DESIGN AND PERFORMANCE OF AN INDUSTRIAL TRANSDUCER FOR THE OFFSET PRINTING PROCESS

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Abstract :

Recent work in our laboratory has demonstrated the relevance of developing an opto-electronic sensor for controlling inking and wetting in an web press. We have subsequently modified this sensor to comply with specifications defined by the constraints of the intended industrial environment.

Miniaturisation, operational reliability, flexibility and modular construction were the principal concerns in this development. The result takes the form of a miniaturised "measurement head" that combines the pulsed light generator (diode laser), optical measurement, synchronous detection, digitalisation, and industrial standard numerical interface. Each of the small heads or units can easily be mounted on modern printing machines (which are themselves very compact) without risk of interference by parasitic light, electrical noise or mechanical vibrations, thus providing a reliable measurement up to the running speeds of today's machines (15 m/s). Each unit is connected by a numerical bus to the central processor. In this way the assembly can be adapted to the very large variety of machine configurations that are to be controlled.

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Historical account

We have previously demonstrated in our laboratory that an optical sensor can quantify the quality of offset printing by measurement on the printing **plate** [Balducci, 1991a ; Catusse 1993]. This work, which was based on optical theory and on phenomenological models appropriate to this printing process, formed the basis for the design of a sensor [Balducci, 1991b].

A laboratory model was therefore designed to make the first validation trials for the system. At this stage, our principal aim was to obtain numerical recordings that could demonstrate the real usefulness of the sensor and, after numerical analysis of the results, study the feasibility of a control loop for the wetting. The results were encouraging and two objectives emerged : to transform the sensor from its laboratory prototype into an industrial form (if necessary in several stages), and at the same time to improve understanding and analysis of the results. For a university laboratory this task is unusual and uncertain in its outcome, but very rewarding in many respects. The main lines of this approach are described below.

Basic concept

The laser beam strikes the rotating plate cylinder perpendicularly. The reflected light signals are focused by a lens, and a photosensitive detector is placed in its focal plane [Balducci, 1991a]. The mechanical and optical arrangement are displayed in Figure 1.

To understand the origin of the constraints, which will be stated later, some of the main characteristics of the laboratory prototype are listed below :

Light source	Size	Lens	Cell
HeNe laser 633 nm	diam. 45mm	diam. 50mm	34x34 mm
7mW continuous	L 470 mm	focal length 150 mm	

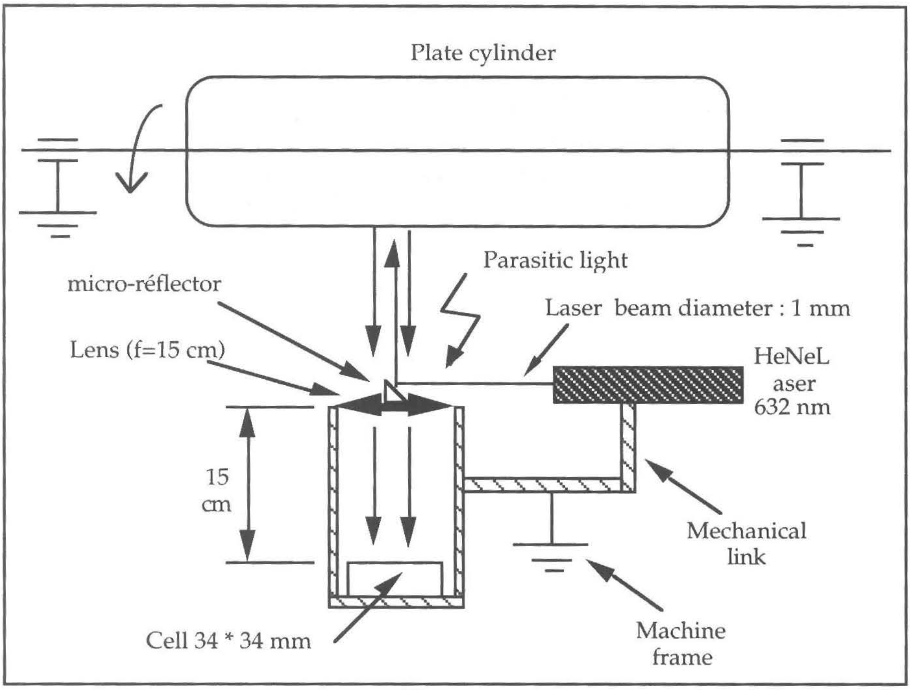

Figure 1

Modifications to the laboratory prototype

a) Reliability of the measurements: modulation of the light signal

We first studied the reliability of the measurements from our system, beginning from the light source and analysing the parasitic noise. The measurement is made in the open, i.e. it contains a useful part corresponding to the measured quantity, and an unwanted part mainly consisting of the ambient light (see Figure 1 : parasitic light), which in the vicinity of an offset press can be worse than an ordinary fluorescent light (for example stroboscopic lighting).

Two main techniques can be used to avoid this difficulty. First, a dichroic filter can be used that transmits light of only one wavelength, that of the laser. It is also possible to modulate the light signal from the source and then use synchronous detection at the receiver. This second technique was chosen, as it is more reliable and efficient in terms of signal to noise ratio. We therefore changed to a diode laser, whose beam is easy to pulse,and which, for the same power, is seven times smaller than the HeNe laser arrangement.

An analysis of the signals that are present is now in order :

- the useful signal is that generated by the passage of a target placed on the offset plate, and whose size (to simplify the calculation) is 1.5 cm. Assuming that variations of 1.5 mm can be resolved in this aim **pattern**, and given that the running speed of the rotary printing machines is about 15 m/s, we obtain a band-pass of about 10 kHz.

- the spectrum of the optical noise extends from d.c. to about 200 kHz, if we include flashes coming from control systems of other peripheral devices found on rotating printing machines (corresponding to a typical flash pulse length of 5μs). It was therefore decided to modulate at 230 kHz. The spectral response is shown in Figure 2.

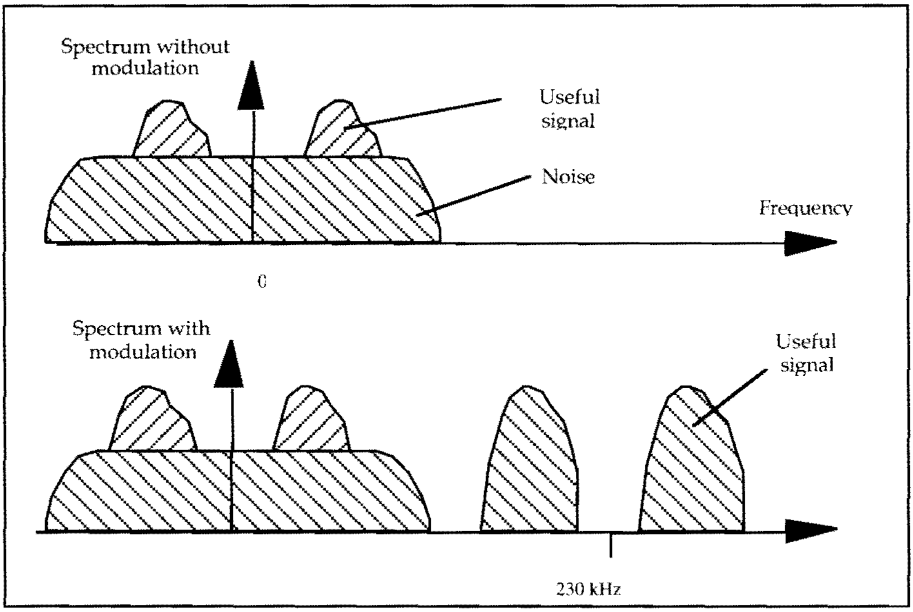

Figure 2

b) Triggering

The detection system and analogue treatment (Figure 3 : filtering, detection, anti-aliasing) has been the subject of a detailed investigation that will not be described here. The size of the detector cell was reduced to minimise the contribution from scattering, but also to improve the response and to investigate the influence of this size on the system.

At each rotation of the **plate cylinder** the measurement had to be made only at the position where the test aim **pattern** was placed. The measurement was thus triggered (its localisation at each rotation) by a coder the zero point of which could be adjusted electrically. A general view of this technical description is found in the synopsis of the complete measurement shown in Figure 3.

Some of the salient properties of our new system are summarised below.

Light source	Size	Lens	Cell
diode laser 670 nm	diam. 25mm	diam. 50mm	1.1x1.1 mm
7mW pulsed	L 145 mm	focal length 150 mm	

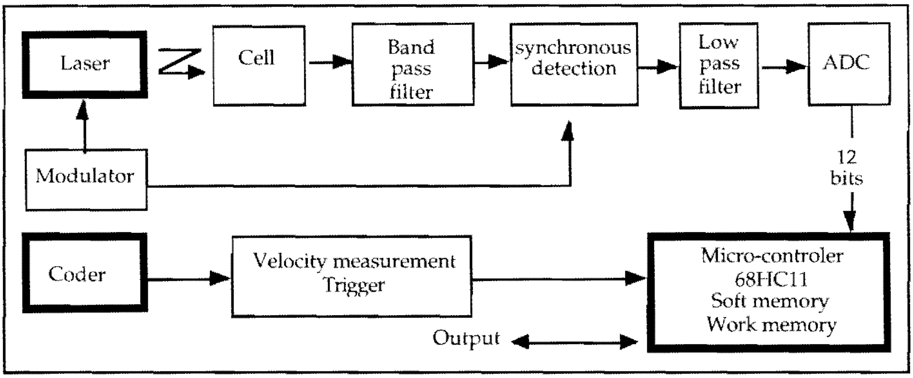

Figure 3

c) Validation of the new laboratory sensor

A large number of tests were performed to validate this new configuration, not only in its basic functions (recording of measurements that vary with the wetting level of the press), but also investigating its insensitivity to optical parasites and mechanical vibrations (similar to optical noise) and the reproducibility of the measurements.

For those parameters that are more specifically related to printing, the bulk of the investigation effort was devoted to wetting. The tests were always carried out with the same sequence of variation in the amount of solution placed on the plate.

This was done for different printing configurations, such as for example the type of offset plate, target pattern, paper, ink colour, wetting solution and printing speed. Below (figure 4) are given typical response curves for a plate (GP60), a aim pattern (10% coverage), a speed of 4000 r/h and 4 different colours of ink (trails made on a sheet machine - Note : gain is not constant for all colours).

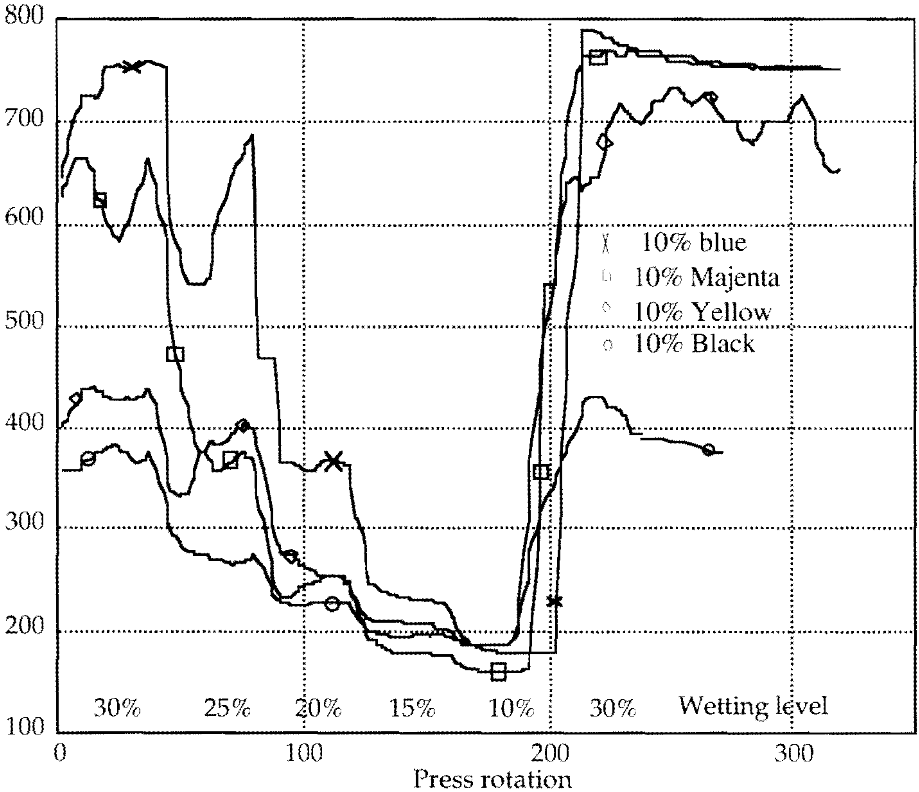

Figure 4

As well figure 5 gives typical response curves for a plate (GP60), a aim pattern (10% coverage), a speed of 6000 r/h, 2 different colours of ink, and a more filtration applied to the signal (Note : gain is constant for all colours).

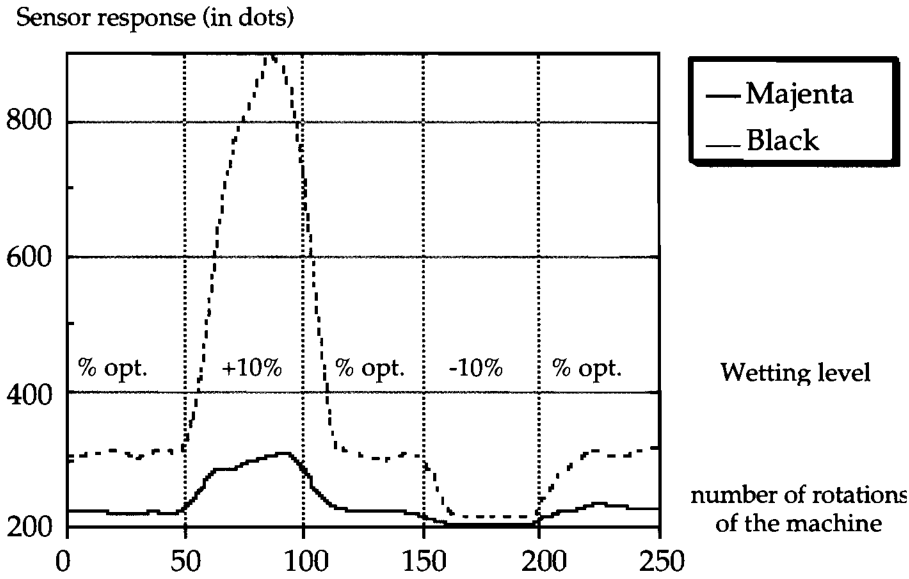

Figure 5

Industrial Sensor

Our system is now much more efficient than before, but it is not yet at a stage of industrial application. The previous stage, which involved analysis of the industrial context for the sensor and contacts that we established with our industrial partners, has brought out the following points.

The sensor system must be completely modular. The device can be divided into several parts (Figure 6) :

1- The part described above comprising light generation, optics, analogue treatment, digitalisation and serialising the useful signal, which together form the "measuring head" (MH). The size of the MH, contained in a robust sealed box, is reduced to a minimum, since it has to be installed on very compact machines where the offset plate must be kept as accessible as possible. The numerical output from this first part is sufficiently robust not to be perturbed by the electrical environment (electromagnetic interference).

The series transmission format minimises the number of connections to the rest of the system, thereby reducing complexity and cost of connections. Each MH is constructed as shown in Figure 3 without the **trigger** and microcontrol units. For even greater reliability, a dichroic filter has been added at the detector cell. In this way parasitic light, which would inactivate the synchronous detection, cannot saturate the input cell. Programmable signal fitting has also been included, to allow normalisation.

The dynamic is thus automatically adjusted according to the printing configuration, which influences the absolute value of the measurement. The analogue to digital convertor (ADC) samples the signal continuously at 100 kHz. For a given rotary printing machine, the number of MHs is equal to the number of printing groups. Their number "i" can vary from one set-up to another.

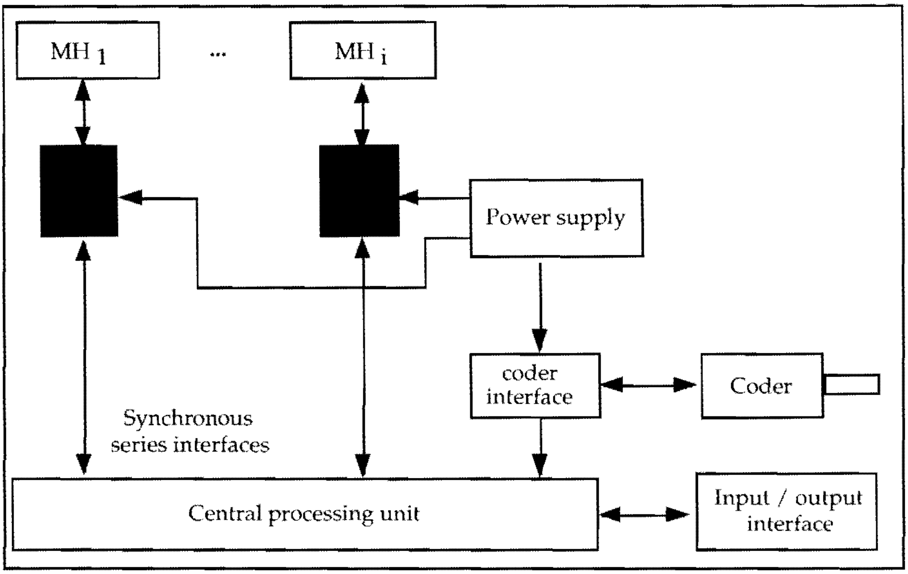

Figure 6

2 -For this reason the MHs are connected by a bus to the second part of the device composed of a central processing unit (CPU) which handles the data supplied by the MHs. From the data received (at a rate of 1.6 Mbit/s) and the signals coming from the coder, the CPU calculates the average of the measurements made on the target pattern for each rotation of the machine and for each printing group. This average is then used by part number 4.

3- The third part of the system consists of the **register** device for the measurement, i.e. the coder and its interface. This generates the signals for the CPU to use only the representative data from the target pattern on which the measurement is to be made. It is necessary to establish a setting for this part. This consists of advancing the offset plate cylinder to just before the zone where the test pattern is located (the visible laser beam makes this setting easy), and then, when the machine is stopped, simply pressing a button. The positioning of the target is then done automatically.

4- The last part, the input/output interface, is optional. This could be a simple digital indication of the measurement and thus of the printing quality, or else the interface for the wetting control loop.

Since this choice of configuration is modular and flexible (Figure 5), the system is reliable, robust and efficient and can easily adapt to the very large variety of machine configurations. As to the central processing unit, except for a specific part (connections, power supplies and coder interface), it is composed of standard industrial elements that are obtainable from several suppliers.

Perspectives

Constant printing quality can be ensured with this industrial sensor, provided the system is instructed which point of operation is to be regulated.

Current work is being directed towards automating the process (sensor, wetting). It is not impossible that these studies will help locate the point of optimum wetting, both in the absolute level and in the speed at which this point is reached.

The approach that we have followed in this project has consisted in transforming a research concept into an industrial application. It was encouraged by industrial partners each of whom contributed to its success through their speciality (precise knowledge of the process environment, integration of the sensor). Such a collaboration is a rich experience for a research laboratory.

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