Controlling entrained air in paper machine systems

Bret Magness, Business Development Manager - ECHOWISE®, Buckman

INTRODUCTION:

The presence of foam in a paper machine system can be a problem. But the presence of foam can be an indicator of the much more costly problem of entrained air. ECHOWISE provides real-time visibility into this problem and sheds light on how it can negatively impact papermaking operations. More importantly, ECHOWISE used with closed loop control provides a means to eliminate these negative impacts.

Foaming in the wet end of a paper machine is an obvious problem that is regularly treated through the application of defoamer chemistries. Foam buildup, as shown in Figure 1, can lead to problems like carry around on the forming wire, slipping issues on walking surfaces, and surface deposition. But the visual presence of foam is a lagging indicator of a problem that can have even greater consequences; that problem is entrained air. Entrained air will impact a paper machine in much the same way as fines or filler loading. When trained air is high, drainage will be slowed. When entrained air is varying, the drainage will move up and down on the machine. This drainage variability can lead to draw breaks, sheet moisture variability, and other product quality issues.

Most times, defoamer chemistries are applied at a dosage level that will eliminate the visual presence of foam in the wet end of the paper machine. These chemistries can be costly and, depending on many machine conditions and other factors, can have varying degrees of effectiveness. A defoamer application methodology based on visual foam provides a downward shift in the threshold of both foam and entrained air but retains the base variability in both conditions that is caused by changes in furnish coming to the paper machine.

Figure 1: Foam buildup on a paper machine.

This unseen, underlying variability in entrained air levels can cause the paper machine issues mentioned above along with excessive spending on defoamer chemistries. The question then moves to, if foam is a lagging indicator of this entrained air variability, what metric can the papermaker use to get ahead of the issue?

What Is Ackumen™ ECHOWISE® Technology

ECHOWISE technology from Buckman provides real time, continuous, non-invasive entrained air measurement. ECHOWISE equipment can be installed in one of two forms. The ECHOWISE 100, as seen in Figure 2, can be plugged into an existing sample tap on a paper machine to pull a continuous process sample through the sensor and then return the sample to the process.

Figure 2: ECHOWISE 100

Figure 3:ECHOWISE 360

The ECHOWISE 360, shown in Figure 3 can be installed around existing process pipe to gather entrained air information anywhere in the process that is needed. ECHOWISE has no moving parts, the equipment will not plug, and it has a long service life. The equipment uses sonar to gather information that is converted into entrained air data. Both types of ECHOWISE equipment provide entrained air readings once every 1.5 seconds generating continuous, real-time information for the paper machine operation. The equipment uses basic 120 VAC or 20VDC power and can be mounted in the most severe environments. The entrained air data collected can be accessed in several ways as the ECHOWISE is equipped with MODBUS, HART, USB, and 2 X 4-20mA outputs. All the considerations embedded into the ECHOWISE equipment provide for a reliable, flexible tool that can provide the paper machine crew the feedback it needs to proactively control entrained air to the proper level 100% of the time. It then becomes important to determine the most effective way to use this tool.

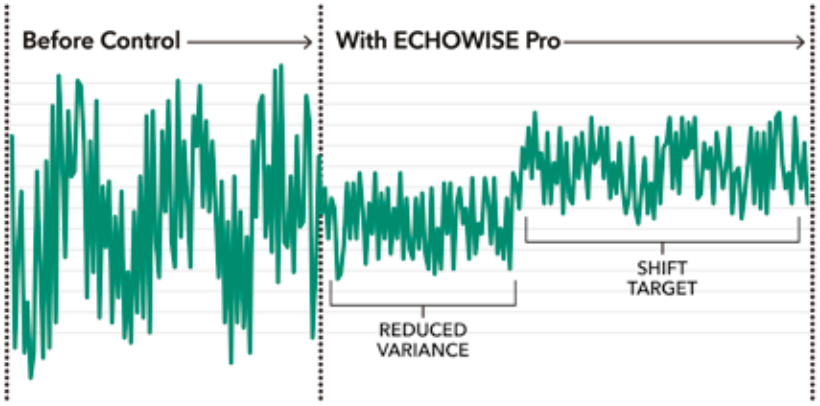
The goal of installing and using the ECHOWISE equipment is to locate an installation point that will provide information that is relevant to the location in the process that suffers due to entrained air and eventual foam. Most of the time for paper machines this location is the headbox jet. When installing on paper machines the ECHOWISE equipment will typically be installed on the immediate stock approach to the headbox or on the headbox recirculation system. This will provide entrained air information at a location and a frequency relevant to what the headbox is experiencing in real-time. The next step is to now decide how to best use this information.

Entrained Air Monitoring Versus Control

Now that a tool has been established to collect continuous entrained air information, it must be decided how best to use this new data. One option is to send this information to the paper machine control room so that operators can see current entrained air level and make defoamer dosage changes as needed. However, this option still relies on manual intervention and continuous monitoring by the operator. Another option is to establish closed loop control of the defoamer dosing. This method requires that a 4-20mA signal be sent from the ECHOWISE equipment to the paper machine DCS or to a Buckman supplied controller. This signal is then used to establish a PID control loop that continuously adjusts the speed of the defoamer pump to control entrained air values to a target setpoint. Figure 4 shows an example Buckman controller for use in closed loop control.

Closed loop control of defoamer dosing is where the true value of ECHOWISE can be realized in papermaking operations. Paper machine additives, furnish, and machine conditions change very rapidly. If a goal of the operation is to minimize variability, continuous control is necessary to eliminate the negative effects of constantly changing conditions. Closed loop control of defoamer dosing using ECHOWISE will hold the paper machine entrained air at a constant level while continuously adjusting defoamer dosage rather than allow entrained air to vary while defoamer dose remains constant. By holding entrained air constant, its impact to paper machine drainage will be reduced or removed. This will be seen in stabilized wet end vacuums, more stable draws, and potentially reduced sheet breaks. An additional benefit to closed loop defoamer control is a reduction in defoamer chemistry spend. Without continuous visibility into the state of entrained air and foam potential, a paper machine operator must dose defoaming chemistry for worst case conditions. This means that the dosage is held at a level that the operator feels will prevent any issue that might occur, and issues do occur as defoamer demand is constantly changing. However, if an operator is dosing to control an issue that happens 5% of the time, then defoamer is being wasted 95% of the time. Continuous closed loop defoamer control will eliminate this wasted spend. This waste can mean hundreds of thousands of dollars in unnecessary spending.

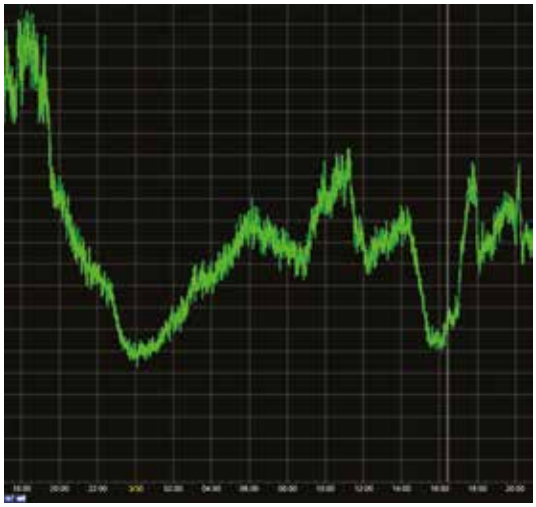
Figure 4:Controller for closed loop control of defoamer dosing.



Improved process performance as a result of combining chemistry with technology.

Figure 5:(left) Variation reduction with the ECHOWISE closed loop control process.

Figure 6:(below) Typical entrained air data monitored by ECHOWISE but not yet being controlled by it.



After Control is Established – Additional Learnings

Once ECHOWISE has been installed and the subsequent move has been made to use closed loop control, much of the variability and waste due to manual defoamer dosing have been eliminated. An additional step is to find the optimum air setpoint for the specific paper machine. For many years there have been industry targets used for wet end entrained air. These targets might be anywhere from 0.3 – 1.0% based on grade and furnish. These targets were established through use of manual testers that were single point in time measurements. The targets had to be set artificially low so that they could account for variation to higher levels in between test sample collection. Figure 5 is a visual representation of each stage of the ECHOWISE Closed Loop Control process. ECHOWISE enables modern air targets to be established and is providing insight that each paper machine can have a different entrained air threshold. Closed loop control with targeted air setpoints allows the papermaking operation to find the optimal setpoint for a specific paper machine and hold entrained air at that level. This setpoint will minimize additive waste while also minimizing the impact of entrained air on the papermaking operation. In many instances, this target will be higher than the historical standards.

What are the Benefits of ECHOWISE Entrained Air Control

The impacts of entrained air can be varied across different types of paper machines and different grades produced. These benefits are typically isolated to a few different groups: machine performance in speed or break frequency, sheet quality, and additive cost and defoamer spend. Following are some graphic examples of how ECHOWISE closed loop air control can positively impact paper machine operations.

Machine Performance

The impact of entrained air on machine performance is almost entirely based in the impact of entrained air on wet end drainage. When the forming section drainage rate is slow or variable, this will drive the subsequent moisture profile down the machine. As discussed, this can drive draw variation, high steam consumption, defects, and breaks. Figure 6 shows an example of typical entrained air data collected once an ECHOWISE unit is installed. This is a period of data collection where the air is not being controlled, only monitored. As can be seen in the graphic, the air varies throughout the period based on incoming defoamer demand variability.

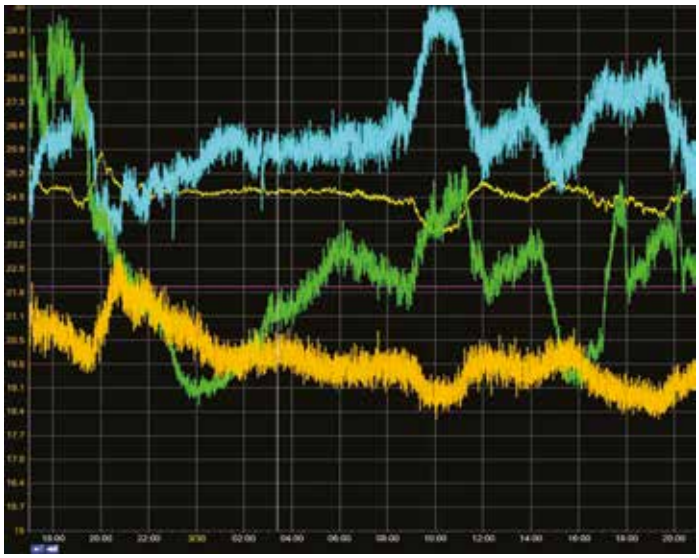


Figure 7:(above) Entrained air data plus some wet end drainage indicators.

Figure 7 shows this entrained air data paired with some of the wet end drainage indicators. For simplicity, the focus here will be on entrained air (green) and Auto-slice Vacuum (Blue). Higher Auto-slice Vacuum is indicative of a wetter sheet coming to the top former section of the paper machine. As can be seen in the figure, when entrained air increases, Auto-slice Vacuum increases. Also seen in the graphic are the Gamma gauge consistencies in yellow. These consistencies confirm what is seen in the Auto-slice Vacuum. This type of entrained air / drainage rate relationship has been seen repeatedly in ECHOWISE installations. So then, what happens to these drainage indicators when closed loop entrained air control is established?

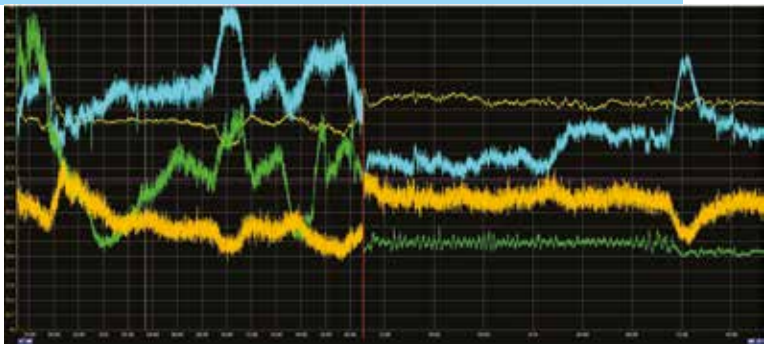


Figure 8: Left side is the same as Fig 7 . Right side of chart shows control achieved with ECHOWISE.

Figure 9: (below) Statistical analysis of production rate before and after ECHOWISE closed loop control was established.

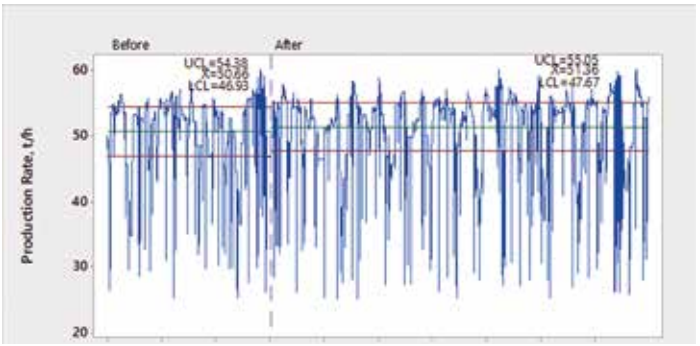


Figure 8 shows the same graphic but with the period after control is initiated added to the right-hand side. As shown in the graphic, all wet end drainage indicators become more stable once control is established and entrained air no longer varies. Of note in this graphic is a period when Auto-slice Vacuum varies without an associated entrained air change. This is an example of another drainage driver external to entrained air. This is an important point to discuss: Entrained air control will not remove all drainage variability drivers, but it will remove one of the most dominant drivers and will allow the papermaker to uncover others more easily.

Now that a link between entrained air and drainage is established, a papermaking operation would need to be able to attach a concrete value to removing this variability. One example of this value can be seen in Figure 9. This figure shows statistical analysis that was done on production rate data from a paper machine before and after ECHOWISE closed loop control was established. As shown in this graphic, the overall production rate increased by 0.7 ton/hour, a 1.4% improvement. What is not shown in this graphic is that the overall defoamer consumption decreased by 40.2%. While this defoamer consumption reduction was remarkable, its value is minute when compared to the value of the production increase.

Sheet Quality

Figure 10 is a fortunate example that was captured of the impact entrained air can have on sheet quality. ECHOWISE units had been installed for several months on a 2-ply paperboard machine. During the period following installation there had not been much observed entrained air variability and the move to closed loop control had been delayed. The figure below captures a period when the machine experienced an upset and began rejecting paper due to smoothness and print test falling out of range. In a review of the entrained air data, it was noted that the entrained air had moved well beyond the values seen in the preceding months. An effort began to institute closed loop control. Figure 10 captures this conversion period. In this graphic the entrained air, in gray, starts out at greater than 0.5%. In the preceding months the entrained air value had hovered continuously around 0.15%. As can be seen, during this elevated period of entrained air Parker Print and Smoothness test values (orange and blue) were falling outside of target and paper was being rejected. There is a period in the middle of the graphic where defoamer dose (yellow) was extremely high and variable, but the controls were able to bring levels down to the point where sheet quality returned to spec. It can also be seen how the controls began working smoothly once the system had been tuned to handle the upset by adding more defoamer pump capacity. Finally, the graphic shows that the defoamer speed returned to minimum after the upset had passed.

Additive Cost

Another important point can be taken from Figure 10 there had been no entrained air upset like the one in this graphic for months prior to this episode. So, after rejecting hours of production, it was noted that entrained air was high and defoamer dosage was increased tremendously to overcome the issue. In this case, ECHOWISE control was initiated during the upset, but what would the scenario look like without ECHOWISE control? The defoamer dosage would likely remain very high following the upset without some way to know it had passed. Figure 10 is a visual example of how ECHOWISE with closed loop control can eliminate wasted defoamer spending.

Closed Loop Control Using ECHOWISE®

As discussed, the presence of foam in a paper machine system can be a problem. But the presence of foam can be an indicator of the much more costly problem of entrained air. ECHOWISE provides real-time visibility into this problem and sheds light on how it can negatively impact papermaking operations. More importantly, ECHOWISE used with closed loop control provides a means to eliminate these negative impacts.

Figure 10: (below) ECHOWISE was monitoring but not set for closed loop control when an entrained air upset happened (gray); ECHOWISE was switched to control during the upset, and it regained control.