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Fiber length of pulp by classification

1. Scope

1.1 This method is designed to measure the weighted average fiber length of a pulp. If a fiber is 1 mm in length and weighs w mg, then for a given pulp, the weighted average length (L) is $\Sigma(wl)/\Sigma w$, or the sum of the products of the weight times the length of each fiber divided by the total weight of the fibers in the specimen.

1.2 Use of either Clark type or Bauer-McNett type classifier will produce identical results within the stated precision.

1.3 Fiber length may also be measured by TAPPI T 271 "Fiber Length of Pulp and Paper by Automated Polarized Optical Analyzer Using Polarized Light." The results may not agree as the measurement methods are not the same.

2. Significance

2.1 Fiber length is a fundamental property of pulp. There have been indications (1, 2) that, provided the coarseness of the fibers remains constant, the tensile strength of a sheet made from relatively unbeaten pulp (other factors being the same) will vary as $L^{1/2}$, the burst strength will vary as L , the fold endurance as L^5 , and the tear resistance as $L^{3/2}$. These relationships will be true independent of the uniformity of lengths of the fibers, whether they are a mixture of various lengths or all of one length, but the numerical values of the exponents will decrease as the pulp is beaten. The density of the sheet will be appreciably affected by L if the fibers are the same coarseness.

2.2 The numerical average fiber length is of much less significance. If the fibers are of mixed lengths, it is an arbitrary measurement, largely influenced by the lower limit adopted, below which a particle is no longer regarded as a fiber. The weighted average fiber length of a pulp may exceed the numerical average length several times, if particles down to a length of 0.01 mm are included in an estimate of the numerical averages.

2.3 Ideally, it would be desirable to classify a pulp sample into a very large number of fractions and weigh and measure the length of each in order to determine the weighted average length. In practice, however, satisfactory results may be obtained from the weights and lengths of five graduated fractions which are provided by a four-screen classifier.

3. Apparatus

3.1 *Fiber classifier*¹. Any good classifier with four or more screens is suitable, and the two types described in the Appendix will give identical results if used as described in Section 5. Preferably the series of screens used for a given sample should be selected so that not much more than one-fourth of a specimen is held on the coarsest screen. It is also desirable to provide for the closer separation of the longer-fibered fraction than the short ones, since the weight effect of the long fibers is the greatest. The recommended series of screens is given in 3.1.2.

3.1.1 The series of screens used in the classifier is not of great importance if the weighted average fiber length is calculated, because the smaller the screen mesh used before a compartment, the more will be the quantity of that fraction retained and the less will be its average length. Table 1 lists the usual screens and dimensions of their openings:

3.1.2 Recommended openings in the series of screens used for the classification of pulp are as follows:

3.1.2.1 For long-fibered pulps: Tyler screens 10 (1.68 mm), 14 (1.19 mm), 28 (0.595 mm), and 48 (0.297 mm).

3.1.2.2 For medium-fibered pulps: Tyler screens 14 (1.19 mm), 28 (0.595 mm), 48 (0.297 mm), and 100 (0.149 mm).

3.1.2.3 For short-fibered pulps: Tyler screens 28 (0.595 mm), 48 (0.297 mm), 100 (0.149 mm), 150 (0.105 mm), or 200 (0.074 mm) for groundwood.

3.1.3 As a guide to the selection of the screens, a good classifier will retain most of the fibers on a given screen if the fiber lengths are over twice the mesh opening, unless they are very flexible.

3.2 *Disintegrator*, for the preparation of dry samples. The disintegrator is described in TAPPI T 205 "Forming Handsheets for Physical Tests of Pulp."

Table 1. Screen openings.

Tyler series	Opening, mm	U. S. standard
10	1.68	12
12	1.41	14
14	1.19	16
20	0.841	20
28	0.595	30
35	0.420	40
48	0.297	50
65	0.210	70
100	0.149	100
150	0.105	140
200	0.074	200

3.3 *Stock containers*: crock, 18 L or larger; beaker, 4000 mL, preferably of polyethylene or stainless steel, with mark at 3000 mL and also marked with its net weight.

3.4 *Dipper*. A domestic, wide-mouth, plastic-ware cup or a polyethylene, wide-mouth measuring cup with handle, 8- or 16-oz size (225- or 450-mL).

3.5 *Büchner funnel and flask*. A 90-mm diameter funnel is preferable.

3.6 *Filter paper*, fast-flowing, for funnel and classifier. A closely woven cloth may be used instead.

3.7 *Timer*, stopwatch or clock with a second hand.

3.8 *Projector*, for the measurement of fiber lengths. One is described in TAPPI T 232 "Fiber Length of Pulp Projection" and another by Clark (3).

3.9 *Other apparatus*: graduated cylinders or beakers to hold 500 and 2000 mL; beakers, preferably plastic or stainless steel, 4000 mL.

¹ Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list in the set of TAPPI Test Methods, or may be available from the TAPPI Quality and Standards Department.

4. Sampling and test specimens

4.1 Obtain a sample of 24 g of moisture-free pulp by a previously determined sampling procedure. If the pulp is dry (less than 30% moisture content) soak it in water for at least 4 h and disintegrate in the standard disintegrator (TAPPI T 205) until no fiber bundles remain. The end point to be determined visually by cylinder; if fiber bundles remain, continue disintegration and repeat dilution procedure. If the pulp is moist or in slush form, disintegrate until no fiber bundles remain using the procedure previously discussed.

4.2 It is not easy to measure out an exact weight of long-fibered pulp, especially in a concentrated suspension. The following procedure gives more accurate results than measuring a quantity of concentrated suspension in a graduated cylinder to determine its consistency and then measuring the required volume for classification.

4.2.1 For the 5-g specimen required in the Clark classifier, dilute the 24-g sample to 16 L in the crock, giving a consistency of about 0.15% as for sheet making in accordance with TAPPI T 205.

4.2.2 For the 10-g specimen required in the Bauer-McNett classifier, dilute the 24-g sample to 8 L only. Stand the 2000-mL cylinder or a tared beaker next to the 4000-mL beaker and the crock. Stir the stock vigorously with the dipper or cup, add a cupful to the beaker, stir again, and add about two-thirds of a cup to the 2000-mL cylinder or tared beaker. Stir again and repeat the division so that when about 5000 mL have been distributed there will be about 1800 mL in the cylinder or tared beaker and about 3000 mL in the 4000-mL beaker. Weigh the beaker and contents and subtract the tare weight of the beaker.

4.3 Record the exact volume or weight in the tared beaker or cylinder (do not try to adjust the volume); pour through a tared filter paper in the funnel, dry, and weigh. Subtract the weight of the filter paper and calculate the extra volume of stock to add to the 4000-mL beaker so that it will contain 5.0 or 10.0 g of pulp (moisture-free). After vigorously stirring the stock in the container, measure out this extra volume (about 330 mL) and add to the 3000 mL in the beaker. During the measuring operations, keep the suspensions well stirred so as to prevent any settling of the fibers both in the container and in the measuring cup. The contents of the latter should be swirled around continuously except while pouring.

NOTE 1: For ordinary purposes, since the result is calculated as a percentage, it is not important to add exactly 5 or 10 g of pulp to the classifier. Accordingly, measure about 3333 mL into the 4000-mL beaker with alternate dips while adding a lesser quantity to a 1000- or 2000-mL graduated cylinder or the tared beaker. Weigh, then add the measured 3333-mL specimen to the classifier, after which the suspension in the 1000-mL cylinder or the tared beaker may be filtered, dried, and weighed to determine the exact weight of the specimen added. If within 10% of the required weight, the percentages of the quantity added, found in the different compartments, will not be greatly affected.

4.4 If the sample is not in slush form and test sheets are not required, accurate 5- or 10-g specimens may be prepared from a sample of dry or moist pulp prepared as follows:

4.5 Determine the moisture content of the sample in accordance with TAPPI T 208 “Moisture in Wood, Pulp, and Paperboard by Toluene Distillation” or TAPPI T 210 “Sampling and Testing Wood Pulp Shipments for Moisture” and weigh a specimen equal to 5.0 or 10.0 g moisture-free. If dry, disintegrate the specimen in 1500 mL of water in the disintegrator (TAPPI T 205) for 25 min. and dilute to 3333 mL or concentrate to 1000 mL with the Büchner funnel, as required. Do not use a high-speed electric mixer, because it may cut the fibers appreciably.

NOTE 2: For ordinary purposes it may save time to weigh a test specimen in solid form, to be approximately 5 or 10 g, followed immediately by weighing another specimen for a moisture determination. The latter may be dried while the classification is proceeding and the result used to calculate the exact weight of the test specimen added to the classifier.

5. Procedure

5.1 *Classification with the Clark classifier.*

5.1.1 Make sure that the screens are free from fibers. They may be easily cleaned, especially when dry, by using two suede-shoe brushes (having fine brass bristles) and pulling them out radially across the face of the screen after pressing the bristles of each brush lightly together, a brush being on each side of the screen. Hose off the screens and compartments.

5.1.2 Turn on the water to the constant level tank so it just overflows thus, if the metering cock is properly adjusted, supplying water to the compartments at the rate of 10 L/min. Place all the drain plugs (including the 3.2-mm diameter intercompartmental plug) in position, and when the tub is full of water, start the motor driving the classifier screens.