Ink distribution and surface roughening in cold- and heatset printed surfaces

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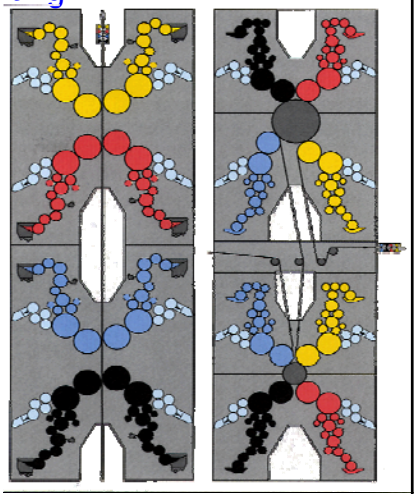
Outline of the presentation

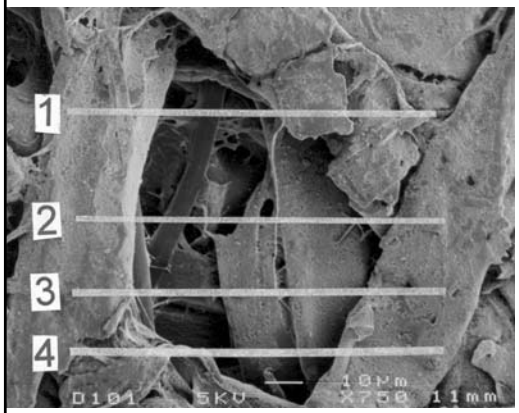
- Introduction to offset printing
- Ink distribution in uncoated offset-printed paper
- Effect of coating structure on heatset printed paper
- Change in surface roughness and gloss during printing
- Conclusions

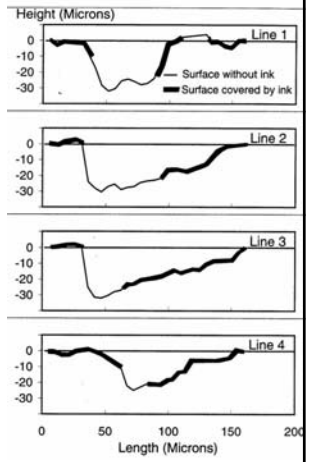
Introduction to offset printing

- An offset printing press adds a fountain solution and an emulsion of fountain solution and ink in an approx. 1µm thick layer to the sheet in each printing nip.
- The ink and fountain solution are transferred from the printing plate to a rubber blanket and then to the paper.
- In coldset printing the ink dry by absorption of the low viscosity oils into the paper, whereas in the heat-set process the ink dry by evaporation of low molecular oil molecules in an hot air dryer after all 4 colours are printed.



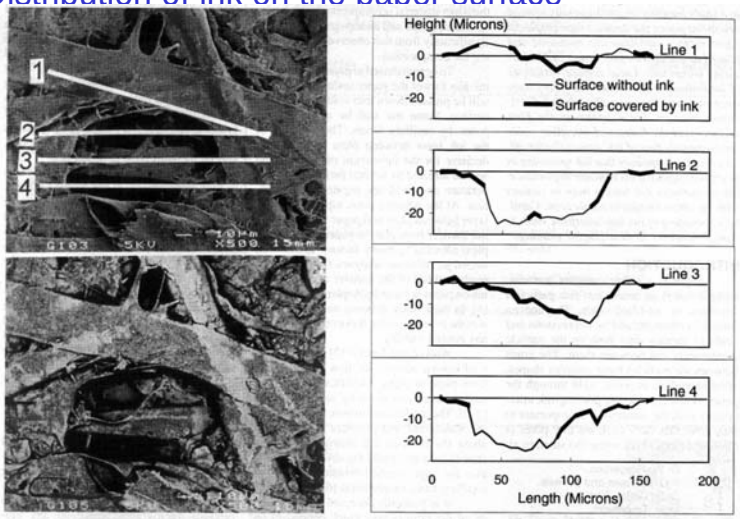
Distribution of ink on the paper surface



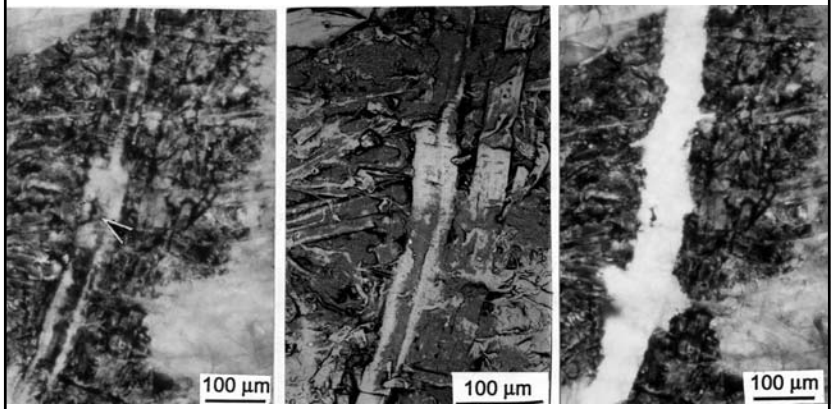


Deep pores are not covered by ink.

Distribution of ink on the paper surface

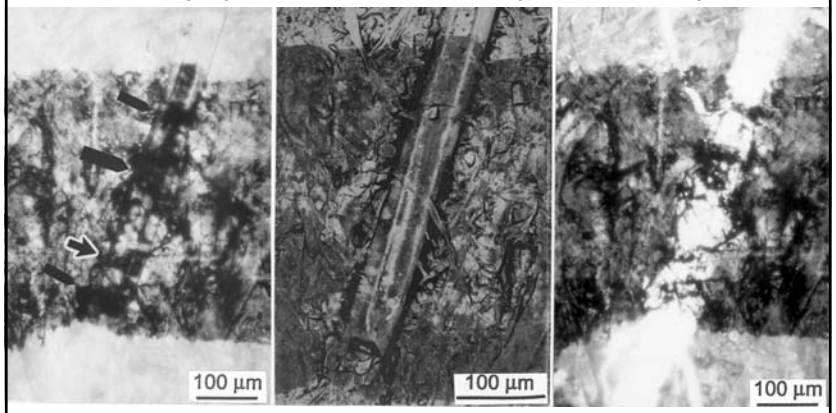


Ink on the paper surface - offset



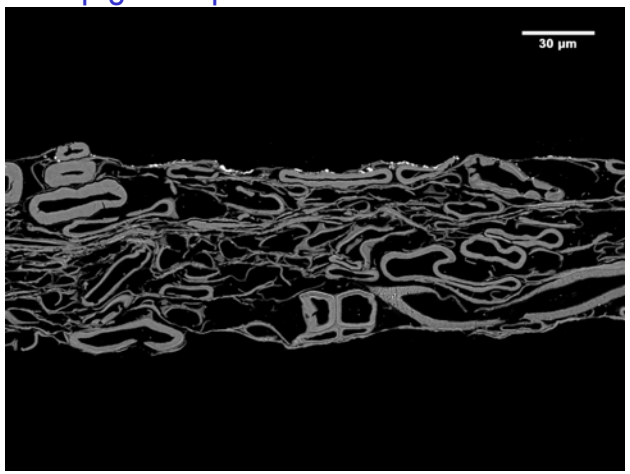
The ink hardly penetrates under surface fibres during offset printing

Ink on the paper surface – flexo (waterbased)



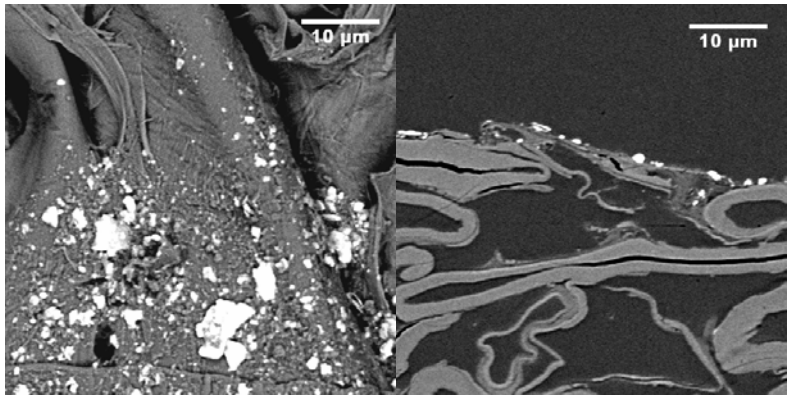
There is much more penetration of the low viscosity flexo ink into the paper structure.

Ink pigment penetration



SEM backscatter image showing the whole cross-section of a printed paper.

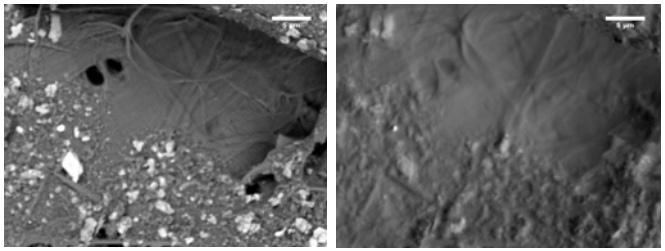
Ink pigment penetration



SEM backscatter surface image of a boundary between yellow printed area and unprinted area (left), SEM backscatter image of yellow printed paper cross section (right).

Are clay particles in yellow ink a good indicator of the position of ink pigment particles?

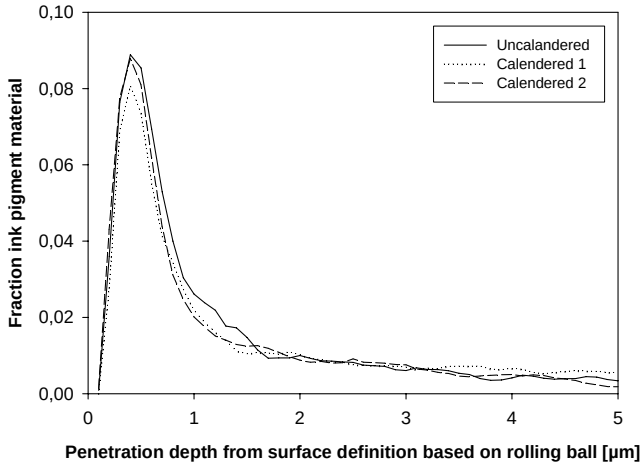
- Both clay particles and ink pigment particles can be seen as increased micro roughness in the paper surface when observed in SEM secondary electron or topographic mode.



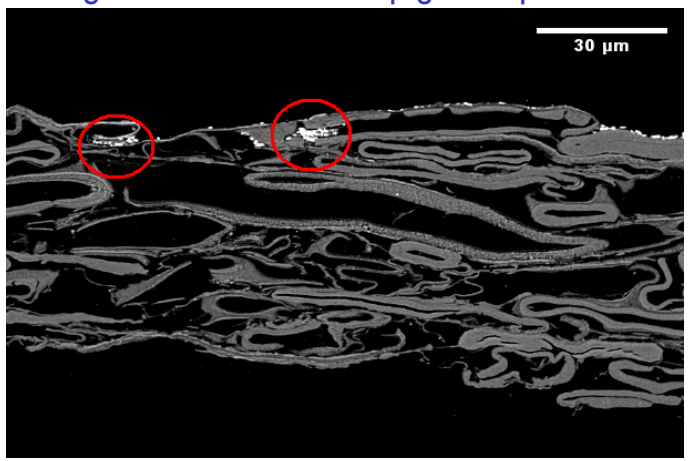
SEM surface images of yellow print. Left: COMP, right: TOPO

Examination of several printed areas showed that 80% of all clay particles were closer than 0.1 µm to an ink pigment particle, and 99% were closer than 0.9 µm.

Ink pigment penetration depth



Interesting observation about pigment penetration



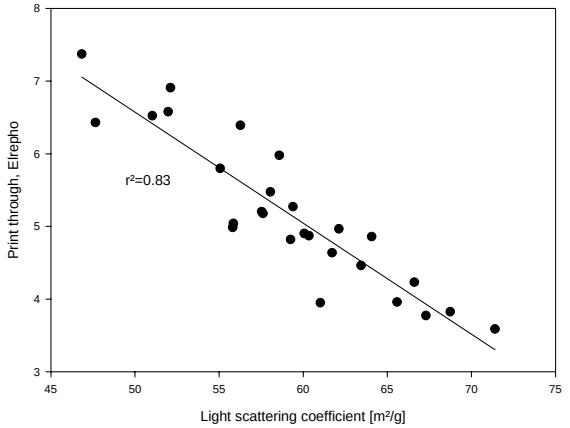
Part of a SEM backscatter image showing ink pigment agglomerates.

An experiment to investigate pigment penetration

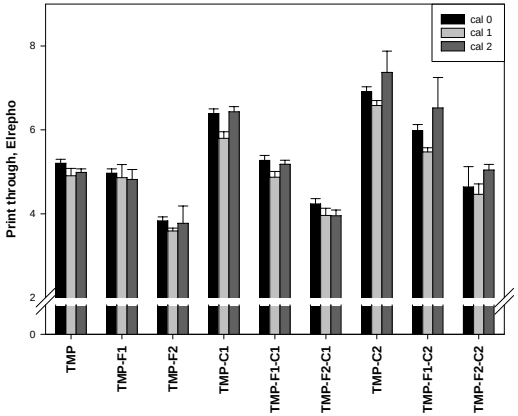
- Laboratory sheets with basis weight 45 g/m² were made according to a 3x3 experimental design.
- Variables:
  - Addition of fines (0,10,20%)
  - Addition of chemical pulp (0,10,20%)
  - Calendering (two nips soft/hard 75 kN/m, two nips soft/hard 200 kN/m and a hard nip 150 kN/m)

Furnish	TMP [%]	Additional fines [%]	Chemical pulp [%]
1	100	-	-
2	90	10	-
3	80	20	-
4	90	-	10
5	80	10	10
6	70	20	10
7	80	-	20
8	70	10	20
9	60	20	20

Print through vs light scattering

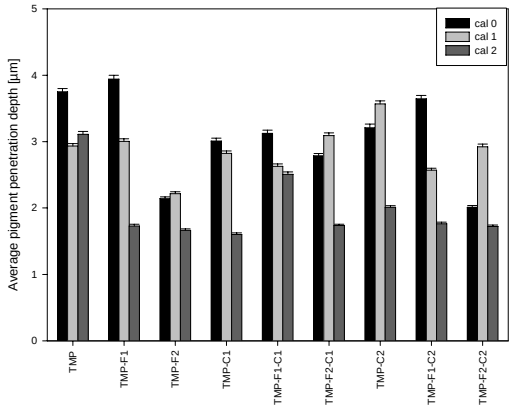


Print through measured with Elrepho



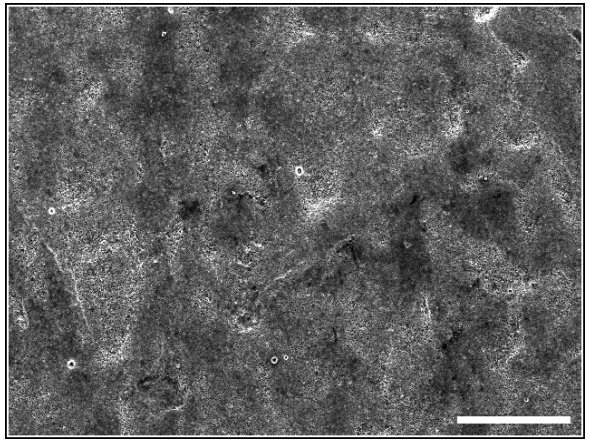
Increased amount of fines in the paper reduces print through, increased amount of chemical pulp increases print through.

Pigment penetration measured with SEM



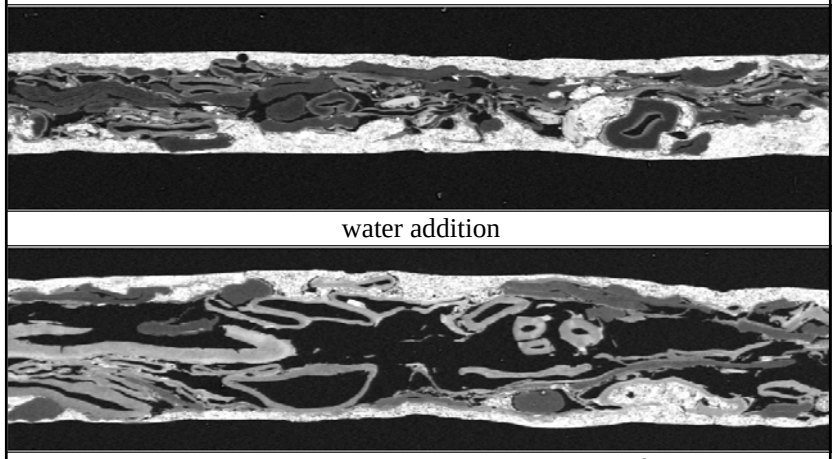
The pigment penetration decreases with increased calendering and increased amount of fines. Addition of chemical pulp had no significant effect.

Ink and water on coated and uncoated papers



Secondary electron image of a LWC paper surface. Bar: 50 μm.

The effect of water on the paper structure



water addition

Expansion caused by moisture-induced release of stresses in the fibers created by calendering

The effect of water on the paper structure

Irreversible expansion and decollapse of a surface fibre after printing SC paper with water.

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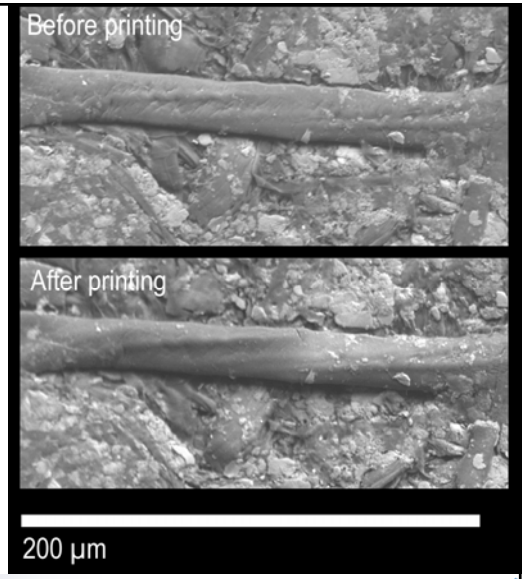
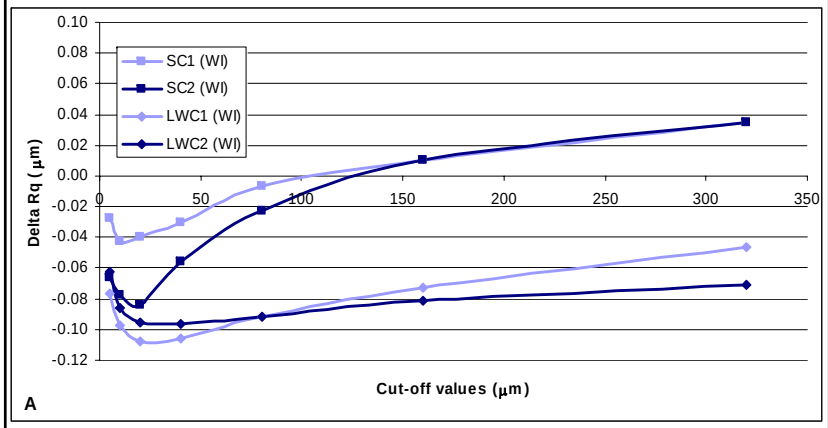


SC and LWC printed with water and ink



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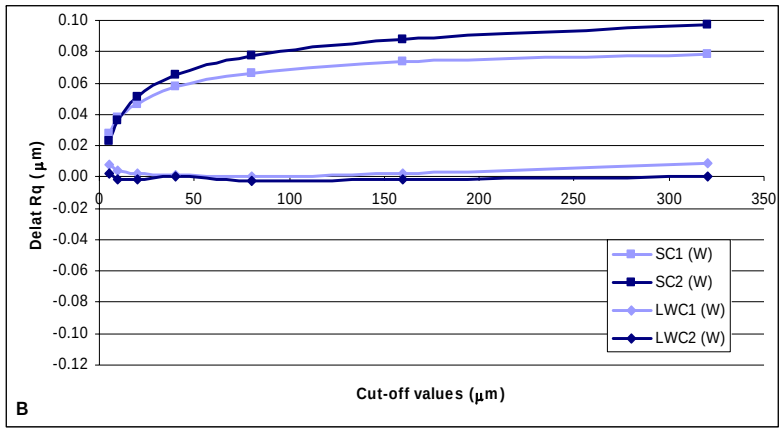
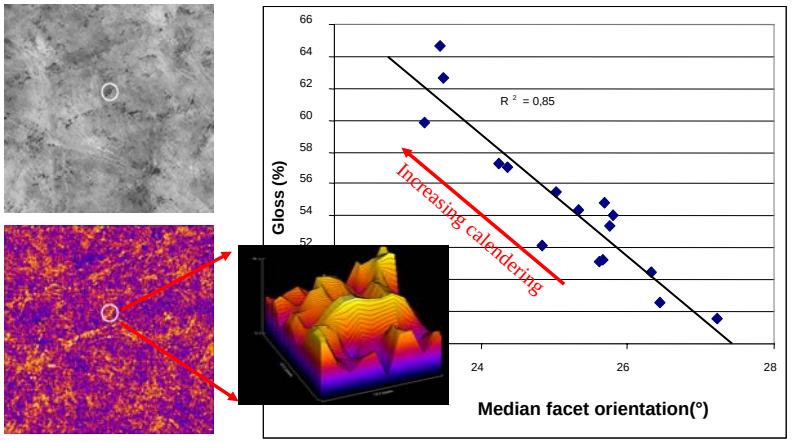
SC and LWC printed with water

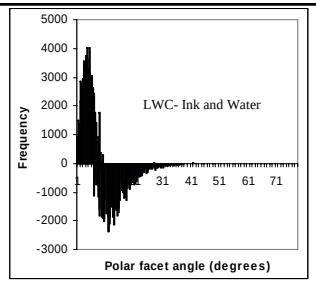


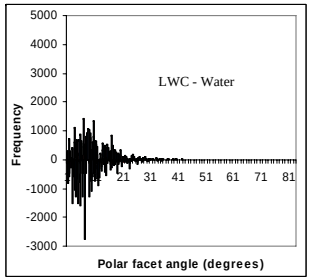
Surface topography and facet orientation



Change in facet orientation

- Roughening effect due to printing
  - Specific local changes after printing are analysed
  - The levelling effect of the printing ink is exemplified as well as the roughening effect of water application
  - The levelling effect is also indicated by an increment of facets having a low orientation





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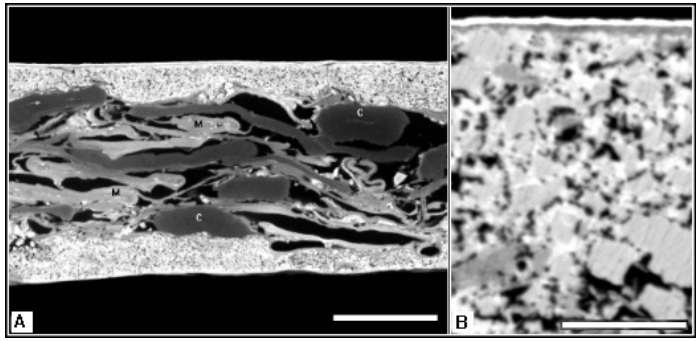
Coating pore structure and gloss

- In addition to surface roughness, the coating pore structure influences print gloss



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Conclusion

- Offset ink pigment particles on newsprint will not move by capillary forces after the printing nip.
- In the printing nip, the ink is squeezed away from local peaks in the topography like fibre ridges.
- Pores in the surface will not be covered by ink if the combined effect of ink thickness on the blanket, paper compressibility and blanket compressibility is not sufficient to make direct contact between ink and fibres in the pore.
- Pigment penetration is reduced with more fines and more calendering.
- Water that comes into contact with wood containing paper will cause an irreversible decollapse of fibres and thus a roughening of the paper.
- If the paper is coated, the coating layer may protect the base sheet against the water until it is evaporated and no roughening will occur.
- The ink even out optical roughness in coated and supercalendered surfaces and thus increase the smoothness and printed gloss