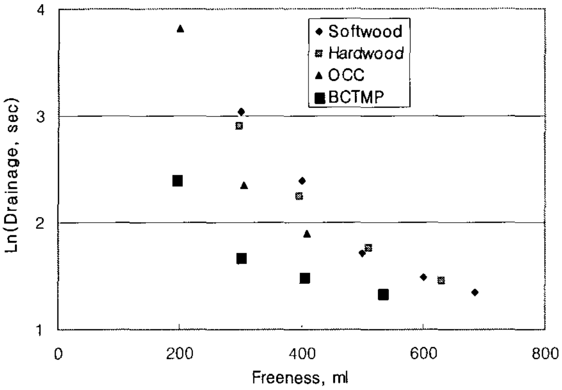


Fig. 13. **Relationship between freenesses and drainage. (Drainages and freenesses measured from whole furnishes only)**

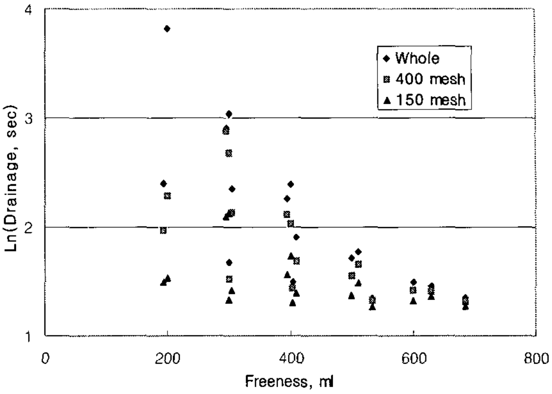


Fig. 14. **Relationship between freenesses and drainage. (Drainage measured from whole furnishes only)**

index of the corresponding fiber furnish. We did not include the effect of fiber curl in this study. We know fiber curl increases tear strength without affecting fiber length (7-11).

For the drainage of whole furnish, we found a meaningful relationship only with the freenesses of whole furnishes (Fig. 13). It seems the drainage of BCTMP has its own exclusive relationship with its freeness as in Fig. 13. When the freenesses of 400 and 150 mesh-screened furnishes were plotted against the drainage of the whole furnish, wide variations came out as shown in Fig. 14. We believe, in darinage and freeness, the fines removed in the screening process did a significant role.

4. Conclusions

Wet compaction test (WCT) was developed for the potential on-line tester for fiber evaluation, and its usefulness was tested by using four different fiber furnishes such as SwBKP, HwBKP, BCTMP, and KOCC, which are refined and fractionated further by 150 and 400 mesh screens. To quantify the usefulness of the WCT, multiple linear regression analysis was extensively used as a tool. We made a few conclusions based on the experiments as followed.

- WCT always had high coefficient of determination with WRV in four different fiber furnishes (SwBKP, HwBKP, OCC, and BCTMP) and at their different refining levels.
- WCT gave higher coefficients of determination over WRV in fitting the regression models with handsheet strength properties and drainage.
- WCT and WRV measured from the long finbers of 150 mesh screen, gave better coefficient of determination for the breaking lengths and burst indices than those measured from the whole furnish.
- Fiber lengths are always excellent predictors of tear indices of the corresponding furnishes.
- Each individual furnish has its own drainage and density linear curves against WCT. Different furnish showed different linear curves.

Acknowledgment

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