

Using a microprocessor to determine the consistency of kraft pulp

Peter W. Hart, Jeffery S. Hsieh, and Keith S. Medlock*

Pulp and Paper Engineering Program, School of Chemical Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0100

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Precise determination of pulp consistency typically involves time-consuming oven-drying procedures. Standard oven-drying techniques require a minimum of 4 h to complete. This report describes a rapid method of determining pulp consistency that can reduce the required testing time by as much as 75%. The method involves the use of a microprocessor in conjunction with a resistive heating element and an accurate force balance.

The microprocessor monitors the weight loss of a pulp sample as water is evaporated under controlled heating. These data are used to develop a drying curve depicting weight loss over time. Figure 1 illustrates a typical drying curve for kraft pulp. Once the shape of the drying curve has been obtained, the microprocessor continuously extrapolates the weight-loss data to predict the consistency of the sample. When the predicted weight-loss curve falls within a preset percentage of the actual drying curve, the microprocessor terminates the test and reports the predicted final consistency.

Time savings of 75% over oven-drying methods have been reported. The time required to run a sample depends on the initial consistency of the sample. High-consistency samples contain less moisture than low-consistency samples and thus require less time to analyze. Pulp samples at 20-30% consistency can be run in under 30 min. Low-consistency sam-

ples (about 3% consistency) can take up to an hour.

Description of method

The reason for the large reduction in testing time can be explained by looking at the shape of the drying curve. As seen in Fig. 1, a typical drying curve is divided into three distinct sections:

- Segment A-B: initial heating phase, where the rate of evaporation begins to increase slowly
- Segment B-C: linear phase, where evaporation proceeds at a constant rate
- Segment C-D: exponential phase, where the rate of evaporation begins to slow down.

During the initial phase, the sample is rapidly heated from ambient temperature to test conditions. The microprocessor controls the temperature of the test chamber by manipulating the power to a nichrome heating element. Radiant heat from the nichrome element rapidly elevates the surface temperature of the pulp sample. To prevent charring of the sample during this initial rapid-heating phase, the microprocessor cycles the heating time, allowing the sample surface to cool through evaporation.

During the linear phase of the drying process, the sample is maintained at a constant temperature. The linear rate of weight loss (drying) in this portion of the drying curve is associated with the removal of unbound water from the pulp sample.

The final and longest portion of the drying curve is the exponential phase.

Bound water within the fibers is slowly removed at this time. The microprocessor carefully monitors the profile of the exponential weight-loss portion of the drying curve. The resulting data are continuously fit to a mathematical regression formula dictated by the shape of the drying curve.

The final moisture content of the sample is determined by extrapolating the weight-loss data to a final consistency. This is what makes the large reductions in testing time possible. By extrapolating the weight-loss data to total dryness, the long oven-drying times needed to remove the bound water from the fiber are avoided. The exponential phase on the drying curve can take up to 75% of the total drying time. Using a microprocessor to eliminate this drying phase can save a lot of time.

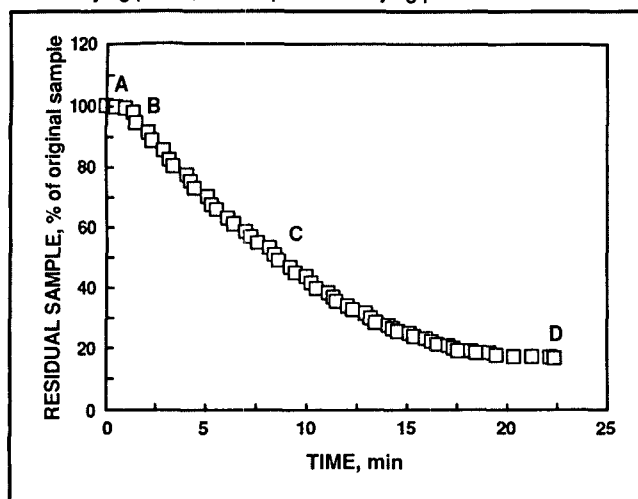
Before it can predict the final moisture content of a pulp sample, the microprocessor must obtain data from the initial portion of the exponential phase of the drying curve. All unbound moisture must be evaporated in the linear phase of the drying curve before the exponential drying phase can begin. Thus low-consistency samples, which contain larger quantities of unbound water, require a longer time to run than high-consistency samples. Figure 2 shows the required test times for a range of pulp consistencies.

Setup procedures

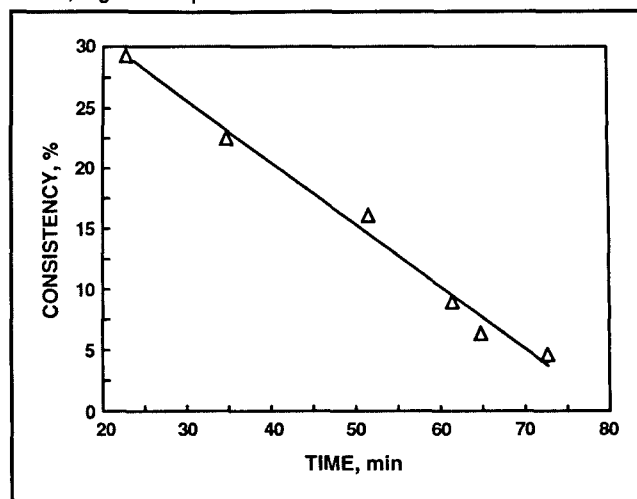
Operation at the proper temperature was found to be critical to the accuracy of the microprocessor prediction. When the operating temperature was too low, the microprocessor tended to

*Current address: Fluor Daniel, 100 Fluor Daniel Dr., Greenville, SC 29607.

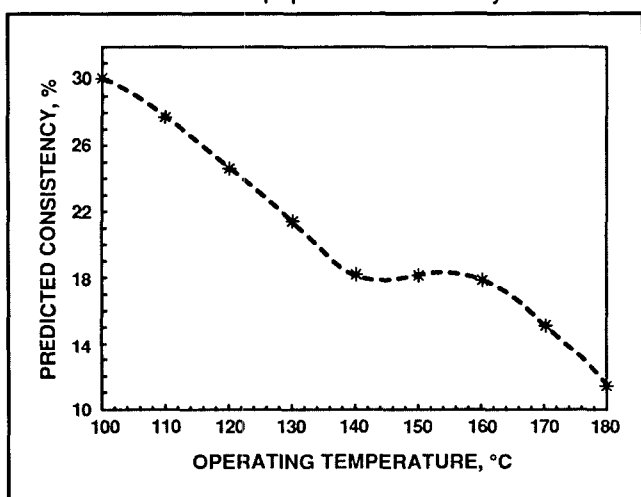
1. Typical kraft pulp drying curve: A-B, initial heating phase; B-C, linear drying phase; C-D exponential drying phase



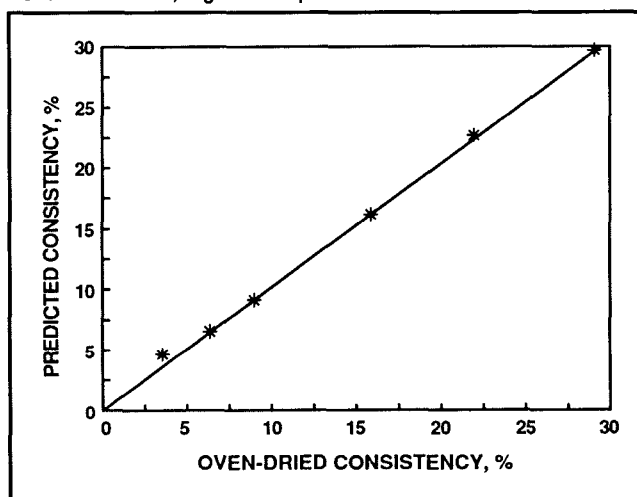
2. Test time as a function of sample consistency. Operating conditions: 150°C, 5-g wet sample.



3. Predicted consistency as a function of operating temperature for unbleached softwood kraft pulp at 18.2% consistency



4. Experimental error as a function of sample consistency. Operating conditions: 150°C, 5-g wet sample.



overpredict the consistency of the pulp. Low temperatures require long drying times in the exponential portion of the drying curve. When the sample weight changes only slightly because of the low temperature setting, the microprocessor is able to fit the data to the final and flattest portion of the drying curve and predict a final consistency that is too high.

Operation at excessively high temperature yields predictions that are lower than the actual consistency. High-temperature operation tends to char the surface of the sample during the exponential drying phase. Evaporative cooling is only effective in preventing surface charring during the initial phase of the drying curve. It does not prevent charring during the exponential drying phase, since

only small amounts of evaporation occur during this phase of the drying process. The charred material is recorded as weight loss and thus is computed as moisture in the pulp sample. By mistaking the weight loss from charring as water, the microprocessor predicts the resulting consistency to be lower than the actual consistency.

Figure 3 shows predicted consistency as a function of operating temperature for a kraft pulp at 18.2% consistency. The plateau corresponds to the acceptable range of operating temperatures for the sample in question. Operation anywhere within the plateau temperature range provides acceptable results for the specific sample of interest.

We determined the appropriate

operating temperature for kraft pulp by developing eight such curves using four bleached and four unbleached pulp samples, all at different consistencies between 3% and 30%. Results for each curve were compared with the actual sample consistencies obtained from 24-h oven-drying tests. The temperature associated with the smallest total error for the four test samples was chosen as the operating temperature for the unit. An operating temperature of 150°C was chosen as the optimum for kraft pulps. (Similar results were obtained for both bleached and unbleached kraft pulp samples.)

The appropriate sample size was determined in a similar manner. Sample size was varied from 1 g to 10 g. There was a trade-off between

test time and accuracy. Small samples had a smaller weight loss associated with drying, thus resulting in short test times at the expense of accuracy. Larger samples (about 5 g) eliminated the accuracy problems.

The final setup procedure was to test the precision of the method. Pulp samples of varying moisture content

were prepared. The consistency of randomly selected samples was determined both by the microprocessor and by the traditional oven-drying method. Each test was repeated three times. The final results, shown in Fig. 4, indicated that moisture-content predictions were within an acceptable range for the entire range of pulp

consistencies. Error for the high-consistency pulps was about 0.1%, while error for low-consistency pulps was close to 7%. □

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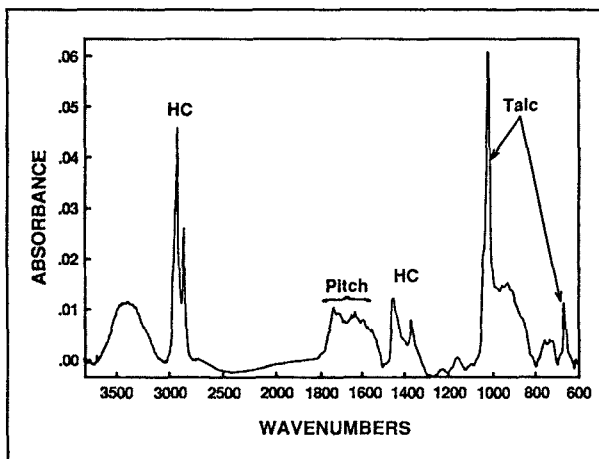
CORRECTION

Incorrect figures in wire contamination paper

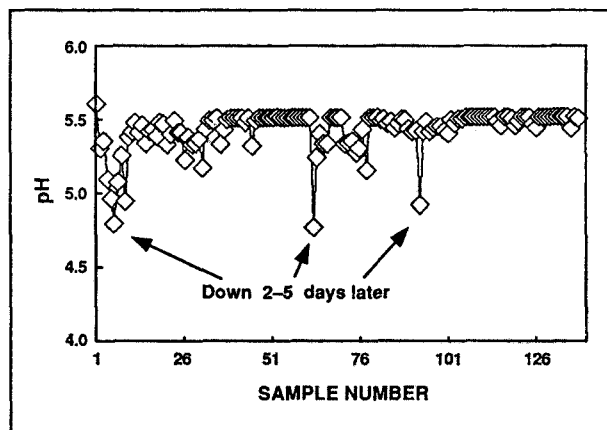
Three figures were incorrectly represented in "Resolving wire contamination on a tissue machine," by Daniel J. Pekrul and Charles W. Neal in the October journal.

The graphs were inadvertently omitted from figures 5, 6, and 7, located on page 98. The correct figures are shown here.

5. FT/IR of wire contamination



6. Fabric layer pH (shift averages)



7. Fabric layer of pH (12 minute averages)

