Zero-span and short-span tests track pulp strength throughout one Pacific Northwest mill and reduce the need to retest bales before shipment

BY LORI BALINT

Automated Strength Testing Technology Optimizes Market Pulp Mill's Output

MANY PULP PRODUCERS ARE FACED with the challenge of how to maintain uniform strength properties in their pulp to meet customer demands, while using new pulping and bleaching strategies that are necessary to comply with environmental guidelines. In this changing environment, operations personnel need to know quickly and reliably how pulp strength properties deviate in response to varying process conditions, as well as being able to assure the customer that the strength still meets their expectations.

One market kraft pulp mill, located in the Pacific Northwest, has used automated strength test technology to optimize pulp strength under these operating conditions. There were several challenging issues facing this mill, including:

- If K Number is lowered to achieve reduced effluent loading, what is the effect on pulp strength?
- How can new delignification and bleaching sequences be optimized to produce the best quality pulp?
- Since the mill subscribes to a "just-in-time" shipping philosophy, how can operations personnel be sure that good quality pulp is being shipped as soon as possible after it is produced?

As new delignification and bleaching processes were being introduced, the mill found that existing or traditional pulp testing methods were either too slow or not representative enough to answer these questions.

THE STRENGTH TEST CHALLENGE. TAPPI standard sheet property tests such as burst, tear, and tensile were the standard strength tests used by the mill. The drawback to these tests was that they took more than 24 hours to complete. This is not rapid enough for process evaluation and to prevent low-strength pulp from being made. The tests were usually completed after pulp had been shipped out of the warehouse and so were not practical for the disposition of pulp.

This meant that the mill operators relied on viscosity at various points in the process to provide information about pulp strength. However, it became apparent that viscosity was not always a reliable predictor of pulp strength properties. New bleaching processes produced different levels of viscosity, yet still maintained the same level of strength properties.

Attempts to quantify the relationship between viscosity and sheet properties, such as burst, tear and tensile were not successful. With lack of confidence in the viscosity test, the mill needlessly held and retested many tons of production. This was a big drawback for a mill with limited warehouse space and limited testing staff. Moreover, the type of fiber species used at this mill has been changing to meet customer demands, thereby introducing another source of variation that viscosity couldn't measure.

The new pulping and bleaching sequences being considered by the mill were capable of producing bright, clean, and strong pulp. This was shown by standard TAPPI tests on pulp from lab experiments. The mill needed a rapid, reliable test of strength properties to measure pulp strength when these sequences were run in the mill—a test that was more meaningful than viscosity and took less time to get results than traditional tests. The ability to monitor strength properties during new process startups and mill trials was the pulp strength test challenge.

MEETING THE CHALLENGE. In search of a more repeatable and timely measure of pulp strength, the mill installed a Z-Span 3000 (manufactured by Pulmac Instruments of Montpelier, Vt.). This zero span testing technology allowed an operator to test pulp strength and have results within 25 minutes of taking a sample from the pulping process or end product pulp.

TAPPI Standard Test T 273 pm-95 specifies the equipment involved in zero span testing, and the unit purchased by the mill included the following components:

Before the mill had the ability to measure pulp strength on a regular basis, it was possible to make long runs of low strength pulp that had to be rejected after it had been baled. Now, operations can pinpoint where the strength is being lost in a couple of hours. The situation can be turned around quickly to produce a run of good strength pulp. Operations has gained a large degree of confidence in the ability of the zero-span testing technology as a troubleshooting tool.

RELATING PROCESS VARIABLES TO STRENGTH. One of the common practices of reducing effluent load in response to environmental demands is to reduce the K (or kappa) number of the brown stock pulp. The mill found that measuring brown stock fiber strength allowed the mill to relate K Number and the degree to which it affects fiber strength. Figure 3 shows that fiber strength tracks the changes in K number variation.

The mill lowered brown stock K number by installing oxygen delignification as part of its pulping process. However, due to a 50% drop in viscosity across the reactor at 35% delignification, they were reluctant to push the reactor to its full potential. When fiber strength was measured across the reactor, there was little or no loss.

These results were reflected in the strength tests performed on the end product. Burst, tear and tensile strength were not significantly different than prior to using oxygen delignification. This gave the mill confidence to optimize the reactor by increasing temperature.

QUALITY OUT THE DOOR. Viscosity was initially used as a predictor of pulp strength. If the viscosity test for the pulp was below the lower specification limit, the bales in question were held and segregated in the warehouse. The samples were then sent to the lab for strength measurement by TAPPI standards. Most of the time, the pulp which was held was well within its normal tolerances. This caused unnecessary handling of bales and extra testing.

After installing the zero-span testing unit, both viscosity and fiber strength were tested in parallel. Within a few months it was apparent that, by using fiber strength instead of viscosity, much less pulp would be held unnecessarily. The confidence that the shipped pulp was of good quality also improved. Just six months after receiving the equipment, the mill switched to fiber strength to disposition the final product.

The fiber strength specifications were determined by comparing histograms of tear, burst, and breaking length, and relating them to the histograms of fiber strength, fiber length, and bonding. With this step, the mill was able to determine the capability of the processes, as well as the normal variability of fiber strength values. Fiber strength, length, and bonding also gave information on the different species run at the mill.

The use of zero-span measurement is growing as more information is gathered about the pulping and bleaching process. With a fast turnaround time, operators are learning how the processes affect fiber strength and how they can reduce variation. Process decisions can be made with knowledge about the effects on brightness, cleanliness and strength as well.

LORI BALINT *is technical sales manager for Pulmac Instruments International., Pulmac Instruments, Montpelier, Vt.*

FIGURE 2: *Fiber strength is measured at four locations in the pulping process.*

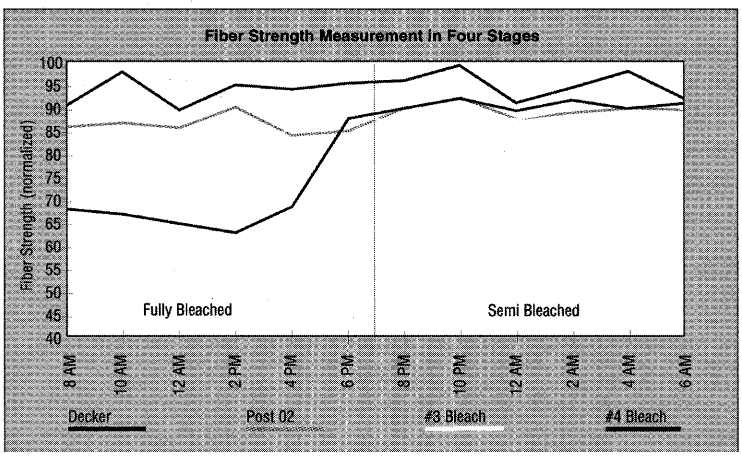
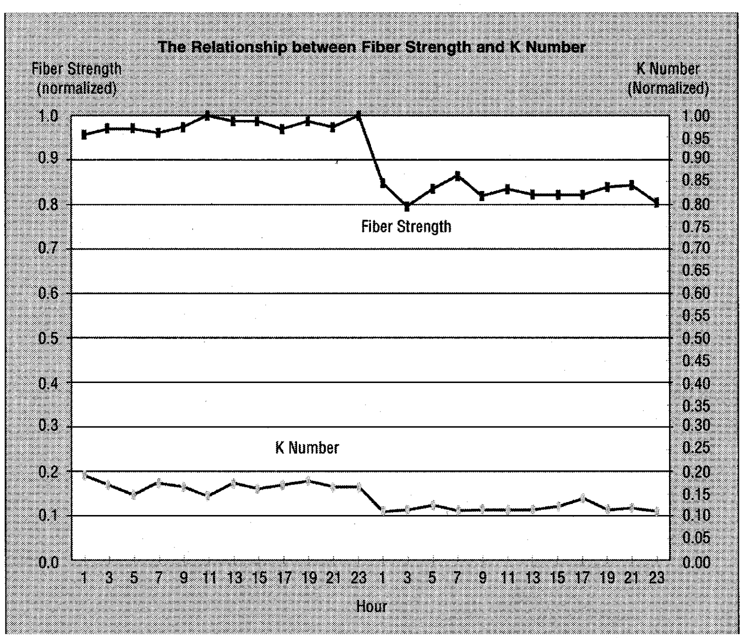


FIGURE 3: *As shown in this graph, fiber strength tracks K number variations.*



• A beater that provides shear energy to swell the fibers slightly to reduce testing variability.

• An automated sheet former that forms six standard 60 gsm dry sheets with random fiber orientation in about five minutes.

• A computer-controlled Z-Span 3000 tester that provides up to 24 tests for a repeatable, accurate measure of pulp strength. The tester measures tensile strength of fibers at zero span, the tensile strength of fibers that span a 0.4-mm gap, and dry short span tensile of the fibers that span the same gap. Fiber strength, fiber length, and fiber bonding are calculated from these test results within the system's processor and are shown automatically on the same computer screen, which the operator uses to start the testing sequence.

WHY TEST WET ZERO SPAN? When dry tensile strength is tested at traditional spans, the tensile load in the test sheet must pass through and between the fibers that form the load-bearing network. When the paper is wet, the load-bearing capability of the network is reduced, since the load is transferred only between the fibers that span the gap between the jaws.

Testing with zero span between the jaws means the load passes through and between fibers that are clamped by both jaws of the tester. When the zero span test is performed wet, the load bearing capability of the network is reduced, leaving the tensile load to pass through only the fibers clamped by the jaws. Testing the tensile strength at zero span is a measure of the average strength of the fibers clamped by the jaws.

The difference between the wet and dry tensile and the wet zero span tensile is the difference between paper testing and fiber testing. The wet and dry tensile test values at standard span are determined by average paper properties that include fiber strength, fiber length, and fiber bonding. The wet zero span test value is determined by the average strength of the individual fibers.

TABLE 1: *Pulp mill repeatability of TAPPI standard test methods.*

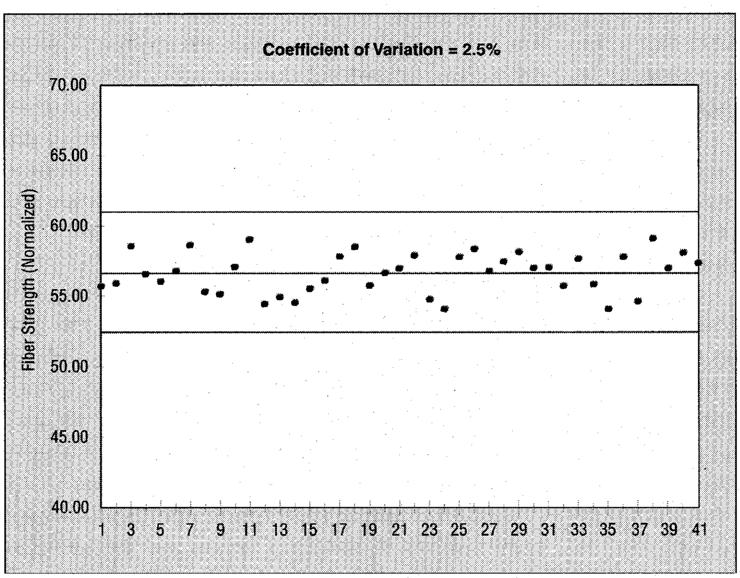
Test	Coefficient of Varients
Viscosity	6.0%
Tear	6.3%
Tensile	7.6%
Burst	10.0%
Wet Zero-Span Tensile	2.5%*

**Coefficient of variation of standard calibration run by 4 shift testers for a period of 30 days.*

TABLE 2: *Time to complete selected pulp quality tests.*

Test	Coefficient of Varients
Viscosity (fast test)	45-90 minutes
Tear	over 24 hours
Tensile	over 24 hours
Burst	over 24 hours
Wet Zero-Span Tensile	25 minutes (10 minutes after the first test)

FIGURE 1: *Wet zero-span variations across four pulp testers during a period of 30 days.*



INCREASED REPEATABILITY. The zero-span testing technology offered the mill advantages in both the repeatability of the measurement and the testing turnaround time. This is due to the ability of the instrument to generate test sheets that have uniform formation no matter who is running the instrument, as well as providing a test result that is the average of up to 24 tests. Table 1 shows that the zero-span tensile test exhibits the best repeatability among TAPPI standard test methods as measured in the mill. Figure 1 shows the variation exhibited between four shift testers during a period of more than 30 days.

A tester could generate the first set of strength numbers from the instrument within 25 min. After that, a set of strength numbers could be generated every 10 min. This provided a much faster turnaround time than standard TAPPI strength test methods. This test could also be run in less time than a viscosity test, and gave much more information. The considerable decrease in time for testing is shown in Table 2.

TRACKING STRENGTH. Through regular, repeated measurement of the fiber strength of brown stock and bleached stock, the mill has been able to determine the characteristic strength loss through each stage in the process. This gives operations personnel timely feedback on the effect of process changes on strength during trials or day-to-day operations.

Fiber strength is measured semi-hourly before and after oxygen delignification and in the two final bleaching stages. The test results are entered into the mill information system and are displayed on the DCS in the mill control room. Figure 2 shows an example of these measurements, as well as the difference between measuring fiber strength on fully bleached pulp versus semi-bleached pulp.