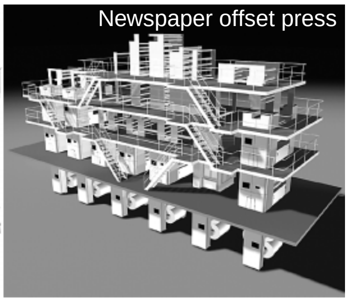
Sheet-fed printing press

Commercial web offset press



Newspaper offset press

Advanced Technologies That Support Printing Machinery

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This paper introduces the latest technologies, found in printing machinery of Mitsubishi Heavy Industries, Ltd. (MHI), for accurate tone reproduction and precise registration of printing as important keys satisfying the mounting demands for higher print quality. Regarding accurate tone reproduction, "printability analysis equipment" developed by MHI and examples of measurement of ink film in sub-micron units are shown. Other examples include color sensing and control of high precision for precise and fast color control system. Concerning accurate registration of printing precise position detecting is realized by using image processing technology in an electrically coupled distributed motor drive system.

1. Introduction

Printing is a technique for duplicating information efficiently in mass quantities. In catalogs and other such applications, in particular, the original and the copies should look exactly the same to the eye of an expert having very high sensitivity. Print copy is judged mainly by the tone of color and sharpness of image. In the offset printing process, the tone is determined by the uniformity of ink and water mixture, and the sharpness of image depends on the positioning precision of printing processes. At present, ink film thickness is measured in sub-micron units, and position when transferring to paper is measured in units of 10 μm, and high-speed/high-quality printing machinery could not have been realized only by conventional experience and professional skill.

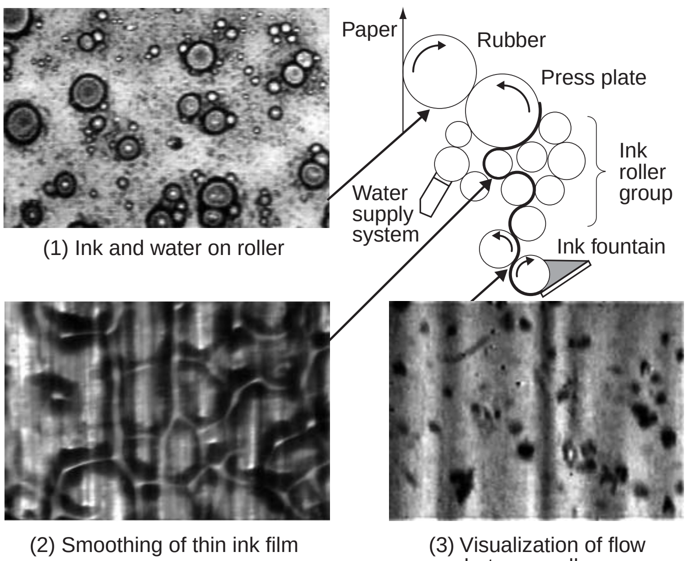
This paper introduces advanced technologies in ultra-thin ink film forming, high-precision color (tone) control, and ultra-small phase error detection developed by MHI.

2. Ultra-thin film forming

A printing press spreads high-viscosity ink into a thin film of several microns. This thin ink film is adjusted to a uniform viscosity and water content as mixing and separation are repeated among rollers, but a smooth and uniform film is not always obtained because of surface undulation by ink filament when the ink film is divided at the roller nip exit, or as a result of changes in emulsified state by forming and breakage of internal water drops. In printing, a uniform ink film is vital, and it is important to analyze these phenomena in order to enhance the speed and quality. MHI has developed "printability analysis equipment" capable of changing the printing section and measuring various parameters at a maximum speed of 20 m/s (1.5 times the product speed), and is promoting studies on ultra-thin ink film transfer. Examples of measurement are shown in **Fig. 1**.

(1) Ink and water on roller: Ink is in an emulsified state dispersing ultra-fine water drops, and to obtain stable characteristics, a film thickness profile of ink and water of an ultra-thin film of 1 to 10 μm during high-speed rotation is measured in real time by a special technique using infrared rays.

(2) Smoothing of thin ink film: Surface undulations (sub-micron pattern resembling melon rind) due to splitting of ink between rollers cause an uneven printing surface (difference in print density). Such splitting behavior is dominated by shearing force from rollers



(1) Ink and water on roller

(2) Smoothing of thin ink film

(3) Visualization of flow between rollers

Fig. 1 Examples of ink transfer behavior

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as well as from ink properties, and the ink shearing force during operation is measured by this equipment for the first time in the world.

(3) Visualization of flow among rollers: According to the conventional lubrication theory, the splitting characteristic of the high-viscosity fluid appearing in thin ink film forming cannot be explained, and it has been difficult to predict ink transfer. Roller surface behavior for a very short time (15 ms) between a roller and other roller is visualized and monitored, the ink transfer mechanism is analyzed by high-speed image processing, and print density stability in a high-speed printing press is enhanced.

3. High-precision color control

In printed matter, color is a very important element in determining the impression of observers, giving “beautiful” and “rich” etc., but in terms of printing technology, it is more important to reproduce the original color with high fidelity. In a printing press, the ink film is stabilized as mentioned above, but small changes occur depending on the type of ink and paper and the working environment, then it is necessary to measure the printed matter and adjust the final appearance of the finish. In the past, skilled operators adjusted color visually, but at the present, measurement and evaluation are quantitated and automated. In line with this trend, MHI has developed a color control system based on optical sensing technology and color control technology, and its performance is being highly evaluated throughout the world.

In sensing system, an infinitesimal color difference that human cannot distinguish is measured by means of a high-speed sensor having an original optical system (15 seconds in measuring about 1 meter). This sensor separates one color into a spectrum of more than 20 domains (wavelength bands), which gives high precision. Automatic position correction and other convenient functions allow printer work with this system without depending on the operator’s skill.

In color control, the optimum ink supply amount is calculated from the measured color reflectance data considering separation of primary colors and black in overlap printing, the effect of adjacent images, and change of dot area in printing process, which realized the integrated press control system (**Fig. 2**).

Fig. 2 Examples of application
(1) Control console for color control system, (2) small color sensor with optical system.

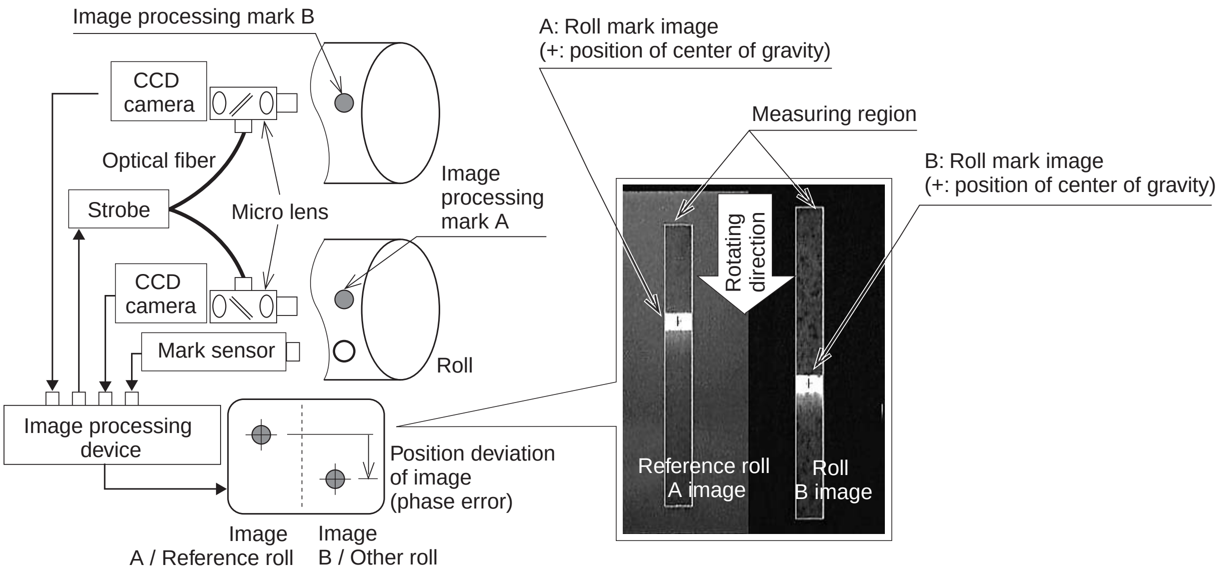

Fig. 3 Example of processed image
Change of rotation phase error can be monitored in real time during measurement.

4. Ultra-small phase error detection

Eliminating use of shafts or gears for coupling the parts of the printing press, dispersed individual motors are synchronized and the machine is made up of mechatronics. In this way, controllability and maintainability are enhanced, degree of freedom of installation of machinery is increased, and power consumption is reduced. Since no driving shaft (the distinctive feature of a large printing press) is used, this is also known as shaftless driving.

The key to this development is the rotation phase angle control technology in the printing section. In conventional technology, this is measured only at the motor position, but MHI has developed a measuring technology with small rotation phase error between rollers for the first time in the world, and product reliability has been enhanced by inspections before shipping. It is a feature of this system that a very small rotation phase error between rollers in the unit of 10 μm can be measured directly, by processing the images taken by various CCD cameras and one strobe (**Fig. 3**).

In the development of the shaftless driving system, in order to detect the synchronism precision of overlap printing of three primaries and black (a total of four colors) a system was developed to measure the phase difference of four rollers by four CCD cameras and an image processing device. Development of shaftless driving involved many problems, such as compounding of the control system and mechanical system, but the practical development was promoted by using this detection technology. Since the roller surface can be measured directly, or the phase error state can be measured on the screen, this technology is used effectively as a tool for searching the causes of printing troubles, aside from the aspects of doubling of printing or shaftless driving.

5. Conclusions

A printing press is a precision rotating machine for transferring ink onto paper in micron order at predetermined microscopic halftone positions. For example, the world's fastest newspaper offset press (DIAMONDSTAR) is designed as a high-speed precision rotating machine on the basis of the ink transfer technology at super high speed. In the highly digitalized sheet-fed printing press, high-precision color control is benefited by the data linkage between the measurement system and the original data from the prepress section. In shaftless driving used in commercial web offset presses and newspaper offset presses, high-quality printing is also realized in phase control of high precision in various printing operations other than steady operation. MHI is promoting research and development of leading technologies that support printing machinery to meet customers' expectations and to offer high quality products constantly, taking account of mounting demands and needs.





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