Wet-end profiling via ultrasonic measurement

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The drainage characteristics of a fourdrinier forming section can be readily determined without interrupting production by using a portable ultrasonic measuring device.

Today's papermaker faces increased demands for higher production levels, quality improvements, and cost minimization. Knowledge of a forming section's drainage characteristics can help bring about changes in the wet-end configuration to:

- Increase first-pass retention
- Improve water removal
- Improve sheet formation and physical characteristics.

To make appropriate changes in the forming section's table elements, the papermaker must have a quick and reliable method of assessing the effect of any adjustments that are made.

Current profiling techniques

Until recently, the only commonly used procedures for profiling wet-end drainage were blow sampling and gamma-gauge measurement.

Prior to the development of the gamma gauge, blow sampling was the dominant profiling procedure. Blow sampling is not only time consuming, but can lead to periods of lost production. Furthermore, blow-sampling results take 24 h to complete and are subject to considerable error.

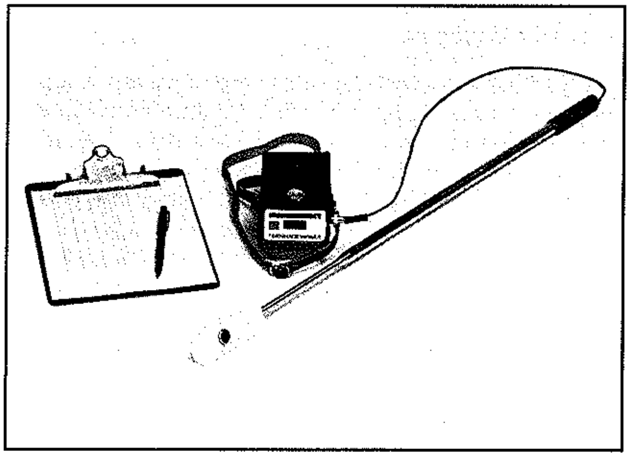
Gamma-gauge measurement is effective, but requires a computer and one of several available software programs to compile the gathered data. The compiled results can then be plotted by hand or by the computer's printer.

Another limitation of blow sampling and gamma-gauge measurement is their inability to provide a picture of table activity (turbulence). Table activity is normally monitored through a stroboscope (alone, or in conjunction with high-speed photography). Activity is a slurry condition of concern to the papermaker since variations in magnitude can significantly affect sheet formation.

Although both gamma-gauge measurements and blow sampling can give a quantitative picture of machine drainage throughout the entire length of the wet end, the area of most practical interest to papermakers is in the forming area of the table.

The Unaform drainage meter was developed as a means of reliable, qualitative evaluation of forming-area drainage characteristics and table activity.

1. Unaform drainage meter



Description of the drainage meter

The drainage meter was developed and first used in 1984 by Unaform Ltd., the company's U.K. division. In 1986, Unaform Inc. of Shreveport, La., began using the instrument as part of the analytical services offered by its Technical Service Group.

The unit, shown in **Fig. 1**, is small and easily portable. The combined weight of all components totals 1.5 kg, which minimizes operator fatigue. The case contains vital components, a battery power source, a digital readout, and power switch. Power is supplied by a standard 9-V alkaline battery.

The main unit is attached to the measuring probe by a lightweight cable approximately 1.8 m long. The probe is 0.9 m long and breaks down into three separate segments

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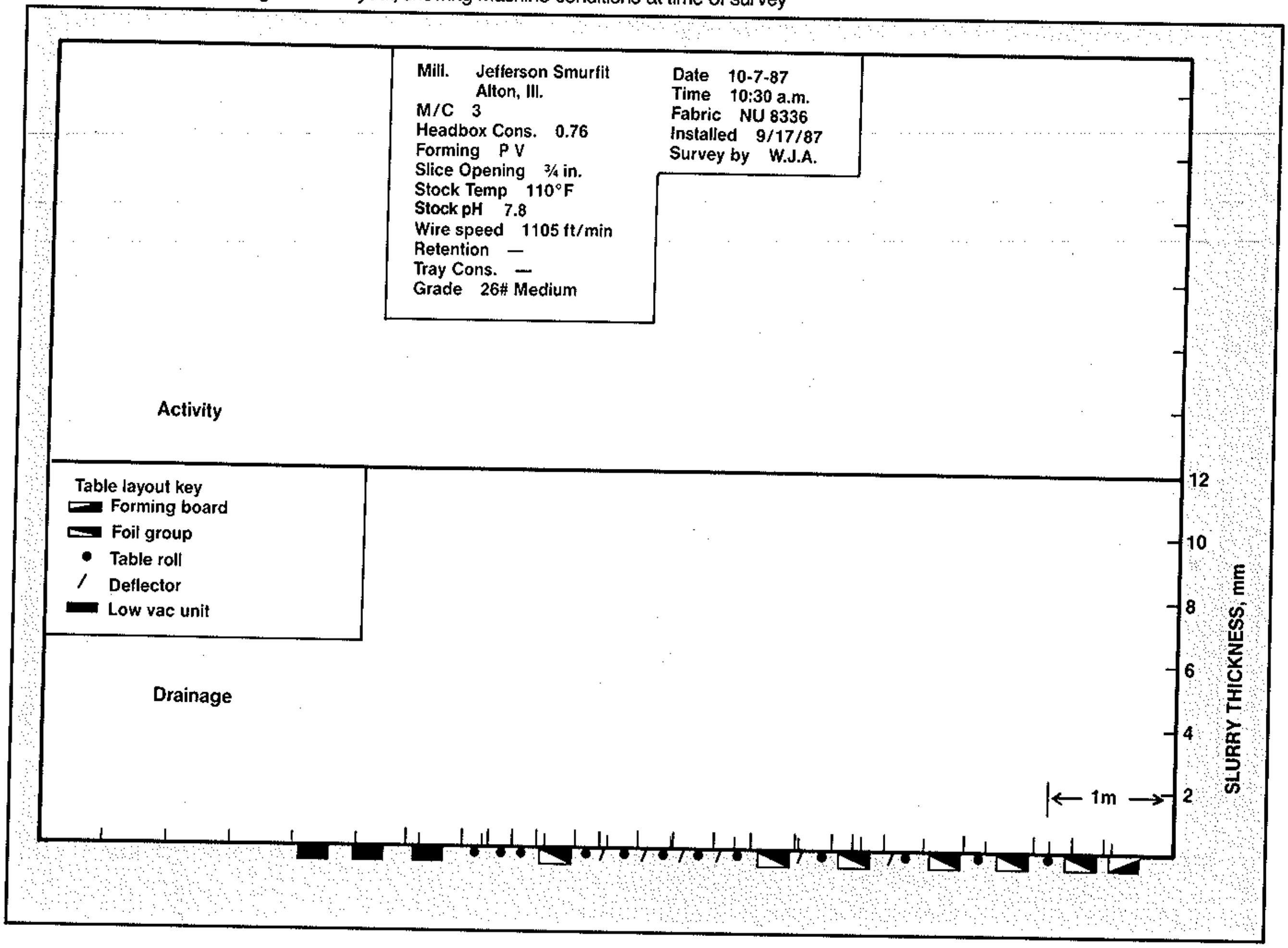
2. Diagram of initial forming-section layout, showing machine conditions at time of survey



for easy portability. The probe is constructed of 316 stainless steel. Internal connections link a 5-MHz crystal transducer, located at the end of the probe, to the main unit.

The probe's transducer is flush-mounted in a block of HDPE (high-density polyethylene) with tapered edges, and is of a size that permits it to be inserted between most foils.

When the unit is activated, its "ready" condition is indicated by the appearance of a decimal point on the digital readout. Battery condition is constantly monitored; a flashing decimal point indicates that the battery needs to be replaced. The unit draws little power, and battery life is normally in excess of 5 h of instrument use. When the meter is not in use, the power automatically shuts off after 60 s to conserve power.

Once the transducer is activated, it begins to emit pulses of a known and constant frequency. These pulses are directed through the stock slurry. At the point of air/slurry interface, a proportion of the pulses are reflected back to the transducer. The instrument then measures the time between pulse transmission and reception, which varies directly with the thickness of the slurry. Time measurements are converted into slurry-thickness measurements in units of 0.1 mm and displayed on the digital readout.

The measurements obtained are accurate to ± 0.1 mm, and the unit itself can measure over a range of 2–75 mm.

The maximum/minimum readings obtained when the meter is used on a stock slurry can then be utilized to determine the fabric activity.

Limitations of the device

The Unaform drainage meter is:

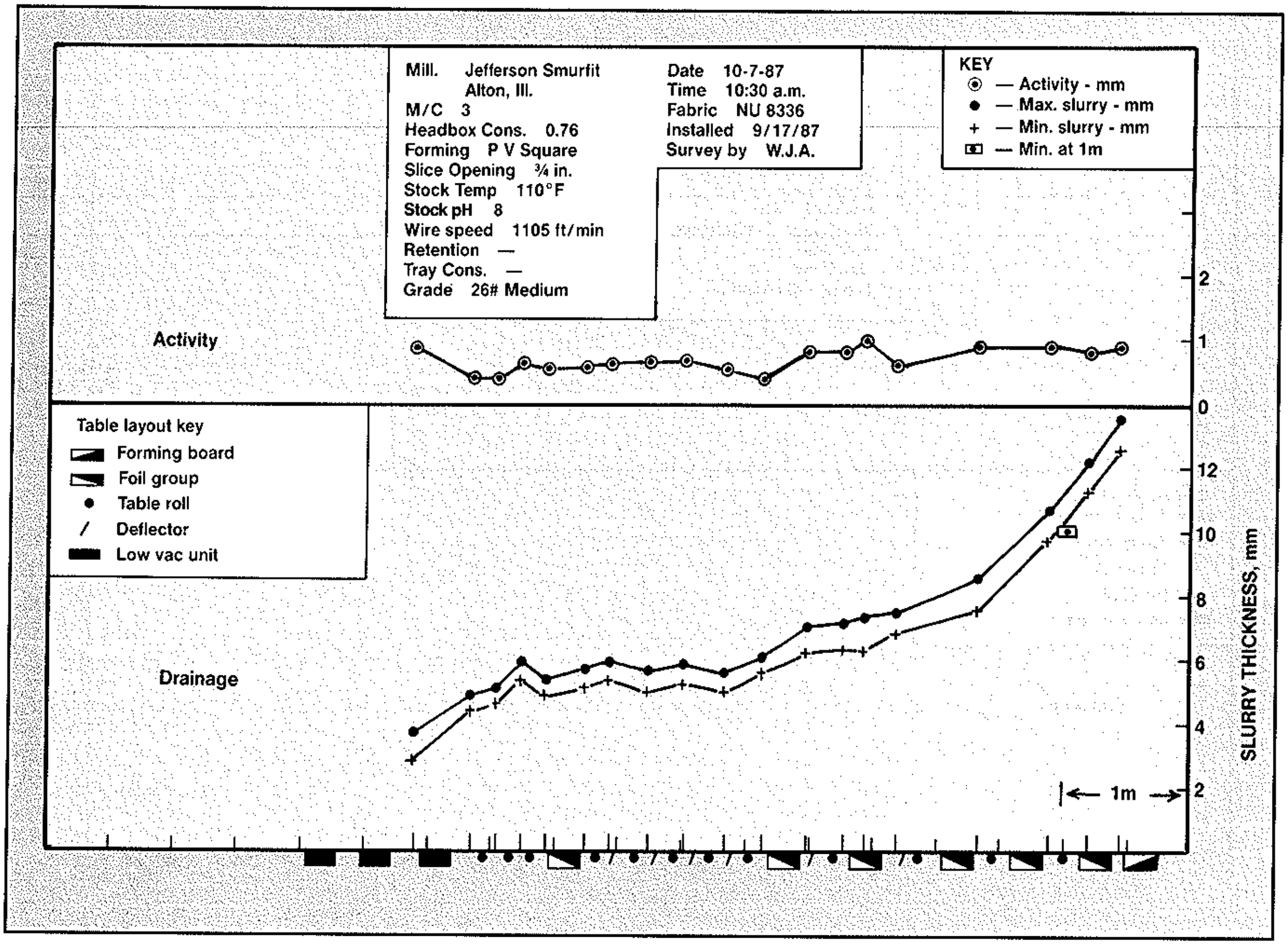
- Effective only from the slice to vicinity of the dry line
- Ineffective if the stock slurry contains more than approximately 0.7% air. If too much air is present, the instrument only displays readings in the minimum range of 2.0–2.3 mm.

Although this latter characteristic prevents the device from being used with some machines and/or paper grades, it can prove very useful in pinpointing any forming area units actually pumping air into the slurry. Such an effect retards table drainage and/or affects formation. The presence of air is not detected by blow sampling or gamma gauge techniques.

Drainage-survey procedure

The procedure for carrying out a drainage survey is as follows: Using graph paper, draw a diagram of the forming section to be evaluated. Map out the forming

3. A completed survey graph



section along the horizontal axis, as shown in **Fig. 2.** Use appropriate symbols to represent the various portions of the forming section.

Your diagram should also record:

- Foil angles, to help detect any effects of future foil changes
- The slice opening
- A point on the forming table 1 m from the slice.

Your diagram should also list the basic wet-end machine conditions at the time of the survey to simplify comparisons after later surveys. See Fig. 2 for examples.

Using the drainage meter, gather the slurry/fabric thickness measurements. The survey can be conducted by one person, but is completed more easily and quickly when surveyors work in pairs, with one person operating the meter and the other recording results.

Turn the drainage meter on and place the transducer face firmly against the underside of the fabric at the measurement points chosen. To minimize edge effects, hold the transducer at least 1 ft inside the slurry edge.

During the test intervals of 20–30 s at each measurement point, the instrument displays fluctuating headings. Record the minimum and maximum readings obtained. Although the values vary appreciably (particularly throughout the first third of the forming area) it takes little practice to become adept at obtaining correct minimum/maximum values.

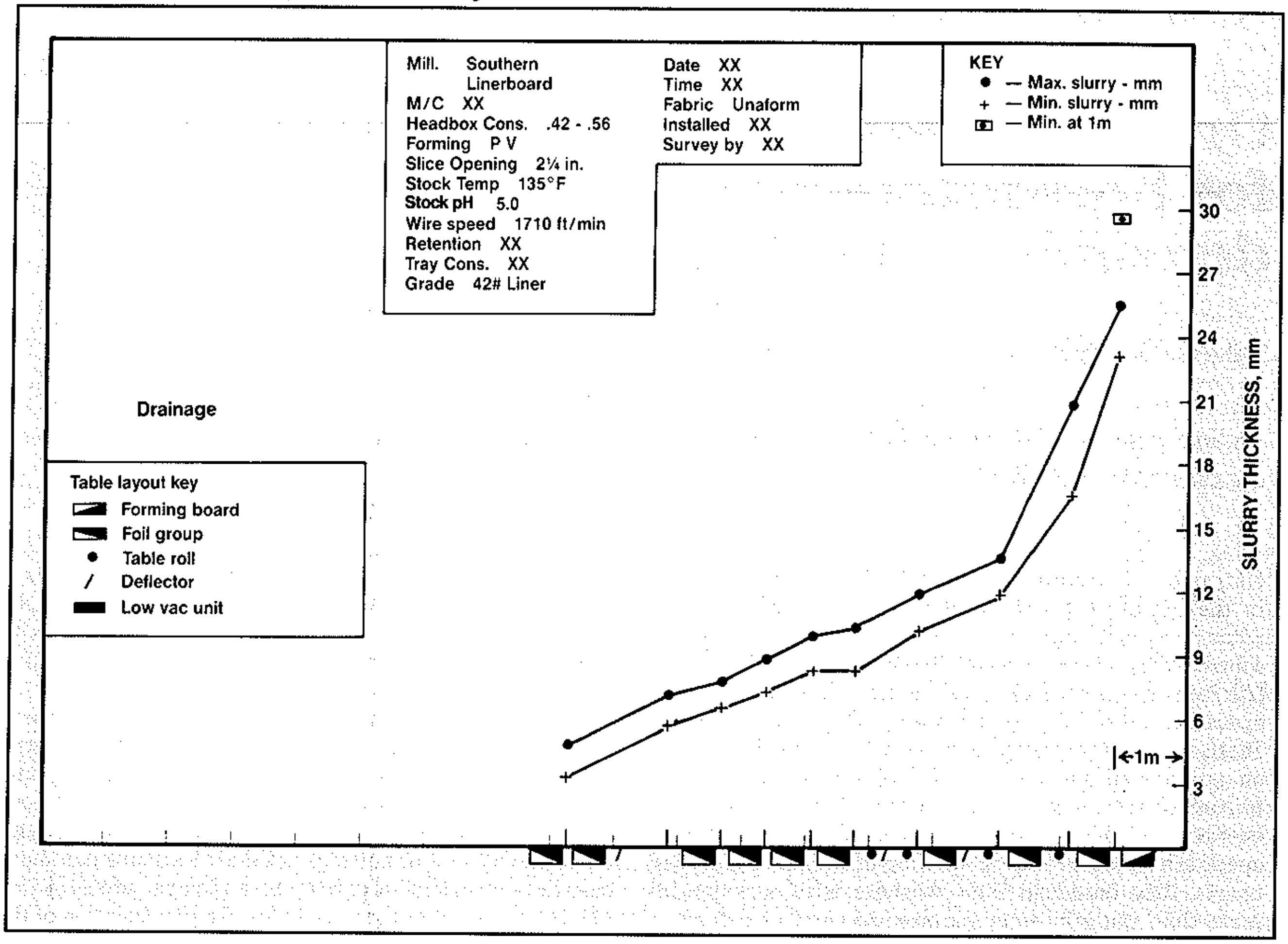
Drainage/activity graphs

After the maximum/minimum values are gathered, plot their respective curves, as in **Fig. 3.** Next, to plot activity, derive the difference between the maximum and minimum values, and plot the resulting values.

It should be noted that a point 1 m from the slice is noted on the horizontal axis of the drainage-survey graph. The first value noted on the vertical axis immediately above the slice represents a value in mm of 0.8 times the actual slice opening. The jet contracts to varying degrees depending on configuration of the headbox and actual slice design, but is normally reduced to between 0.6 and 0.9 of the slice opening. We have chosen an arbitrary contraction of 0.8 times the slice opening and use it to compare it to the slurry thickness at a distance of 1 m from the slice lip.

Although we have no definitive quantitative data to substantiate it, our English counterparts feel that slurry thickness reduction at a point 1 m from the slice should be equivalent to no more than 30–35% of the contracted thickness of the jet as it leaves the slice if sheet sealing is to be prevented. The value of the figure and/or its precise magnitude is open to discussion, but is worth considering

4. Drainage curve, showing high rate of initial drainage



when running a drainage survey. The results of the drainage survey shown in **Fig. 4** are from a Southern linerboard machine showing an extremely high rate of slurry thickness reduction within this 1-m distance.

Each machine's drainage/activity curves should be repeated periodically to compare results obtained on different fabrics, grades, after wet-end configuration changes, and so forth. These comparisons help create a comprehensive picture of a machine's forming-area characteristics.

In its present state of development, the Unaform drainage meter is not intended to give drainage characteristics in quantitative terms. Since the present unit does not automatically calculate a mathematical average of the maximum/minimum slurry readings, any back calculations to actual drainage in gallons per unit would be subject to considerable mathematical error. If actual unit drainage information is desired, blow sampling or gamma-gauge measurement is recommended instead.

Future developments

Modifications are currently under way to enable the drainage meter to record for printout and/or display:

- Maximum/minimum slurry thickness readings
- Arithmetic average values of the readings.

These improvements will allow the operator to test the entire forming section without having to stop and record readings. They will also eliminate operator error/variation in choosing the correct maximum/minimum values at each test point. The ability to obtain a mathematical average of the maximum/minimum values at each point tested will, when coupled with appropriate flow data, enable quantitative drainage data to be obtained for the area under study.

Summary

The Unaform drainage meter is an effective papermaker's tool that permits the drainage characteristics of the forming area to be easily determined. Although nonquantitative drainage data is obtained, the profiles established assist the papermaker in determining whether table changes might promote productivity improvement. Follow-up testing can then gauge the effect of changes made to the forming table.

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