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Drainage evaluation by mass measurement

Scope

Measuring the mass of stock on the forming fabric at the wet end of the paper machine is very useful for optimizing the machine's performance. An optimized wet end can have favorable benefits to paper quality, paper throughput, energy usage and paper clothing life cycles.

The technique used to measure mass of the stock employs the use of a backscatter gamma radiation device. This method is desirable because it is very accurate in obtaining mass data. Further, the device can be used without interrupting paper machine production.

Once the mass data is measured, the data should be compiled and calculated to flowrates and to percent solids performing a material balance. This publication describes how to calculate the material balance from this data.

Safety precautions

All pertinent safety procedures for working around the wet end of a paper machine must be followed. These include the standard safety precautions for working around moving equipment, in addition to the specific safety regulations required by the facility where the work is to be performed.

The mass measuring device uses a low radiation source. Additional safety precautions should be taken that fully comply with state and Federal Nuclear Regulatory Commissions. For all current available gamma mass measuring devices, a specific license must be obtained if the gauge will be moved from mill to mill. It is highly recommended that the unit has a ground fault interrupter attached to the power cord. This will prevent electrical shock from short circuits caused by moisture.

Introduction

This Technical Information Paper describes a procedure that was developed to provide a method for evaluating drainage on the wet end of a paper machine with a mass measuring gauge. The method described is a nondestructive alternative to the blow sample method described in TAPPI TIP 0410-07. The measurements are useful because the data provided can be used to monitor machine drainage and retention, optimize flatbox vacuum, aid formation studies, and determine headbox flow. The following method is intended to minimize errors and major variations in the procedures used to evaluate paper machine drainage. The use of mass sensors is declining due to the introduction of microwave based sensors. This TIP will serve as a data and calculations reference source for mass measurements.

Sampling

Consistency and percent ash determination are required of samples from the headbox or headboxes and from the white-water of each of the drainage elements where a mass reading is to be taken. The samples should be collected and stored in air-tight containers. For those elements where an individually representative sample cannot be taken, such as low vacuum units or flatboxes, a sample from the seal pit or pits or the tray may be used for each

element. The consistency and ash determinations are performed according to TAPPI Test Methods T 240 and TAPPI T 211, respectively.

Before calibrating the mass gauge, allow time for the instrument to warm up. Mass readings are taken between drainage elements where accessible. Sampling time for each measurement should be sufficient to obtain a representative number for each location. A common sampling time used is seven to ten seconds. Longer sampling times may not be of any benefit due to error caused by operator fatigue.

Great care must be taken when operating the gauge near the in-going edge of an element. If too much force is used the fabric may be pushed up, allowing the gauge to become lodged between the top of the drainage unit and the fabric. Likewise, on the outgoing side of an element, too much force could lift the fabric off the element and change the drainage at this location. If the location between two or more elements is not accessible with the mass gauge, treat the elements between measurements as a single drainage element.

Two mass readings should be taken at each measuring point to ensure repeatability. If the readings vary by more than $\pm 2\%$ then the mass measurement should be repeated. The mass measurements should be made at the same distance from the edge of the fabric to minimize effects of cross direction variations, unless that effect is being studied. Avoid measuring in the wake caused by a deckle board.

The mass measurements include the mass of the forming fabric and the water in its voids, and the mass of the fiber, filler, and water above the fabric. To determine the mass above the fabric, the forming fabric/void water mass must be subtracted from the total mass reading. The accuracy of the forming fabric/void water mass measurement will have a direct effect on the absolute value of consistency calculations. Any error in the fabric weight used is amplified as measurements move from the wet end to the dry end of the drainage section. This means that the consistency value calculated at the couch can be greatly different from the actual value, if there is error in the fabric weight used. This is complicated by the fact that the water held in the fabric voids changes once the sheet begins to travel over vacuum dewatering elements.

Determining mass value for the fabric

Numerous methods are being used to determine the mass value for the fabric. Each method has its own advantages and disadvantages. The user of the mass gauge will often pick different methods based on the machine configuration. The most common methods are listed below.

1. A value measured after the couch before showering.
2. A value supplied by the fabric manufacturer.
3. A value measured at another position on the return run.
4. A dry weight value approximated by measuring with the mass gauge while blowing the water from the fabric directly ahead of the gauge.
5. A value calculated using a dry manufactured weight plus a correction factor for water held in the fabric based on the fabric style.
6. A calculated fabric weight based on the correlation of a grab sample value and a mass reading, both taken after the couch.

The generally preferred location for measuring the forming fabric plus void water weight is immediately after the couch roll before any showering of the fabric. At this position, only the weight of the fabric and the water continuously retained in its voids is measured. For a top-former, the top fabric weight should be measured after the two fabrics separate and before showering. It is impossible on many machines to measure at these positions; on such occasions the operator may choose to use one of several alternative fabric weights.

Determining the proper fabric weight

The problem of determining the proper fabric weight for a mass measuring gauge drainage survey is the most important issue facing gauge operators. The method chosen often depends on the machine configuration. The operator must realize the effect each method will have on drainage results. For example, if one method results in a lower fabric weight than others, the resulting consistency values at any position of the drainage section will be lower than those determined with a higher fabric weight. Additionally, the same error in fabric weight will cause a greater error in results for lower basis weight. If absolute values for consistency are not required, any of the above methods for determining a fabric weight can be used.

Several forming fabric suppliers use the manufactured dry weight method. This is subject to errors due to the water weight retained in the fabric, but it has the advantage of reporting the most conservative (wettest) consistencies at the dry end of the forming section and avoids introduction of assumption errors. Some manufacturers are also supplying correction factors for the dry weight based on caliper, but this also has error potential due to the type of wear, such as top- or bottom-sided wear.

On machines where a total mass reading can be taken after the couch roll, alternative method No. 6 can be used to generate a correction factor for the other methods, to be used when the surveys must be nondestructive. With this method, determine what fabric weight is needed to generate the couch consistency value that agrees with the grab-sample reference measured during a mass gauge survey. A correction factor can then be obtained for future use. The accuracy of this correction factor is probably good only for a short period of time on a given fabric due to wear of the fabric with time. Remember that a couch sample at the edge of the sheet may not be representative of the actual couch moisture.

It is imperative that the fabric weight used and the method by which it was determined be a part of the final drainage report. The dry weight of the fabric as manufactured should also be included in the final report. If the drainage results are to be used for evaluating changes made on the machine, then the same method of fabric weight determinations should be used for each survey. If the end user of the drainage report has the information on the method used to obtain fabric weight, then the information will help to determine in which direction the consistencies may be biased. The fabric weight can vary by as much as 50% or more depending on the style of fabric and the method of weight determination used.

Sufficient clearance of any structure or material above the fabric is needed to prevent reading error due to backscatter from other mass sources. The minimum clearance necessary varies depending on the distance and mass loading from the fabric, stock, and water. More detail on this type of interference is included in Appendix C.

Calculations

A material balance around the table of the paper machine must be performed to determine consistencies and flow rates down the table. To make a balance around an element or combination of elements, an assumption of the solids content leaving the table has to be made. Normally it is assumed that there are no solids lost between the last measurable mass point on the dry end of the table and the reel, only solids added by surface application.

The calculation of the material balance of the next accessible element is performed by assuming that mass is conserved. In other words, the total solids of the upstream element is equal to the sum of the total solids of the downstream element plus the total solids lost due to the drainage of these units. The summation of the results of all the individual drainage elements then defines the overall operation of the forming table. The minimum data required for drainage calculations are:

- Fabric weight as measured
- Fabric weight as manufactured
- Sheet width before trim
- Sheet width into presses
- Sheet width at reel
- Headbox width
- Fabric speed
- Reel speed
- Basis weight
- Reel moisture
- Ream size
- Weight of surface sizing added
- Coat weight added
- Headbox consistency (ash optional)
- Mass readings after each drainage element
- White water consistencies from each drainage element (ash optional)