Using the drainage time to evaluate mechanical pulps

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In most research papers on the characterization and evaluation of mechanical pulps, the characterization factors correspond to the average fiber length and shape of the particles in the pulp. The average fiber length can be easily obtained by means of fiber length classification data. On the other hand, there is no commonly agreed-upon method for determining the shape factor.

Forgacs (*1*) determined the shape factor from the freeness of the 50:100 fraction. The procedure requires that more than one batch of pulp be classified to get a big enough sample for that purpose. Kindler and Clark (*2*) surmised that the shape factor determined in this way was a measure of the slenderness of the fiber. As a factor, they used the drainage time of the 50:100 fraction in the drainamometer, a simple apparatus designed for this purpose. This method requires that the consistency of the pulp fraction be determined before performing the drainage test. Besides, the water for the experiment has to be at a specified temperature.

Taking into account that the drainage behavior is important in evaluating a pulp, we decided to study the drainage phenomenon as it occurs in the standard sheet machine. We found that the drainage behavior can be characterized by only one parameter, which we called "resistivity" (R) and which can be readily determined from the drainage time test by using any sample weight within a wide range and using running water with no temperature requirements.

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Drainage time equation

We applied the macroscopic mechanical energy balance to the drainage process in the ordinary sheet machine. Among the assumptions (*3*), the main one was the invariability of the average specific drainage resistance through the thickness of the mat being formed.

The flow through fiber beds in papermaking conditions produces a porosity distribution throughout the bed which varies from a maximum value at the upstream section to a minimum value at the downstream section (*4*). Nevertheless, we thought that for a pulp without fines under the conditions of a typical sheet machine, we could leave aside the porosity variation and, consequently, the drainage resistance variation.

Darcy's equation of flow through a porous medium was used in the following way:

$$\Delta P = G \mu v R \qquad (1)$$

where

ΔP = the pressure drop across the mat, dynes/cm²

G = the basis weight of the mat formed at each moment, g/cm²

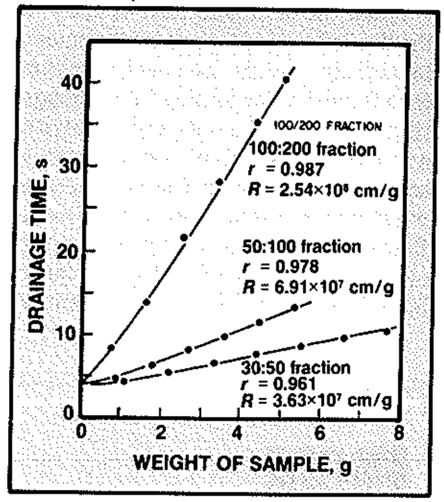
μ = the viscosity of water, g/cm·s

v = the velocity in the free section, cm/s

R = the resistivity, characterizing drainage behavior.

The application of the energy balance, first over the mat and then over all the sheet machine, led us to the following expression of the drainage time:

1. The fitting of Eq. 2 over drainage time of three fractions of the same chemimechanical pulp. (R = resistivity. r = correlation coefficient.)



I. Resistivity values obtained at different water temperatures from 5.5 g of a 50:100 fraction

Temp., °C	Drainage time, s	Resistivity, 10^7 cm/g
38	13.4	8.43
35	14.15	8.48
31	15.0	8.38
27	16.3	8.48
25.5	16.55	8.35
23.5	17.0	8.27
22	17.55	8.27
21	18.25	8.43

$$DT = \alpha/2g\,[\alpha + F_m - F_n - (B/2)\ln(F_n + n + B/2)/(F_m + m + B/2) + m \ln (F_n + m\,B/2m + m)/(F_m + B/2 + m)] \qquad (2)$$

where

a = 48.47

n = 80

m = 115

$\alpha = s \gamma r$

F_n = $(n^2 + B\,n + m^2)^{1/2}$

F_m = $(2m^2 + B\,n)^{1/2}$

B = $2[g\,(K/\alpha^2)] - m$

K = $154.9\,(DT_w)^2$

s = the slurry consistency in the sheet machine, g/cm³

γ = the kinematic viscosity of water, cm²

g = the acceleration due to gravity

DT_w = the drainage time of water alone, s.

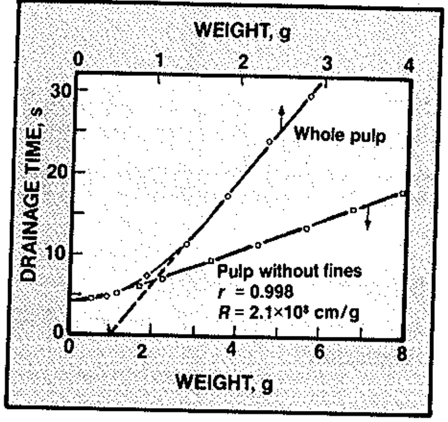
Equation 2 corresponds not only to the TAPPI machine but also to the SCAN machine. To obtain an R value from a experimental DT value, it is useful to have a table of DT against α.

When the drainage time is close to the time of water alone, it is convenient to slightly modify the sheet machine with the aim of increasing the drainage times. A removable screwed tube with a quarter of original section and a screwed flange attached to the machine wire may be used. Also, a removable flow restriction has to be placed at the outlet tube to keep the DT_w value near 3.8 s. In this way, the arrangement or removal of these fittings only takes a few seconds.

Drainage times in the modified machine against the sample weight of the three fractions are illustrated in **Fig. 1.** Equation 2 fits well for the 50:100 fraction as well as for the 100:200 fraction. On the other hand, an acceptable invariability of R obtained from DT at different water temperatures can be observed in **Table I.**

Figure 2 shows that Eq. 2 also fits well for a chemical pulp without fines (R 100 fraction). Nevertheless, the real importance of Eq. 2 arises from the fact that it makes it possible to easily determine the resistivity of a 50:100 fraction of a mechanical pulp which, according to my experience (*3*), may be successfully used to characterize the pulp.

2. Drainage time of a bleached kraft pulp (400 mL CSF) in an ordinary sheet machine.



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