For smooth printing substrates $k > 0.5$ and $b < 1$, while for rough papers $k < 0.5$ and $b > 5$. These figures can vary considerably depending upon ink rheology, and especially viscosity. Because A is the fraction of the area covered by ink and B is the fraction of the immobilised ink, it could be assumed that $B \leq A$. However, such a relation is not always found e.g. Chou and Tasker (1994).

As in equation (1) ink transfer is commonly divided into the following stages; coverage, immobilisation, and splitting. During splitting it is considered that the portion of ink penetrated into capillaries could 'rise away' from wider capillaries (Oittinen 1976). In addition, at the end of the splitting the compressed paper could revert to its original form thereby creating widening of capillaries which creates further ink absorption (by suction). However, penetration by aspiration after the printing nip may only be theoretical and as Oittinen and Lindqvist (1981) have noted, over that period measurements of the magnitude of the penetration have not been possible.

The mathematical parameters and related functions should describe paper properties such as smoothness and absorption. The difficulty in establishing such a relationship with paper properties has been one reason for doubting the theory. It has been found also that the parameters describing coverage, immobilisation and splitting have either been too high in variation, or the parameters inter-correlate (Mangin et al. 1982, Chou and Tasker 1994).

Evaluation of the ink transfer process has often been achieved using sheet fed offset inks and coated paper grades. Letterpress newsinks and newsprint paper grades have been used also in these studies. Today the coldset web offset printing (CSWO) method dominates newspaper printing. From the ink transfer perspective these printing processes differ from each other. Low shear viscosity, which is important for ink coverage, is much higher in the case of sheet fed inks than for CSWO, e.g. 20-50 Pas and 10-15 Pas respectively. In sheet fed offset printing, it is usual to use anti set-off powders to prevent set-off. Thus, it is possible to print with higher amount of inks to reach a required high print density. Letterpress newsinks have a lower viscosity than CSWO inks.

In letterpress printing, higher ink amounts are used because the inks are less pigmented (about 12%) compared with CSWO inks (about 20%). The higher pigmentation of CSWO inks and the higher tack and viscosity help in printing with a lower ink transfer to paper. Approximately 1.5-2 g/m^2 is sufficient for achieving the target print density. This ensures less dot gain, lower print through, and less set-off. Less than 4 g/m^2 in the printing nip is needed as the amount of ink transferred is above 50%. However, much higher ink amounts up to 25 g/m^2 have often been studied. It might not be a surprise that the ink transfer mechanism is different for lower and higher amounts of ink. It is concluded e.g. (Walker and Fetsko 1955, Chagas and Baudin 1996, and Nordstöm and Grön 1998)) that with low ink amounts, ink coverage dominates the ink transfer, followed by immobilisation, and splitting which covers the larger ink amounts.

Ink transfer in CSWO printing to uncoated, rough paper

Compressible rubber blanket

For analysing ink transfer it is necessary to study the materials performance in the printing nip. Oittinen and Lindqvist (1981) have pointed out that the distribution of pressure in the nip is dependent upon the ink, the paper, and the rubber blanket. However, the overriding factor is the behaviour the rubber blanket in the input and middle of the nip. The reason is that the blanket is the most compressible material of the three.