Estimation of ink tack in offset printing and its relationship to linting in offset printing

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ABSTRACT

Linting is the removal of material from the surface of newsprint grades during the offset printing process. Excessive linting leads to a reduction in image quality and can reduce press productivity. The forces on the paper surface that produce lint have been divided into forces acting in the nip (free ink film flow force and porous ink film forces) and a tack force arising from the splitting of the ink film after the printing nip. While ink tack is believed to be important in linting, it has been difficult to measure in a way that is relevant to linting on the printing press.

The Prüfbau Deltack is a relatively new instrument that has been developed to measure the tack force at the exit of the printing nip. This instrument was used to examine the effect of printing speed and ink weight on tack for different batches of newsprint and improved newsprint. It was found that tack increases with increasing speed and ink weight.

Printing conditions in the Deltack were selected so as to best approximate the printing conditions in a small commercial press, a Heidelberg GTO52. This involved interpolating the Deltack results to a speed of 0.75 ms^{-1}, which gave approximately the same ink splitting rate as in the commercial press and selecting the pressure and ink volume applied on the Deltack.

The average measured tack for the six batches of newsprint was 30% higher than for the seven batches of improved newsprint. However, surprisingly, the averages of both the 50% screen and the solid lint were about 30% lower for the newsprint, compared to the improved newsprint.

INTRODUCTION

Linting is considered to be one of the more serious paper related problems in the offset printing of newsprint *[1, 2]*. It occurs when the particles from the paper surface are removed during printing and accumulate on the blanket, following which they may also transfer to the plate and the ink and fountain solution trains. Linting not only causes a deterioration in image quality, but the build-up of lint on the offset blanket and within the press inking and dampening systems can cause runnability problems, resulting in stopping the press for cleaning.

Lint is composed of three different types of particles – fines and fibre fragments, ray cells, and filler particles *[3]*. Almost all lint particles are less than 15,000 μm^2 in size *[4, 5]*. Their common characteristic is their low level of bonding *[6]*.

The forces on the paper surface that produce lint have been divided into forces acting in the nip (free ink film flow force and porous ink film forces) and a tack force arising from the splitting of the ink film after the printing nip *[7]*. Studies have shown that the application of higher surface forces is generally associated with the removal of larger particles as lint *[1, 4]*. The tack force should be distinguished from ink tack itself, which is measured by instruments such as the Inkometer. Ink tack was found in one of our previous studies to be a poor predictor of lint *[5]*, as the lint measured on two commercial presses was approximately independent of tack in the range 4-9, before increasing somewhat when an ink with tack 13.5 was used. In another study *[7]*, low viscosity and high viscosity Newtonian fluids were used in printing. It was found that the higher viscosity fluid produced more lint under most, but not all, printing conditions. Clearly it is preferable to measure the tack force in the nip directly. Recently a new instrument, the Deltack, has become available to do this. This instrument measures the tension in a printed web required to pull the printed substrate away from the printing forme. Most applications to date have been for the measurement of the build-up of tack on coated papers *[8]*.

The purpose of this work was to measure the tack force for different batches of newsprint and improved newsprint measured by the Prufbau Deltack and to study the effect of printing speed, printing pressure and ink weight on tack force. These results will then be compared with lint collected from a Heidelberg GTO-52 single colour offset press.

EXPERIMENTAL

Printing trials

The lint measurements were performed using a Heidelberg GTO-52 (**Figure 1**) at Norske Skog Boyer mill. This is a sheet-fed offset press that can run a maximum size of A3. A speed of 8000 copies per hour and a nip pressure of around 3.4 MPa was used. The plate was of A3 size, with solid in the top half and 50% tone, at 150 lines per inch, in the bottom half of the plate.

To start up the machine, ink and water were run for a period of 60 seconds in order to achieve stable emulsification. The volume of fountain solution used (5% fountain solution in distilled water) was measured during printing by recording the volume of fountain solution in a measuring cylinder, which acted as the reservoir for the fountain solution. A print density of 1.0 was targeted for each trial. This was controlled by measuring the print density with a Gretag Densitometer. For each trial, solid and 50% screen lint was collected after 7000 impressions by using a tape of known area, which was adhered to the blanket with a roller before being pulled off. This resulted in the removal of lint on the blanket as well as any residual ink. The weight of the tape before and after lint collection was recorded from which the lint weight per unit area of blanket was calculated.


Figure 1. Heidelberg GTO-52

Prüfbau Deltack Printability Experiments

The laboratory experiments were performed using the Prufbau deltack printability tester. The experimental set up is shown in Figure 2.

The Deltack consists of an inking unit and a printing unit. The inking unit comprises of an ink roller and four inking stations. The printing unit has two measuring units 1 and 2 and printing cylinders A and B, which can be used with sensors of different force ranges. All of the measurements presented here were done with the lowest force range sensor with a measuring range of 0.1-1.7 N.

Paper samples of dimensions 285 mm by 55 mm were cut, punched with holes and reinforced with adhesive tape before being transferred to the sample carrier of the appropriate measuring unit. Ink was applied using a standard ink distributor on the inking unit for 1 minute before inking the forme for 30 seconds. The forme was then transferred to the printing unit and the sample was printed.

The initial quantity of ink on the forme was determined by the weight difference of the forme before and after inking. The weight of the forme after printing was also recorded. Temperature and humidity were maintained in the range of $23 \pm -2^{o}C$ and $50 \pm 1\%$ respectively. The forme and printing unit were cleaned with heptane and allowed to dry after each print run and the ink roller was cleaned with at the completion of each set of 4 runs.

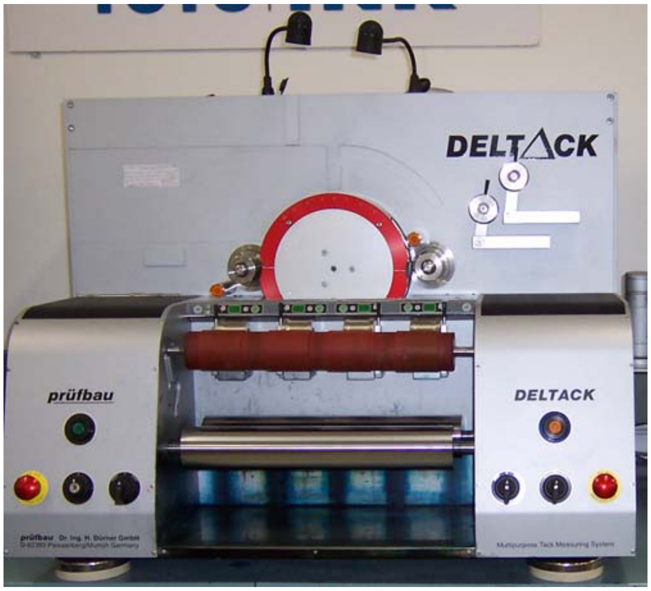

Figure 2 Prüfbau Deltack printability tester

The tack force was continuously measured and averaged over a distance specified by the operator.

The experiments were conducted at speeds of 0.5 m/s, 1 m/s and 1.5 m/s and a printing force of 500 N. The ink weight used varied slightly from batch to batch. The method used to select the ink weight is discussed in the results.

Materials

The papers tested in the laboratory and the commercial printing press trials were from six separate rolls of 45 gsm Nornews grade newsprint, and seven separate rolls of Norstar, an improved newsprint of 52 gsm with a brightness of ISO 74, for a total of thirteen comparison points. All test material was produced by Norske-Skog Australia.

Black coldset offset ink of tack 13.5 manufactured by Colortron was used for the trials. The tack was measured on a Thwing-Albert Electronic Inkometer operating at a water bath temperature of $32.2^{o}C$ and a speed of 800 rpm. It should be noted that the tack of this ink is considerably higher than that used to print daily newspapers. This tack ink had been chosen to produce reasonable amounts of lint in the relatively short printing runs used for the trials.

RESULTS

Effect of experimental variables on measured tack.

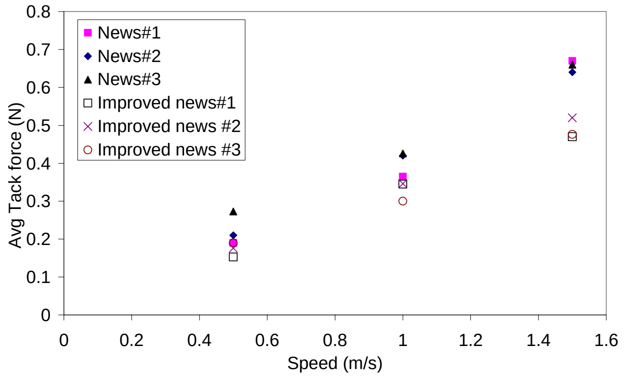

Figure 3. Effect of Printing Speed on Average Tack Force.

The Deltack experiments showed that the tack force required to split the free ink film was strongly related to the print speed. **Figure 3** shows representative results for three different rolls each of newsprint and improved newsprint. It can be seen that tack force increases approximately linearly with printing speed for all samples. Both the news and the improved news data are approximately consistent within each data set. The improved newsprint samples also had a consistently lower tack force than the newsprint samples at all speeds tested.

The increase in tack force with print speed arises both from an increase in the force required to split the free ink film, as speed increases, as well as an increase in the thickness of the free ink film that is split. The free ink film thickness increases at higher speeds as the printing forme has less time in contact with the paper and thus less ink will enter the pores.

Figure 4 shows the relationship between the measured tack force and the ink volume applied to the Deltack distribution system for one batch of 52 gsm improved newsprint. The data is rather scattered as these points show the individual measurements, while all of the other data presented in this paper are averages of three or four measurements. The data shows that the tack force generally increases as more ink is applied. This data is consistent with previous measurements on newsprint and improved newsprint that we have made.

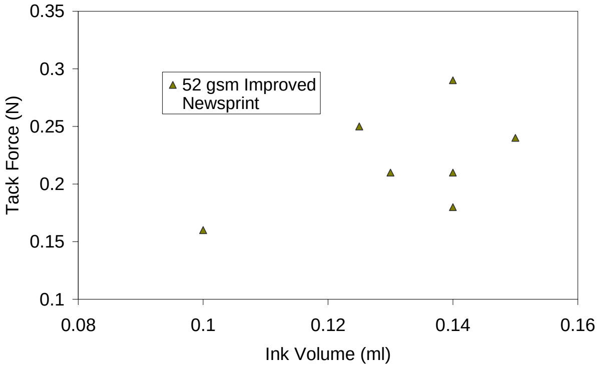

Figure 4. Tack force as a function of ink volume at a speed of 1 ms^{-1}

The corresponding print densities for the data in **Figure 4** are shown in **Figure 5**. Print density increases approximately linearly with ink weight applied to the distribution unit.

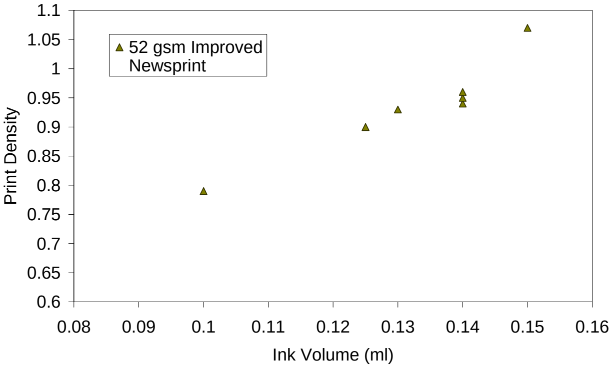

Figure 5 Relationship between print density and volume of ink applied to the inking roll for one batch of 52 gsm improved newsprint

Deltack test conditions for comparison with Heidelberg lint measurements.

It can be seen from the preceding results that the measured tack depends on the velocity used and the volume of ink applied. However, the question then remains as to which test condition should be selected to best match the conditions under which the samples were printed on the Heidelberg GTO-52.

We assumed that the tack force measured by the instrument is similar to that which would occur in the press if the thickness of the ink film, and the rate at which the ink film splits, is the same in both cases. If we define position in centre of the printing nip as $x = 0$, then it can be shown that distance between the surface of the paper and the blanket cylinder, y, is approximated by

$$y = \frac{1}{2R}x^2 \qquad 1$$

where R is the radius of the printing cylinder. This assumes that the paper leaves the printing cylinder along the tangent at $x = 0$. In reality the paper will partially follow the printing cylinder around due to the tackiness of the ink. This will impose an additional complication on the analysis that is not considered here.

In order to for Deltack printing to be comparable to the Heidelberg, the speed of the Deltack must be chosen such that the rate at which the ink film splits is the same in both cases. This will occur when y in the two printing nips is identical at the same time after passing the middle of the nip. From equation 1 it can be shown that for two different printing operations, labelled with subscripts 1 and 2, this occurs if

$$\frac{V_1}{V_2} = \sqrt{\frac{R_1}{R_2}} \qquad 2$$

The radius of the blanket cylinder of the Heidelberg GTO-52 is 0.09m, while the radius of the printing forme used in the Deltack is 0.032m. The speed of the Heidelberg operating at 8000 copies an hour was determined to be 1.26ms^{-1}. Inserting these conditions into equation 2, yields a printing speed for the Deltack of 0.75ms^{-1}. This speed was not available for printing in the Deltack as the speed can only be incremented in 0.5 ms^{-1} intervals. Accordingly it was decided to measure the tack in the Deltack at speeds of 0.5, 1.0 and 1.5 ms^{-1} and to fit the data to extrapolate the tack at 0.75ms^{-1}.

It was assumed that equivalent ink transfer was obtained when

$$\frac{P_1 V_1}{R_1} = \frac{P_2 V_2}{R_2} \qquad 3$$

where P is the printing pressure.

The nip pressure measurements in both the Heidelberg press and the Deltack were done using Fuji pressure sensitive tape. The measurements on the Heidelberg were done at the print setting of 0.05 by inserting the pressure sensitive tape in the nip of the impression roller and running the Heidelberg press until the measured pressure was stable. This yielded an average peak pressure of 3.4 MPa. This pressure value was then substituted into equation 3 to yield the equivalent pressure for the Deltack which was 5.7 MPa. This was found to correspond to an average load setting of 500N.

The final step was to ensure that the thickness of the free-ink film was the same. This was done by matching the solid print density of 1.0 that was used for all the Heidelberg experiments to that in the Deltack. As the print density was shown in **Figure 5** to depend on printing speed, it was necessary to select an ink volume such that the print density at 0.75 ms^{-1} should have been equal to 1.0. The ink volume required for each batch was determined by trial and error to find an ink volume such that the print density at 0.5ms^{-1} was slightly above 1.0 and the print density at 1.0ms^{-1} was slightly below.

The ink volume determined for each batch was then used together with the force setting of 500N. The data at 0.5, 1.0 and 1.5 ms^{-1} were then fitted with a straight line, which was used to determine the interpolated tack at 0.75ms^{-1}. These data points have then been compared with the solid and screen lint in the next sub-section.

Relationship between Average Tack Force and Lint

The relationship between solid lint and average tack force is shown in **Figure 6** for the different batches of newsprint and improved newsprint. Uniform estimated errors for each point are also given. It would be expected that the best relationship between lint and tack force should occur for the solid lint, not the screen lint. This is because the Deltack prints a solid pattern on the test piece and the ink applied in the Deltack has been optimised to give the same print density in the solid pattern as produced in the Heidelberg printing trials. One factor that couldn't be reproduced in the Deltack experiments is the effect of the fountain solution, since the Deltack experiments were conducted with ink only, while on the Heidelberg press, the ink contains around 10% of emulsified fountain solution, by volume.

The average solid lint from the trials on the improved news rolls was 32% higher than for the trials with the newsprint rolls. At the same time, the average tack for the improved news was 30% lower. It would seem that a **negative** relationship exists between the amount of lint produced and the average tack force. This result is very interesting and contrary to what was expected when these experiments were commenced.

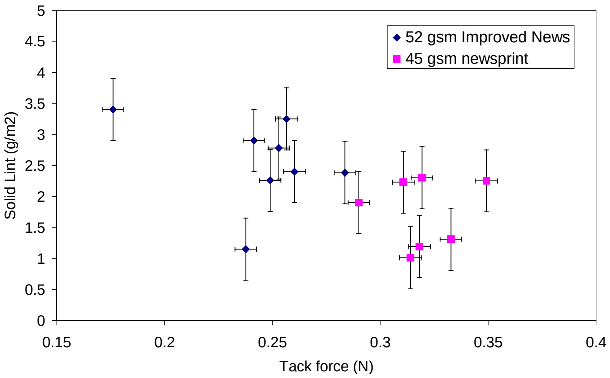

Figure 6. Solid Lint versus Average Tack Force.

The relationship between tack force and screen lint is shown in **Figure 7**. The relationship between average screen lint for the two types of samples is similar to the solid data, with the average screen lint being 28% lower for the newsprint compared to the improved newsprint. However the data is considerably more scattered than for the solid data.

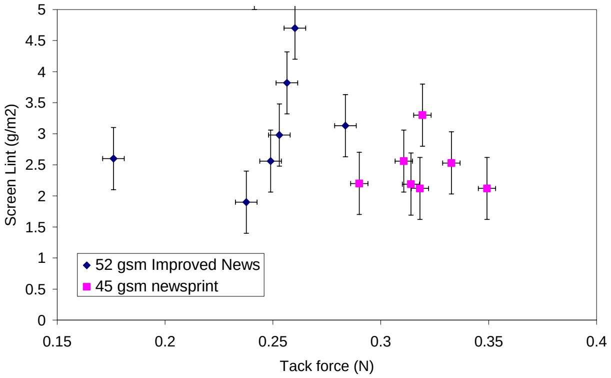

Figure 7. Screen Lint versus Average Tack Force

More data is clearly required in **Figure 6** and **Figure 7** to fully establish the relationship between tack force and lint. However, it is clear from both **Figure 6** and **Figure 7** that a higher tack force is not associated with higher lint. This is surprising, given that tack is commonly believed to play a significant role in linting. These findings may suggest that the forces that are significant in producing lint are either or both of the free ink film and porous film flow forces operating in the nip *[7]*. The other issue that remains to be examined is why the tack force is different, on average, for the batches of improved newsprint and newsprint. This promises to be an interesting area of further investigation.

CONCLUSIONS

Tack at the exit of the printing nip was investigated using a Prüfbau Deltack. It was also found that average tack force increased greatly with speed. Tack and print density also increased with the amount of ink applied to the distributor on the machine.

Printing conditions on the Deltack were then selected so that the tack could be measured under equivalent conditions to those applying in a small commercial printing press. The tack values were compared with solid and screen lint produced during printing trials of six separate batches of newsprint and seven separate batches of improved newsprint.

The results surprisingly showed that, in comparison to the newsprint, the average tack force was lower for the improved newsprint samples and both the solid and screen lint were higher. The data suggest that the tack force applied to the paper surface at the exit of the printing nip is not a critical factor in determining the lint produced in offset printing.

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