EXPERTIP

Category	PRESS
Keywords	Water removal, sheet consistency, sheet solids, water balance, sheet water content, forming, pressing, drying, couch solids

Basic Water Removal Calculations

This ExperTip shows how one simple and fundamental mathematical equation can be very useful to anyone trying to troubleshoot, or simply understand the water balance of modern paper machines and more specifically, press sections. This document will share useful findings or observations highlighted by this basic equation and point you to a public excel worksheet you can use to apply this information to your own machine.

Use the approach described if you already have the web consistency information and are attempting to estimate the web water content or flow at various points on the machine. The same equation holds true if you are trying to determine the paper consistency, but that is not part of this discussion. The web solids content values can be actual (measured via grab sampling, see TAPPI TIP 040401) or just estimates for modeling purposes.

In this article, we will show the impact of various sheet consistency values on water balance.

The only equation you need to calculate how much water is in the sheet at any point:

Equation 1a.

$$\%\ \text{solids} = (\text{Sheet Basis Weight} / (\text{Sheet Basis Weight} + \text{SPECIFIC WATER MASS})) \times 100$$

This equation deals with “specific” values, by which we mean ”per area” quantities. For example, SPECIFIC WATER MASS, or water mass per area, which is commonly expressed in grams per square meter (g/m^2). Similarly, your sheet basis mass is typically expressed “per area” based on standard industry ream weights. For non-metric ream basis weights, you can use appendix A to convert your ream weight to grams / square meter or use the provided worksheet, which can accommodate all units.

Since this exercise is about calculating WATER content and flows, the more useful form of the equation will rearrange the terms to isolate the unknown quantity: SPECIFIC WATER MASS.

Equation 1b.

$$\text{SPECIFIC WATER MASS} = \%\ \text{solids} / (100 \times \text{Sheet Basis Weight}) - \text{Sheet Basis Weight}$$

Tip: To convert specific water mass (g/m^2) to total water removed (liters or gallons per minute) simply multiply the specific water mass value by machine speed and width. Ideally, your water collection system’s flow values should match measured water. This can be used to troubleshoot the machine or the flow measurement systems.

Application #1

Your former takes most of the water out [fig.1]. This may sound obvious, but equation 1b truly illustrates the magnitude of difference between sections. What this means in practice is that almost all of the fiber motion, thus sheet consolidation (aka formation), takes place before the sheet enters the press section, so most sheet properties will be determined prior to that point.

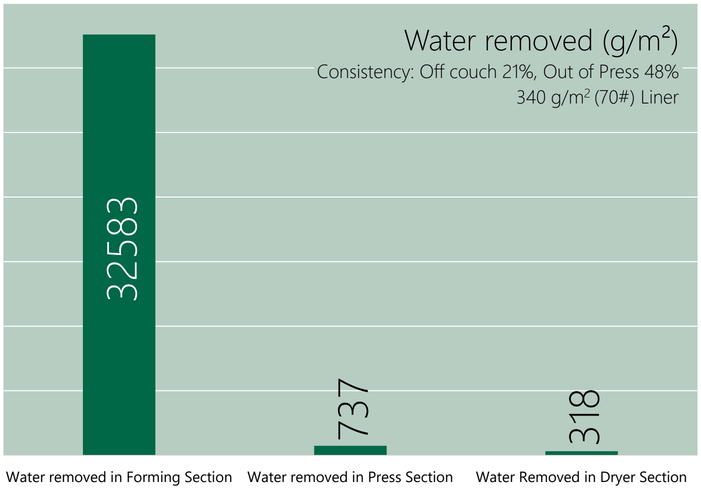

FIGURE 1. Water Removed by Section

Application #2

Since the forming section removes approximately 95% of a machine's water, it cannot be overlooked when troubleshooting wet streaks or overall poor water removal performance. These issues inevitably affect downstream operation, but remember that a small malfunction in the forming section will be severe in later sections.

Application #3

The dryer section is usually the longest and is the largest consumer of power in any mill; but in fact, this section removes relatively very little water [fig.1]. It follows that any increase in sheet solids entering the dryer section carries significant financial savings. It bears repeating that the rule of thumb is 1% improvement in pressing efficiency yields roughly 4% in energy savings.

Universal g/m²	Fine lbs/3300ft²	News lbs/3000ft²	Liner lbs/1000ft²
10	7	6	2
20	14	12	4
30	20	18	6
40	27	25	8
50	34	31	10
60	41	37	12
70	47	43	14
80	54	49	16
90	61	55	18
100	68	61	20
110	74	68	23
120	81	74	25
130	88	80	27
140	95	86	29
150	101	92	31
160	108	98	33
170	115	104	35
180	122	111	37
190	128	117	39
200	135	123	41
210	142	129	43
220	149	135	45
230	156	141	47
240	162	148	49
250	169	154	51
260	176	160	53
270	183	166	55
280	189	172	57
290	196	178	59
300	203	184	61
310	210	191	64
320	216	197	66
330	223	203	68
340	230	209	70
350	237	215	72
360	243	221	74
370	250	227	76
380	257	234	78
390	264	240	80
400	270	246	82
410	277	252	84
420	284	258	86
430	291	264	88
440	298	270	90
450	304	277	92
460	311	283	94
470	318	289	96
480	325	295	98

APPENDIX A.

Application #4

Variations in off-couch sheet consistency have a tremendous impact on how much water the press must handle [fig.2]. This suggests that some of the normal variation we see in flow rates measured on machines could be explained by the constantly fluctuating off- couch consistency [fig.3].

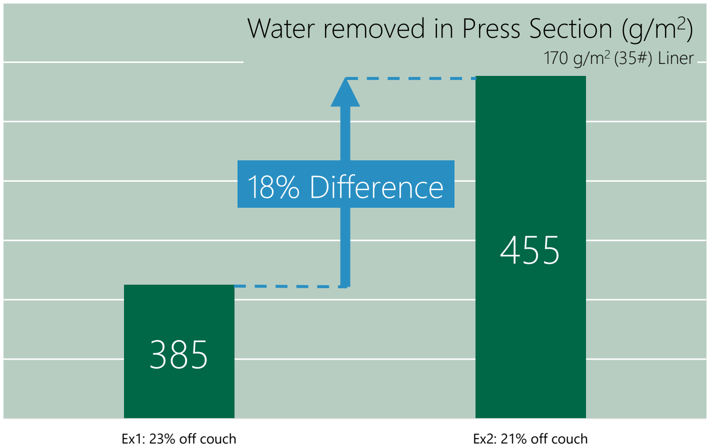

FIGURE 2. Water to Press at different off-couch solids

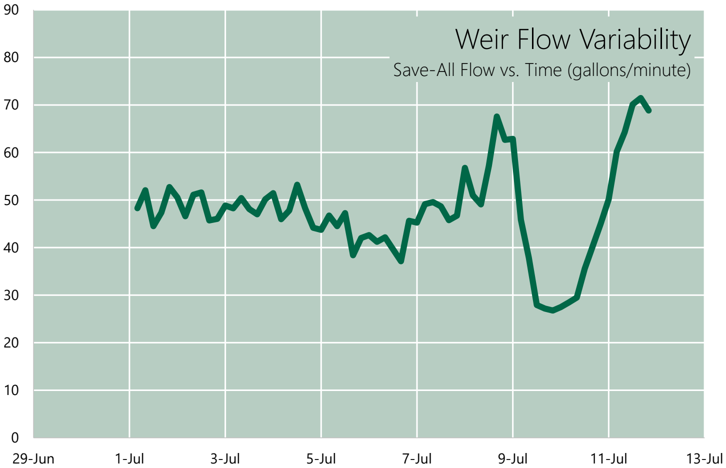

FIGURE 3. Weir Flow variability over time

Application #5

Shower water is usually a significant contributor to your press water balance. The water required to dislodge contaminants, carry them away, and lubricate uhle boxes quite often contributes as much water to the press water balance and sheet profile as your web. If your machine has a "complete" water collection system in the press section, you can use equation 1b to calculate how much water the web is contributing using the ingoing and outgoing press consistency. Then you can compare the theoretical water removed to the actual water measured at save-all pans and uhle box separators.

The ratio of shower water to total water represents your "Press Dilution Factor (PDF)". High dilution factor machines consume more water but should maintain press fabrics cleaner. Typical PDF values range between 0.5 and 3.0. Machines with incomplete press water collection points will always underestimate the PDF value, but the PDF trend can still provide good information.

Figure 4 shows the measured press water on a machine where the web contributes roughly 500 g/min of water, yet the press measures between 1.6 and 2.7 more water than that. Figure 5 is another example where we find that the calculated water removed far exceeds the water captured. Here the water capturing is lacking, but the inaccurate dilution ratio (0.6 to 0.9) can still show useful trends.

Note that press water capture is rarely complete as shower water is never 100% absorbed by the press fabric. Ideally, machines would collect this "rejected" shower water as well, to complete the water balance however very few mills document this relatively small flow.

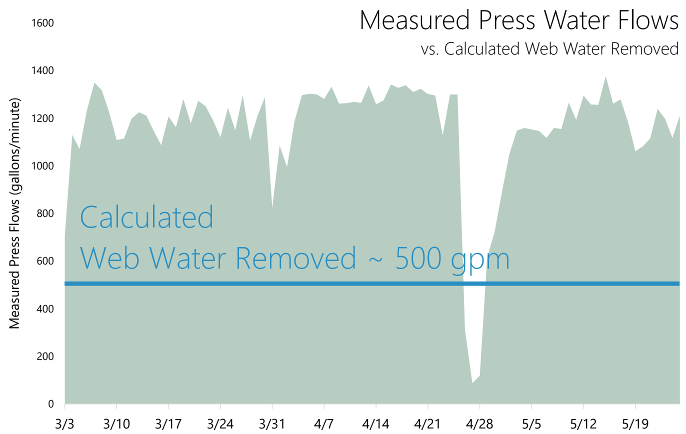

FIGURE 4. Measured Press Water Flows
vs. Calculated Web Water Removed

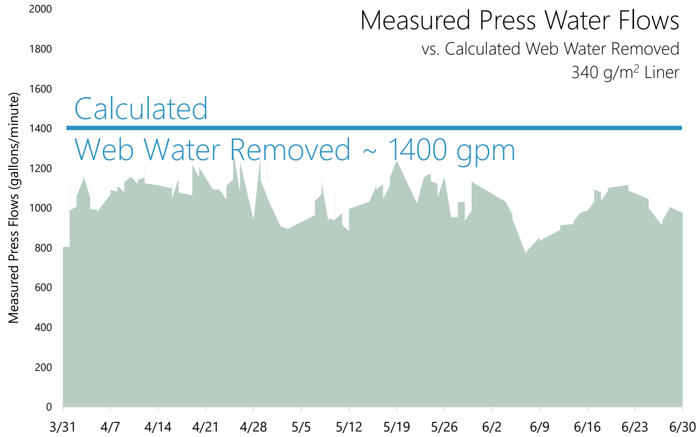

FIGURE 5. Linerboard machine not capturing all the sheet
and shower water?

Conclusion

As you can see, one very simple equation helps us visualize and understand the impact of off-couch consistency and uniformity, the importance of optimizing press solids, and significant contribution of showers to the overall water balance.

I hope you can apply this technique in troubleshooting and understanding your own machine.

Questions?

We are here to help. We distribute **ExperTips** to help you improve the performance of your paper machine. Not just fabric performance, but the overall efficiency, reliability, and productivity of your mill.

If you have questions about anything you see here, please contact us by emailing **expertip@astenjohnson.com** or visiting our website **www.astenjohnson.com/expertips**.

And, if you have suggestions about other topics you would like to receive an ExperTip on, we would love to hear from you!