Print Quality of Sheet Fed Offset & Digital Printing Technologies

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Abstract

Digital printing has revolutionized the whole concept of traditional printing systems, particularly in the recent couple of years. This is equally true both in Indian as well as worldwide scenario. The essential gap between the sheet fed offset printing and digital printing is becoming narrow to narrower. Sheet Fed offset process of printing is the most widely form of technique in terms of quality and print lengths. The time is not too far, when it will be very difficult to draw fine line to separate these two printing systems from the point of print quality. It is the proper time to analyze and interpret the difference between the Sheet fed offset and digital print quality factors.

The broad objective of the above research work was to throw light on the above mentioned problem, by measuring the differences in print quality in both the sheet fed offset and digital printers. By using printing industry based questioner survey, the differences between the two printing systems are examined. Sheet fed offset process basically leads to number of printing defects due wide choice of materials and at the same time digital printing suffers from technical constraints, like image resolution, etc. Two print quality factors, like solid ink density and dot gain were taken into account in this research work. At the end it was concluded that there is a very fine line gap between the print quality of sheet fed offset and digital printing and coated paper is best suited to the sheet fed offset while digital printers produce better results on un-coated papers.

Introduction

Digital printing is just a decade old concept and all the credits goes to Indigo and Xeikon printers for their early efforts to opening a new era of printing. Early days digital printers were designed basically to take care of print-on-demand and with short run jobs. Sheet fed offset press system consumes roughly more than half-an hour for make ready steps and more prominently this time varies from press to press, and the production cost is only justified with few thousands of print lengths. On the other hand, digital press viable for even a single print length, while minimizing the set up time. Over the years, not only reliability, but also a wide range of substrates have added into its base. Still the sheet fed offset market holds a strong position in the print media production category. The question that comes into everybody's mind is the print quality factors of these two printing systems. Most of the research in this field has shown that the high end digital printers are capable of producing image quality that is comparable with the sheet fed offset printing results.

According to Pope and Biscos (2002), Digital printing can be defined as any printing process using a digital file to create an image using a non-impact printer. Such printers include ink jet, electro-photographic devices, production printers or digital printing presses, and Direct Imaging offset presses (Pope & Biscos, 2002, p.6). These devices range in size from those found in small office environments up to large production machines found in commercial and industrial printing facilities.

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Basically, the digital printing technology can be divided into two distinct categories based on how the substrate is imaged or printed. These categories are direct to image carrier and direct to paper. Direct to image carrier includes black and white and multi-colour electro-photography, while direct to paper includes ink jet, dye sublimation, thermal direct transfer, electrostatic, and other printing methods. Both of these categories are classified as non-impact printing, which Pope & Biscos (2002) define as "a method of printing in which the writing print head never comes into contact with the printed medium" (p. 8).

In this particular research work, electro-photographic technology is taken in to account. It essentially uses an electrical charge to create a latent image on a photoconductor. Electro-photography is one means of arranging 100 million pigmented plastic particles on a sheet of paper to faithfully replicate an original. It is based on many diverse phenomena and employs many properties of matter. These include gaseous ionization in the charging step; photo generation and charge transport through disordered solid-state materials in the latent-image-formation step; triboelectricity in the particle-charging step; mechanical, electrostatic, and magnetic forces to detach particles in the development and transfer steps; and the application and transfer of heat in the fixing step. Subsequently, the photoconductor is cleaned and restored to its original condition for the future use.
Electro-photography technology is employed in many print environments, ranging from small laser printers used in homes and offices to large digital presses that print at speeds at 100 print per minute or faster (Romano, 2004).

Numbers of methods are available under the digital printing to work on the system of direct to paper printing. One of the most prevalent technologies employing this method is ink jet. According to Kipphan (2001), "In the ink jet process the ink can be transferred directly onto the paper, ink jet technologies can be classified as continuous or drop on demand ink jet" (p. 62). Both methods rely on a mechanical method to squeeze a volume of ink through a nozzle and deposit or shoot an ink drop onto the substrate.

Dye Sublimation is another direct to paper thermal transfer process. In this process, heating elements cause a specific amount of dye to be transferred

from a color ribbon to the resin-coated receiving medium. The technology allows for according to Pope and Biscos (2002), "near photographic continuous-tone quality" (, p. 115).

Direct thermal printing technology has many uses, and was a popular technology for fax machines before multifunction laser printers became prevalent. The process consists of exposing chemically treated thermo-graphic paper to heat in order to produce an image (Pope & Biscos, 2002). The main use of this technology is transaction receipts like those issued at stores and banks. A technology closely related to direct thermal printing is thermal transfer. Thermal transfer printers use a "specially coated ribbon that releases its pigmenting materials at a threshold temperature" (Pope and Biscos, 2002, p.
113).

Another direct to paper process losing ground to other digital printing technologies is electrostatic printing. Electrostatic printing devices rely on technology similar electro-photography, but they don't use optical imaging or a print drum to create and transfer toner to the substrate (Pope & Biscos, 2002, p. 117).

There are seven steps to transfer toner from the imaging system to the substrate. They can be summarized as follows:

1. Charging a photoreceptive material, also known as an organic photo conductor (OPC).
2. Create an image on the OPC by exposing it to light with either a laser or a light-emitting diode (LED) array.
3. The areas that remain charged on the OPC pick up toner particles that are then transferred to the substrate.
4. Transfer of the toner particles from the OPC to the substrate.
5. Fixing or fusing the image to the substrate.
6. Any toner, paper dust, or foreign particles are removed from the OPC.
7. The OPC is cleared of any remaining latent image.

Paper for digital printing

Print medium of communication is still the largest form of communication all over the globe, and this is the only reason behind paper being extensively as the substrate in the digital printing technologies. In comparison to the sheet fed offset printing technology, this particular printing system places different stress on the printing substrate. Most paper substrates use the cellulose fiber of trees to create a sheet of paper. Paper is a cellulose fiber mat, in which fibers are uniformly and irregularly interlocked.
Paper can be further classified as uncoated or coated. Coated papers are covered with a coating material such as clay, calcium carbonate, or titanium dioxide (MeadWestvaco, 1999, p. 86-88. According to MeadWestvaco (1999), "the purpose of the coating may be either to impart functional properties to the final product or to contribute to the appearance" (p.81). These functional properties include smoothness, opacity, and brightness. Uncoated paper undergoes a similar calendaring process, but no coating materials are applied. The purpose of the uncoated calendaring process is to create a paper sheet that is uniform and without large voids on its surface and within its structure.

Paper mills are seeing the affect of the growth with the surge in demand for paper products that are designed or certified to be digital-compatible (Cody, 2003, p. 30). Most paper mills and distributors are offering digital printing paper grades to meet the current market demand, with most offering a wide variety of grades, finishes, and colors (Romano, 2004, p. 1).

The three main components needed to create a digitally printed image are the digital printing system, toner and the substrate. The main substrate for toner-based digital printing systems is paper and of the three components, utmost care must be given to the paper, as a wide variety of paper is available in the market place with variations in characteristics and properties. Variations in paper are basically due to the raw material used, trees with all their variables, and the paper manufacturing process itself with its speed of production and technology limitations. The papermaking process is complex and a manufacturer's goal is to produce paper with consistency and quality in mind (Xerox, 2004, p. 5). The main goal when making paper for digital printing is to create a piece of paper that meets the requirements and can handle the stresses placed on it by the printing system. By using digital optimization, paper can be designed and developed to ensure the best performance on digital printing systems. There are physical characteristics that must be built into the various paper properties in order for the paper to be optimized for digital printing (Xerox, 2004, p. 9).

A number of requirements should be met in order for a paper to be optimized for digital printing systems and processes. The paper should be free of paper dust, loose fibers, and other particle debris that can cause contamination of the imaging mechanisms in the printing system. The paper sheet should be free of excessive curl and wavy edges. Excessive curl my cause paper jams and feed issues. Papers should have porosity and frictional properties that are compatible with the various feed mechanisms found in the printing system. Paper should have characteristics to handle the electrical charges used by the imaging mechanisms in the printing system. Paper should also have the ability to withstand the heat and pressure placed on in by the image fusing mechanism (Xerox, 2004, p. 9). Smoothness of the paper plays an important role in the digital printing. Papers used in digital printing processes typically have a paper smoothness reading in the 90 to 150 Sheffield unit range (Pope & Biscos, 2002, p. 14), with high-quality digital papers falling within the 50 to75 Sheffield unit range (Houghton, 1998, para. 6). Caliper variation can also cause runnability problems in digital printing systems due to the sensitivity of the paper feeding and transport mechanisms (Pope & Biscos, 2002, p. 16). Moisture levels in papers designed for digital printing systems are typically 4.5 percent (Xerox, 2004, p. 12-13), compared to offset papers that have moisture content in the 5 to 7 percent range (Pope & Biscos, 2002, p. 15).

The electrical properties of paper have an important role in quality image production. Paper with a high resistance to electrical charge will hamper the toner transfer process and will result in poor image quality.
Acid and alkaline papers both hold up to the stress of the digital printing process. The only downfall in using papers with high acidity is the issue of permanence (Xerox, 2004, p.12). Paper mills have found alkaline-processed papers have better strength characteristics (Romano, 2004, p. 2).

Optical paper properties such as brightness and whiteness do not play an important role in the processes related to imaging the sheet; however they do play

a role in the subjective judgment of image quality. According to Romano (2004), paper brightness and whiteness is a buyer preference. Paper used in the electro-photography process must be able to hold up to the stresses and demands placed on it during the imaging process. The sheet must withstand physical extremes such as high heat, pressure, and electrical charge without curling or loss of dimensional stability.

The more you know about the characteristics of paper, the better able you will be to save money when specifying paper for your printing jobs In fact, if you specify the qualities you require in your paper, rather than a specific name brand, your printer may be able to offer several acceptable options.

Paper Issues related to digital printing system

1. Uncoated papers will greatly exaggerate the deficiencies of a toner system (dry or liquid) in areas of heavy coverage or large areas of solids or screened tints.
2. Trapping is not usually an issue with digital presses.
3. Toner may crack or flake when the paper is folded because the paper does not absorb it. It sits on top.
4. Liquid ink digital press has less of a problem with cracking.
5. Heavy toner coverage on both sides may cause the paper to curl. May also cause the toner to appear glossy.
6. Liquid ink digital press does not tend to curl.
7. It typically uses a slightly heavier weight paper.

Paper for Sheet-fed Offset printing

Majority of the print quality factors are measurable, like, colour density and contrast, alignment with colour norms, colour gamut, evenness of colour application, print gloss, registration or print sharpness. The table shown below indicates the relationship between paper properties and print quality factors.

The offset process of printing demands that paper withstand;

1. The pressure of the blanket.
2. The tack of the ink.
3. Tension of the feed rollers.
4. The moisture added with the application of fountain solution.
5. The heat that may be applied during the drying phase.

The consumption of digital media has become more common during the past few years. Electro-photography is an important technology base for non-impact line printers. Its significance will very likely to increase as non-impact printing commands greater share of the text and data processing business.
Digital printing is one of the best-kept secrets in the business these days. Using this new, stimulating expertise, you can print full-color documents with crisp text and sharp and clear pictures - in very short runs, on-demand.

Sheet fed offset and digital printers works on the system of how the Print-Centric models work. Sheet fed offset press process controls are guided by the different standards that are available to them. While the digital printers have little latitude with respect to the options as because very little choice is left, when it comes to the printing consumables and technology related factors, as because both of them are of proprietary in nature. This survey was carried out only to the printing establishments using both the sheet fed offset and digital printing facilities.

PAPER PROPERTIES	PRINT QUALITY
Paper gloss	Density & contrast
Colour & brightness	Colour gamut
Porosity/absorbency	Evenness
Uniformity/formation	Print gloss
Surface roughness	Print sharpness
Basis weight	Tone graduation
Dimensional stability	Registration

,Experiments

To initiate the process of evaluation of the print quality in sheet fed offset press and digital press, a test form has to be designed first. The test form contains a variety of quality control targets in addition to color reproduction targets. The quality control targets can be divided into three categories according to their use: diagnostic targets, process control targets, and standardization targets. Although some quality control targets can be used for more than one purpose, the functions remain distinct. Though it sound very easy, but yet the most difficult task, because it should represent all the components of the image that are used frequently in both the sheet fed offset and digital printers. This test form should be in a position to measure the print quality of the sheet fed offset printed press sheet and the press sheet obtained from the digital printers. The list of the print products that are printed by the digital printers and the sheet fed offset press is quite long, but in this particular case book or magazine cover and poster or calendar were selected for measuring the print quality of the sheet fed offset and digital printer. These print products essentially take care of the micro text, line and half tone graphical parts.

The printers in India were selected which employ both the high end digital printers and four colour sheet fed offset press into their establishments. High end digital printers include HP Indigo 5500, HP Indigo 3050, Xerox iGen3 110, Xerox DocuColor 5000, Xerox DocuColor 7000, Xerox DocuColor 8000, etc. From the four colour sheet fed offset category, the presses with four colour Heidelberg Speed Master 74, Man Roland, Dominant were selected. As far as the substrate is concerned, one coated paper and one un-coated paper was used for both the printing systems.

Following procedures were used to design the survey, implementing the survey via a suitable medium, and analyzing the data.

The survey was designed to collect information regarding the characteristics of each responding printing establishments in terms of size and the number of years in the business, along with the measurement of print

quality in both the sheet fed offset and digital printers with respect to solid ink density and dot gain.

From the various sources, 20 potential printing establishments were identified all over the country (offering both the sheet fed offset and digital printing facilities). By using both the e-mail and the direct mailing system, they were invited to take part in the survey system. The questioner was supplied with detailed information regarding the nature and the purpose of the research. Care was given to collect the set of answers back in time and the questions were framed which would produce accurate and relevant information.

Data analysis was carried out in two ways, the first one on the coated paper and the other on the uncoated paper, further under the coated paper, both the print quality factors (solid ink density and dot gain) were analyzed separately. As the printing establishments were having both the printing facilities, these analyses were administered to find out the differences in quality between the two printing systems.

Results & Discussion

As per Swanson (2000) on his paper research work titled "Measuring Digital Image Quality", "the consumables of digital imaging output are as varied as their definition of image quality". This statement essentially indicates that all the print products can be included into the digital printers.

Out of the 20 presses contacted, 12 of them responded to the survey. In the first part of the survey, which relates to the characteristics of the printing establishments, there were two questions addressing the size and the number of years they are into the particular business. With the size of the press, three categories were taken into account (presses with one digital press, presses with 2-3 digital presses, and presses with more than 4 digital presses). Out of the 12 presses, 3 presses are equipped with 1 digital press and 9 organizations with 2-3 presses, none having more than 4 digital presses. Under the sheet fed offset press category, three slabs were given, 1, 2-5, and 6-10 four colour press. There were 2 presses in the 2-5 presses slab and 10 presses in the 6-10 slabs.

The second question was related to the number of years the printing establishments being engaged in production system. Three slabs were used, the first one is 1-10 years, the second slab is 11-20 years, and the third is more than 20 years. Out of the 12 respondents, 4 were in the first slab, 5 were in the second slab and the rest 3 in the third slab.

The printers were instructed to compare the above mentioned press sheet printed on both the presses, i.e. sheet fed offset and the digital offset press. Both the book cover or the magazine cover and the poster or calendar, that were printed on the un-coated paper and coated paper were considered by the particular press. Their variation both in sheet fed press and the digital presses, were collected. In case of coated paper, most number of the presses (9 out of 12) recommended that sheet fed offset press has the edge over the digital press, both in terms of solid ink density and dot gain factors. While in the case of un-coated paper, 11 out of 12 presses recommended that the digital printers produce better print results in terms of both the solid ink density and dot gain in comparison to the sheet fed offset press.

This finding indicates that the gap between the present day high end digital printers and the sheet fed offset presses are shrinking.

Conclusion

As the sheet fed offset presses and digital printers selected are highly restricted (there is wide range of sheet fed offset and digital printers are available in the market place), hence different results can be obtained from different presses. Even the same supplier of the particular sheet fed offset press or digital press can result into different set of values. This is also true for the same model of the equipment, different working day, or the press operators. Hence, it is practically difficult to obtain the exact result from such wide range of variables. Hence, during conclusion special care and attention must be given. The best way is to take into consideration of the recent trends in this particular segment.

Print quality is not highly differentiated with respect to the sheet fed offset and digital printers. High end digital printers produce print quality which is highly comparable with the digital printers. Very thin line exists between them. More systems and standards are available to the sheet fed offset segment, in terms of controlling and measuring the print quality factors. For the digital printers, very less number of such standards is in existence. Finally, sheet fed offset press is best suited to the coated paper and uncoated paper is the choice to the digital printer.

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