# Development of Color Control System by Measurement of Whole Print Image for Offset Printing Press


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*In the operation of a printing press, color control depends very much on the operator's skill and experience. However, with the development of the color control system by color scale, the conventional operator's skill is being replaced by numerical evaluation of color quality, and productivity is greatly enhanced. Recently, it has been attempted to measure the whole print image and develop a color control system for the next generation based on a new concept of controlling the print color tone. This system guarantees the quality of the image of the merchandise, and presents a new solution for digital system of print work flow that is rapidly advancing in the directions of print standardization and color management.*


## 1. Introduction

Printing companies are being required to improve the operation rate of the printing press and to stabilize quality to cope with the needs for smaller lots and shorter delivery terms of printing production. Accordingly, printing press operators are required to have a very sophisticated technical level to print products of superior quality. Such requirements include the ability to change the machine setting in consideration of printing conditions that change moment by moment depending on the ambient temperature, humidity, roller temperature in printing press, state of dampening water, type of ink, type of paper, etc. In particular, color matching of prints depends very much on the skill of an experienced operator, and lack of experience on the part of operators can often cause uneven color quality or increase the printing preparation time and the number of sheets with defective printing.

With the object of enhancing productivity and matching colors of printing without depending on operators' skills, MCCS II (Mitsubishi Color Control System II) was developed in 1995. This is a system intended to adjust ink supply amounts automatically depending on the desired color, by measuring the color scale printed on the blank margin of paper at high speed by a spectrophotometer. It is now installed at many printing companies as a system capable of evaluating the color quality of printing objectively and controlling numerically, independently of operators' skills.

This concept is further advanced in a new color control system introduced in this paper. At present, it is being verified in the field. The paper reports mainly on the outlook of the color control system in sheet-fed printing machines, and discusses the technical merits introduced in this system.

## 2. Concept of color control system

The color control system using a color scale has dramatically promoted automation of color matching jobs, but has also left some problems unsolved. Usually, the operator of a printing press is required to match printing colors to color samples. In the case of a color control system by color scale, when it is controlled on the basis of colors on the color scale and if the printing colors and color samples are different, the operator is expected to make fine adjustments on his own decision.

In addition, color scale is not printed in all jobs – for example, if there is no blank margin in the paper for the printing color scale, or plate making data is not compiled in own printing companies. In such cases, the color control system cannot be used and the quality of operation depends on the operator's skill. These are the main factors hindering completion of automation of color matching.

Quality control of printing will be required at a higher level henceforth by ISO 9000 and others. In addition, digitization of printing work flow will be promoted, and efforts toward printing standardization are indispensable. To cope with these trends, numerical control of color quality of the image of the merchandise is required. Against this background, the new color control system has been developed on the basis of the following concepts.

(1) A system capable of checking the quality of the entire printing job by measurement of the whole print image.

(2) A system capable of controlling the color tones of the image itself by using measurement data of the whole print image.

(3) A system applicable to printing standardization by use of a full digital system.


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## 3. Configuration of the system

An outline of the color control system is shown in **Fig. 1** and its main specifications are given in **Table 1**. It mainly comprises a suction board for spreading paper, a sensor head, a scanner, a processing board, a touch monitor as user interface, and a desk unit including a computer and other devices for controlling and supervising the entire system.

The operator starts operation by using the touch monitor, and necessary information is set automatically by printing job setting by IPC II(Note 1). By measuring the printing sample, the optimum control value of the printing press to a preset target color is displayed, fed back and controlled in the printing press as required.

(Note 1) Intelligent press control II. A computer system for supervising manipulation and operation of the printing press.

## 4. Technical features of the system

### 4.1 Sensing technology

The main feature of the system is measurement of the whole print image. The sensor resolution is 0.5 x 0.4 mm, which is nearly equal to the image data stored in PPF data(Note 2).

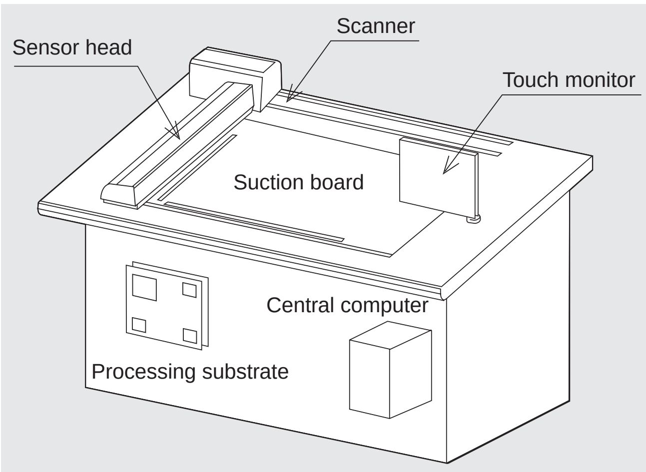


**Fig. 1 Appearance of color control system**

Therefore, when measuring a printing paper of, for example, 939 x 636 mm, measurement data of about 240 0000 points can be obtained. In control of the printing press, colors are separated into four process colors (cyan, magenta, yellow, black) from measurement data of mixed color dots, so the light spectrum of the near infrared region can also be detected in addition to the visible light region.

To realize these functions within a practical measuring time, an original sensor head that operates by switching light source and photo diode array has been developed. **Fig. 2** shows the difference in measuring method between color scale type and this developed system.

The sensor head includes a total of more than 2 000 photo diodes disposed in an array, and the whole print area can be measured by one scanning. By means of the original parallel processing circuit using various digital signal processors (DSP), a very large volume of measurement data of the whole print image can be processed at high speed.

(Note 2) Print production format. A standard format for obtaining numerical data from information corresponding to job instructions.

**Table 1 Main specifications**

| Item | Specifications | |
|---|---|---|
| Sensor head | Measuring method | Line scanning type |
| | Max. measuring area (mm) | 1 020 (W) x 720 (H) |
| | Resolution (mm) | 0.5 (W) x 0.4 (H) |
| Paper thickness | 0.04 to 1.0mm or less | |
| Measuring time | About 25 seconds (measuring condition: 939 x 636 mm paper, measuring start-result screen display) | |
| Colors to be controlled | CMYK process 4 colors/ special color (monochromatic) | |
| Number of corresponding colors | Print on one side: max. 12 colors<br>Print on both sides: max. 6 colors on face/ 6 colors on back | |
| Number of IPC II units connected | One side: max. 4 units (recommended 2 units)<br>Two sides: max. 2 units (recommended 1 unit) | |

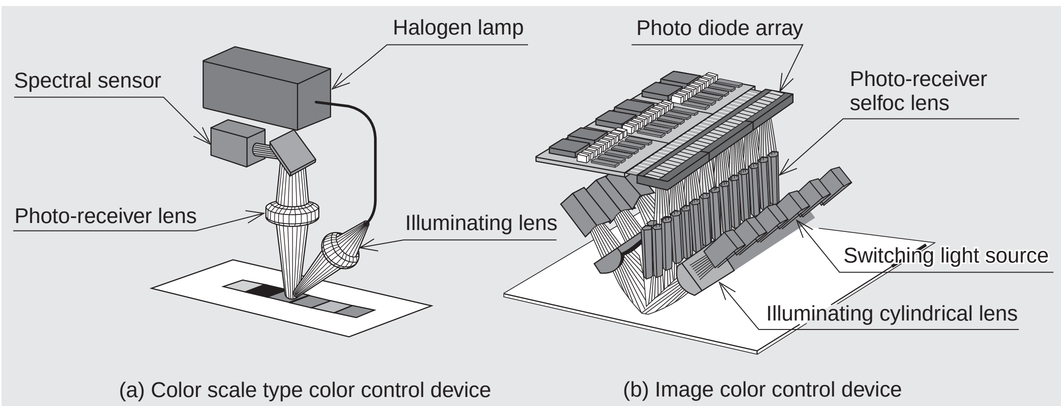


**Fig. 2 Comparison of sensor measuring methods**

By the paper suction mechanism based on the air suction system, paper setting error is prevented during measurement. In addition, by measurement of paper thickness by a laser displacement meter and lift mechanism of the sensor head, the sensor optical focal position is adjusted automatically. As a result, the paper thickness can be measured stably in a range from 0.04 to 1.00 mm.

**4.2 Color control technology**

In color printing using four process color inks, for automatic control of amounts of inks supplied for correction of color deviation from color samples in the image area, the required measurement data is extracted from the measurement data of the whole print image, and excessive and insufficient amounts of each ink must be calculated in the each ink key unit.

Accordingly, it is necessary to position the color samples and measurement data of the print sample correctly, and relate to the ink key positions of the printing press. In measurement, however, various disturbances can occur, including expansion or contraction of paper with temperature changes, and deviation of paper position when the paper is set by an operator.

In order to create a system not influenced by disturbances, it is intended here to enhance the working efficiency by an operator and to stabilize the precision of measurement by realizing an automatic position tracking function of measurement data on the basis of the position of image data.

From position coordinates data and pattern image data, the points suited to control are selectively integrated and averaged in ink key units. Color deviation can then be detected even in an ink printed in a small area without lowering the precision.

At this time, in the steeply changing portions (edges) of image mode, the color difference is largely due to a slight difference in the measuring position. In measurement, edges are likely to be disturbances, and since human visual evaluation tends to feel more acutely color deviation in the smooth region than at the edges, the evaluation is weighted depending on the smoothness of the image.

Using the measurement data integrating and averaging the optimum region in each ink key unit and ink type, excessive and insufficient amounts of ink from the target color are calculated. Measurement data after integrating and averaging process may be expressed as follows.

$$\begin{pmatrix} D(380\,\text{nm}) \\ D(390\,\text{nm}) \\ \vdots \\ D(860\,\text{nm}) \end{pmatrix} = \begin{pmatrix} Dc(380\,\text{nm}) & Dm(380\,\text{nm}) & Dy(380\,\text{nm}) & Dk(380\,\text{nm}) \\ Dc(390\,\text{nm}) & Dm(390\,\text{nm}) & Dy(390\,\text{nm}) & Dk(390\,\text{nm}) \\ \vdots & \vdots & \vdots & \vdots \\ Dc(860\,\text{nm}) & Dm(860\,\text{nm}) & Dy(860\,\text{nm}) & Dk(860\,\text{nm}) \end{pmatrix} \begin{pmatrix} tc \\ tm \\ ty \\ tk \end{pmatrix}$$

Here, $D(\lambda)$ is a density spectral value of measurement data extracted by integrating and averaging process, and $Dc(\lambda)$, $Dm(\lambda)$, $Dy(\lambda)$, and $Dk(\lambda)$ are reference contrast spectra value of cyan, magenta, yellow, and black. Subscripts $tc$, $tm$, $ty$, and $tk$ are ink component amounts expressing the transfer amount of each ink onto the paper.

In multiple regression calculation, by calculating the ink component amounts of color samples and print samples, excessive and insufficient amounts of each ink from the target color can be ascertained. By converting these values into control amounts of ink supplies in the printing press, color control is achieved.

## 5. Verification results

Using the color control system, color control of the printing press was tested in a state where the color was intentionally made to deviate from the color sample of the target color. The results are shown in **Fig. 3**.

In process colors and special colors, the color deviation from the color sample was color difference $\Delta E^* < 2$ (Note3) in average, settling within a controllable range, and a satisfactory color control performance was obtained.

In solid density control using a conventional color scale, due to temperature changes in the printing press or fluctuations of the ink and water balance, if the printing characteristics (dot gain (Note4), trapping efficiency (Note5)) are changed, color deviation occurs mainly in the intermediate tone area of image if the solid contrast is controlled to the reference value.

In the case of color control system, since it is intended to control an appropriate ink supply amount for color matching of pattern, as compared with color control using color scale, resistance to such situation is enhanced.

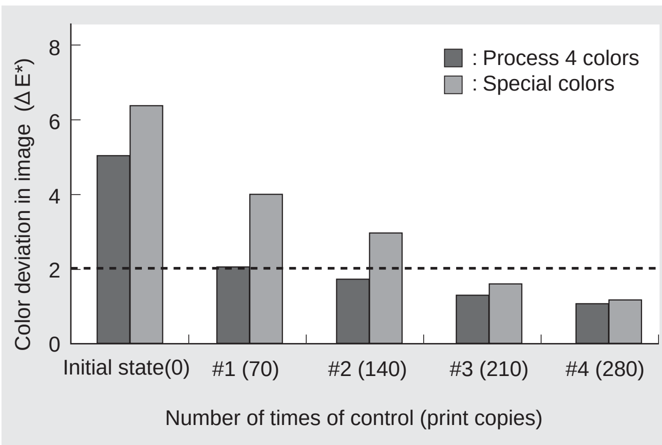


**Fig. 3 Verification results of color matching control**
Deviation of color from color sample of target color is expressed by ΔE*.

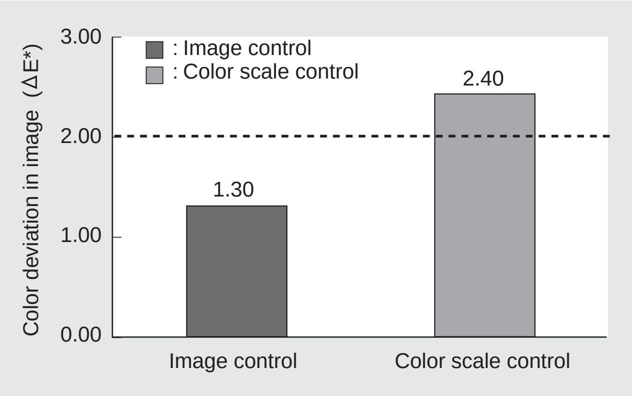


**Fig. 4 Comparison of color control performance by difference in control system**
Evaluation of color deviation from color sample in intermediate tone portion in image (dot percentage 75% or less).

**Fig. 4** shows the results of a color control test in the printing condition by changing the dot gain by 3% of the reference printing characteristic. In this test, with use of this developed system as compared with the conventional color scale type device, the color deviation in the intermediate color tone portion of the pattern has been improved by about 45%.

In this algorithm, by averaging in each color in the ink key unit, in the case of a pattern mainly composed of solid area, colors are matched mainly in the solid area, or if mainly composed of intermediate colors, colors are matched mainly in the intermediate color area. If the solid area and intermediate color area are similarly contained, color matching is neutral and a generally satisfactory color matching result is obtained as compared with color samples.

(Note 3) Distance between two points in CIELAB color space. Generally, at color difference ⊿E*=2, color difference cannot be recognized by comparison between layers.

(Note 4) Phenomenon of growth of printing dots as compared with printing plate. Dot gain is evaluated at 50% of plate area rate.

(Note 5) Ink transfer efficiency in multi color printing.

## 6. Toward printing standardization

In the trend to digitization of printing work flow, CTP(Note 6) of printing plate and DDCP(Note 7) of color sample are promoted, and printing standardization is inevitable at present. In the printing industry, therefore, efforts have been concentrated on creating standards of reproduction of printing colors, such as Japan Color. For realizing color management, many printing companies are also trying to set their own corporate standard colors.

In this developed color control system, in the light of printing standardization, printing a color chart of original 625 colors serves the function of generating a color table using special software. In this table, the relation between dot percentage and reflection spectrum is described, and a target color can be preset from the PPF data by using this color developing table. By making the color table in the standard printing condition, proof printing is not required at the printing shop, and print color control with full digital operation using the present standardization data can be realized.

By this function, digital numerical control of color reproduction hitherto required up to the pre-press process can be extended to the press process, enabling realization of a new printing standardization system. This color developed control system also includes the function of making ICC(Note 8) profile in the printing press.

(Note 6) Computer-to-plate. A direct plate making.

(Note 7) Direct digital color proof. A digital output machine capable of issuing a color sample.

(Note 8) A device profile describing the characteristics of devices defined by the International Color Consortium.

## 7. Conclusions

A color control system has been created from a new concept of directly controlling the colors of the image of the merchandise by measuring the whole print image. As a result, the quality of the merchandise can be guaranteed, and at the same time this system presents a new solution for printing standardization and digitization of printing work flow. Rapid advances are being made in the direction of color management and others.

Future digitization in the printing industry is inevitable, whether within a process, between factories, or between enterprises. Without being limited to the color matching process, the entire job flow relating to production of printing must be further analyzed with the common purpose of developing a new system that can enhance productivity without depending on operators' skill.

**References**

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