EMPIRICAL INVESTIGATION OF WEAVE VERSUS WEB-TO-ROLLER TRACTION IN FLOATING LOOP DRYERS

by

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INTRODUCTION

This report details the results of a laboratory experiment to better characterize the behavior of floating-loop dryers with respect to web-to-roller traction. The results show that roller traction primarily affects the frequency at which weave is amplified in a floating-loop dryer. Increased traction increases the frequency of weave amplification, which then requires more responsive web guiding equipment to control weave.

DEFINITION

A floating-loop dryer (Figure 1) consists of a repeated series of conveyance sections, each consisting of two parallel perforated plates, which form two walls of a pressurized plenum (Figure 2). A series of rollers is placed outside of these walls to set the location of the web. An air reverser consisting of a cylindrical piece of perforated material is located at the bottom of the section. Entrance and exit rollers at the top of the section typically have a nominal 90-degree wrap, and convey the web from one section to the next. These top rollers may also contain other conveyance elements, such as web guiders, motor drives, and tension control elements.

BACKGROUND

Weave in floating-loop dryers has been a low-level chronic problem. It was noted that attempts to include higher-traction rollers in floating-loop dryers resulted in more weave in floating-loop dryers when running at higher web speeds. This prompted conveyance engineers to use rollers that had an intermediate level of traction. These difficulties also pointed out that we did not understand or anticipate the weave behavior that was observed. This project was begun in order to gain understanding of those observations.

EXPERIMENTAL EQUIPMENT AND TECHNIQUE

These experiments were conducted in a laboratory, rather than on a production machine. A single floating-loop dryer section was installed in the laboratory (see Figure 3). The laboratory floating loop contains 10 rollers. This floating loop was populated with typical rollers from production machines, but with new bearings. Careful attention was paid to the bearing and roller mounts so that bearing friction was low (as it is in production conditions).

Rather than attempting to vary roller traction by using various webs with differing degrees of traction, a single typical web was used. In addition, a wide range of roller traction was desired for the laboratory trials. Rather than attempt to change our rollers with various surface treatments, we taped the rollers. For the low-traction case, the rollers were covered with Teflon tape, and for the high-traction case, cloth tape was used. An intermediate-traction case used the normal production rollers. Using this technique, we were able to vary the web-to-roller traction over a range of about a factor of 10, as shown in Figure 4. All 10 rollers in the floating-loop section were taped, even though the first and the last rollers had 45 degrees of wrap.

The laboratory equipment contains a web guider used to position the web laterally on the machine. To introduce weave to the floating-loop section, another guider called the test guider was installed just ahead of the floating loop. The test guider used an AccuWeb Micro-4000 guider sensor, controller, and actuator. The sensor on the test guider was translated to generate weave with a nominal one-inch amplitude (peak to peak). The amplitude of the weave at the floating loop was monitored using two weavemeters, one at the entrance to the floating loop, and one at the exit. It was desired to observe only the behavior of the floating-loop section, and not the behavior of the guider's ability to introduce weave or the behavior of the web on the two rollers prior to the entrance roller of the floating loop. To accomplish this, the ratio of the output weave amplitude to the input weave amplitude was generated as the main experimental output. This observation was made as the frequency of the weave was swept from 0.01 Hz to 5 Hz. This results in an experimental transfer function, the characteristics of which may be used to compare one run with another.

Because of safety concerns, web-to-roller traction was not measured with a Prony brake. Rather, with the web running, each roller was manually stopped in turn, and its acceleration was measured when it was released. Given knowledge of the radius and inertia of a roller, one may compute the traction that generated a given acceleration. In addition, the bearing drag of each roller was measured to verify that the roller bearing drag was low enough to be negligible in comparison to the traction that occurred between the web and the roller. The roller inertia was measured by observing the roller acceleration as a known weight suspended by a string wrapped around the roller was permitted to fall freely. Roller acceleration and deceleration were measured using Kodak equipment.

All experiments for this study were performed at a fixed web speed. All theories and previous observations led to the conclusion that if web-to-roller traction remains the same, the weave behavior also remains the same when viewed from the perspective of how much web has passed. For example, if the web-to-roller traction is the same at X m/s and 2X m/s, weave behavior at 2X m/s will be the same, except that it will occur twice as fast. This will be true for splice weave response, for weave from web non-straightness, for splice weave response, and for weave that is amplified in air-conveyance devices such as floating-loop dryers.

RESULTS

The floating loop in the laboratory always exhibits a weave amplification peak at a certain frequency. Such peaks are characteristic of a resonant system. The frequency of the resonant peak increases with roller traction, as shown in Figure 5. The amplitude of the peak is typically in the range of 1.2 to 1.3, and is not a strong function of the roller traction. The amplitude of the peak declines somewhat for high-traction cloth-taped rollers. For the low-traction case, most of the trace is somewhat elevated. This is because the traction is so low the web tends to randomly wander from side to side in the floating loop. This causes the output amplitude to be slightly higher than the input amplitude even at low frequencies, resulting in an apparent increase in gain at low frequencies. Note that the plots are log-log plots, so the "noise" inherent in the edge position of a running web appears to be 10 times as large at a ratio of 0.1 as it does at a ratio of 1.0. That is one reason why the plot looks noisy at lower amplitudes. The traces begin to dissolve into noise at frequencies above about 0.5 Hz. At higher frequencies, the test guider is less capable of introducing disturbances and the web path from the test guider to the floating loop inlet is less capable of transmitting higher-frequency weave. Thus, the amplitude of the input weave (and, consequently, the output weave as well) falls off somewhat, which also contributes to the higher noise level at higher frequencies. The desired signal becomes buried in the noise. The data is completely useless above 1 Hz, so that data is not shown.

Additional data was taken with alternate high-traction-surfaced rollers, with every other roller removed, and with the use of smooth rollers in place of the Teflon-taped rollers. In addition, data was taken at various web tensions, floating loop reverser pressures, and floating loop plenum pressures. Nothing in all this, however, provided significant additional information about weave behavior to that shown above, so this additional data is not shown here.

FUTURE WORK

This technique should be repeated on a variety of dryers to see the effect of roller traction on weave amplification for other dryer configurations. Theoretical explanations for the behavior shown need to be developed. A combination of these approaches should lead to a predictive model for weave amplification behavior in dryers of various configurations.

SUMMARY

Roller traction has a dramatic effect on the manner in which web weave is amplified in a floating-loop dryer. It does not affect the amplitude of weave amplification to nearly the extent it affects the frequency at which the amplification occurs. Disturbances at the peak amplification frequency will build rapidly down the dryer. Web guiding equipment must be effective at significantly attenuating disturbances at this frequency, or weave will get out of control. Guiders with pneumatic sensors and actuators are not adequate for higher speeds when rollers and webs with higher traction levels are used. Faster response is needed both due to the higher weave frequency generated from the higher speeds, and from the higher weave frequency generated by the higher frequency amplification resulting from higher traction rollers.

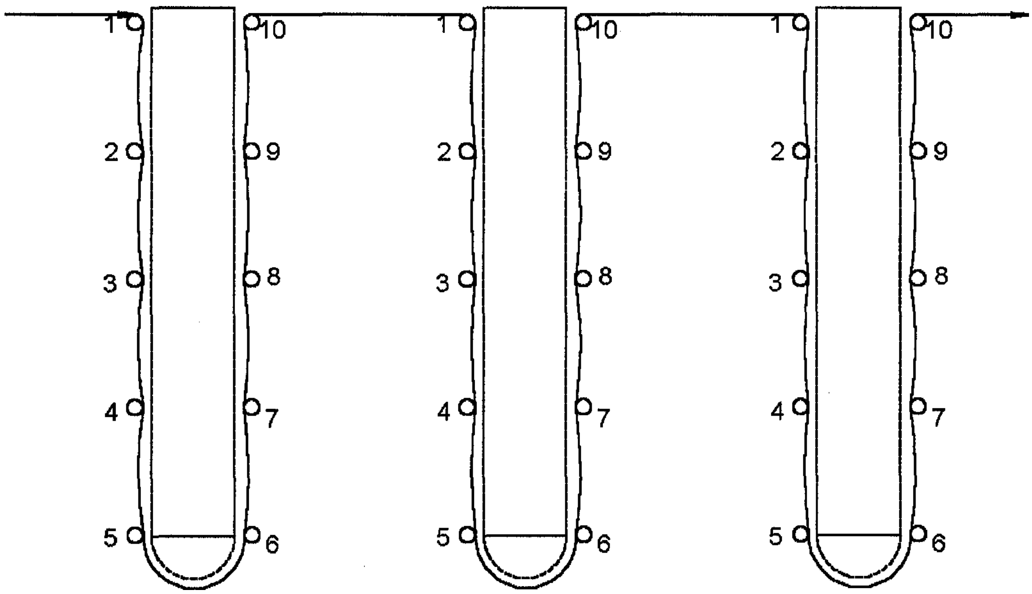

Figure 1: Floating-loop dryer layout

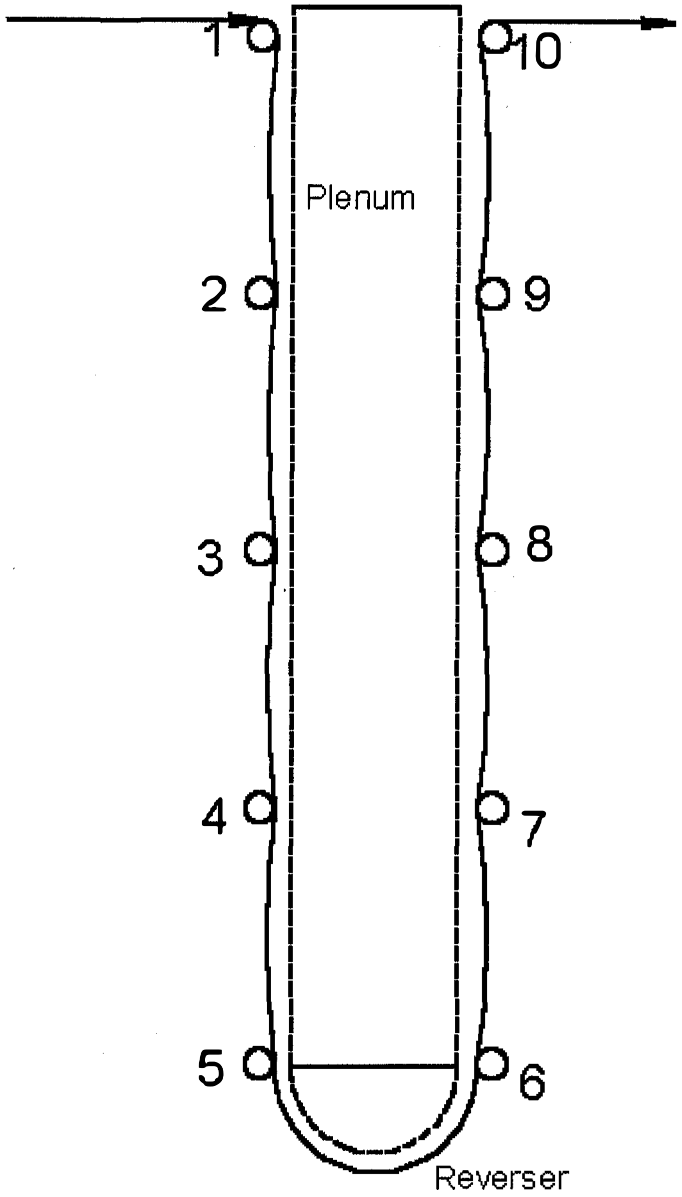

Figure 2: Detail of a floating-loop conveyance element

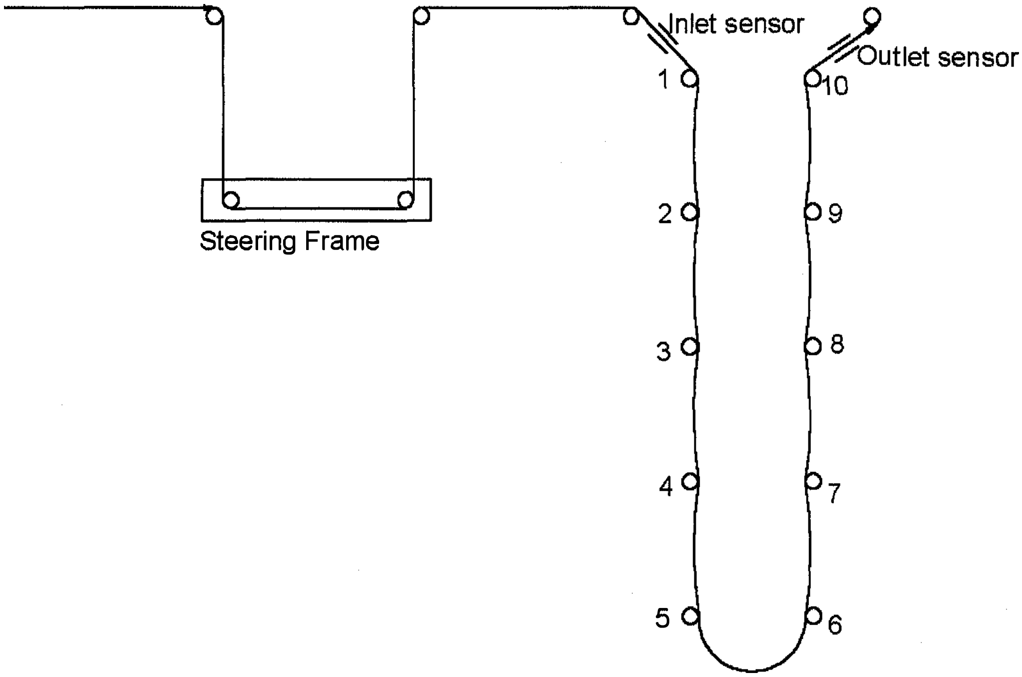

Figure 3: Laboratory threadup

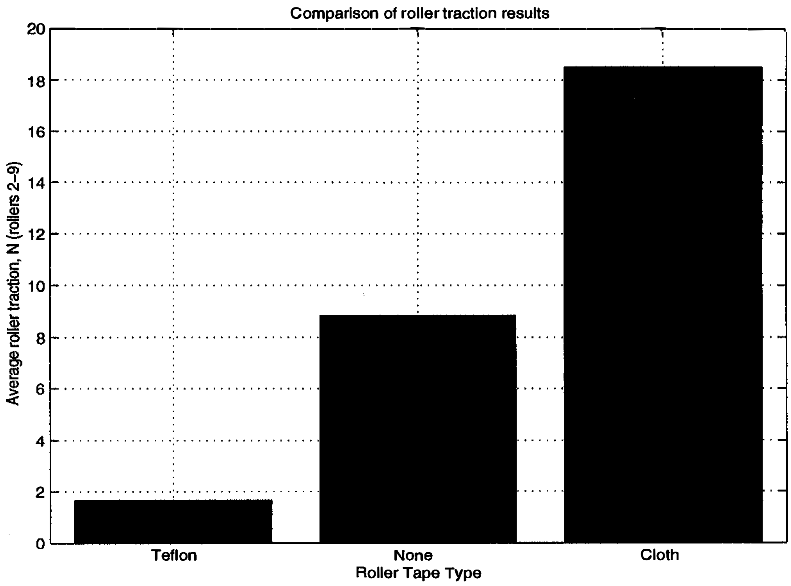

Figure 4: Comparison of web-to-roller traction for rollers with Teflon tape, no tape, and cloth tape

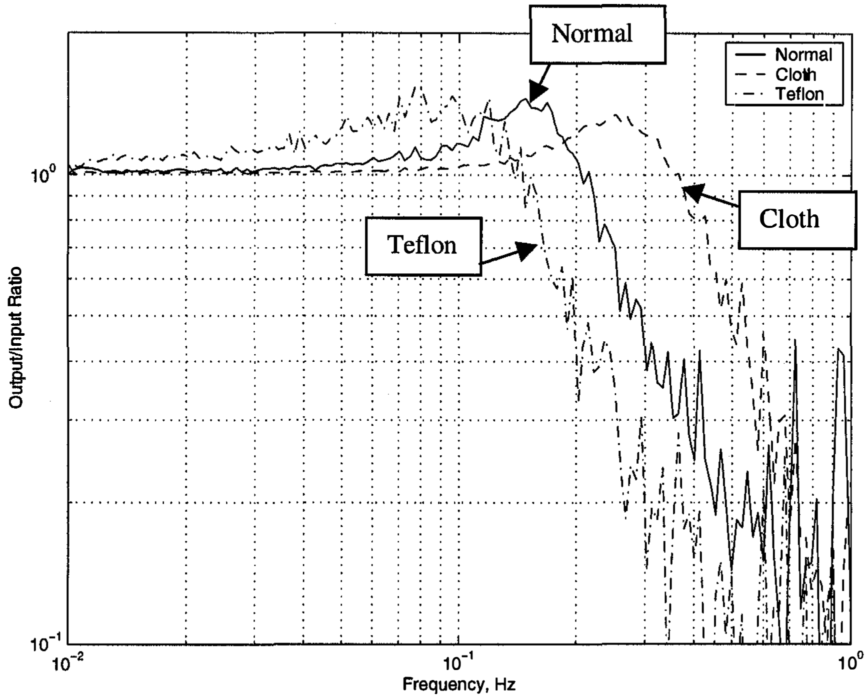

Figure 5: Frequency response of floating loop with Teflon-taped low-traction rollers, normal rollers, and cloth-taped high-traction rollers.

Name & Affiliation	Question
N. Michal – Kimberly-Clark	In looking at your results, one thought comes to mind. Have you considered if this is a pre-entry span problem, which is a situation where weave is magnified just simply because of the mechanics of the general arrangement?
Name & Affiliation	**Clarification**
R. Walton – Eastman Kodak Company	You are asking whether the response we got could have more to do with the entry span, than the floating loop itself?
Name & Affiliation	**Answer**
N. Michal – Kimberly-Clark	Yes, since it's air floatation, certain roller s are going to have more traction engagement than others, so if you were to evaluate that from a traction force standpoint, then look at your distance between each one of those controlling points, could you not have a situation where it's your pre-entry span is longer than your entry span?
Name & Affiliation	**Answer**
R. Walton – Eastman Kodak Company	I really don't know. That would be subject for further review.
Name & Affiliation	**Question**
J. Dobbs – 3M	You do not mention whether you did your test under thermal conditions as would be expected in your dryer or not. Obviously traction and web properties, if you have any kind of polymer web, are highly dependent on temperature. Would you comment on that?
Name & Affiliation	**Answer**
R. Walton – Eastman Kodak Company	We did the tests at 70 degrees Fahrenheit and 50% relative humidity, which is different than what we would typically see in our dryers, however, we varied our traction experiment by the use of the tape. It is true in dryers we see a range of traction depending on the temperature and the coatings on the web and so forth. We wanted to avoid as many unknowns as possible, so we tried to keep everything constant in our experiment other than the roller traction itself.
Name & Affiliation	**Question**
D. Pfeiffer – JDP Innovations, Inc.	Is there any chance that the pressure in the reverse chamber could have a strong influence on this extra steering magnification?

Name & Affiliation	Answer
R. Walton – Eastman Kodak Company	We did do quite a number of additional test runs in addition to the one I show there. That is one of the things we did vary and none of them had as big of an affect as what the roller traction did.
Name & Affiliation	**Question**
D. Pfeiffer – JDP Innovations, Inc.	Is it possible for you to put some low friction rollers in the bottom near the reverser and higher friction rollers at the top?
Name & Affiliation	**Answer**
R. Walton – Eastman Kodak Company	That would be possible, however the production logistics of just keeping all those rollers straight, and trying to insure that they actually get installed per design is enough of a headache that we would try to avoid that.
Name & Affiliation	**Question**
R. Lucas – GL&V	I have a question dealing with the variable traction question. Concerns are, depending on whether the web may be sliding or rotating, the web guiding effect of each roller is going to depend on whether it is slipping or sliding, because the mechanics are quite different. When I see a web moving back and forth, it usually means that there is a variation in the steering affect of one or several of the rollers. So, the thought process evolves towards how accurately were your rollers aligned and were you getting down to fairly good levels of precision as far as alignment, so that at least the steering effects is predictable?
Name & Affiliation	**Answer**
R. Walton – Eastman Kodak Company	We paid very special attention to the alignment of these rollers in our experimental apparatus, probably more than in our production machines, but the alignment was within one mil. If you put a cylinder around the ideal axis, the ideal align axis of it, both ends would fall within a cylinder that was five mils in diameter.
Name & Affiliation	**Question**
B. Lucas – GL&V	What sort of a span, or width of web were you dealing with?
Name & Affiliation	**Answer**
R. L. Walton – Eastman Kodak Company	This web was approximately 1.4 meters wide.
Name & Affiliation	**Comment**
B. Lucas – GL&V	That is a large angular misalignment limit.
Name & Affiliation	**Answer**
R. Walton – Eastman Kodak Company	We consider that acceptable.