

Differential Gloss in Electrophotography

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Abstract

Differential gloss is the gloss difference between substrate and the imaged areas and between imaged areas of different toner lay-down. This study is to determine the amount of differential gloss on an EP print that's visually unacceptable. Our experience and previous studies indicate that certain amount of gloss is desired on EP prints regardless of paper types. And too much differential gloss might not be acceptable by the end users. Two experiments were conducted using several EP engines with various fusing controls to generate prints with a wide range of gloss and differential gloss. The finding is that differential gloss is not an issue as long as the finished surfaces of an image is perceived uniform.

Introduction

Due to the fusing temperature variability of an Electrophotographic process, the printed images could have different surface appearance. With a high fusing temperature, the image area will appear glossy. When the fusing temperature was low, it might create a matte appearance on an image. Also, when fusing temperature was held constant, high toner lay-down could provide a gloss finish while low toner lay-down could result in a matte finish. Other than controlling the fusing temperatures, different techniques like finishing roller or lamination could be applied on EP prints to create glossy looking finish. Based upon experience and previous studies, we had learned that some gloss on EP prints is desired. It enhances contrast and saturation of the image especially for uncoated papers. It also had been observed that prints with surface glare generated by a high gloss finish made reading anything printed on that surface difficult. The unanswered question remains as at what level the differential gloss of an EP print became visually unacceptable. This study was designed to provide answer for the question.

Previous Work

There was a study of preferred gloss in a 1996 TAGA paper.[1] Several things should be noted in that work. The visual effect of gloss was not kept separately from saturation. These two variables were evaluated together on sample prints. Individual color toner's gloss behavior was not investigated. Gloss readings on the saturated colors of cyan, magenta, yellow, red, blue, and green were taken and averaged to give one single reading to represent the overall gloss condition of sample prints at each fusing condition. Gloss readings of black and the less saturated colors with low toner lay-down were not measured. These less saturated colors tend to give a matte finish and some of them will have lower gloss readings than that of the papers.

Experiment

The simple and straight forward design of experiment is to keep all the variables constant and allow only the one in question to change in a controlled manner. In this study, the primary concern is gloss and differential gloss and the secondary one is substrate type. At the first part of the experiment, a series of sample prints on the Russell & Fields Silverblade 130 gsm semi-gloss paper were generated by the Xeikon DCP30 machine with a wide range of gloss levels. This was accomplished by varying the fuser and finishing rollers temperatures within allowable range provided by the Xeikon DCP30. There were twenty different fuser/finishing settings all together. Ten sample prints were made for each condition. Then, the same procedure and conditions were repeated on the Russell & Fields 4CC 130 gsm paper to generate the same number of prints on a matte finish substrate.

Each sample print is 11" by 17" in size, printed on one side only. It consists of a flesh-tone image, a high-contrast image of shining metal parts and dark background, two paragraphs of 12 point Times New Roman fonts, and seven steps tone scales of cyan, magenta, yellow, black, red, green, blue, and three-color. These steps were designed to provide a range of total area coverage from 10% to 300%. 60 degree geometry gloss measurements were made on each step of the tone scales with a Gardner micro-TRI-gloss glossmeter. There were fifty six gloss readings of each sample print. Readings taken from ten repeat sample prints were averaged to give a single set of fifty six readings for each fuser/finishing condition. These gloss readings were plotted against percent coverage for each color of the tone scales. Cyan, magenta, yellow and black all share similar curve shape and behavior.

Paper gloss was also measured with the same glossmeter and geometry on each print then, the average was taken. Paper gloss readings were evaluated together with the fifty six tone step readings averaged for each condition. The differential gloss was then calculated by taking the difference between the biggest and the smallest gloss readings at each condition. The range of the differential gloss of this study is between 5 and 28 gloss units.

Subjective Evaluation

To understand the relationship between perceived differential gloss and physical measurements of gloss readings, rank order psychophysics experiments were conducted with 30 qualified observers on each group of twenty sample prints on two different substrates. The JND of differential gloss is around 20% of paper gloss for glossy stock and 15% of paper gloss for matte stock. There was no significant perceived difference between prints at this level. Statistical significance can be observed on prints that have three times or more JND difference.

In addition to rank ordering, observers were also asked to indicate where on their ranking scales the differential gloss became unacceptable based upon their experience of high-quality printing products. Although observers ranked sample prints differently, all the sample prints were identified as acceptable by all the observers. To confirm this finding, the whole experiment was repeated on an IBM Info70 machine. This machine uses the same engine as the Xeikon DCP30 but has a different front-end. The substrates, toners, procedure, and fuser/finishing conditions were kept the same as in the previous experiment. The results obtained this time are statistically identical to the results of the previous experiment. There was no unacceptable sample prints from this experimental design. This situation proposed a question, is the range of differential gloss in this study not wide enough? It needs to be extended to fully understand the effect and impact of the variable.

Second Experiment

The Xerox DC40 machine was used on five different paper types with two paper settings to generate the desired wide range of differential gloss in this part of the study. The five paper types were ColorTech 90 gsm, Enso 4CC Art 130 gsm, Enso 4CC Art 170 gsm, ChromoLux 135 gsm, and Lustro Laser 118 gsm. These are all high quality paper stocks with gloss or matte finish. The two paper settings provided by the Xerox DC40 are plain and thick or normal and heavy. These paper settings allow prints to pass through fuser at a different speed hence give gloss or matte finish to the final prints. The same test page was printed here. And sample prints of each condition were collected for evaluation. Gloss readings were obtained using the same Gardner glossmeter. The range of differential gloss was widened. It's between 22 to 60 gloss units. Black toner behaves differently and has higher gloss than that of cyan, magenta, and yellow. Color difference was minimized through the use of color management software. And there is no significant saturation difference between sample prints of different paper types and paper settings.

Rank order psychophysics experiments were conducted and the same thirty observers were asked to ignore the slight color differences between sample prints when making their judgments and decisions. The result was that all the sample prints from this experiment were not acceptable except the ColorTech 90 gsm. Observers were not bothered by the high gloss but found the uneven finish and the almost three-dimensional surface relief of the image areas very objectionable.

Conclusion

For the two types of electrophotographic machines investigated in this study, differential gloss bigger than 30 gloss units is not desirable. Because this tends to generate unwanted surface artifacts on image areas that are objectionable to customers who are used to high-end printing products. However, this phenomenon is highly machine dependable. Electrophotographic machines could be built to provide highly gloss images without unwanted surface artifacts. In fact, printing process prints images with uniform finished high gloss is a very desirable feature. The printer's ability to provide high gloss surface finish is useful to many applications. The key issue here is that the surface finish has to be uniform and without unwanted artifacts. Therefore, the level of differential gloss is not an issue in high-end graphic arts products as long as the surface finish of the image areas is kept uniform.

Reference

1. Edul N. Dalal and Paul C. Swanton, *TAGA Proceedings*, 1996, pg. 195 - 205.

Biography

C. Jeffrey Wang is a senior scientist at NexPress, a Kodak/Heidelberg joint venture. He had worked at RIT Research Corporation from 1987 to 1996 as one of their research scientists. His research interests are Color Reproduction and Electronic Imaging. He holds an MS degree from the Center for Imaging Science at RIT.