Mottling – Why it is difficult to predict in laboratory tests

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Abstract: Mottling in offset printing remains a major problem. Paper laboratories are looking for new ways to predict it. The CTP is taking a new approach by trying to separate the so-called phenomena of backtrap mottle and local ink refusal using as analytical tool the diagnostoc curve created during industrial trials. The purpose of these new tests and analyses is the definition of specifications for new equipment.

Introduction

Mottling is a rather important problem for printing coated offset paper. Every papermaker has already met or will meet this problem and will be ill-prepared in predicting mottling during printing when setting up the controls for making the paper. Mottled printing is difficult to predict in certain cases with the existing range of tests. At the request of a number of coating manufacturers, a study has been relaunched at CTP with the final aim of designing specific equipment to reveal the phenomenon in the laboratory. This future device could be installed upstream from the KHEOPS device which itself measures the mottling.

Before making this equipment, it is essential to understand why the laboratory tests and industrial observations show poor correlation. This approach must clearly incorporate an understanding of industrial situations which lead to mottling.

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The two major phenomena which lead to mottling: backtrap mottle and local ink refusal are reviewed in Figure 1. Knowledge of these two phenomena and the observation of printed papers can be used to establish the diagnostic curve. This quantifies mottling according to the printing sequence.

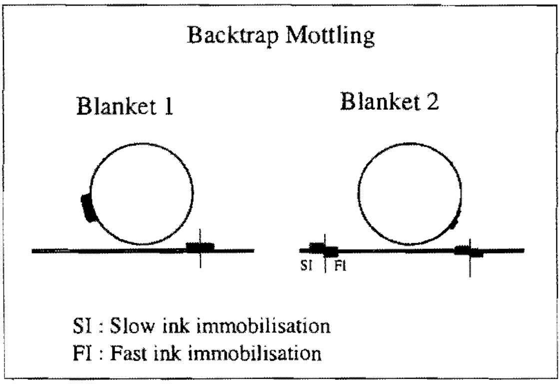

Figure 1a : Explanation of Backtrap mottling

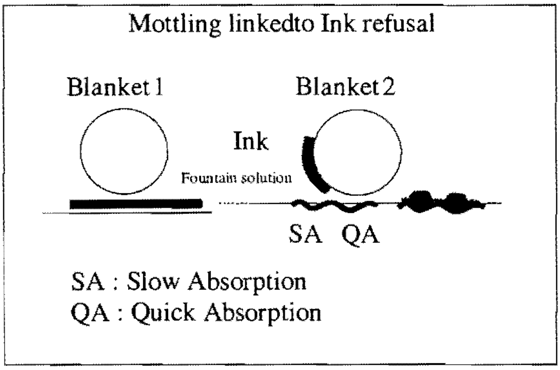

Figure 1b : Explanation of Mottling linked to ink refusal

Means employed

The paper used in these tests all came from coating trials on the high speed coating unit BGV. These were wood-free and wood-containing coated papers of basis weight ranging from 60 to 120 g/m^2, with single or double-sided coating.

For this report, two batches of paper were selected. They were chosen because they showed different mottling depending on the printing sequence. In batch nb 1, the predominance of the mottling phenomena were not known (local ink refusal or backtrap mottling). Batch nb 2 corresponds to papers known for mottling by local ink refusal.

Industrial printing was carried out using a GTO 4 sheet-fed machine (4 in-line units) and a Roland 204 (5 cylinders). The same test pattern and the same inks were used for all the tests. In order to distinguish the effects of colours and units, cyan ink was used on all the units.

The first series of prints was carried out using 4-colour printing under industrial conditions. In this way, a commercial comparison of the papers was made and diagnostic curves were established (Figure 2).

This diagnostic curves revealed 4 different types. Given the explanations of the two mottling phenomena by backtrap mottling and local ink refusal, in this curve which represents the mottling index as a function of the number of units integrating the number of backtraps, we can conclude that the A-type diagnostic curve is predominantly characteristic of backtrap mottling. The B-type curve is mostly characteristic of backtrap mottling with a small influence from local ink refusal. The C-type curve is characteristic of equal influence from both types of phenomena. Finally, curve D shows a predominance of local ink refusal compared to backtrap mottling since unit 2 give more mottling than unit 1.

Specific procedures were then applied to study the individual influence of wetting and the penetration speed of the inks.

The laboratory test for backtrap mottling, was in fact the printing on the IGT, of industrial yellow ink, followed by industrial magenta ink with a variable time delay between the two ink transfers. The mottling index is expressed as a function of the time delay which varies from 0.1 second to several hundred seconds. The influence of water is measured on the IGT with a water transfer via a ceramic roller followed by industrial black ink via a blanket-covered roller.

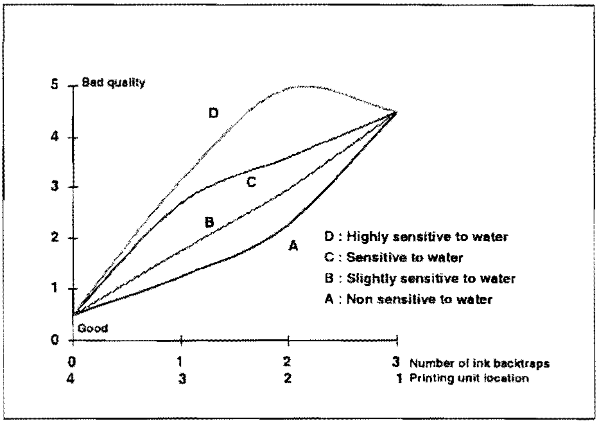

Figure 2: Theoretical diagnostic curves

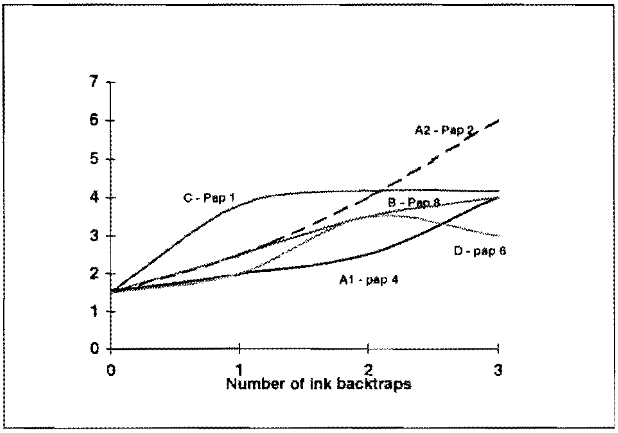

Figure 3 : Diagnostic curves on GTO. Commercial printing on batch 1

- Commercial behaviour of batch nb 1 papers

Commercial printing was used to establish the diagnostic curves of the five chosen papers (figure 3). Papers 4 and 2 have type A diagnostic curves with different intensities. Paper 8 has a linear curve characteristic of type B. Paper 1 has a type C diagnostic curve and paper 6 has type D. At this stage we can say that the practical behaviour of the papers is in line with the logic defined for the theoretical curve.

We now check the influence and the sensitivity of the water so as to identify whether the papers are more or less sensitive to backtrap mottling or to local ink refusal.

- Distinguishing the two phenomena (backtrap mottling and local ink refusal) in the laboratory: batch n° 1.

According to the theory of the diagnostic curves, we expect the papers to have a growing sensitivity to the water from type A to type D as indicated in the forecast curve of figure 4. In fact, the results are quite different. There is no correlation among the paper types (A, B, C or D) and sensitivity to water for these 5 papers.

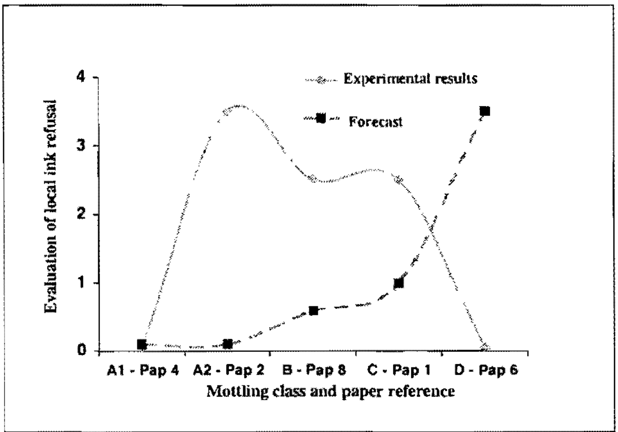

Figure 4 : Test of sensitivity of papers to local ink refusal.

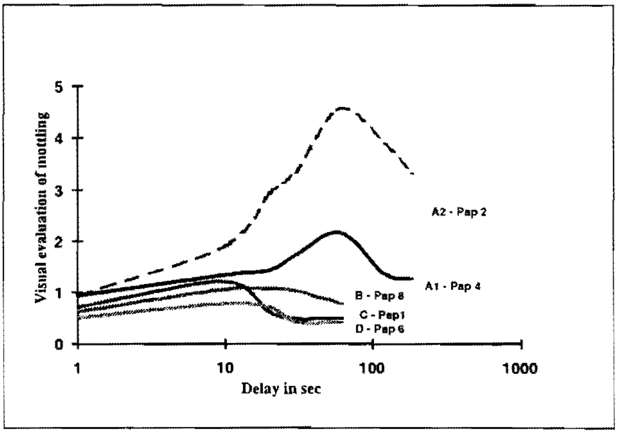

Figure 5 : Laboratory test of backtrap mottling (Yellow + delay + Magenta)

The backtrap mottling test is used to quantify the influence of the penetration speed of the ink. The results of the 5 previous papers, shown in figure 5, seem to provide an explanation concerning the commercial behaviour of type A, B, C and D defined in figure 2 (the type A papers show maxima of the mottling index for long delays, whereas those of type B show maxima for medium delays and types C and D show maxima for short delays i.e. 10 seconds).

Given our current knowledge, a laboratory delay of 10 seconds corresponds to industrial delays. On the other hand, delays of 100 seconds no longer correspond to the industrial process.

It would therefore appear that the industrial behaviour of the 5 papers are predominantly influenced by the penetration speed of the inks rather than their sensitivity to water.

- Influence of the penetration speed in industrial tests: batch 1

Another way to analyse the phenomenon of penetration speed is to create diagnostic curves of the same five papers on another machine which has different transfer kinetics compared to the GTO 4. We observe that papers 2 and 4 which were type A on the GTO 4 become type B on the Roland 204. Paper 1 changes from type C to type B and paper 8 changes from type B to type D. Paper 6 remains type D on both machines. This diagnostic curve result obtained on a different machine confirms the predominance of the influence of penetration speed associated with the transfer kinetics on this batch of paper.

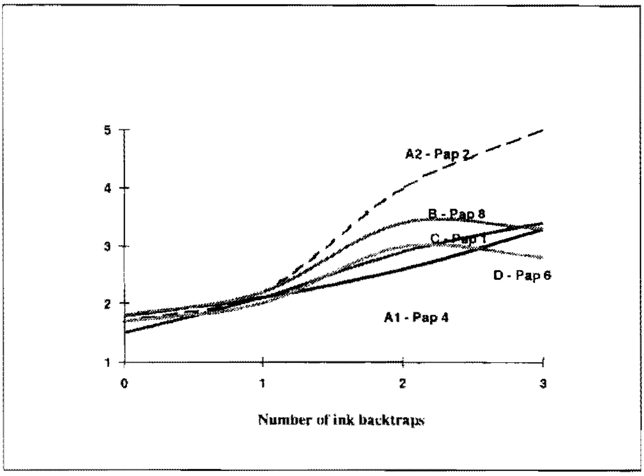

Figure 6 : Diagnostic curves. Roland 204 at 5 k ex./h. selection of papers.

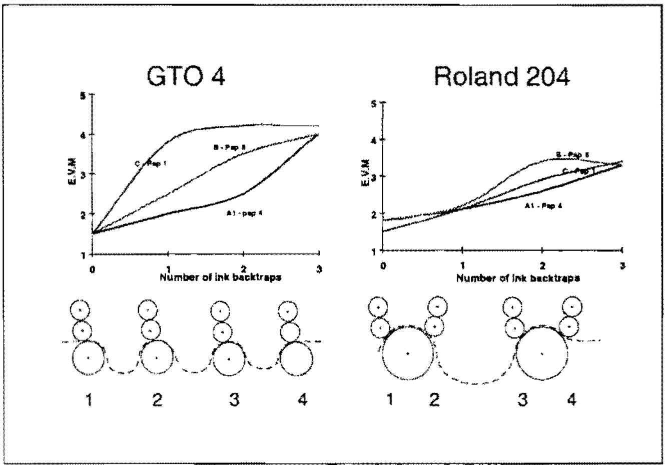

Figure 6 bis : Diagnostic curves on GTO and Roland 204.
Commercial printing on batch 1

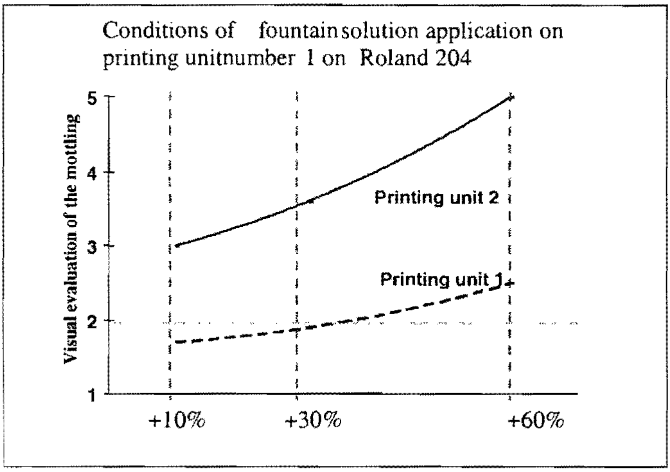

Figure 7 : Industrial local ink refusal depending on the wetting –
General case, Batch 2
Visual evaluation of mottling
Wetting conditions on unit 1 on Roland 202 exprimed in scumming
+ X % of dampening solution

- Case study of papers (batch 2) known for sensitivity to local ink refusal.

Figure 7, we set out to prove the sensitivity to water and local ink refusal of such papers by increasing the quantity of water, i.e. from dry scumming to +30 % or from dry scumming to +60 %. There is little mottling on unit 1, whereas unit 2 is already affected by 10 % excess water and with 30 and 60 % we observe high levels of local ink refusal mottling. This technique is most appropriate to indicate whether a paper is sensitive or not to local ink refusal.

Figure 8 shows the diagnostic curve of a batch 2 paper established from a four or three-colour printing. The only difference for units 2, 3 or 4 using three colours compared to four colours, is that the sheet is not wetted by unit 1. We observe that when using 4 colours we obtain a type D diagnostic curve with more mottling on unit 2 than on unit 1. However, when we remove the wetting from unit 1, the mottling in unit 2 totally disappears.

We have also studied the influence of the printing speed (figure 9). The type D diagnostic curve obtained at 5 Thousand Copies/hour is no longer found at speeds of 2.5 and 10 (TC/h), which corresponds to different travel times between units 1 and 2.

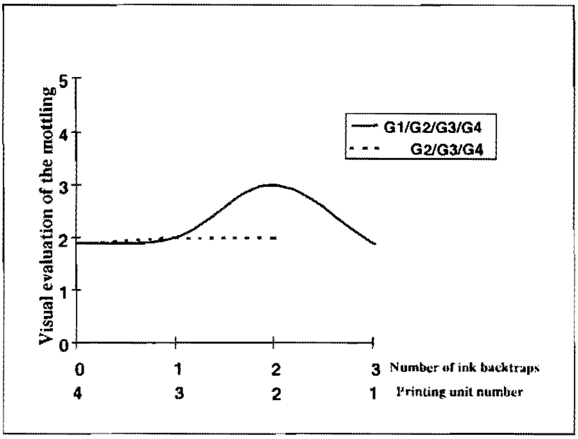

Figure 8 : Influence of unit 1 on other units general case, batch 2

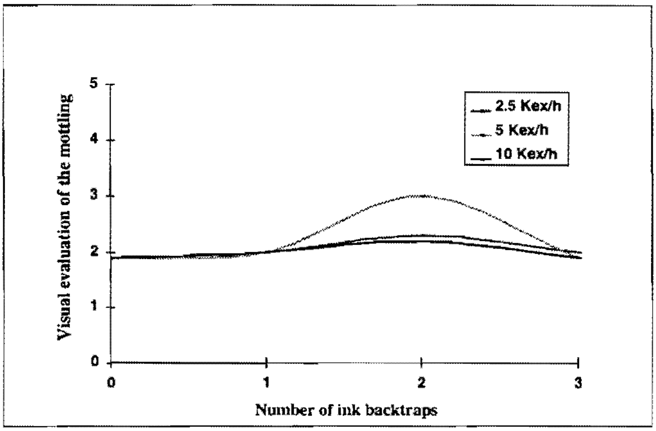

Figure 9 Diagnostic curves depending on the speed general case, batch 2

Conclusions and perspectives

Following these studies we can say that on the basis of the study of batch 1, the influence of the penetration speed of the inks and the travel time between the units must be taken into account. This requires that we reflect on the delays and on the number of delays to be implemented in a laboratory device.
Secondly, from the studies on the batch 2 papers, we can see that the printing speed and the water on the first unit are always important parameters. We have just mentioned the ink penetration speed which is a very general term. It comprises the evolution of the ink film in the coating. This evolution of the ink on the paper surface can be measured by the variation of the free ink volume or thickness, but also by a modification of the ratios of the ink's constituents. When designing specific equipment, one must take these various parameters into account. At the present time it would seem too early to define the device. If we have to do so, the reply would be to create a mini-rotative, but which?

One of the important elements in the definition of an Offset mottling device is the integration of the ink penetration speed. To do this, it would be necessary to carry out in-depth studies on the phenomena. Studies of the quantification of the volumes of ink transferred on blankets 2, 3 and 4 as a function of blanket 1 have already begun. Studies of the characterisation of the porosity of the coating are being carried out in parallel. In addition to the variations of the ink in terms of volume or thickness which will be approached by these first two phases, one must study the influence of the modifications of the rheology of the ink at the surface of the coating. An in-depth study was started some years ago and is called "tack of a freshly printed surface". It has already led to the creation of a CTP device.

We will close by reminding you that in the case of mottling, we must take account of the penetration speed and the water provided by the first unit. Our current state of knowledge does not enable us to define the specifications of the equipment for characterising mottling. It will require obtaining deeper understanding of phenomena of filtration, the evolution of the ink volumes, and the tackiness of the print on the surface of the coating. While being of the opinion that Offset will remain for some years the major process for printing on coated paper, we should still continue to improve our knowledge of the fundamental processes. Similarly, theses should be related to improvements in our knowledge of the structure of the coating.