Analyzing Print Quality of Large Printed Area of Toner-based Press

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Abstract

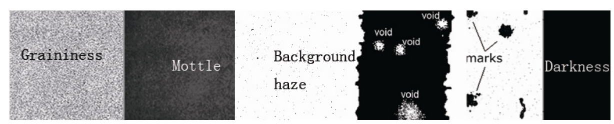
Image quality attributes are important keys for evaluating quality of printed areas. According to ISO 13660 (2001), the first international standard for digital printing, describes a set of image quality attributes for large area including graininess, mottle, darkness, background haze, and voids. Most research about image quality is focused on graininess and mottle. There were very limited reports about image quality of darkness, background haze, and voids. Image quality evaluation in large area is a multi-parameter process. The parameters include printing processes, inks, substrates, and RIP quality. It is necessary to understand the image quality attributes of all aspects. In this paper, the image quality parameters of large area are analyzed based the prints output by a HP indigo press. Different paper types and halftone screen rulings were considered for evaluating the print quality of large area. The result suggested that the image quality attributions defined in ISO 13660 (2001) could be used for evaluating image quality of solid and halftone areas.

Introduction

Image quality evaluation is a complicated process. There are two common evaluation methods, which are objective and subjective assessment. The assessment methods involve quantitative analysis and perceptual analysis [1]. In fact, adding perceptual factors to the evaluation is subjective but not quantitative.

ISO 13660 (2001) – Information Technology - Office Equipment - Measurement of image quality attributes for hardcopy output - Binary monochrome text and graphic images, is proposed by ISO/IEC JTC1/ SC28 [2]. It is the first international standard that provides quantitative evaluation of fundamental printed attributes for large areas and lines [3]. It also defined the measurement methods for studying those attributes. ISO 13660 (2001) is originally defined for image quality assessment of monochrome text and graphic images. It is now extended to color image measurement.

Among all the attributes, graininess and mottle are often considered as most important parameters. The other four attributes are not often studied. As defined in ISO 13660 (2001) [2], background haze is measured as the average optical density of the region of interest (ROI), by using an aperture that has an area of at least 19.6mm and a minimum dimension of 5 mm., as shown in Figure1(c). Darkness is calculated the mean of means of the area of each divided superpixel in ROI, as shown in Figure1 (f). Mottle is defined as aperiodic fluctuations for density at a spatial frequency less than 0.4 cycles per millimeter in all directions, as shown in Figure1 (b). The measurement of mottle across the ROI is calculated as the standard deviation of means. Graininess is defined as aperiodic fluctuations of density at a spatial frequency greater than 0.4 cycles per millimeter in all directions, as shown in Figure1 (a). The measurement across the ROI is calculated as the mean of standard deviations. Extraneous marks is defined as colourant particles or agglomerations of colour particles in the background area visible as distinct marks at standard viewing distance to the unaided eye, as shown in Figure1 (e). The measurement is for the area within the edge threshold of each mark of at least 100 micrometers in the smallest dimension. Voids is defined as visible holes or gaps within a solid image area which are large enough to be individually distinguished at standard viewing distance by the unaided eye, as shown in Figure1 (d). The measurement is done to the area of each hole of at least 100 micrometers in the smallest dimension within a nominally solid image area.



(a)Graininess (b) Mottle (c) Background haze (d) Voids (e) Extraneous marks (f) Darkness

***Figure1.** Large area quality attributes*

Extraneous marks related to the error of toner inking signal, image carrier defect, and false inkjet drops [4]. It is an intermittent phenomenon [5]. Sometime this problem may be solved by using heavy weight paper. Sometime the paper size has influence to the problem. Sometime it is related to the mechanical problem of the printer or press. In this case, the suggested solution is to contact a certified technician and/or check printer documents.

Background haze means large amount of small drops and piles of toners appearing intermittently in a relatively straight line down the page as it could not be found with naked eyes. Toner builds up behind this “dam” and intermittently spills out around it [6]. A fine printer can be used without background haze due to the quality of the driver. A new set of toner cartridges may solve the problem as well[7]. Paper surface is considered as the another reason for this problem..

Void is white spot, line, or area that should be black. It can be temporary, intermittent, might move across printing page, or always appear in the same area, or get progressively worse. It is normally caused by the developer, transfer corona wire, fuser roller and/or paper structure. [6] .

Digital printing paper types, toner particle sizes, and screen rulings could affect image quality at different levels. This study was to compare six different image quality attributes, including darkness, background haze, graininess, mottle, extraneous marks, and background voids, on large printed areas. The test targets were printed with different types of paper, including coated and uncoated paper, and different screen rulings for comparison purposes.

Experimental

Test target was designed in Illustrator and output as PDF file. The file was RIPed by the HP Indigo 5500. There are two parts in the test target. One part has screened cyan, magenta, yellow, and black color patches ranged from 10 percent to 100 percent with step of 10 percent (Figure 2). Another part has solid cyan, magenta, yellow and black color patches with size of 30*30 mm. The distance between two patches is 10mm for testing extraneous marks, background haze and voids.

In the first part of the experiment, different type papers were used to output for understanding the effect of paper types to darkness, graininess and mottle. The papers used were 200g/m^2 gloss coated paper, 200g/m^2 matte coated paper, 200/m^2 uncoated fine art paper (texturized) and 100/m^2 uncoated paper (smooth finishing). The targets were printed with same resolution (dpi) and screen ruling.

The second part of the experiment is to print the targets with different screen rulings. Different screen rules used were 144lpi, 175lpi and 230lpi. The substrate used was gloss coated paper. This experiment was to test the effect of screen ruling to darkness, graininess and mottle.

All printed the targets were measured by a flat-bed Epson scanner with a resolution of 2400dpi. The scanned images were analyzed using the image quality analysis Expert system , which is developed according to the definitions defined in ISO 13660 (2001).

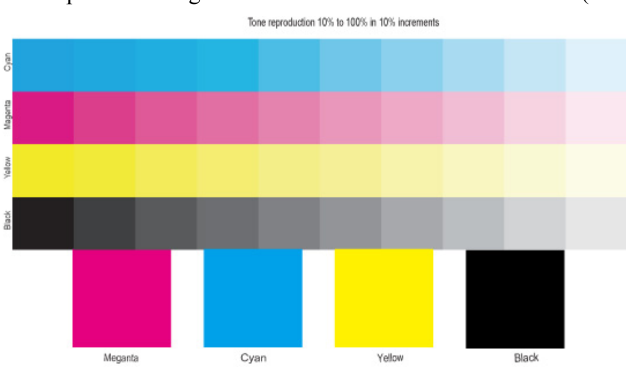


***Figure2**. Test Targets for testing darkness, graininess, and mottle. The upper wedges are screened cyan, magenta, yellow, and black patches. The bottom patches are solid magenta, cyan, yellow, and black for testing.*

Results and Discussions

Background haze, extraneous marks and voids were measured as part of the six image quality attributes. Ideally, there are no such image quality defects if the press works appropriately. The results were shown in Figure 3.

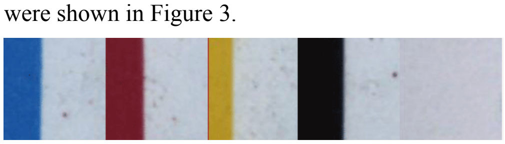


***Figure3.** Background haze, extraneous marks and voids were scanned by an Epson scanner and measured by the imaging software..*

The extraneous marks can be seen from the scanned images on the blank area (the part next to the solid color patches in Figure 3). It may be due to the error in inking signal on image carrier or inappropriate paper types. The exact reason that caused extraneous marks needs to be researched further in the future. There was no void could be detected by naked eyes on the solid patches. It may indicate that the toner filled the surface of paper completely in the solid area. There was no background haze detected, which may indicate that HP Indigo 5500's liquid toner could avoid this problem due to the specific ink characteristics.

Graininess

Graininess is as micro-uniformity, which is related to the variation of optical density. According to ISO 13660 (2001) measurement methods, solid area is sampled at least 161mm^2, the smallest dimension of one side is at least 12.7mm. Divided the ROI into at least 100 uniform squared tiles, within each tile, 900 evenly-spaced measurements of density are made. The formula of determine the graininess is (Equation. 1 to 3)

$$m_i = \frac{1}{n}\sum_{j=1}^{n} D_j \qquad (1)$$

$$\sigma_i = \sqrt{\sum_{j=1}^{n}(D_j - m_i)^2 / n} \qquad (2)$$

$$Y = \sqrt{\sum_{i=1}^{N}\sigma_i^2 / N} \qquad (3)$$

Where, D_j is the density value of measurement of the tile number j. For each tile i, m_i is the average density of these measurements; σ_i is the standard deviation of the measurements (Figure 4). In ISO 13660 (2001), the measurement of graininess is defined as for solid area. In fact, it can be used to measure halftone patches as well.

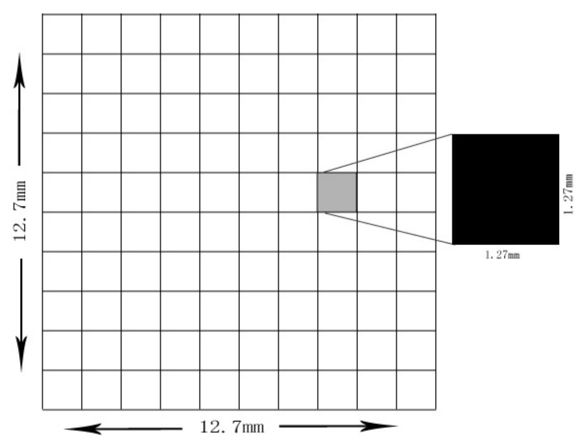


***Figure 4** Sampling method for graininess and mottle measurements.*

Graininess is the basic noise attribute of image quality. Ideally, there are same values in the halftone and the solid areas. However, the tested results showed that they are different.

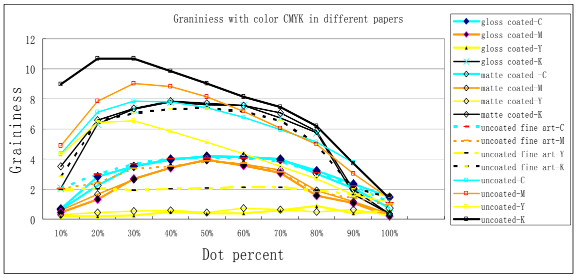


Figure5. *Graininess values for solid and halftone patches on different types of paper.*

Graininess values of targets printed on four different types of paper were shown in Figure 5. The results showed that all the lowest graininess values are in the solid areas. This suggested that ink fused into the paper surface and fill into the low spots of the paper, which showed lower variation in density. The graininess values of 10 percent tints of cyan, magenta, and black are close for all three coated papers. However, the graininess values of 10 percent tint are higher than the value of solid area. This can be explained as that 10 percent tint has more influence from the paper than the solid area. The graininess values of 50 percent tints appeared to have the highest values. This showed that accumulated influence of the spatial frequency of real dot and the high frequency noise generated during printing. The graininess values of yellow did not follow the same trend as cyan, magenta, and black. This may be due to the color of paper.

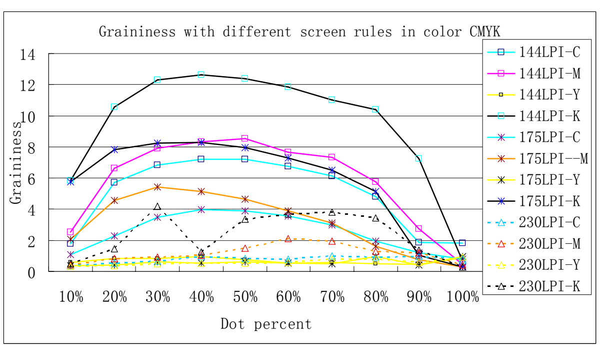


Figure6. *Graininess values of halftone patches printed at different screen rulings.*

Experiments showed that screen rulings affect graininess as well. The results were shown in Figure 6. The results suggested that higher screen rules had less influence to graininess. Higher screen rules in different halftone patches showed the same graininess values. The results suggested that the outputs with high screen rulings could have less graininess and relatively higher image quality.

Mottle

Mottle is as macro-uniformity of large area, which is calculated as the standard deviation of the means of divided all superpixel areas. It uses the same measurement method as for graininess.

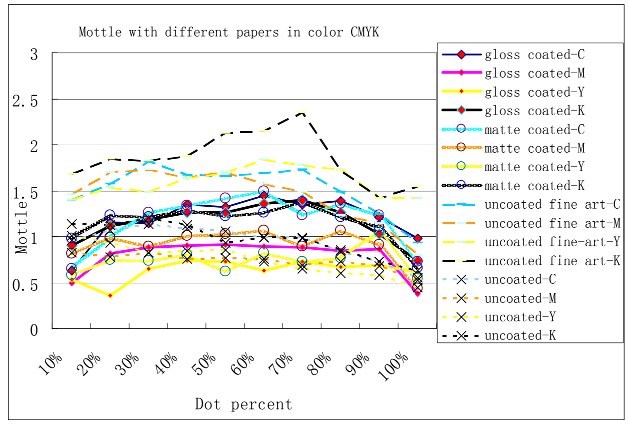


Figure7. *Mottle values for different type of paper at same screen rulings*

Mottling is defined as unevenness [8]. The results of mottle values were shown in Figure 7. Two types of coated papers showed similar mottle values. However, two types of uncoated paper showed different mottle values. The targets printed on fine art paper showed the highest mottle values overall. This suggested that paper surface roughness might contribute to higher mottle values. Fine art paper has the highest surface roughness, therefore, the highest mottle values.

Figure 8 showed the mottle values of different screen rulings printed on the same paper. Cyan, magenta, and yellow showed higher mottle values when printed at 144 lpi.

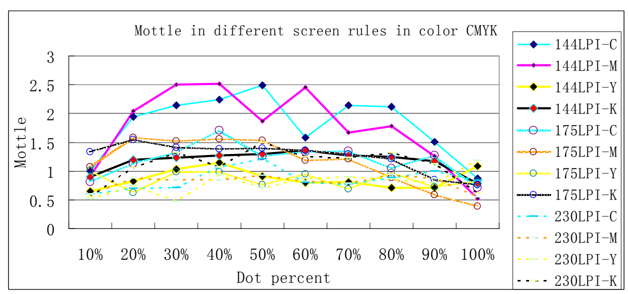


Figure8. Mottle values of halftone targets printed on same paper with different screen rulings.

Conclusions

Six print quality attributes were studied. The results showed that paper types and screen rulings impact the most to image quality in terms of mottle and graininess. Background haze, marks, and voids were examined as well. The results suggested that those attributes should be measured for image quality evaluation even though those defects happen intermittently and have no quantitative measurement method in image quality analyzing system empolyed.

From the experimental study, it suggested that paper types affect graininess and mottle. Toner fusing and paper structure together affect image quality of spatial uniformity. Uncoated paper will cause more graininess due to the surface roughness of the paper. High screen ruling cause less graininess and mottle.

Future Study

This paper is measured and evaluated graininess and mottle according to optical density. Some research suggested adding perceptual factors into quantitative image quality [1]. Human eyes are sensitive to luminance variations. L* was chosen to calculate the standard deviation of luminance variations. ISO 13660 (2001) could provide meaningful comparisons of print quality output by different printing devices. The proposed International Standard ISO/IEC WD 19751 is still under development, which offers new quality attributes, such as, micro non-uniformity, macro non-uniformity, gloss uniformity, color rendition, text, and line quality, etc. It combines subjective and objective factors together. More experimental works need to be done to test the methods defined in ISO/IEC WD 19751.

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