The Effect of Relative Humidity on the Toner in the Developing Process

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Abstract

In the image developing process, the latent electrostatic image on the photoconductive surface is converted into visible by the deposition of the toner particles on the photoconductive surface. The toner is either dual components or mono-component developers.

In the mono-component development system, the magnetic toner is held by the magnetic forces on the sleeve, the toner is moved around the sleeve spaced several hundred micrometer from the photoreceptor, under the electric field the magnetic toners jump over the gap onto the photoconductor.

It is found that, the optical density and the background of the printed image is dependent on the relative humidity of the toner. Hence, we investigate the causes by the measurement of Q/M or Q/A of the toner under different humidity. As the humidity increases, the water film will induce the instability of the electric charge, so the Q/M will decreases, but Q/A. increases.

Introduction

In the image developing process, the latent electrostatic image at the photoconductive surface is converted into visible by the deposition of the toner particles on the photoconductive surface.

The amount of water vapor in the air influences the print quality. The higher the relative humidity, the more electrically conductive the air. The low relative humidity has lower conductivity. The relative humidity greatly affects the toner charging.

In the high-end laser printers, relative humidity sensors are used, and adjustment are done to eliminate the humidity effect on the print quality. These are not usually the mono-component toner printer.

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In this paper, we are going to investigate the effect of the relative humidity on the mono-component toner only.

Experiment

A number of experiments were carried out to investigate the effect of the relative humidity on the mono-component toner, which included:

1. The effect of relative humidity on the Q/M of the toner.
2. The effect of relative humidity on the M/A of the toner.
3. The effect of relative humidity on the optical density of the print image.
4. The effect of relative humidity on the background of the print image.
5. The effect of the relative humidity on the toner particle size ejected onto the OPC drum.

Test Equipment:

The test equipment used in the experiment were as follows:

1. **Printer**. HP LJ 4000
2. **Cartridge**. HP C4127X
3. **Q/M meter**. Q/M was measured by a vacuum-sucking unit that takes toner samples from the OPC drum. The head of the sucking unit has a curvature surface of one cm^2 fitted onto the OPC drum surface. Inside the unit, a filter with the pore size of 0.5 μ was used to capture the toner. A coulomb meter was used to measured the charge of developed toner,
4. **Balance.** The balance used to measure the toner having a precision of ± 0.01g, and readability of 0.1g.
5. **Humidity chamber**. A humidity chamber with an adjustable humidity range of 20~90 %RH was used.
6. **Densitometer**. Densitometer with the incident angle of 45 degrees is used to measure the optical density and the background.
7. **Smart box**. Used to print the standard print pattern.
8. **Toner-size analyzer**. A machine used to measure the toner particle size and distribution.

Precondition:

The cartridges and the printer were placed in the environmental chamber for 12 hours conditioning before each consecutive test. An opening is made on the cartridge to let the toner inside the cartridge to be in contact with the air in the humidity chamber. The toner-stirring agitator is made to rotate to provide even humidity affect on the toner for each three-hour interval.

Test Procedure:

1. Insert the test cartridge in the laser printer and leave them in the humidity chamber. Adjust the humidity of the chamber to the temperature of 30 degree Celsius and 90%RH. Leave the printer and the cartridge in the chamber for 12 hours conditioning. Stir the toner agitator for each three hour-interval.
2. Switch on the printer and use the smart box to print a black page and a white page simultaneously.
3. Use the densitometer to measure the optical density and the background of the black test page and white page respectively.
4. Start the black page printing again, but stop the printer intermediately before the toner image on the OPC is transferred onto the test paper.
5. Withdraw the cartridge, to reveal the toner leave on the OPC drum. Use the sucker head of the sucking unit to suck the toner attracted on the OPC.
6. Use the charge meter to measure the charge of the sucked toner.
7. Measure the toner mass per unit area by weighing the filter of the sucking unit before and after toner suction
8. Calculate the charge to mass ratio of the toner by dividing charge by mass measured in step 6 and 7.
9. Take a sample of the toner attached on the OPC; use the toner diameter analyzer to investigate the toner size distribution.
10. Repeat step 1~9 under the relative humidity of 65% RH and 40% RH respectively.

Results and Discussion

The Relationship Between Q/M and the Relative Humidity

Triboelectric charge is defined as charge divided by mass or Q/M. The Q/M was observed to be inversely proportional to the relative humidity as shown in Figure 1. During the low humidity, toner charges to a higher level. At the higher humidity, toner absorbs more water; it would be more difficult to charge and to hold the charge.

The Relationship Between M/A and the Relative Humidity

The mass of the toner particle per unit area attached onto the OPC is denoted as M/A. From Figure 2, we can see that M/A is inversely proportional to the relative humidity. At low humidity, the toner charges to a higher level, it is more difficult for the toner to leave the sleeve. Therefore, the toner mass measured per unit area on the OPC will be lower.

The Relationship Between Optical Density and the Relative Humidity

Only larger particles with lower triboelectric charge are moved onto the OPC drum surface, so the image density will drop as the larger particles are depleted. From Figure 3, the optical density was observed to be directly proportional to the relative humidity.

The Relationship Between Background and the Relative Humidity

Most of print background problems are related to undercharged toner. When the humidity is high, the toner will be undercharged, then the toner will attracted to the white area of the pages causes print background problem. The larger size particles have lower tribo-electric charge and may be print in the white areas because they are not as strongly attracted to the discharged areas of the OPC. From Figure 4 we can see that the background increases as the relative humidity increases.

The Relationship Between Toner Particle Size and the Relative Humidity

Different toner particle sizes will be charged to different level. At the lower humidity, the toner will be overcharged; the mutual attraction between each toner particle limits the ability of the magnetic sleeve voltage to push the toner towards the OPC. Only larger particles with lower triboelectric charge are moved onto the image density. From Figure 5, we can see that, toner with the larger particle size was found jumped onto the OPC when the humidity is low. The toner manufacturer tried to produce toner with a very narrow particle size distribution. The more uniform the toner particle size, the more predictable its performance will be.

The triboelectric charge property of the toner at the developing roller greatly influences the image print quality. The toner with a high triboelectric charge will be clumped to the developer roller and difficult to leave the developing roller. Only the larger particle with lower triboelectric charge will move to the OPC, the image density will drop. If the triboelectric charge of the toner is low, the larger size particle have lower triboelectic charge and not as strongly attracted to the discharge area of the OPC, print background will be experienced. Besides the print quality, the yield of the cartridge is influenced by the print density of the image.

The relative humidity greatly affects the toner charging. It is the changes in toner charges, which induce the entire related humidity problem. The problem induced as the relative humidity decreases is summarized in Table 1.

Conclusions

Since the quality of the laser toner cartridges is dependent on the yield and the optical density of the test image. The yield of the printer cartridge is inversely proportional to the optical density of the print image.

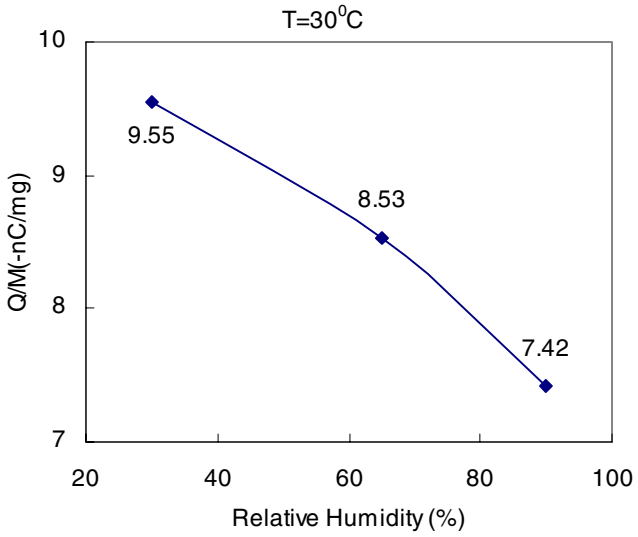

Figure 1. Q/M versus relative humidity

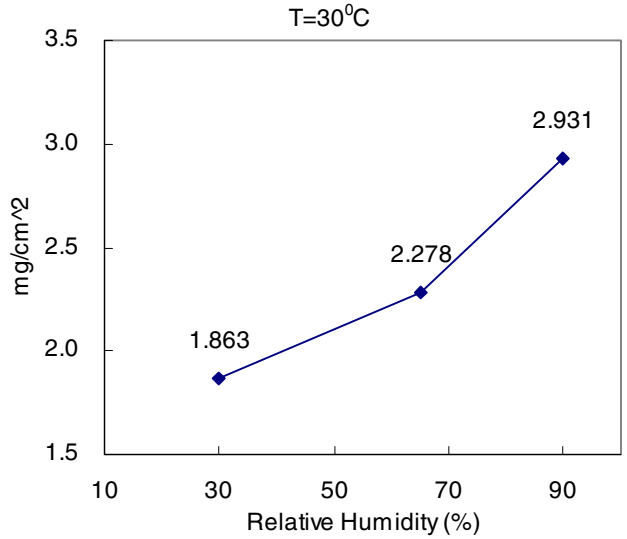

Figure 2. M/A versus relative humidity

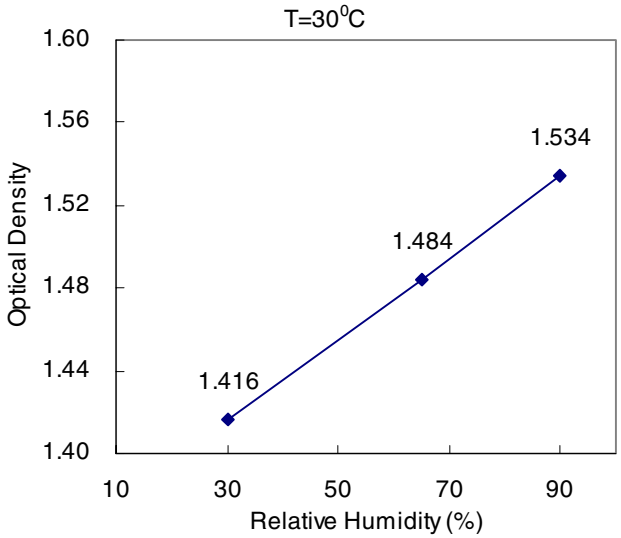

Figure 3. OD versus relative humidity

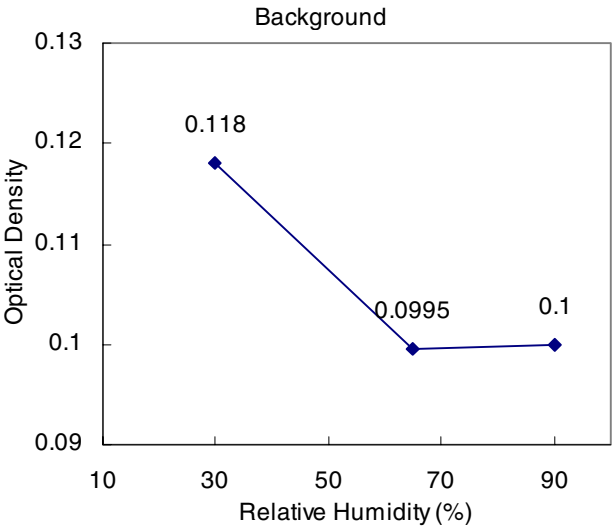

Figure 4. Background versus relative humidity

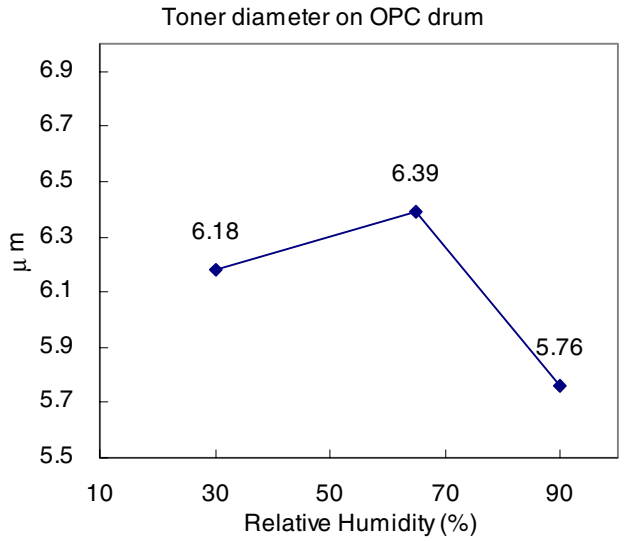

Figure 5.Toner particle size versus relative humidity

The goal of printer designer is to achieve the highest development efficiency by having the largest mass of toner transferred to the OPC using the lowest toner charge possible without creating print background.

From the above tests, we deduced that optical density and the background of the print image is effected greatly by the relative humidity of the environment due to the water film which induce the instability of the electric charge. These factors should not be ignored in the design of the development system.

Table 1. The Influence of the Toner Properties with Increases in Relative Humidity

Q/M	Decreases
M/A	Increases
Optical density	Increases
Background	Increases
Cartridge Yield	Decreases
Toner particle size on OPC	Larger particle size on OPC surface

References

1. Lester Cornelius, R Humidity and Print Quality: Balancing Cartridge Component Properties, Recharger, and pg. 54. (1997.5)

Biography

Howard Liu received his Ms in the opto-electricity in the National Central University in Taiwan. He is the Opto-electric engineer in the printing Technology Department, Opto-electronics and System Laboratories, ITRI, Taiwan. He had been involved in the research on the electro-photography for six years. working not only on the designing of laser printer but also the laser cartrtidge and the F-theta lens design.