Image Quality Improvement by Embedding Toner into a Special Resin –coated Layer in Digital Electrophotography

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Abstract

We have developed a receiving sheet which has a special resin-coated layer on the top that meets the demands for image quality in digital electrophotography. The special resin-coated layer reduces the differential gloss-this is defined as the difference between the maximum and minimum gloss of the image. The differential gloss is reduced because the transferred dry toner particles on the surface of the sheet are easily embedded into the resin-coated layer during the fixing process by heat and pressure; and therefore the layer exhibits uniform gloss, independent of the density of the fused toner. Embedded surface has been confirmed using a gloss meter and an interferometric microscope. This uniformity makes the image quality of electrophotography as high as that in offset printing.

On the other hand, in the case of a sheet coated with conventional resin or pigment, the dry toner particles on its surface are not sufficiently embedded. Since this non-embedded toner results in the surface roughness of the image on the sheet, the differential gloss between the printed and non-printed areas is greater, and depends on the area covered with fused toner. This non-uniformity of gloss lead to poor image quality in electrophotography.

In general, the image qualities of receiving sheets used in digital electrophotography are evaluated by measuring graininess, edge sharpness, color reproduction, gloss and differential gloss. Although not dealt with in this proceeding, at the 17th conference we describe the relationship between the image qualities mentioned above and the characteristics of the special resin, such as its molecular weight and glass transition temperature.

Introduction

In past few years, the color printers based on electrophotographic copying machine spread rapidly from "Office document reproduction " to a "Print on Demand" market. This is because electrophotographic technology has advanced to allow high speed, high quality and easy handling of variable digital data.

Over the years, several research groups have investigated the difference in image quality between electrophotographic, offset and silver photographic printing.[1]

In general, the image qualities of printed sheets are evaluated by measuring graininess, edge sharpness, color reproduction, gloss and differential gloss. The gloss uniformity of an image printed by electrophotography is generally lower to that achieved by offset and photographic printing.

The image printed through electrophotography (dry toner system) is formed with toner particles of ca. 7 µm, which consist of Y, M, C and K colors. The toners is transferred on to the surface of the sheet and fixed by heat and pressure. Since the toner generally makes the printed area glossy, the differential gloss of image in electrophotography is greater, dependent on the density of the fused toner.

Recently several approaches have been proposed in order to improve the uniformity of gloss in electrophotography. For example, a lamination technique can be used: this covers the printed and non-printed areas with a thin glossy film, which is applied to even out the surface roughness.[2,3]

However, this system requires a large machine with which to carry out the lamination. Its initial cost and running cost have precluded its in this market. A simpler method is clearly preferable from an industrial point of view.

In our research program, we have focused on media to improve the uniformity of gloss in electrophotography. For example, we have investigated a matter-type sheet having a microporous layer on the top. This microporous paper sheet exhibits quite low differential gloss, independent of the density of the fused toner. We have already succeeded in commercializing such paper sheet and reported the characteristics of this sheet, with particular emphasis on its microporous layer, at the 16th conference in 2000.[4,5]

In addition, we have recently developed and comercialized another paper sheet, which exhibits high gloss as well as low differential gloss. This is because the transferred dry toner particles on the surface of the sheet are easily embedded into the special resin-coated layer during the fixing process by heat and pressure; therefore the layer exhibits uniform gloss, independent of the density of the fused toner.

In this present work, we observe the effect of the surface roughness of the sheet after printing using a specula gloss meter and a white light interferometric microscope (Zygo).

We will also describe the relationship between the image qualities and the characteristics of the special resin, such as its molecular weight and glass transition temperature.

The Technology for Embedding Toner into the Resin-Coated Layer

Mechanism for Embedding Toner into the Resin-Coated Layer

The mechanism for embedding toner particles into the special resin-coated layer of our receiving sheet, namely high glossy paper, is described in Figure 1.

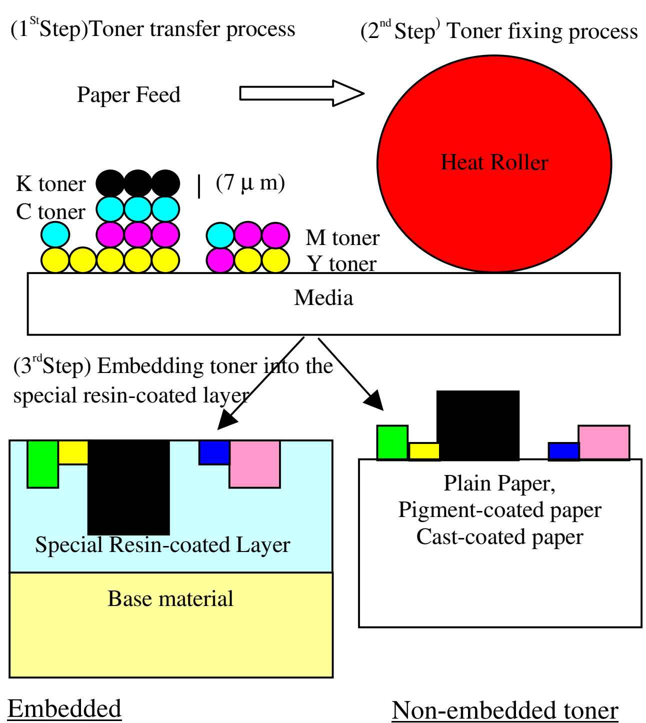

Figure 1. Mechanism of embedding toner into special resin-coated layer

(1st Step)

During the toner transfer process, the dry toner particles of 7 µ m are transferred onto the surface of special resin-coated layer.

(2nd Step)

During the toner fixing process, both the toner particles and the special resin layer are softened by heat from the heat roller.

(3rd Step)

The softened toner particles are embedded into the special resin-coated layer by pressure.

When using pigment-coated paper for offset printing, cast-coated paper and plain paper, dry toner particles on their surfaces are not sufficiently embedded. The surface roughness leads to non-uniformity of gloss.

The Characteristics of the Special Resin for Embedding Toner

Considering that the driving forces for embedding the toner are heat and pressure from the roller during the toner fixing process, the characteristic of the resin such as molecular weight, its distribution, glass transition temperature and its miscibility with the toner play important roles.

- glass transition temperature
- molecular weight
- molecular weight distribution
- miscibility of the special resin and toner

Structure of High Glossy Paper

A schematic diagram of the cross-section view of our high glossy paper is shown in Figure 2. It has a special resin-coated layer on top which acts as a toner embedding layer; a pigment-coated layer in middle which acts as a protection layer for controlling the penetration of the special resin into the base paper; and the pigment-coated layer on back which acts as a curl control layer.

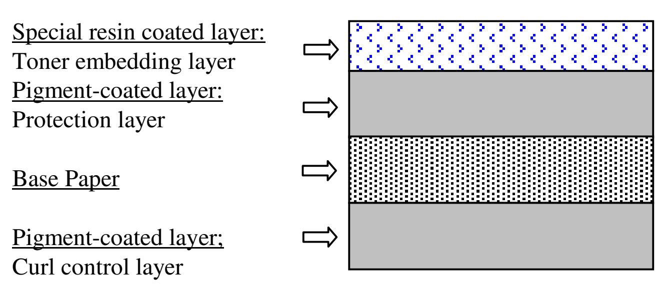

Figure 2. Schematic diagram showing the cross-section view of high glossy paper

Evaluation of Uniformity of Gloss on the Printed Area

The target of high glossy paper, microporous paper, cast-coated paper, pigment-coated paper and plain paper were printed using the Docu Color1250 manufactured by Fuji Xerox Co., Ltd. Then the gloss of these test targets was measured as a function of the solid fill area covered with toner using a specula gloss meter at 75°.

Figure 3 shows the image gloss of paper sheets as a function of the solid fill area covered with toner.

In the case of cast-coated and pigment-coated, although the gloss of non-printed area exhibits relatively high, lower gloss is observed at a solid fill area of 10-20%. As a result, the differential gloss of the cast-coated and pigment-coated paper is about 40% and 50%, respectively.

With plain paper, in spite of the low gloss of the non-printed area, as the solid fill area increases, the gloss increases up to 45% at a solid fill area of 100% and then the differential gloss is about 40%.

We found that the problem with cast-coated, pigment-coated and plain paper is their high differential gloss that leads to poor image quality.

On the other hand, the gloss of our high glossy paper exhibits constantly close to 100%, independent of the solid fill area, and hence the uniformity of gloss is quite high.

Our microporous paper maintains its gloss around 10% and the gloss is not influenced by the solid fill area very much.

This is because the transferred toner particles on the surface of the microporous paper are embedded into the pores.

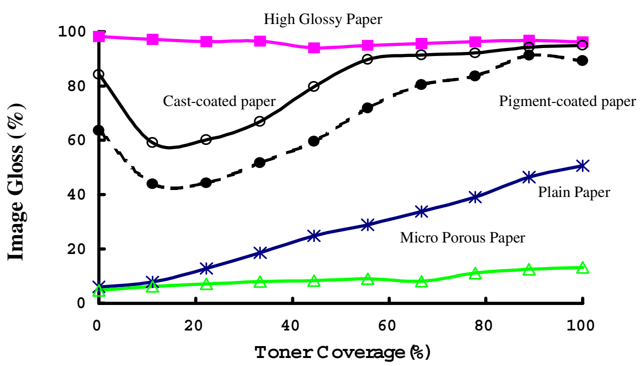

Figure 3. Gloss of paper sheets as a function of the solid fill area covered with toner (Magenta + Yellow) (Printed by Docu Color 1250)

Microscopic Observation of Image Structure

The test targets of high glossy and cast-coated paper printed by Docu Color1250 were characterized in terms of their structures using a white light interferometric microscope (Zygo New View Microscope). This microscopic study enables us to observe the three-dimensional structure of the printed image with toner and to measure the distance between the surface of the sheet and the top of the toner.

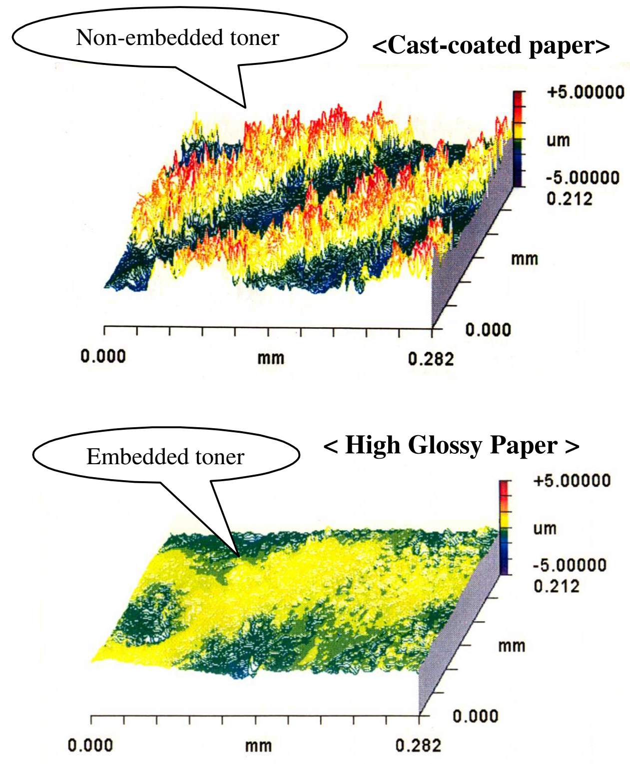

Figure 4. Three-dimensional structure of printed areas of high glossy and cast-coated paper at 50% solid fill area of cyan (Printed by Docu Color1250)(Bird's-Eye View Analysis by Zygo)

Figure 4 shows the three-dimensional structure of the printed areas of high glossy paper and cast-coated paper at 50% solid fill area of cyan.

In case of high glossy paper, the distance between the surface of the sheet and the top of toner is less than 1 μ m, while that of cast-coated paper is more than 5 μ m.

This observation suggests that with high glossy paper the dry toner particles on the surface are easily embedded into the region of the special resin-coated layer during the fixing process, while with cast-coated paper the particles are not sufficiently embedded.

Light Reflection on the Printed Area

The special resin-coated layer is to reduce diffused reflection of light on the print surface because the dry toner particles on the surface of the sheet are embedded into its layer (Figure 5-a).

On the other hands, in case of microporous paper, although the fused dry toner particles are penetrated into the pore of microporous layer, the diffused reflection of light on the print surface is quite high due to the influence of roughness of microporous surface (Figure 5-c).

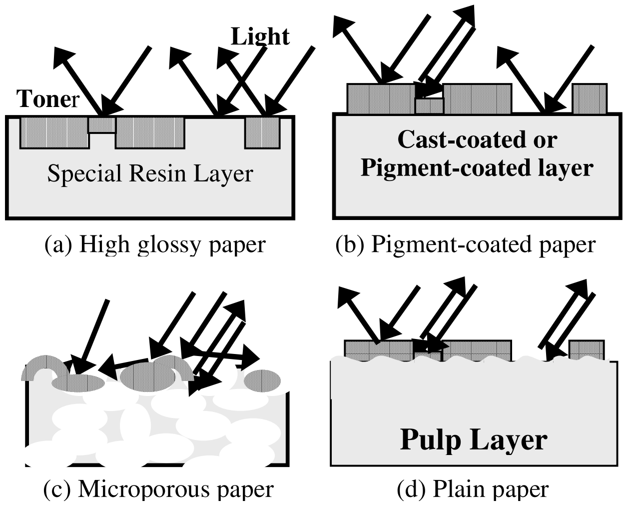

Figure 5. Light reflection on image

In case of cast-coated, pigment-coated and plain paper, it is difficult to reduce diffused reflection of light on the print surface because the dry toner particles on its surface are not sufficiently embedded (Figure 5-b, d).

Print Qualities of High Glossy Paper

High glossy paper, pigment-coated paper for offset printing and plain paper were evaluated for use in electrophotography in terms of their optical density, color reproduction and mottle using several test targets printed by Docu color1250. Our high glossy paper has at least three advantages relative to the pigment-coated paper and plain paper: (1) the higher optical density of the image, (2) the wider color reproduction range and (3) the quality of the half-tone mottle.

- the higher optical density
- the wider color reproduction range
- the quality of half-tone mottle

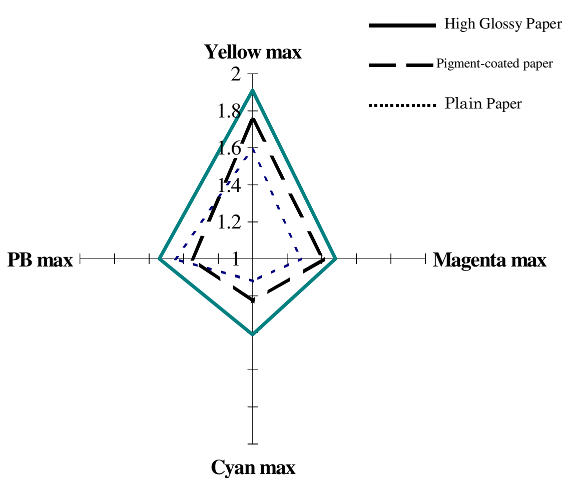

Figure 6. Optical Density of Images printed on high glossy paper, pigment-coated paper and plain paper

Durability of the Printed Image

The durability of paper and its printed image is key for applications such as photography, poster and catalogues.

Our high glossy paper exhibits excellent durability with respect to water resistance, light resistance etc.

- light resistance
- water resistance

Conclusion

Our high glossy paper exhibits excellent characteristics as regards the optical properties required for use in electrophotography. It exhibits both high gloss and quite low differential gloss. This is because dry toner particles on the surface of the sheet are easily embedded into the special resin-coated layer during the fixing process. The other characteristic of our high glossy paper such as print quality is higher than that of other conventional paper sheets. Therefore there is no doubt that high glossy paper can improve the image quality in electrophotography.

In the future, we believe that our high glossy paper meets the demands of the "Print on demand" market and has the potential to expand the market.

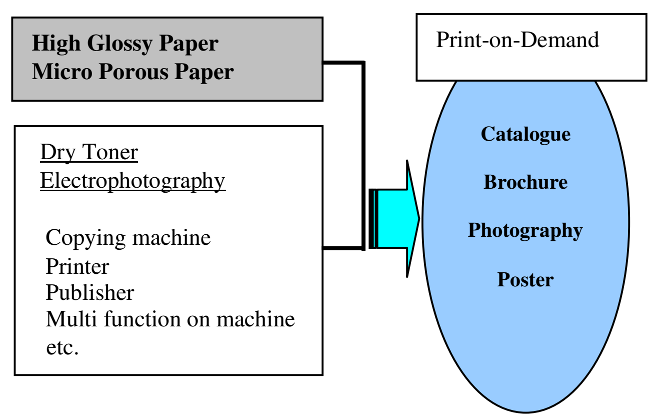

Figure 7. Expand of Electrophotography Market

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Biography

Tomofumi Tokiyoshi is a senior research scientist at Oji Paper Company. He received his M.Sc. in Applied Chemistry from Kagoshima University and then joined the Tomioka mill at Oji in 1986. He has been at the Imaging Media Development Laboratory at Oji since 1988. He worked on the receiving sheet for thermal wax/resin transfer printing from 1988 to 1994. His current interest is the development of media for digital electrophotography.