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Objective Print Quality Analysis and The Portable Personal IAS® Image Analysis System

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While color and density have been synonymous with print quality for a long time, the importance of other print quality attributes such as sharpness and details, and printing artifacts such as bleed, edge acuity, banding, and gloss non-uniformity can hardly be overemphasized. The growing recognition of the importance of such "non-color and density" attributes has been partly driven by the introduction of many digital printing processes that exacerbate such print quality (PQ) problems. To advance digital printing technology and to solve PQ problems, a necessary first step is to objectively quantify the critical print quality attributes beyond density and color, hence creating a demand for new tools other than the familiar densitometer or spectrophotometer. Responding to this need, *image analyzers* have been developed in parallel with the development of the digital printing industry over the last two decades. The early image analyzers were typically large tabletop units that were often installed in a central laboratory and required the support of a specialist. Bringing the technology of PQ analysis to a much broader community of users, a handheld image analyzer called the Personal IAS was introduced by QEA in 2001. This battery-powered, portable instrument makes it possible for the first time to make objective print quality measurements anywhere, including in the field and on the production line. This paper describes the design of the instrument and demonstrates its capabilities by means of a series of practical applications in digital printing.

1. Introduction

Many people approach the assessment of print quality with the attitude "I know good quality when I see it." While such a subjective approach may be reasonable from the perspective of an end-user, it is neither helpful nor acceptable in the engineering and manufacturing environment. Instead, to make progress and to facilitate effective communication, quantitative measurements must be used in order to specify or qualify a printing system objectively and unambiguously. Often, this is done by breaking print quality (PQ) down into a number of relevant and quantifiable PQ attributes and their corresponding PQ metrics.

The choice of PQ attributes and metrics varies from one author to the next, but generally there is a lot of similarity. For example, a recent paper[1] categorizes print quality into the following list of attributes

1) Color Rendition
2) Process Color Gamut
3) Effective Tone Levels
4) Gloss Uniformity
5) Effective Resolution
6) Line Quality
7) Text Quality
8) Micro Uniformity
9) Macro Uniformity
10) Adjacency

Top on the above list are color, tone (or density) and gloss. Indeed, the first generation of PQ instrumentation included densitometers for density, spectrophotometers for color, and glossmeters for gloss measurements. As these instruments matured and were gradually adopted by the printing industry, international standards such as ISO 5-3 for density measurements[2], CIE L*a*b* for color measurements[3] and ISO-2813 for gloss measurements[4] also came into existence. The availability of both instruments and measurement standards together has contributed substantially to the improvement of the commercial printing industry based on traditional printing processes such as offset, gra-

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vure, flexography and screen printing.

As digital printing technology evolved over the last two decades, most people in this industry learn quickly that PQ goes beyond density, color and gloss. The reality is that as the technology develops, many critical PQ issues such as sharpness, details (e.g. effective resolution, line quality and text quality in the above list) and printing artifacts (such as micro and macro uniformity, and adjacency in the same list) are often exacerbated and therefore must be improved. Unquestionably, a necessary first step in PQ improvement is to measure the PQ attributes objectively rather than subjectively. Such recognition created the demand for a new class of instrument beyond densitometers, spectrophotometers, or glossmeters. Responding to such a need, printing system developers as well as instrumentation manufacturers developed a class of instrumentation called *image analysis systems or image analyzers*. In such systems, an image is acquired, either through a camera or a scanner, and analyzed to quantify attributes such as dot gain, line and text quality, and color non-uniformity such as graininess and mottle. Similar to the history of densitometer and spectrophotometer development, such image analysis systems are now supported by standards such as the ISO-13660 print quality standard[5] and the ISO-19751 appearance-based print quality standard[6] currently under development. Once again, instrumentation (image analyzers) and standards (PQ standards) work together to provide the tools essential for PQ improvement, particularly for the rapidly growing digital printing industry.

2. Image Analyzers

Instrumentation for measuring print quality invariably uses a light source and some form of photodetector in a defined geometric arrangement. **Fig. 1** shows typical arrangements for densitometers and spectrophotometers and **Fig. 2** for glossmeters.

Image analyzers work similarly to densitometers and spectrophotometers, but a CCD or CMOS sensor replaces the photodetector. As shown in the schematic in **Fig. 3**, the geometry of an image analyzer is typically 45°/0° similar to the densitometer or spectrophotometer.

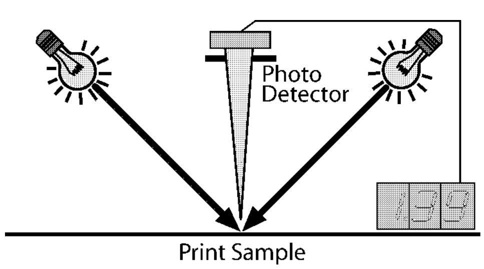

Fig. 1 Architecture of a Typical Densitometer or Spectrophotometer

Over the last 20 years, many papers have been written[7-12] about image analyzers, their calibration methods, and their applications to a wide range of PQ analysis problems. Prior to the introduction of portable units, image analyzers have come in two main styles, 1) camera based units, and 2) flatbed scanner based units.

2.1 Camera-Based System

Camera-based systems include a properly configured light source, optics, and an image sensor with a resolution sometimes as fine as 1 μm/pixel resolution, although 5 to 10 μm/pixel is more typical in order to achieve a wider field of view.

In the operation of camera-based systems, the sample is typically placed on a vacuum platen that can be moved on an X-Y stage so that any portion of the print-under-test can be examined. The entire analysis is under software control, which instructs the system on the type and location of measurements to be made on the sample. Within a single print sample, it is not uncommon to program the system to make automated measurements at a hundred or more different locations within the sheet in a single sequence.

To supplement the camera measurements and boost productivity, additional features such as precision optical encoders, glossmeter, spectrophotometer, and automated document feeder (ADF) are frequently installed onto such systems. Such additions to the basic camera system combine geometric measurements using the camera, density and color using the spectrophotometer, gloss using the glossmeter, and automated testing of a large number of samples without user-intervention by means of the automated document feeder (ADF).

Camera based image analyzers are well developed, and offer the best range of analysis capability. However, they

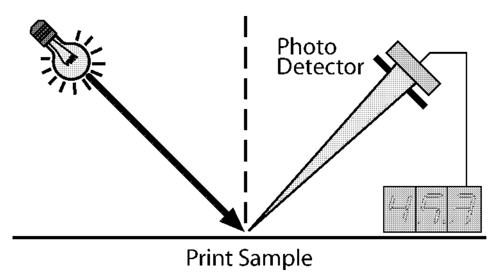

Fig. 2 Architecture of a Typical Glossmeter

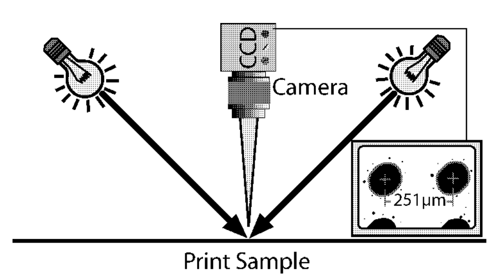

Fig. 3 Architecture of an Image Analyzer

tend to be more expensive than the scanner-based systems.

2.2 Scanner-Based Systems

Scanner based image analyzers are preferred for some applications for several reasons. First, scanner based systems often have lower initial acquisition cost. Secondly, the scanners can quickly capture a large area of the sample, which can facilitate certain PQ analyses such as banding and jitter more efficiently. Further, the scanner based systems also tend to be more compact. As with the camera-based image analyzers, automated measurements can be performed in a pre-programmed sequence and multi-page testing can be performed with the use of an ADF.

At the time of this writing, high quality, reasonably priced professional-grade scanners are available with up to 2400 dpi (or 10.6 μm/pixel) optical resolution. Note that most consumer grade scanners claiming to be 2400 dpi or higher are not suitable for quantitative image analysis applications because of their generally inadequate optical qualities.

Comparing the camera and scanner based systems, the camera-based systems offer higher resolution and very accurate position measurement, whereas scanner based systems have lower resolution and lower accuracy in motion control. The other strength of camera-based systems is the option of integrating other measurement devices such as spectrophotometer and glossmeter into the same system. This feature is not available (at least not automated) in scanner-based systems. On the other hand, scanner-based systems can be used to get an image of the entire page at one time relatively easily. This greatly facilitates measurements of large area properties like banding and results in the scanner being faster for these types of measurements.

2.3 Need for Portability

The power of camera-based and scanner-based analyzers lie in their measurement productivity and potential for full automation, once they are programmed to do a repetitive task. Measurement productivity and minimal user-intervention are clearly extremely important business issues in many organizations today. However, it is now also clear that in order to make quantitative PQ analysis available to more people in the printing industry, issues of cost, size, and complexity issues needed to be addressed.

Learning from the success of "classical" portable PQ instruments such as densitometers, spectrophotometers and glossmeters, the authors envisioned that a portable version of the camera-based system could potentially bring objective PQ analysis to a much larger audience than a handful of specialists alone. The key to success for such a tool would hinge on a design that is truly portable, standalone, low cost, and most important of all, easy to use.

3. The Personal Image Analysis System

QEA introduced the Personal IAS (PIAS) in 2001 and started shipping in 2002. The analyzer is battery powered, weighs approximately 700 grams, and is small enough to operate with one hand.

With many users worldwide and several years of experience in the field, the authors believe that the PIAS has and will continue to serve the digital printing industry well.

The PIAS is one of a family of portable instruments developed by QEA[13], which include: the DIAS™ for distinctness of image (DOI) measurements[14),14], PocketSpec™ for color and density measurements, FlexoIAS™ for flexographic plate measurements, and Personal QMD™ for PQ analysis in security printing[16].

3.1 Hardware Design

The Personal IAS hardware consists of a few key components:

1) White LEDs in a ring geometry
2) Internal reference target
3) Optics
4) Color digital camera
5) Integrated computer and color display

The lighting geometry is 45°/0°. The viewable area is 2.5 ×2.5 mm with a magnification of 5 μm/pixel. To give a sense of the size of the viewing area, a 10-point letter "X" fills the largest field-of-view.

Built into the analyzer is a reference target. This target is checked during each measurement to compensate for any changes in the lighting intensity or camera sensitivity.

The analyzer can be powered by either a rechargeable internal battery or by AC power. Images or data can be stored internally to the unit, or transferred to a Personal Computer via a USB cable.

3.2 Software

The software on the PIAS serves three main functions.

1) Convert uncalibrated camera data to calibrated reflectance (optical density) and distance values.
2) Perform the image analysis.
3) Store and manage the data and images.

In typical usage, the PIAS is put into a live video mode so that what is under the measurement head appears as a live image on the color display of the analyzer as shown in **Fig. 4**. The user then positions the analyzer over the spot of interest on the test sample and selects one of the analysis buttons, e.g. the dot tool. Next, the software uses the system calibration curves and data from the internal reference target to convert the image to calibrated reflectance values. The image analysis is performed, e.g. the location, size, and other properties of the dots are found. Finally the data and image are displayed on the screen and/or saved to the

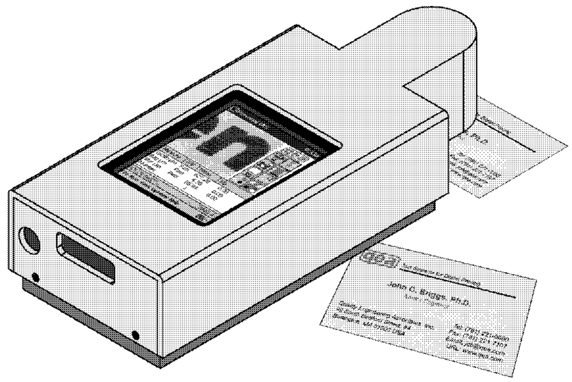

Fig. 4 Personal IAS (PIAS) Image Analyzer

computer memory.

The PIAS has a comprehensive set of tools for PQ analysis built-in:

1) Dot, e.g. size, circularity, size histogram
2) Line, e.g. width, raggedness, darkness, blurriness, line profile
3) Area, e.g. reflectance, density, mottle, graininess
4) MTF, modulation transfer function
5) Tone reproduction analysis
6) Image histogram and profile

These built-in tools can be applied to solve a broad range of PQ problems such as:

1) AM/FM halftone and dot gain analysis
2) Inkjet satellite analysis
3) Toner background measurement
4) Line and edge quality analysis
5) Ink wicking measurements
6) Resolution analysis
7) Text quality evaluation
8) Barcode print quality analysis
9) Inter-color bleed determination
10) Color registration analysis
11) Granularity assessment
12) Density and color estimates
13) Toner fusing evaluation

The measurements are not limited to any specific printing technology. The PIAS has been successfully applied to electrophotography, inkjet, thermal, offset, gravure, flexography, screen printing, letterpress, and intaglio printing.

The data can be saved directly into the memory of the integrated computer in several different ways. One method saves the entire set of data from the analysis, which includes a summary of the analysis as well as comprehensive details, for example, the position, size and other metrics from each single dot in a dot analysis. Such data can be transferred to a PC for further analysis, e.g., in Excel. Another way of saving the data is a logfile. Data from each analysis performed are automatically recorded to a logfile so that statistical and other analyses can be performed later. Finally, in addition to data, the images can also be stored.

The integrated computer in the PIAS runs under the Windows CE operating system. Since most PC users are already familiar with the Windows operating system, such familiarity adds to the ease-of-use of the PIAS. Additionally, many third-party software applications are available to further expand the functionality of the system.

4. Algorithms and Standards

Image analysis begins with the desire to quantify some aspects of an image. Clearly an algorithm is needed. But how does one get started?

There are three different approaches to developing an algorithm. These include:

1) International Standards
2) Industry Standards
3) Proprietary Standards

International standards are methods that are defined in documents by organizations like ISO. Industry standards are standards in common usage by one or more companies. They may or may not be carefully documented but often are known by the key people in the business. Many international standards actually begin as industry standards prior to being adopted by the standards committees. Lastly there are proprietary standards. These are often algorithms developed by a single programmer for a single company that may or may not be willing to disclose the method to other people.

4.1 International Standards

The preference when developing an algorithm is to use international standards. These standards have benefited from the input of many people and are usually well developed. If no suitable international standards exist, the second choice is to look for industry standards. These can be discovered by talking to colleagues in the business or reading journals such as this one. If no industry standards exist, the only option left is to use proprietary standards. Sometimes they can be purchased in code form. However, frequently, the algorithms have to be developed from scratch.

In the PIAS, all three types of standards are used. When possible, international standards are employed. Otherwise, industry or proprietary standards are used.

One standard used extensively is the ISO-13660 print quality standard. Chapter 5 of this standard defines 14 print quality metrics for text/lines and large area as follows.

Large area density attributes:

5.2.1) Darkness, large area
5.2.2) Background haze
5.2.3) Graininess
5.2.4) Mottle
5.2.5) Extraneous marks, background

5.2.6) Voids

Character and line attributes:

5.3.1) Blurriness
5.3.2) Raggedness
5.3.3) Line width
5.3.4) Darkness, character
5.3.5) Contrast
5.3.6) Fill
5.3.7) Extraneous marks, character field
5.3.8) Background haze, character field

This is the first standard of its kind in the industry and allows practitioners in print quality analysis to move beyond basic PQ measures like density and color. Detailed descriptions of the metrics can be found in the standard[5] or in other papers[11-12].

4.2 Industry Standards

When no international standard is available, the PIAS uses a number of industry standards. One example of an industry standard is the metric for quantifying the severity of toner background in electrophotography. The metric, called GS (or RMS GS)[7),17)], uses the number and size of the background dots detected. It is calculated according to:

$$GS=\sqrt{\frac{4.74\times10^{-6}\sum_i(d_i)^4}{a}} \quad (1)$$

where $\boldsymbol{d}_i$=diameter of the ith particle (μm), $\boldsymbol{a}$=area of the ROI (region of interest, μm^2). This metric is used by a number of leading companies in the industry and therefore it is widely accepted.

4.3. Proprietary Standards

Where no international or industry standards are available, proprietary standards are used in the analyzer. To facilitate understanding and communication of results, the methods are defined in the PIAS User' s Guide. One such analysis is dot analysis (also known as blob analysis). Dot analysis is so basic to image processing that it is performed by most image processing software. So in some sense, dot analysis can be considered an industry standard. However, the details of how the analysis is performed are often different from one software package to the next, and it is therefore more of a proprietary standard. Such details include how to set the threshold, calculations of perimeter length, and circularity.

4.4 Challenging Issues

Even when international standards exist, shortcomings in the standard will often necessitate the use of proprietary solutions to fix problems with the analysis. In the development of the PIAS, the ISO-13660 method of line analysis was found to work satisfactorily on well-formed isolated lines. However, experience has also shown many problematic situations[11] using the basic methodology, for example

1) A dot placed near the line
2) A break (interruption) in the line
3) Lines placed close together
4) Narrow lines with slope, etc.

Each one of these situations caused the algorithm to fail or give unexpected results. None of these situations are discussed in the ISO standard and yet occur often in real world samples. The key point here is that even when international standards are available, much work may still remain to develop a robust system suitable for daily use.

5. Application Examples

The need for PQ measurement is not restricted to R & D. Incoming QC, production, quality audit, product test, and marketing and sales can all benefit from the value of objective print quality measurements. Also, print quality measurement is not restricted to one printing technology. Whether the technology is electrophotographic, inkjet, thermal transfer, or some other technology, print quality measurements are needed. The particular types of measurements may be different for different technologies, but the need remains.

Perhaps the best way to understand the importance of quantitative PQ analysis and the application of the PIAS is through the use of a broad range of examples.

5.1 Dot Quality

Many printing technologies build images from dots. Poor dot quality and improper dot gain can result in a range of problems from producing the wrong density or color to making the image look grainy.

Consider the inkjet dots printed on two media types (using the same printer and same ink) shown in **Fig. 5.** The dots on media A are significantly smaller than media B, 40 μm versus

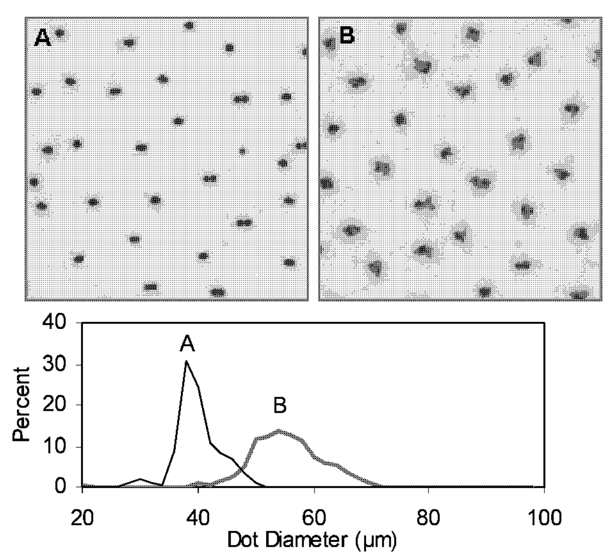

Fig. 5 Inkjet dot quality analysis

55 μm diameter. However, just as important is that media A has less variation in dot diameter, standard deviation 3 μm versus 8 μm. This results in a more uniform appearance to the halftone and better control of the print density.

The dot analysis tool can also perform AM halftone analysis to determine dot gain, dot shape, dot position, line screen (lpi or lpmm), and screen angle as shown in **Fig. 6.**

The halftone analysis can be used to calculate physical (geometric) dot gain data as shown in **Fig. 7.** In this figure, the printer density setting was adjusted and the impact on physical dot gain was quantified.

A common problem with laser printers is toner background, that is, toner on part of the paper intended to be white. As mentioned earlier in this paper, this can be quantified using the GS metric as shown in **Fig. 8.**

The dot tool can also be applied to many "unconventional" applications. Consider the problem of a "star-wheel" marking the paper in inkjet printing. Star-wheels are used in inkjet printers to feed the paper after the printing has occurred. Unfortunately the star-wheels can mark the paper as shown in **Fig. 9**. The two marks in this image have an average diameter of 111 μm and are quite visible. The lower image shows the dot edge contours drawn by the analyzer after performing a void analysis using the dot tool.

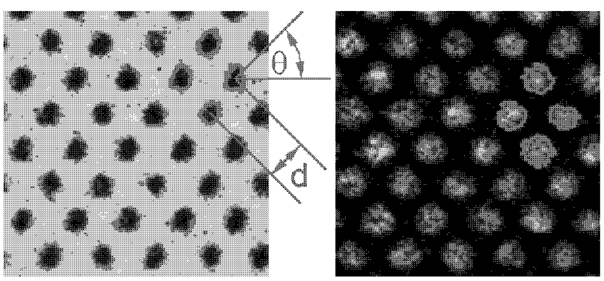

Fig. 6 Laser Printed AM Halftone

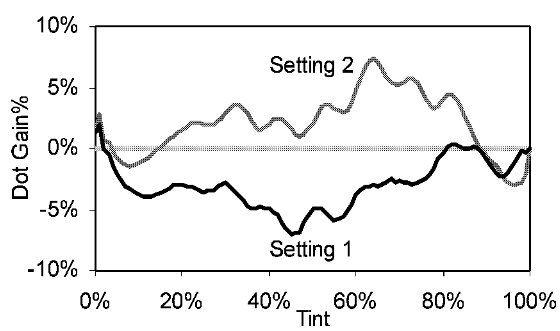

Fig. 7 Dot gain for AM halftone

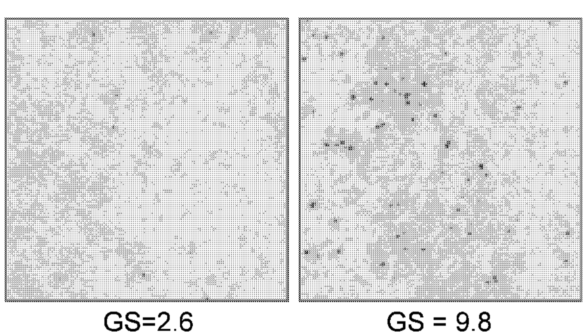

Fig. 8 Background measurements.

5.2 Line and Text Quality

The line tool can be applied to evaluate both text and line quality. Using carefully designed test targets, it can also be used to evaluate other printing problems like inter-color bleed, positional errors from a marking engine, and color registration problems.

The first example here shown in **Fig. 10** are two samples produced using two different toner cartridges in the same laser printer. The sample on the right shows excessive toner blasting and generally higher level of toner transfer than the sample on the left. Analyzing the samples using the PIAS shows significant differences in line quality. The excessive stroke width and raggedness (edge roughness) of the sample on the right reduce its legibility as well as page yield. Armed with such information, one can proceed to investigate further the root cause (such as wrong sign toner or some other mechanisms) and begin the improvement process much more intelligently and objectively than in the past. Such an example highlights the benefits of quantitative measurements as a prelude to solving PQ problems.

Quantitative measurements also have a clear advantage in improving the communication of PQ problems. Without objective measurements, we are limited to describing the

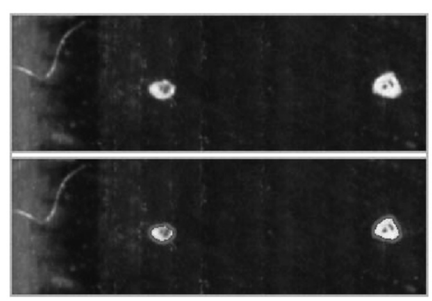

Fig. 9 Star-wheel marks

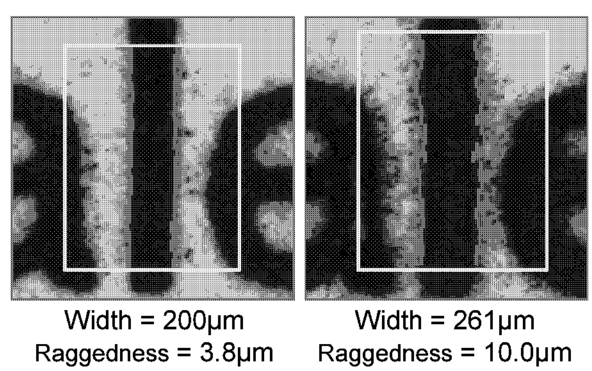

Fig. 10 Text Quality for two toner cartridges.

right side as "bad" and the left side as "good." With the measurements, a goal might be described precisely as width of 200±20 μm and raggedness less than 8 μm, for example.

This type of line quality problem also exists in inkjet printing as shown in **Fig. 11**. Printing the same line on two different media types shows the impact on print quality. The ink on Media A wicks much more than Media B resulting in a higher line width and worse edge quality. Such quantitative information is of great value when developing inkjet media coatings.

In addition to wicking, inkjet printing has a related problem known as Inter-Color Bleed (ICB). **Fig. 12** shows an example of ICB where horizontal black and yellow lines should be the same width but are not due to black ink bleeding into yellow ink. This type of bleed greatly reduces legibility of small inverted text, e.g. 6 point yellow text on a black background. Other color combinations have this problem as well.

The ICB can be quantified using the analyzer :

$$Bleed = (W_{black} - W_{yellow})/4 \quad (2)$$

where W is the width indicated in the subscript. The indicates the severity of lateral spreading at each edge. The division by four in the equation is because there are four edges involved, 2 edges for the black line and 2 for the yellow. For the example the bleed is :

$$Bleed = (461 - 229)/4 = 58\ \mu m \quad (3)$$

These types of uncontrolled printing problems often lead to low quality text and other graphic arts elements. Recently[18], a text quality study was conducted on a group of ten newly available desktop printers (inkjet and laser). The printers had surprising difficultly in producing text in the intended stroke weight (width of the stroke), as shown in **Fig. 13**.

As a measure of stroke weight accuracy, a ratio was defined called the normalized stroke weight (NSW).

$$NSWE = W_{Measured}/W_{Intended} \quad (4)$$

where $W_{Measured}$ and $W_{Inteded}$ are the measured and intended measured vertical stroke width, respectively.

The range of NSE on these samples was between 1.28 (28% too wide) to 0.87 (13% too narrow). At 1.28 the text has a bold appearance, whereas at 0.87 it looks faint and weak as if the printer was running out of ink or toner. Yet these are all newly available printers in good working condition. Clearly the printer manufacturers need to work harder to create good text, and PQ measurement is an important tool in that process.

The line quality tool can be applied to basic applications of the control of the marking engine. One key indicator of marking engine performance is the consistency of spacing of horizontal and vertical lines. If the line spacing is not consistent, then halftones created with the marking engine will have tonal variation across the page and banding.

The line patterns shown in **Fig. 14** were printed on a laser printer to look for problem areas of the marking engine. The line pattern is a nominal spacing of 169.3 μm. The image analyzer was used to calculate the line spacing every 6 mm along the length and width of the pages. The data are shown in **Fig. 15** and **Fig. 16**

In the laser scanning direction Fig. 15, the line spacing is smaller on the two edges of the page (position=0 and 260 mm). This will result in higher density halftones on the edges of the paper. Sources could be problems with the optical system or laser-timing signal.

In the paper feeding direction Fig. 16, the line spacing also

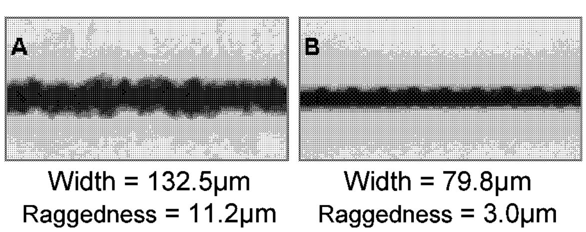

Fig. 11 Line quality for inkjet print samples

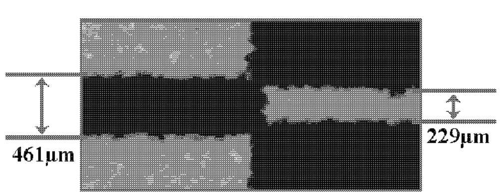

Fig. 12 Intercolor bleed.

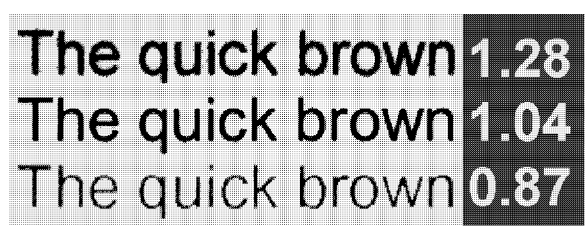

Fig. 13 Normalized Stroke Weight (NSW) for three printers. 11 point.

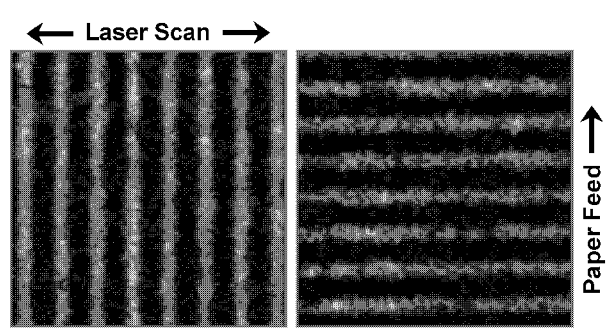

Fig. 14 Line spacing variation.

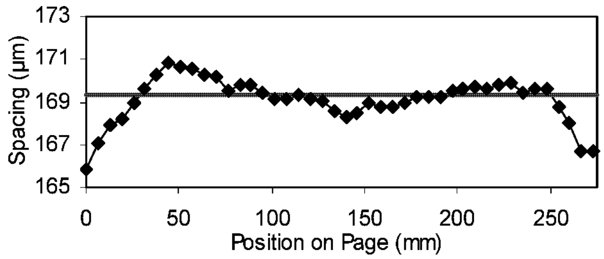

Fig. 15 Line spacing in laser-scan direction.

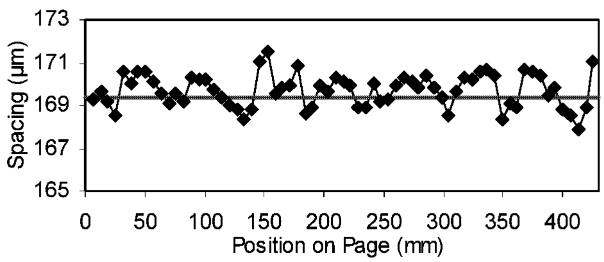

Fig. 16 Line spacing in paper-feed direction.

shows variation although there is no clear pattern. The cause might be geometric errors in the gears and other components. The result will be banding in halftones.

5.3 Area Quality, Graininess and Mottle

The examples so far have all related to geometric problems in print quality. However, many print quality problems are the result of poor reflectance uniformity, e.g. graininess, mottle, and banding. In photographic type images, these problems can often be spotted in non-busy areas of the image like clear blue sky or skin tone. There can be many sources of these problems in digital printing.

One common source of non-uniformity in inkjet printing is coalescence. Coalescence occurs when the ink sits wet on the surface of the media for some time before it has a chance to dry. During that short period of time, the dye (or pigment) molecules migrate together or coalesce. This results in darker and lighter areas in the image as shown in **Fig. 17**.

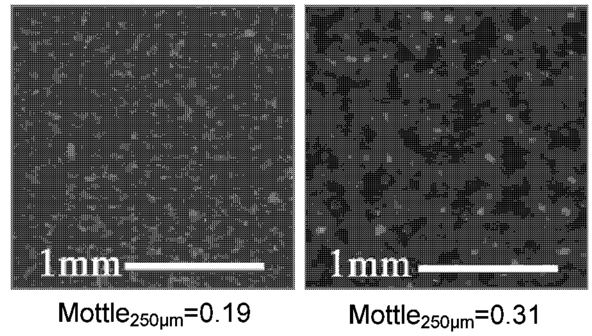

Fig. 17 Mottle caused by ink coalescence.

This type of non-uniformity can be quantified using an image analyzer and the ISO-13660 mottle methodology. This approach breaks the image into a number of square tiles of a certain size (in this case 250 μm). The reflectance of each tile is computed from the image. The standard deviation of these reflectance values is reported as the mottle.

Mottle is a useful way to quantify many non-uniformity problems and is not limited to coalescence.

When non-uniformity occurs on a small scale, it is typically referred to as graininess. This term is a holdover from the photographic days when this form of noise was caused by the film "grains." Now the term graininess is applied more broadly to any form of small-scale non-uniformity in density.

In printing, there can be many different sources of graininess. **Fig. 18** shows graininess that results from a stochastic FM screen on two inkjet printers. For the printer on the left, the graininess is lower due to the small drop size. On the right, the large dot size creates higher graininess. Inkjet printers have been using progressively smaller dots in recent years to reduce the visible graininess. In some cases, inkjet printers include light gray, light cyan, and light magenta inks to further reduce graininess in halftones.

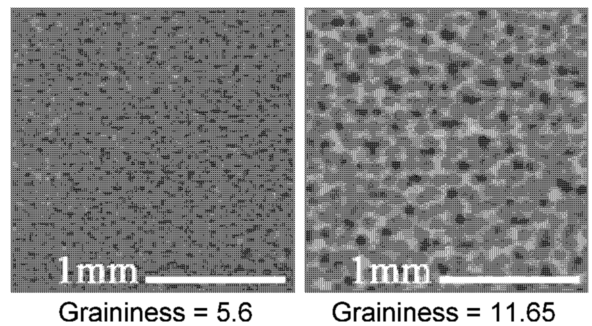

Fig. 18 Graininess on two inkjet printers.

The PIAS is not limited to the measurements shown here. In the process of pursuing their daily work, the users of PIAS are continually finding new and innovative measurements that can be made using the basic built-in analysis tools.

6. Discussion and Conclusions

Successful evaluation of PQ requires breaking down the problem into its component parts. PQ can be roughly divided into areas like density and color, gloss, text and line quality, and micro-and macro uniformity.

Objective analysis of PQ offers many benefits including repeatability, removal of subjective differences between observers, and the precise communication of PQ goals and standards. The different aspects of PQ analysis require different instrumentation: densitometer for density measurement, spectrophotometer for color measurement, glossmeter for gloss measurement, and the image analyzer for measuring dots, text, lines, and uniformity.

The Personal IAS now allows these PQ measurements to be made easily by non-specialist operators and engineers alike. The portable, battery powered, handheld unit makes it possible to make measurements anywhere including the factory floor or a conference table, not just in a central laboratory as is the case with traditional PQ equipment.

As shown in this paper, the range of built-in image analysis tools in the Personal IAS allows it to be used for a wide variety of applications. For example, the dot tool can be used for measuring halftone dots or print defects like star-wheel marks or background toner. For a second example, the line tool can be used for measuring text and line quality, or other problems like intercolor bleed or non-uniform paper feeding.

The analysis algorithms in the Personal IAS are based on a combination of international, industry, and proprietary standards. International standards such as ISO-13660 are used in the analyzer and are an important part of providing a clear and consistent method for PQ evaluation.

Ease-of-use and application versatility make the Personal IAS a very effective enabler for quality improvement in the printing industry. In addition, its portability and relatively low cost help accelerate the adoption of quantitative print quality analysis. As image analyzers such as the Personal IAS become more widespread, and more international standards develop, the printing industry can look forward to more reliable and precise communication of PQ issues. This will aid all aspects of the industry from R & D, to manufacturing, to sales and marketing.

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