GAERF REVIEW COPY

8

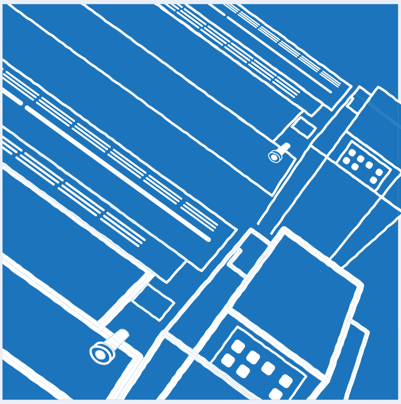
Printing Processes

NOT FOR SALE

Printing Processes

Chapter Preview

SCAN



Overview

Physical printing involves colored inks, toners, or other colorants repeatedly applied to sheets of paper, plastic, metal, or other materials. Conventional print processes range from traditional letterpress (raised surface) and gravure (engraved surface) to offset lithography, flexography, and screen-printing. Digital printing includes both inkjet and electrophotographic (EP) processes.

This chapter covers the mechanical principles of putting ink or toner onto a substrate. Armed with this basic technical knowledge, you will be able to make better decisions when planning, designing, and managing your print projects.

GAERF REVIEW COPY

A Heidelberg sheetfed offset press and a manroland web offset press, both with multiple, in-line printing stations or units.

The Printing Press

The press is the basic unit of the entire printing process. It is a precision instrument—far evolved from Gutenberg's modified wine press. Although a press is typically the largest and heaviest piece of equipment used in printing, it is highly controllable—to thousandths of a degree—on matters such as cylinder pressure, color balance, and image positioning. Often operating at high speeds, with computerized automation, and working in concert with many other systems, a press is a formidable piece of equipment.

Presses are configured as either **sheetfed** (individual sheets of cut paper) or **web** (continuous rolls of paper to be cut after printing). They are configured with printing stations or **units**—each one printing a different color or providing other applications such as special coatings or varnishes, to enhance the look of the finished piece.

A typical configuration is a four-color press, with each of the units printing one of the four process colors (CMYK), as discussed in Chapter 6. One-color and two-color presses can suffice for simpler applications, while five- and six-color presses are common in commercial printing environments. Hi-fidelity or HiFi printing requires at least six units—typically adding orange and green ink to the normal CMYK process inks. Presses are also manufactured with more than six units for specialty printing purposes, especially where custom or "spot" color inks or varnishes are required.

Multiple units allow the press to print more than one color on a substrate in a single pass through the press. (It is possible to print a four-color job on a one-unit press, but that requires a separate set-up—and wash-up—for each pass.)

Another important configuration is **the combination press**—those that incorporate more than one printing process. For example, some presses use both flexographic and gravure printing processes to create product packaging. Another common combination press uses a combination of offset lithography and inkjet printing to create color publications or direct mail pieces with unique, customized information (such as a mailing address) printed on each piece.

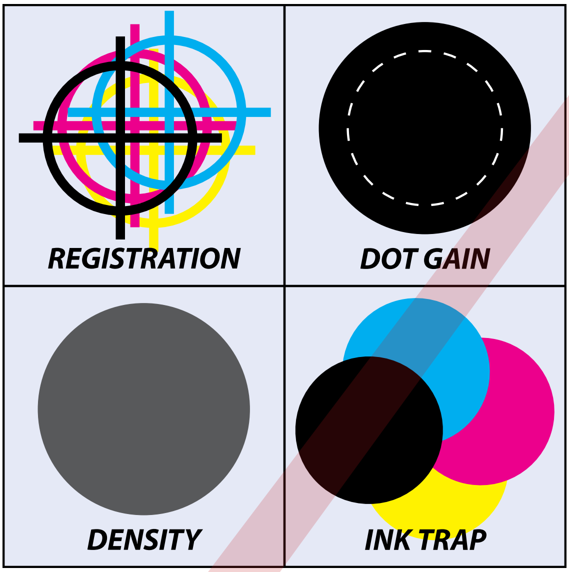
NOT FOR SALE

GAERF REVIEW COPY

Combination presses are also used in security printing, where documents must be produced that are difficult to copy or counterfeit. Scratch-off gaming or lottery tickets are produced on combination presses using many processes, including lithography, gravure, flexography, and inkjet printing. These presses sometimes have as many as sixteen units, because of the number of colors printed as well as the various layers of coatings needed to enhance security.

Every printing process is characterized by its image carrier or plate characteristics. They are also characterized by the formulation of their inks (or toners in the case of electrostatic or electrophotographic or EP printing) and of the substrate types they are capable of handling. For example, not every kind of paper can be used with certain digital presses; special coatings are required for the inks or toners to adhere properly.

Each process can be identified under magnification, usually 12x or greater, by someone skilled in the art of printing. Offset lithography has a different look than letterpress; gravure has a different look than flexography; inkjet printing has a different look than EP. Although the quality of print produced by these methods is constantly improving—making it harder to tell with the naked eye—important differences remain.



Common printing attributes include registration, dot gain, ink density, and trapping.

Important Print Attributes

Regardless of what technique is used, there are four important attributes of a printed color image. Each of these can have a significant impact on the quality of the work.

Registration is the relative positioning of the image on the substrate and the relative positioning of each ink layer over another. If the positioning of ink colors over each other is not accurate, the printed image will appear blurred.

Dot Gain is the extent of growth that takes place in the size of a halftone dot or screen tint dot from the printing plate to the printed sheet. All printing processes—with the exception of electrostatic or electrophotographic printing—are subject to dot gain. It occurs because the ink is squeezed onto the substrate under pressure. Because the ink is a liquid and has a thickness to it, there is a tendency

NOT FOR SALE

GAERF REVIEW COPY

for the ink to spread under the pressure. In inkjet printing, the ink is squirted onto the substrate and the force of the ink spot on the substrate causes the dot or spot to grow. Dot gain does not occur in electrostatic printing because dry toner particles are used that do not grow. Dot gain influences the look of a printed image. It is expected on the printing press and can be controlled in platemaking or in building digital files for printing. For example, if a dot gain of 30 percent is expected in the magenta ink being printed using the lithographic process, there are ways of reducing the size of the halftone or screen tint dot on the printing plate that will print the magenta ink.

Density is the intensity or visual strength of the ink that influences the color quality of the final printed image. In full-color printing, standards have been established for ink density when all other printing press variables are properly controlled. In other words, the density standard or target for yellow, magenta, cyan, and black are different in full-color printing. A densitometer is used to measure the density of ink on a printed sheet. (A spectrophotometer, is used to measure the actual color wavelengths as well as other attributes of color.)

A densitometer measures the degree of darkness or light absorbance of a material—in this case a layer of ink or toner covering a substrate.

Trapping is the extent to which one film of ink sticks to another when printing one ink film over another. In four-color printing, the yellow, magenta, cyan, and black halftone dots must partially overprint each other to satisfactorily produce the resulting red, green, and blue colors needed in full-color printing. Ideally, 100 percent of an ink film will stick to the other. This often occurs when a wet ink film is applied to a dry one. However, in reality, because the inks are wet on a multicolor press, less than 100 percent of one ink film adheres to the other. If only 85 percent sticks or transfers, this is called 85 percent trapping. The degree to which trapping occurs influences the look of the final print. The percentage of trapping too is measured with a densitometer or a spectrophotometer.

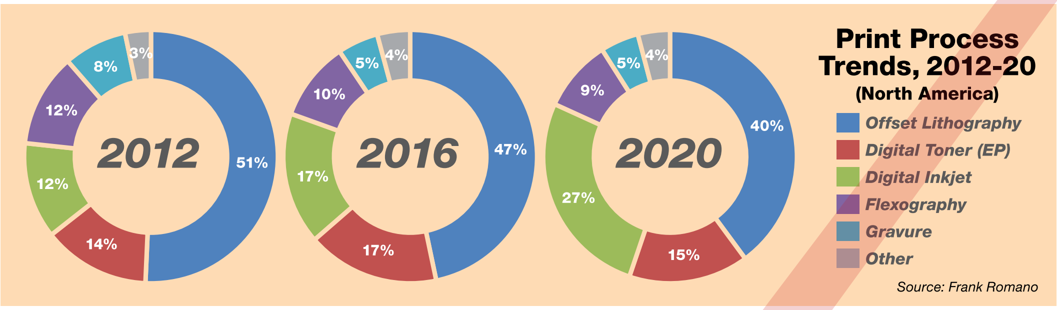
The term trapping was also once used to describe the creation of overlapping areas between two adjoining colors. The goal of these overlaps—created by specialized software like Luminous TrapWise and Scitex Full Auto Frame—was to avoid noticeable gaps caused by press or plate registration errors. The problem itself has diminished with improvements in press technology. So, that alternate use of the word "trapping" is outside the scope of this book.

Other components of a press that impact the appearance of the final printed piece include plate-to-blanket squeeze pressures (on offset presses), ink film thickness, the balance of fountain solution (water) and ink, the pH

NOT FOR SALE

GAERF REVIEW COPY

and conductivity of the fountain solution, roller settings and roller hardness, the tension of the substrate going through a web press, and more. Controlling these variables scientifically—and with less manual labor—has been the goal of modern press manufacturers for many decades.



Traditional printing processes are being significantly displaced by digital. Shown here is the percentage of North American print sales (customer price per page impression), by printing process, 2012–2020.

Traditional Printing Processes

Although nearly all printing today has a digital component, there are five technologies known as conventional or traditional printing processes: **letterpress, offset lithography, gravure, flexography,** and **screen-printing.** With the exception of letterpress, all are represented by major press manufacturers, and occupy a substantial portion of the multibillion dollar printing industry.

Although traditional printing has long dominated the industry, it is displaced by digital processes described later in this chapter. This is especially true of the centuries-old letterpress process. Here is an overview of the traditional printing processes:

Letterpress

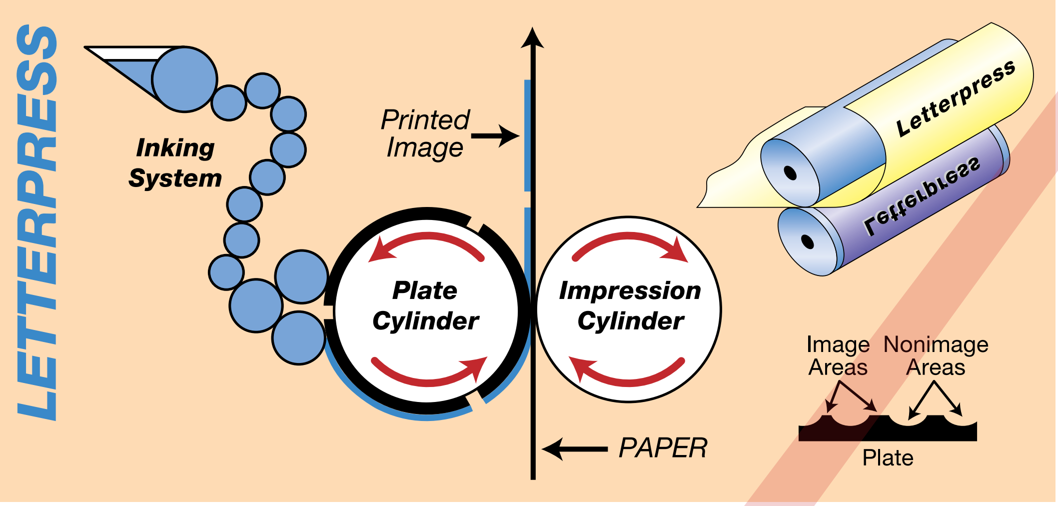
Letterpress was once the mainstay of printing, but it is largely obsolete today. Briefly, letterpress is **printing from the surface of a raised image.** It is also called relief printing, where the plate image is uniformly higher than the nonprinting areas. By far the oldest of the conventional processes, it has declined significantly in the past 50-60 years, as more efficient, economical, and higher quality printing processes emerged.

Less than three percent of all printing in the United States involves the letterpress process. Its demise is directly related to the amount of set-up time required; the heaviness, cost, and cumbersome nature of the plates (made of zinc, copper, lead, and photopolymers); and image resolution limitations.

In letterpress printing, ink is placed in an ink fountain and is then distributed onto mechanized ink rollers. The ink rollers apply the ink onto the raised image of the plate, and the plate transfers the image onto a substrate—usually paper. The image on the plate must be "wrong-reading" (a mirror image) so that the printed image on the substrate will be "right-reading."

NOT FOR SALE

GAERF REVIEW COPY



The principle of letterpress printing, a relief printing method where the image areas are raised above the nonimage areas. Rotary letterpress, showing the raised, wrong-reading type on the plate cylinder and the right-reading image on the paper.

Letterpress printing exerts variable amounts of pressure on the substrate depending on the size of the image elements being printed. The amount of pressure per square inch—or "squeeze"—is greater on some highlight dots than it is on larger shadow dots. Expensive, time-consuming adjustments must be made throughout the press run, to ensure that the impression pressure is accurate.

In traditional letterpress printing, letters were assembled into copy, explanatory cuts were placed nearby, line drawings were etched or engraved into plates—and all these were placed (composed) on a flat "stone" within a rigid frame called a chase, spaced appropriately with wooden blocks called furniture, and tightened or locked-up with toothed metal wedges called quoins.

In its heyday, letterpress was used to print a vast array of products and publications. However, with the exception of specialized art prints and other niches, letterpress has been relegated largely to the finishing processes of embossing, die-cutting, and foil stamping.

There are three types of letterpress printing presses: platen, flatbed, and rotary. The platen variety—often using a slow, handfed process—is the direct descendant of Gutenberg's modified wine press.

In a flatbed cylinder press, the plate is locked to a horizontal or vertical bed. That passes over an inking roller and then against the substrate. The substrate is passed around an impression cylinder on its way from the feed stack to the delivery stack. A single revolution of the cylinder moves over the bed, so that both the bed holding the substrate and cylinder moved up and down (or back and forth) in a reciprocating motion. Ink is supplied to the plate cylinder by an inking roller and an ink fountain.

Flatbed cylinder presses operated very slowly, with a production rate of not more than 5,000 impressions per hour. As a

 NOT FOR SALE

GAERF REVIEW COPY

result, much of the printing formerly done on this type of press was moved to rotary letterpress or lithography.

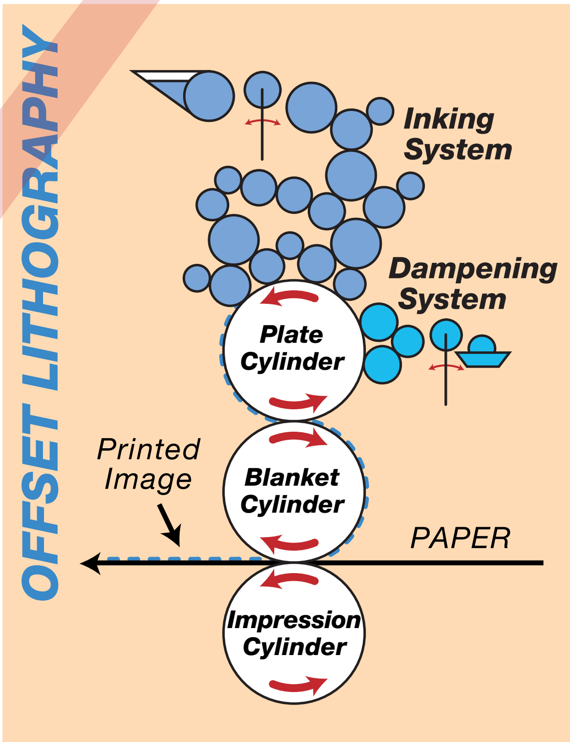
Rotary letterpress required curved, image-carrying plates. Typically, these were created from the original, flat-surface plates, using molded plastic or rubber, and known as stereotype or electrotype plates. When printing on coated papers, rotary presses used heatset inks and were equipped with high-velocity, hot air dryers.

When letterpress was dominant, web-fed rotary presses were used primarily for printing newspapers. These were often "perfecting" presses—designed to print both sides of the web simultaneously. The web width was up to four pages across, although later presses printed up to six pages across on a 90-inch web. Although largely replaced by other processes today, rotary letterpresses were also used for long-run commercial jobs, packaging, book, and magazine printing.

Offset Lithography

Lithography is printing from a flat surface on which the image areas and non-image areas are on the same plane. The process is based on the principle that grease and water do not mix. The image and non-image areas are separated chemically in such a way that the image on the plate will accept greasy ink and the non-image areas will accept water and afterward reject ink.

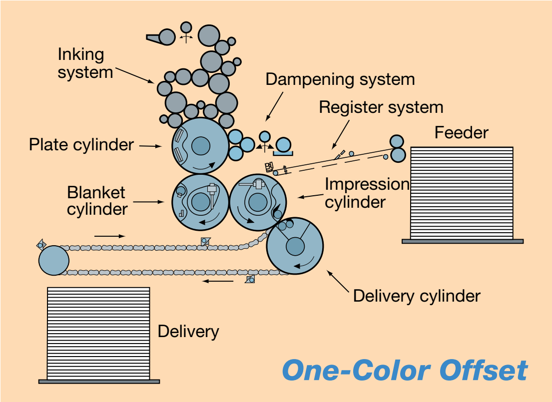
On a typical lithographic press, there is an ink fountain and a water or dampening fountain. Ink is distributed from the ink fountain onto a set of ink rollers. Simultaneously, the water fountain distributes a dampening solution, primarily composed of water and as small percentage of chemicals that help the water desensitize the non-image areas. The combination is called fountain solution that is then applied to dampening rollers. The rollers dampen the plate before ink is applied to it. The water sticks to the non-image areas that were chemically treated to accept the water. The ink rollers then apply ink to the plate. Because the water on the non-image areas rejects the greasy ink, the ink will only stick to the image areas. The lithographic plate is typically made of aluminum, although other metals as well as paper and plastic can be used.



The principle of offset lithography, a planographic printing process where the image and nonimage areas are separated chemically in such a way that the image on the plate will accept greasy ink and the nonimage areas will accept water and afterward reject ink.

NOT FOR SALE

GAERF REVIEW COPY



A single-color sheetfed lithographic press diagram showing the basic systems common to all such presses.

The inked images are then transferred to a synthetic rubber blanket that is wrapped around a cylinder that comes in contact with the plate cylinder. From the imaged blanket, the image is transferred to the substrate being printed.

The blanket performs three tasks. The first is to allow a right-reading image on the plate to become right-reading on the substrate. Without the blanket cylinder, the image would go from right-reading on the plate to wrong-reading on the substrate. The blanket's second function is to reduce the amount of fountain solution that reaches the substrate. When printing on paper, moisture absorbed by the paper causes paper distortion or dimensional instability. The third role of the blanket is to allow printing on a large variety of substrates—regardless of texture in most cases. The blanket allows for a certain degree of compressibility so, when printing on rough-textured substrates, the ink can be forced into the "valleys" of the paper.

Offset lithographic presses can be sheetfed or web. On the former, the substrate is fed into the press one sheet at a time at a very high speed, using highly specialized hardware for picking up and moving each sheet. Web-fed presses print on a continuous roll of substrate, or web, which is usually cut to size on the delivery end of the press.

Lithographic presses are classified as heatset or non-heatset, depending on the type of ink used and how it is dried. Heatset inks—typically used on high-quality, glossy stock—require special drying mechanisms on the press such as heating ovens, ultraviolet, infrared, or electron beam dryers. Non-heatset inks are typically dried via oxidation and absorption, and are used when the substrate is more porous, such as in newspaper printing.

Today, lithography is the most widely-used traditional printing process, used on a wide array of work, from simple, single-color to high-quality full-color work. It is well suited for printing text and illustrations in short to medium length runs of up to one million impressions. Approximately 50 percent of all printing in the United States is produced with the lithographic process, but its use is declining as digital processes improve in speed, capabilities, and quality.

Gravure & Engraving

The gravure process has its origins in the early seventeenth century when the intaglio printing process was developed to replace woodcuts in illustrating the best books of the time. In early intaglio printing, illustrations were etched on metal, inked, and pressed on paper.

NOT FOR SALE

GAERF REVIEW COPY

Gravure, a common type of intaglio printing, makes use of the ability of ink to fill slight depressions on a polished metal plate. The process of gravure printing today consists of a printing cylinder, a rubber-covered impression roll, an ink fountain, a doctor blade, and a means of drying the ink.

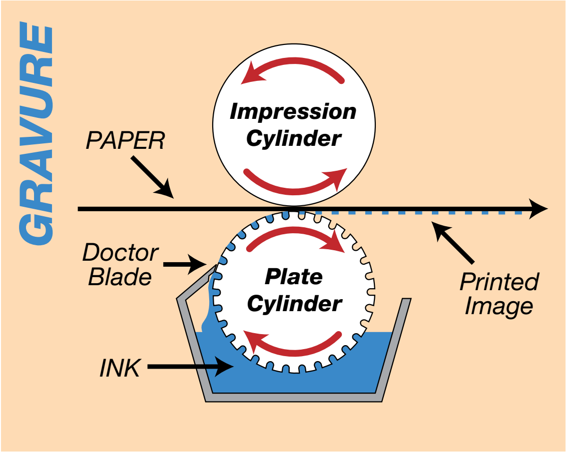
In principle, gravure printing can be thought of as the opposite of letterpress printing. Where letterpress prints from a raised image, gravure prints from a recessed image. In gravure printing, the image area is beneath the plate surface and the non-image area is on the plate surface. A typical gravure plate is a large copper- or chrome-surfaced cylinder. Through chemical, electro-mechanical, or laser engraving processes, an image is etched or engraved onto the cylinder in the form of microscopic wells or cells.

Initially, ink in the gravure press is applied directly to the copper cylinder, not only filling the wells but also adhering to the surface of the cylinder. It is applied to both the image and non-image areas of the cylinder. However, a doctor blade made of hard rubber or plastic then passes over the cylinder and scrapes off ink from the non-image area on the surface. After this occurs, the substrate being printed comes in contact with the cylinder at high speed and under high pressure. As the paper is rapidly pulled off of the cylinder, capillary action pulls the ink out of the cylinder ink wells, which represent the image area, and the ink is transferred onto the substrate. This all occurs at a high rate of speed.

Gravure printing involves high costs, including the time required to prepare the plate cylinder. It is, therefore, economical for very long press runs where the cylinder does not have to be changed often. Typically, printing requiring tens of millions of impressions lends itself to the gravure process. Another unique aspect of gravure is its potential for producing high quality images. It allows for smooth tone transitions from highlights to midtones to shadows.

The dominant gravure printing process, referred to as rotogravure, employs web presses equipped with cylindrical plates as image carriers. A number of other types of gravure presses are currently in use. Rotary sheetfed gravure presses, though rare, are used when high-quality pictorial impressions are required. They find limited use, primarily in Europe. Intaglio plate printing presses are used in certain specialty applications such as printing currency and fine art. Offset gravure presses are used for printing substrates with irregular surfaces or on films and plastics.

Today, almost all gravure printing is done using engraved copper cylinders,



The principle of gravure, an intaglio printing process where the image areas are engraved, or recessed, below the nonimage areas.

NOT FOR SALE

GAERF REVIEW COPY

A TR 10B gravure press.
(Courtesy Koenig & Bauer AG)

protected from wear by the application of a thin electroplate of chromium. Rotogravure cylinders vary widely in size, depending on the application. Publication press cylinders can be up to eight feet wide, while packaging press widths rarely exceed five feet. Specialized presses, for printing paper towels, can be 20 feet wide. The diameter of a gravure cylinder can be as large as three feet, or as small as three inches—for printing wood grains.

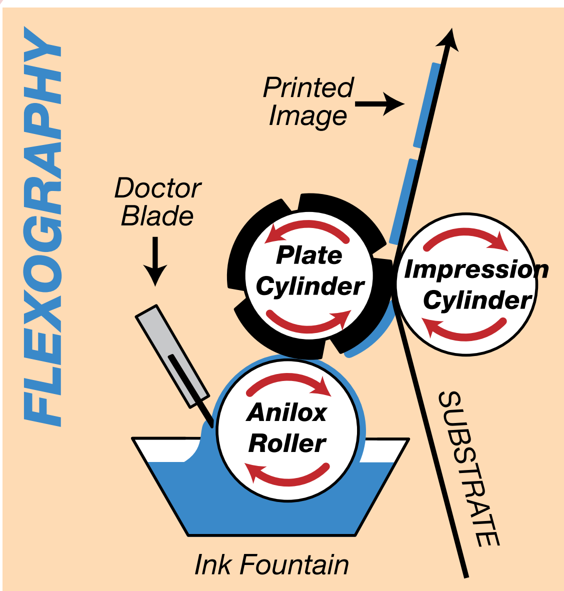
Gravure is a popular process for long-run, large volume publication and catalog printing, where image quality is vital. It is also used for package printing on non-paper or board substrates such as foils, plastics, cellophane, and other substrates having little or no absorption. It is also a popular process for printing on specialty items such as wall coverings and linoleum and for producing synthetic wood grains on pressure-sensitive substrates. Gravure represents approximately 12 to 13 percent of all printing today, but is gradually declining in use.

It is important to note that gravure is not the only form of intaglio printing. Traditional engraving is still part of graphic communication today, with more than 30 engravers in the United States alone.

Today's engraving methods involve etching an image onto a copper plate, which is then mounted on the press with a matching counter. The image is transferred from plate to paper resulting in a finely detailed, raised image on the paper's surface.

Flexography

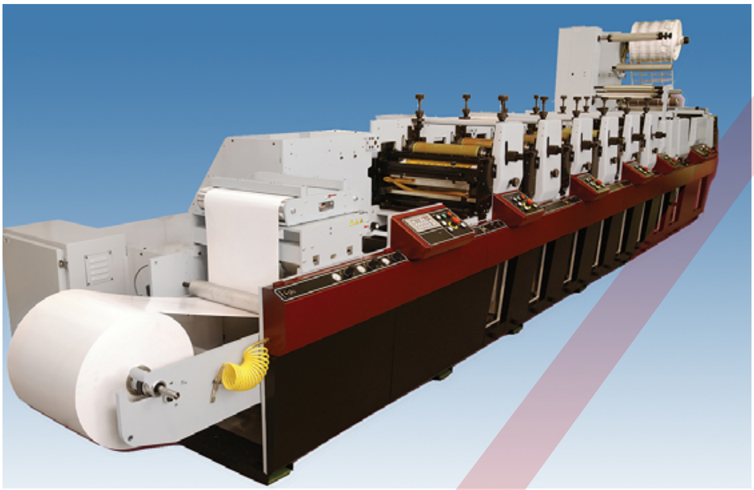
Similar to letterpress printing, flexography involves printing from a raised image on the plate. The difference, however, is that the flexographic plate is typically made of synthetic rubber or a photopolymer material. Some of the harder flexographic photopolymer plates print relatively sharp and produce high-resolution images. However, the softer, synthetic



One variation of the flexographic process that uses an anilox roll and a doctor blade to apply ink to the raised surface of the printing plate.

NOT FOR SALE

GAERF REVIEW COPY



Mark Andy LP 3000 flexographic, web label press (Courtesy Mark Andy, Inc.)

rubber plates are not as suitable for high-quality printing and are typically used for long-run imaging requiring one or two flat colors where image sharpness is not of critical concern.

In the typical flexographic printing sequence, the substrate is fed into the press from a roll. The image is printed as the substrate is pulled through a series of stations or print units. Each print unit prints a single color. As with gravure and lithographic printing, various tones and shading are achieved by overlaying the four process ink colors—magenta, cyan, yellow, and black.

Flexographic printing begins with image and artwork preparation, in most cases comparable to the prepress process described in Chapter 5. Manual image assembly involving "mechanical" artwork and analog image photography is no longer frequently used, having been replaced with digital processes. Flexographic work, especially packaging, does require some skills that are distinct from typical print preparation, however. On-press color behavior is often different in offset printing and flexography, for example. Proofing is also different, due to the need to create three-dimensional proofs and prototypes, particularly for packaging.

Flexographic plates are relief plates that come in contact with the substrate being printed. The plates are attached to a roller or cylinder for ink application. They are made using three different processes: photomechanical, photochemical, and laser engraving.

There are five types of printing presses used for flexographic printing. These are the stack type, central impression cylinder (CIC), in-line, newspaper unit, and dedicated four-, five-, or six-color unit commercial publication presses. All five types employ a plate cylinder, a metering cylinder known as an anilox roll that applies ink to the plate, and an ink pan. Some presses use a third roller as a fountain roller and, in some cases, a doctor blade for improved ink distribution.

Flexographic inks are similar to packaging gravure printing inks in that they are fast drying and have a low viscosity. The inks are formulated to lie on the surface of non-absorbent substrates and solidify when solvents are removed by drying devices. Solvents are removed with heat unless UV-curable inks are used.

The technology of flexography has improved rapidly over the past decade,

NOT FOR SALE

GAERF REVIEW COPY

as has its quality. The process is popular for label printing, packaging, corrugated board printing, and for printing on non-paper substrates. These include cellophane, plastic, polyester, foils, folding cartons, paper bags, plastic bags, milk and beverage cartons, disposable cups and containers, adhesive tapes, envelopes, food wrappers, and other substrates with little or no ink absorption. In recent years flexography has also become popular for newspaper printing because the process lends itself to the use of water-based inks that do not rub off when handled. Flexography represents approximately 20 percent of all printing today, and its use is growing.

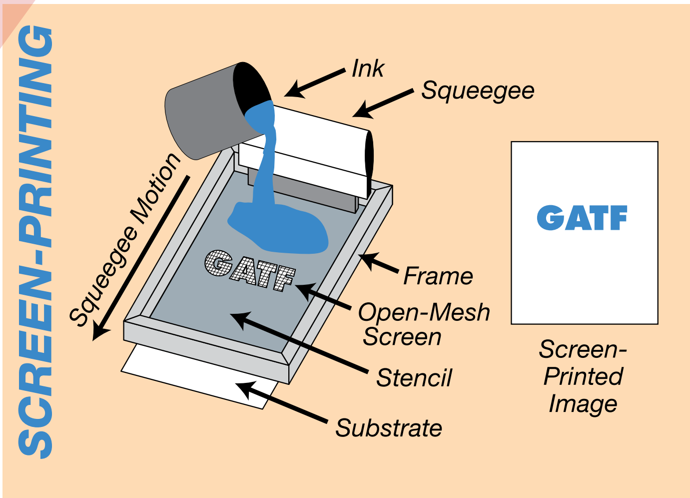
Screen-Printing

Screen-printing is the simplest of the traditional printing processes. The image to be printed is formed on a screen made of synthetic fibers over which a stencil is placed that represents the non-image areas. The area of the screen not covered by the stencil represents the image area because it is here where ink can pass through the screen and onto the substrate.

Stencils can be formed in a number of ways. One way is by photographically exposing—through negative or positive film—a light-sensitive emulsion applied to the screen. When developed, the image and non-image areas are defined. Stencils can also be formed by applying pressure-sensitive stencil material on the screen or by "painting" a liquid stencil on the screen. Once the stencil is formed, the screen is brought in contact with the substrate, ink is placed on the screen, and a squeegee drags the ink over the stencil and the entire screen. The ink that is not blocked by the stencil will go through the screen and onto the substrate to form the printed image. The process uses a porous mesh stretched tightly over a frame made of wood or metal.

Many conditions such as composition, size and form, angle, pressure, and speed of the blade (squeegee) determine the quality of the impression made. Proper tension of the frame is essential for accurate color registration. At one time, most blades were made from rubber that was prone to wear, subject to edge nicks, and tended to warp and distort. Most blades are now made from polyurethane that can produce as many as 25,000 impressions without significant degradation of the image.

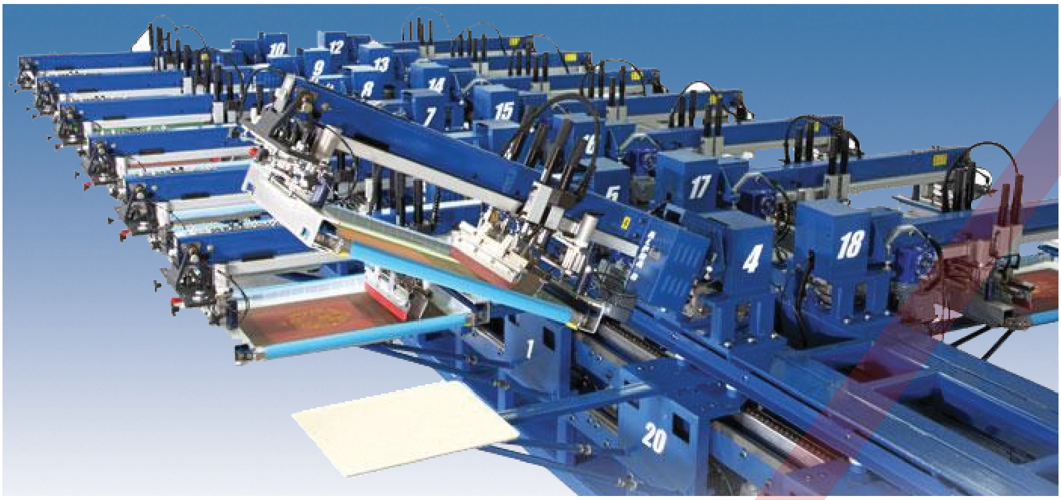
A significant characteristic of screen-printing is that a greater thickness of the



The principle of screen printing, in which ink is forced through openings in a stencil to create an image.

 NOT FOR SALE

GAERF REVIEW COPY



M&R ALPHA 8 Automatic Oval screen-printing press

ink can be applied to the substrate than is possible with other printing techniques. This allows for some effects that are not possible using other methods. Because of the simplicity of the process, a wider range of inks, including solvent-based, water-based, plastisol, and UV-curable is available for use in screen-printing.

The use of screen-printing has grown slightly in recent years because production rates have improved. This has been a result of the development of automated and rotary screen-printing presses, improved dryers, and UV curable ink. The major chemicals used include screen emulsions, inks, solvents, surfactants, caustics, and oxidizers used in screen reclamation. The inks used in this process vary dramatically in their formulations.

Following the screen-printing process, the printed product is placed on a conveyor belt to a drying oven or UV curing system. The rate of screen-printing production was once dictated by the drying rate of screen-printing inks. However, due to advances in automation, rotary-style presses, drying, and UV-curable ink technologies, the production rate has greatly increased.

There are three types of screen-printing presses: flatbed (the most common), cylinder, and rotary. Until relatively recently, all screen-printing presses were manually operated. Now, however, most commercial and industrial screen-printing is done on single-color and multicolor automated presses.

The screen process lends itself to printing that does not require long runs, and is often used for printing T-shirts and other textiles such as nylon and cotton, as well as for printing short-run posters, bumper stickers, billboards, labels, decals, and signage. It can also be used on electronic circuit boards, glass, leather, wood, and ceramic surfaces. Its advantage over other printing processes is that the press can print on substrates of many shapes, thickness, and sizes. Screen printing represents under five percent of all printing, and its use has experienced gradual growth in the recent past.

NOT FOR SALE

GAERF REVIEW COPY

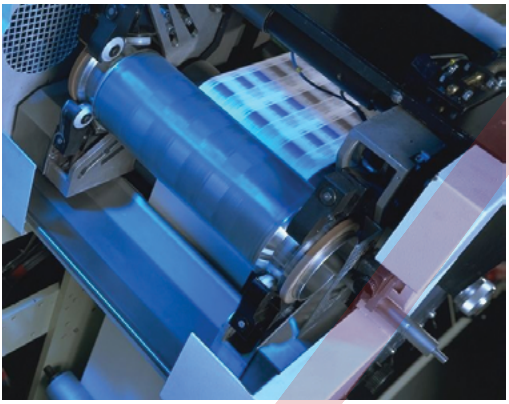
Combination Printing

Combination or hybrid printing involves printing presses that use two or more printing processes. For example, security printing—such as scratch-off lottery tickets—typically employs printing presses having three or four processes such as lithography, gravure, flexography, and inkjet printing. Package printing often involves combination presses to create different effects of solids, screens, or foil finishes.

In 1995, the DI (Direct Imaging) press combined offset printing and on-press digital imaging of the printing plate. (Image courtesy of Heidelberg.)

Combination printing is not a new phenomenon. Gutenberg combined several existing technologies with his own to invent a process that lasted for centuries.

Another popular form of combination printing involves adding inkjet printing to



A Stork RSI rotary screen print module in operation on a combination, or hybrid, press. (Image courtesy of Stork Prints America, Inc.)

four-color web offset printing. This allows for the printing of high-quality publications, catalogs, and direct mail, where each individual piece can be personalized, using variable data printing or VDP.

A Kodak Prosper inkjet head, combined with high-speed web offset to imprint each page with personalized information. (Image courtesy of Eastman Kodak.)

A Graphium UV press, combining flexo and digital inkjet. (Image courtesy of Fujifilm.)

NOT FOR SALE

GAERF REVIEW COPY

Digital Printing

Today, almost all printing involves a high level of digital functionality. Conveying text and graphics to a device that can reproduce them at high volumes (a printing press) involves increasingly fewer manual steps.

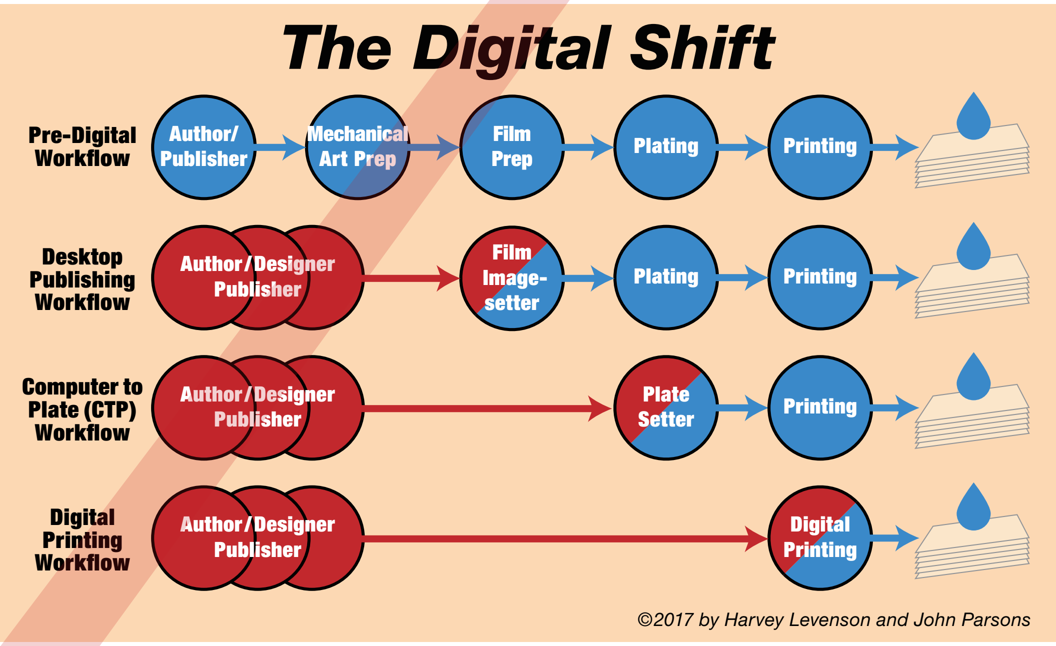
Of the "conventional" printing types—offset, gravure, flexography—only the physical printing process differs from that of what we know today as digital printing. Those are based primarily on inkjet and electrophotographic or EP technology.

Most of the digital printing processes discussed in this section are "pressure-less" in nature. For example, EP printing does not use traditional wet printing ink but use toner that is directed to the image area on the substrate via electrostatic charges. Inkjet devices, as the name implies, apply their inks directly to paper from a nozzle or similar device. Hence, with inkjet and electrostatic or EP digital printing, there is no printing plate squeezing the ink onto a blanket or directly onto the substrate.

Digital Print Benefits

Besides their different imaging methods, digital printing presses are also able to more easily accept jobs directly from a computer system, and produce a printing plate or image a cylinder "on-the-fly." They can produce jobs with shorter run lengths and greater variability than conventional presses could cost-effectively handle.

Digital printing has come of age in the early 21st Century. Digital presses now produce images that rival offset



All printing, even today's inkjet and EP devices, employs a physical process to put ink or toner on a substrate. The difference is where the digital process stops and the mechanical process occurs. Before the desktop publishing phenomenon, every step was mechanical (shown in blue). With DTP, early steps in the workflow were combined digitally. Then, with each successive advance, the digital process (in red) moved closer to the actual moment an image was printed.

NOT FOR SALE

GAERF REVIEW COPY

lithography, and lower cost-per-page pricing makes them a viable printing alternative.

Digital printing represents a growth area for many graphic communication companies. Digital printers do mostly digital printing, but some do traditional printing as well. They are also producing a growing amount of full-color printing to complement the large volume of black-and-white printing traditionally associated with digital printing through companies and corporate data centers where large volumes of transactional printing is produced, including bills, statements, policies, and reports.

While the cost-per-page of digital color is currently too high to compete with offset for long runs, that cost will continue to fall, eroding the role of conventional printing.

In these market segments, black-and-white printing used to be predominant. Today, color is typically used in their documents. In some cases, companies print variable black text on a shell that has been preprinted in color using offset presses. Direct mail printers who previously printed almost exclusively in black when it came to digital printing have now incorporated full-color digital printing into their production mix.

The majority of digital printing companies are small, typically employing between five and ten people. They serve a variety of industries, including business and financial services, retailers, nonprofit organizations, and education and government organizations. In an industry where many firms are still fighting to survive, digital printers are thriving.

Digital printers produce a variety of printed products. Books and manuals make up the largest page volume, printed predominantly in black-and-white and sold at a relatively low cost per page. The revenue makers and growth areas are color applications, such as brochures, sales collateral, and direct-mail printing. Individual companies have also developed specialized color markets, such as business cards, short-run posters, and calendars.

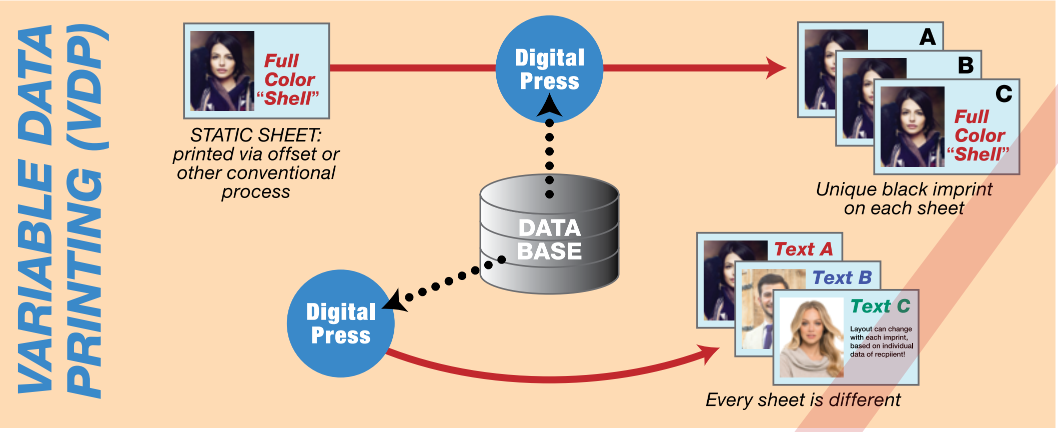
One reason digital printers are growing—in an environment where other printing companies cannot—is the availability of affordable digital color. Their printed products were once impractical using traditional printing equipment. But with color digital printing costs dropping below ten cents per letter-size page, the economics have become more attractive. While the cost-per-page of digital color is currently too high to compete with offset for long runs (over 20,000 pages), that cost will continue to fall, further eroding the role of conventional printing.

The VDP Process

One unique aspect of digital printing is the ability to incorporate Variable Data Printing or VDP into a job. Because each sheet or page is imaged at the moment it is printed, it can literally be different from any other page in the press run. VDP workflows are dependent on the system's

NOT FOR SALE

GAERF REVIEW COPY



Variable Data Printing (or VDP) is based in the principle that an inkjet or EP press images each page individually from digital data. The most common technique is to imprint variable data—such as name and address information—on a pre-printed color "shell." The other, which requires greater computing power, is to create a unique page for each impression, based on unique data for text and images.

ability to handle high data volumes, and rapidly respond to each change without unduly slowing down the press. There must also be reliable and secure data handling processes in place, so one customer does not receive a printed piece clearly intended for someone else.

The benefits VDP to marketers and publishers are obvious—and only possible with digital printing. (Note that each copy of this book has a unique, data-generated serial number printed on the inside front cover.) In the past, relatively few digital printers utilized the potential of VDP fully, although the technology has been available for years. That number is growing, however.

Previously, digital printing equipment vendors promoted VDP because, in certain applications, variability justified the high cost of digital color pages. For static pages, digital printing was just not able to compete with offset lithography, except for extremely short runs. Today, however, VDP is only one aspect of digital printing, which is continuously displacing conventional processes in most printing applications.

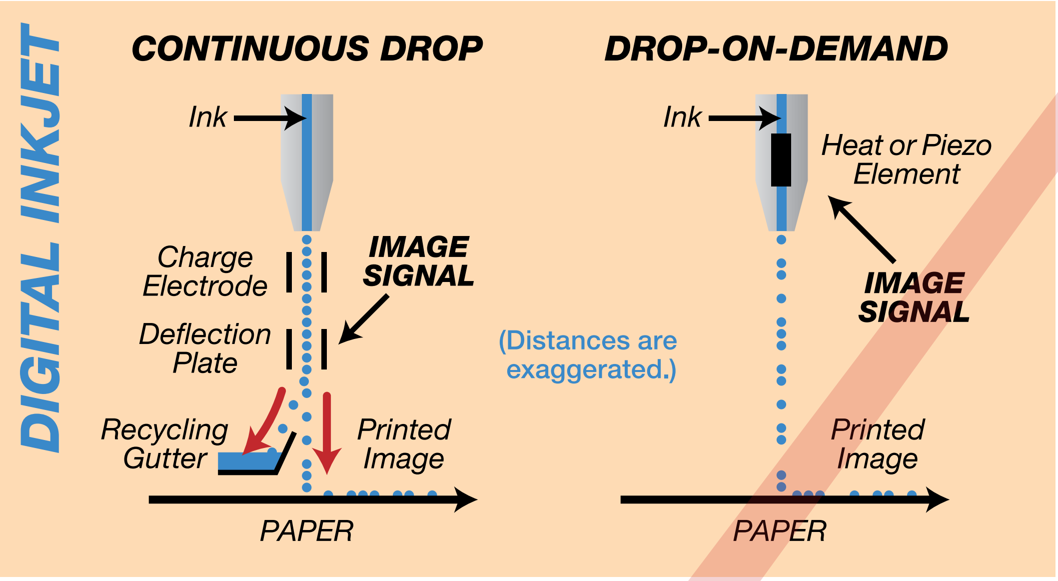
Digital Printing Engines

There are different printing engines that drive digital presses. Digital systems consist of inkjet, electronic, electrophotographic (EP), magnetographic, ion deposition, light-emitting diode (LED), liquid crystal shutter (LCS), electron beam imaging (EBI), thermal, and electrostatic printing. These are all processes—used mainly for short runs and printing variable or personalized information—in which data representing the images are in digital form until the moment of actual imaging.

Inkjet printing. In the early days of the technology, inkjet printing was used mainly for simple, monochrome printing such as variable addressing, barcoding, computer letters, sweepstakes forms, and personalized direct mail advertising. Increasingly, however, inkjet devices are increasing in speed, versatility, and cost-effectiveness, putting them in contention for an increased share of the color printing market.

NOT FOR SALE

GAERF REVIEW COPY



Inkjet printing uses either a continuous drop process (where an electrical charge deflects droplets that are not to be imaged) or drop-on-demand (where an electrical charge initiates the correct droplets).

During the inkjet printing process, microscopic droplets of ink are squirted onto a substrate from a print head containing one or more nozzles. One type of inkjet printing is the **continuous drop** process, where a stream of ink droplets is forced through a nozzle under constant pressure. The ink droplets are deflected to the image area via electrostatic charges. Unneeded droplets are not charged and are deflected into a gutter for recycling

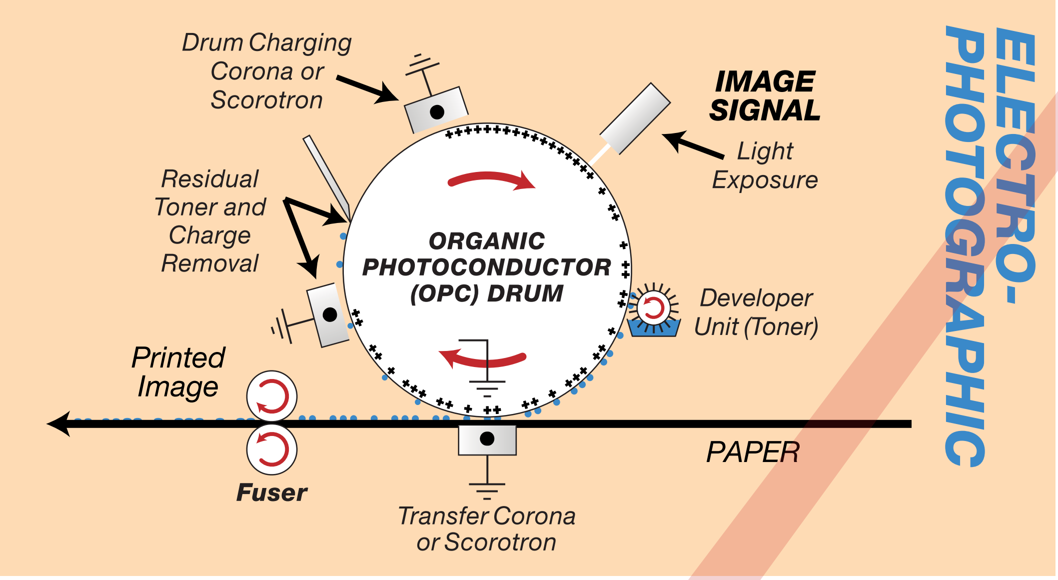
One disadvantage of inkjet printing is that the inks are often water-soluble and can easily smudge when subjected to moisture (applying a protective coating can prevent smudging).

The other major inkjet printing technology is the **drop-on-demand** process, where ink drops are forced through the nozzle only when needed. There are three types of this process. One is **piezoelectric**, where an oscillating crystal produces an electric charge that causes the ink drop to be expelled. Another, **bubble jet/thermal liquid ink**, where an electric charge is applied to a small resister causing a minute quantity of ink to boil and form a bubble that expands and forces the ink droplet out of the nozzle; The third, **solid ink**, involves a wax-based ink that melts quickly and solidifies on contact with a substrate.

Electrostatic and Electrophotographic (EP) printing. Electrostatic and electrographic (EP) printing are similar in that they relate to the principles of xerography, where toner particles are used to form an image. In electrostatic printing, unlike EP printing, there is no print drum. Toner particles are attracted directly to the paper through controlled conductivity. No optical system is used. The copier glass is exposed at once and an electrostatic charge is directly deposited onto the paper. The toner is fused to the paper through hot air. The electrostatic process is typically found in office printers.

NOT FOR SALE

GAERF REVIEW COPY



The operating principle of an electrophotographic digital press like that of an office copier. Charged toner particles adhere to selectively charged portions of a drum, and are then transferred to the paper substrate.

Electrophotographic or EP printing uses a print drum and photoconductor that is charged by a corona discharge and then imaged by a moving laser light beam modulated by digital signals from a PostScript-based or PDF-based digital imaging system. In this process, a laser beam is focused on a rotating mirror that deflects the beam through a focusing lens that forms a latent image on a photoconductor. EP devices are faster that electrostatic printers and used for both monochromatic and full-color, production printing.

Other Digital Print Processes. There are a host of secondary technologies that relate to the print engine driving the digital printing processes. These include electron beam imaging (EBI), ion deposition, light-emitting diode (LED), liquid crystal shutter (LCS), magnetographics, and thermal printing. Typically, they are "pressureless" in nature, are components of print heads, have few moving parts, and emit high-intensity lights and electrical signals to convert data into printed pages. Unlike inkjet and EP technologies, these processes are largely confined to office printers, and are not widely used in high-production environments.

Wide-Format Digital Printers

Wide-format digital printers provide individuals and companies with access to inexpensive large-sized prints. A growing number of companies manufacture systems that produce full-color digital prints ranging in size from 36 in. to 54 in. However, systems that produce larger sizes are also available. There are two components to these systems: a large-format printer and a RIP. Large-format digital printing systems print on a variety of substrates including paper and Mylar and use engines represented by

NOT FOR SALE

GAERF REVIEW COPY

inkjet, electrostatic, or thermal wax transfer technology.

Large format devices typically use a drop-on-demand inkjet process. Applications include contract color proofing (see Chapter 6) and a variety of art reproduction and signage uses, from poster-sized sheets to large "wraps" for vehicles and even buildings. The inks can be aqueous or solvent-based. Traditional wide-format inks require the use of specially-coated papers. More recently, however, Ultraviolet- or UV-curable inks are used in order to print on uncoated substrates (among other benefits). Water-based latex inks—introduced by HP—are also used in wide format printing, as an environmentally friendly way to produce outdoor media.

This market is growing rapidly and finding its niche in the "quick printing" and on-demand printing industry segments. Users of this technology also include advertising agencies, screen printers, and in-plant printing departments of many businesses. The applications are numerous and include items such as art-on-demand, backlit signage, transportation advertising displays, engineering drawings, maps, murals, posters, window graphics, and more.

Digital Printing Presses

Since the introduction of the first models in the early-to-mid 1990s, the evolution of digital color printing presses has accelerated beyond the imagination of color theorists and technicians. The paradigm that printing technology depreciates over a ten-year period has been replaced with a "scientific revolution" reducing the cycle of technological transition in the graphic arts from a decade or more to a few years or even months.

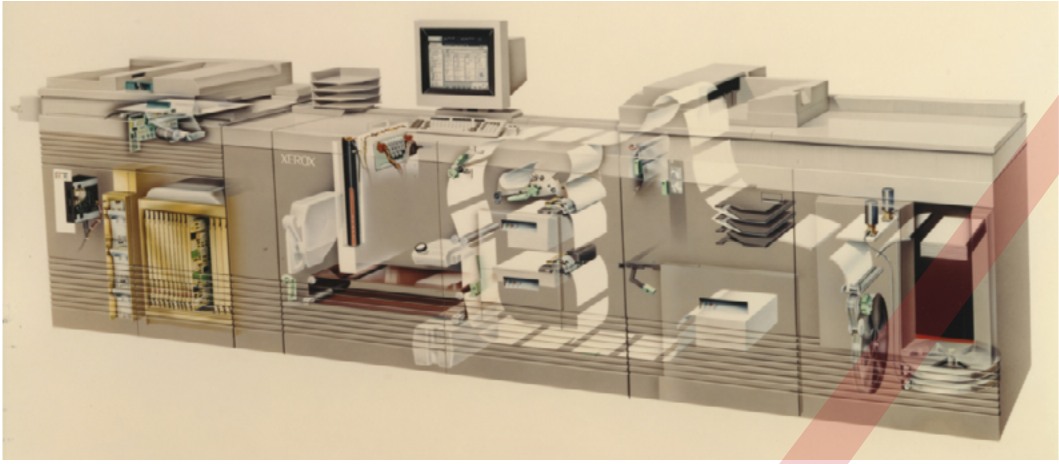
The technology of computer-to-film, bypassing the laborious tasks of graphic arts photography and image assembly, was a monumental step toward automating the printing processes in the late 1980s and early 1990s. Computer-to-plate technology, and its popularity in the 1990s, was an extension of this technology. However, computer-to-press technology has provided complete integrated printing systems putting the author, copywriter, and artist in the position of producing finished printed products.

The Xerox DocuTech represented the first wave of such technology in the production of black-and-white printing. However, soon after DocuTech's introduction in the late 1980s, other

ValueJet 1204, a wide-format digital printer. (Courtesy Mutoh America, Inc.)

NOT FOR SALE

GAERF REVIEW COPY



The Xerox DocuTech 135, introduced in 1990 (Image courtesy of Xerox Corporation.)

manufacturers saw the future of direct-to-press technology in color markets and nearly all systems afterwards addressed this demand. Heidelberg, the first to introduce a direct-to-press color system in its GTO-DI, was quickly followed by Indigo, Xeikon, Agfa, and others. By the year 2000, Heidelberg had already introduced several generations of direct-to-press systems. Today, a growing number of companies are producing digital color printing systems to compete with commercial printing presses.

Much of the accelerated development in this area is the result of mergers, joint ventures, and acquisitions where companies acquire existing technology rather than reinventing it. Thus, two or more technologies are brought together to create improved systems, speeds, and technological advances.

Digital printing has resulted in a wide range of new companies serving the industry's equipment needs. While traditional companies such as Heidelberg and manroland have entered the digital arena and then left it to focus on their core traditional technologies of offset lithographic printing presses, companies including Canon/Océ, EFI, Fujifilm, Hewlett Packard, KBA, Kodak, Komori, Konica Minolta, Landa, Memjet, Pitney Bowes, Ricoh, RISO, Scitex, Screen Americas, Xanté, Xeikon, Xerox, and others all are now manufacturers of printing technology, but of the digital variety. These companies provide not only hardware but also intangibles such as software and digital front-end work-flow systems. Digital workflow strategy and production workflow processes are as important as hardware in driving printer production and productivity.

On the hardware side, systems that handle a greater variety of substrates, including very lightweight paper, have been developed. The concept of "universal copier/printer" devices has been developed. These are devices that output color and monochrome pages at competitive costs with dedicated color and monochrome printers. Adding value by integrating all services from front-end to printing to finishing is key to digital printing, as is flexibility and process improvement.

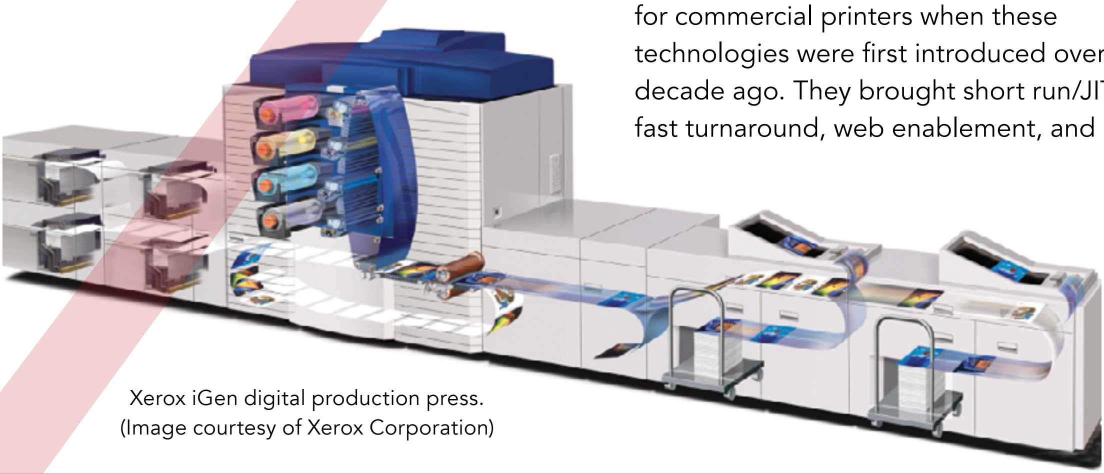
NOT FOR SALE

GAERF REVIEW COPY

Ricoh Pro VC60000 inkjet press, the device used to print this book. (Image courtesy of Ricoh USA Inc.)

A modern printing operation today also uses the Internet and World Wide Web as common business tools for receiving information and for executing related business functions. Innovations in RIP, server, and workflow technology are making it easier to integrate digital devices into almost any printer's array of output services.

Digital printing has caught up with offset lithography in quality of output, and the digitally driven convergence of the two output technologies is already underway. Within the range of applications that they were designed for, digital presses compare with offset in color in such a way that even trained eyes can no longer distinguish the differences. Digital output systems now complement conventional offset lithographic equipment.



Xerox iGen digital production press.
(Image courtesy of Xerox Corporation)

Digital Device Comparisons

Digital color printers and copiers. Color copiers represent the broadest range of manufacturers and features. Once relegated to the office environment, new digital color printers have become ubiquitous in printing companies as well. They employ basic laser imaging technology to charge an image on either drums or belts, from which the developed CMYK image is ultimately transferred to paper. Any project that demands process, full-bleed color in runs of up to 5,000 can be imaged on these high-resolution, toner-based devices.

Digital color production presses. The Kodak NexPress and Xerox DocuColor iGen series represented a breakthrough for commercial printers when these technologies were first introduced over a decade ago. They brought short run/JIT, fast turnaround, web enablement, and

NOT FOR SALE

GAERF REVIEW COPY

personalized printing into the press department. Although there are individual differences, these toner-based presses are fast and feature extremely high print quality and the ability to deliver collated sheets at the end of the press. They run smooth and textured papers in a range of sheet sizes and basis weights, with the ability to mix stocks in a single run.

Xeikon-engined printers. A toner-based web press, the Xeikon-engined printer feeds its web through a series of drums, each charged with the image and each applying one process color. Process color toner is fused to the sheet with adjustable heat and pressure; changing the heat and pressure levels results in more or less gloss in the toner.

Xeikon 5000 web-fed digital press (Courtesy Punch Graphix)

An on-line cutter trims pages to length. For optimum performance paper must be scripted in order to establish set points on the equipment for heat and pressure as well as other key characteristics. This high-resolution duplexing printer has full variable-data capability—meaning that some or all of the text or images can be changed from one document to the next.

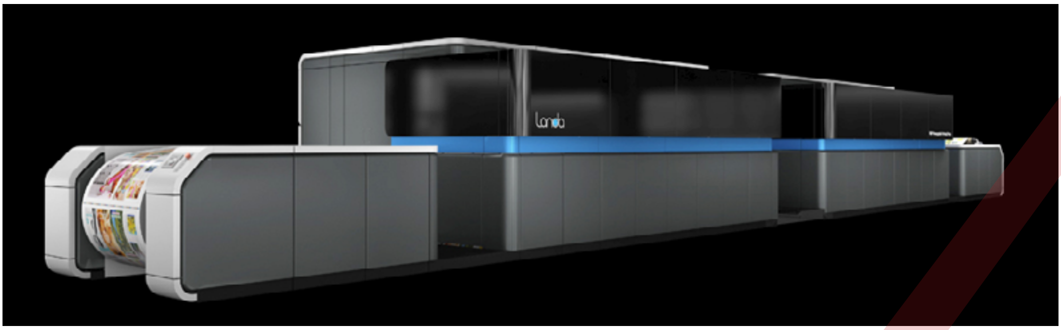

HP Indigo 5000 sheetfed press
(Image courtesy of Hewlett-Packard)

HP Indigo presses. These presses use one imaging drum and patented liquid ElectroInk. Both drum and ink are charged; ElectroInk adheres to the image area on the drum and a blanket transfers the image to paper. No ink is left on the blanket. The plate charge is cleared and the process is repeated for subsequent colors. This process supports fully variable data and very high-resolution images. The HP Indigo press can print on a wide range of substrates, but for optimum performance pretreated paper often improves toner adhesion.

DI presses. These sheetfed presses were popular for a short time but were replaced by presses with a more fully digital workflow. The DI presses worked like offset presses with an electronic twist: directed by digital data, pre-mounted plates were imaged with a laser right on the press, reducing makeready time to minutes. They were ideal for process color jobs from 500 to 10,000, and produced high-resolution offset images using

NOT FOR SALE

GAERF REVIEW COPY



Landa W10P Nanographic Printing Press (Courtesy Landa Corporation)

traditional inks and were ideal for promotional and sales literature, publications, and even packaging.

High-speed and high-volume digital presses are used for documents requiring hundreds of thousands or even millions of copies. They have variable-data capabilities and are very popular for transactional documents such as telephone bill, cable television bills, utility bills, and much more. They often have the capabilities of producing full-color images along with personalized messages directed specifically to the recipient.

Nanography. One of the latest of the digital printing processes is Nanography, developed by the Landa Corporation. It has enough attributes that differ from other digital printing processes that makes it worthy of notice. The process uses pigment particles under 100 nanometers in size. (A nanometer one-billionth of a meter. This produces images with ultra-sharp dots of high uniformity and high gloss. The process begins with the jetting of billions of droplets, not ejected directly onto the substrate—as in the typical inkjet process—but onto a blanket from ink ejectors positioned one to two millimeters away.

Printing Economics

Several trillion pages are printed in North America each year, mostly on offset equipment. Much of that volume will eventually be a candidate for digital printing. For at least half of those pages, printing cost is the primary obstacle to shifting from offset to digital. And the cost of digital printing is finally reaching a level at which it can compete for a growing number of those pages. While this represents a growth opportunity for digital printing, it still requires a good marketing strategy, an efficient workflow, and good customer service.

Besides the improvements in color quality and VDP, digital print offers other important economic incentives. Among these are the "on-demand" nature of the technology. Because each job can be economically produced in much smaller quantities, there is less need to stock inventories of printer materials—or dispose of outdated materials. This allows for "Just In Time" printing and fulfillment, and resulting cost savings. The actual equipment and labor costs for digital printing are also significantly lower than they are for conventional processes.

Perhaps one of the most common arguments for the use of digital printing is the reduction in "makeready" overhead.

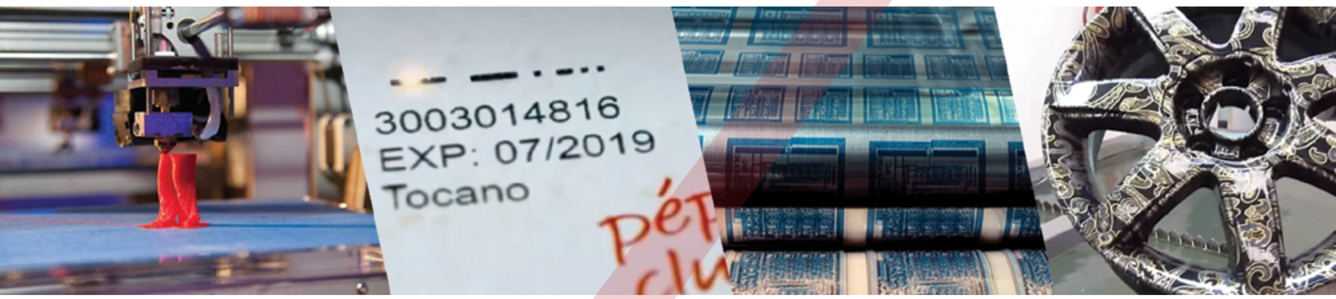
NOT FOR SALE

GAERF REVIEW COPY

Conventional presses often require the operator to print (and then discard) multiple copies of a job before it is acceptable. This is the result of adjusting ink levels and other variables, measuring the results on a press sheet, and repeating the process until the desired results are achieved. Digital presses, in theory, require far less makeready, and are, therefore, more economical.

There are a growing number of digital printing presses affecting print production and distribution. Such systems currently appeal to niche markets such as on-demand, variable-data, and short-run "quick" printing services. These offer both black-and-white and color printing of commercially acceptable quality on a relatively small range of page sizes.

However, this trend is increasingly true for more traditional commercial printing companies presently dominated by offset and other conventional processes. This promise will be realized as digital printing systems continue to improve in the quality of the printed image, the size of sheet or web accommodated, and the speed of production. For all these reasons, digital printing represents the fastest growing printing process.



The Future of Printing

Offset, gravure, and flexography are likely to endure for a long time, but the incursions of digital printing will continue to dominate the graphic communication industry. A sampling of Original Equipment Manufacturers (OEMs) at major printing events illustrates this. At DRUPA 2000 and PRINT 01, exhibition halls were filled with conventional printing equipment, and relatively few digital devices. Today, the situation is reversed. Most of the traditional printing OEMs and many new players are promoting digital print as the future of the industry.

The future of digital printing will undoubtedly include significant improvements and new developments in web-to-print, print-to-web, printed electronics, and even more exotic applications like 3D, inkless, and water transfer printing.

The book you are presently reading is such an application. It was printed on a digital press, using many of the technologies described in this chapter. It is also used to trigger a variety of non-print content and interaction.

As in Gutenberg's day, the printing press is still the central "engine" of graphic communication. While the choice of processes has never been greater, the end results—mass-produced text and images on a durable, practical surface—remain the same.

NOT FOR SALE