A NEW GENERATION OF QUALITY MEASURING STATIONS

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Abstract : The application of CCD technology in the form of vector or matrix sensors opens new possibilities to the design of print quality measuring systems. The image sensor technology also allows the use of more advanced quantities for the definition of print quality than conventional densitometers do. Using the new quantities it is possible to draw more reliable conclusions about the reasons of quality failures. The new computer-controlled measuring system deploys both conventional densitometry and the new CCD technologies. The paper discusses the main features of the new quality measuring station and gives examples of the measuring results.

1 INTRODUCTION

In competition with the coloured and very informative electronic media, printed media have to meet increasing demands for more colour and a better print quality. HIgh waste and costs figures are the result when printing top-class products, in the case the printing conditions and the quality control of the production are not handled efficiently. Special automatic methods are needed to control print quality and the printing conditions. The ascertainment of print quality during the production as well as the verification and documentation of the quality standard and its stability are new challenging tasks. The progress of standardization is also rapid, e.g. in the form of ISO 9000 Standard documentation.

To meet the abovementioned challenges, printing production must become more cost effective and more productive print quality measuring and recording methods are needed in the printing departments.

Indeed, the ultimate solution to the quality control of printing production is on-line and automatic quality measuring and closed-loop control by a control system. We have reported VTT's achievements in this field at previous TAGA Conferences /1,2/. This paper discusses an off-line solution to quality control. Especially the production departments of sheet-fed presses do not usually have any other possibility to solve the problem of automatic quality measurement than by measuring off-line. When

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measuring is done by a computerized and automatic quality measuring station, it is also possible to ascertain the quality efficiently and economically.

2 PREVIOUS DEVELOPMENTS

The concept of an automatic quality measuring station for printed sheets is not new. The first automatic, computer-controlled quality measuring station was designed at FOGRA /3/. It was able to measure the optical densities throughout the printed sheet as programmed. A commercial version of the equipment was produced by Grapho-Metronic AG /4/. Gretag, AEG, MacBeth Polygraph etc. have also introduced their commercial versions of the device. In the USA the first quality measuring station was launched by Tobias Ltd. /5/, who has since brought into the market new generations of the equipment. A common feature of the first-generation commercial devices was that they only measured the density in one test-strip line. The Japanese company Dai Nippon Screen Co. was the first to introduce a commercially available density measuring station, which measures the density throughout the printed sheet and Tobias Ltd was to follow suit.

The available quality measuring stations are still not able to measure the colour registers quantitatively and automatically.

Two generations of quality measuring stations have been designed at VTT. This paper discusses the third generation.

The first version was developed in the early 1980s and is still in use at the laboratory. The basic concepts of *density and colour register measurement* were developed for the first microprocessor-controlled device which can measure the quality factors in any position on the print sample according to the measuring program /6/. The device, which we call **ALMA** (an abbreviation of the Finnish definition), is used especially to measure the printed samples of test trials in connection with our acceptance testing service (we test the performance of new printing press lines). Some of the results are in section 5.

The second version was designed in 1985 for a Finnish printing house, which still uses it for the quality ascertainment of a sheet-fed press printing four-colour, high-quality products. For this device (**SELMA,** again an abbreviation of the Finnish name) we designed a microprocessor-controlled density measuring head.

This paper gives a progress report on the development of **the third**-generation quality measuring station, **VILMA,** named after the video-based sensors (CCD technology) used for the measurements.

3 FEATURES OF THE NEW-GENERATION DEVICE

The device was developed to meet the needs of research and development at VTT and in the Central Laboratory of the Finnish Pulp and Paper Industry, one of the cosponsors of the project. The Central Laboratory contributes to the design of the system features and will be the second user of the finished equipment. Another goal of the development was to design a device of commercial value. This is especially the task of the third part of the project involving the Finnish manufacturer DATA Oy, also the producer of the plate scanner for presetting systems, which we have reported in a previous TAGA Conference /7/. Our equipment is expected to awaken interest in research centres as well as in the quality departments of printing plants and paper mills. Fig. 1. gives a wiev of the measuring station and Fig. 2. shows some details of the measuring heads.

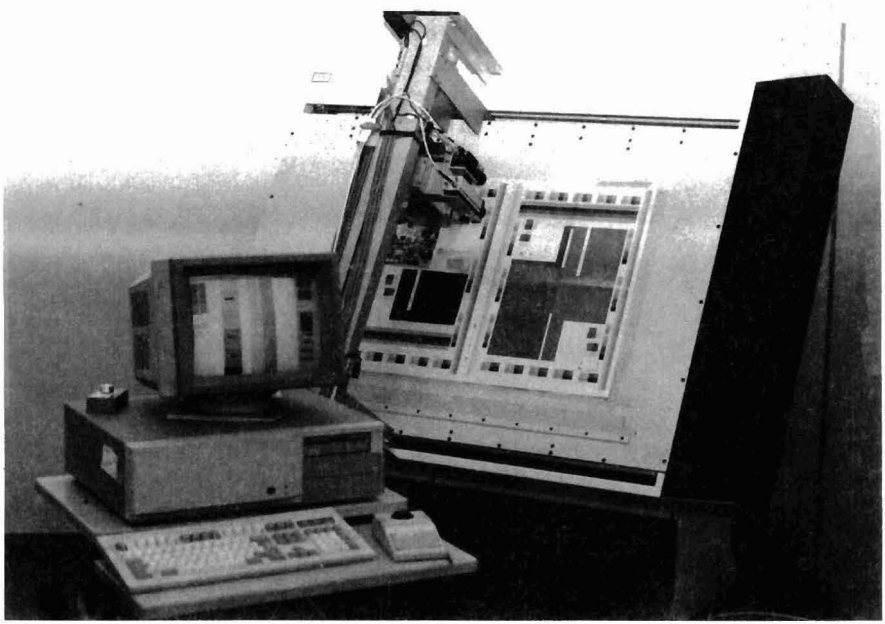

Fig. 1. A wiev of the measuring station.

3.1 SENSORS

The quality measuring station has measuring heads for several purposes.

- **Print density** is the most important print quality factor measured with the equipment.

The original idea was to design a measuring head using CCD vector technology for measuring. These detectors are, however, not efficient enough to meet the measuring requirements of high-quality prints, in which the black printer may have a density scale of up to 2.5 D-units. We shall follow the technological

development and as soon as the detectors have been improved we shall adopt this technology to the measuring station.

We solved the measuring problem by using a microprocessor-controlled densitometer, which is able to communicate with the computer by a standard serial line. The densitometer is a small X-Rite 428 densitometer installed in the measuring mechanism of the device. The different features of the densitometer are used in the quality measuring station.

- **Colour register** is measured by a CCD matrix sensor using the technique described in the TAGA Conference in 1989 /8/. The measuring area is very small and can be anywhere on the printed sheet or in a number of places to measure errors in plate skewness or the elongation of paper between the printing units.

- **Print gloss** is an important quality factor especially when printing on coated stock in heatset or gravure processes. Our gloss sensor, installed in the measuring mechanism, is a microprocessor-controlled glossmeter, "Micro-Gloss" by BYK-Labotron GmbH, installed.

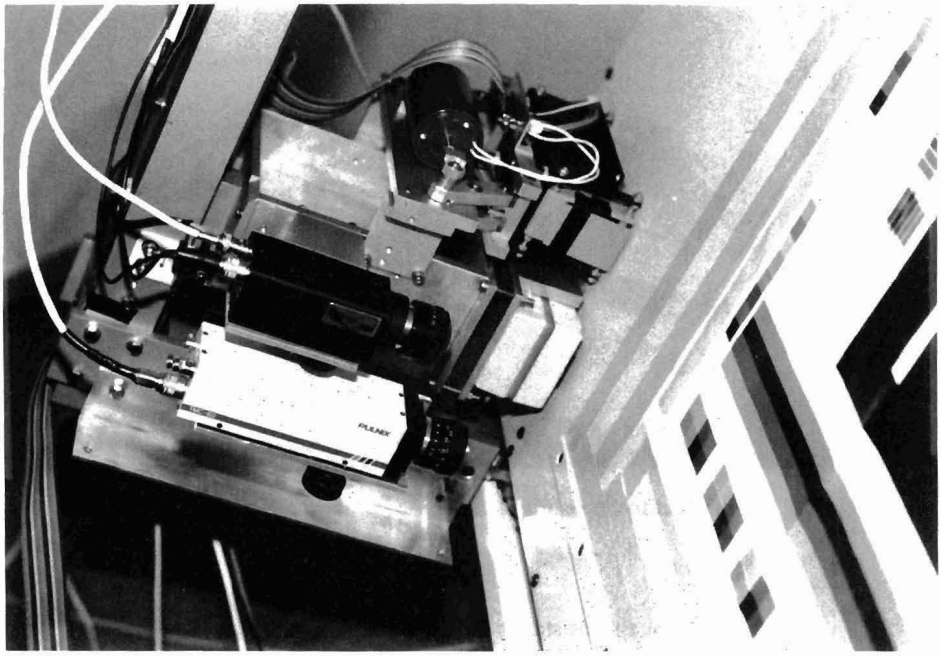

Fig. 2. Details of the measuring heads.

3.2 MECHANICAL SOLUTIONS

The measuring heads are installed in a fixing chuck which can be driven up and down on a balk which, in turn, can be driven across the whole table from left to right or vice versa. The mechanism is driven by two servo-motor systems controlled by the

computer of the measuring system. The positioning accuracy of the mechanism is better than 0.1 mm in both directions.

The printed sample is placed on a precision-ground measuring table in approximately the right position required (positioning accuracy about +/- 1 cm). The device automatically determines the accurate position of the sheet by two selected image edges of the print which have been entered in the system. Before the measuring sequence, also the positioning of the standard test strips is checked (about +/- 5 mm relating to the sheet position is accepted). The sheet is held on the table by a vacuum. If a half-size sheet is measured, one sheet can be positioned on one half of the table while another sheet is measured on the other half. This speeds up measuring considerably.

3.3 MEASURING SYSTEM AND USER INTERFACE

The computer of the measuring system is a 386-type microcomputer with a VGA-driven full-colour display. The system also includes a video grabber board (MVP-AT from Matrox Inc.) to capture the pictures of the prints.

The versatile and user-friendly user interface is based on MicroSoft-Windows. Besides the normal mouse (a track-ball is used instead of a mouse) and menu bar controls all the basic functions are function key selectable. The device contains three different display window types: graphic base window, graphic special windows and dialog-box windows for selections.

In the **base window** the measurements are presented on the screen in versatile high-resolution graphics. The window consists of four fields for density and a maximum of four graphics fields for register measurements. Each of the density graphics fields can be replaced at any time by **difference graphics** or **trend graphics**. In the **register graphics** field the measuring scale is automatically selected according to the register error (scales 0..0.3 and 0..3 mm). Besides this the densities, trends and register graphics can be maximized to cover the full screen for more accurate inspection. The mouse-selectable push buttons of the base window can be used to accept the production quality for the base reference of the difference graphics.

The **special windows** are used for displaying the values of print gloss, dot gain, colourness or special register graphics.

The numerous **dialog-box windows for selection** are easy to use because the system itself opens the proper dialog-box window when needed. Dialog-boxes are used to select the tolerances, the standard strips, etc.

All the above measurements can be made throughout the printed sheet and as many measurements can be made on one sheet as necessary. The measuring

coordinates are programmed and other specifications are given for the measurements by a user interface. The image of the print appears on a full-colour video display (MVP-AT supports 16.7 milj. simultaneous colours) and the areas to be measured are selected by a mouse-driven cursor. The measuring programs are stored in the memory of a hard-disk. Old measuring programs can be edited for further use. There are routine measuring programs for standard test strips. The measuring coordinates are determined by the edges ? of the test field to be measured: if you point roughly to the target field, the system recognizes the edges of the field and suggests a central point and the colour for measuring.

3.4 Reporting

The measured data is stored on a hard disk in ASCII format. A preprocessing program computes the averages and standard deviations of parallel samples. Next the data is transferred to an EXCEL spreadsheet for further computations and to report the results by presentation graphics automatically produced by Excel macroprograms. The tables and graphs are stored for trend presentations as well. Excel makes the tailoring of new types of reports very easy.

4 Quality measuring station in a production environment

A quality measuring station can serve the print production line in two different ways.

1 It may be a quality measuring centre to ascertain the quality of one or more press lines.

2 Or, it may be part of the on-line control system of a press line, possibly a component of a closed-loop control system.

If the measuring station is used on-line in a closed-loop control system there are some disadvantages:

- Closed-loop control based on the measurements made on a manually taken sample sheet is not very fast.

- A quality measuring station can hardly serve more than one press in a closed-loop operation, which means higher capital costs per unit.

- The speed of a closed-loop control is limited because a single sample sheet includes short-term density variations. These variations have to be filtered out before making any feed-back adjustments.

- Automatic density control is based on the measuring of test strips on the edge of the sheet. The actual image areas of the sheet are not under complete control.

- In an automatic measuring operation the very small dimensions of the test fields in connection with the inaccurate positioning of the standard test strips (6 mm) may easily cause measuring errors.

The first on-press densitometer for sheet-fed presses was introduced by Crosfield in the mid 1950s /9/ and the first commercial version was produced in the mid 1980s by Reprotest B.V. in Holland /10/ in cooperation with Miller-Johannisberg. The greatest measuring problems are the difficulty to maintain an unchanged distance between the head of the density sensor and the freely fluttering paper sheet, and to deal with the sheet delivery mechanism of the press.

In view of the above difficulties in solving the problems of closed-loop control and keeping in mind the short production periods in sheet-fed presses, we have come to the conclusion that the best method of quality measuring in sheet-fed press departments is a quality control centre for quality ascertainment and quality development rather than a tool for the continuous control of the printing conditions during the production. The progress made in the quality systems, like the standard set ISO9000, demands more effective tools for an accurate and comprehensive determination and recording of quality. Manual measurements with desktop devices will not be possible in future because of the rising labour costs and - in many countries - also because of a shortage of personnel.

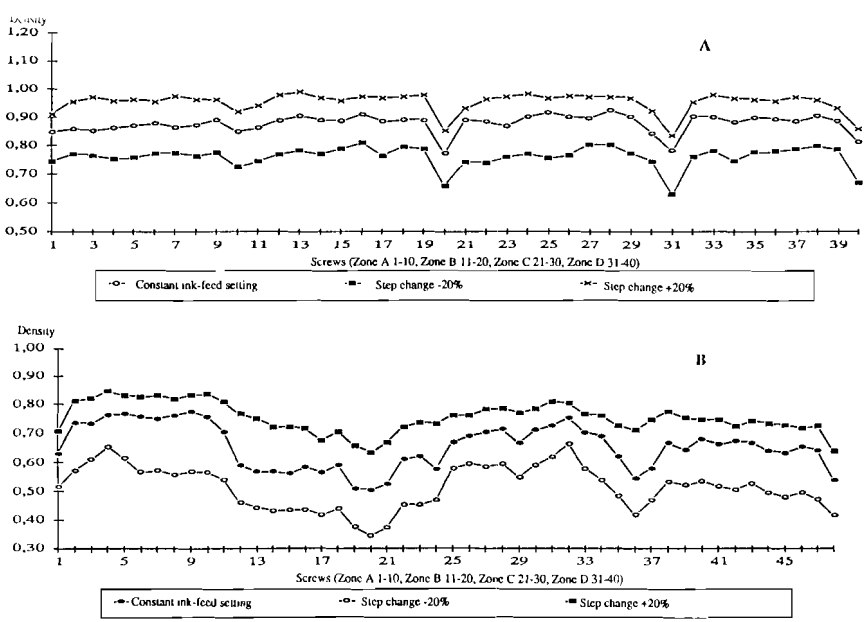

Fig. 3. An example of the results of the testing of the accuracy of the remote control system of ink screws. The density profiles across the web in the case of a bad accuracy a) and a good accuracy b) of the remote control system.

5 USE OF A QUALITY MEASURING STATION

At VTT the quality measuring station has been used mostly in connection with the acceptance testing of new printing presses for printers and publishers /11/. For a medium-sized newspaper web-offset press that prints for example 48 pages, half of them in full colour, we can easily supply a measuring program for density and colour register, which consists of 50,000 individual measurements on the sample pages with a total of 800. These examples have been collected from test runs which included the performance testing of the printing press and its automation system. Fig. 3. gives in the form of graphs an example of the results of the testing of the accuracy of the remote control system of ink screws. The density profiles across the web relate to a case in which the ink coverage of all the inking zones on the test plates was constant and the settings of the ink screws were identical on the remote control display. Step changes were made with the ink feed master control of the ink screws from graph to graph on the remote control console. To carry out the acceptance testing program by manual density measurements and a visual assessment of the colour register by means of Vernier targets would have been far too laborious, expensive and time-consuming. With the quality measuring station we can run the whole measuring program, compute the results and output the graphs and tables within two working weeks.

6 FURTHER DEVELOPMENTS

The best results are produced with the equipment by measuring the test strips. Rather good results can also be obtained by measuring the printed image. Densities can be measured in the areas with no abrupt changes of tone in the measured spot, for example a spot with a diameter of about 3 mm for density measurement. For colour register the measuring targets are so small that they may be positioned in almost every free margin of the image to be printed.

In the near future it will be possible to get a better picture of the quality properties of prints by an image analysis using an enlarged image capture by a colour matrix CCD detector. This method allows a quantitative analysis of the structure of the screen dot shape and also makes it possible to accurately characterize the image definition efficiency. The characteristics of the fluctuation of evenness in various tone areas are also determined accurately. Image analysis algorithms for the system are in preparation. We hope to complete them and have the whole system installed before the end of this year.

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