Evaluation of deinking performance

A review of test methods

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ABSTRACT *Test methods for evaluation of deinking performance are not well defined. Standardized test methods are needed to help in assessing the efficiency of alternative deinking systems and the quality of deinked pulp. Techniques that are currently used to evaluate the deinking process include brightness improvement and ink-speck count. This article examines a variety of methods used to prepare brightness pads and discusses some of the factors that can affect pad brightness. Procedures are recommended for consideration as standardized test methods.*

KEYWORDS
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Deinking is normally a single stage in a multistage wastepaper processing system. The objective of wastepaper processing is to produce a low-cost fiber of acceptable quality. If this objective is to be achieved, then

- Wastepaper must not reduce consumer acceptance of the end product
- Wastepaper must be economically attractive relative to other fiber sources
- Wastepaper must not reduce morale of the operating personnel.

Test methods for assessing wastepaper and secondary-fiber quality should measure:

- Product performance (quality), as viewed by the consumer and, preferably, by the mill
- Overall economics of use, including an assessment of changes in machine and mill productivity.

Since about 30% of global fiber consumption is derived from wastepaper, it is astonishing that internationally acceptable test methods have not been developed to meet these objectives. In addition, the lack of standard test methods makes it more difficult to assess the efficiency of recycling equipment. Data that are produced by a wide array of home-grown test methods are difficult to interpret. This has the effect of slowing the development of new equipment and processes (and their acceptance by mills).

To fill the gap created by this lack of standards, numerous tests have been developed for the evaluation of secondary fiber and wastepaper processing. In the specific case of deinking, these tests include:

- Brightness measurements (*1–13*)
- Ink removal, ink-speck analysis (*2, 3, 6, 10, 14–16*)
- Yield (*9*)
- Solvent extraction (*2, 17*).

Other tests include physical tests of pulp strength, drainage, etc. These tend to be used in conjunction with other test methods and are not considered here.

Brightness measurements

Because product brightness is usually a crucial end-product attribute, measurement of brightness is an essential measure of quality. However, there are considerable weaknesses when brightness is used as a measure of deinking efficiency. This is because brightness is "the numerical value of the reflectance factor of a sample to blue light" (*18*). This reflectance factor is influenced by a range of agents, some of which are affected by deinking processes. Those agents whose influence on reflectance factor is determined by the chemical and physical deinking conditions include:

- The ink content of the stock or pulp
- Fiber type and fines content
- Filler type and size distribution
- The presence and type of optical brightening agents (OBA)
- Color.

Influence on reflectance values

Ink content of pulp. The effect of ink on reflectance values is well documented (*8, 10, 15, 16, 19*). Given a fixed quantity of ink, the distribution of ink particle size determines brightness. As the dispersion increases, (i.e., as the average particle size becomes smaller), the brightness decreases. In some cases, overall ink-removal efficiencies may be high, but if residual ink is finely dispersed, brightness improvement may be poor.

Fiber type and fines. Given a fiber type, the brightness value changes as the fines proportion changes. Thus a difference in fines proportion following deinking would contribute to a difference in brightness.

Filler type and size distribution. More filler is removed by washing, as is the case with fines. The effect this has on brightness depends on the type

I. Brightness of pads formed on filter paper with collected water recycled through pad

Stock consistency, %	Brightness, °ISO Top	Bottom	Mean	Difference (top less bottom)	Ash in pad, %
0.2	49.2	45.8	47.5	3.4	13.4
1.0	49.7	47.1	48.4	2.6	13.6
3.0	48.8	48.8	48.8	0	13.3
5.0	49.3	49.8	49.6	−0.5	13.9

II. Brightness of pads formed on 150-mesh screen

Stock consistency, %	Brightness, °ISO Top	Bottom	Mean	Difference (top less bottom)	Ash in pad, %
0.2	52.2	49.5	50.9	2.7	11.0
0.6	50.2	50.4	50.3	−0.2	11.9
1.0	50.0	50.4	50.2	−0.4	12.3

of filler. Filler removal possibly provides a good overall measure of washing efficiency. It is usually an important contributor to yield losses.

Optical brightening agents. OBA are added to many papers to improve apparent brightness. OBA can be washed out or chemically removed. As OBA are removed, recorded brightness falls. One attempt was made to compensate for this (*5*), but the apparent effect of OBA increased with deinking, which suggests that the correction was inaccurate.

Color. When colored grades of wastepaper are being processed, brightness measures become meaningless. Color comes primarily from dyes used in paper manufacture, from water, dispersed inks, or from chemical reactions that can occur during wastepaper processing. Dyes can be removed by washing, which can contribute to an apparent increase in deinking efficiency. However, even a small degree of color can disguise improvements in brightness resulting from good ink removal.

Formation of brightness pad

The method selected must allow a true measure of the brightness of the pulp or stock under test. No washing should take place during preparation of the brightness pad. This has been widely acknowledged (*1, 2, 4, 5, 8, 9, 13, 15, 17*), yet many test methods allow washing to take place. When both sides of the brightness pad are used to provide reflectance values, there frequently are significant differences between them. This is taken as an indication of the degree of dispersion of ink and its ease of washing out. While this is correct, a difference in reflectance values from the top and the bottom of the brightness pad also indicates that the method adopted is unsuitable for brightness measurement, since washing has clearly taken place. When the pad is drained through a mesh, the bottom side is often brighter, indicating that ink has been removed. When a filter paper is used, the bottom side is often less bright, indicating that ink has been concentrated on this surface.

When a stock suspension is drained under vacuum, efficient washing takes place as the fiber mat is forming. Some of the ink lost from the stock passes through a mesh, and the quantity lost depends on the mesh size. Ink can also pass through a filter paper, depending on pore size, but with a filter, most of the ink from the stock is collected. As drainage proceeds, water moves through the fiber mat, taking some ink particles with it, until they are trapped by the fiber mat. Consequently, the top surface has undergone some ink removal and is not representative of the stock that is being tested. Thus, neither the top nor the bottom surfaces are representative of the stock. Clearly, an average of these is unlikely to be representative of the pulp's real brightness.

Several alterations to TAPPI Test Method T 218 os-75 (*18*) have been discussed (*1, 2, 4, 7*). All comment on the difference in brightness between the top and bottom sides of the pad. Two alternative methods for pad preparation examined by PIRA serve to illustrate the problems inherent in pad formation. Brightness pads were formed from the same stock at a range of consistencies by two methods:

1. Using a technique similar to TAPPI T 218 os-75, but recycling the collected water through the brightness pad.
2. Using a dynamic sheet former, to reduce filtration effects, forming the pad on a 150-mesh screen.

Results are provided in **Tables I and II.** Results in Table I show clearly the difficulties experienced in determining brightness values from pads formed on a filter paper. The brightness varied from 45.8° ISO to 49.8° ISO (bottom side), while the mean brightness varied from 47.5° ISO to 49.6° ISO.

Table II shows results for pads prepared from the same stock using a 150-mesh screen. The maximum brightness achieved was 52.2° ISO, and the average brightness increased to a maximum of 50.9° ISO. The effect of recycling backwater onto the filter paper is clear. The top surfaces of the pads formed on the 150-mesh screen were considerably brighter than the pads made on filter paper with backwater recycling. Ash content without backwater recycling was also significantly lower, and the ash content increased as consistency increased, signaling a considerable difference in washing. Brightness measurements are, therefore, a sensitive measure of changes in washing during pad formation.

These results clearly demonstrate the importance of having a recognized standard test for assessing the real brightness of deinked pulp. However, brightness alone should not be used as an assessment of deinking efficiency, since the effects of residual ink on brightness depend on ink-particle size.

Other important factors to be considered in formation of a brightness pad include:

- Water type used for dilution (*2*)
- pH difference in TAPPI and Scan (*2*) procedures
- Surface smoothness of pad
- Basis weight of pad.

Ink removal, ink-speck count

Ink removal is obviously the primary function of a deinking stage. However, ink removal does not relate easily to any finished-product attribute. Given a fixed quantity of ink in stock, brightness values and ink-speck count will vary, depending on the size distribution of ink particles. Thus ink-removal measurements are restricted to the assessment of deinking efficiency, and in this context they have been well documented (*3, 8, 9, 10, 14, 16*). Image analysis equipment, capable of examining ink particles with diameters in the range 0.1 μm to 100 μm, is essential for ink-removal studies. This equipment tends to be expensive, methods are laborious, and sample sizes small. Results can be difficult to interpret, possibly because of agglomeration of ink particles (*15*). Thus, this test method is likely to be confined to a relatively sophisticated research laboratory.

Ink removal should not be estimated by TAPPI Test Method T 213 om-85 (*20*). Small ink particles (less than 40 μm) form the bulk of ink particles present during normal deinking (*8, 10, 14–16*), and these have the greatest impact on pulp brightness. Since these particles are below the limit of visibility, 40–60 μm (*8, 16*), they are not counted using TAPPI T 213 om-85. Although this test method is suitable for estimating deinked pulp quality, it must be used carefully. The test is subjective. Image analysis is objective, though its objectivity is dependent on the gray-level detection limits selected by the operator.

Yield

Yield measurement is essential if a mill is to calculate the economics of wastepaper use. However, calculation of yield is difficult under normal mill conditions, and laboratory measures are difficult to relate to mill conditions. Other factors that are important in determining the economics of wastepaper use include:

- Wastepaper price
- Treatment costs, including chemicals, energy, extra labor, machine and mill productivity, impact on labor relations.

Yield cannot be used as a measure of deinking efficiency, since it cannot be related to product quality. Nor can it be related, in isolation, to the economics of wastepaper use. Yield, or ash removal, is normally a good indication of washing efficiency, but it is not necessarily an indicator of deinking efficiency, because of particle size differences.

Solvent extraction

Solvent extraction was dismissed as inappropriate for measuring stock quality (*2*), but more recently it was suggested as a method for estimating the probable effect of flotation-deinked stock on machine productivity (*17*). Again, this is important in determining the economics of wastepaper use. However, it cannot be a measure of deinking efficiency, since it measures all impurities that are soluble in the selected solvent. The deinking process is not designed to remove all of these impurities. Moreover, the solubility of different inks and other impurities varies. As the proportions of components change through deinking processes, results become difficult to interpret. Differences in solubilities also prevent the use of this measure to estimate the quality of deinked pulp. Its use is therefore not recommended.

Conclusions

The preceding discussion supports the following conclusions.

1. No standardized test methods exist that allow the international comparison of deinked pulp quality. There are also no standardized methods for assessing the efficiency of deinking systems.
2. The proliferation of methods designed to fill these gaps has actually hindered the development of deinking systems and, ultimately, the use of wastepaper.
3. Brightness and ink-speck measurements are most suited for the assessment of deinked pulp quality. However, the method selected for preparation of the brightness pad will significantly influence the final results. The "Dirt in Pulp" test method (*19*) is not ideal for deinked pulps, since speck count is affected by the method selected for test-sheet formation. In addition, it is a subjective test.
4. Ink-removal measurements are most suitable for assessing deinking efficiency, provided that suitable image-analysis equipment is available. In some circumstances, changes in brightness or yield are acceptable as an estimate of deinking efficiency.
5. There is a need for the development of standard tests that can be used to assess both deinked pulp quality and deinking efficiency.

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