Development of "Auto-Pilot Printing (APP)" for Newspaper Web Offset Presses

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Mitsubishi Heavy Industries Machinery Systems, Ltd. (MHI-MS) developed the automatic operation function, "Auto-Pilot Printing," for newspaper web offset presses (hereinafter, "offset presses") jointly with The Yomiuri Shimbun. The verification of this function was conducted with the actual equipment at the Tsurumi Plant of The Yomiuri Shimbun, and the function is already in operation. Conventionally, the operations for paper tension control and various settings required at the start-up of an offset press relied on the operators' experience and skills. With the Auto-Pilot Printing function, these operations are automatically conducted using AI, and the operations from the initial setting before the start-up of an offset press to the stop of the offset press are also automatically conducted. Therefore, in case of emergency situations such as the occurrence of disasters or the expansion of infectious diseases, even a limited number of operators can temporarily operate the offset press. The Yomiuri Shimbun, with which MHI-MS jointly developed this function, received the "2022 Newspaper Technology Award" for this function from Nihon Shimbun Kyokai (The Japan Newspaper Publishers & Editors Association).

1. Introduction

Although automatization of offset presses has been advanced, manual operations are still required at the start-up of an offset press and in the final check of pages of newspapers. It is not too much to say that whether an offset press is started up in a short time and high-quality newspapers can be printed depends on the operator's experience and skill. Due to retirement of skilled operators, however, a shortage of operators and acquirement and handing down of the operating technique are becoming major issues. Furthermore, even if the number of operators temporarily decreases in emergencies like the recent coronavirus pandemic or the occurrence of disasters, newspapers need to be printed as usual. In order to solve these problems, we developed the automatic operation function using AI, "Auto-Pilot Printing (hereinafter, APP)." At present, the APP requires the manpower to respond to problems and labor saving in the operation of the equipment; this is yet to be achieved. But, at a plant operating multiple sets, a future reduction of the total workforce can be expected with this technology. This report describes the development policy, system overview, key technologies and future development of the APP.

2. Development policy

We worked on the development of the function under the development policy of printing newspapers having a good printing quality close to the quality controlled by skilled operators, without manual operation. In the conventional operation by operators, the operators controlled the web tension at the startup of the offset press, increased the print inspection speed (generally, 60,000 copies/hour (paper speed of 4.6 m/s)) and repeated the operations such as registering, color tone control and paper cutting position adjustment to judge the printing quality. After good printing quality was obtained, the operators increased the paper speed to the operating speed (generally, 120,000 to 130,000 copies/hour (paper speed of 9.1 to 9.9 m/s)), and after the operating speed was reached, the operators conducted only fine adjustments, and no major adjusting operations were required. Therefore, in order to eliminate the operations by operators after the start-up of an offset

press until the operating speed is reached, we focused our efforts on increasing the precision of various initial setting values ([1] AI preset function), [2] enhancing the web tension control at the startup of an offset press, and [3] developing an automatic good printing quality judgment function. With these technologies, as shown in **Figure 1**, we could automatize the operations that were conventionally conducted manually or semi-automatically as well as all the operations that were conventionally conducted by operators, "start-up operation," "preparatory printing operation," "good printing quality judgment," "increase in speed to the operating speed" and "operating control."

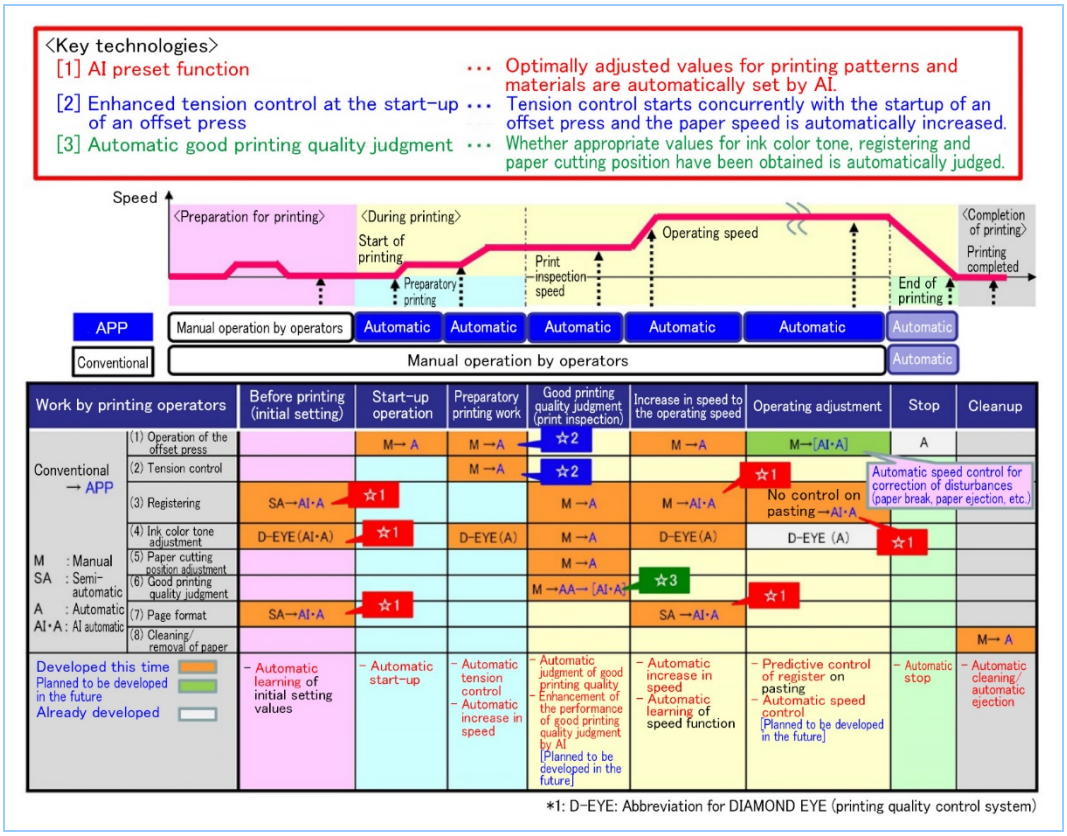

Figure 1 Overview of APP

3. System overview

Figure 2 shows the general configuration of an offset press. An offset press mainly consists of a paper feeding section, a printing section, a web path section and a folding section. Printing is performed at the printing section while web attached to the paper feeding section is unrolled and the web is passed through the web path section, cut into a newspaper format and folded at the folding section. When a number of printing sections are connected, newspapers having a number of pages can be produced. In addition, when the paper passing route of the web path section is changed, the position of a color page can be changed. **Figure 3** shows the configuration of the control system of an offset press. It generally consists of an offset press control system, CCS-PC (Computerized Control System by Personal Computer) (Note 1), which monitors the condition of the whole offset press and conducts (presets) various initial settings and a PLC (Programmable Logic Controller) control system which controls the whole offset press. The key technologies described in chapter 2 which are the basis of the APP are realized as follows: (1) the AI preset function is realized by collection, learning and management of various offset press data by the CCS-PC, and (2) the tension control at the startup of an offset press and (3) the automatic good printing quality judgment are realized by the PLC control system. These three key technologies are described below.

Note 1: In a special specification, the function of the CCS-PC may be incorporated in the PLC and PC may be eliminated. In this case, a dedicated PC for the AI preset function (PC for operation support) is prepared and connected to the PLC control system.

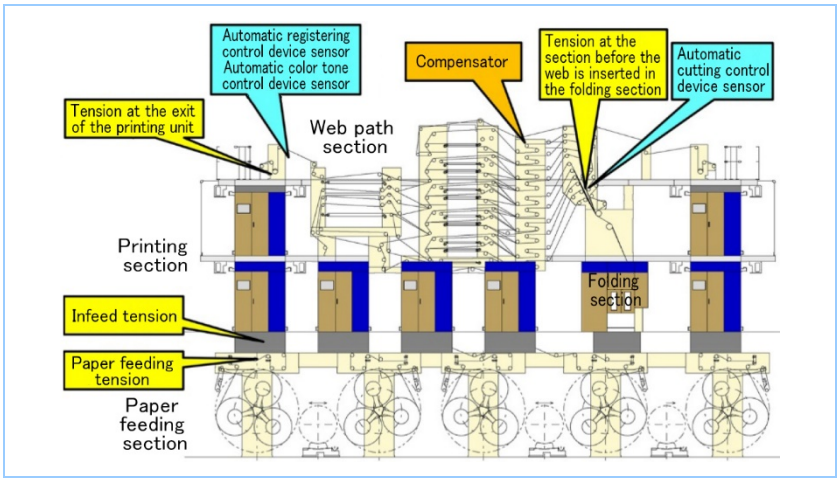

Figure 2 Newspaper offset press

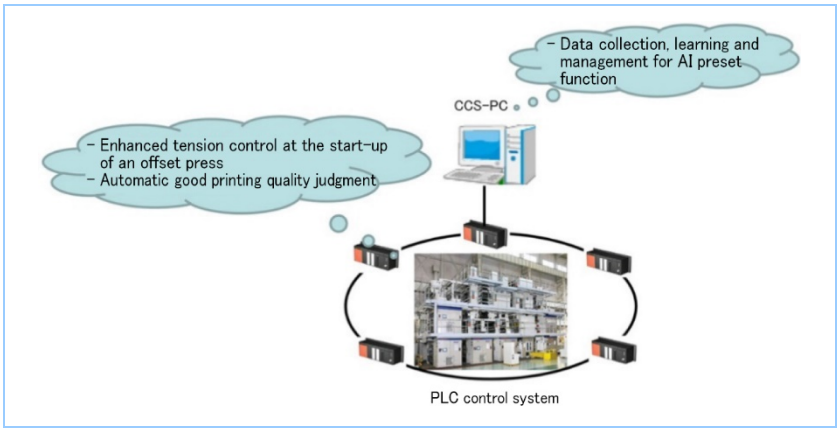

Figure 3 Overview of the control system

4. Key technologies of APP

4.1 AI preset function

Conventionally, values adjusted by the operators were incorporated for the initial setting at the time of the next printing preparation and for generation of a speed function (Note 2). In an offset press using consumable items having different usage states and different materials, the adjusted values in the previous operation may not be appropriate to the next operation. Therefore, adjustment was conducted on an as-needed basis, relying on the operators' experience and skill. In this development, we statistically analyzed the accumulated data (one-way analysis of variance) and found the tendency that the data can be classified by a manufacturer of web paper, kind of paper, web width and printing pattern. We constructed a dedicated AI engine for machine learning of each classified data and incorporated it in the CCS-PC. To this dedicated AI engine, the improvements described below were made, so that high-precision initial setting values and speed function for each classified data can be generated, resulting in the elimination of the operations not only at the time of start-up and during an increase in speed but also during a decrease in speed.

(1) In consideration of the deterioration status of a consumable item that may affect the initial setting target, learning is conducted according to the number of days for which the consumable item is used.

(2) Abnormal data (such as a sample value substantially deviated from the original learned value) is not incorporated.

(3) In learning speed function, by putting restrictions not to incorporate sample values substantially different from the original function, the precision of the speed function is also increased.

Figure 4 shows one example of the learned data of the initial setting values for registering in the vertical direction of the page. As shown, the initial setting values gradually changed according to the number of days for which the consumable item was used, and when the consumable item was

replaced, the values returned to the initial setting values. Thus, with consideration given to the number of days for which a consumable item was used, the precision of the initial setting values could be substantially improved.

Note 2: Various setting values need to be adjusted according to the operating speed of an offset press. The adjustment amount for each operating speed is preset as a function and when the preset operating speed is reached, the registering position is moved by the adjustment amount to the operating speed. This is a predictive control function.

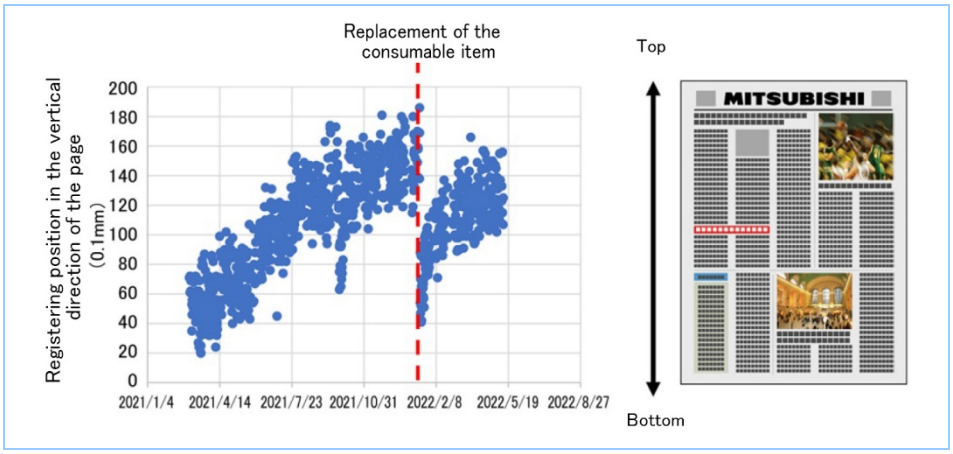

Figure 4 Learned data for AI preset values

4.2 Enhanced tension control at the start-up of an offset press

Conventionally, the operator monitored the web tension on a monitor, predicted the state of tensioned web and increased the operating speed at the operator's discretion. With the APP, the tension control is started at the start-up of the offset press. The tension of the web is controlled at a certain level or above, sequentially from the most upstream paper feeding section to the inlet of the most downstream folding section. However, with some web passing routes, even after the infeed tension was controlled, the tension at the web gathering section (before the web was inserted in the folding section) did not exceed the threshold and the speed could not be automatically increased. In such a case, when the compensator (cutting position adjustment roller) on the route concerned is temporarily moved to the web tension direction, the tension at the web gathering section (before the web is inserted in the folding section) exceeds the threshold and the speed can be automatically increased.

4.3 Automatic good printing quality judgment

Conventionally, the operator judged the printing quality by visual inspection. With the APP, whether the printing quality is good is judged based on the correction signals from the automatic control devices for paper cutting, registering and color tone. Specifically, each sensor for the automatic control devices for registering and color tone is installed at the exit of the printing unit, and a sensor for the automatic control device for paper cutting is installed at the web gathering section (before the web was inserted in the folding section). When the above-mentioned correction signals from the automatic control devices are not received and the printed page, which has good quality in the above-mentioned positions of the sensors, is ejected to the exit of the folding device, the page is judged as having good printing quality in the whole system. In the future, we will make improvements so that the printing quality is judged not based on correction signals but based on good printing quality signals received from the automatic control devices and the good printing quality judgment can be conducted with higher precision according to the printing pattern.

5. Future prospect

MHI-MS is currently working on the development of the following automatic speed control function toward further automatization and labor saving:

<Automatic speed control function>

In printing of newspapers, the necessary number of copies and the printing finish time are predetermined and the necessary number of copies must be printed at an appropriate operating speed by the printing finish time. However, if any problem occurs during the

printing operation, such as massive paper ejection due to defective pages detected and stopping of the operation due to web breaks, the printing with the last operating speed setting may not be completed by the printing finish time, and therefore, the operator adjusts the operating speed. This function will automatically adjust the operating speed so that the printing can be completed by the printing finish time in the event of a problem. In a plant having multiple sets, it will allow the operating speed to be automatically adjusted in view of the state of problems in other sets as well.

Moving forward, we will complete the above function and also continuously make improvements based on requests from our customers. The APP can be added not only to new offset presses but also to existing offset presses without renewal of the offset presses and respond to the needs of existing plants having fewer and fewer skilled operators. We will continue to contribute to the stable operation of offset presses with the APP for a wide range of customers.