Lateral Paper Web Position during Commercial Heat Set Web Offset Printing

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Abstract

The interaction of water with paper plays a role in web handling characteristics during commercial heat set web offset printing. Water absorption leads to lower web tension for a given strain. The purpose of this work was to determine the papermaking reasons for lateral shift of the moving paper web made from a particular paper machine on a specific printing press during heat-set web offset (HSWO) printing. The lateral movement is seen as a steady state shift to the gear side of the printing press, which can be measured at the exit of the chill section. In upset conditions, such as start up or blanket wash the web may shift so far that it runs off the paper guiding rollers and/or jams the folder section of the printing press. The paper in question is a coated mechanical paper made on a Fourdrinier paper machine (PM) in the northern United States using pressurized groundwood (PGW) mechanical pulp and northern bleached softwood kraft (NBSK) pulp. The paper is coated with a blend of kaolin and ground calcium carbonate pigments along with starch and latex binders, and supercalendered to 64% gloss. Absorption rate and air permeability testing showed that supercalendered (SC) papers absorb water faster than the target PM and air permeability of SC paper is greater than that that from target PM yet they suffer no lateral movement during printing. The reason for lower web tension in the target paper machine web is most likely due to lower fiber orientation. Fibers oriented in the direction of stress have reinforcement from the cellulose microfibrils. The stiff microfibrils serve to reinforce the matrix and prevent movement. Fibers oriented in the cross direction do not have this reinforcement. Therefore, a less oriented sheet has less reinforcement from the microfibrils and is more susceptible to lateral movement.

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Introduction

In commercial printing using the heat set web offset process, water is the largest component of dampening solution, which is applied to the paper surface in conjunction with oil based inks. Part of the water prints and sorbs into the paper (non-image areas), part of the water emulsifies with the ink and prints (image areas) and part of the water evaporates. Hot air floatation dryers are used to evaporate the printed water and a portion of the oils from the ink (Kipphan, 2001). The interaction of water with paper plays a role in web handling characteristics during commercial heat set web offset printing. Water absorption leads to lower web tension for a given strain. The effect of water and heat on the behavior of paper sheets has been studied frequently over many years. Two effects of water on paper sheets, either in liquid or vapor form, are hydro/hygro-expansion (Kajonto & Niskanen, 1998) and softening of the fiber matrix through plasticization (Niskanen, 1998). In both cases, it appears that water molecules interact with fiber material through a hydrogen bonding mechanism. Swelling of the fiber wall and translation of the swelling to the paper sheet dimensions is the result of hydro/hygro-expansion. Fiber plasticization and the corresponding loosening of the fiber matrix occurs because water acts as a softener preferentially bonding with hydroxyl sites in the amorphous polysaccharides in or between the microfibrils which makeup fibers.

The purpose of this work was to determine the papermaking reasons for lateral shift of the moving paper web made from a particular paper machine on a specific printing press during heat set web offset (HSWO) printing. The lateral movement is seen as a steady state shift to the gear side of the printing press, which can be measured at the exit of the chill section. In upset conditions, such as start up or blanket wash the web may shift so far that it runs off the paper guiding rollers and/or jams the folder section of the printing press. The lateral shift has been observed on several HSWO printing presses running the subject paper and attempts to correct the problem have met with little success. The propensity of the web to shift in the extreme during upset conditions has been linked to how the web shifts under steady state printing conditions. For the paper in question made under specific conditions the amount of water applied during printing appears to govern the magnitude of the lateral shift during steady state conditions (Shields, 2015).

The paper in question is a coated mechanical paper made on a Fourdrinier paper machine in the northern United States using pressurized groundwood (PGW) mechanical pulp and northern bleached softwood kraft (NBSK) pulp. The paper is coated with a blend of kaolin and ground calcium carbonate pigments along with starch and latex binders, supercalendered to 64% gloss and wound into customer rolls on a single drum winder.

The subject printing press is a side by side design two web HSWO press operating at a nominal speed of 1600 fpm. Figure 1 illustrates the pertinent parts of the target printing press. Each web is fitted with a reel, pre-tensioning section and guiding section prior to 4 printing units and a 3-zone hot air floatation dryer followed by a chill section. One of the two webs (Left Hand Press, LHP) follows with a short web lead, displacement guide, silicone applicator, slitter section and then on to a combined folder section. The second web (Right hand press, RHP) is identical to the LHP through the chilling section but differs after in that the web passes through a silicone application unit and then a long web lead which crosses two 45° air turns before meeting a displacement web guide, slitter section and the common folder section. A key factor in the design of the target press is the extra distance the web travels between the chill section and web guide on the RHP. The distance is 17.4 m. Assuming a nominal press speed of 8.1 m/s the extra time is 2.15 s. The RHP is the subject of this work.

The hypothesis for why the lateral web shift occurs is related to the air currents within the floatation dryers of HSWO printing presses. The air currents have a machine direction component and a lateral component. Low web tension allows the lateral component of the air flow to move the paper web sideways. Papers with higher web tension will be less impacted by the lateral air flows and therefore be more centered on the printing press. Moisture addition from printing will reduce the tensile stiffness of the paper and therefore web tension. The time from water application to drying during printing is short and it is possible that the rate of tension loss is more important than residual steady state tension.

Experimental Procedure

A total of 25 paper samples, including the 11 target PM trials manufactured for the printing trials (Table 1), plus 14 other paper samples, 11 of which are known to not suffer from lateral web movement, were tested in the laboratory conditions.

The moisture content of the papers after printing but before drying was calculated using a quantity of 3 g/m^2 moisture estimated to be added during printing (Per-Olav, 1995; Kela and von Hertzen, 2007).

Air Permeability. The air permeability of all 25 papers was measured using a Technidyne Profile Plus set up for Gurley permeability. Units for the test results are sec/100 mL. Higher Gurley porosity results indicate lower permeability. The procedures, according to TAPPI test method T 460 om-11, section 5.2.1, were followed. Each paper sample was tested 10 times, 5 on each side. The results reported were the average and standard deviation.

Fiber Orientation was measured as the ratio of machine direction to cross machine direction tensile strength. MD tensile strength and CD tensile strength of the samples was measured at 50% RH, 23°C (TAPPI standard conditions) and the ratio of MD/CD tensile strength was reported as Tensile Ratio. Tensile Ratio is an indicator of fiber orientation (Niskanen, Kajano, & Pakarinen, 1998, p. 37).

Trial Condition		Infeed Tension	Lateral Web position at chill section exit	Press Speed	Chill Gain	Folder Gain
		pli	$^1/_{32}$" above 3"	fpm	%	%
1	Standard Front Edge Roll	2.96	12	1584	0.325	0.295
2	Standard Center Roll, increased fiber orientation	4.00	18	1559	0.32	0.295
3	Edge Flow Closed, increased fiber orientation	2.58	31	1641	0.325	0.295
4	Increased Strain at 20% Solids	2.47	22	1574	0.325	0.295
5	Reduced J/W Ratio, decreased fiber orientation	2.84	8	1625	0.325	0.295
6	SBK Refining Increased	2.47	14	1574	0.325	0.295
7	SBK Refining Decreased	2.92	12	1584	0.325	0.295
8	Zero PGW Refining	2.84	10	1574	0.325	0.295
9	Lower Wet End Starch	3.91	14	1559	0.32	0.295
10	Higher Wet End Starch	2.92	14	1559	0.325	0.295
11	Reduced Strain at 90% Solids	2.66	16	1574	0.325	0.295

Table 1. *Experimental paper set and print trial results for target paper machine*

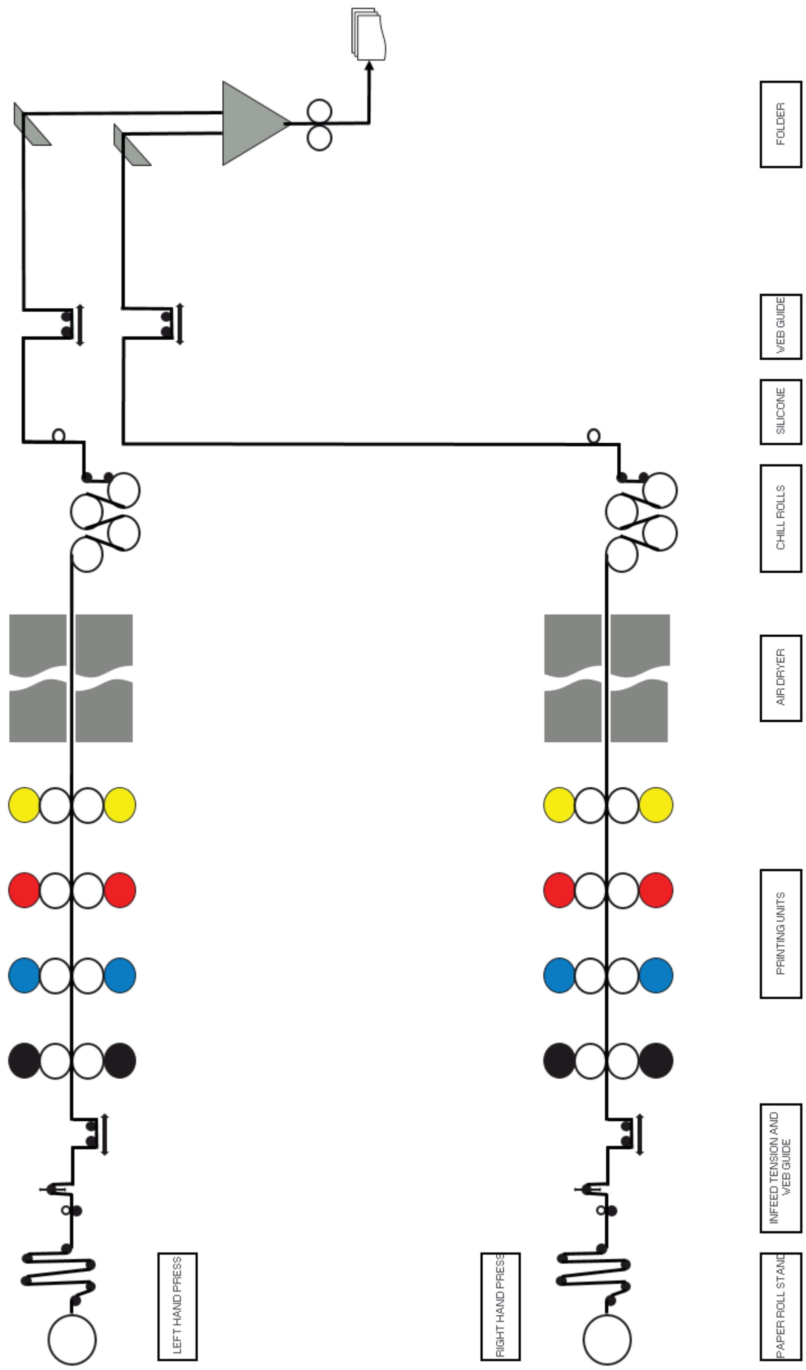

Figure 1. *Schematic diagram of the target printing press side by side layout*

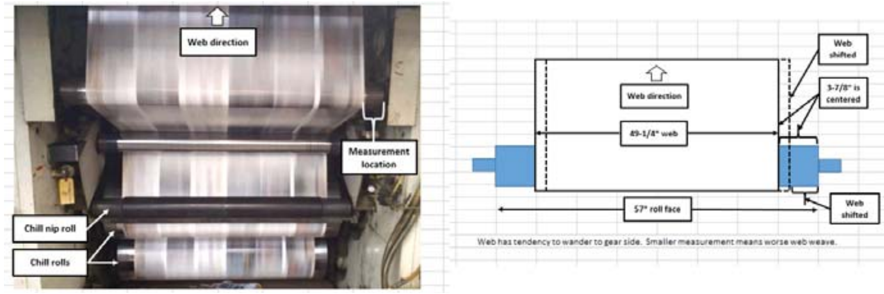

Figure 2: *Target printing press chill section exit. Left-actual measurement location, Right-schematic of measurement area. (Shields, 2016).*

The trials were printed on the target printing press (Figure 1) and the lateral web position was recorded as noted in Figure 2. The same printing plates and press conditions were used for all experimental papers. A ranking of test rolls by lateral web position was made.

Understanding the methods to reduce the lateral web movement may lead to further understanding about the impacts of water on sheet properties during HSWO printing and possibly methods to reduce web break rates for papers made with mechanical pulps.

Results and Discussion

Trial (Figure 3) showed the sensitivity of the paper produced on the target paper machine to press operations. The target paper machine standard sheet was compared to a competitive sheet of similar basis weight. Tests included subjecting the sheets to each step of the printing operation cumulatively and measuring the effect on lateral web position. The web was pre-tensioned to normal press operating range and all conditions were run at this infeed tension level. The printing nips were closed with the dryers operating as per normal operation however no dampening water or ink was applied to the printing plates. The gain settings for the chill and folder sections were constant through the tests. After stable operation was reached the dampening water for each printing unit cumulatively was engaged in succession and the tension at the chill exit recorded. For both sheets, the dampening water addition made little difference.

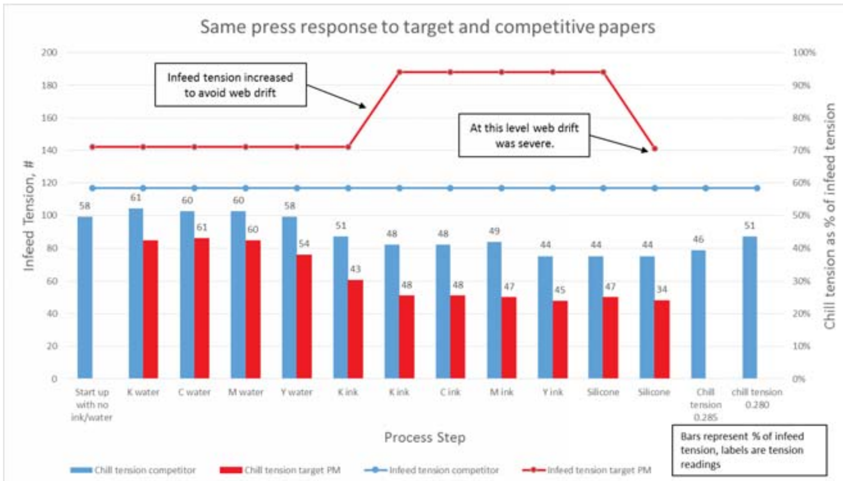

Figure 3: *Tension loss from infeed to chill exit as a result of printing operations for two papers (Shields, 2015)*

The ink feed for each print unit was started in succession, again cumulatively. The loss of tension is quite noticeable for both sheets however for the target paper machine the magnitude of the change was larger. As the tension decreased in response to the ink and water the web changed position (Table 1). For the target paper machine, the web shifted enough that the web was in danger of running off the paper carrying rolls. Increasing the infeed tension moved the web back closer to center and raised the tension at the chill exit. The addition of ink for the target paper machine continued. At no time was the printed material out of register indicating that all lateral movement was after the 4th printing unit. The conclusion reached for this test was that paper from the target paper machine was much more sensitive to tension loss from the water amount applied during printing.

Gurley air permeability of the samples was measured (Figure 4). While there were differences in air permeability, the papers showing highest air permeability (lowest Gurley permeability results) did not experience web movement. These were the SC sheets. In fact, the papers with the lowest permeability were on the target paper machine. Two competitive sheets showed the same permeability range as the target PM and they did not experienced lateral web movement on press. It appears that lateral web movement on the target PM cannot be predicted by Gurley permeability.

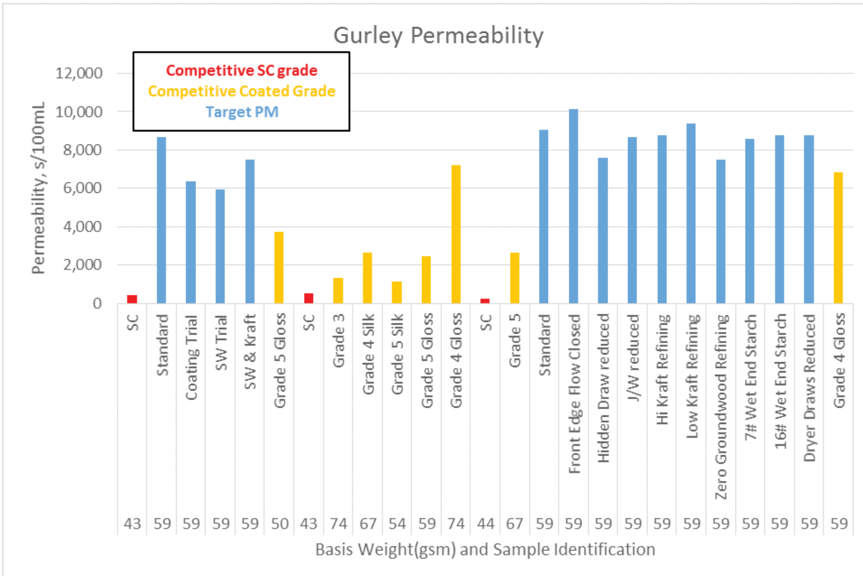

Figure 4. *Gurley permeability of experimental paper samples*

MD tensile strength and CD tensile strength of the samples were measured at 50% RH, 23°C (TAPPI standard conditions) and the ratio of MD/CD tensile strength was reported as Tensile Ratio. Tensile Ratio is an indicator of fiber orientation (Niskanen, Kajano, & Pakarinen, 1998, p. 37). A plot of tensile ratio for the available papers is shown in Figure 5. Only SC (supercalendered) sheets or samples for which base paper from coated sheets was available were measured. What is immediately evident is that the trial papers, both from this round of testing and previous samples for which base paper was available, have the lowest tensile ratio. All trial papers had some degree of weave whereas none of the competitive sheets, coated or uncoated, had any degree of weave. Fiber orientation is largely governed by the j/w ratio, (j/w- Ratio of headbox jet velocity to forming fabric velocity) and the degree to which the initial alignment produced as the fibers touch the forming fabric can be captured. In gap forming paper machines the stock jet is trapped between the two forming fabrics almost immediately and the fibers are not free to move relative to each other. In this way, the orientation of the sheet can be controlled. In Fourdrinier paper machines the stock jet is not trapped between forming fabrics. The fiber mat is purposely agitated on the forming table to aid in dewatering. It is quite difficult to attain high levels of fiber orientation on Fourdrinier paper machines, and lower orientation is most likely the reason for lateral web movement.

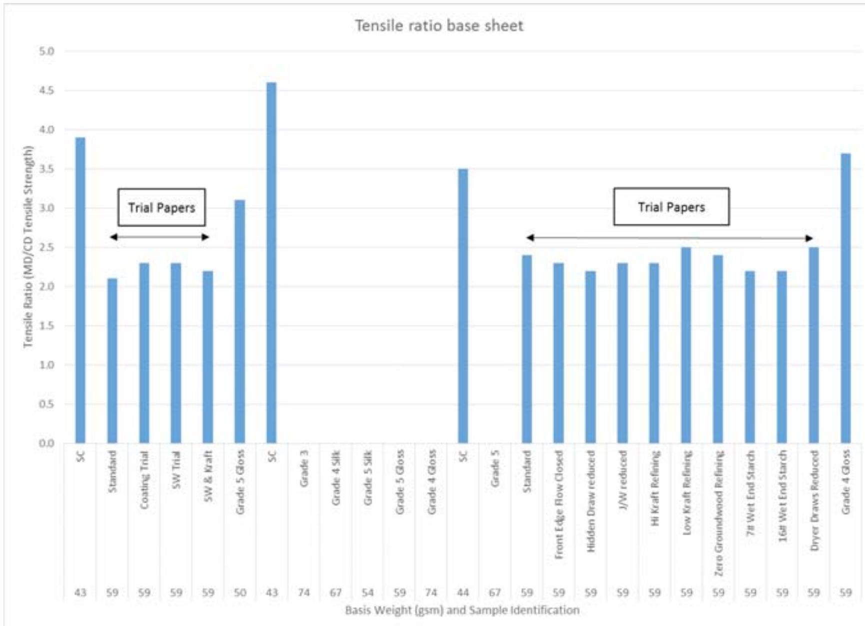

Figure 5. *Fiber orientation in various test sheets as measured by tensile ratio*

Conclusion

The reason for lower web tension in the target paper machine web is most likely due to lower fiber orientation. Fibers oriented in the direction of stress have reinforcement from the cellulose microfibrils. During printing the matrix softens to some degree due to the addition of water. The stiff microfibrils serve to reinforce the matrix and prevent movement. Fibers oriented in the cross direction do not have this reinforcement. Therefore, a less oriented sheet produced on the Fourdrinier machine has less reinforcement from the microfibrils and is more susceptible to lateral movement of the matrix on the press.

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