BJ Card Printer with 4-inch Print Head

Hiroo Ichihasi and Takao Miyashiro
Canon Aptex, Inc.
Tokyo, Japan

Abstract:

We introduce the high-speed color printer equipped with 4-inch-wide, Bubble-Jet & full-line head.
We describe the detail design of BJ Card Printer, especially for the ink supply method suitable for the full-line heads, the bubble-push-away method and the ink recycling system.

1. Introduction

Color printers using a ink-jet system have been remarkably gaining popularity in recent years. However, most of them are for office and personal use and are mainly based on the shuttle print system using an ink jet with several tens of nozzles. Most of printers using this system have commonly a low printing speed and with relatively a small number of sheets to be processed.

In this paper, we will introduce a color printer using a full-line head of bubble-jet type, which enables large-volume and high-speed printing to cope with high-speed image data processing devices, which have developed remarkably recently, and is also suitable as industrial equipment, and we will also describe the design method of that printer, particularly that of the ink supply/recycling system for the full-line head.

2. Outline of the system

This printer is a color printer that uses full-line heads of bubble-jet type for four colors and is used for printing cards/ seals such as labels, tugs, namecards, and postcards.

Either of two types of paper feed/ejection units: roll paper or cut sheet, can be selected depending on the application.

Table 1 shows basic specifications of this printer and Figure 1, its structure.

Table 1. Basic specifications of BJ Card Printer

Printing system	: BJ full-line head x 4 (Bk, C, M, and Y)
Effective print width	: 94.75 mm
Effective number of nozzles	: 1392/head
Density of nozzles	: 360 dpi
Volume of ink	: 200 cc/color
Paper	: Dedicated. coated paper (mat/gloss)

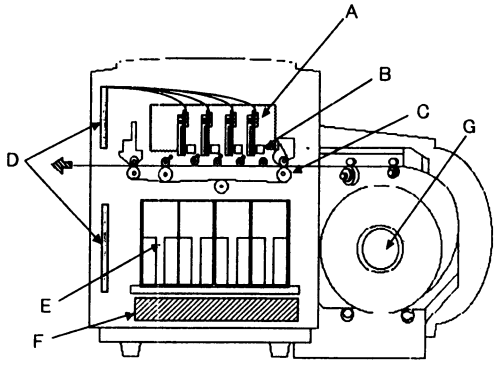

Figure 1. The structure of BJ Card Printer

(A): Head holder, on which four full-line heads for Bk, C, M, and Y are mounted in this order from the right to the left in Fig.1.

(B): Head cleaning unit, which consists of a wiper blade to clean the head face and an absorbent to absorb the ink purged from the head orifice.

(C): Paper feed unit, which feeds paper by holding it with the conveyer belt, pinch rollers, and spur rollers. The optical sensor detects the tip of paper or the mark on continuous paper to control the ejection timing of the ink.

(D): Printed circuit board comprises electrical circuits, which are broadly divided into those for controlling the engine and those for controlling the interface.

(E): Ink supply unit, in which ink cartridges for four colors are installed on the front side and pumps and ink tanks for supplying fresh and purged ink are installed on the rear side.

(F): Power unit. (G): Paper feed unit, of which the roll paper is shown in this figure.

When printing, the head holder (A) lowers as shown in the figure until the tip of the head comes near to paper and the cleaning unit (B) is placed between each head. When not printing, the head holder (A) rises and the cleaning unit (B) moves to the left so that it goes below the head and caps the head face.

3. Ink flow of this system

Figure 2 shows the channel of ink.

The BJ full-line head (H) consists of a common liquid chamber that composes the channel and nozzles and is equipped with the filter (J) at both ends. To charge ink without leaving any bubble, we adopted the processing of applying pressure to the ink. We have judged that the process of giving a negative pressure to the nozzle section for charging ink is more difficult to implement than the processing of applying pressure.

Sequences of operation are as described below.

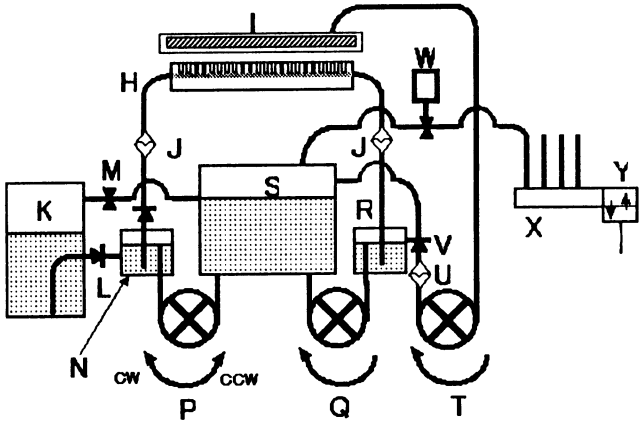

Figure 2. The schematic diagram of ink supply and recycling system

A tube pump is adopted due to its compactness, self-absorbing capability and no-mist. The pump (P) turns counterclockwise. In this case, check valves (O) and (V) are closed, solenoid valve (W) is closed, and pump (Q) crushes the tube so that it is closed. In other words, the cartridge (K) and sub-tank (S) constitute a closed loop and the ink from the detachable ink cartridge (K) is fed to the sub-tank (S) via the check valve (L) and air buffer (N). The air in the sub-tank (S) is fed to the cartridge via the open valve (M) only when the cartridge is mounted. If the ink level in the sub-tank (S) has risen, the ink overflows and is returned to the ink cartridge (K) via the valve (M) so that the ink level in the sub-tank (S) is maintained at a height that is suitable for the head (H). In this case, the air volume in the air buffer (N) is restored to the normal level automatically.

Then, the procedures for charging ink to the head (H) are described below.

The solenoid valve (W) opens and the air in the sub-tank (S) is connected to the atmosphere via the valve (Y) of the breather (X). All pumps (P), (Q), and (T) turn clockwise. The ink in the sub-tank (S) is charged into the common liquid chamber nozzle of the head (H) via the air buffer (N), check valve (O), and filter (J) and then returns to the sub-tank (S) via the filter (J), air buffer (R), and pump (Q). After purging the air from the ink supply system and charging ink, the pump (Q) stops earlier than pump (P) by 0.5 sec. During that process, a higher pressure is applied to the head (H) so that ink is surely charged into the nozzle section, which has a large channel resistance. Then, the check valve (L) closes and the air volume in the air buffer (R) is restored to an adequate level automatically. The pump (Q) is used to suppress the volume of ink that flows out of the head nozzle by suppressing the pressure risen in the head (H) to an adequate level, so its flow rate is set to a level that is lower than that of the pump (P) by 20%.

Air buffers (N) and (R) are used to reduce the fluctuations of pressure caused by the tube pump so that the pressure inside the head (H) can be controlled easily.

Characteristics of the tube pump (P) used for this printer are shown in Figure 3.

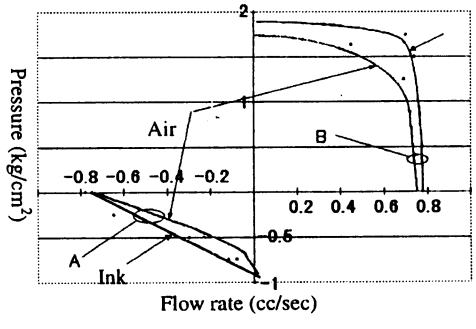

Figure 3. Flow characteristic of the tube pump

Here, the first quadrant represents the case where this pump is used as a pressure pump and the fourth quadrant, the case used as a suction pump. Although there are no large differences in characteristics between ink and air, both are the fluids used in this printer, there is such a trend that air has slightly lower flow rate and pressure. It is considered that this is because air will leak more easily when the tube is crushed. Point (A) is the trigger point for the ink feed from the ink cartridge (K) to the sub-tank (S), i.e., for the start of counterclockwise rotation of the pump

(P). It is considered that channel resistance include the forward resistance of the check valve (L) and the neck between the cartridge and joint section. Point (B) represents the operating state where the pump (P) is turning clockwise, i.e., the normal state where most of the air has been purged from the channel during the charging of the tank.

The largest among channel resistance is the filter (J) (diameter: 5.5 mm, mesh diameter: 8 μm). The following must be taken into consideration when designing the filter:

<1> No cavitation shall occur at any flow rate of the pump.
<2> Fluctuations in flow rate/pressure caused by the occurrence of meniscus due to bubbles shall be taken into consideration.
<3> Changes in channel resistance caused by the changes in ink viscosity due to the changes in temperature shall be taken into consideration. As an example, pressures before and after the filter are shown in Figure 4.

The pressure at either end of the head (H) while operating under the above mentioned conditions is shown in Figure 5.

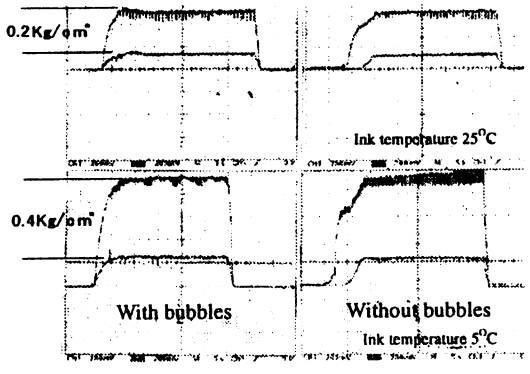

Figure 4. Pressure loss from the filter

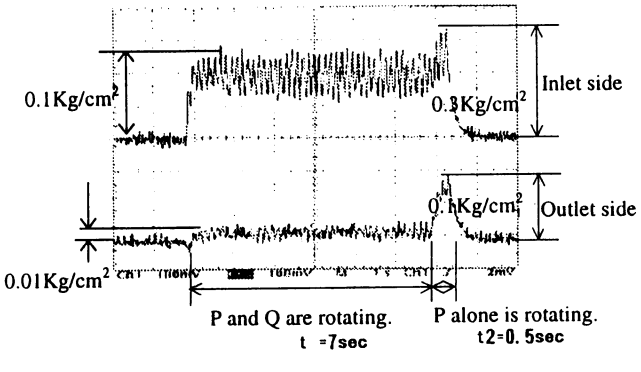

Figure 5. Pressure at either end of the head

The volume of the ink purged from the nozzle:
1.7 cc/(t_1 + t_2) sec (1.4 cc/t_1 sec, 0.3 cc/t_2 sec)

The above mentioned operation can be used from time to time for purging the bubbles in the channel as well as for initial charging of ink. In addition, there is an operation mode only to apply pressure to ink for purging small bubbles from the nozzle and for purging the ink with increased viscosity in the tip portion of the nozzle.

Figure 6 shows the pressure at either end of the head.

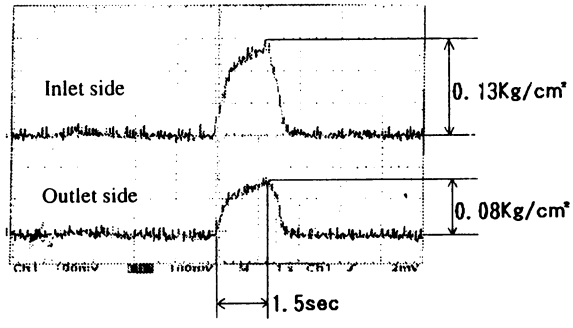

Figure 6. Pressure at either end of the head

A time is set longer than the above mentioned compressing time by taking the delay in start up into consideration. The purge volume is 0.3 cc.

The ink purged through the above described operation is trapped by the head recovery unit (I) and then returned to the sub-tank (S) by the pump (T). Figure 7 shows a cross section of the head recovery unit (I).

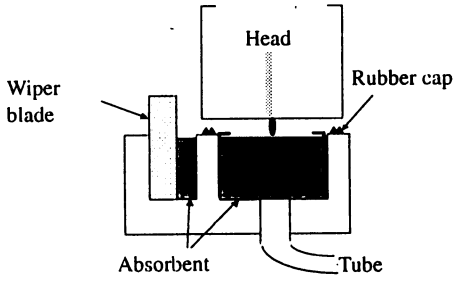

Figure 7. The cross section of the head recovery unit (I)

After the purged ink has been absorbed by the adjacent absorbent, the head face is finished by the wiper blade.

The absorbent must always be maintained in the state where it can absorb the ink in the volume that was purged in the above.

Figure 8 shows the volume loss curve for the absorbent during the operation of the pump (T).

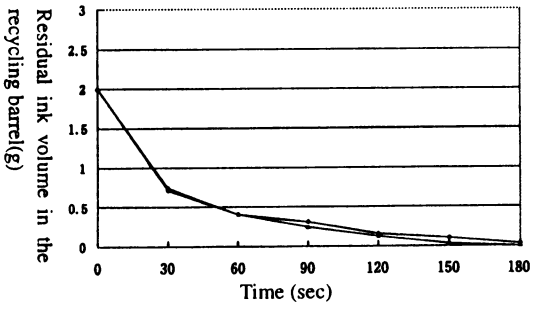

Figure 8. Time dependence of residual ink volume

In this printer, the pump (T) is operated for 120 sec. to cover the fluctuations in purging volume. The recycled ink is contaminated with debris such as paper chips. Although the absorbent itself functions as a filter, debris are further removed by the filter (U) (diameter: 10.2 mm, mesh diameter: 8 μm). This kind of recycling function is a very effective means for the cases where recycling operation must be performed frequently and for adjusting ink consumption in case where various colors of inks are used unevenly.

According to our calculations, it is possible to increase the number of sheets that can be printed by a cartridge to 5 times to 10 times depending on where the recycling function is adopted or not though these figures may vary depending on the size of image data, number of sheets printed per day, and other conditions.

Points to be noted when designing the recycling function with this system are as follows:

<1> Suitable materials shall be selected for the parts that contact the fluid so as to reduce the contamination of the recycled ink.

<2> The increase in the density of ink due to the evaluation form the head recovery unit (I) and sub-tank (S) shall be suppressed as far as possible. The value (V) is a valve that has the characteristic as shown in Figure 9 and is devised so that it can suppress the volume of ink to evaporate in the sub-tank to the minimum.
Further it is important to improve the shield-ability of the rubber cap for the head recovery unit (I).

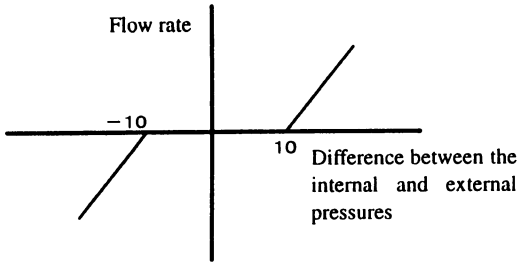

Figure 9. The characteristic of the value

4. Summary

We have introduced a full-color card/label/seal printer using the BJ full-line head and described the detail design for the new ink supply system which includes the recycling of the purged ink.