Print Technologies and Design Concepts for Hybrid Printing Systems

Walter d'Heureuse and Helmut Kipphan
Heidelberger Druckmaschinen AG,
Heidelberg, Germany

Abstract

The several printing technologies, conventional (e.g. offset, flexo) and non-impact printing (NIP) (e.g. electrophotography, ink jet) have their special applications, strengths and weaknesses. This is especially visible when considering the economical run-length, the print quality, the cost structure in general and the ability to vary the image during the print run. The combination of different printing technologies can create efficient and powerful production possibilities and systems such as in-line imprinting, personalization and coating (print finishing).

This paper mainly discusses hybrid-systems, combining conventional and Non-Impact Printing technologies (e.g. offset with ink jet), but also discusses hybrid-systems of NIP with NIP (e.g. electrophotography and ink jet) and conventional with conventional (e.g. offset with flexo) as shown in figure 1.[1]

The hybrid-systems of conventional with NIP (e.g. offset with ink jet or electrophotography) can achieve the superior image quality associated with conventional technologies while adding customized information on a page by page or job by job basis.

The attributes associated with the various technologies in hybrid printing technologies such as the necessary paper specifications, speed and architecture as well as examples of existing and possible hybrid-systems are described. These systems take advantage of the strength of the individual print technologies. Especially for digital production printing the combination of computer to press with offset direct imaging technology and an ink jet imprinting unit (page wide) is also described.

Introduction

In today's market, there is an ever growing demand for print products that fit the special, individual needs of the customer, or a whole customer group. Personalized print products (i.e. names and/or addresses that vary from print to print in an otherwise fixed print image) and segmented print orders (i.e. parts of the print run that are modified) try to meet this demand.

At the same time, the market requires high print quality, short times for completing the whole process from order to delivery, and the usual cost structure for medium run lengths. In order to meet these demands, companies have to make use of the special advantages of the various printing technologies and integrate these in a complete workflow for the production of a print product.[1-5]

Hybrid systems, combining the strengths of different printing technologies in one printing system, are capable of producing special print products while maintaining a high level of economic efficiency and productivity.[4]

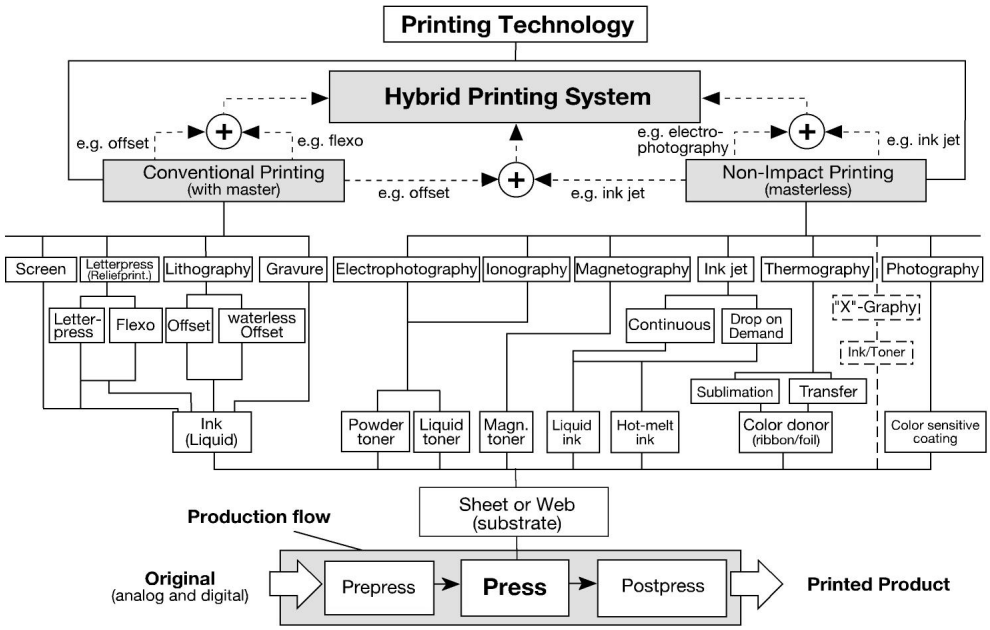

Figure 1. Combination of various printing technologies to set up hybrid printing systems.[1]

Printing Technologies for Hybrid Printing

It is evident that every technology has its own special applications which can be characterized by the run length, the quality of the print, further processing options, cost structure and economic efficiency.

The diagram (fig.1) gives an overview of the most important conventional printing technologies requiring a master as well as non-impact technologies which operate without a master and shows how so-called hybrid printing systems can be set up from a combination of these technologies.[1] Production on sheet or web material using the relevant inks is possible. Sheet-fed printing systems are generally characterized by a higher degree of format flexibility, web-fed systems by a higher productivity. Printing is done on different substrates such as uncoated and coated paper, cardboard and also plastic film material. The different substrates require special inks tailored to the printing process itself and to the use of the end product (in- or outdoor, food packaging, etc.).

The highest print quality is achievable with offset (with the exception of gravure printing), in particular for multicolor images. High printing speed is possible (sheet-fed up to around 4 m/s and web-fed up to 15 m/s) and the printing plates are produced quickly and economically compared to other technologies.

Flexographic printing technology is especially suitable for printing with varying inks and ink/varnishing systems particularly in high film thickness.

High ink film thickness is also applied with gravure and screen printing. Gravure printing is however only of low importance in connection with hybrid printing systems due to the expensive production of the printing plate/cylinder. Rotary screen printing is preferred for very high ink layers with high color density.

NIP- printing technologies, such as ink jet and electrophotography, make it possible to print a variable image page per page but in general at a lower print quality and higher cost per page than with offset or gravure printing.[1,6,7]

The combination of various printing technologies can bring about very interesting production options with both a high degree of economy for the printing company and benefit to the customer. Figure 1 also shows how technologies can be combined with hybrid systems, merging conventional technologies, NIP-technologies or conventional with NIP.

When using hybrid printing systems the characteristics of the printing substrates, ink acceptance, print quality expectations and paper transport are of particular importance. The combined printing technologies have to fulfill requirements and must be well suited to each other. The type of drying and fixing process used to attach the ink to the substrate largely determines the sequence of printing. Chemical and physical reactions of the inks with each other (e.g. decomposing or non-wetting) must also be taken into consideration. Furthermore the design of high economic print systems are determined by the maximum and reasonable printing speeds of the respective print technologies. From an economic efficiency point of view, a very fast system should not be combined with a slow one. The requirement to print with variable speed, for instance in case of feeding difficult paper, might reduce the variety of combinations. In table 1 the most relevant properties of print technologies are shown for building up hybrid systems.

Table 1. Selected Important Features of Print Technologies (see also fig. 1)

Offset	- transfer of one ink film/color separation (around 1 micron ink film thickness) with high pressure onto the paper - almost independent of paper substrates, but limited to plastic material - high print quality - high speed (up to around 4m/s in sheet-fed) and variable speed is common - ink is not dry (exception UV-ink) - ink cost is a very low percentage of the TCO (total cost of ownership)
Flexo	- ink film (around 1 micron) with “kissprinting” onto the substrate, but also high ink/varnish film thickness possible (around 2.5 microns) - printing on various substrates - print quality not as good as offset - high speed and variable speed - UV-curing inks are preferred (fast drying, good quality and high density - ink cost is a very low percentage of the TCO
Screen	- transfer of ink film with low pressure - technology is preferred if very high densities (ink film thickness up to around 12 microns) or special effects are requested - printing on various substrates
Ink jet	- no contact with print substrate - very low viscous ink (nearly like water) - print quality dependent on substrate; penetration into the substrate (spreading) or non-wetting the "glossy" substrate surface (UV-curing inks and hot-melt inks are less “critical“) - speed up to around 2 m/s (400 ft/min), variable speed is possible - drying, depending on ink type - ink cost is a high percentage of theTCO
Electro-photo-graphy	- transfer of toner by contact with print substrate and electrostatic field (toner layer thickness around 5-10 microns) - overall print quality worse than offset - limited printing substrates - speed up to around 1 m/s, no variable speed (control of process) in general - toner fixing usually by heat and pressure - ink cost is a very high percentage of the TCO

Concepts and Examples of Production Systems Combining Different Printing Technologies

Combination of Conventional Technologies

Within conventional printing technologies, hybrid systems that combine offset and flexographic printing, such as sheet-fed offset presses (see fig. 2), are already well-known. The latter have an attached coating unit for printing on the whole surface or partial (spot coating) application of a coating onto a high-quality multicolor print produced in the same press.[1] With these systems it is also possible to produce colored imprints using a flexographic plate, for instance, with special effect coatings or special colors (spot color). The coating or varnishing unit consists of a plate cylinder, a chambered doctor blade inking unit and an impression cylinder. The varnish is laid on top of the offset ink, which is not yet dry. In this example, drying of ink and varnish (or special effect inks) is done by an IR-dryer.

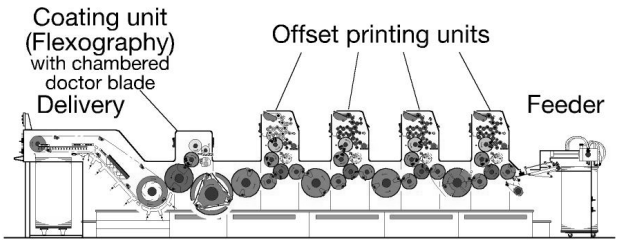

Figure 2. Multicolor sheet-fed offset press with coating unit as a hybrid printing system combining offset and flexographic printing

Another example of the combination of conventional printing technologies is demonstrated in figure 3, a label printing press with flexo and screen printing units, and an additional unit for hot-foil stamping.[1] UV-dryers are installed between all units to cure the UV-ink. Wet-on-wet printing, that is without intermediate drying, is not possible in multicolor flexo/screen (like in offset). The different printing units are designed in such a way that they can be changed according to the special print job requirements.

Combination of NIP-Technologies

Figure 4 shows a system where electrophotography, for high speed monochrome printing, has been combined with an ink jet printer for imprinting additional information in spot colors.[1,6] The electrophoto-graphic printer is the main system and can print a page-wide image. The ink jet unit (piezo drop-on-demand, using hot-melt ink) for imprinting spot colors can only print a width of around one inch per head. Several print heads (e.g. eight) can be positioned across the width of the web and each head can print with a different color. Highlighting of names and results in bills or lists is done with this printer. It is fast, up to around 1 m/s (200 fpm, 240 dpi), and the quality of the printed image/text is acceptable. A multicolor electrophotographic system capable of this high speed and also suitable for this type of work (black and one or two spot colors) is not yet available for cost reasons.

Combination of Conventional and NIP-Technology

Combining conventional offset or flexo with a NIP-technology is shown in figures 5 and 6. Offset and ink jet printing are shown in figure 5 are similar to the demonstration by Heidelberg as a technology/concept study at Drupa 2000 (at Drupa with a single color Quickmaster). The high quality fixed image is printed on the QM DI 46-4, a 4-color offset press with direct imaging technology, and the imprinting,[1,8-11] which adds variable information to the offset print with one color, is done over the complete sheet width with ink jet. At full speed, 10000 A3-sheets/hour are printed. The ink jet imprinting unit is based on the piezo technology from Spectra and images with 7680 independently addressable nozzles (325 mm/12.8" wide) at a resolution of 600 dpi and 38 kHz at full speed (1.6 m/s, 320 fpm).[12] At the end of the imprinting unit a UV-dryer is installed to cure the UV-offset ink as well as the UV-ink jet ink. Only one dryer is needed to dry/cure the images of both printing units simultaneously. After passing through the UV-dryer the inks are completely dry and the print is ready to ship or for additional finishing processes. Since the ink jet print head has a short distance (about 1 mm) – no contact - to the paper surface with the wet offset ink, it is possible to install the imprinting unit after offset printing. With sheet-fed printing it is preferable to print the fixed image first and then at the end of the paper travel the variable image. The workflow for reprinting sheets in the event of print interruptions (e.g. paper misfeed) is easier to handle. (In electrophotography the photoconducting surface or the intermediate carrier has contact to the substrate; the imprinting unit therefore has to be installed before offset printing or the offset ink must be dried in advance.)

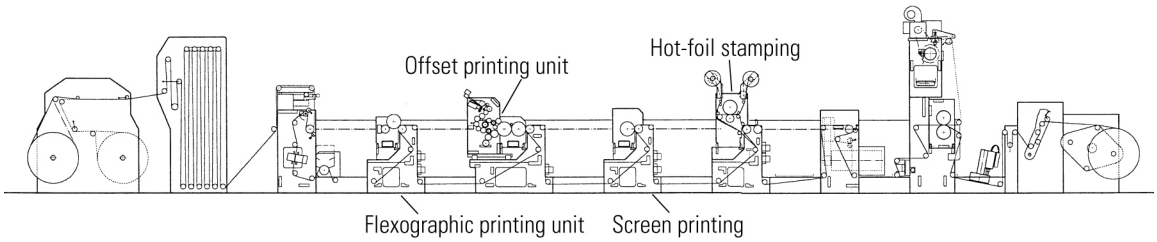

Figure 3. Hybrid printing system for label printing combining flexography, offset and screen, as well as letterpress for hot-foil stamping/embossing (CombiPrint, Goebel/Drent)[1]

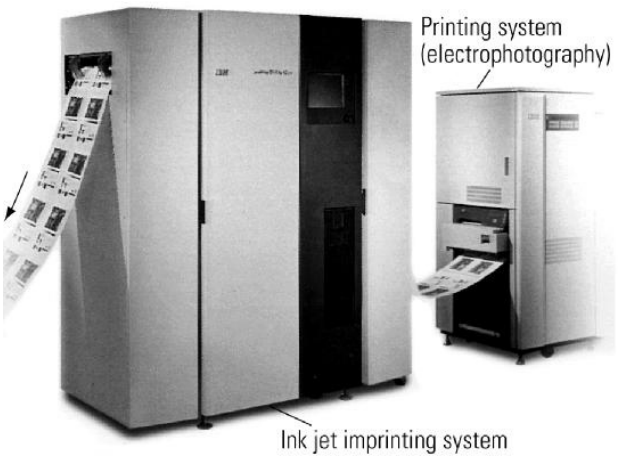

Figure 4. Hybrid printing system combining the NIP-technologies of electrophotography (single-color printing) with ink jet imprinting system for multicolor (spot color) imprints (InfoPrint 4000/Info Print Highlight Color, IBM/Accent Color Sciences)

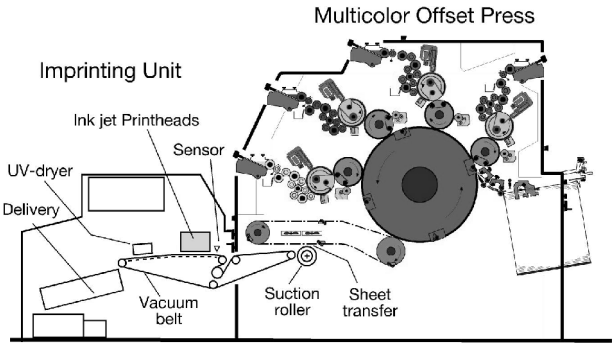

Figure 5. Digital hybrid printing system using the combination of offset and ink jet technology (Heidelberg)

The hybrid printing system as shown in figure 5 is modular in design (the imprinting unit is not rigidly incorporated in the computer to press offset system). This offers benefits with regard to the flexibility of the printing system and the modular structure of different model variants. The complete print job can be processed with regard to its fixed and variable image content using digital job definition. Digital in-line imaging of the master prior to print start is used for the fixed image portions, and real-time imaging during printing is used for the variable page content (a detailed description of the hybrid system and the design of the print head is given in the presentation of Yong Zhou/Clemens Rensch; Applications of Page Wide Piezo Ink Jet Printing to Commercial and Industrial Market[12]).

An early installation of an imprinting system based on continuous ink jet print heads and used especially for numbering and personalization is shown in figure 6.[1] Eight separate print heads (with multi-deflection continuous ink jet technology) are spread over the length of the last impression cylinder of the offset press. Only columns can be printed since there is no overlap of the heads.

Figure 7 shows a possible design of an electrophotographic printing unit installed in a larger format sheet-fed offset press. The dryer of the offset ink (UV-curing ink) is positioned downstream of the offset units. Instead of an electrophotographic system it is of course possible to install a magnetographic, ionographic or ink jet system.[1]

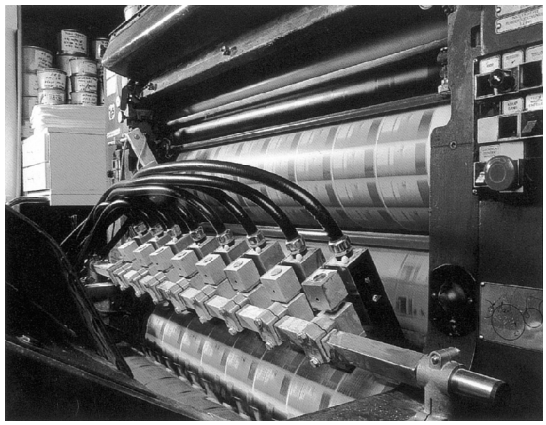

Figure 6. Hybrid printing system: Multicolor offset printing press with ink jet imprinting system for numbering, personalization, addressing and segmentation of the job (Domino/Heidelberg)

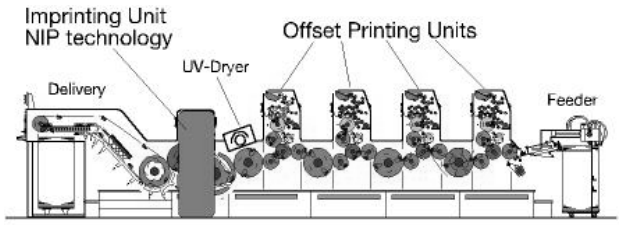

Figure 7. Hybrid printing system combining offset printing for multicolor printing with NIP-technology for the imprinting unit to produce partly variable contents from sheet to sheet (Heidelberg)

The combination of an electrophotographic system based on liquid toner with flexographic printing units in a web-fed label printing system is shown in figure 8. The electrophotographic printer in front of the flexo units can print variable multicolor images. The web is fed intermittently (because the installed electro-photographic printing system is a multipass system, needing 4 cylinder revolutions for the multicolor print[1]). The flexo units have to "wait" (turn without contacting the web) for the next variable image. The toner image is fixed on the web before it enters the flexo unit.

Figure 8. Digital label printing system with NIP-multicolor printing system (electrophotography with liquid toner; Omnius, Indigo), flexographic printing, and finishing equipment for coating, laminating, and die-cutting (DO 330, Gallus/Indigo)

Figure 9[1] shows the components of a hybrid printing system for the production of print media by web-fed offset. A direct imaging imprinting unit for non stop plate change (segmenting the job) is positioned in front of the multicolor offset printing system (printing identical images). The imprinting system with ink jet (non-contact to the web) for individual text or personalization is integrated after conventional printing.[13] Drying of the ink can take place after all printing processes.

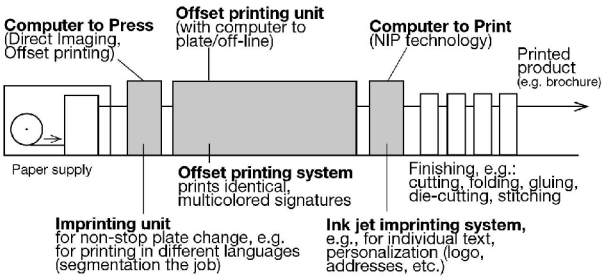

Figure 9. System study: components of a digital hybrid printing system for web-fed printing for the production of segmented, personalized/individualized print media.[1]

Conclusion

Various print technologies may often be in competition with each other for the production of print media. Whether using masters/printing plates or the NIP-technology, every technology has its advantages for specific applications, types of production and production strategies.

As described the combination of various printing technologies (hybrid printing systems) can create powerful means of production, making special production methods and strategies possible. It is to be expected that an increasing number of combination systems will be employed for the in-line production of printed matter, especially with ink jet technology for variable imprinting and segmentations. With the help of different digital printing technologies it is possible to meet the most diverse, job-specific customer requirements. The use of production systems based on various printing technologies and hybrid printing systems is being increasingly taken for granted. It is also essential for successful economic production of high quality print media in short throughput times.

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Biography

Walter d'Heureuse joined Heidelberger Druckmaschinen AG in 1982. He managed a design department for 10 years and has worked as a Senior Manager in "Advanced and Future Technologies" department since 1992. He studied mechanical engineering at the Technical University of Darmstadt and held the executive R&D position at a duplicator company in Germany (former Pelikan Informationstechnik). He is the holder of several patents.

Dr. Helmut Kipphan did his apprenticeship as a toolmaker at HEIDELBERG. He studied mechanical engineering in Mannheim and at the University of Karlsruhe. Doctoral thesis and professor in measurement technique. In 1978 he joined Heidelberger Druckmaschinen AG again as a research engineer. He has held several management and executive positions in R&D and technology/product development. Since 1992 he has held the position of Senior Vice President for Technology and Innovation Research (now: Advanced and Future Technologies), dealing especially with new and future technologies for digital printing production with conventional and NIP-technologies. He holds leading positions in international committees within the graphic arts industry and industrial joint research. He is a member of IS&T and the TAGA board of directors. He is the holder of many patents, a speaker at various international technical conferences, author of several publications as well as author and editor of the newly published "Handbook of Print Media – Technologies and Production Methods".