Improving Consistency Control

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Abstract

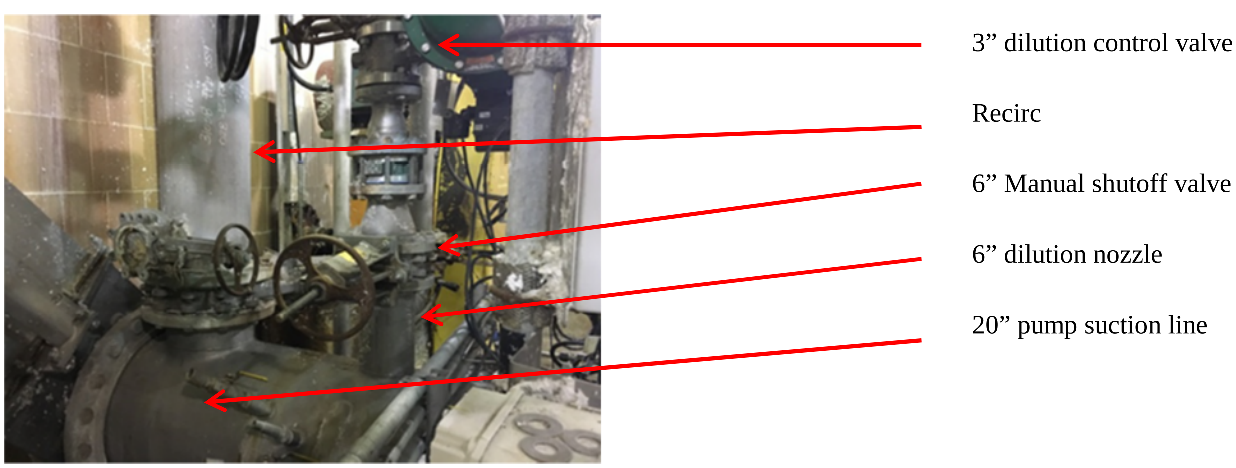
Paper machines are being made bigger and faster than in the past. Older machines are being stretched beyond design production to keep pace. Pumps and other process equipment have become more efficient as Energy cost management has become more important. In short: bottom line profitability demands more from operations and the process. How should your mill's fundamental control of consistency change to keep up? What steps can be taken to optimize control in this new environment?

As many mills migrate to pumps, drives and motors that are more energy efficient, changes occur in process conditions that can adversely affect consistency control. These changes to throughput, pumping, mixing and control type have an impact on dilution capacity, agitation, and injection properties that can impact the mixing of stock and dilution water. Without understanding the impact of these conditions, they may not be getting mixed properly.

Understanding your current capabilities and the options that exist are critical to knowing how to proceed. For example, some mills use standard consistency control, while others have started to control consistency by using dilution flow. Each of these choices has pros and cons. Understanding this choice, along with injection nozzle design and current dilution capacity will be covered in this discussion. It can provide a starting point to aligning consistency control with the current conditions in your mill.

Introduction

A large packaging machine was updated to increase production and to save energy. One of the key modifications was changing to a variable frequency drive with a larger, more efficient pump that was capable of increased throughput. Picture 1 below shows the discharge of the stock chest. The consistency control loop is standard with a pump, control valve, single dilution nozzle, dilution water header, controller (DCS), agitator and consistency transmitter.



Picture 1

Intermittently the mill would see stock chest consistency variations that went through to the dry end. These would cause issues with basis weight being too high or too low and could even lead to sheet breaks. This is shown below in Figure 1. This particular mill uses dilution flow for consistency control. In Figure 1 Con PV is the measured value from the consistency transmitter and Con Out is the calculated value sent to the dilution control valve. In the graph you can see that the blend chest consistency PV changes, this changes the blend chest consistency output causing the stock to get light (over diluted). After a time lag this shows up on the machine chest PV. Note that this mill does not control consistency at the machine chest, but uses it only for buffering high frequency noise.

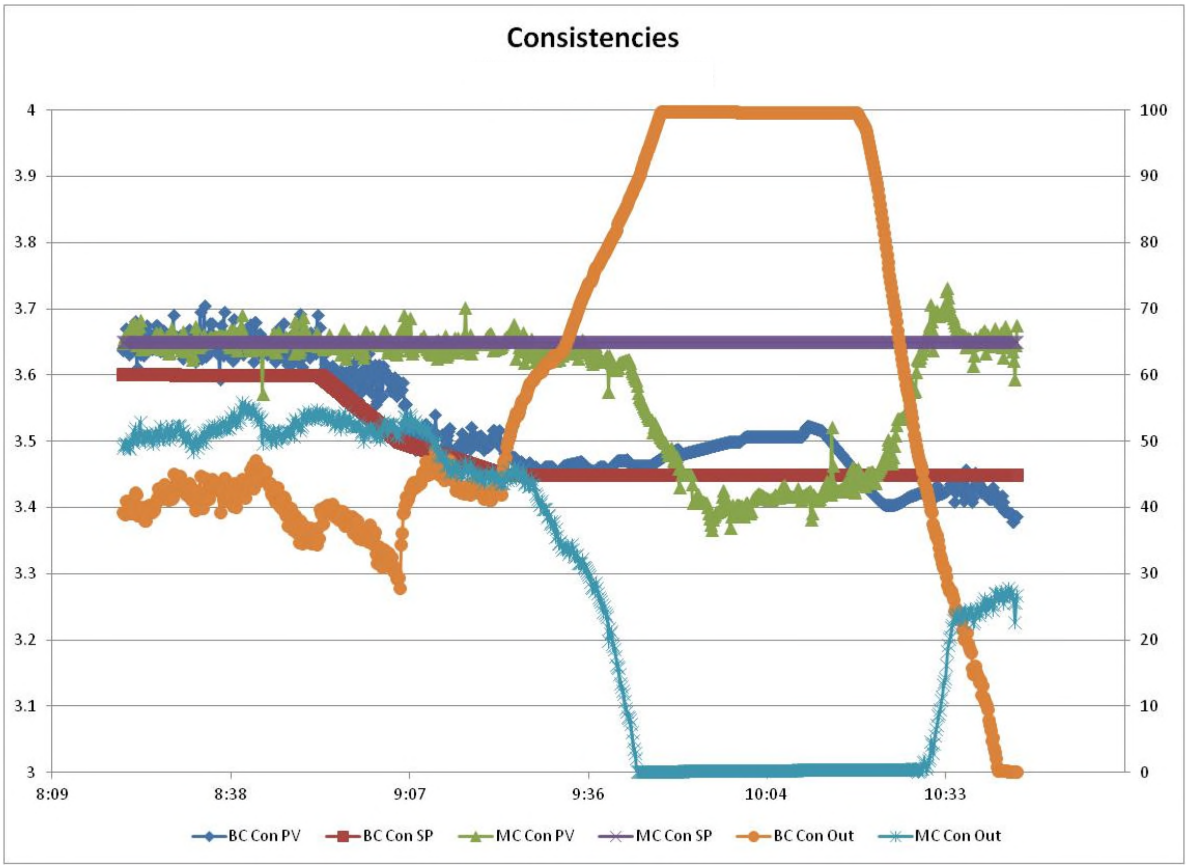


Figure 1

Solution

Troubleshooting with the mill led us to believe that the problem was poor mixing of the dilution water and the stock. This was a new problem that was not seen before the production/energy project. Proper dilution mixing relies on two main things: mixing within the pump and the dilution nozzle being properly designed.

Pump design has changed tremendously in the past years. Pumping more efficiently at lower cost is now a primary goal. Pump case design, vane design and other improvements have been made to drive this increased efficiency. Unfortunately as pumps have become more efficient they create less turbulence and have less backflow. Because of this newer efficient pumps do not mix stock and dilution water as in the past. This demands that dilution nozzle design be optimized to provide the necessary mixing. Proper dilution nozzle design is shown on the next page in Figure 2. When the process is running it is not possible to see the internal section of the dilution nozzle, that is, does it have the correct “G” dimension? Is it butt welded onto the pipe? With the exception of a complete rebuild or greenfield project dilution nozzles are not something that we have any control over, we use what we have.

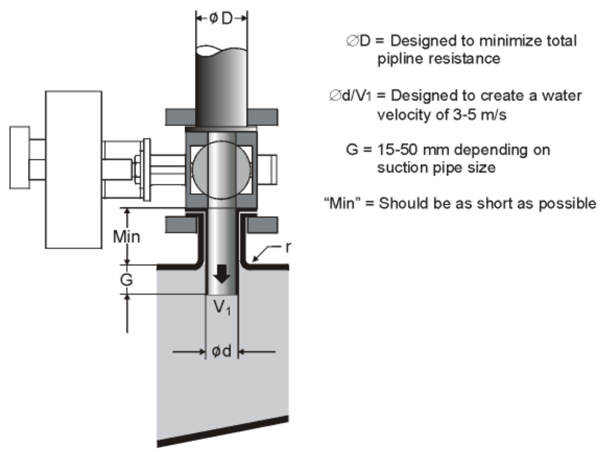


Figure 2

In this case the mill was willing to make the changes necessary to have the consistency control loop working as well as possible. They were willing to invest in a new dilution nozzle. The calculated G dimension is 40mm. Previous experience and calculations showed that the nominal dilution flow is 375 gpm. With the existing 6" nozzle the dilution flow is only be 1.3 m/s, too low to provide good mixing. As shown in Figure 2 above the dilution flow target is 3-5 m/s. Changing to a 4" nozzle increases the dilution flow to 3 m/s, the minimum. Changing to a 3" nozzle increase the flow to 5.2 m/s, over the maximum.

Normally a single dilution nozzle is used and works very well. However in the case it is not the path that was taken. If you refer back to Picture 1 on page 1 you will see that the suction line is 20" in diameter. This is larger than is typically found and there was concern that the stock and dilution water would still not be adequately mixed. It was decided to go with "ring dilution" similar to what is seen on some high density chests. The 6" control valve is still in place, but it now feeds a 4" dilution header that circles the suction line. Off the header there are three 2" dilution nozzles spaced 120^{o} apart. The nozzles were designed and installed with the proper 40mm G dimension. The dilution water velocity is now 3.9 m/s right in the sweet spot. Below figure 3 shows is a simplified drawing of what was done.

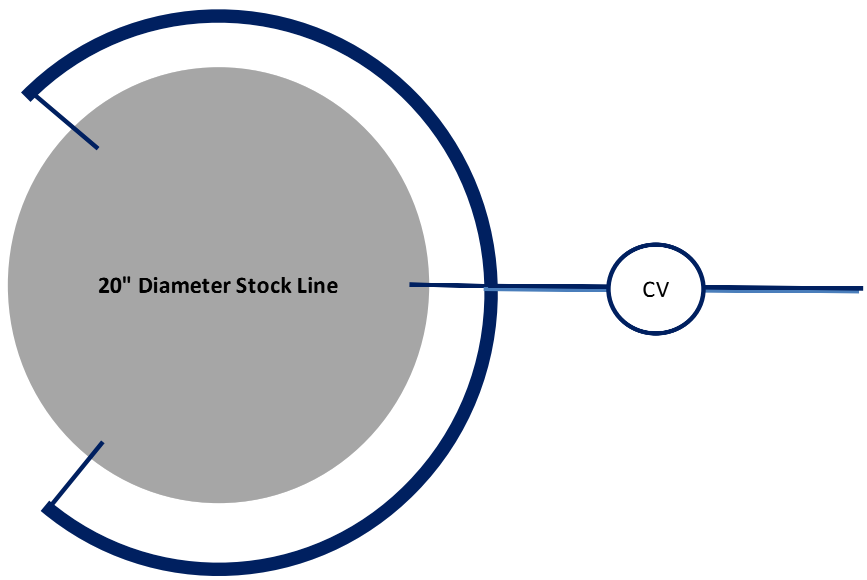


Figure 3

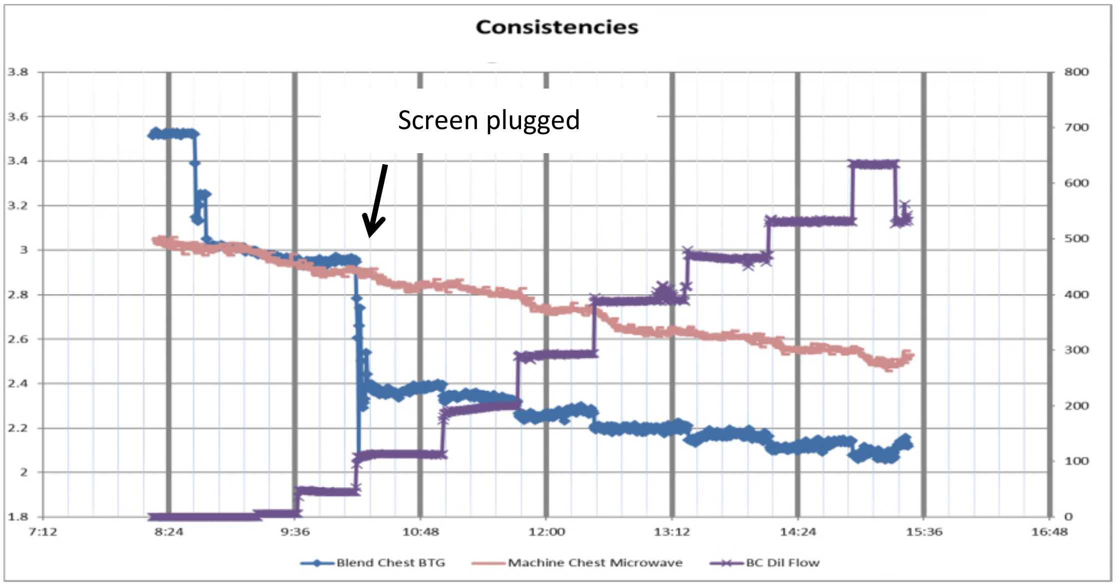


Figure 4

The results are shown above in Figure 4. You can see that the consistency transmitter responds in a repeatable manner to dilution control valve steps. After the expected time lag you also see the changes at the machine chest showing that the mixing problem is now gone.

Dilution Flow Control for Consistency

Almost all pulp and paper mills control their consistency loops using feedback control as shown in the figure 5 on the next page. It is simple and well understood by most mill people.

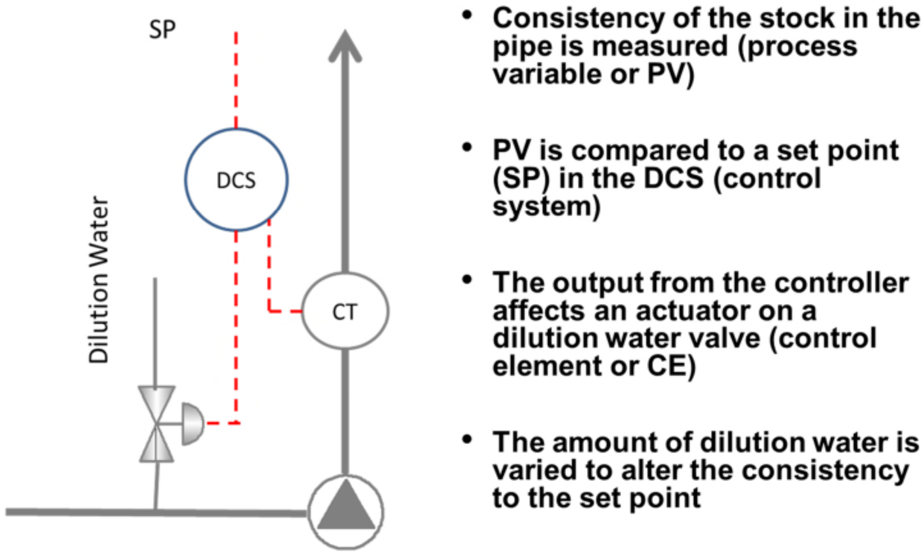


Figure 5

The question is can it be improved upon? How? What is required? What if we add dilution flow? We are still measuring consistency, the loop is basically the same, but now there is a flow meter in both the stock and dilution lines. The control formula in the DCS is different. Figure 6 below is a basic diagram.

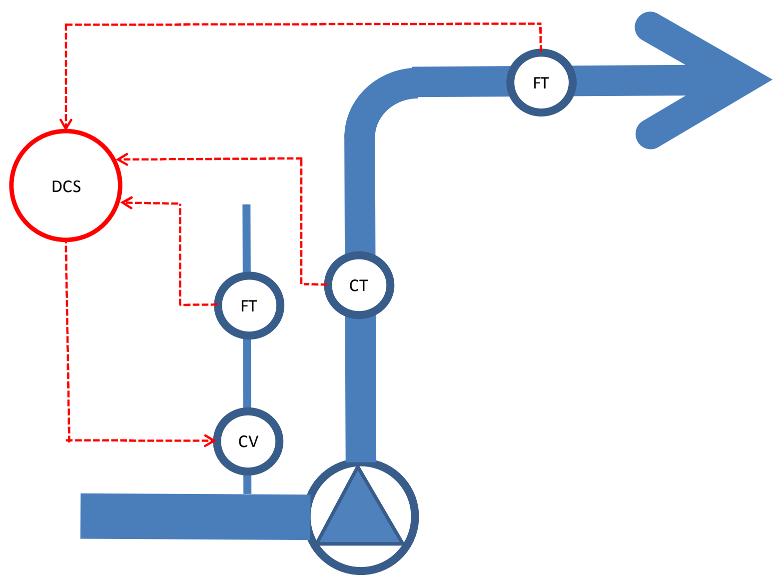


Figure 6

The benefit of using dilution flow as part of consistency control is being able to more precisely add the correct amount of dilution water. You measure consistency and flow of the stock you want to dilute and calculate tonnage. Dilution water addition is still controlled by the control valve, but instead of controlling it with only a feedback consistency signal it is controlled by the actual amount of dilution that needs to be added.

Summary

The consistency control loop is one of the oldest control loops found in the pulp and paper industry. Because of this it is often taken for granted and that is a mistake. Along with flow, consistency measurement and control are the fundamental building blocks of process control. If these are not done right all the other measurements and controls that follow will suffer. Do not take consistency for granted.