Wet-end pressure pulsations: case histories

Warren S. Miller and G. R. Oleson

Spectrum analysis techniques can reduce the time necessary to diagnose the sources of MD basis-weight variations.

For good basis weight control in the machine direction (MD), it is essential to deliver a uniform mass of stock to the wire. Variations in pressure at the headbox not only reduce MD uniformity, but they can make cross machine (CD) profile control more difficult.

Scanning basis-weight gauges use time averaging techniques to separate MD variation from CD variation. As MD variation increases, more averaging—and more time—is necessary for good estimates of the CD profile. To extract the frequency components of wet-end pressure pulsations, the use of high-frequency pressure probes in conjunction with digital signal analysis techniques (including the Fast Fourier transform) is an important tool to the papermaker.

A good first step in a pulsation study is to determine if there are cyclic variations in the MD basis weight of a paper. This measurement can be made by putting the scanning basis weight gauge into a nonscanning, or single-point, mode and accessing the raw signal. Off-line basis weight gauges have been used to obtain the same measurement. It is often best to use an off-line device to confirm on-line results. Spectrum analysis is then used to determine the patterns of the MD variations. Based on this analysis, it is possible to find the source of the variations.

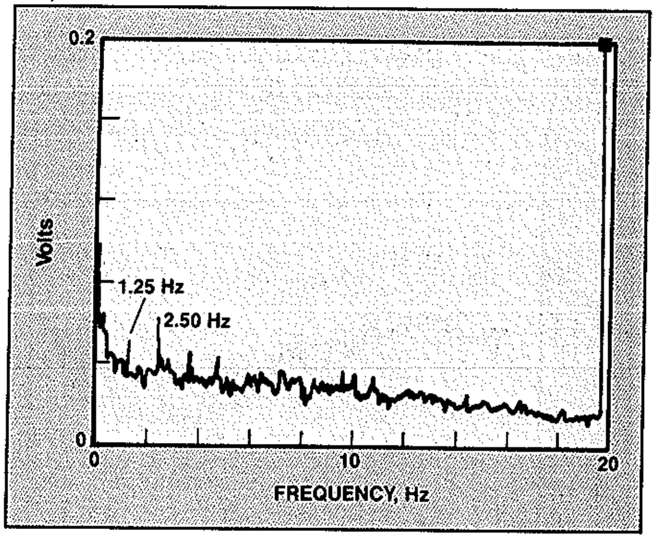
Here, we will look at mill case histories of pressure pulsations that did cause MD basis weight variations. We will also examine the appropriate corrective actions taken to reduce or eliminate these variations.

Case 1: Air pad headboxes

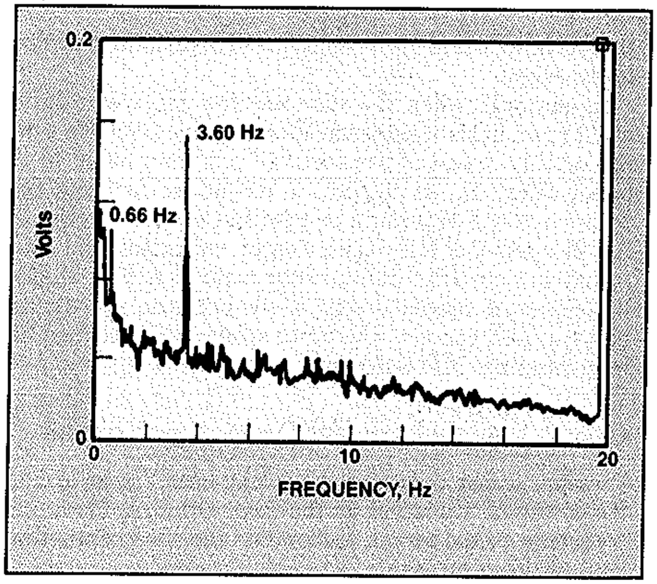
In air pad headboxes, the slice rectifier roll is often the cause of MD basis weight variations. Since the slice rectifier roll is the last rotating element in the wet end, its condition is critical to uniformity. Out-of-roundness, misalignment of the roll, the hole size and drilling pattern, and the speed of the roll can cause periodic pumping of

Miller is senior research scientist, International Paper Co., Long Meadow Rd., Tuxedo Park, N.Y. 10987. Oleson is manager, diagnostic group, Weyerhaeuser Co., Tacoma, Wash.

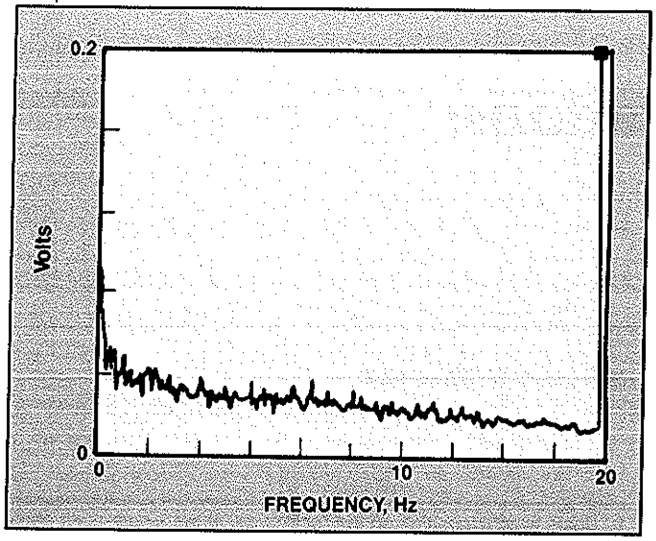
1. Basis weight variation on the rectifier roll at the single-point center, 73 rpm



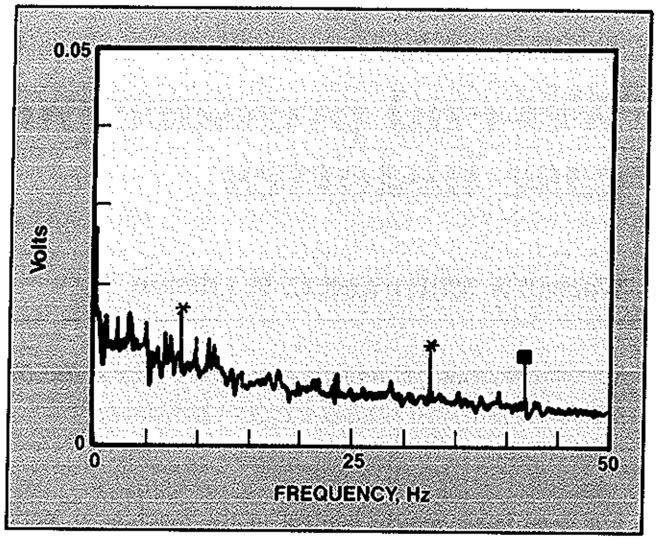
2. Basis weight variation on the rectifier roll at the single-point center, 9 rpm



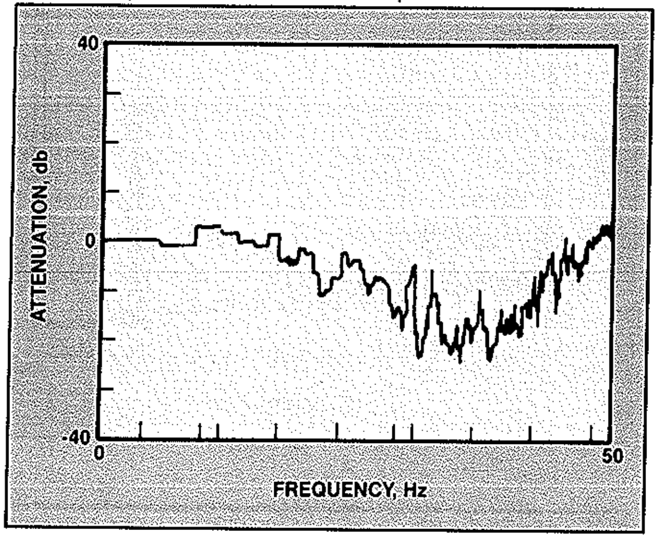
3. Basis weight variation on the rectifier roll at the single-point center, 33 rpm



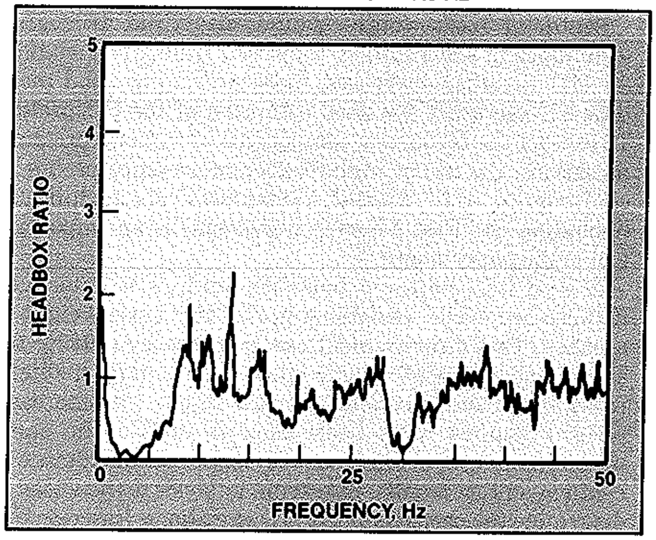
4. Basis weight variation, with a 41.75-Hz periodic pulse



5. Attenuation and reduction for a good attenuator having a three-fold reduction in pulses at its most efficient frequencies



6. Insertion loss, or headbox ratio with the attenuator on vs. off, of an attenuator with an effective band width of 1-7.5 Hz



the stock, which in turn can cause MD variations in stock basis weight.

In one mill, when the slice rectifier roll was rotating at 73 rpm, basis weight variations at one and two times the rotation speed of the rectifier roll were found in the paper (**Fig. 1**). At 9 rpm, a frequency for hole pass patterning (3.6 Hz) could be detected at the reel (**Fig. 2**). At 33 rpm, the MD basis weight variations and stock pulsation were at a minimum due to this roll (**Fig. 3**). Good maintenance, proper design of the hole size and drilling pattern, and correct rotational speed and direction can help minimize MD pulsations.

Case 2: Unusual pressure screen pulsations

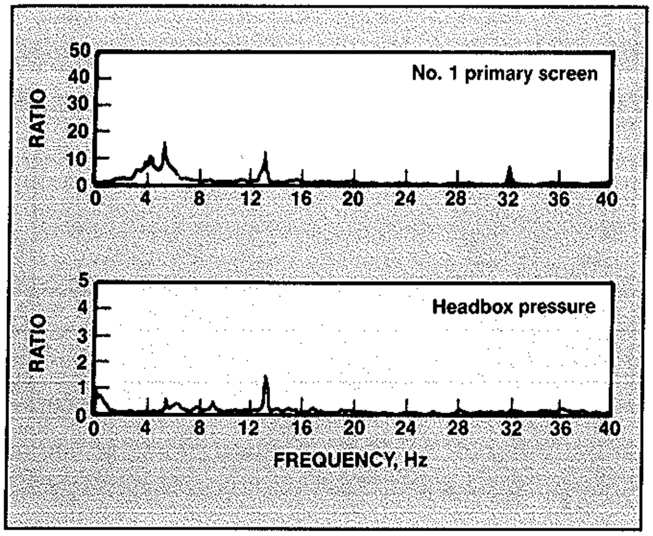
Pressure screen pulsations have long been known to cause basis weight variation at the reel. Often, a blade pass frequency of the screen is found on the sheet. Sometimes analysis is not so easy.

A 41.75-Hz periodic pulse was detected at the headbox and on the sheet (**Fig. 4**). All attempts at matching this frequency with a rotating element of the machine were unsuccessful. The frequency did not track with machine speed, it was always discrete, and it drifted slightly. The pulsation was largest at the outlet of the primary pressure screens.

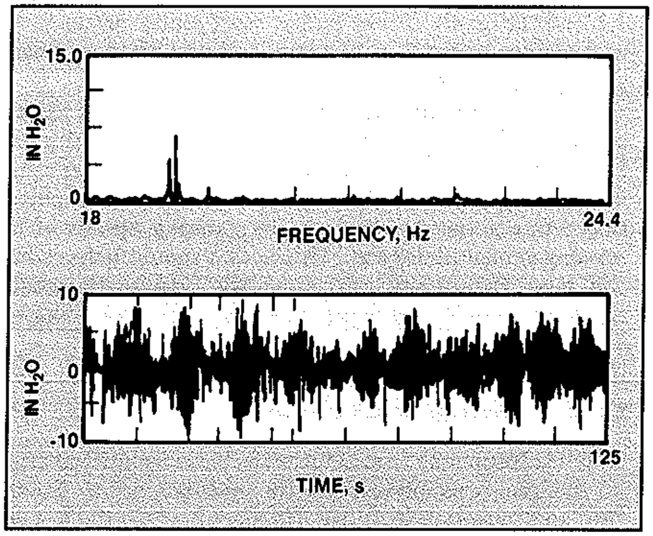
Several days after the troubleshooting attempts had been terminated without success, the primary pressure screen's internal bearing rollers fell to the basement floor. After repair was completed, the 41.75-Hz frequency disappeared. A bad bearing that had escaped detection by routine vibration analysis techniques had produced the basis weight variation at the reel. The slight frequency drift observed at constant machine speed can be explained by slippage of the roller bearing elements.

Loose, wet, or damaged drive belts in a pressure screen can also cause frequency drift. As an example, a screen that had a calculated blade pass frequency of 13 Hz was

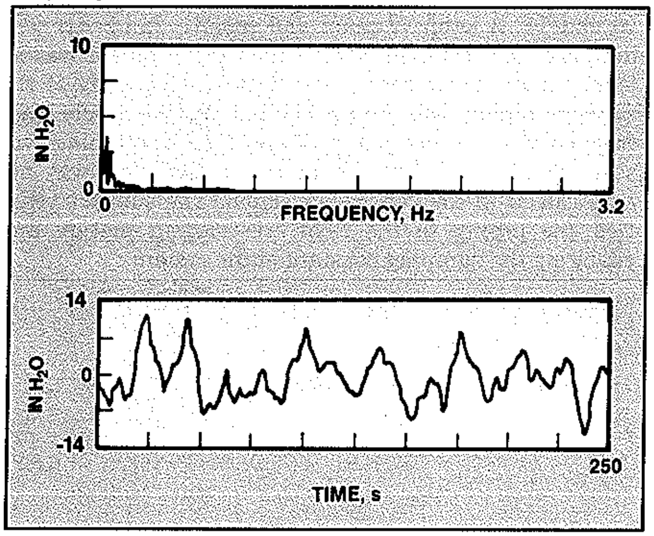
7. Broad band flow disturbances in the range of 3-5 Hz



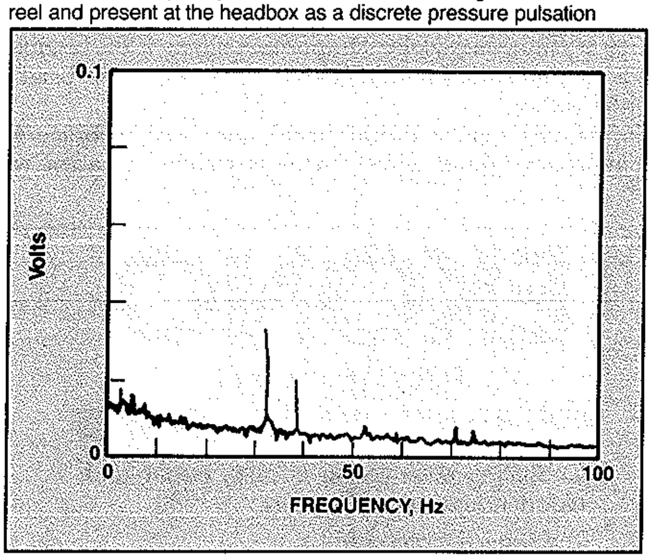
8. A complex beat frequency created by five primary screens running in parallel



9. Low-frequency pulses producing basis weight variations of the same frequency



10. A 39-Hz frequency first detected as basis weight variation at the reel and present at the headbox as a discrete pressure pulsation



pulsing at 12.8 Hz. Inspection showed a worn belt.

Case 3: When to shut off your attenuator

Attenuators and surge suppressors are common wet-end pulse reducers. Typically located between the primary high-pressure screens and the headbox, these devices are designed to passively absorb pressure pulsations. Knowledge of how the attenuator responds to different frequency pulses can aid the papermaker in reducing MD basis weight variation. This measurement, sometimes called an "insertion loss" measurement, is the ratio of the spectrum with the attenuator on vs. the spectrum with the attenuator off.

A value of 1, which is equal to 0 db, means that attenuator has no effect on the given frequency. This measurement defines the effective bandwidth of the attenuator and shows the frequencies at which the attenuator is a pulse amplifier. A good attenuator can have an effective bandwidth of from 1 Hz to 30 Hz, with a threefold reduction in pulses at its most efficient frequencies (**Fig. 5**).

An attenuator had an effective bandwidth of 1-7.75 Hz (**Fig. 6**). The attenuator amplified at 13 Hz, which is blade pass frequency of the primary pressure screen. Broad band flow disturbances were creating pulses in the range of 3-5 Hz (**Fig. 7**). Optimum use of the attenuator was obtained by turning off the air supply to the air pad of the attenuator at times when the screen pulses were high. The installation of a low-pulse rotor assembly to the screen enabled continuous operation of the attenuator.

Case 4: Attenuators and pressure screens

Five primary screens running at similar rotational speeds in parallel were exhibiting a complex beat frequency (**Fig. 8**). The source was the blade pass frequencies (all slightly different) going in and out of phase with each other. At the headbox, no sign of the screen frequencies could be detected; only five discrete low-frequency pulses could be detected (**Fig. 9**). These pulses were quite pronounced, with swings up to 27 in. of water, and they produced basis weight variations of the same frequency.

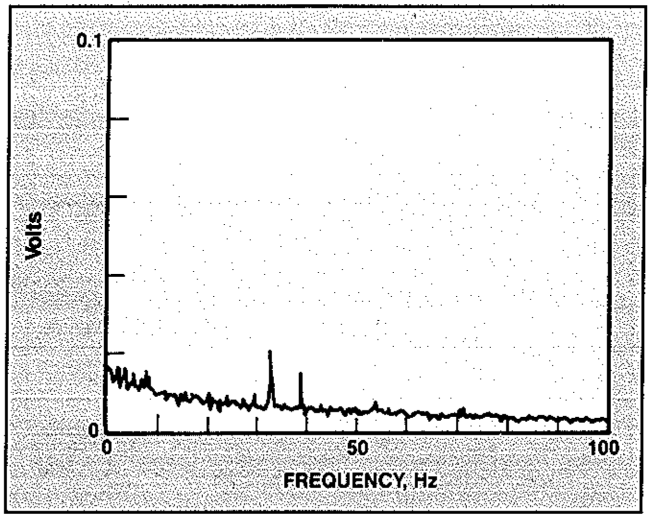
It was postulated that a large suppression tank located before the headbox was effectively dampening the frequencies of the screens, but the beat remained unattenuated and rectified to the low-frequency pulses. Corrective action to separate the running speeds of the screens is now underway. This action should help reduce the beat frequency and simplify future diagnostic measurements to detect which screens are producing the worst pulses.

Case 5: Natural frequencies

A 39-Hz frequency first detected as basis weight variation at the reel was present at the headbox as a discrete pressure pulsation (**Fig. 10**). No machinery in the wet end was rotating at that frequency. Furthermore, the frequency was independent of machine speed, although its amplitude did increase with increasing machine speed. By using a vibration probe and plotting the amplitude of the 39-Hz frequency along the approach piping to the headbox, a maximum value was detected just before a 90° bend in the piping.

At this spot, a forklift truck was used to brace the approach piping while the basis weight variation was monitored. Supporting the pipe from underneath had a negative effect on basis weight variation; support from above significantly reduced variation, as shown in Figs. 10 and **11**. A support beam and passive dampener was designed and installed, after which the problem was no longer found. Apparently, the natural frequency of the support piping was being excited by the blade pass frequency of the fan pump (32–36 Hz). The piping was supported by a hanger from the ceiling and was not constrained in the vertical direction. The support beam tied the piping to the floor, restricting motion and changing the damping constant of the system.

11. Variation was reduced when the pipe was supported.



Received for review Jan. 6, 1988.
Accepted April 21, 1988.

Presented at the 1988 Papermakers Conference.