Sensor Response to Variations on Web Offset Presses

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Key words

Web Offset Press - Sensor - Control - Quality

Abstract

We have previously presented [1] the main stages and the restrictions involved in transforming our laboratory prototype sensor into an industrial version. Our transducer which quantifies the wetting level and, therefore, the ink-water balance in the offset printing process, had been tested on a sheet-fed press.

We will present herewith the main results obtained with an industrial web offset press directly on site in industry and in regular conditions of production. We studied, in particular, the response of the sensor according to wetting level, printing speed and inking level. In addition, We will indicate the most recent developments in the configuration of our sensor for use in industry.

Introduction

Our laboratory now has at its disposal the first industrial version of a sensor. We have already indicated its working principle and how we developed it starting from its laboratory prototype version [1]. This new sensor was first tested on the sheet-fed press of the EFPG. We then proceeded with trials on web offset presses which, relative to their high-speed printing rate, fully justify the use of our sensor as a means of control and adjustment. These tests took place in two sessions : one on an industrial site during a regular run; the other, at the Institut des Communications Graphique du Québec (ICGQ - Montréal) on the basis of specific tests.

1 - Development of the measure system

Figure 1 presents the configuration of the measure system used for the tests.

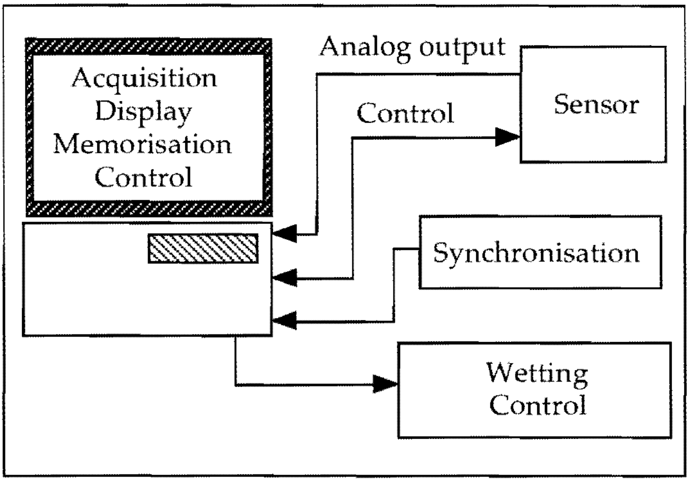

Figure 1 : test system

Our sensor [2] of which the gain and offset signal parameters can be remotely controlled, continuously delivers a numeric signal on 12 bits and sampled at 100 kHz. For our measures and for the sake of convenience, we took the sensor's internal analog signal just before conversion to be digitalized by an acquisition board of the same performance installed in the calculator. The latter was, in turn, connected to the coder which generates a synchronization "pip" each time the target for our measure goes through. Set up in this way, the system acquires and displays, in real time, the useful signal (an average of 100 dots at 100 kHz taken on the target) upon each rotation. For a plate cylinder perimeter of 0,5 m and at 36000 rotations per hour (5 meter per seconds), 100 dots have an equivalent length of 5 mm. Consequently, the movement of the signal during the speed variations of the press can be reliably followed in so far as the target of the measure is long enough. Lastly, the calculator directly controls the wetting level of the printing unit on which it carries out the measure (this is the case for the sheet-fed press at the EFPG). This ensures perfect synchronization between the wetting level and the sensor's measure which makes the identification stage of the process necessary from the automatic point of view.

This system was, therefore, first tested on the sheet-fed press of the EFPG whose maximum speed is 10000 rph. The foremost goal of these tests was to compare the results obtained with our sensor in its laboratory version. The results were very satisfactory. The gain in compacity and a new optical design made it possible to enhance the sensitivity of the industrial version notwithstanding a weaker laser light source than the one on the laboratory prototype version.
Figure 2 represents typical responses of the sensor at varying degrees of wetting around the optimum value for the printing conditions of the test at two speed : 5000 and 10000 rph (20% coverage pattern, black ink).

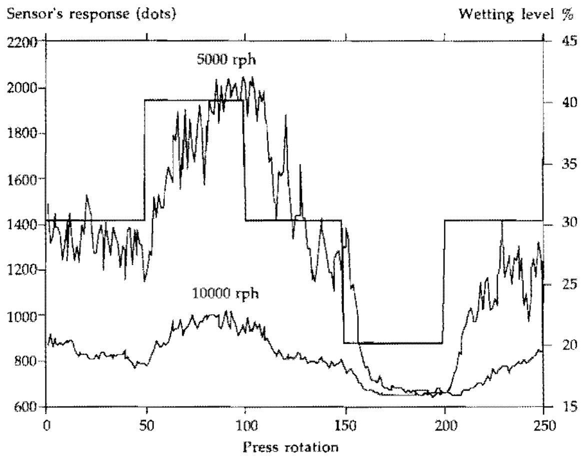

Figure 2 : variation of wetting level at constant printing speed

Remarks :

For this graph as well as for all of those presented hereafter, the axis of the abscise represents the number of machine rotations, the ordinate axis on the left represents the measure of the sensor in dots (one dot = 2,44 mV) and the ordinate axis on the right represents the wetting in percentage (%) (machine reading), or the printing speed in rotations per hour, or the inking level in percentage in relation to the optimum value. Each time the optimum value is mentioned for a printing parameter, it is the value which represents the level of correct quality for the printed matter before the test begins and is, therefore, considered to be a reference.

Signal variations in figure 2 are just as marked for all speeds. For a same wetting level, it has been noted that the measure increases as the speed decreases. This is directly visualized in figure 3 where the speed varied at a constant wetting level.

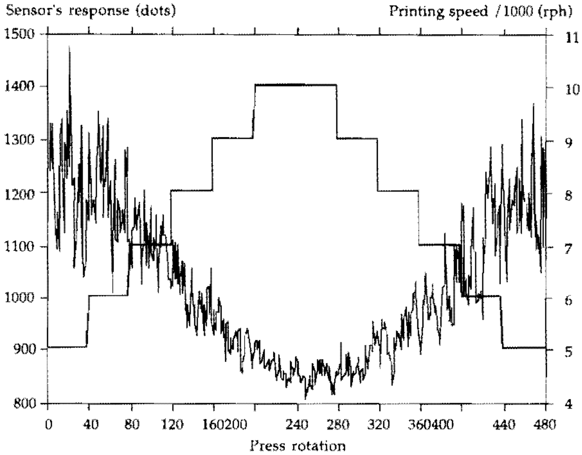

Figure 3 : printing speed variation at constant wetting level
sheet fed press, wetting level at 30%, target at 20% coverage

For this test, the speed varied in stages every 40 rotations of the machine from 4000 to 10000, then from 10000 to 4000 rph. The independence of the wetting and printing speed controls are clearly visible in this figure. The wetting control monitoring the rotation speed of the water pan roller, it is obvious that at a constant wetting level, the quantity of wetting solution carried onto the plate depends then on the rotation speed of the plate cylinder, or, to be more exact, on the differential between the machine and the wetting system (here, 30% wetting = 4000 rph of the water pan roller, for a rotation of the water form roller between 13000 and 26000 rph).
The first stage of tests on the sheet-fed press will have made possible to both test the sensor in its industrial version, and have a high-performance measure system available for high-speed printing tests on web offset presses, which are the machines most concerned by an automatic wetting adjustment.

2 - Results on web offset presses

2-1 - On-site industrial production tests

This first test campaign took place on an industrial production site on a HARRIS M110 machine intended for the production of magazines. Having available only one sensor, we worked on the black unit and on a low-percentage coverage pattern target. For obvious reasons, we could not interfere with production by applying well-marked steps on the wetting, but the interest here was to clearly qualify our sensor in real conditions of industrial production.

Consequently, we were able to record the starting procedure stages of the press as well as a few small variations in the wetting whose synchronization was not provided. This means that, considering the running conditions, the moment wetting level variations was applied is only know within a few rotations. In spite of experimental conditions far removed from "laboratory" conditions, we were able to check that our system presented a good level of sensitivity on the press. Quite obviously, this first campaign had to be completed by much freer tests were we could control and vary the different parameters. We also checked the reliability of our system of measure regarding the industrial environment which presents serious drawbacks for instrumentation (Electro-Magnetic Compatibility, vibrations, temperature).

2-2 - Some significant results

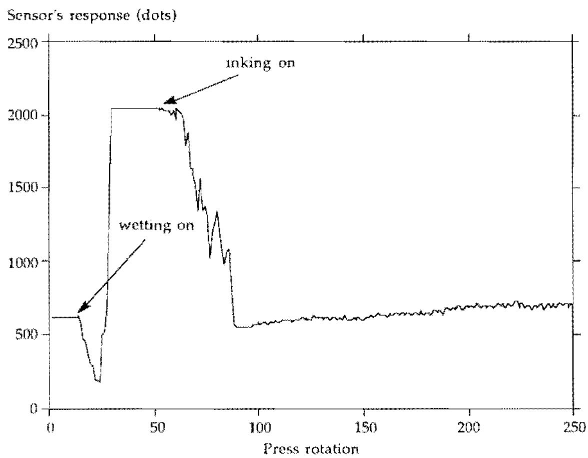

Figure 4 : starting procedure and then 28000 rph

In this experiment, one starts with a dry plate at low speed. Wetting is activated first, provoking the saturation of the sensor's output signal after about 20 rotations because of the great quantity of wetting solution present on the plate. Inking is activated in turn, and the speed rises to 28000 rotations per hour. A steady rate is reached at 250 rotations.

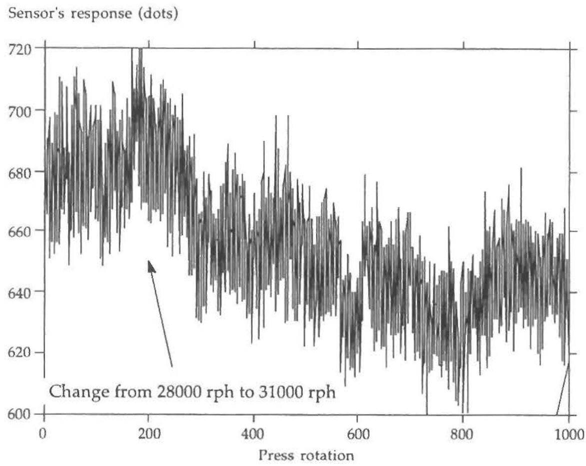

Figure 5 : change in printing speed

In figure 5, we visualize the transition from 28000 à 31000 rph, just before the operator of this machine readjusted the wetting level (speed controlled machine / non-coupled wetting).

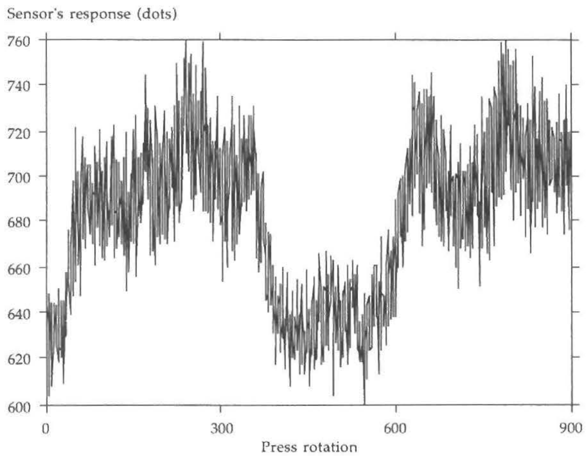

Figure 6 : variation of wetting level at constant printing speed

Here, the wetting level of the printing unit varies several times from 50 % to 60 %, for a constant printing speed of 31000 rph.

2-3 - Tests at the Institut des Communications Graphiques du Québec

During this second testing campaign, we effected tests on the web offset press of ICGQ, a HARRIS M110, on the black unit.
The availability of this machine made it possible for us to carry out a more study on three parameters : printing speed, wetting and inking level. The target was a screen with a 10% coverage pattern set on a specific ICGQ test form. We printed on two types of paper : super calendered grade B, and coated 89 g/m2.
It must be noted that the wetting control of this machine presents a relatively long response time. In curves presented below, the step represented is relative to the action to the wetting control. The effective variation of the rotation of the speed of the water pan roller, takes place itself as if it were a ramp whose slope is of the order of 10 seconds per variation of 10%, namely, about 100 rotations at 35000 rph. This phenomenon "crushes", in part, the possible dynamic differences during the wetting transitions between the two papers tested. We will see that experiments with these two papers (paragraph 2-8) gives very similar results.
On last precision must be given about this press : the wetting control is not in any way coupled with the printing speed control of the machine.

2-4 - Starting procedure

Control of the experimental conditions made it possible here for us to go very precisely into the detail of the starting procedure.
A starting procedure at 15000 rph can be found in figure 7.

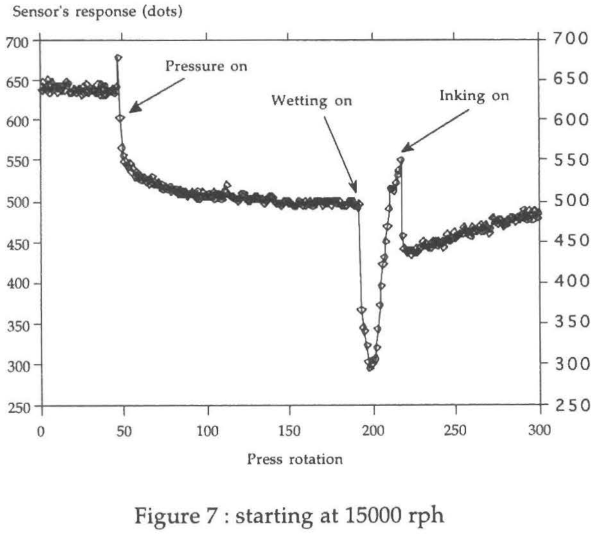

Figure 7 : starting at 15000 rph

Three stages are visualized: pressure put on, wetting and inking of the plate on.
Once the press is put into rotation and when the pressure is put on, the blanket comes into contact with the plate marking it once again, thus, re-creating a more absorbent zone for the light given off by the sensor. This phenomenon is visualized by the first step on the signal.
When the contact is made with the water form roller, the signal begins by decreasing and then moves toward saturation as seen in figure 4. The saturation phase was never reached here, because we active inking much sooner. The explanation put forward for this transitory phenomenon is the following (also on figure 4) :
when the water form roller is put into contact with the plate, it is likely that the film of wetting solution transferred onto the plate begins by being absorbed by various dirt marks which come from contact with the blanket. These more or less agglomerated particles would at first make the plate less reflective. In addition, when the water form roller is put into contact with the plate, it can be done for the first rotations before the wetting solution rise the water form roller. In this case, it cause the same effects that the contact of the blanket with the plate.
Afterwards, with the increase in the quantity of the solution, it completely covers the surface of the plate thus forming a surface which reflects light more and more.
The application of the inking rollers then creates the ink-water emulsion, and a new balance is reached all the more rapidly as the wetting system has been maintained alone for a short time interval.

2-5 - Variation in wetting at constant speed and inking

For each tests presented in figures 8 et 9, the wetting level follows an identical sequence of variation (ordinate axis on the right) :
35 % -> 45 % -> 35 % -> 25 % -> 35 %.
Whatever the speed, the aspect of the response is similar. The levels appear here as clearly as they did when recorded on the sheet-fed press.

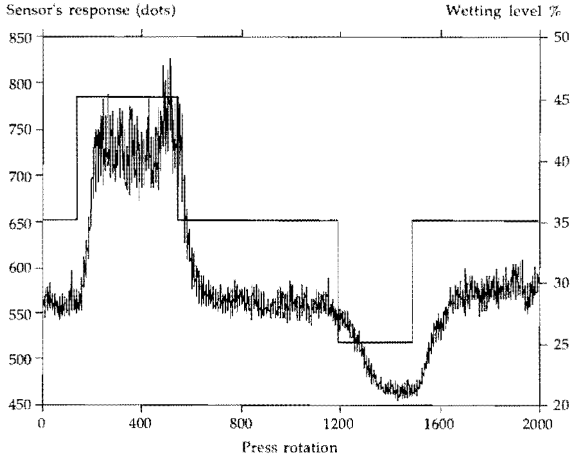

Figure 8 : variation of wetting level, 25000 rph

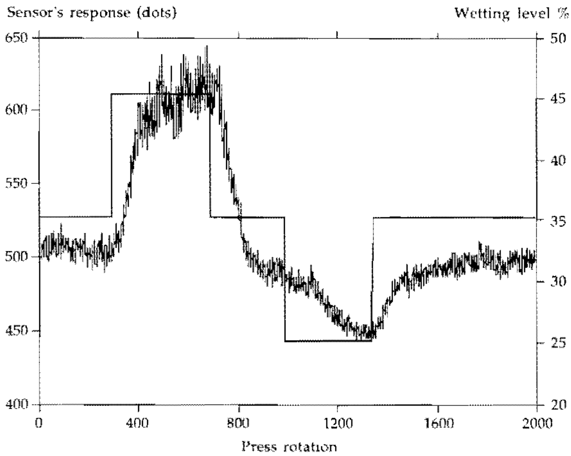

Figure 9 : variation of wetting level, 35000 rph

The mean level is smaller (500 dots) for 35000 rph, regarding to 25000 rph (550 dots). At low wetting level, the signal is quietly the same for the two speeds (460 et 450 dots) (also on figure 2).
So the dynamic decreases with the wetting level; it confirms the benefit of having a gain and offset remotely controlled for the output sensor's signal.

2-6 - Variation in inking at constant speed and wetting

In figure 10, the results are presented for an increase of 50% in inking, starting at the optimum value for three printing speeds (constant wetting level = 35%). The results are identical, whatever the paper used.
With a view of automatic control, it is always simpler to have available a measure coupled with only one input, in other words, to be in the case of mono-variability. Our 10% coverage pattern target presents the best noise-sensivity for variations of the wetting input to adjust, and is also as we hereby demonstrate, barely sensitive to inking with regard to this measure.
In figure 10, verification has been made to show that for an increase of 50% in the opening of ink ducts, which is an excessive value that leads to total disturbance of printing quality, the measure of our sensor is hardly influenced by this variation, whatever the printing speed of the press. The increase in inking level produces a slight decrease in the signal, that is to say, the same effects as a decrease in wetting for 25000 and 35000 rph; here, there is a change in the ink-water emulsion balance, which is constituted with a smaller percentage of water solution. For 15000 rph, we attain over-wetting; the supply of extra ink has no effect on the signal.

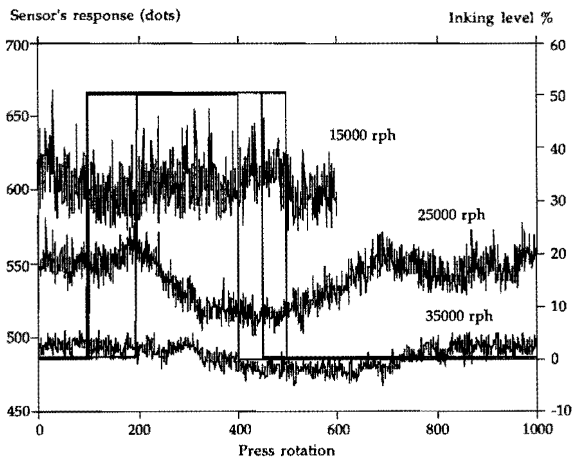

Figure 10 : variation of inking level

2-7 - Variation in speed at constant wetting and inking.

This test was carried out to confirm the previously obtained results, namely, at constant wetting, the more speed decreases and the greater the amount of wetting solution present on the plate, the more the signal measured increases.

In the curve in Figure 11, it can be noted that the direction of the measured signal is correct for the transition from 35000 to 25000 and vice versa, but the phenomenon is reversed for the transition from 25000 to 15000 rph.

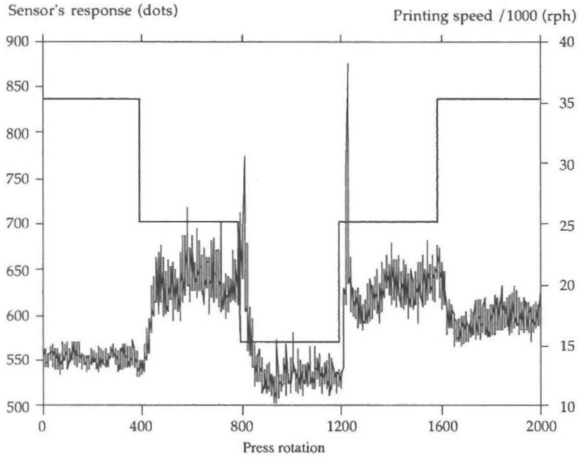

Figure 11 : variation of printing speed
wetting level at 40%

The curve presented in Figure 12 is a close-up of Figure 11 at the time of this transition.

It can be observed in A that the signal seems at first to develop toward a correct level then falls back to a stable level below the one recorded for the speed of 25000 rph. An identical phenomenon is observed in B at the moment of transition from 15000 to 25000 rph.

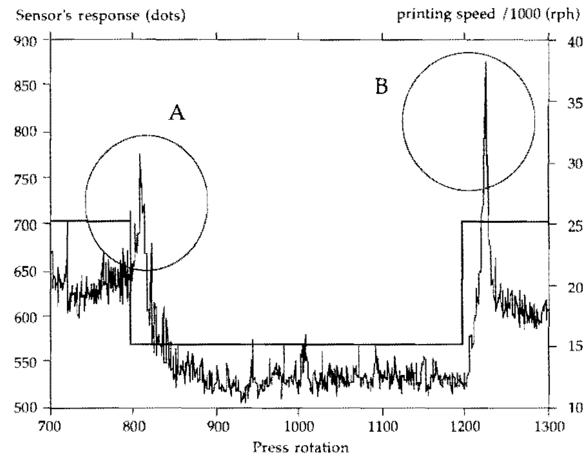

Figure 12 : 250000 rph to 15000 rph

To explain the origin of this problem, other experiments were led applying speed variations using levels of lesser amplitude(Figure 13).

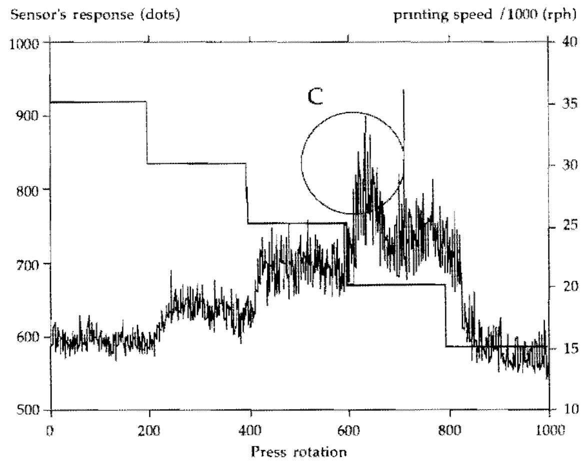

Figure 13 : variation of printing speed

The tendency is hereby confirmed and the problem does appear during the transition from 20000 to 15000 rph. It is also noted that at point C, a phenomenon of lesser amplitude but identical to A in Figure 12 takes place.

The wetting circuit of this machine is given in Figure 14.

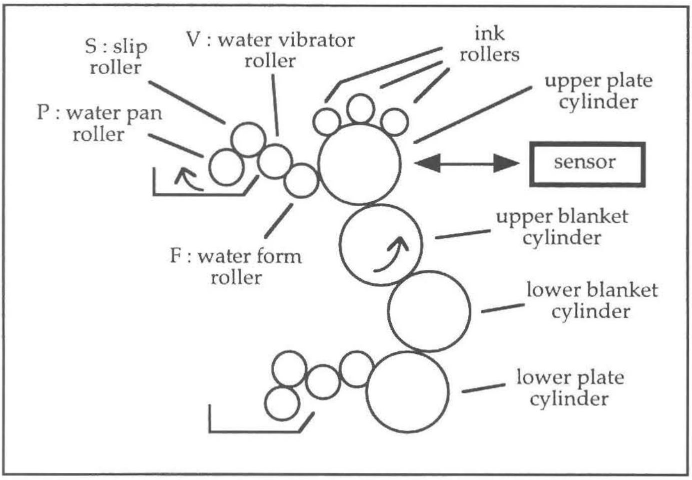

Figure 14 : dampener

This circuit is composed of four rollers which are brought into rotation as follows :

- wetting control pilots the speed of the motor of the wetting section; it pilots water pan roller P which sets slip roller S into motion
- water vibrator roller V is linked by gearing to the main motor of the press, it sets water form roller F into motion by friction.

Four our experimental conditions, the 40 % level is equivalent to a rotation speed of 10000 rph of water pan roller P. The rotation speed of V is two times the rotation speed of the plate cylinder.
The sliding between S and V occur with a minimum ratio of 1:3 for the 15000 rph printing speed.
Another experiment is presented in Figure 15, where speed variations of the same order are effected for a different wetting level (30 %, that is, a speed for water pan roller P of 7000 rph). This reversal of direction of variation of the measure signal no longer appears.

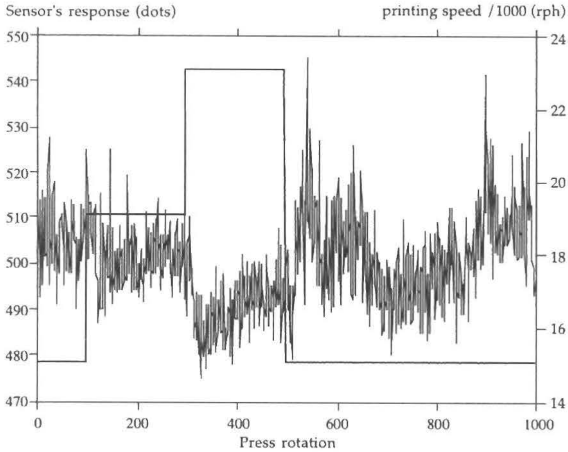

Figure 15 : variation of printing speed
wetting level at 30%

In this case, the sliding between S and V occur with a minimum ratio of 1:5 for the 15000 rph printing speed.
Comparing with figure 14, the water film sharing between S and V always turn in favor of V.
We can say that the water transfer is always effective from the pan roller to the plate.
For the wetting level at 40%, the minimum sliding S:V (at 15000 rph) reach a value that makes the quantity of wetting solution coming back to the pan that can't be neglected.
For us, it has the same effect that a diminution of the wetting level.
The transitions A et B figure 12 show how this phonomenom appears and disappears.
With the support of different studies [3], it is also greatly probable that other phenomenom occurs, like water surface generation on the ink rollers, at the high wetting level used for the experiment presented figure 11.

This experiment was carried out with anormal settings on the press.
Normally, the conductor adjust the wetting level while printing speed varied, to avoid over-wetting.
However, it is very important for us to consider these types of setting, and each time to put forward correct explanations, to perform a good adjustment of this printing process.

A similar phenomenom was observed on the sheet-fed press of EFPG.

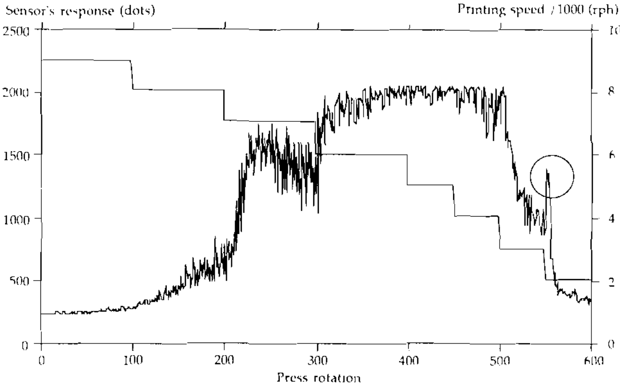

Figure 16 : 9000 rph to 2000 rph
sheet fed press, wetting level at 50%

For a black ink, a 10% coverage target and a 80 g/m2 offset paper, the same phenomenom appears for the two wetting levels 50% (figure 16 : saturation for the signal at 2048 dots) and 30 % (figure 17).
The direction of the measured signal is reversed on figure 16 for 3000 rph. For this speed, the sliding between the two rollers of the wetting circuit (identical to figure 14) is about 1:1 (7100 rph for S and 7500 rph for V). In figure 17, the rotation speed of S is 4100 rph and the minimum speed of V is 5000 rph. In both cases, for the printing speed of 2000 rph (0,4 m/s), evaporation of the wetting solution can't be neglected.

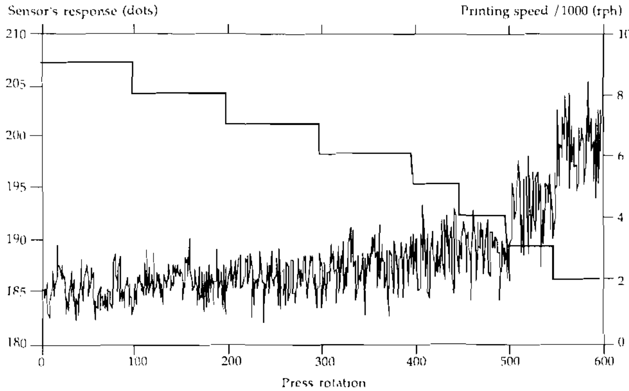

Figure 17 : 9000 rph to 2000 rph
sheet fed press, wetting level at 30%

2-8 - Paper's influence

All of the experiments described in this article were led using two types of paper :
paper 1 - super calendered grade B, and
paper 2 - coated 89 g/m^2.
The difference in the settings for printing on these papers is situated at the general wetting level : slightly higher for paper 2 (15 % general wetting instead of 13 % for paper 1).
With wetting level follows a sequence of variations as describe in paragraph 2-5, we don't note any significant differences between these two paper's for the recorded signal.

We simply note two phenomenons :

- for the two papers, time constants are higher when we decrease the wetting level.
Though similar results can be found in others studies [4], we don't trust this result because of the machine wetting control system (paragraph 2-3).
- time constants for paper 2 are hardly higher than paper 1.

This type of experiment was previously performed on the sheet-fed press at the EFPG (6000 rph), for the case of 80 g/m^2 offset paper as well as for 115 g/m^2 gloss-coated paper. It led to dynamic differences that we can see figure 18.

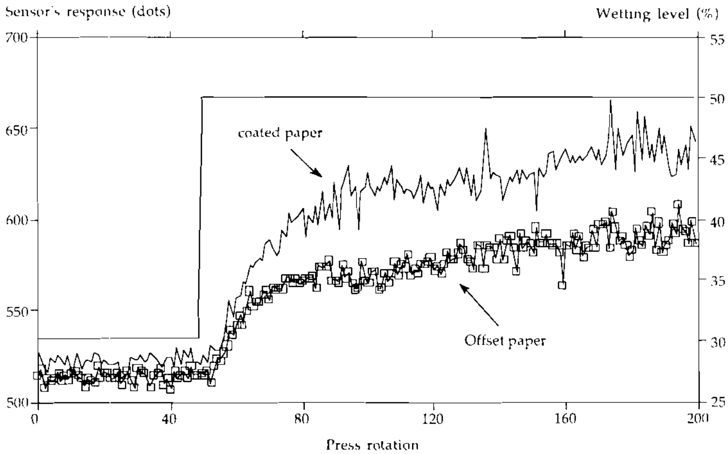

Figure 18 : sheet fed press at 6000 rph
paper's influence

When we set the press to over-wetting, the difference can be explained by the differences of the properties of the two types of papers, according to their absorption rate of the wetting solution. (test with the Bristow's wheel at 0,1 m/s, {offset - gloss-coated} and {super calendered - coated}).
The uncoated paper directly absorbs the excess wetting solution transferred from the plate to the blanket at each machine rotation.
We reach a new balance more quickly, and less water stays on the plate.
Not so much water is absorbed by the gloss-coated paper. A new balance is reached more slowly and more water stays on the plate.

4 - Quality - Wetting indicator

Our end goal is to guarantee constant printing quality through wetting adjustment. With this goal in mind, we tried to find out what simple measure would be good evidence of quality variation in relation to wetting. We, therefore, went about a test on our sheet-fed press during which the wetting level was varied by stages of 5 % while a simultaneous densitometric reading on screens at different coverage pattern percentages was carried out. The result of this test for a 115 g/m^2 gloss-coated paper, black ink and a speed of 4000 rotations per hour (variation of wetting every 15 rotations) is given in Figure 19
For this machine, the rotation speed of the water pan roller varies on a linear basis from 5500 to 1000 rph for a wetting level going from 40% to 10%.

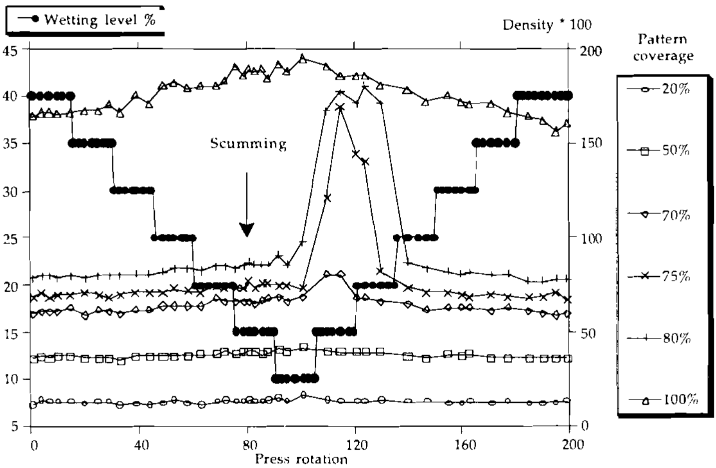

Figure 19 : density as a function of wetting level, sheet-fed press, 4000 rph

The first traces of scumming appear here starting at 80 rotations for a wetting level situated between 20 % and 15 %. No water mark is found on the solid in what concerns the high wetting levels.

The screen at 100 % coverage pattern clearly seems to be the one presenting the greatest sensitivity and, especially, the one on which significant variations appear before the low quality zone is reached. This is not the case for screens with a lower percentage rate of coverage pattern where the variations only appear when the printing quality has become very low (scumming traces).

These results were confirmed during the tests on the web offset press at the ICGQ where, during some tests, a densitometric reading was effected for different wetting levels.
In the case of paper 1 at a printing speed of 20000 rph, we obtain

wetting 25 % -> density = 1.35
wetting 35 % -> density = 1.23
wetting 45 % -> density = 0.91

5 - Conclusion

Our main goal was to show that our sensor will make it possible to adjust automatically the wetting level of web offset presses, for a quality control of offset printing. This has been achieved.
Indeed, we noticed that :
- around the normal setting for the wetting level, the sensitivity of the recorded responses, whether for printing conditions in industry or for laboratory tests, is totally satisfactory (web offset press or sheet-fed press)
- the choice of a 10 % target measure which can be separated from inking, delivers information with dynamics sufficient for adjustment
- the response of the sensor can be linked to a simple quality index, that is, the density of a solid.

Moreover, all the tests have shown that not only is our sensor an instrument of automatic control for the offset process, but it can also be helpful for the adjustment of the machines and a valued research tool for enhancing the knowledge we have of this printing process, as well.

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