DEVELOPMENT OF THE TOTAL AUTOMATION SYSTEM FOR PRINT DENSITY AND COLOUR REGISTERS

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Abstract

In the paper a description and experiences of the use of a new computerized automation system for heat-set offset presses are given.

The system, called PRINTA, has been developed by a Finnish firm Altim Control Oy in cooperation with the Technical Research Centre of Finland (VTT). The new control and monitoring system includes adaptive presetting according to a plate-scanner, press-running sequences, closed loop control of inking as well colour as folder registers, remote control by means of keybords and colour-video terminals with a finger-point display and production-reporting system. The system is easily configured for the needs of a particular printing house. Two of the systems have been delivered for production printing. The sensors for the closed loop control of the inking and register together with the control-theory background for printing press control have been based on the research work at VTT. The results of this reseach have been reported in several earlier TAGA-meetings.

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1. Background

Many efforts have been made to solve the problem of automatic control of the inking in the heatset offset printing. Non of the suggested solutions has proved succesfull in the production environment as yet. The newest control technology on decentralized computer technology has given a new approach to the control systems to solve difficult and complex control problems.

The closed-loop control of inking in a heatset offset press presented in the paper has been based on the computer control system mentioned above. The suggested integrated control system is taking advantage of a presetting control system and uses the information given by the plate scanner on the ink demand for the various zones of ink screws. For an effective production the presetting system itself has to be efficient enough to avoid the problems caused by the malfunctions of the actuators or their position sensors.

The control of inking alone is not the total solution. Very important quality variables in rotary printing are the variations of the colour register in both directions and the registers in the folder. These controls have been included in the total control system described in the paper. This makes it possible to account for the effect of the interactions of the two control variables.

The results with the pilot system for closed-loop control of inking in web offset have been reported in the earlier TAGA Conferences /1,2,3/. This paper reports the development of sensors and control programs included in a commercially available computer control system for printing presses. The development included the construction of the necessary software as well as the hardware.

The problems were solved by intensive cooperation between the parties:

R&D institute	(innovations, technologies)
Systems manufacturer	(control systems technology)
Press manufacturer	(machine technology)
Printer	(production technologies)

Involved in the development cooperation were the Technical Research Centre's (VTT) Graphic Arts and Instrument Laboratories, and Altim Control Ltd, a Finnish automation manufacturer with more than 400 employees and an annual turnover of about 25 million $. Altim developed a new automation system for process industry called Alcont, which has been installed for different kinds of processes, such as power mills, pulp mills, coating machines etc., in Europe and the USA. We had the opportunity to cooperate with Altim to develop the version for printing presses. Our job was to define the process and control variables to be connected to the system (including the actuators needed to control them) and the most important interactions and effects of the various variables, and to describe the functioning of the user (printer) interface best suited for the practical working concepts in newspaper printing. The first PRINTA system was installed in the KoeBau Commander newspaper press at the Savon Sanomat. The press manufacturer, too, played an important part in this operation.

PRINTA AUTOMATION SYSTEM

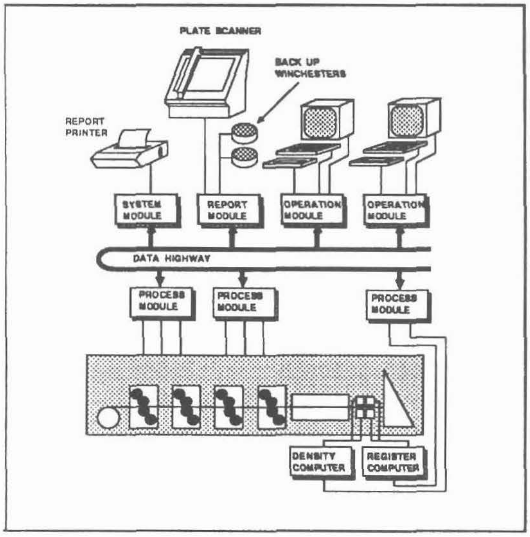


Figure 1. The control system PRINTA with closed-loop controls of print density and colour registers.

When constructing the closed-loop control systems we worked, besides Altim, in close association with the printing house Kunnallispaino, which also installed the first systems developed for heatset presses.

2. PRINTA, the printing press control system

Figure 1 shows the total automation system for heatset presses. This system is based on decentralized functions and centralized control. The functions are distributed among independent microcomputers which intercommunicate by a fast (1 MHz) data highway. The printing process is monitored and controlled in a control room with colour video display units, keyboards and fingerpoint display screens. The functions are performed by the operator modules, the system module and the report module. The report module is also linked with the plate scanner. The expanded PRINTA/AQUC system includes adaptive presetting with a computer-controlled plate scanner, closed-loop controls of the print density, colour registers and some online finishing registers. The process modules connect the system to the printing press. They control the main press drives, settings of the actuators on the press, and they continuously monitor the condition of the printing press.

3. Description of the control system

3.1 Computer-controlled plate scanner

No details of the plate scanner will be given here. More information may be found in references/4,5/. The benefits from using a computer-controlled plate scanner are obvious, and I have listed them as follows:

- Calibration of the measuring device is easier and more accurate by the computer.

- By using a small measuring spot in the measuring head and a computer, even small printing areas such as lines between the columns, small figures, etc. can be detected by the scanner.

- Special logic sequences are needed in the computer to detect possible optical variations due to illuminating or burning the plate after development.

- Adaptive presetting may be included in the computer program of the plate scanner.

- On-line connection is needed between the plate scanner and the control system.

- Effective failure diagnostics can only be performed by a computer-based diagnostics program.

3.2 Adaptive presetting

Figure 2 gives a block diagram of the adaptive presetting in the PRINTA control system.

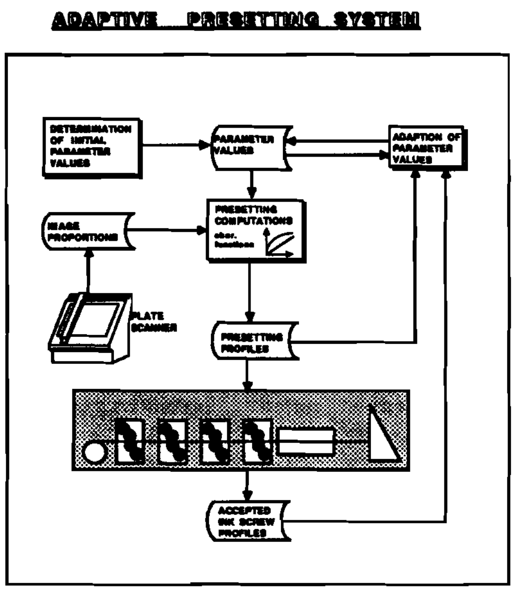


Figure 2. A block diagram of the adaptive presetting of the ink screws.

Each ink screw has two characteristic parameters in the computer memory: positioning offset and adjustment gain values. These parameters define the position and the shape of the characteristic functions of the screw. The presetting computation is based on these functions, and on the scanner readings and material parameters.

After presetting, printing is started as usual and the final adjustments of the screws are made to achieve the required print quality. When the acceptable print is ready the printer instructs the system to store the final values of the screw position. The system compares these final positions with the preset values. According to the differences, new values are computed for the offset and gain parameters. This is done in conformity with certain computation rules depending on the shape of the image printed in the zones to be corrected and in the adjacent zones. The old values are replaced after digital filtering by the new ones.

The advantage of this method is that the control system finally learns to know the exact characteristic parameters of each individual inking screw with a satisfactory accuracy. This is especially important in heatset printing, where the need for presetting accuracy is much greater than in newspaper printing, and the ink feed adjustments are not as accurate as in sheetfed printing. This method also provides for the slight changes in the feeding mechanisms occurring with time and caused by wearing.

3.3 Flexible control by a computer

During the operations, all the programs and parameters of the PRINTA system are in a RAM memory. Two hard-disk units (Winchester) are provided as a back-up memory. This makes the changing of the parameters or characteristic curves, e.g. curves for speed changes, very flexible and easy to draw. In result, material parameters, webbing up and page imposing programs can be easily updated and recalled.

The starting, running up and stopping sequences can be programmed separately and flexibly for different situations.

The advantages of the abovementioned programmability are the reduction in starting waste and the shorter time needed to get the first print to the mailing line. This means lower costs and the possibility of later deadlines.

Easy and centralized handling of the press functions by means of video operating stations makes it possible to reduce the manning of the press during the production.

3.4 Closed-loop controls

PRINTA's closed-loop control system for the density and colour register is based on the developments made at the VTT and reported on earlier occasions /1,2,6/. No details of the system components need to be given here. The control strategy is based on the black-box model of the two processes obtained by using computer based control algorithms. As shown in Figure 1, the connections are made by a density computer and a register computer. The computers take care of the measurements, synchronization, preliminary computation of the results, and they send the results through a serial connection to the process module.

In regard to the use of the computer, there are some fundamental differences between the measuring of density and the measuring of register.

3.4.1 **Measuring of density.** The measuring of density consists of four filter measurements with each of the 16 measuring heads. Measuring is carried out during each press revolution in either a solid test field or a halftone test field of the measuring strip by means of sample and hold circuits in the measuring heads, analogic multiplexers and an A/D converter controlled by the computer. This function requires fast and accurate (12 bit A/D conversion) data logging and a preliminary computation system to store and average the measuring results before sending them to the process module of the control system, where the closed-loop control program is located.

For synchronization there are two sensors to detect the targets on each end of the measuring strip permitting to take into account possible skewness of the strip across the web. Basic gating of the measurement is done by a pulse detector that gives one pulse per each revolution of the press cylinder. The synchronization operation is fully automatic based on the identification of special synchronization targets. The measuring bar is automatically traversed across the web to make the measurement in the crosswise centre of the measuring fields of the strip.

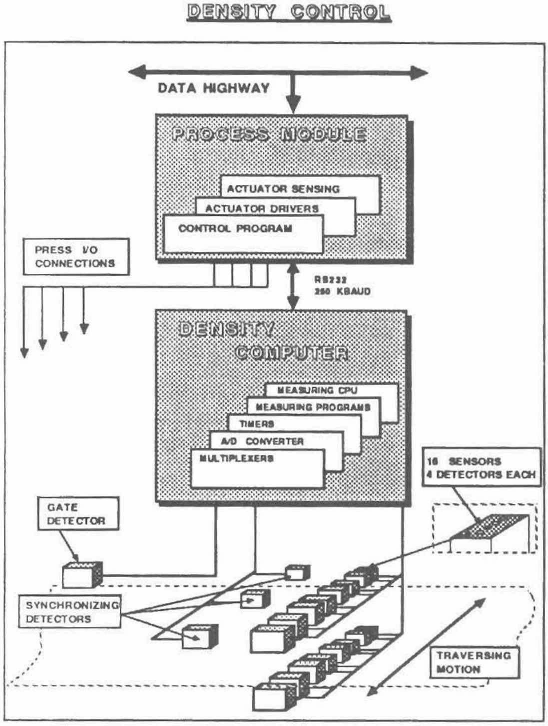


Figure 3. A block diagram of the density control.

Automatic calibration (dark current) and failure diagnostics, such as checking the skewness of the strip, and illumination levels of the light sources, have also been included in the computer program for measuring.

3.4.2 **Measuring of register.** Control is provided for six colours printed on each side of the web. The measuring head is designed to permit the measuring targets (triangular targets) to be positioned across the adjacent web or along the web adjacent to each colour. There are not as many measuring channels as in the densitometer. On the other hand, the required measuring speed is about ten times higher. Very fast preamplifiers and A/D conversions are therefore needed. Hence, for each one of the colours to be measured a signal transient is recorded in the digital RAM memory units. This signal covers the area of about one cm before the test target, the test target, and the area about one cm after the test target. After recording the signal for each colour, the computer begins to analyse the signals in order to compute the lengthwise and crosswise register differences from the reference colour. Variations in the density values of the test targets do not affect the accuracy of the measuring.

Automatic crosswise transfer of the measuring head adjusts the measuring to take place in the centre of the test targets.

Synchronization is fully automatic based on the identification of special synchronization targets.

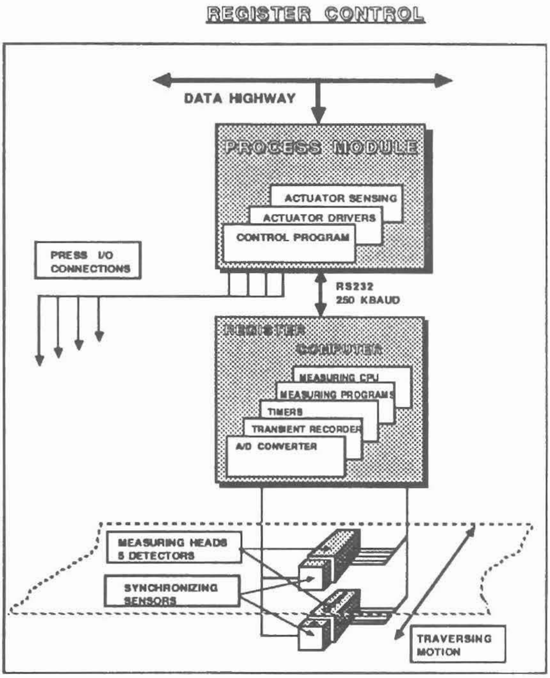
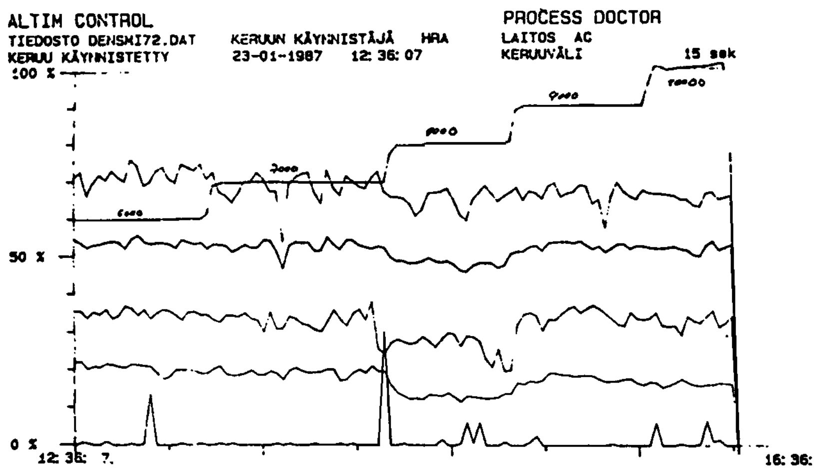


Figure 4. A block diagram of the colour-register control.

The purpose of the above features is to make the use of the density and register controls as easy and reliable as possible in industrial conditions.

3.4.3 **Closed-loop control.** In both controllers the control programs are located in the process module where the control actions take place as fast as possible. Only information on the status of the controllers and a summary of the measuring results are sent to the operation module to be shown by the video display units. The printers control commands are sent from the operation module back to the process module. The printer can turn off the closed-loop control of a certain colour, or of some or several ink screws, he can change the setting values during the operation, or he can change certain control parameters to make the controller react to the changes faster or more slowly.

4. Experience with the computer controls



NIMI	TUNNUS	ASEMA	0 %	100 %	AIKASIIRTYMÄ	SUODATUS
DMU8	P1767	22	1350.00	1550.00	0 sek	1
DSY8	P1775	22	1100.00	1300.00	0 sek	1
DMA8	P1783	22	1000.00	1200.00	0 sek	1
DKE8	P1791	22	800.00	1000.00	0 sek	1
VAIHTELU	P1829	22	0.00	25.00	0 sek	1
NOPEUS	P1839	22	0.00	10000.00 mm/s	0 sek	1

Figure 5. An example of the bench tests of the on-press densitometer.

Printa also tests the developed measuring and control systems. Testing consists of a set of programs, called a

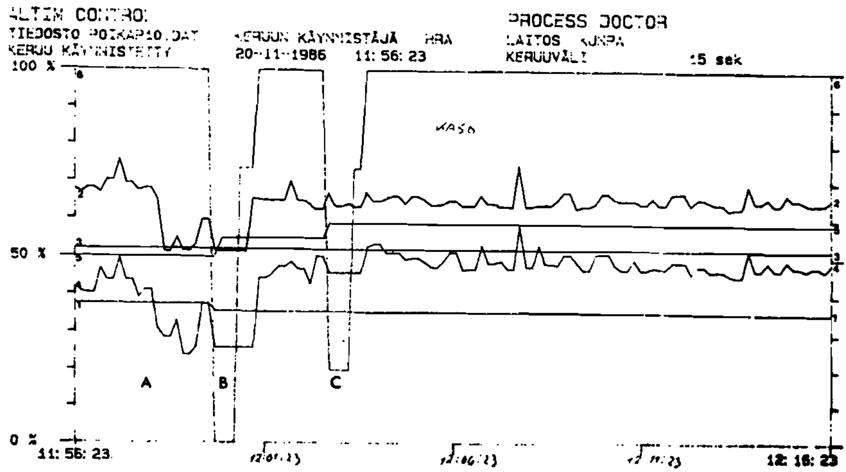
Process Doctor, which is able to collect the measuring data from the sensors, compute averages and deviations, show the results on a colour display, and record them on a multicolour plotter.

A full bench-test program was carried out in the colour register and density measuring systems. In the tests the repeatability of the density measurements was better than +/- 0.015 D-units and the repeatability of the register measurements was better than +/- 0.02 mm. Measuring reliability was tested at a speed of up to 13 m/s (the maximum speed of the tester); no effect of the speed on the measuring results was detected. The measuring programs are able to respond to normal speed changes of the press without disturbances in the results.

An example of the results from the bench tests has been given in Figure 5. The graphs in the figure show the effects of speed changes on the measuring result of the density sensors. The graph rising stepwise shows the speed of the tester. The other graphs show from top down the densities of the yellow, magenta, black, and cyan spots. The graph's scale from 0 to 100% is equal to a density change of 0.2 D-units. Consequently, the largest density variations during the speed changes (6...10 m/s) have been less than +/- 0.02 D-units. No trends relating to the speed change are shown in the graphs.

The complete control system has been installed in the production presses at the purchaser's printing plant. The measuring reliability of both types of sensors has been tested and found to satisfy the requirements of production printing. The closed-loop control of the colour registers has been tested, too. The results are rather satisfying, as can be seen from the example given in the following:

Figure 6 shows the results graphically. The black print has been used in the example as a reference for the register adjustments (graph 1 in the figure). The values of the crosswise register have been recorded. Position A is the starting point in the figure. As shown by graph 2, the cyan register is about -0.1 mm, and as per graph 4 magenta is about -0.2 mm off the correct register values. The control logic has adjusted the value of the reference colour (black), because the errors of the other colours are more or less similar. Besides, the magenta register has been corrected by +0.05 mm (graph 5), and again, in postion C, by 0.05 mm. Graph 6 indicates by value low, that the regulation of the register is permissible. As shown in the figure, the system has a certain delay time between the successive regulation operations to give enough time for the actuators to respond and for the new registers to reach the steady state.



NIMI	TUNNUS	ASEMA	0 %	100 %		AIKASIIRTYMÄ	SUODATUS
1 MUKEOHJ	Y625	22	-3.00	3.00	mm	0 sek	1
2 CYKEMIT	P2345	22	-0.50	0.50		0 sek	1
3 CYKEOHJ	Y692	22	1.20	2.20		0 sek	1
4 MAKEMIT	P2346	22	-1.00	0.00		0 sek	1
5 MAKEOHJ	Y763	22	1.00	2.00		0 sek	1
6 SAATOLUPA	P3135	22	0.00	15.00		0 sek	1

Figure 6. An example of the closed-loop control tests in a production press

5. Conclusions

The first results with the new total control system in a heat-set production press have been very promising. More experience is still needed to confirm the usability of the system in the long-run, high-quality printing works.

The control of the water feed is still not included in the total control system described in the paper. This control is an essential and important part of the efficient control system but also the most difficult one to complete. The preliminary results of this development at the VTT have been published in the TAGA Conference /7/ and subsequent test runs are under progress.

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