THE DEVELOPMENT OF INKING AND DAMPENING CONTROL SYSTEMS FOR HEATSET-OFFSET PRESSES

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Abstract: A progress report is given on the development of an integrated inking control system for a heatset weboffset press. Under review is a control system using a multichannel on-press densitometer as a feedback signal- giving device and an offset plate scanner as feedforward signal-giving equipment. Inking and the ink/water-balance, later on, are controlled by means of the control system.

The results of the experiments with the closed loop inking controller are described in the paper. Developmental goals of the next controller generation are also discussed.

To preset the ink screws an offset plate scanner is preferred to a film scanner. Details of the construction of the plate scanner developed at the Technical Research Centre of Finland are given.

Automatic control of the water feed is also needed for an integrated control system. The existing measuring systems and the possibility of controlling dampening by the on-press densitometer are discussed and some results of the experiments are given.

1. INTRODUCTION

The lithographic offset printing method has high time and material waste figures. The solution here seems to be

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computerized control of the printing process. An integrated control system for an offset printing press has been plotted in Fig. 1. A lot of development work has been done at the Technical Research Centre of Finland to develop and construct system components for the control system. Progress reports of the development work have been given at earlier TAGA Conferences. This paper will then confine to the latest experiences with the closed loop control system for inking. Plans for further development of the control system are also discussed.

The aim of the forward control of inking is to adjust the ink screws before printing. For this purpose the zonal ink feed values have to be known. In newspaper printing the page film can be measured by a page-film scanner. Our previous efforts in this field have been reported in the ref. (1). For heatset presses or for sheet-fed presses this is, however, not the best concept. Scanning of large positive films with picture fixing tapes and masking shablons has many disturbing factors. For this reason we developed an offset plate scanner to measure directly from the printing plate the relative printing area corresponding to each ink

THE CONTROL SYSTEM OF AN OFFSET-PRINTING PRESS

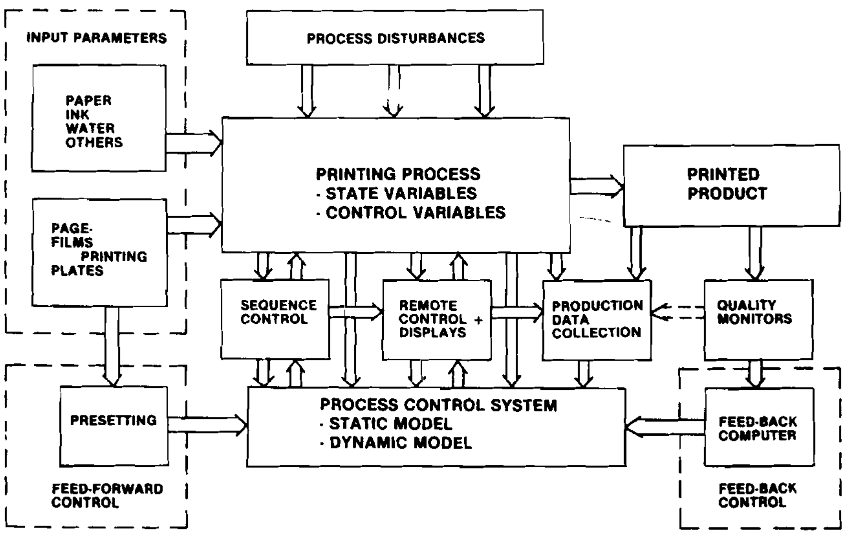

Figure 1. Block diagram of an integrated control system of a web-offset press.

screw and, then, to compute the presetting profile of the ink screws. The construction and functioning principles of the scanner are described in the paper.

For integrated, closed-loop control of the offset printing press, dampening control is also needed. A short review is given of the methods available for measuring water feed. Methods adaptable to productional conditions have been lacking. This is why we started research to develop combined control of inking and dampening. Our aim was to get the necessary feedback information for both controls by using the on-press densitometer. Test runs were made with the laboratory's single-unit WEPE-0 rotary offset press. We have been working to find out the effects of the variation of dampening on the quality of the print - especially as regards the contrast between compact and certain halftone areas. On the basis of the results we try to find mathematical relations for the dampening controller. Also, special test strips were developed for the tone control. The preliminary results of the test runs and our future plans in this field are discussed in the paper.

2. CLOSED LOOP INKING CONTROL

Design and development of the control system as per Fig. 1. has been reviewed at earlier TAGA conferences (2,3,4). The implemented controller and the underlying theory are described in the references (4) and (5). A diagram of the prototype system produced by the Technical Research Centre of Finland is given in Fig. 2. Since the last TAGA-report test trials have been carried out with the closed-loop controller. Different starts, the effects of the changes in water feed and the press speed changes were studied. In the following we shall give a few examples of the results.

Figure 3. illustrates a starting test with the controller. Printing was started with an even ink feed profile and at a duct roller speed producing a density that was clearly below the setting value given to the system. After about 500 revolutions the density profile was brought by the controller to a commercially acceptable level and after a thousand revolutions the density profile was within the tolerance limits of the controller.

Fig. 4. gives the results of a production run during which the water feed was varied. From revolution number

4833 up to 5400 the water feed was varied within the tolerance range of the ink-water balance. By means of the controller the density profile could be kept rather constant. When the water feed was reduced after this period, toning began to occur along the edge of the web. The results proved that such disturbances hamper the operation of the closed-loop control system.

Fig. 3. also shows that the changes in the press speed do not much affect the density of the print; the density profile and the average density level remain relatively constant.

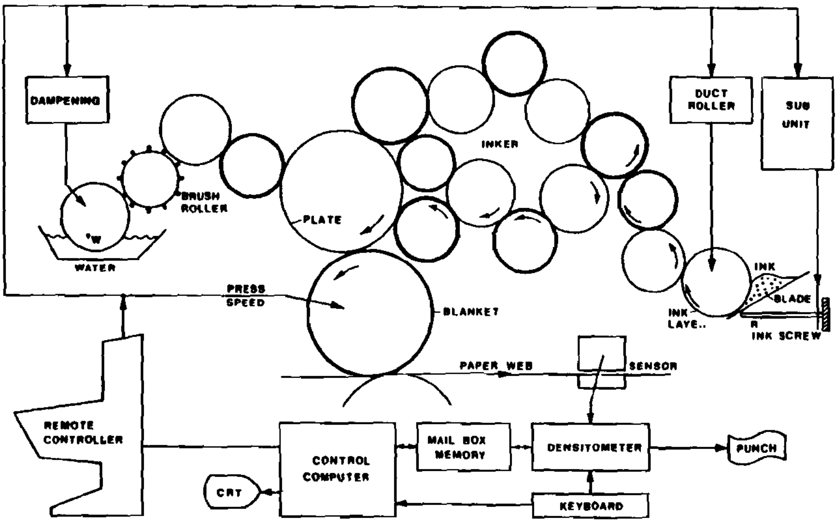

Figure 2. Diagram of the prototype closed-loop control system for inking.

The results will be used to improve the system still further: The gain of the controller should be adjustable according to the ink consumption in the zones of the ink screws. This means that an inker presetting system is needed to obtain in advance the ink feed values and, thus, the parameters for the closed-loop controller. In the present system the duct roller and the ink screws are controlled independently. Interaction between these two control modes should be provided to keep the screw positions close to the optimum level in all conditions. Production presses must be provided with the possibility of manual change of the setting values of the density in each screw zone. This is required for individual correction of the gray balance or the

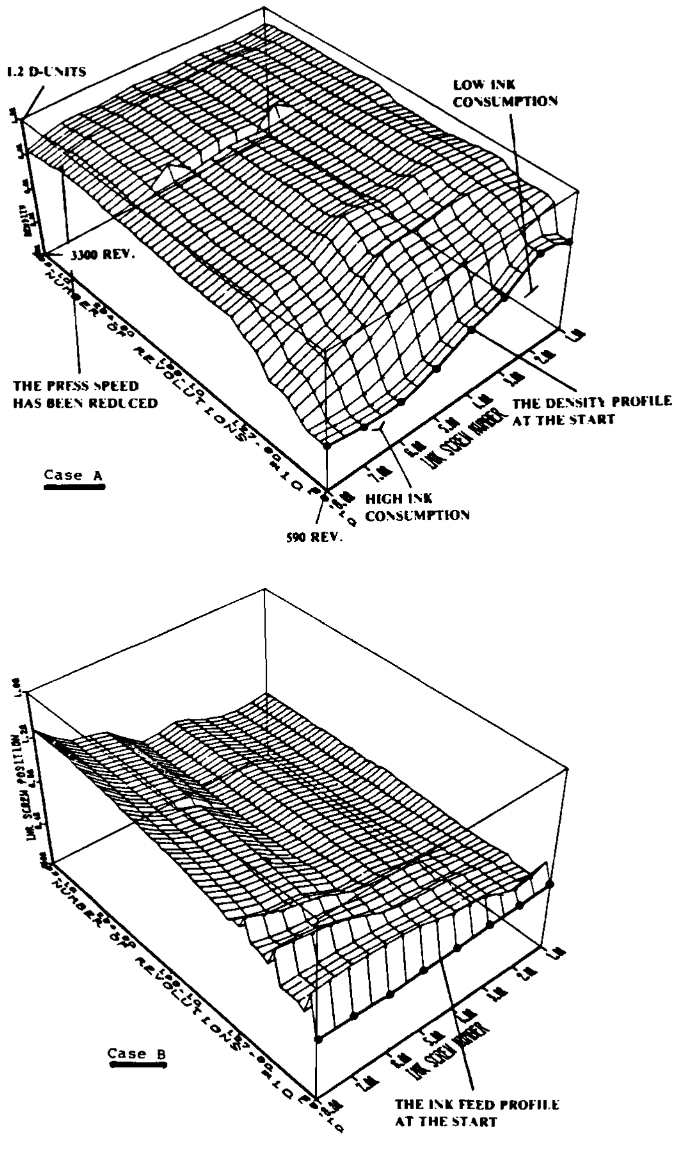

Figure 3. A perspective graph of a starting test under the closed-loop control of inking. Case a) Density profiles as a function of the number of revolutions printed. Case b) Ink screw positions as a function of the number of revolutions printed

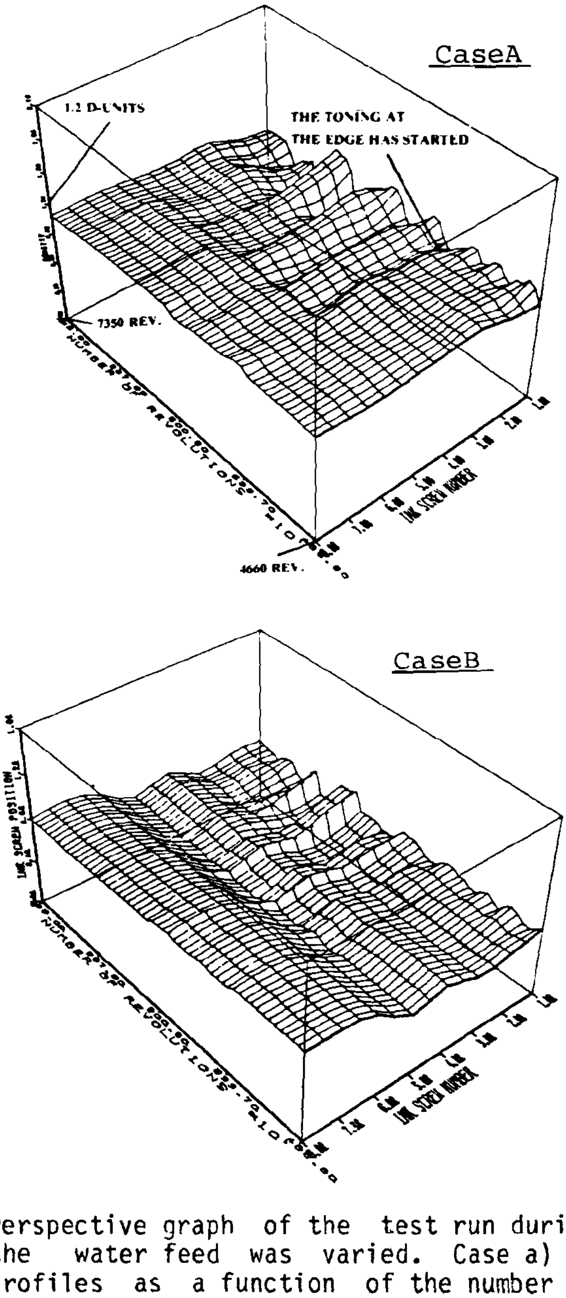

Figure 4. Perspective graph of the test run during which the water feed was varied. Case a) Density profiles as a function of the number of revolutions printed. Case b) Ink screw positions as a function of the number of revolutions printed.

tone rendering of the printed four-colour pictures. All the screws (about 30) across the web must be handled by the eight measuring heads of the densitometer.

This summer a new process computer will be taken into use and it will facilitate comletion of the new controller. Later on, the system will be complemented by a new control program for the ink/water-balance.

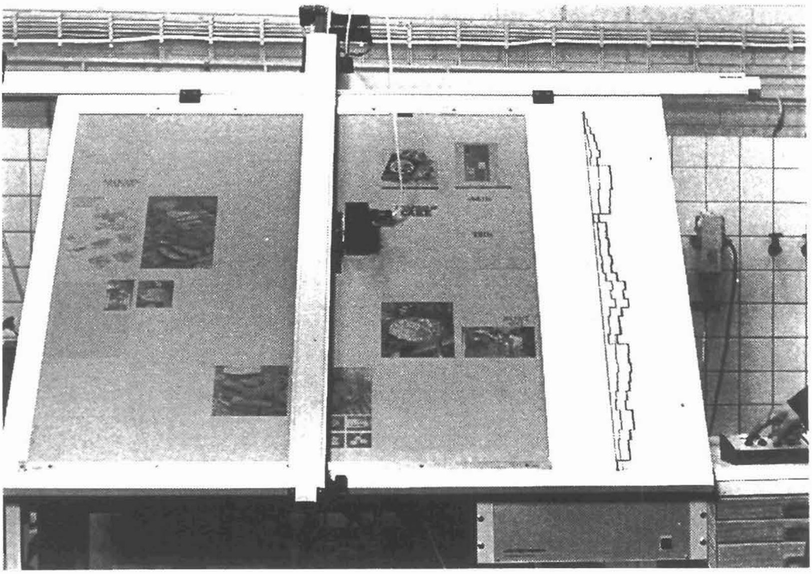

Figure 5. The OPS plate scanner.

3. OFFSET PLATE SCANNER

To take full advantage of the integrated inking control system, a feed-forward feature, i.e. presetting, ought to be included. As mentioned before, with a heatset offset or sheet-fed presses a plate scanner is preferred to a film scanner. The plate scanner measures the ink feed values from the lithographic printing plates.

Principle of operation

The new plate scanner consists of a measuring table, to which a plate and an output foil have been fastened, of a transport apparatus, a measuring head and a computing unit (Fig. 5.). The measuring head scans one zone after another for the ink screw zones on the plate. Based on the measuring results and the necessary information supplied by the user, the scanner automatically computes the ink screw position profile and outputs it to a transparent foil. The scaling of the output diagram on the foil corresponds to the scales of the ink feed displays. Thus, by hanging the foil in front of the ink screw position display on the control console the printer can set the ink screw positions to the right levels.

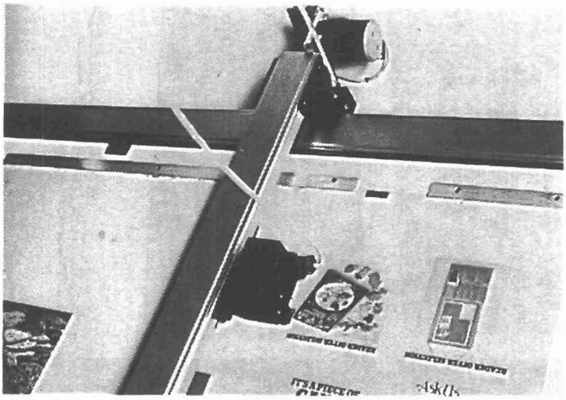

Figure 6. The measuring head and the calibration point of the plate scanner.

Scanning. The measuring head moves driven by a step motor. It is equipped with two kinds of optics. At the beginning of a measurement it moves onto the calibration test strip at the edge of the plate. Calibration and selection of suitable optics take place according to the plate type. Two kinds of plates, Al-plates and multi-metal offset plates, can be measured with the scanner (Fig. 6).

The measuring head then moves to scan the entire printing plate. Within each scanning zone measuring is carried out in 3-mm steps. The scanning of a 1050x1050 mm plate takes about three minutes. The movement of the measuring head can, when needed, be programmed for several plate sizes.

Computing unit. The microprocessor in the scanner is a MC 6809 type. Nonlinearity corrections (the position of the ink screw as a function of the relative proportion of the printing area) are programmed into the EPROM-memory of the OPS plate scanner.

The measured relative printing areas are automatically transferred to the ink profile diagrams of the press separately for each printing unit. The user only needs to give the ordinal number of the printing unit with the thumb wheel. The control program also sees to it that the difference between the adjoining ink screw positions does not cause too much bending of the ductor blade.

Output. Output is performed with the same step motor-steered measuring head, now equipped with a felt pen. The plotter outputs an ink profile on a foil fastened on to the table (Fig. 7). As described above, the foil can then be removed on the ink screw display unit of the control console.

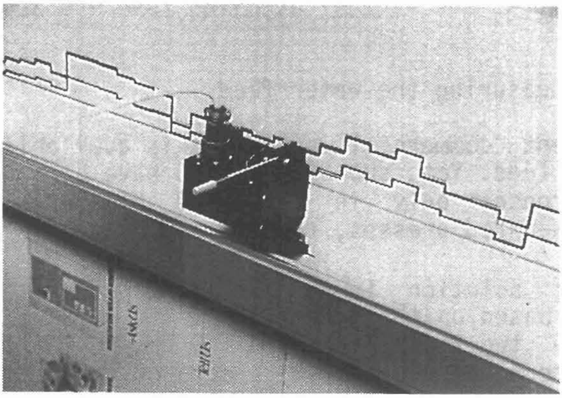

Figure 7. Output of an ink profile on a foil.

The output can also be fed into the process computer of the control system by a standard serial on-line connection. The process computer then automatically makes the adjustments of the ink feed.

If needed, the scanner also outputs the relative printing areas without the correction functions.

The prototype plate scanner is already used in productional tests and the experiences will be reported in the near future (6). So far the results have been more than promising. We would, however, like to emphasize the importance of the reliability and accuracy of the calibration of the remote control actuators, sensors and displays of the ink screws. They primarily determine the accuracy of the presetting procedure.

4. CONTROL OF THE DAMPENING PROCESS

There are two main methods for controlling the dampening process in an offset press. One is to measure the process state variables, such as the water amount on the rollers or on the plate, to get the information of the variations in dampening. The other is to get the necessary information from the output variables of the printing by measuring certain print variables such as the densities of the solid and tone areas. These measurements allow to define the variations in tone rendering, proportional to the ink/water-balance. The variation gives the feedback information for the control of water feed and ink feed.

Measuring the water feed

At present commercial equipment is available to measure the water feed. Yet, such facilities have been used for research purposes only in sheet-fed presses, and to some extent in web-fed presses, too.

The best solution in regard to detector technology is measuring based on the detection of the infrared absorption (7,8). The two light beams, in the proper infrared region, are directed to the non-image area of the printing plate. The wavelength of the first beam has been selected to give a high absorption in water and the slightly different wavelength of the second beam has been chosen to give as low an absorbtion as possible. The latter is used as a reference for the measuring. These instruments are available in the Federal Republic of Germany and Great Britain. The construction of the measuring head is relatively complicated and the price is rather high.

Another extensively studied method for measuring the water amounts on the printing plate is based on the detection of gloss variations on the plate surface (7,9). Gloss variations in the non-image area of the printing plate, which are proportional to the thickness of the water layer on the plate, are detected. Detectors can be constructed at a low cost because of the easy and sensitive detection. The weakness of the concept lies in the instability of calibration resulting from the wear of the plate surface structure during printing, which then causes changes in the gloss properties.

The third method is to measure the so called wet-tack of the printing ink on an inker roller (10). This measurement gives a signal proportional to the water feed. The wet-tack, however, depends on many other variables besides the water feed, and therefore calibration to control the water feed is hardly possible.

Tone rendering and the ink/water balance in offset printing

In offset printing tone rendering of the prints mainly depends on the water feed, the ink feed and the ink/water-balance, when the temperature of the inker is kept constant. As we know, the water feed has a tolerance range that depends on the printing conditions and materials used. Within the tolerance range there is a water feed rate, which together with the proper ink feed, gives the optimum print quality. Usually the NCI-method is used as a criterion to judge a good print quality. The largest contrast between a dark halftone (65-75%) and the solid areas is the optimum. This means that the dot gain of the dark tones is not too strong. When the water feed is increased a little too much, snowflake patterns and speckles begin to appear in the halftone dots and solids. At the same time the density of these areas decreases. Water marking appears at the upper limit of the tolerance range. It is caused by the excess water that the ink cannot emulsify. Also, the density of the print continues to decrease. If the water feed is reduced below the optimum rate, patterns of small ink grains or speckles begin to appear in the non-printing areas of the image, shadow dots gradually begin to fill in and the density increases in these areas. Tinting begins to appear at the lower limit of the range. The water amount is too low, the dark halftone areas start filling in and some ink is transferred to the non-printing areas, too (11).

Studies of the ink/water balance

Following the above tone rendering theory we decided to investigate whether we might find a mathematical relation between the dot gain and the ink/ water balance. Two test runs were made with the laboratory's web-offset press during which the water feed was varied from excess water to obvious lack of water. The closed-loop control of inking was used during the first run, the second run was performed under manual control. At the beginning of the run water feed and ink feed were adjusted to their optimum levels: the ink feed on the NCI-level and the water feed on the empirically correct level. The speed of the press was kept constant, at 10 000 r/h. The paper used was a SC-newsprint grade. Solid areas and different halftone areas were used in the test image on the plate. The densities of these test strips were measured by the 8-channel on-press densitometer. The thickness of the water layer on the plate was measured on the IR-absorbance principle (Infragauge, manufactured by Infrared Engineering Ltd.). The amounts of water and ink transferred onto the paper were measured by tracers and a neutron activation analysis. This was performed out in cooperation with the reactor laboratory of the Technical Research Centre.

Results

Fig. 8. shows the variations of the densities on two channels with varying ink requirements as a function of the water feed variations during the manually controlled run. The computed contrast values are also listed. The results show that the density contrast value has an acceptable level in a wide range of water feed. The scope of the range dependens on the ink requirement of the printed surface. It seems to be smaller when the ink requirement grows. The value of the water feed giving the best print contrast appears to be close to the tinting limit. When the water feed is reduced below this value the contrast decreases very rapidly.

Following conclusions can be drawn from the results presented in Figure 8.:

When the water feed grows too high, the densities of the halftone and solid areas decrease. If the amount of excess water is small, the density of the halftone area can remain constant. Usually the density of the solid decreases more rapidly; also the contrast value (absolute and relative) decreases.

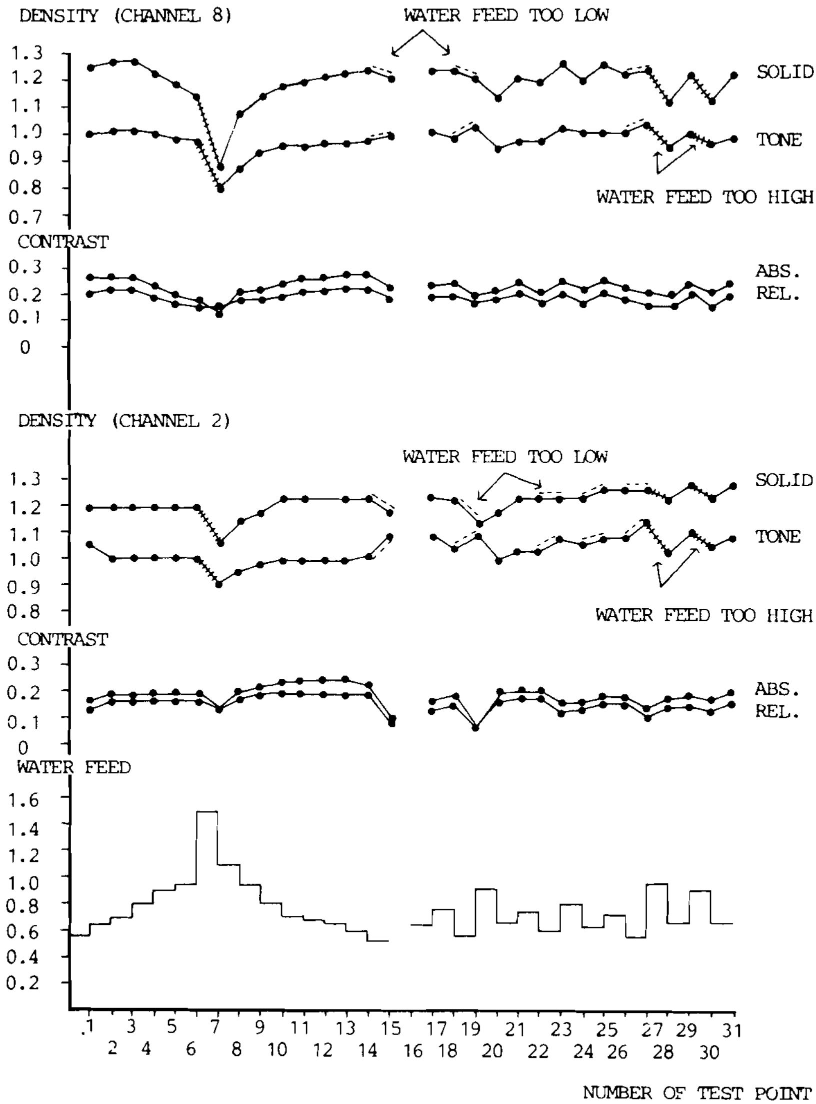

Figure 8. Diagram of the water feed changes made during the manually controlled test run. Solid and halftone densities measured at each test point on channels 2 and 8 and contrast values computed from these are seen in the diagram.

When the water feed is correct, the densities of the solid and halftone areas return to normal.

When the water feed decreases too much, the density of the halftone area grows, whereas the density of the solid area decreases or remains constant. The contrast decreases rapidly.

Print gloss was measured, too. The results showed that no significant correlation with the water feed could be found on rather rough paper.

During the tests the water feed was reduced to such an extent that tinting began to appear. As shown in Fig. 9 it took rather long before it disappeared totally. Maximum contrast values of the tests were lower at the end of a long run. Slow changes, during the trials in the structure of the ink/water emulsion in the inker probably explain the trend.

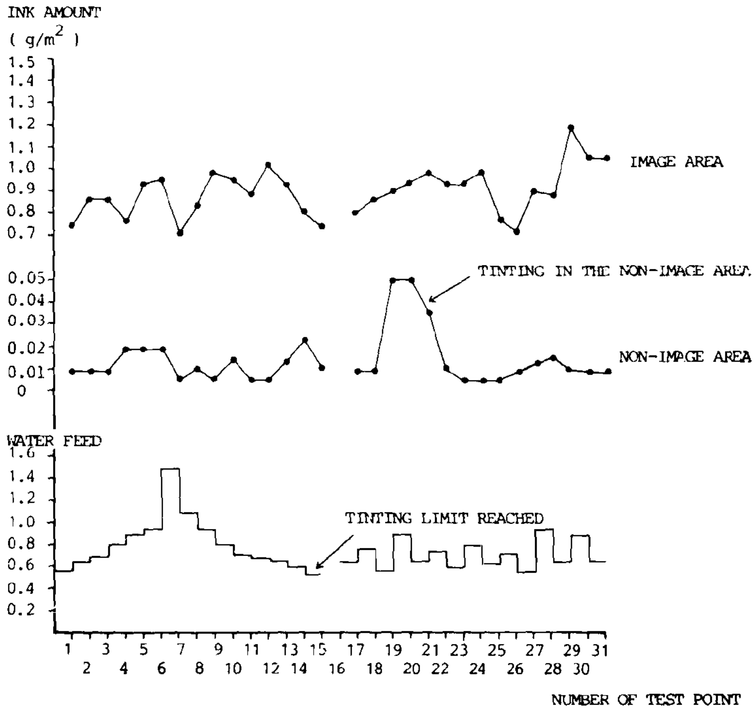

Figure 9. The amount of ink transferred to the printing and non-printing areas of the print during the manually controlled run.

According to the results obtained it seems possible to find a mathematical relation between the dot gain and the water feed. Our next step is to continue processing the information obtained by using mathematical computation methods. New test strips will be developed for water feed control and further test trials will be carried out. The behaviour of the print quality under closed-loop control of inking will then be examined in particular.

5 CONCLUSIONS

Because of the high waste level and the expensive paper grades typical of heatset offset printing the control of inking cannot be realized satisfactorily by means of the closed-loop control only. Adaptation of the feedforward feature, i.e. the presetting of the ink screws, makes it possible to further reduce the waste figures at the starting period of the printing. It also permits to optimize the control parameters of the closed-loop controller making it react faster to the effects of the disturbances.

Adoption of the plate scanner for presetting seems to give satisfactory results as well. The on-line connection is recommended for optimum performance. It allows to take into account the disturbances and inaccuracies of the remote control system.

Control of the ink/water-balance is an essential part of the integrated control system of a heatset offset press. We started experimenting with a difficult paper grade, the rough SC-paper. The results so far have been promising, but with coated paper grades we expect to find still more evident interactions between tone rendering and the ink/water-balance.

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