A Comparison of Folding Carton Printing Processes

Today's packaging buyers have some viable choices in the selection of printing processes. Offset lithography, flexography, and rotogravure still dominate the industry, but additional processes such as digital, ink jet and rotary screen are also contributing to the mix.

Advancement in prepress, color management, ink technology, press control systems and increased speeds are benefiting each of the processes. Levels of quality as defined by resolution are ever improving, as each of the dominant processes is now capable of reproducing good quality process color images on most grades of paperboard. Enhancements such as product coding, authentication, tamper evidence, and electronic surveillance features serve to customize some packaging. Special treatments such as metallization, holography, scuff protection, slip control, scented, dull, and glossy surfaces can all be achieved through printing.

Printing Process Considerations

Key Parameters Influencing Printing Choices

Product applications vary by category. These may include food products such as bakery, dry and frozen foods, ice cream novelties, candies, confectionaries, soft drinks and brewery. Non-food applications may include personal care, pharmaceutical, medical, media, tobacco, hardware, housewares, apparel, toys, sporting goods and automotive products. Each of these will impact the selection of printing process or processes.

Design features and end use requirements such as the size and style of the package can influence the choice of printing process. Panels, windows, opening, closure, filling line requirements, end use and end-of-life scenarios may favor one process over another. Some products are used indoors or outdoors. Some may be exposed to harsh conditions including sunlight, humidity, temperature, corrosion, bleach, oils and greases. Some may be refillable or reusable, and some may be primarily for information purposes only. Direct food contact, taste and odor might play into the decision.

Color, copy and print performance are important considerations. Photographic images still favor offset lithography, although flexography is making great inroads with paperboard substrates. Metallic, opaque, white, and fluorescent inks favor rotogravure, and overprints

tend to do well with flexography. Certain colors or sequences of inks may favor one process over another. Print requirements may vary from one or two colors of simple text for information purposes only to nine or more colors of brilliant graphics for attracting attention and stimulating the senses. The print requirements for secondary packaging have traditionally been low, but that's changing with a trend toward retail-ready packaging where dual-purpose shipper units are ingeniously transformed into shelf-ready, point-of-purchase displays.

Run length often influences the choice of printing process. Short to medium run lengths tend to favor offset lithography, longer runs may be more cost effective with flexo, and the longest print runs justify the high tooling costs for rotogravure. Sometimes, regardless of the process, higher prepress costs can be justified by ganging jobs on a single press sheet, the use of extended gamut printing, and/or faster make-ready times through increased automation.

Sustainability is increasingly important in packaging specifications. The choice of substrate has a sizeable influence on the performance of packaging against the metrics of scorecards and life cycle assessments, including carbon footprint.[1] Printing also influences these metrics. Bio-based materials for inks and adhesives are often preferred. VOC emissions from incineration and objectionable odors from some inks and curing systems are undesirable. Certain printing inks and methods of curing can affect recyclability, compostability and biodegradability of the package. Plate processing chemistry, solvents and cleaning materials are also considered. Generally speaking, aqueous-based and vegetable oil inks are more environmentally friendly than solvent or petroleum-based inks but may result in compromises in productivity, scratch resistance and gloss.[2]

Overall value can be defined as the expectation of benefits gained for the price paid.[3] Just as with substrates, low-cost inks and inconsistent print quality may be acceptable for some lower margin packaging but totally unacceptable for high-end applications. Inexpensive, weaker inks and adhesives often require a thicker ink film to achieve acceptable results and increased energy for curing, thus negating any savings in cost.

Primary Printing Processes

Sheetfed Offset Lithography

The most prominent process for the printing of multi-purpose folding cartons is sheetfed offset lithography. It reproduces high-quality graphics with coated and uncoated paperboard. Tooling costs are modest, repeatability is good, and cartons can be printed in multiple locations with similar results.

Offset is a chemical form of printing, based on the principle that water and oil don't mix. Images are "burned" into a light-sensitive coating on the surface of a thin aluminum plate. These exposed image areas are hardened after processing. They are highly receptive to oily substances such as petroleum-based, soy or linseed oil printing inks. The unexposed non-image areas of the plate remain highly receptive to water and non-receptive to ink. By contacting the plate first with water and then a tacky ink film, each of these is attracted to their respective areas. The inked images are transferred first from the plate to a resilient rubber-covered "blanket" then pressed onto the substrate.

Oil-based inks and water-based dampening solutions are actually quite sophisticated materials, contributing properties which are particular to the system employed. Inks are specified by curing mechanism (e.g., conventional, UV, EB and IR) as well as thickness, viscosity, tack and strength of pigmentation. Dampening solutions contain additives such as "surfactants" which vastly improve the efficiency by which they wet out the non-image areas on the plate. They also contain lubricants, anti-emulsification agents, phosphates and/or silicates, and buffering compounds for pH control.[4]

Newer offset presses utilize water-cooled cylinders to control the buildup of heat in the ink train. Other advancements such as computer-to-plate systems, automated ink fountains, scanning densitometry, registration control, plate mounting and blanket washing systems, continuous feed, and delivery allow for greater efficiency and higher repeatability. Sleeve technology allows for some presses to have a varied print length.[5] Offline operations include sheeting, die cutting, gluing and carton assembly. Productivity is expressed as impressions per hour, and today's presses boast speeds as high as 16,000 iph.

Primary suppliers of sheetfed offset lithographic presses include: Heidelberg, MAN Roland, KBA, Komori, Ryobi and Mitsubishi.

Web Offset Lithography

Although similar to sheetfed offset, web offset lithography eliminates the need for offline sheeting since rolls of paperboard are fed directly into the press. Splicing systems allow for continuous running; inline rotary die cutting allows for carton blanks to be delivered, sometimes glued and case packed sans any additional handling. Heatset, UV and EB curing systems are common to web offset. Productivity is measured in feet per minute, and run lengths are often expressed in total linear feet. Some presses boast speeds as high as 3,000 fpm.

Web offset captures its greatest value in long runs of repeatable sizes such as national brand cereal cartons. Newspapers and magazines thrive with this process. Tooling costs are relatively low, and overall productivity is quite high. Variable sleeve presses are also gaining momentum in this platform.

Primary suppliers of web offset lithographic presses include: Goss, Harris, Hantscho, Mitsubishi, MAN Roland and Müller Martini.

Flexography

Also known as "flexo," flexography is a fast-growing process for package printing. It produces good quality graphics on coated and uncoated paperboard surfaces and flexible films. Tooling costs are slightly more than with offset; however, advancements in inks, presses, digital plates, and sleeves are reducing make-ready times and increasing print quality.

Flexography is a mechanical form of printing where a raised image area on a hardened photopolymer plastic plate contacts the substrate directly. Inks are highly fluidic solvent or more commonly today, water-based solutions. They also consist of pigments, processing aids such as drying accelerators or retardants, binders, and additives as well as photo initiators in the case of UV inks.[6]

The individual color units are much less complicated than with offset lithography; however, separate press units are often required to build line and process colors. Ink is transferred from a doctor blade-controlled, anilox metering roll to the printing plate, then directly to the substrate. Flexo delivers a thicker ink film than offset lithography, allowing for increased opaque coverage. Aqueous or UV coatings are commonly applied by flexo alone or in combination with offset lithography. Advancements with flexography include gearless and shaftless drive systems, sleeve technology, enclosed ink feed systems, laser-engraved anilox rolls, and durable plates, allowing for reduced printing pressure and improved print quality. As with web offset, productivity is measured in feet per minute, and run lengths are expressed in total linear feet. Typical flexo speeds are 600–800 fpm with reciprocating die cutters and up to 1,500 fpm when printing roll-to-roll.

Three types of flexo presses are common, including the stack, inline and central impression. Primary suppliers of flexographic presses for package printing include: Kidder, Fischer & Krecke (F&K), Omet, Uteco, Windmoeller & Hoelscher (W&H), FMC and CMF.

Rotogravure

High-quality packaging such as tobacco, brewery and detergent cartons, spirits and cosmetics use rotogravure. It's a direct application process, meaning ink is transferred directly from the plate onto the substrate.

As with flexo, gravure is also a mechanical form of printing; however, the image areas are represented by tiny depressions or "cells" engraved into a printing cylinder by a precision diamond stylus that is subsequently chrome plated for durability. The process of preparing the cylinders is time consuming and expensive. These costs are recovered over extremely long runs in the millions of impressions. Gravure allows for printing fine detail with smooth coated paperboard. Low-viscosity solvent and water-based inks are common, and EB curing is on the horizon to eliminate VOC emissions and reduce energy consumption.[7] Lightweight sleeves are becoming available as an alternative to steel cylinders, which allow for much easier handling and storage.

Gravure also allows for very thick ink films, since there is only one film split versus two with flexography and many film splits with offset litho. Consequently, gravure is capable of producing unmatched white ink opacity, vivid metallics and fluorescents. The high line resolution of gravure is an advantage for packages with small text.[8] Separate printing cylinders are often required to build line and process colors.

Like flexography and web offset, rotogravure is also a web-fed process that enjoys the benefits of continuous printing, rotary die cutting, and in some cases, inline carton assembly. Most gravure presses are multi-color inline. Productivity is measured in feet per minute, and run lengths are expressed in total linear feet. Common

gravure speeds are around 900 to 1,000 fpm with inline die cutting. Roll-to-roll printing may accommodate speeds up to 1,500 fpm.

Primary suppliers of gravure printing presses include: Chambon, Rotomec, Cerutti, Zerand, Chesnut and Bobst Champlain.

Other Package Printing Processes

Digital, ink jet and rotary screen are examples of other package printing processes. These allow for variable images such as bar coding and custom labels to be applied to any run length and are sometimes used in combination with traditional processes. Digital presses are economical for producing full-color prototypes in small quantities, but production runs of as much as 5,000 linear feet are becoming more common.[9]

Digital presses may include additional capabilities such as die cutting, cold-foil stamping, laminating, and two or more flexo print stations. Digital press manufacturers include: Xeikon, Canon, HP Indigo, Kodak and Xerox.

Ink jet systems are often used for full-color proofing but have also been used for batch and bar coding, labels and logos. Ink jet suppliers include: AGFA, Epson, Roland, Videojet, ProteusJet, HP and KBA Metronic.

The thickest of all ink films can be delivered by screen printing. In this process, the ink is pushed through a fine mesh screen in selected areas which represent the image to be printed. For package printing, this might be used to apply raised textures or an opaque white panel as a background for full-color images. Due to a simple application process, a wider range of inks is available for use in screen printing than with any other printing process.

Combination printing captures the best of several processes. Offset presses often employ one or more flexo units at the back end for application of aqueous overprints and varnishes. Additionally, one or two flexo units might be placed at the beginning of the press to lay down highly concentrated UV dispersion inks in spot areas then building conventional offset colors on top. Combination printing of offset, flexo, gravure, rotary screen and digital printing are all possible.

It's an exciting time for package printing, as the options abound. Finding the sweet spots in every printing opportunity is both challenging and highly rewarding. The choice of printing processes can be summarized in a decision matrix as follows:

Printing Process Decision Matrix The following are guidelines and estimates only.

Process	Sheetfed Offset Lithography	Web Offset Lithography	Flexography	Gravure	Digital
Print Resolution	high 150–175 lpi	high 150–175 lpi	very good 120–150 lpi	excellent up to 300 lpi	extremely high up to 1,200 dpi*
Ideal Run Length	up to 1 million impressions	1 million impressions	1 million + impressions	1.5 million + impressions	short to medium runs
Common Applications — Characteristics	general folding cartons, including dry and frozen food, personal care, medical, pharmaceutical, confectionery, media, on a variety of substrates	high volume runs such as cereal cartons on coated recycled paperboard	food service, beverage cartons, frozen foods, general purpose folding cartons, secondary packaging	tobacco, brewery, detergent, spirits, personal care, for white laydown; quality and consistency; repeat runs	proofing, labels, personalized imaging, continuous, drop on demand
Presses	six or more units, complex ink trains and transfer mechanisms	nine or more units, complex ink train but straightforward web path	web-fed unitized, stack or common impression cylinder, simple inking systems	web-fed, nine or more units, electrostatic assist, simple inking systems, combination presses	web fed, up to 7 colors
Press Cost	moderate to high	high	wide range	high	moderate
Plates	low-cost aluminum	low-cost aluminum	photo-polymer plastic	engraved cylinders	variable image
Inks	tacky paste consistency, petro-chemical oil, soy or linseed vegetable oil	oil-based, tacky paste-like consistency	fluidic, aqueous or solvent-based	fluidic, aqueous or solvent-based	water or solvent-based, dry toners
Curing Systems	conventional, IR, UV, EB	IR, UV, EB	IR, UV, EB	IR, UV, EB	IR, UV
Ink Film Thickness	1–2 microns	1–2 microns	2–3 microns	up to 20 microns	approx. 8 microns
Sheeting, Die Cutting	offline sheeting, inline or offline die cutting	direct inline rotary die cutting	reciprocating or rotary inline die cutting	reciprocating or inline rotary die cutting	some capabilities inline
Techno-Advancements	variable sleeve, hybrid presses, press controls, extended gamut	sleeves, press controls, extended gamut	dispersion inks, sleeves, ceramic etched cylinders, laser-engraved plates, extended gamut	sleeves, servo controls, scented, holographic, soft touch and thermographic inks	combination presses

*roughly equivalent to 600 lpi

Written By:

Dan Malenke

Dan Malenke is an accomplished training manager, with extensive coast-to-coast and international experience in developing and directing technical seminars for the printing and packaging industries. His career includes 20+ years with a Fortune 500 company, nine years of university teaching experience and accumulated work in production.

About Zumbiel

We are Zumbiel Packaging, one of the largest privately held paperboard packaging producers in the United States. In our $400 billion industry, we know that your package is often the most important contact with your customers; it must convey your values as well as inspire and energize your brand.

Our team of skilled and extensively trained associates is dedicated to providing you with unique packaging solutions that meet your needs and budget. With more than 167 years of experience, Zumbiel stands ready to meet your packaging challenges.

For more information, please contact Zumbiel at sales@zumbiel.com or 513-531-3600.

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For more information, please contact Zumbiel at sales@zumbiel.com or 513-531-3600.

www.zumbiel.com | 513.531.3600
2100 Gateway Blvd., Hebron, KY 41048

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