Improving the Pre-Inking of an Offset Press by Checking Some Simple Paper Properties

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Key words

Offset, Inking, Make-Ready, Paper Porosity, Density

Abstract

In order to optimize ink mileage, *Heidelberg Web Systems* and EFPG carried out a joint research project. The aim of this study was to find the relevant paper properties that allowed a finer setting of the ink keys, thanks to the *Densicontrol®* system.
Tests were conducted on a panel of web offset papers and inks. Emphasis was put on the following properties :
- paper roughness, porosity and printability;
- viscosity, tack and viscoelasticity of the inks.
Since a good correlation was found between paper roughness and the settings of the *Densicontrol®*, this approach was applied to sheetfed consumables, without the use of any pre-inking device.

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Context

The engineering curriculum at EFPG enables about 25% of the students to obtain an "apprenticeship" status : during their last 2 years of studies (out of a total of three), they are under contract with a company. This contract makes them attend all classes in the EFPG curriculum and spend extended training periods in the employer company. Ms. Gateaud had such a status when this study was undertaken.

Introduction

Offset lithography and the consumables that this process involves have been extensively studied. However, new equipment capabilities (which provide new possibilities to the operators as far as make-ready and quality control are concerned) set new constraints on consumables,. What is more, high volume printing enhances the importance of ink consumption on press : optimizing and mastering the latter become issues of major concern, since paper and ink are consumed in large amounts.

The *Densicontrol*® is designed to allow for an accurate pre-setting of the ink keys on *Heidelberg* web presses. Three elements constitute the *Densicontrol*®:

- a plate scanner which measures the surface coverage under each ink key;
- a remote entry console (*REC*) which stores the data sent by the scanner plus information describing the consumables used for a given production;
- a quality control desk enabling the operator to preset the levels of inking and dampening and to correct the registers as well as the opening of each ink key.

By providing information on each plate coverage, the plate scanner saves much time in setting the ink keys. However, the plate coverage alone will not be sufficient to predict accurately the actual level of ink needed on each unit. The ink consumption (and thus its required flow) will of course also depend on the ink itself, the dampening additive and the nature of the paper used (especially its roughness and porosity).

This means that each combination of consumables (i.e., ink, paper, dampening additive, plate and blanket) will require new settings of the *Densicontrol*®. In other words, testing should be carried out in order to key the proper data into this device. Consequently, the risk for incorrect settings exists. Indeed, one can imagine that switching from coated paper to newsprint will affect the ink consumption. However, the plate scanner alone cannot take this change into account.

Heidelberg Web Systems was therefore looking for a solution to this problem: how to enable printers to make better use of the *Densicontrol®* and thus reduce waste without spending too much time in testing? The idea was to find or design a simple test method the results of which would help in properly setting the consumable parameters in the *REC*.

This study tackled only ink and paper properties, which does not mean that other consumables don't play a role in the setting of ink keys.

I. Review of paper and ink properties influencing ink transfer and print quality in offset lithography

Karttunen & Karttunen (1989) wrote that the visible and micro faults of the final ink films and prints were always consequences of the structural features of the base paper, coating, ink and of the printing process.

Influence of paper properties

Lepoutre & De Grâce (1978) established the major influence of surface *microporosity* on print gloss.

Oittinen (1983) split up coated paper roughness into *macroroughness* (from the base sheet) and *microroughness* (from the coating), the two influencing print gloss. Donigian et al. (1998) showed the influence of the coating porosity on the latter.

Bristow & Bergenblad (1992) mentioned the absorptivity and roughness of paper as influencing the set-off tendency.

MacPhee & Lind (1995) showed that print density depended mainly on these last two properties, as well as on whiteness.

The presence of fillers can also affect the print rendering. Pauler (1988) found that highly filled papers could give a lower print density with high ink quantities than a reference sheet without fillers.

Influence of the offset lithographic process

According to Lehtonen et al. (1988), the control of ink and dampening solution feeds are among the most difficult issues in offset process control systems.

De Grâce & Mangin (1984) showed that print density was less affected by changes in printing pressure and speed and by surface roughness and porosity than was ink transfer.

Chou & Harbin (1991) compared experimental data to some ink transfer models in order to possibly predict ink mileage.

Pu and Crouse (1997) confirmed the detrimental effect of paper surface irregularities on ink transfer.

Aspler et al. (1994) defined *printing tack* as the ink tack measured during printing on a paper surface and observed that its value increased with ink thickness in the nip. Printing tack appeared to be higher on relatively non-porous materials than on very porous ones such as newsprint.

Influence of ink properties

Rosenberg (1985) studied the influence of the level of dampening solution emulsified in an ink on its rheological properties and thus on its transfer.

The rheological properties of inks and emulsions have proved to provide useful information on the behavior of inks on press (Bassemir & Schubert, 1985; Chou & Cher, 1989; Blayo & al., 1996; Durand & Wasilewski, 1996; ...).

Chou (1994) showed that the level of consumption of an ink was related to its pigmentation.

This bibliographic review led us to select the following properties :

- paper roughness, porosity and printability;
- ink tack, viscosity and viscoelasticy.

II. Experimental

The aim of this study was to find a way for a printer to determine the proper paper coefficients to be keyed in the *Densicontrol®* without using the web press for testing. Therefore, it was decided to first carry out a number of laboratory tests (physical and printability properties) on various paper grades. This led to a "laboratory" classification of the substrates. This classification was then used to choose the types of papers and inks to be run on press (the high cost of such experiments did not allow all samples to be tested). The next step was to compare behaviors in the laboratory and on press and possibly find the matching ones. From there, we had to design a simple procedure to determine paper coefficients and apply it to field tests.

Out of 15 paper grades tested in the laboratory, 11 were selected for further study. They will be referred to as the samples described in table 1.

Paper	Type	Basis weight (g/m^2)	Thickness (µm)	Bulk (cm^3/g)
B	LWC (matte)	57	60	1.05
C	LWC (glossy)	70 (60 for press tests)	60 (51)	0.86
E	Glossy coated	135	109	0.81
G	Glossy coated	135	111	0.82

Table 1. Characteristics of the papers studied

Paper	Type	Basis weight (g/m^2)	Thickness (µm)	Bulk (cm^3/g)
H	Matte coated	135	83	0.92
I	LWC (matte)	80	78	0.98
J	LWC (glossy)	80	64	0.80
K	directory	36	56	1.55
L	newsprint	45	66	1.47
N	offset	60	76	1.26
O	offset	70	85	1.22

Table 1 (continued). Characteristics of the papers studied

Papers roughness and porosity

Two tests were selected for their simplicity : the *Microcontour test* and the *porometric inks test.*

- The *Microcontour test* enables to evaluate the surface irregularities of papers and may reveal defects in the coating of coated papers. The special blue ink used for this test contains a roughly ground pigment dispersed in a medium viscosity mineral oil. Whereas the oil penetrates into the paper, the coarse pigment cannot do so and remains in the surface irregularities (of the uncoated paper or of the coating), so that the resulting color intensity is a function of the depth of the surface irregularities.

- The *porometric inks test* shows the penetration of an ink into the paper and gives an idea of the rate of absorption of the ink by the substrate. The special ink used is made of a varnish into which a low percentage of black colorant has been dissolved. As it penetrates into the paper, the ink leaves less and less colorant at the surface. The density measurements of, e.g., two ink spots, one wiped after 7 seconds and the other wiped after 120 seconds, give respectively an indication of the surface roughness and of the absorptivity of the paper.

Each of these tests has limitations. The *Microcontour test* works under static conditions and is often used for visual comparisons. The *porometric inks test* works in a much wider time scale than the actual offset printing process. It does not distinguish between the coating microporosity and the base paper macroporosity. Moreover, the ink absorption will also involve its affinity with the paper components.

Nevertheless, these two tests are easy to perform and require very little equipment.

Ink rheological properties

The inks used came from two suppliers. They are described in Table 2:

M1	heatset magenta for LWC
K1	heatset black for LWC
M2	heatset magenta for LWC
C2	heatset cyan for LWC
Y2	heatset yellow for LWC
K2	heatset black for LWC

Table 2. Description of the inks studied

- The inks tacks were measured on a *Tack-O-Scope* apparatus, at 29°C and at a speed of 250 m/min. Measurements were made after 1 minute.

- Viscosities were obtained on a controlled stress rheometer (*CSL-500* from *TA Instruments*) using a cone-plate geometry.

For each ink and each temperature (20, 25 and 30°C), a first test was carried out to determine the maximal shear rate (the latter did not exceed 50 s^{-1} with our inks) and the duration of each experiment. The latter was divided in three steps :
- 30 seconds wait at work temperature;
- imposed increase in shear rate from 0 to 50 s^{-1} in 100 seconds;
- imposed decrease in shear rate.

Viscosities were measured at a 10 s^{-1} shear rate (this value was the maximum value implying no internal break in any ink sample).

The elementary process of flow of a viscous liquid is described by Eyring as the overcoming of an energetic barrier by the elementary unit of the liquid. This transition is favored by an elevation of temperature. This leads to an expression of the viscosity as a function of temperature indicated by the following equation:

$$\eta = A \exp (E_a/RT)$$

where
- η is the viscosity (measured here at a 10 s^{-1} shear rate)
- A is a constant depending on the frequency of intermolecular vibration
- T is the temperature in K
- R is the gas constant (R = 8.31 $J.mol^{-1}K^{-1}$)
- E_a is the activation energy, which depends on the structure of macromolecular chains, their interactions and their molecular weights.

The measurements were therefore carried out at 3 different temperatures in order to get access to the activation energy through Eyring's law.

Samples C2 and K1 were also tested in the form of emulsions, in order to get closer to actual printing solutions. Dampening solutions were obtained from distilled water containing 2 % of a damping additive. The pH was adjusted to 4.8 using caustic soda. The emulsions were prepared according to a method applied earlier in our laboratory (Pineaux et al., 1997) : three milliliters of the dampening solution were forced by a mixer into 20 g of ink during 5 minutes. Emulsions were tested after 20 hours, thus preventing any air bubble in the sample.

• Viscoelastic properties were measured on a *Metravib* viscoanalyzer used in shear ring mode. By applying a sinusoidal stress of known amplitude and frequency to an ink sample placed in a shear ring cell, we got a response with a phase shift. Then the conservation modulus G' and loss modulus G" could be calculated, as well as the loss angle δ ($\tan \delta = G''/G'$). The range of frequencies studied went from 5 to 250 Hz. The temperature was maintained at 25°C.

Printability tests

The 11 papers were tested with the M2 ink. Some tests involved inks MY, MSC and M1. We used an *IGT C1* laboratory press. The pressure applied was 600 N and the printing speed was 0.3 m/s. The resulting optical densities were measured using a *Techkon R410* densitometer. The transfer curves plot the resulting optical density as a function of the amount of ink applied onto the paper.

Tests on press

These tests were designed :
- to evaluate the level of density obtained on the different papers in identical printing conditions;
- to study the influence of the ink by comparing two inks from different suppliers;
- to compare the results with those obtained on the *IGT* laboratory press.

The web press used was the M600 operated for demonstrations and testing at *Heidelberg Web Systems Democenter* in Montataire, France. This 16-page heatset press uses an 80-10-10 inking geometry with three ink form rollers per printing unit. The dampening system is of the direct type and brings a film of dampening solution to the plate.
The height over bearers was 0.1 mm for each paper tested.

The selected papers were :
- paper A (SC, 56 g/m^2)
- paper B (matte LWC, 57 g/m^2)
- paper C (glossy LWC, 60 g/m^2, chosen as reference)
- paper D (glossy MWC, 80 g/m^2)
- paper E (glossy coated, 135 g/m^2)
- paper F (matte coated, 135 g/m^2)
- paper G (glossy coated, 135 g/m^2).

The inks used were named C1 and C2 (for LWC papers, and of the same series as the ones used in the laboratory).

The test forme allowed a regular ink consumption and contained control bars as well as a full width solid area.

The plates, blankets and dampening solution (pH 4.95 $\pm$ 0.05 ; conductivity 1.7 S/cm ; containing an isopropanol substitute) were the ones currently used for printing tests on this web press.

The inking roller speed was set at 44% of its possible maximum.

The dampening speed was set 5% above the minimum value preventing greasing (this value changed with paper quality).
The machine speed was 20,000 copies per hour.

Important remark

The temperature was measured (with an infrared thermometer) on three spots of the machine width and on different places of the inking unit (ink fountain, ink fountain roller, distribution rollers, form roller, blanket). The accuracy of an infrared measurement on a very thin ink film could not be so fine and the resulting temperatures were more likely those of the cylinders or rollers transporting the ink film.

First, one hour was allowed to let the machine temperature stabilize before running the tests. Because the papers were printed one after the other over several hours, paper C (the reference) was printed twice: once at the beginning of the run and once at the end. We could then check if results were reproducible. The significant shifts observed showed that waiting for an hour prior to printing was not enough for the temperature to stabilize. Thorough recording showed afterwards that *2 hours were necessary to reach a stable temperature* (see figure 1).

Further tests took this into account. They involved papers A, B, and C because their similar basis weight allowed to run them all without stopping the press. Ink C2 was used because it had displayed the largest shifts in density on paper C between the beginning and the end of the first run.

Some of the results obtained led us to try quick set consumables in order to check whether the phenomena observed in heat set web offset could be confirmed in sheetfed offset.

We tested 2 papers of similar basis weights : an offset paper (80 g/m^2) and a matte coated paper (90 g/m^2) in the laboratory (*Microcontour test* and *porometric inks test*) and on our *Roland Favorit* 2-color sheetfed press. Two process inks from the same set were used on the press : a cyan and a black. The dampening solution had a pH of 4.9 $\pm$ 0.05 and contained 2.5 % isopropanol. The printing speed was 8,000 copies per hour. The dampening level was set 5% above the minimum value preventing greasing. The temperature measured on the first ink form roller (using an infra-red thermometer) remained at 21.5 $\pm$ 1 °C during the whole test.

After having evened the inking in the width, we increased the inking roller speed from 10 to 100 % of its possible maximum (by 10 % each time) and retrieved samples 250 copies after each change. We measured solid ink densities on 10 consecutive samples for each inking roller speed.

III. Results and discussion

A. Paper properties

The results of the *porometric inks* and *Microcontour* tests carried out on the 11 papers are displayed in table 3. Densities were measured with an accuracy of $\pm$ 0.03.

Papers of similar thicknesses may have very different structures and porosities. The nature of the coating as well as the type of calendering will affect the bulk. We therefore classified the samples according to their bulks. This led to 4 groups :

- glossy coated papers (bulk < 0.9 cm^3/g)
- matte coated papers (0.9 cm^3/g < bulk < 1.1 cm^3/g)
- offset papers (1.1 cm^3/g < bulk < 1.3 cm^3/g)
- newsprint-type papers (bulk > 1.3 cm3/g).

Paper	Bulk (cm^3/g)	Porometric inks (optical density)		Microcontour test (optical density)	
		After 7 s	After 120 s	Minimum	Maximum
C	0.86	0.14	0.27	0.04	0.07
E	0.81	0.18	0.34	0.03	0.05
G	0.82	0.16	0.34	0.05	0.08
J	0.80	0.22	0.46	0.10	0.13
B	1.05	0.35	0.5	0.12	0.21
H	0.92	0.29	0.53	0.16	0.25
I	0.98	0.35	0.66	0.13	0.23
N	1.26	0.86	1.29	0.78	1.03
O	1.22	0.81	1.22	0.74	1.14
K	1.55	0.75	1.32	0.31	0.67
L	1.47	0.88	1.28	0.73	1.07

Table 3. Results of the *porometric inks* and *Microcontour* tests

- The porometric inks results indicate the absorptivity and speed of absorption of the samples. The former appeared to be well connected to the bulk. Therefore, we could also classify our samples according to the density measured after 7s :
  - glossy coated papers (density < 0.25)
  - matte coated papers (0.25 < density < 0.4)
  - uncoated papers (density > 0.45).

The density values after 120 seconds showed how the porosity varied within the bulk of each paper.

- Papers E, G and C kept most of the ink at their surfaces. Paper B, although rough, acted similarly.
- Papers I, H and J kept on absorbing after 7 seconds. This may have been due to the natures of their coatings or to the effect of calendering on the latter.
- The uncoated papers K, L, N and O showed a high absorptivity.

- The classification which could be deduced from the *Microcontour* test was close to that obtained from the *porometric inks* test (the roughness and surface porosity being related).
  - Very smooth glossy coated papers : minimum density < 0.05
  - Smooth glossy coated papers : 0.05 < minimum density < 0.10
  - Matt coated papers : 0.10 < minimum density < 0.25
  - Rough coated papers or smooth uncoated papers : 0.25 < minimum density < 0.50
  - Rough uncoated papers : minimum density > 0.50

Despite their limitations, these two tests allowed us to evaluate and classify our paper samples as far as surface roughness and ink absorptivity were concerned.

B. Ink properties

The results of the measurements of tack, viscosity (at three temperatures) and viscoelastic properties are displayed in table 4.

Ink sample		**M1**	**K1**	**M2**	**K2**	**C2**	**Y2**
Tack	**20°C**	222		231			
after 1 min	**29°C**	150	146	153	151	142	159
Viscosity (Pa.s)	**20°C**	182	140	183	160	175	172
at 10 s^{-1}	**25°C**	145	92.5	94	76.5	73	93
shear rate	**30°C**	91	62.5	64	53.5	70	63
Activation energy (kJ/mol)		51	60	78	81	68	74
Tan δ at 250 Hz and 25°C		2.8	2.7	3.8	3.6	4.0	3.95

Table 4. Tack, viscosities and viscoelastic properties of the inks

As Blayo explained (1992), the tack of an ink depends on the internal cohesion of the latter but is not directly related to its viscosity. Indeed, we find relatively similar tack values from one ink to the other, but the corresponding viscosities may differ significantly.

Inks showed a shear-thinning character. Samples M2 and K2 had lower viscosities at 30°C, probably because of a good pigment dispersion and a good miscibility between the varnish and the resin.

A raise in the temperature (of experiment) improved the resistance of inks to breaking when the shear rate was becoming too high : their internal cohesion improved (for instance, due to changes in the criss-crossing of macromolecules).

The four process inks (samples C2, M2, Y2 and K2) have a lower activation energy than samples M1 and K1. The rheological properties of the former will be less and less stable as temperature increases.

As far as the emulsions are concerned (samples K1 and C2 at 25°C), we could observe that the K1 emulsion was not very stable, probably because it was not homogeneous enough. Regarding the C2 emulsion, we observed no significant change in viscosity compared to the ink alone : this ink gave finer, more homogeneous emulsions than ink K1. However, the presence of dampening solution fragilized the emulsion, which then broke at a lower shear rate than ink C2 taken alone.

The measurements of the loss angles proved that the inks from the #2 series had a more viscous character than those of the #1 series. This explains why inks M1and K1 tended to break their structures at lower shear rates than the #2 series.

We had access to a *Lithotronic®* emulsification tester kindly made available by *Coates Lorilleux*. This device measures the torque applied to a helix mixing an ink while dampening solution is added to it.

We compared inks C1 and C2. The samples weighed 25 g and the temperature was set to 35°C. The ink sample was first mixed for 3 minutes at 1,000 rpm. Then the dampening solution (i.e., the exact same one as that used on press) was added at 2 ml per minute. The test ended when some of the emulsion was projected out of the mixing pan. The dispersion of the results was large, but we could observe general trends, namely:

- ink C2 appeared to generate finer emulsions;
- it also absorbed up to 45% of dampening solution (vs. 15 % for ink C1).
- Consequently, its rheological properties varied more as dampening solution was added than they did for ink C1.

C. Tests on press

- **Evolution of the temperature within the printing unit**

We had observed significant shifts in temperature between the beginning and the end of the first printing test (referred to as test n° 1), resulting in different density values on the same paper (see remark in § II).

Thus, a second series of printing tests (referred to as test n° 2) was run allowing more time for the temperature to stabilize. The same procedure was used (on papers A, B and C only), but we waited for two hours before printing : the press was running at 15,000 copies per hour, the ink fountain roller was set at its maximum speed, and pressure was applied between cylinders without running paper. The web was unwound after 2 hours; the printing unit was then automatically cleaned, but no cleaning occurred afterwards when the other three webs (i.e., papers C, then B, then C again) were pasted.

The temperatures recorded during this sequence are plotted in figure 1.

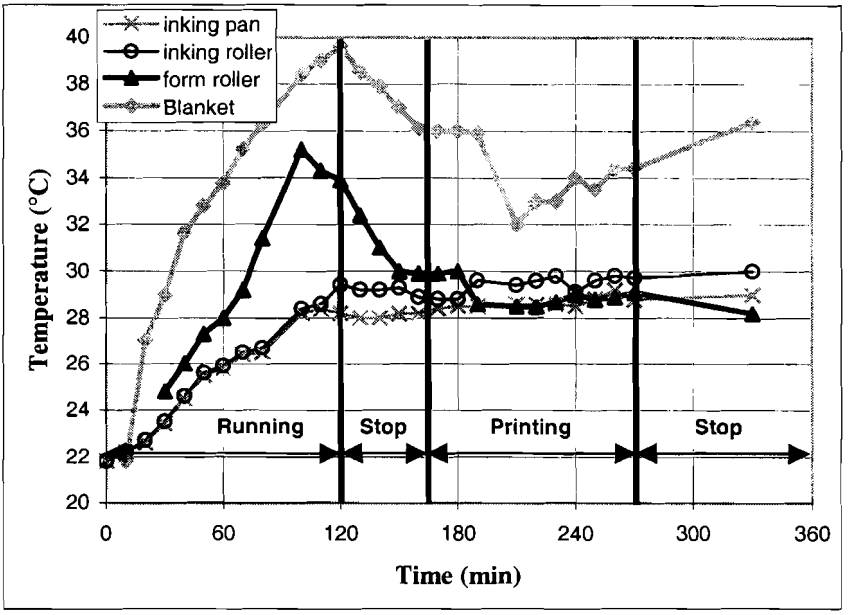

Figure 1. Evolution of the temperature in the printing unit

We can notice that shifts in temperature between a "cold" printing unit and a "warm" unit could exceed 10 °C. Two hours were not enough to stabilize the form roller and blanket temperatures, but the temperatures of the form roller and the inking pan remained stable during printing.

Bringing dampening solution to the plate cylinder implied a decrease in the form roller and blanket temperatures.

We confirmed the effect of temperature by superimposing the curves obtained for paper C (showing the optical density as a function of the opening of the ink keys) at the beginning and at the end of each series of tests (see figure 2). The curve plotted at the end of test n°1 fits well those plotted at the beginning and at the end of test n° 2.

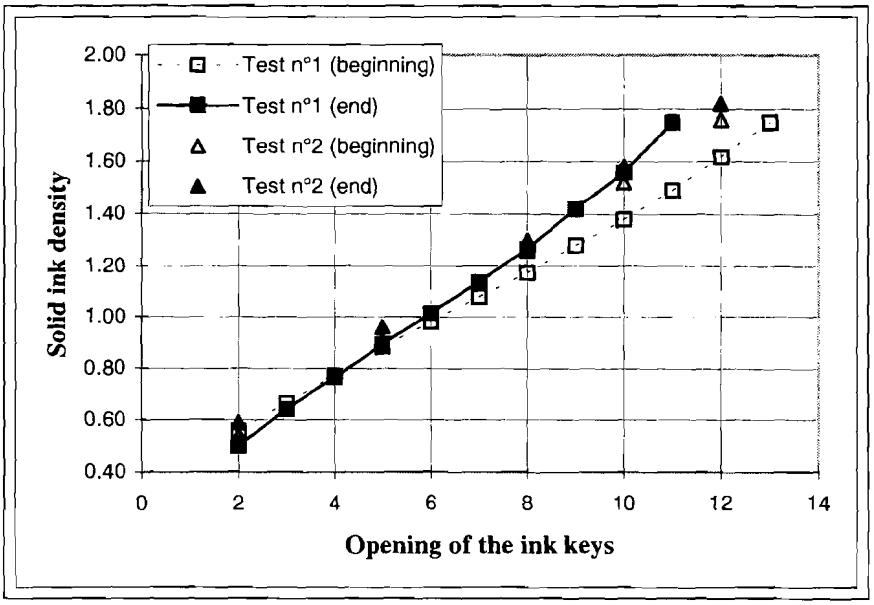

Figure 2. Solid ink density as a function of the opening of the ink keys (paper C and ink C2)

When the temperature increased, the rheological properties of the ink changed : both the viscosity and tack decreased, resulting in a higher transfer of ink within the printing unit. The variation in tack may have affected the level of emulsification (Nieminen, 1992), but the higher temperature also decreased the amount of emulsified dampening solution and thus the transfer of the emulsion. The overall effect of this increase in the temperature was a higher solid ink density on the papers.

The IGT laboratory press allows the operator to know the amount of ink applied to the paper. The graphs displayed in figure 2 take into account both the amount of ink transferred and its consumption by the paper and therefore, we cannot deduce from these the sole amount of ink on paper.

According to these results, we could compare the densities measured on all three papers. Only the dampening level settings had to be adjusted for each paper, in order to prevent any greasing of the plate. No other modification in the settings took place.
We selected ink C2, for its higher pigment content (allowing a higher density) and the finer emulsions it appeared to generate on the *Lithotronic*® emulsification tester.

The solid ink densities measured on papers A, B and C are plotted as functions of the opening of the ink keys in figure 3. The standard deviation of density measurements was $\pm$ 0.03.

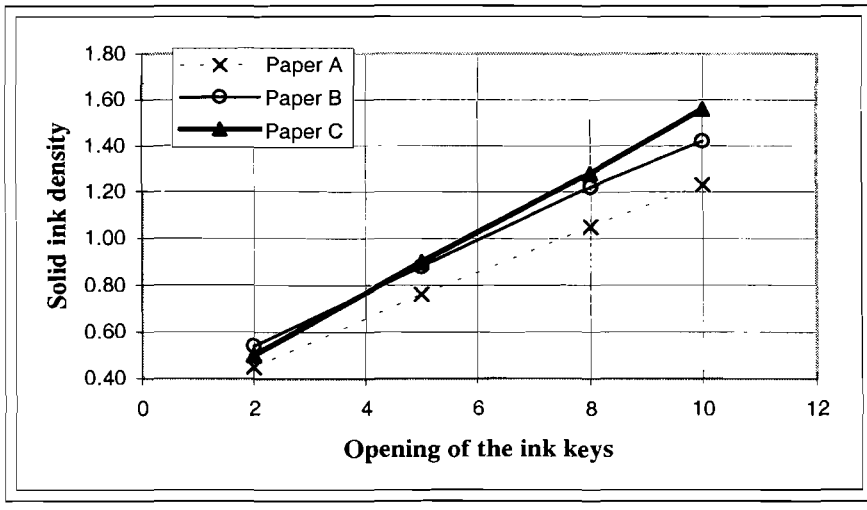

Figure 3. Solid ink density as a function of the opening of the ink keys for different paper grades (ink C2)

The shifts between papers appeared better when a thicker ink film was delivered into the ink train. Because it absorbed more ink, paper A (SC) showed lower densities. As we observed with the porometric inks test, the matte coated paper B absorbed more ink than the glossy coated paper C.

These results encouraged us to compare some of the results obtained in the laboratory to those obtained on press.

The results of tests carried out on an *IGT C1* printability tester did not match those obtained on press, mainly because the paper could not absorb the ink vehicle as easily on a fast web press as it did on the *C1*. Thus, as far as porosity is concerned, coated papers showed larger differences between each other on the laboratory press than on the web press.

We then plotted (for all papers tested) the density obtained on press (the ink keys being set at a "10" opening) as a function of the density measured during the *Microcontour test*. The resulting graph appears on figure 4.

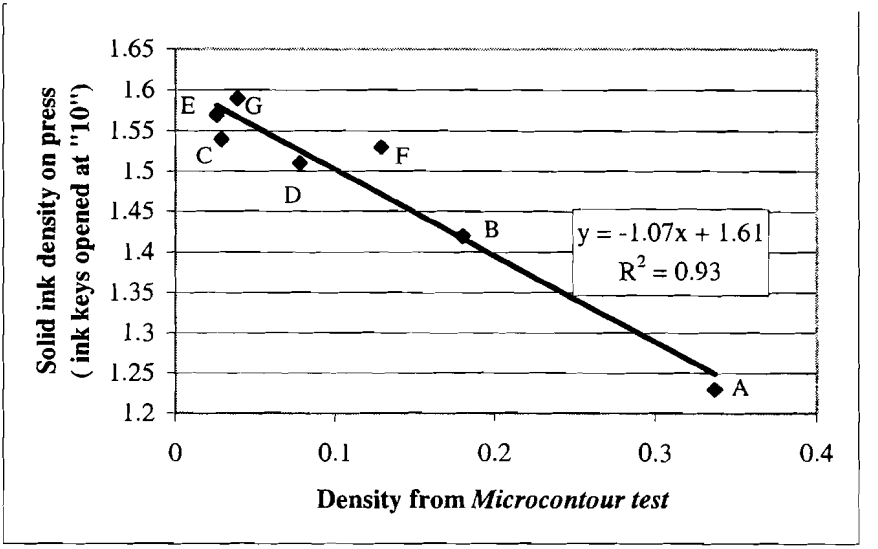

Figure 4. Printing density (ink C2) as a function of the *Microcontour test* density

By applying a linear regression to the plotted dots, we obtained a good approximation. However, the thick papers (F and G) tended to present a larger deviation from this linear regression.

Chiodi and Silvy (1971) showed that both the porosity and roughness were modified by the pressure applied within the printing nip. According to them, only the microporosity of the coating was not modified.

This means that paper roughness will decrease more for a thick paper than it does for a thin one. But the paper will gain back its roughness, the latter being then likely to modify ink transfer (Aspler et al., 1994).

Therefore, the paper thickness also had to be taken into account when we were considering roughness. Using paper C as a reference, we divided each paper thickness by that of the former (51 µm), thus obtaining a coefficient that we then applied to the density measured during the *Microcontour test*:

$$D_c = D \times 51/e$$

Where - D_c is the corrected density as obtained from the *Microcontour test*,
- D is the printing solid ink density, and
- e is the paper thickness (in µm).

By applying this correction, we "decreased" the roughnesses of thick papers and thus took into account their larger variation within the printing nip.

The resulting graph is shown on figure 5.

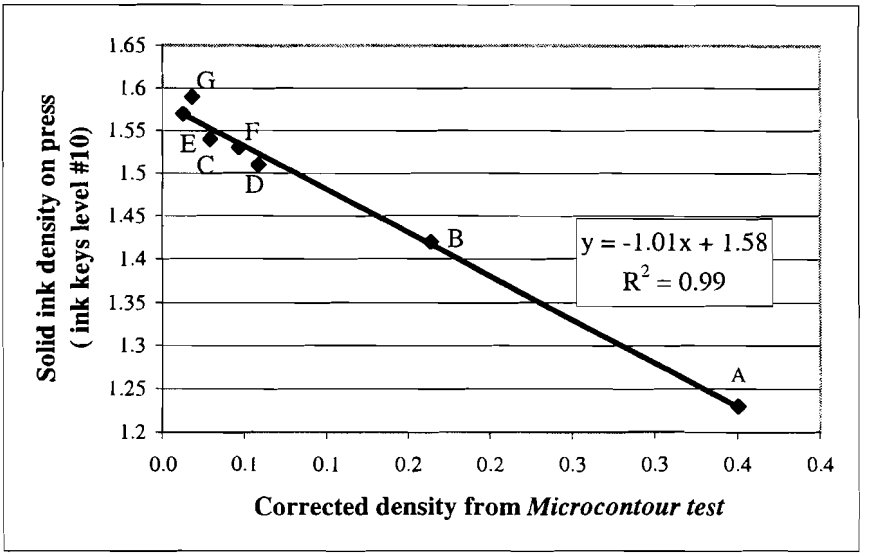

Figure 5. Printing density as a function of the corrected density from the *Microcontour test*

This simple correction significantly improved the correlation coefficient of the new linear regression.

We could then establish a good correlation between a paper roughness test in the laboratory (the *Microcontour test*) and the resulting solid ink densities on press (with a given setting of the ink keys). This simple test could constitute a rather accurate way for the printer to preset the inking level or, if a plate scanner were available, to take the paper parameter into account in the obtained setting of the inking.

From there, we wanted to check whether this method would also apply to sheetfed offset materials. We therefore decided to run a test on our sheetfed press at EFPG.

The selected uncoated "offset" paper (80 g/m^2) will be referred to as X and the matte coated paper (90 g/m^2) as Y. The quickset process cyan ink will be referred to as C3.

Because this press is not equipped with a plate scanner, we ran our test at different inking levels and measured the resulting solid ink densities. For each inking level, we ran 250 sheets of scrap paper before actually printing our two samples in a row. The offset paper (more absorbent) was run prior to the coated one, so that no extra ink might have built up on the form rollers.

The solid ink densities of both papers were plotted as functions of the potentiometer value (corresponding to a percentage of the maximum inking cylinder speed) in figure 6.

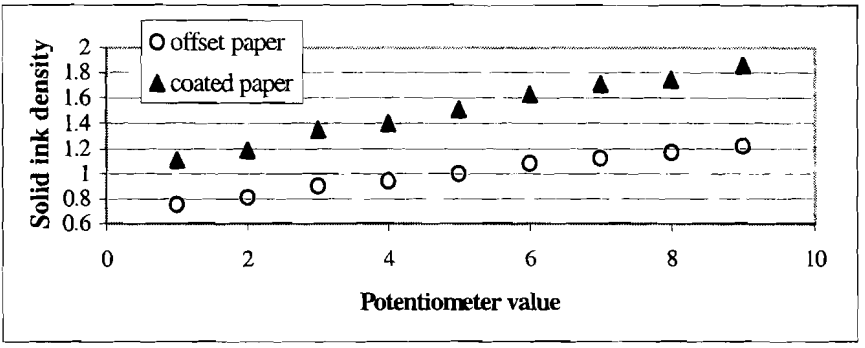

Figure 6. Solid ink density (ink C3) as a function of the inking level on the sheetfed press

We then selected the inking level giving a solid ink density (for paper Y) close to the one obtained with paper B (matte LWC) on the heatset web press. It led us to level # 4. The characteristics of papers X and Y are given in tables 5 and 6.

Paper	Type	Basis weight (g/m^2)	Thickness (µm)	Bulk (cm^3/g)
X	Offset	80	102	1.27
Y	Matte coated	90	79	0.88

Table 5. Sheetfed press paper characteristics

Paper	Bulk (cm^3/g)	Porometric inks (optical density)		Microcontour test (optical density)		Solid ink density
		7 s	120 s	Mean value	Std. deviation	Level # 4 on press
X	1.27	0.98	1.35	1.31	0.08	0.94
Y	0.88	0.29	0.56	0.26	0.03	1.40

Table 6. Results of the *porometric inks*, *Microcontour* and printing tests (ink C3) on sheetfed press papers

Plotting the solid ink density on papers X and Y (level # 4, ink C3) versus the density from the *Microcontour test* enabled us to validate the linear regression obtained with heatset consumables (see figure 7). Interestingly, these two papers fitted quite well : this means that if we had simply applied this laboratory test, we could have predicted the solid ink densities on our two printed papers with the ink keys set at level # 4.

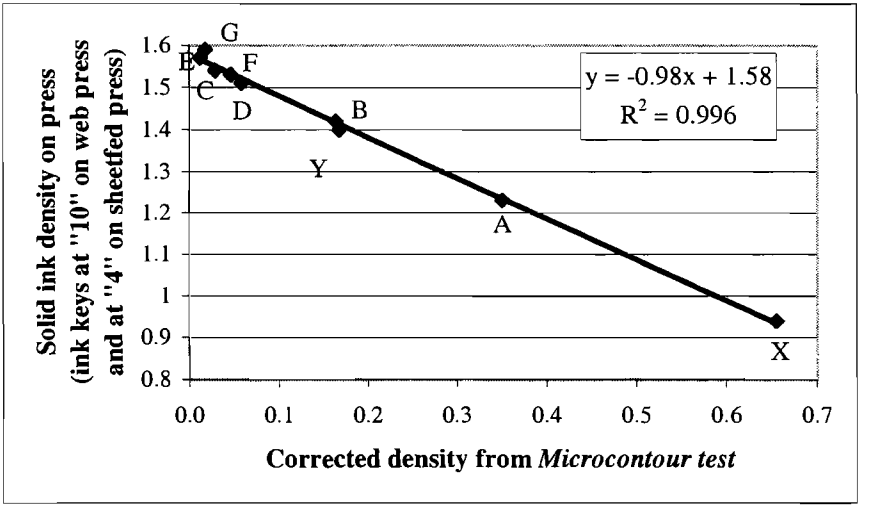

Figure 7. Printing density (inks C2 and C3) as a function of the corrected density from the *Microcontour test* for heatset and quickset materials

Naturally, we only tested a limited number of consumables, but the same method can be applied to different printing conditions. This implies that if we knew the typical solid ink densities of the papers we commonly use, at different inking levels on our press, several graphs like that in figure 7 should be obtained.

In case we later ran a new type of paper, we just would need to measure its thickness and apply the *Microcontour test* to it. For each graph, i.e. for each inking level, the corrected density would lead us to the probable solid ink density we should obtain on press : we just would need to find the intersection between the linear regression and the vertical line coming from the corrected density.

Similarly, if we were aiming at a certain density on a new type of paper, we could pick up the graph that would lead to it from the corrected measured *Microcontour* density.

Conclusion

The aim of this project was partly reached : we found that a simple laboratory test of roughness (the *Microcontour test*), carried out on a given paper, could help in predicting the solid ink density of a cyan ink printed on this paper at a certain inking level.

However, we must take into account that :

- tests were carried out on a limited number of papers and inks;
- controlling press parameters is extremely difficult in usual printing production conditions.

The influence of temperature on the behaviors of the press and consumables proved to be especially significant. Rheological tests carried out on inks and emulsions showed the large variations in behavior one could expect from one temperature to another and from one ink to another. Therefore, the way an ink is brought to the fountain roller (pumping device or spatula), its composition and resulting structure, and the temperature within the printing unit will all affect the distribution, emulsification, transfer and final printing density of this ink.

Consequently, the printer may use this paper test as a convenient tool to set the appropriate inking level on press, but should by no means neglect the ink/emulsion properties in this setting. Testing the latter requires more sophisticated equipment.

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