Simultaneous Measurement of Ink or Coating Tack and Gloss

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Key Words: coating, ink, gloss, tack

Abstract: The measurement of ink tack dynamics after printing is an important technique to characterize ink setting rate. A new micro-tack tester is described here. Some advantages of the new device are 1) a smaller device size, 2) short time between contacts, as low as 0.5 s, and 3) the ability to measure an ink film applied by a laboratory print tester. This new device allows us to measure the ink tack and gloss development right after the nip simultaneously. Its applications in studying ink-paper interactions and coating-paper interactions are presented in this paper. Some new insights into the relationship between the gloss and tack are discussed from these results.

Introduction

The setting of ink on paper surfaces has been the subject of a number of recent studies because it is important to press operation and the quality of the final product. Ink tack and ink gloss dynamics have been used to characterize the process of ink setting and are linked to the final performance on multi-color offset press in the past studies (Gane, *et al*, 1994, Purfeerst and Van Gilder, 1994, Glatter and Bousfield, 1997, Desjumaux, *et al*, 1998, Xiang, and Bousfield, 2000, Xiang, *et al*, 2003). Over the past years, considerable advances have been made in our understanding of the role of coating structure on ink setting rates, but there are still questions with regard to the mechanisms that control the setting events.

Ink gloss dynamics is measured right after the printing nip with this glossmeter mounted on a laboratory press (Glatter and Bousfield, 1997, Desjumaux, *et al*, 1998). Ink filamentation in the nip and the ability of the ink film to level on the paper before drying have been found to have a tremendous effect on the final

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print gloss. It was demonstrated that coating layers that promote rapid ink setting stop the leveling of ink film and often result in low print gloss. The rate of ink tack build as a measure of ink setting rate is determined with a separate device, a micro-tack tester, and is used to explain the relationship between ink setting rate and gloss dynamics (Xiang, *et al*, 1999). However, some disadvantages were noted with the current tack tester such as slow operation speed, differences in ink-paper contact compared to the real situation, and steps to apply ink film to the probe. In addition, the ink contacts the paper surface during the test by the probe without experiencing the nip impression as in the real printing process. Simultaneous information of ink tack and gloss dynamics that might lead to a better understanding of ink-paper interactions is not available.

The rate that paper coatings sets on various papers is important in the application of various coating processes. As a coating dries, it goes through various stages. Watanabe and LePoutre (1982) describe the first critical concentration (FCC) as the time that coating gloss is maximum. FCC corresponds to the condition that a structure must span through the coating layer to disrupt the smooth water layer on top of a pigment layer. The second critical concentration (SCC) is determined by the maximum opacity and corresponds to the empty of water from the pores.

Techniques to characterize coating setting are limited. Often, the setting rate is assumed to be controlled by the flow rate through a filtercake in the coating layer. This dewater rate is often characterized by a filtration test as described by (Herbert, 1988). Some have combined this test within a rheometer (Willenbacher *et al.* 1989) to give some indication of the viscosity change during dewatering. Standard test are available to measure the rate of fluid uptake by paper, but no test actually uses coating in direct contact with paper. Ann and Bousfield (2002) used gloss dynamics to characterize coating dewatering, but some results are not clear. Simultaneous gloss and tack may improve our understanding of coating setting.

To overcome these disadvantages, a new generation micro-tack tester was developed. The new device is portable and more rapid than the older device. With this new micro-tack tester, we are not only able to quickly measure ink tack build after the nip in very short time scale but also measure ink gloss dynamics simultaneously. The device can be used in several different ways to understand both ink and coating setting rates.

Applications of this newly developed technique in studying ink-paper interactions and coating-paper interactions are presented in this paper. Some new insights into the relationship between the gloss and tack are discussed from these results.

Experimental

The new micro-tack tester is schematically shown in Figure 1. New device moves the probe between its raised and lowered positions using magnetic force, rather than a motor. The new device includes an electromagnet that is electrically connected to a computer-controlled power source. The probe is held in its raised position by the magnetic force that is generated when current is applied to the electromagnet. When the probe is to be lowered, the current is turned off, and the weight of the probe causes the probe to drop to its lowered position. The force applied by the probe to the substrate will be the weight of the probe. Once the probe has contacted the substrate, an increasing current is applied to the electromagnet until the probe breaks away from the substrate surface. The moment at which the probe breaks away is detected by a light source and a photo-detector. The light source and photo-detector are positioned on opposite sides of the probe, at a predetermined height from the substrate, so that when the probe breaks away the probe passes between the light source and photo-detector, causing the photo-detector to change voltage. The current is measured at the moment at which the photo-detector changes voltage and this current measurement can then be converted to the force that was required to pull the probe away from the substrate. Some advantages of the new device are 1) a smaller device size, 2) short time between contacts, as low as 0.5 s, and 3) the ability to measure an ink film applied by a laboratory press.

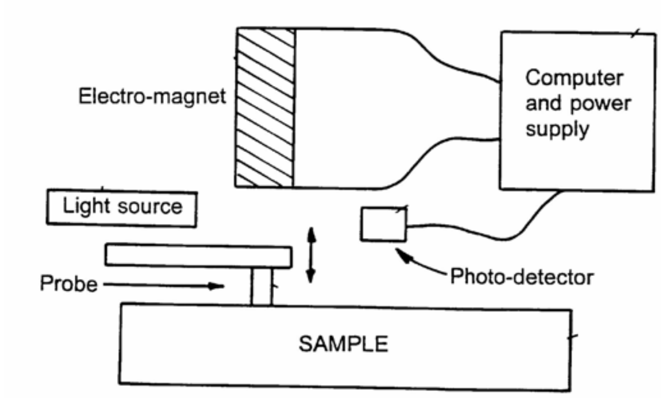

Figure 1 New Micro-Tack Tester

This new micro-tack tester is portable. It can be placed at the end of the laboratory press (KRK) with the probe extended above the print area. A simultaneous measurement of ink tack and ink gloss dynamics can be done with this new device and the dynamic gloss meter, shown in Figure 2, and described by Glatter and Bousfield (1997).

Three coated papers differing in ink setting rates were tested in present study. More detail about these three samples can be found our previous study (Xiang and Bousfield, 2003). Samples A, B, and C have fast, medium, and slow setting coating layers, respectively. Two inks, setting test ink (Michael Huber) and process cyan ink (Flint Ink), were used in our tests. 0.4 mL ink was applied to the ink distribution system and printed on paper surface with a speed of 1.0 m/s and a nip load of 100kgf. Samples A and B were also tested with the old version micro-tack tester (Xiang, *et al*, 1999).

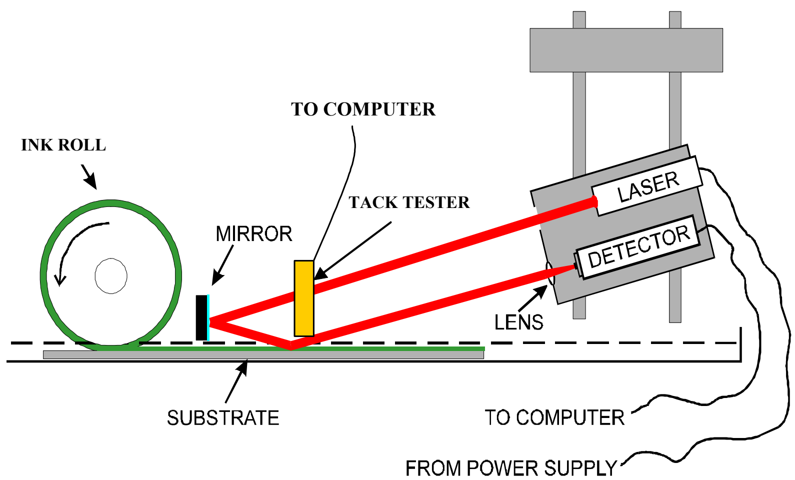

Figure 2 New micro-tack tester and glossmeter are mounted at the end of laboratory press. Tack and gloss are measured simultaneously on two adjacent areas right after the nip.

Results and Discussion

Figures 3 and 4 compare the ink tack dynamics results obtained from the new (Figure 3) and the old micro-tack tester (Figure 4) for paper A and B. With the new tester, tack force is measured right after printing. As shown in Figure 3, with this new device, not only we are able to measure the tack decay time difference between the two samples but also we can measure the differences in initial tack slopes as shown in Figure 5. However, with the old tester, the initial increase of ink tack cannot be detected for sample A, a fast setting paper. The same ink (setting test ink from Michael Huber) was used for both devices. It is also noted in Figures 3 and 4 that the time scale of ink tack change with the new tester is shorter than that with the old version. The amount of ink for the old and new devices is estimated to be 7.5 µm and 4.0 µm, respectively. This difference can explain the setting time difference.

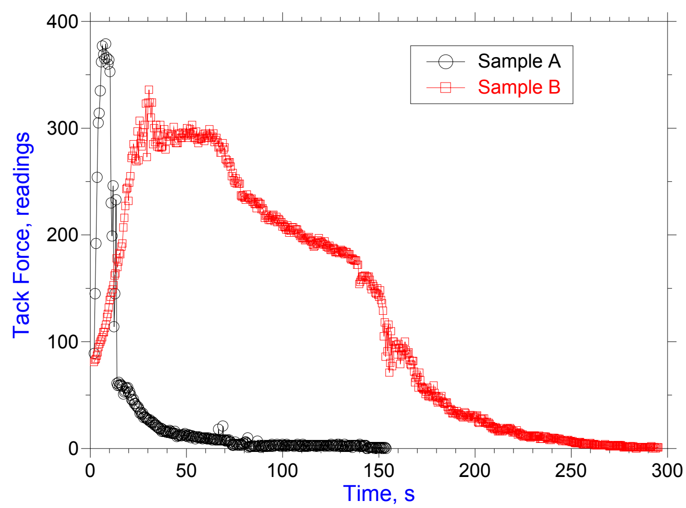

Figure 3 Ink tack dynamics of papers A and B measured with new device

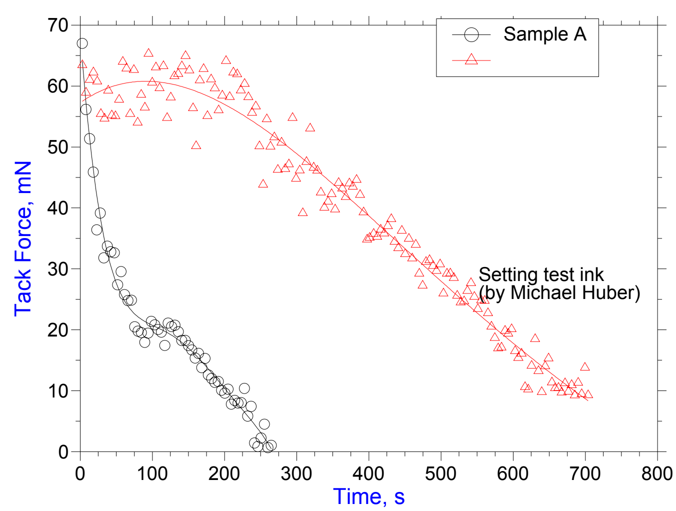

Figure 4 Ink tack dynamics of papers A and B measured with old device

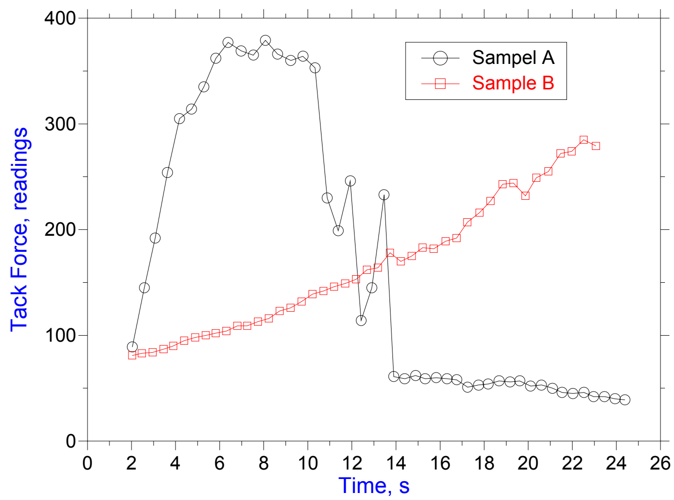

Figure 5 Initial slopes can be measured with the new device for the fast setting sample (A)

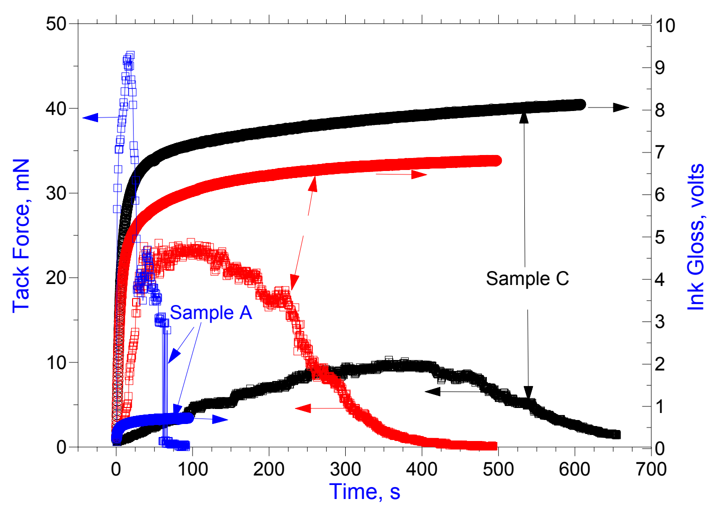

Figure 6 Simultaneous results of ink tack and ink gloss right after printing for three coated samples

The simultaneous results of ink tack and ink gloss of three coated papers with the new device are reported in Figure 6. A process cyan ink (Flint Ink) was used in these tests. The results are consistent with previous observations. Fast setting paper (sample A) has a more rapid ink tack buildup and a lower ink gloss than the other two papers. Slow setting paper (sample C) has a slower tack buildup and a higher ink gloss than other papers.

Figures 7 and 8 show the results from two of the samples in Figure 6 separately in order to have a close look at the simultaneous changes of ink tack and ink gloss right after printing. Ink gloss continues to increase after ink tack force passes the peaks for both papers. For sample A, the gloss is still increasing even when the tack is smaller than the detection range. The ink must still be able to level or rearrange in some way even it is not sticky or fluid like to the touch.

For a given ink, tack development on coated paper is believed to be dependent on the removal of the ink mobile phase by the coating structure. As depicted in Figure 9, tack force increases initially and reaches a maximum due to an increase in the thickness of a filtercake formed at the surface of the coated paper because of the removal of the ink mobile phase into the coating structure. Then tack force starts to decrease due to a dry contact between the probe and the printed surface. Ink gloss development is due to the film leveling over time and will reach the maximum at point of maximum tack force where film leveling is stopped. However, one question remains here: how can ink gloss continue to increase after the tack peak force or after the tack has decreased to near zero value, because tack should be a measure of the fluid like properties and the ability for the ink film to level?

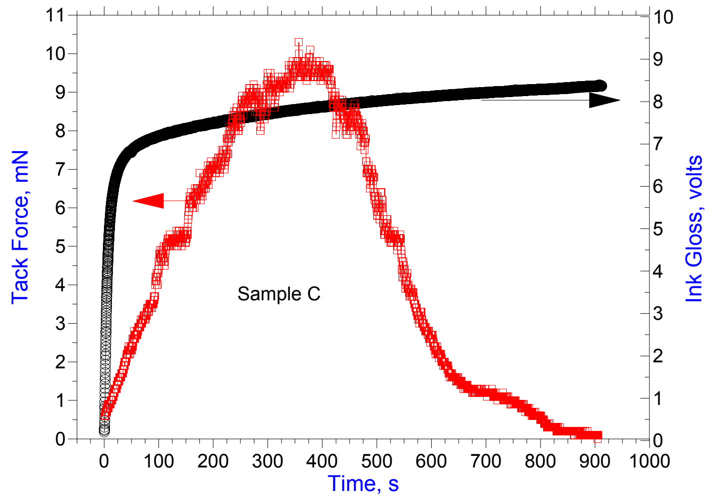

Figure 7 Simultaneous results of ink tack and gloss dynamics for sample C

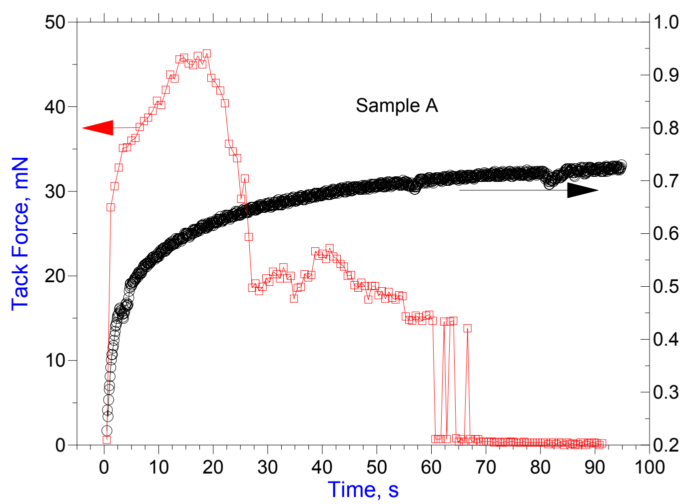

Figure 8 Simultaneous results of ink tack and gloss dynamics for sample C (slow setting paper) (top) and sample A (fast setting paper) (bottom)

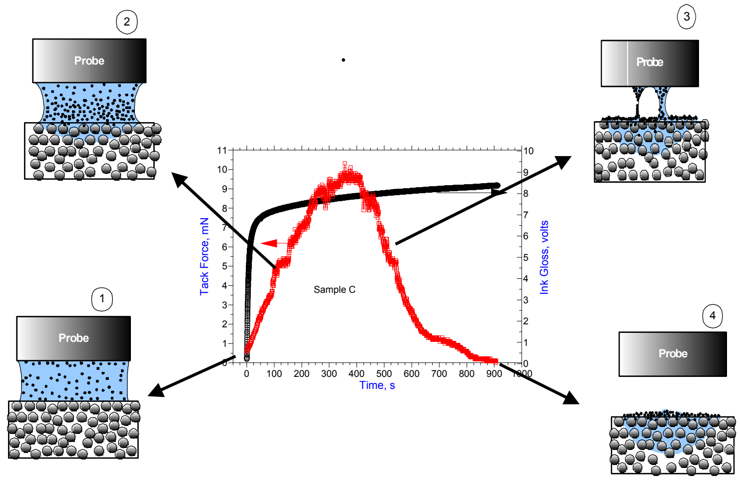

Figure 9 Possible mechanisms of ink tack development on paper surface.

To test the applicability of the new system to paper coating study, a 30µm wet coating was applied on three substrates with a film gap applicator. The coating used contains 100 pph No.2 clay, 7 pph latex, and 0.3 pph thickener. The solid content is around 62%. Three substrates are two coated papers (B and C) with different setting rates plus one plastic film. Results on three substrates are reported in Figures 10, 11, and 12. The new testing system easily distinguishes the differences of coating consolidation process on three different substrates. On the medium setting paper (sample B), gloss starts to drop, referred as the first critical concentration point (FCC) (Watanabe and LePoutre, 1982), earlier and coating tack builds up faster as well than other two substrates. A good relationship between the gloss and tack force is noted. Instead of increasing from the beginning, coating tack force starts to significantly increase only after the gloss starts to drop (FCC). The peak tack force is reached around the time when gloss drop is close to its plateau. This plateau should be near the secondary critical concentration point (SCC) described by Watanabe and LePoutre (1982). This indicates that coating tack force increases by the further loss of water after the FCC and not before. Tack force change before FCC as expected by the filtercake theory is not noted by our measurement results here.

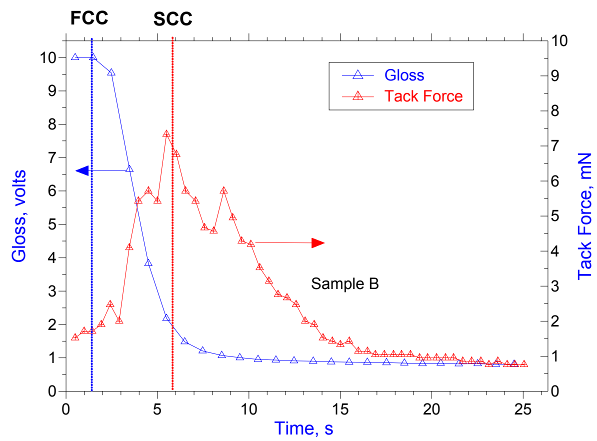

Figure 10. Simultaneous results of coating tack and gloss on paper B

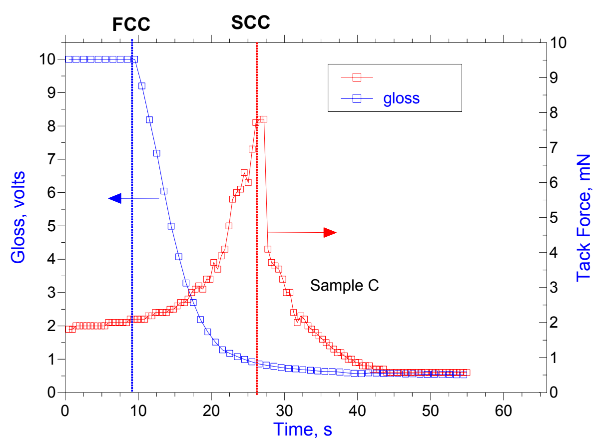

Figure 11 Simultaneous results of coating tack and gloss paper C

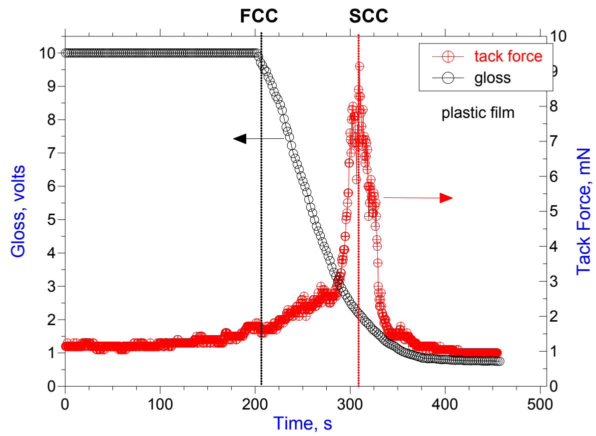

Figure 12. Simultaneous results of coating tack and gloss on plastic film

In Figs. 10-12, the peak in the coating tack is denoted as SCC. This SCC is physically different that what was defined by Watanabe and LePoutre, in terms of opacity and the emptying of pores. The peak in the tack must come from the condition when enough water has left the pores and the junctions between pigment particles, to give some type of strength property within the coating structure. The exact physical condition at the peak, in terms of water content and the amount of film formation from the binders is not clear, but it must represent the first binding of the pigments together into a structure. The decrease after this point must be the lack of wet contact between the probe and the coating layer.

The SCC of Watanabe and LePoutre (1982) has been a useful tool at understanding the generation of opacity, but this value can only be measured when the coating is applied onto a clear plastic film, not onto paper. The tack test gives a value for a similar situation, but can be obtained on paper.

Concluding Remark

A new method was developed to measure the tack and gloss simultaneously. It can be used in laboratory to study ink-paper interactions right after printing and to study coating-substrate interactions right after coating to better understand ink/coating setting mechanisms. Ink gloss continues to increase after ink tack force passes the peaks. This is not predicted by a simple filtercake theory. The ink film must have some ability to level or rearrange even after the tack has decayed. For a water based coating, the FCC can be detected. The tack does not increase until well after the FCC. This result indicates that the cohesive forces are not strong until the later stages of dewatering.

Acknowledgement

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