Optimization Fiber Density Design of Fibrous Ink Retaining Member in the Ink jet Cartridge

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Abstract

In the ink jet printing technology, two types of mechanism were used traditionally in the ink jet cartridge market; the mechanical element and the sponge ink jet cartridge.

In this paper we introduce a new type of pressure regulator in the ink jet cartridge. A bundle of fiber is bundled within a polyethylene film, and inserted into the ink tank of the cartridge. The matrix of the fiber in the fiber bundle is long and straight pipe like structure. The fiber is a good pressure regulator as it provides capillary force to suck the ink and to hold the ink under certain pressure environment

The compactness of the fiber determines the capillary force and the amount of ink that the cartridge can hold it is important to the cartridge designer.

It is found that, the fiber density influences the amount of the residue ink left in the cartridge after depletion, the ink usage efficiency of the ink jet cartridge, and the yield of the ink cartridge. It is suggested to design the fiber density to within the critical fiber density limitation.

Introduction

In the ink jet printing technology, two types of mechanism were used traditionally in the ink jet cartridge market; the mechanical element and the sponge ink jet cartridge. The advantageous of using the mechanical element as the pressure regulator in the ink jet cartridge is that, it is simple and it can retain larger volume of ink in the ink tank. The disadvantageous is that the manufacturing process is complicated and time consuming. The sponge ink jet cartridge uses the sponge capillary force to regulate the pressure in the ink jet cartridge. It is simple and less expensive, but the sponge is space consuming, the volume of the ink it can retain is limited.

In this paper we introduce a new type of pressure regulator in the ink jet cartridge (see figure 1). A bundle of long and continuous tiny fiber is bundled within a polyethylene film; it is inserted into the ink tank of the cartridge to act as the pressure regulator in the cartridge. The matrix of the fiber in the fiber bundle is long and straight pipe like. Fiber is a good pressure regulator as it provides capillary force to suck the ink and to hold the ink under certain pressure environment.

The fiber ink jet cartridge has several advantages over the sponge ink jet cartridge:

1. The matrix of the sponge is porous, it will hold the air in-between the pores, the trapped air will induce the white band problem in the test pattern. The matrix of the fiber is pipe-like structure, it is more aerial, the dissolved air in the ink will be released and pass out to the top of the ink tank.
2. The capillary force of the fiber matrix is higher than the sponge under the same compression condition. So it is able to hold more ink in the cartridge. Hence the efficiency will be higher.

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In this paper we are going to investigate the effect of the fiber density on the amount of ink it can hold and the efficiency of the ink jet cartridge.

Experiment

A number of experiments were carried out to investigate the effect of fiber density on the quality of the inkjet cartridge, which included:

1. The effect of fiber density on the amount of ink left in the cartridge after depletion.
2. The effect of fiber density on the ink usage efficiency.
3. The effect of fiber density on the yield of the ink cartridge.

Test Equipment:

The test equipment used in the experiment were as follows:

1.	Printer	Canon BJC-2000SP
2.	Print head Carriage	BC-21e
3.	Computer	PC with Win 95 OS
4.	Printer Driver	Canon BJC-200SP printer driver
5.	Fiber Bundle	Fiber bundled within the PE film
6.	Cartridge	BCI-21 color and black ink cartridge with bundled fiber replacing the original sponge.
7.	Balance	Balance with the resolution of 0.01g
8.	Test page	The test page with the pattern size of 18.91mm x 16.51mm 100% coverage.
9.	Ink	Yellow, Magenta, Cyan.

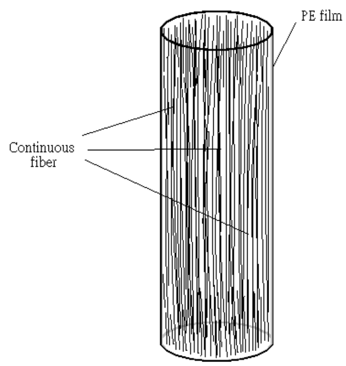

Figure 1. Fiber bundle structure

Precondition:

The printer, cartridges and the fiber bundle were placed at the room temperature and relative humidity for 12 hours conditioning before each consecutive test.

Test Procedure:

1. Insert the fiber bundle into the ink tank of the BCI-21 cartridge. .
2. Use the balance to measure the total weight (W_1)of the cartridge with the fiber bundle.
3. Fill the yellow ink into the ink tank of the cartridge, until the fiber cannot absorb anymore ink, that is when no more ink leakage from the ink filter at the bottom of the ink cartridge. Measure the weight (W_2) of the cartridge with the maximum amount of ink retained.
4. Cap the cartridge with upper cap and put the cartridge back into the print head carriage and fix it in place.
5. Start to print the yellow test page until all the yellow ink in the ink tank is depleted. Calculate the total number of test page printed
6. Remove the ink cartridge from the print head carriage, and remove the upper cap, measure the total weight (W_3) of the ink cartridge again.
7. Repeat step 1~6with the fiber bundle having different fiber density.
8. Repeat step 1~7, but using the magenta ink and magenta test page
9. Repeat step 1~7, but using the cyan ink and cyan test page
10. Measure the surface tension and the viscosity of the ink for each color.

Results and Discussion

The surface tension and the viscosity of the ink are shown in table 1. From table 1, we can see that the surface tension of magenta ink is highest and cyan is lowest. For viscosity, yellow, magenta and cyan has almost the same viscosity of 2.0cps. Both the surface tension and the viscosity effect the ink usage efficiency and the ink left in the cartridge. We investigate their overall effect by comparing with the product, that is the STxVIS with the printing yield of the ink cartridge. The magenta ink has the highest STxVIS, yellow ink has lower, and the cyan has the lowest STxVIS.

Table 1. The Surface Tension and Viscosity of the Ink

	Ink character		
	Y	M	C
ST (dyne/cm)	33.8	34.2	32.9
VIS (cps)	2.0	2.0	2.0
ST x VIS	67.6	68.4	65.8

Note: ST: surface tension; VIS: viscosity)

The Effect of Fiber Density on the Amount of Ink Left in the Cartridge After Depletion

Figure 2 shows the relationship between the residue weight of ink with the fiber density. The residue weight means the amount of ink left in the ink tank of the cartridge after ink depletion. It is calculated as shown in equation 1

$$\textit{Residual ink weight} = W_3 - W_1 \tag{1}$$

The ink cartridge manufacturers tend to design the ink jet cartridge with as little residue ink in the ink tank as possible, in order to achieve the high ink cartridge efficiency. From figure 2, we can see that, the residue weight of the ink cartridge increases rapidly as the fiber density is more than 0.15g/cm3 for the magenta ink, and more than 0.17g/cm3 for both the yellow and cyan ink. It is preferable to design the fiber with the density below 0.15g/cm3 for the magenta ink, and 0.17g/cm3 for the yellow and the cyan ink. The weight of residue ink in the cartridge is almost constant for the fiber density below this value for respective ink. The residue weight in this case is around 1.25g for magenta ink, 1.22g for yellow color and 1.20g for cyan color. It is found from table 1 that the surface tension of the cyan ink is lower than yellow ink, and the surface tension of the yellow color is lower than the magenta color. The ink with higher surface tension will be held more by itself in the fiber, and more residue weight will be found in the ink depletion tank.

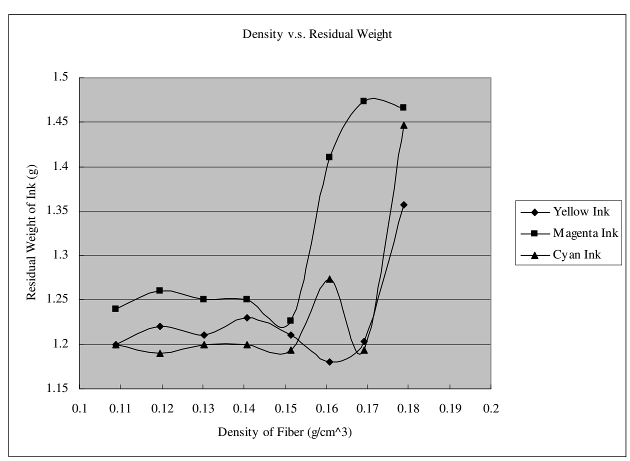

Figure 2. Residual weight versus fiber density

The Effect of Fiber Density on the Ink Usage Efficiency

Figure 3 shows the relationship between the ink usage efficiency with the fiber density. The ink usage efficiency means the amount of the ink usage during the printing process in the ink cartridge before depletion as compare to the amount of the ink added to the ink cartridge. It is calculated as shown in equation 2

$$\text{Ink Usage efficiency} = (W_2 - W_3 / W_2 - W_1) \times 100\% \qquad (2)$$

We hope to design the ink jet cartridge with as large ink usage efficiency as possible. From figure 2 we can see that, the ink usage efficiency of the ink cartridge decreases rapidly for the fiber density more than 0.15g/cm3 for magenta color, and more than 0.17g/cm3 for both the yellow and cyan color. Before these values, the ink usage efficiency increases slowly with respect to the fiber density.

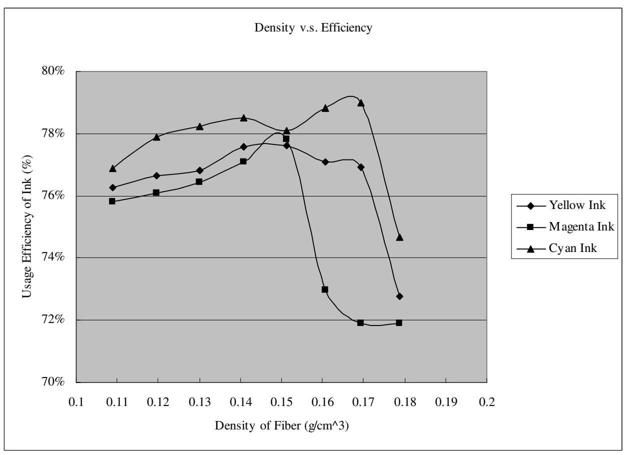

Figure 3. Usage efficiency versus fiber density

The Effect of Fiber Density on the Yield of the Ink Cartridge

Figure 4 is the relationship between the fiber density and the yield of the ink cartridge. We hope to design a cartridge that can print as much test pages as possible before the ink depletion. That is the yield of the cartridge. Before the critical value, the yield of the ink jet cartridge increases slowly with the increases in the fiber density. The yield decreases rapidly when the fiber density is more than 0.16g/cm for cyan and yellow color and 0.15g/cm3 for magenta color.

Figure 5 is the weight of the ink retained in the cartridge when the cartridge with different fiber density is filled up with the ink. From the figure we can see that the weight of the ink retained decreases rapidly when the fiber density greater than 0.15g/cm3 for yellow, magenta and cyan ink. As the fiber density larger than the critical value, the ink retaining ability of the fiber drops rapidly.

From figure 4 and figure 5 we can conclude that when the fiber density exceed certain value, the interface of the fiber is not enough to hold the ink and the ink retaining ability of the fiber in the cartridge decreases. Ink cartridge with lower ink retaining amount will produce lower yield

Conclusions

From the above test results we can conclude that

1. Theoretically, the increase in the fiber density will cause the increase in the residue weight in the ink cartridge, decrease in the cartridge yield, and decrease in the ink usage efficiency. From the experiment, we can see that as the fiber density reaches a certain critical point, there will be rapid changes in the residue weight, the ink usage efficiency and the cartridge yield. The critical fiber density is an important factor in the fiber bundle design in the ink jet cartridge.
2. The critical limitation of the fiber density for magenta ink is about 0.15g/cm3, for yellow and cyan is about 0.16g/cm3
3. Practically, we will not design the fiber bundle with different fiber density to increase the assembly complication and the mass production cost. It is preferable to design the fiber bundle in one standard with the fiber density of below 0.15g/cm3. The range 0.14 to 0.16g/cm3 is acceptable.

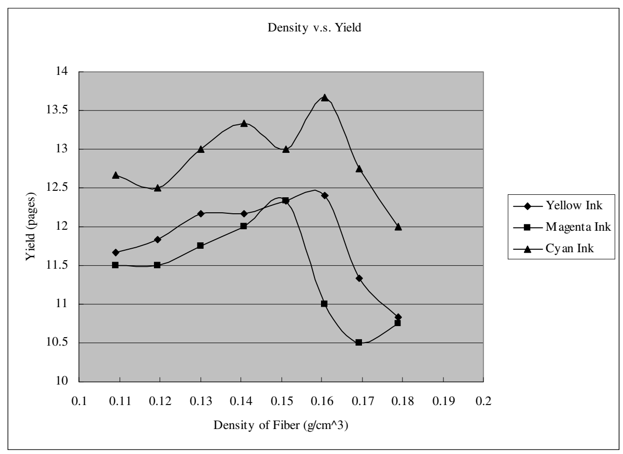

Figure 4.Yield versus fiber density

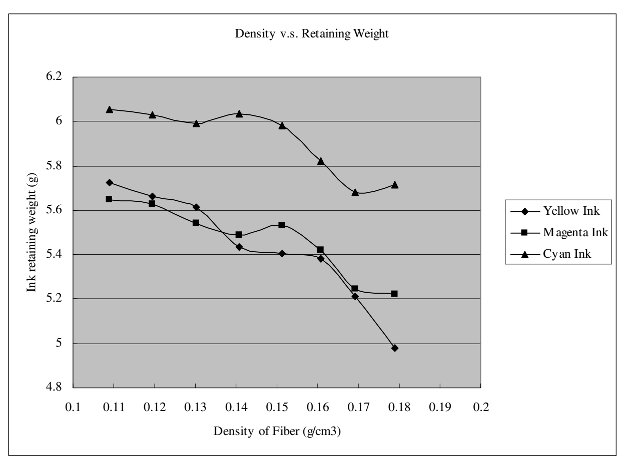

Figure 5.Ink retaining weight versus fiber density

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Biography

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