Direct Imaging in Theory and Practice - Computer to Press vs. Computer to Print -

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Abstract: Since 1993 computer to ... - technologies are spreading into the market. Powerful computer to film and computer to plate equipment are offered and in use. The most fascinating technology is to use the digital data file for the total page to be printed directly into the press, that means computer to press or computer to print technologies.

Using computer to press, the plate is imaged within the press, no stand-alone computer to plate equipment is needed. In comparison there are computer to print equipment which work without a job-specific printing form, examples for this are the E-Print 1000 from Indigo and the DCP-1 digital printing press from Xeikon. The new generation of computer to press equipment, the Quickmaster DI from Heidelberg using Direct Imaging technology, is described in detail as a complete system solution.

Computer to press and computer to print equipment is explained from a technical point of view with a strong user orientation. Technical concepts, imaging systems, used materials, print quality, life time and the advantages and limitation of existing digital printing systems are described.

In addition, newly announced computer to print equipment are explained, for example equipment from Scitex, Mitsubishi and Delphax for multicolor, high speed printing.

A third possibility in computer to press technology is the concept of using rewriteable printing surfaces, as sometimes before described in the patent literature and several conferences. The announced systems from MAN Roland - DICOweb Litho and DICOweb Gravure - as well as the NIPSON technology called Magnetolithography are discussed.

In a summarized comparison the advantages and the expected market segments of all the different computer to press technologies are given.

All in all, this paper deals with technologies which are already in the market or have been announced to be available in the near future. Special attention is paid to the total workflow for digital print production, requirements, changes and challenges are mentioned.

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1. Introduction

During the TAGA '95 conference in Orlando/FL it was the first time that - within the TAGA-organization - the focus was also on digital printing, regarding state of the art and future trends for using digital technology within the whole graphic arts industry as demonstrated by the paper "Digital Multicolor Printing and Computer to . . . - Technologies - Evolution or Revolution in the Graphic Arts Industry?" (Kipphan, 1995b)

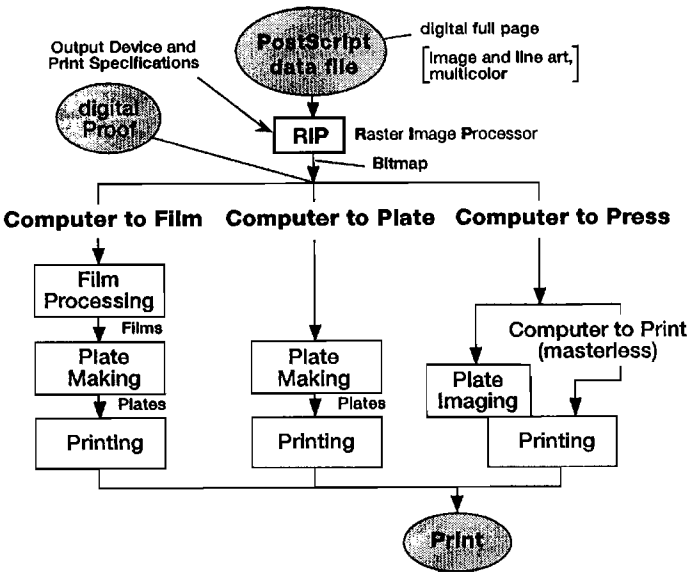


Figure 1. Computer to . . . - Technologies

In Fig. 1 it is shown that there are several possibilities for using digital data in print production: computer to film, computer to plate and computer to press. Computer to film is state of the art and computer to plate-technology is spreading into the market with a high variety of equipment and many digitally imageable plates. Regarding computer to plate Seydel (1996) has given an overview during the TAGA '96 conference, especially describing the workflow, that means the integration of computer to plate-technology into the printing process for producing high-quality multicolor offset print products.

Computer to press-equipment is available since 1993 for multicolor printing with high productivity and high quality, comparable with the high-quality produced with conventional offset equipment. Especially during the recent DRUPA '95 a high number of different digital computer to press-systems was shown, announced and some already available in the market; computer to press-systems with direct imaging technology (on-press imaging), where the plate is produced within the printing press directly onto the forme cylinder, and computer to print-systems which are working without a special job-specific master (Bruno, 1995a, 1995b)

Especially these two technologies - direct imaging and computer to print - will be explained now in this paper. It will confirm the fast changing in digital technology and the growing use of this kind of equipment during the last few years. By comparing the content of the presentations given in the last 3 years, it can be recognized that there are many changes and improvements in quality, productivity, cost reduction and numbers of available equipment and components for digital print production (Kipphan, 1993, 1994, 1995a, 1995b).

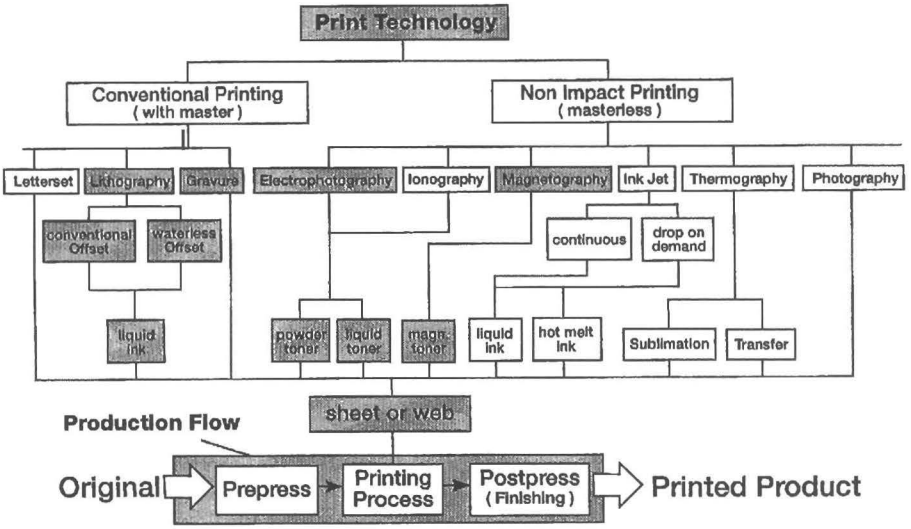


Figure 2. Print Technologies and Production Flow for Producing Multicolor Printed Products

In Fig. 2 again - similar like in the paper of Kipphan (1995b) - an overview of the several printing technologies is given - conventional printing and non-impact printing - together with the workflow for producing multicolor printed products. With this figure it is shown that there is a large number of different non-impact printing technologies. Technologies which are marked (shadowed blocks) will be discussed within this paper in detail.

2. State of the Art in Digital Printing

Based on a portfolio for describing the positioning of the several print technologies for multicolor printing together with trends in development of digital printers, depending on print quality and run length which was at first explained in 1993 (Kipphan). All the recent public information based on the equipment which was available before DRUPA '95.

In Fig. 3 an updated version is shown with a selection of new products which are available and some which are announced to be launched into the market within the next few years.

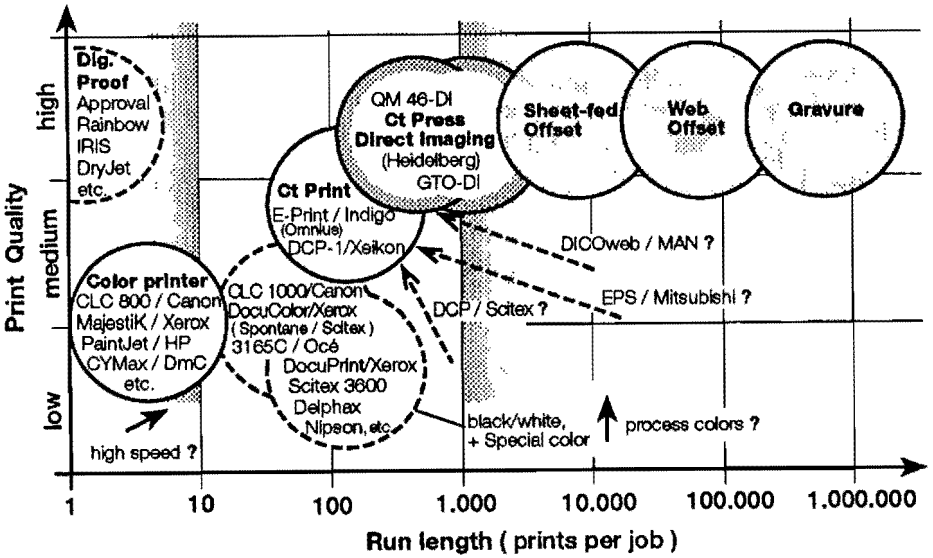


Figure 3. Positioning of Print Technologies for Multicolor Printing and Trends in Development of Digital Printers

HEIDELBERG announced its new direct imaging press, the Quickmaster DI with improved specifications compared with the GTO-DI which result in shorter make-ready times and higher cost efficiency. This is the answer to the earlier question: "Is there a chance for direct imaging technology with improvements, especially for faster make-ready times, that means finally lower run lengths in short run color printing?".

Based on NIP-technologies, especially electrophotography, the question was: "Is there potential for improving the print quality and the productivity?". Fuji Xerox announced the DocuColor 4040 digital printer in unit design with a productivity of 1000 A3 pages/hour during the IGAS 95 exhibition in Tokyo; the same engine is used within the Scitex product "Spontane", as a system together with front-end equipment of Scitex.

Canon also announced an improved version of the digital color printer "CLC 800", the "CLC 1000" with an improvement in productivity from 210 A3-pages per hour to 900 A3-pages per hour (unit design).

During the last CeBIT '96 exhibition Océ presented the prototype of its digital color printer Océ 3165 C.

Indigo expanded its product pallet with the "Omnius" digital printer for printing onto web material, especially for packaging. Indigo announced a faster version of the well-known E-Print 1000, called "Mobius" which also prints on web material with duplex possibility.

Question marks existed regarding the potential of the available "high speed" digital monochrom printers with the possibility to print a special color, like the "DocuTech" and "DocuPrint" from Rank Xerox and the ink-jet based digital printing products from Scitex Digital Printing, Inc. The question was: "Is

there a chance to improve the basic technologies for printing process colors?". Until today, a practical solution is not given, but serious announcements. Scitex Digital Printing Inc. announced its ink jet based "Digital Color Printer" and Delphax is working on a multicolor version with the project name "Cipress", basing on ionography and the use of liquid toner. Xeikon with its "DCP-1" digital printer has a stable and successful position in the market. Improvements by Xeikon seem to concentrate on the workflow regarding digital print production, especially very short RIPing time and network based distributed print production. It was surprising that Mitsubishi announced during DRUPA '95 and presented at IGAS '95 a lab prototype of its "Electronic Printing System", printing on web material, using electrophotography and liquid toner.

The announcement of MAN Roland regarding two kinds of direct imaging printing systems, DICOweb Litho and DICOweb Gravure - using a rewriteable forme cylinder - will be explained later more in detail.

Publication regarding new kinds of equipment are given in overviews, for example, by Bruno (1995a, 1995b) and De Schamphelaere (1995).

3. Direct Imaging Technology (Computer to Press)

3.1 Principle of the Technology

Based on the description in Fig. 2 of the two versions in computer to press-technology, in Fig. 4 a more detailed explanation is given.

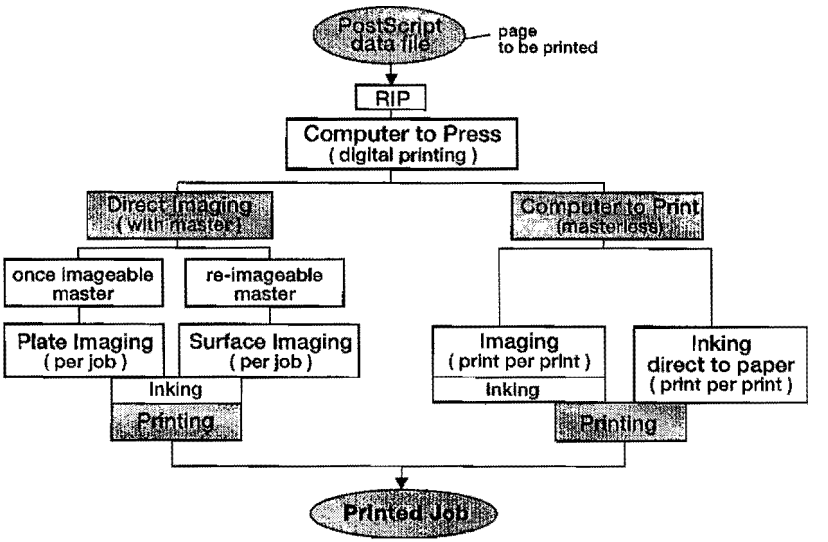


Figure 4. Computer to Press-Technologies

Computer to press-technology realized within printing systems which are using a printing plate, a master, will be named "direct imaging technology". Direct imaging technology is devided in two possibilities. The criteria for this splitting bases on the specification and features of the printing plate. Within present available direct imaging printing presses, the GTO-DI and the Quickmaster DI, a master is used which can be imaged only one time. After the

job is printed, a new plate must be imaged, the plate used before can not be re-imaged.

If the plate consists of materials that allow to image and to store the image for printing the complete job and with the special advantage that the image can be erased and the basic surface can be re-imaged after that with the image of the next new job - a re-imageable master is in use.

In both cases, after imaging the plate, inking is done on the plate surface before printing onto the paper.

The version using a re-imageable master is the basic concept for the announced digital printing presses from MAN Roland: DICOweb Litho and DICOweb Gravure, as well as the announced printing technique "Magnetolithography" from NIPSON which is basing on magnetography. These three principles will be described in chapter 5 more in detail.

It should be mentioned that on press imaging/developing is an other terminology for direct imaging. Due to unpublished information it can be assumed that within some companies, many researchers are working on plate/surface materials which are imageable and erasable inside the press as well as on imaging/coating technologies; surface preparation for building up an imageable plate could be made, for example, with techniques like spraying, film coating etc.

Computer to print-technology is described with examples in chapter 4. From a general point of view now an introduction is given with the second main path in computer to press-technology, shown in Fig. 4, which is called "computer to print". This technique does not need a physical, job-specific master.

Within this path a difference is made based on the way how to put the inks onto the paper. Non-impact printing technology must be generally used in computer to print-technology.

For example, with electrophotography, a latent image is built up on a photoconductive layer, and after imaging, via a developing unit - for example, powder toner is transmitted onto the imaged surface. After that, the image is printed onto the paper, either directly or indirectly via an intermediate system, typically with a drum.

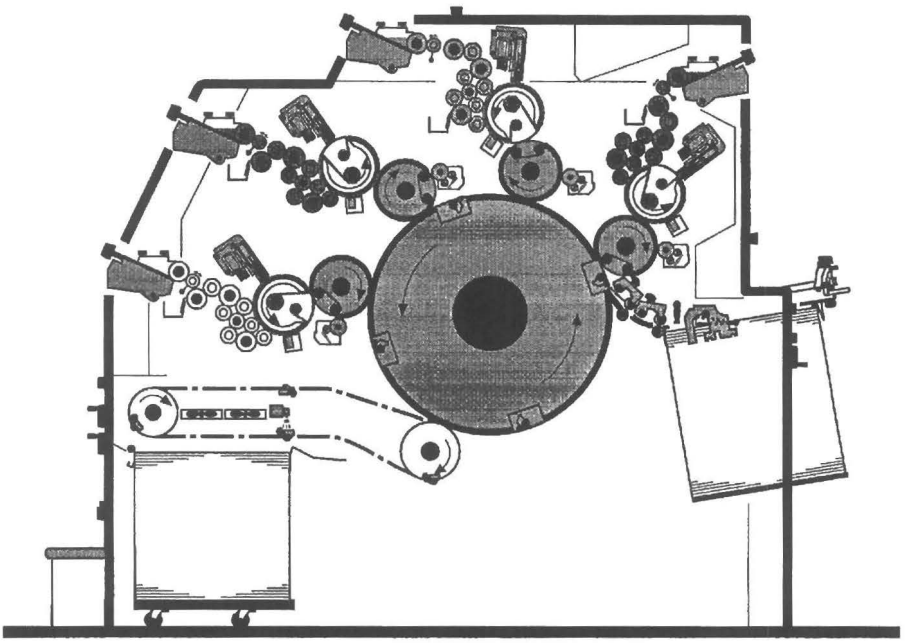
Otherwise, for example, when using ink-jet technology, the digitally controlled ink flow can be set with an array of ink jet nozzles directly on the paper; that means the inking process is not done onto a special intermediate surface (imaging cylinder or belt) - the inking process is directly generated within the computer for controlling the engine.

3.2. Direct Imaging Computer to Press-System: Quickmaster DI (HEIDELBERG)

Now, the available direct imaging, state of the art system - the Quickmaster DI 46-4 - will be described.

As shown in Fig. 5, the technology used is conventional offset technology in waterless version, no dampening unit is required. Via an intermediate blanket

cylinder the inked image of the plate cylinder is transmitted onto the paper.



Technology:	Offset (waterless)
Addressability:	1270 dpi
	2540 dpi
Grey levels:	2 per dot
Printing speed:	10.000 A3/h
Size:	A3 / portrait

Figure 5. Quickmaster DI 46-4 Computer to Press/Direct Imaging Digital Printing System (HEIDELBERG)

Direct imaging of the plate is realized with a laser-based imaging system via a raster image processor (RIP). The RIP transformes the PostScript data file which describes the full page to be printed in a digital forme incl. all the images, line art and text information into a bitmap for controlling the laser imaging system.

The press design is a satellite design; all the 4 printing units are positioned around a centralized impression cylinder. Normally the color sequence in printing is Black, Cyan, Magenta and Yellow. The satellite design leads to a very small floor space. Ink key presetting is done automatically via the DI-controller based on the data file and optimized with the knowledge regarding the print process and its characteristics.

The sequence of the several steps for preparation and production of a print job can be described as follows, starting with an unused plate.

Simultaneously in each printing unit with laser energy the printing plate is produced within the press. The resolution/the addressability is 1270 dpi, switchable by the operator to 2540 dpi. After imaging, a process for cleaning the

plate surface from the ablated material particels must be done. After that, the printing process can start with a maximum printing speed of 10000 A3-pages per hour. The printing speed is variable; depending on the paper quality, the production speed can be changed to a lower level for safe paper transportation and high-quality printing.

After printing the job, before starting the imaging process for the next order, on the surface of the plate cylinder the plate from the job done is automatically removed and replaced by unimaged plate material. The Polyester based plate material is stored as a ribbon on a cartridge within the plate cylinder with the capacity for 35 jobs. The used part of the plate web is rewinded and stored inside the cartridge for recycling.

The time for removing the plate material, imaging the surface and cleaning of the imaged plate is (with an addressability of 1270 dpi) approx. 12 minutes; that means a job with a run length of 500 prints is completely produced in a quarter of an hour, based on a RIPed PostScript data file.

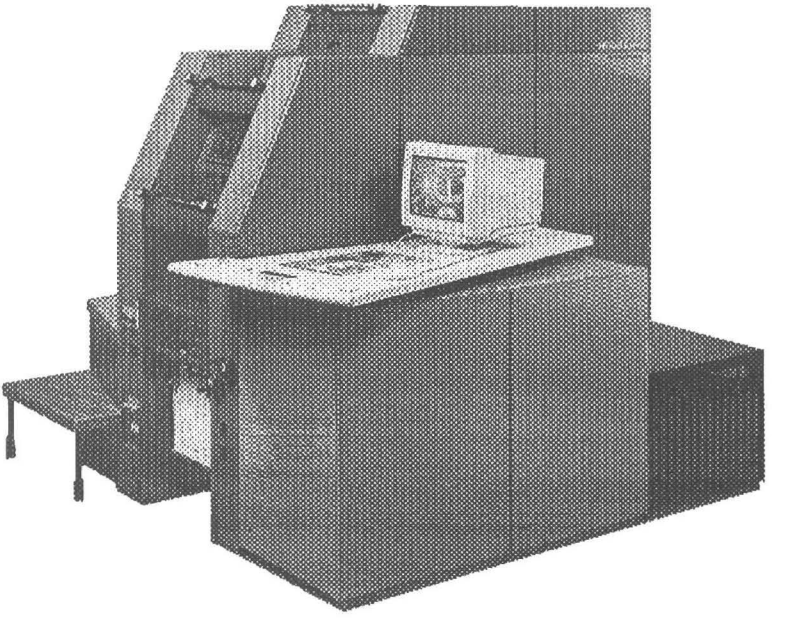


Figure 6. HEIDELBERG Quickmaster DI
Digital Multicolor Printing System

In Fig. 6 the Quickmaster DI is shown, together with its operator console and monitor for controlling the press and with the possibility for the operator to have a look on the job - getting a softproof on the color monitor - before he starts plate imaging and producing the job.

In Fig. 7 the direct imaging technology within the Quickmaster-DI is shortly explained. The plate for waterless offset, polyester based, is covering the plate cylinder. The imaging process is done with an array of 16 independent lasers, simultaneously controlled. Each laser diode has a power of approx. 1 Watt; the wave length of the laser light is approx. 860 nm - thermal laser

energy leads to a material ablation effect. For plate imaging the laser light is transmitted via fibre optic to the beam forming optic, the resulting spot size on the printing plate is 30 µm. Imaging is done by rotation of the plate cylinder and axial motion of the imaging head.

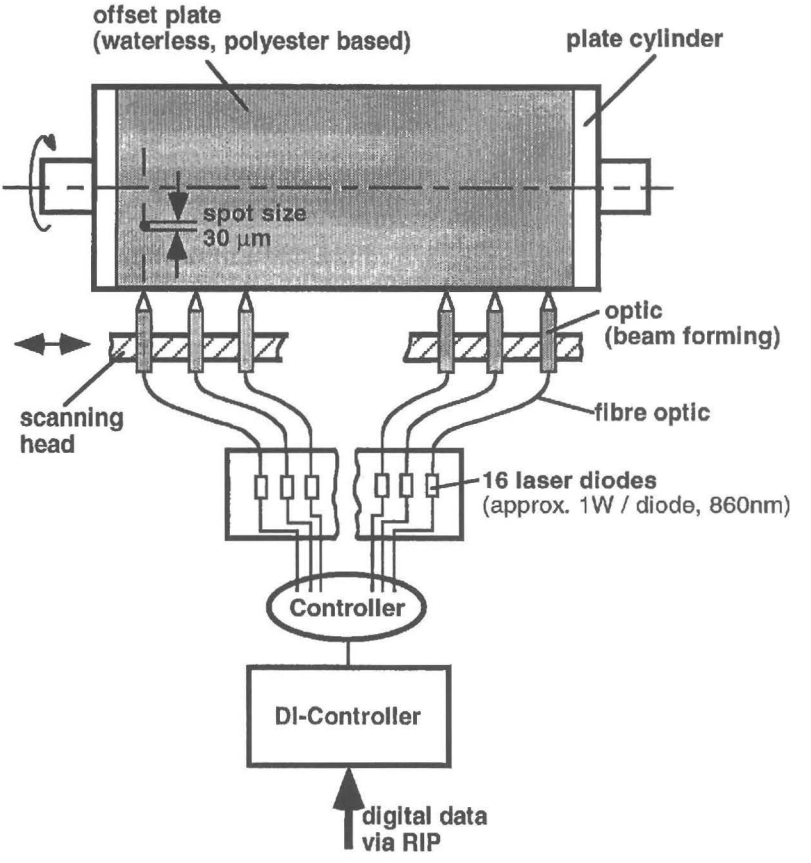


Figure 7. Laser Imaging System within Quickmaster DI

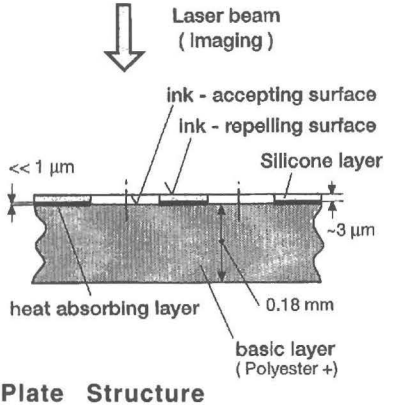


Plate Structure
(waterless printing)

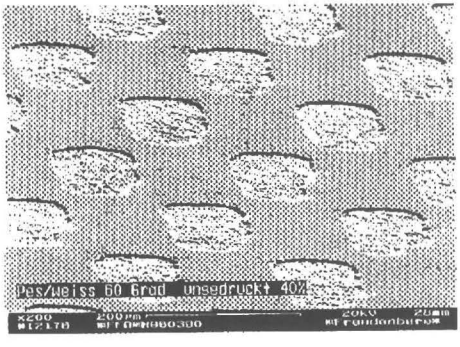


Plate Surface
(tone value: 40%, screen ruling: 152 lpi)

Figure 8. Printing Plate for Direct Imaging with QM 46-DI

The physical imaging process is laser ablation technique. This needs a special structure of the printing plate. In Fig. 8 a cross section of the printing plate is shown. The basic layer with a thickness of 0,18 mm consists of Polyester material including special additives. This Polyester layer is covered with a very thin heat absorbing layer with the importance to absorb the laser energy for ablating the top Silicone layer which is ink-repellent. The Polyester surface is ink-accepting (oleophil) for storing and printing the image. The surface energy of the Silicone layer is the basis for realizing waterless offset printing.

The physical and chemical stability of the plate material allows to print jobs with a run lengths in the range up to approx. 20000 high quality multicolor prints. In Fig. 8 additionally a magnified picture from the imaged surface is shown, taken with an electron beam microscope. It can be recognized that the single, final dot is generated with many small dots, depending on the laser beam size; in this example, the tone value is 40 %, the screen ruling 152 lpi and that means the printed dot is built up with approx. 16 single laser dots.

The Quickmaster DI as well as the two preceeding versions - the GTO-DI with spark erosion technique (since 1991), as explained by Uhrig and Williams (1993) and the GTO-DI with laser technology (since 1993) / (Kipphan, 1994, 1995a) - has been developed and produced from HEIDELBERG in narrow cooperation with the US-based company Presstek; Presstek is the supplier of the imaging head and the plate material.

The Quickmaster DI is not only a printing press, Quickmaster DI is a total digital direct imaging printing system. A standard equipment of the Quickmaster DI is the raster imaging processor, accepting PostScript data files, as shown in Fig. 9.

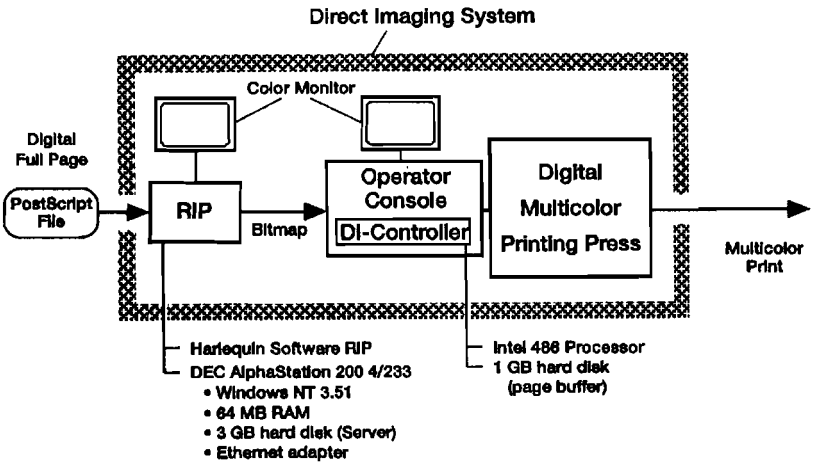


Figure 9. Direct Imaging System Quickmaster DI (HEIDELBERG)

The digital multicolor press, as well as the plate imaging system, is controlled via an operator console and the direct imaging controller which is installed there.

This system design gives the guarantee to the user that the digital production can start immediately if the PostScript file is correct. The user can concentrate only on the quality of the PostScript file before starting imaging and print production and does not need to communicate with many suppliers in the case of problems with the workflow.

The performance of the RIP and the DI-controller inside the operator console is designed for high quality, high speed printing; the EDP-specifications of the Quickmaster DI are shortly listed in Fig. 9.

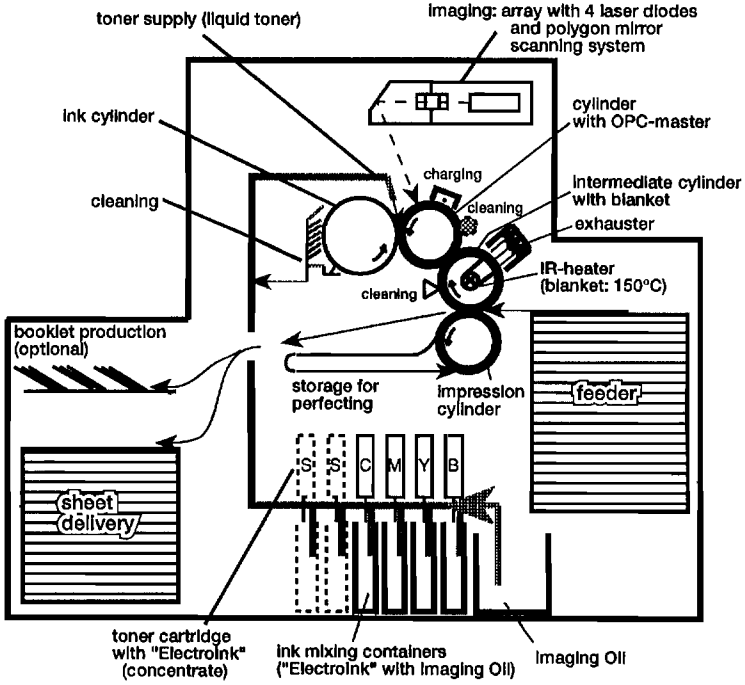
The Quickmaster DI has been launched very successfully into the market. A worldwide distribution has been started. Until today more than 700 signed orders have been received, preproduced systems are in use worldwide. The Quickmaster DI bases on the 3 years experience with the 100 GTO-DI presses, which are worldwide running and producing. The success and the great acceptance of this pioneering technology especially within the US printing industry also convinced the GATF award jury to honour the HEIDELBERG Direct Imaging System QM-DI and the technology behind it with an GATF InterTech Technology Award in 1995.

4. Computer to Print

Computer to press equipment which is working without a master bases on a non-impact technology like listed in Fig. 2. For relatively high speed multicolor printing especially equipment from Indigo, the E-Print 1000, and from Xeikon, the digital color printing press DCP-1 (identical with the Chromapress from Agfa) have started in 1993 to spread into the market).

These presses were, from a technical point of view, described and compared by Kipphan (1994, 1995a). Within this paper, only a short updated information is given.

4.1 E-Print 1000 Digital Color Offset Press (Indigo)



Technology:	Electrophotography, Liquid Toner
Addressability:	≈813 dpi (320 dpcm)
Grey levels:	2 per dot
Printing speed:	1000 A3/h (4 color, one side)
Size:	approx. A3 / portrait

Figure 10. E-Print 1000 Digital Color Offset Printing Press (Indigo) (system schematics, Issue: 1995, not confirmed)

The system schematics in Fig. 10 of the E-Print 1000 show that electrophotography is used for imaging via an imaging system with 4 laser diodes and scanning optics. Development of the latent image onto the organic photoconducting (OPC)-master is done with a specially tailored liquid toner, called "ElectroInk". Via an intermediate cylinder, covered with a blanket - like offset - the ink is printed onto the paper. In an improved version, announced during DRUPA '95, the collection of all the color separations for multicolor printing is done onto the blanket before printed onto the paper with one contact between blanket cylinder and paper, called "one shot technology". Principally the use of a blanket, like in offset, and the use of liquid toner leads to a high print quality, comparable with offset quality. System descriptions are given, for example, from Landa (1994) and Niv (1994).

4.2 DCP-1 Digital Color Printing Press (Xeikon)

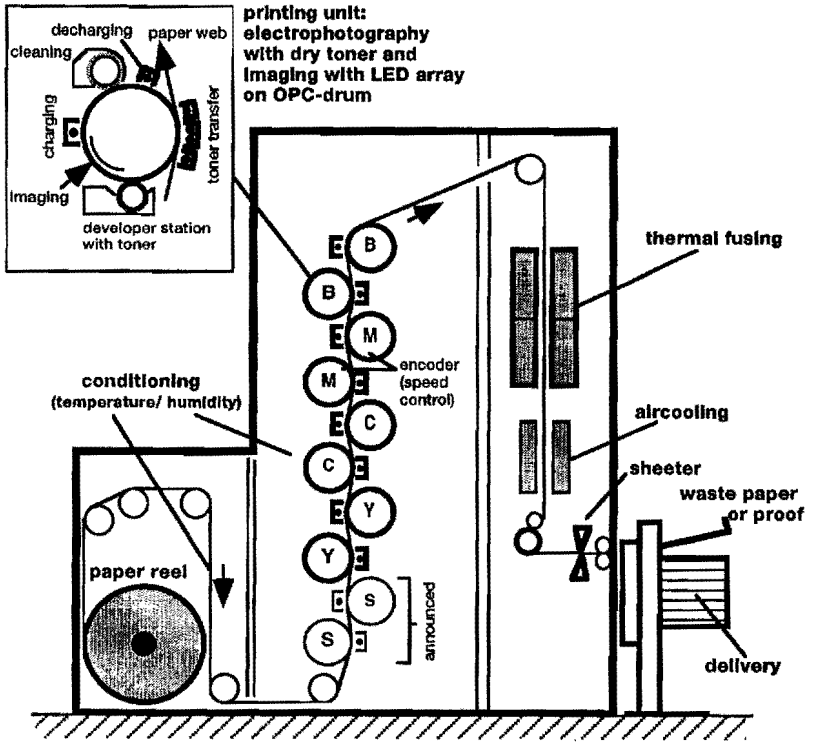


Figure 11. DCP-1 Digital Color Printing Press (Xeikon)

The DCP-1 from Xeikon also uses electrophotography. Printing is done onto web material, simultaneously on both sides of the web. The imaging head is equipped with an array of light emitting diodes (LED). The used powder toner is especially designed and produced with relatively small toner particles to improve print quality; however, inking with powder toner has a limitation in print quality, especially in appearance and gloss. The mechanical synchronisation of all printing units is done without gears only by web feed and web tension. The DCP-1 is an economical digital printing system with high acceptance in the market. Also Xeikon earned in 1995 a GATF Intertech Technology Award. Technical descriptions are given, for example, by De Schamphelaere (1994, 1995).

4.3 Comparison of Direct Imaging and Computer to Print

In chapter 6, a general comparison including direct imaging systems using rewriteable surfaces will be given, however, at first in this section the present available technology and experiences in the market will be compared.

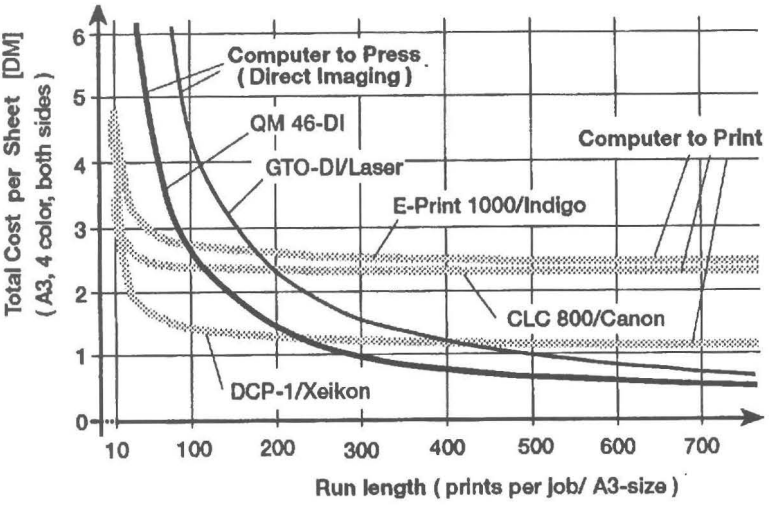


Figure 12. Comparison of Total Costs for Digital Multicolor Printed Sheets (only confirmed for HEIDELBERG products, Issue: Jan. 96)

In Fig. 12 the total costs for producing digital printed sheets are compared. The comparison is done especially for the Quickmaster DI, the E-Print 1000 and the DCP-1. In addition, the characteristics for the digital direct imaging press GTO-DI and a computer to print equipment, the CLC 800 from Canon with a relatively low productivity, are shown. (Until today, regarding the new announced digital printing presses - for example, the faster systems are CLC 1000 or the DocuColor 4040 - there are no real numbers for the comparison, the systems are only announced or just start to spread into the market).

It can be seen in this figure that the break-even regarding costs and run length of the job for the direct imaging system QM 46-DI compared with the DCP-1 is in the range of 250 prints per job and for the E-Print 1000 already for shorter run length. That means for producing multicolor print jobs - short run color printing in the range of approx. 250 and more - the Quickmaster DI is much more economical than the other presses and - as an important advantage - in addition, the produced multicolor print quality is on a higher level, based on the offset technology and the use of a master.

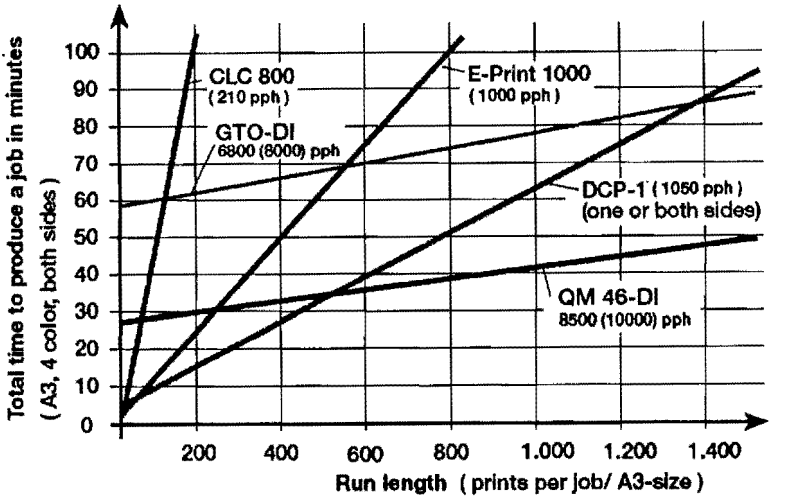


Figure 13. Comparison of Time to Produce Digital Multicolor Printed Sheets (Remark: The calculation for QM 46-DI and GTO-DI based on a 15 % reduction of the maximum possible production speed)

Fig. 13 shows accordingly the comparison regarding productivity, that means the time which is needed to produce a multicolor job. It can be clearly recognized that the Quickmaster DI should be - especially also from this point of view - the preferred printing system for run lengths in the range of 500 prints per job and more without any question mark.

5. Rewriteable Surfaces in Computer to Press (Direct Imaging)

Digital multicolor printing presses/systems using re-imageable masters, as described in Fig. 4, are at present not on the market. However, from the patent literature, conference proceedings and announcements it can be recognized that activities in research and development are running in order to realize such kinds of presses.

The basic idea is that on a stable, special surface on the forme cylinder inside the press the color separation can be imaged for the job to be printed in a way that after imaging a permanently stored image information - a master is generated. As an advantage, a relatively slow imaging speed for creating a permanent image of the job to be printed on the image carrier/print forme can be accepted in favour of inexpensive design in computing and imaging technology, and after that, fast printing speed for producing the job is possible with continuous high quality.

This surface must have the specification that after the print process the job depending image information can be erased and after that the basic surface can be homogeneously prepared for re-imaging, depending on the next job to be printed.

Kipphan (1995a) gave a first overview about possible technologies. Especially from MAN Roland it is known that many experiments are done to realize direct imaging with re-imageable master, for example, using ferro-

electric ceramic (Hirt, 1994) or ink jet imaging (Berchtold, 1994). At last during DRUPA '95, thermotransfer was shown to build up a printing plate which can be used for offset printing (Schneider, 1995a) and thermoablation technique to create a forme cylinder for gravure printing (Schneider, 1995b). NIPSON published in 1995 the concept of magnetolithography for direct imaging basing on magnetography (Eltgen, 1995).

Following, the above listed three systems will be shortly described, they have been shown and announced as lab-prototype systems.

5.1 DICOweb Litho (MAN Roland)

During DRUPA '95, MAN Roland showed a lab-prototype for multicolor printing on both sides of a web for its DICOweb Litho offset printing system (DICO means: DIgital Change Over). The basic idea is to use a special metal alloy sleeve, mounted on the plate cylinder (Schneider, 1995a). The material specifications of this sleeve are developed to be ink-repellent and water-friendly, but not with the roughness like grained offset plates (in direct imaging the basic surface has to be very smooth for relatively easy and safe cleaning operations which are needed within the total imaging and erasing process).

Via thermal laser energy from a special ribbon (PET-substrate coated with a special oleophilic resin) using a thermotransfer effect, an ink-accepting layer is transmitted onto the basic hydrophilic (water-accepting) sleeve surface. After that, to stabilize the transmitted imaging substrate, via heat a fixing process must be done. Then the plate is prepared to print the job.

If the job is ready, with chemical and mechanical cleaning equipment (similar to state of the art blanket wash-up systems ?) the imaged part of the plate cylinder/sleeve is erased by ablation of the imaged material and by activating the hydrophilic surface characteristics. After that, a new imaging process can be done. In Fig. 14 a schematic drawing is shown based on company brochures handed out during DRUPA '95.

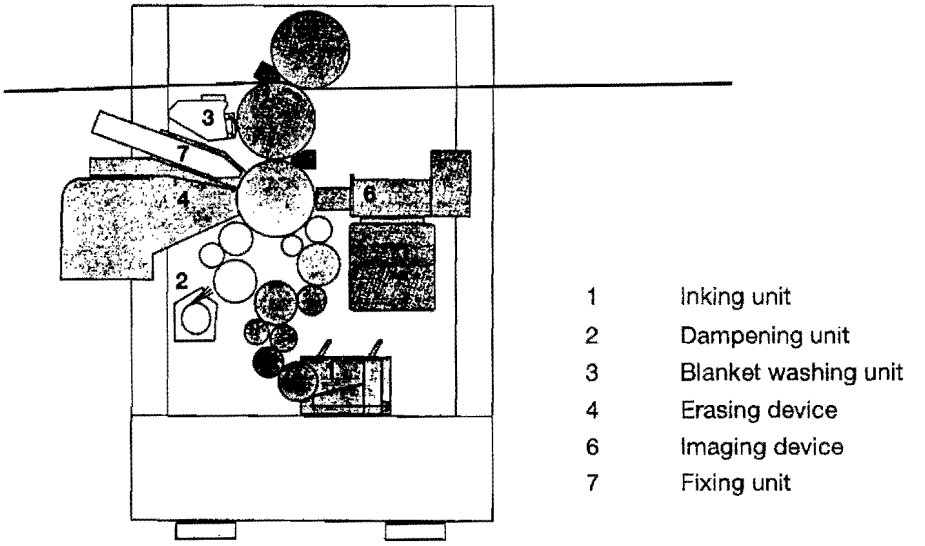


Figure 14. DICOweb Litho Direct Imaging Technology
(schematic drawing, MAN Roland)

The announced system is using a special multi-beam YAG-laser imaging system, designed by the Canadian based company CREO, well-known with its powerful and successful computer to plate equipment.

The presented and explained concept works on the lab-prototype with a resolution of 2400 dpi, printing is done with small sizes, but allows the estimation that for A3-size printing the total plate making process needs approx. 12 minutes. The print quality can principally reach a high level. The question marks are the life time of the basic surface (sleeve) and the quality limitation of the printing plate itself produced with thermotransfer. MAN Roland announced that the sleeve could be used more than 20 times (it could be possible to improve this up to the range of 100 ?). The digital change over (DICO)-process for short make-ready times needs all the equipment for imaging, fixing, erasing/cleaning and storing the ribbon material around each forme cylinder (Fig. 14): the sleeve on the forme cylinder must be easily changeable. From the engineering point of view, there are manageable risks - pioneer engineering must be done. The big question mark could be the complexity of the total system and the consequences regarding costs and reliability.

Remark: It should be mentioned that DICOweb Litho was additionally announced with an off-press imaging system for producing the image on the ribbon out of the press and coating the forme cylinder on press with heat transfer (two-step imaging process for monochrom prints).

5.2. DICOweb Gravure (MAN Roland)

MAN Roland announced a second direct imaging printing system called DICOweb Gravure using the gravure printing technology.

In Gravure technique, the printing unit itself is - when compared to lithography/offset - relatively simple. Via an inking system, the engraved/formed cells in the cylinder surfaces must be filled with ink and after that via a doctor blade the cell walls are cleaned. The ink within the engraved cells is transmitted via pressure directly or via a blanket cylinder onto the paper.

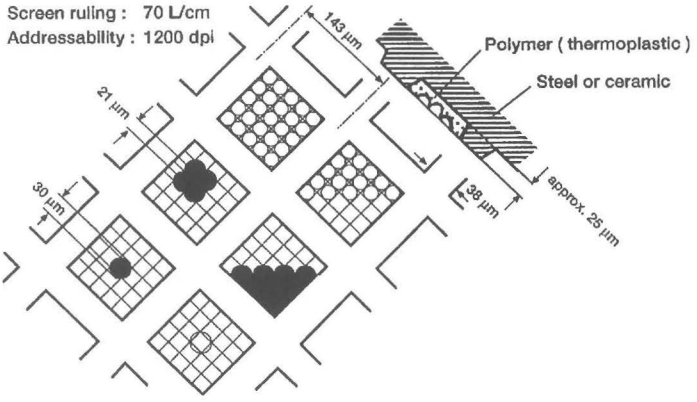


Figure 15. DICOweb Gravure (MAN Roland)
(cell structure of the gravure forme cylinder)

The DICOweb Gravure system uses a basic cylinder or sleeve which is engraved, as shown in Fig. 15, with a homogeneous grid of square cells (178 cells per inch). Each single cell is filled with a special thermoplastic polymer. Via thermo laser energy within each single cell of the gravure forme cylinder with the resolution of 1200 dpi the image can be generated based on thermal erosion technique as a job-depending, engraved surface structure (a high power Nd-YAG-laser is used). The laser energy is controlled within 16 levels for creating different ink volumes of the single imaged micro cells for creating grey levels.

The erasing process is realized with high pressure multibeam hot water cleaning equipment.

If all the polymer material is removed from the sleeve cells via a cleaning unit, melted thermoplastic polymer is filled into the cells; the overfiling above the top of the cell walls is removed by a heated doctor blade.

5.3. Magnetolithography (NIPSON)

Last year, Eltgen *(1995)* gave the first official presentation of magnetolithography, which is basing on the non-impact printing technology magnetography in combination with offset printing.

The French company NIPSON is producing digital printing systems for multicolor printing and for printing an additional spot color, using magnetography. In magnetography, the building up of a latent image on the imaging cylinder surface is done with an array of ferroelectric micromagnets (up to 480 dpi today). The magnetic field for imaging changes the orientation of the polarization of micromagnets within the recording layer on the imaging drum.

After imaging, the orientation of the micromagnets within the imaging cylinder is stable, that means a permanent, latent image is generated and could principally inked repeatedly without the necessity to image the surface anew after each print cycle. However, this effect has not been used until today, but magnetography is the basis for building up a printing plate for the practical use of this technology.

Magnetolithographic plate making is done with the following steps (Eltgen, *1995):*

With a magnetic imaging head the forme cylinder is imaged depending on the print job. After that, with magnetic toner, the surface is developed and for fixing the toner particles on the forme cylinder a heating and melting process is done. The surface tension characteristics of the forme cylinder (hydrophilic) and the magnetic toner (oleophilic) allow to print conventional offset using a flow of water and ink. The erasing process is done via melting the ink layer of the forme cylinder for mechanical cleaning (for example, with scraping); an additional chemical cleaning is necessary to get a hydrophilic basic surface again.

The known state in research is that with a lab-prototype the basic concept is confirmed thus encouraging further activities on the way to build up a technology for practical use.

6. Comparison of Computer to Press-Technologies

In Fig. 16 a comprised flow of the several process steps for direct imaging with rewriteable master/surface is shown on the left part, and on the right part the steps for computer to print-technology can be seen (Kipphan, 1995).

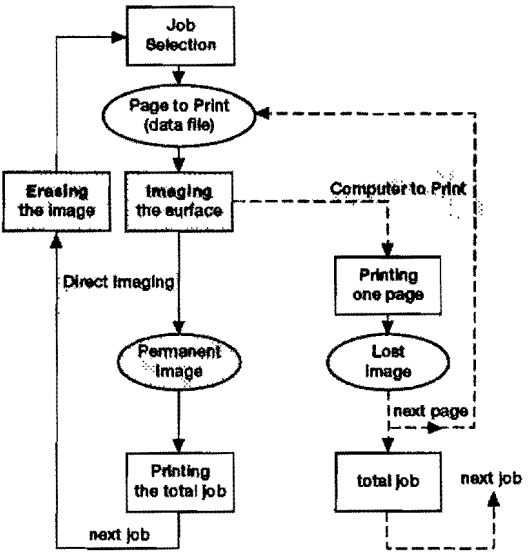


Figure 16. Production Cycle for Computer to Press with Erasable/Rewriteable Master (compared with computer to Print)

In Table 1 a brief comparison for computer to press-technologies is given.

Table 1. Computer to Press-Technologies
Direct Imaging vs. Computer to Print (brief comparison)

Specification \ Technology	Direct Imaging (once imageable master)	Direct Imaging (re-imageable master)	Computer to Print (masterless)
Productivity (printing speed)	high	high	low
Imaging Speed	low	low	high
Re-imageable Cycles (possible)	1	ca. 100 ?	ca. 60000 ?
Print Quality: - single page - page to page	high constant	high / medium constant	medium varying
Page Content per Job	permanent	permanent	variable
Paper Flexibility	high	high	medium / small
Run Length	medium (very high)	medium (high)	low - medium
Imaging Process	rel. simple	complex	complex
Inking Process	simple	simple	rel. complex
Reliability	high	medium / high	medium / low
Make-Ready Time	short	short / medium	very short
Costs per Printing Press	medium	medium (+)	medium / low
Costs for Consumables/Page	low	low	high
Total Costs per Page: - run length approx. 1000	low	low (+)	high
- run length approx. 300	medium	medium (+)	medium (+)
- run length approx. 50	high	high (+)	low

The most important facts in direct imaging technology are the possible high productivity and the produced high print quality on a single page as well as continuously page-to-page. The basis for this is the use of a master as the guarantee that the single prints can be identical to each other within the whole job.

The press design is relatively simple, which results in a high reliability. The used inks are standards on the market, produced in high volumes, which leads to relatively low costs for consumables.

The advantages of using re-imageable masters for direct imaging are that manual plate changing is avoided, the new plate is generated totally automatically within the press. The announcement of MAN Roland leads to the optimistic estimation that more than 20 imaging cycles can be done (approx. 100 ?) before the surface must be changed, manageable via sleeve technology. (It should be mentioned that with the Quickmaster DI design - using direct imaging technology with one imageable master - this disadvantage compared with re-imageable master-technology is eliminated, because within QM-DI there is a cartridge for plate material with a capacity of 35 plates - that means: digital change over can be done for 35 jobs before the cartridge with the plate web material must be changed.)

The advantages of computer to print-presses are the possibility that each page can be printed with different content for personalizing or, for example, "book-on-demand"-printing, or jobs with "run length 1"; of course, this requires special performance and capacity of the EDP hard- and software. The make-ready time is very short. The total costs per page are only in the range smaller than 100 prints per job cheaper as the production with direct imaging printing systems.

7. Workflow for Digital Print Production

Digital printing technologies are spreading into the market. Computer to film is state of the art, computer to plate (explained before) is coming slowly, but continuously, and computer to press is no science fiction, it is true reality.

This leads to a new orientation in print production. The organization within a printing company has to be changed or expanded.

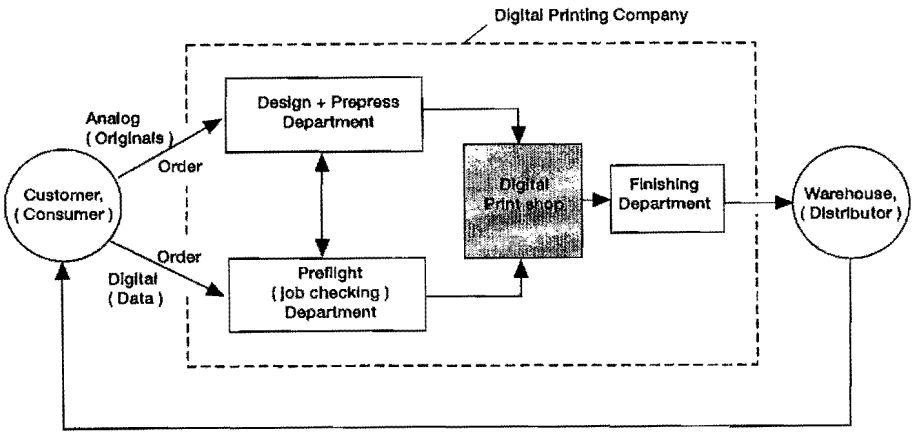


Figure 17. Digital Print Production
(departments within a digital printing company)

As shown in Fig. 17, in addition to the conventional prepress department, for the workflow of digital production a so-called preflight department is needed. This preflight department has the task to check the job which is ordered by the customer based on digital data. Before the digital print production is started, the quality of the data file must be proved.

This offers a new kind of business. A preflight department is not only a quality insurance department for the internal production, it can offer the customer to repair the data files if problems are recognized - and this, of course, is a possibility for added value.

It can also be seen from Fig. 17 that a digital printing company must be prepared/equiped for doing both: dealing with conventional orders based on analog input information and with digital orders. For generating a digital file for using the digital printing equipment, the analog orders must be digitized and the job must be designed for creating the PostScript file for the total page/job to be printed.

For the complete production of the printed products, the finishing department for stitching, cutting, folding, collecting, etc. should be included in the total workflow, under "one roof" within the digital printing company.

There is space for improvements in printing system design, and also in job management within a digital printing company. Connecting stand-alone equipment for finishing with a digital printing press via hard- and software is an example.

Special interfaces are in development for this purpose. For example, the CIP 3 consortium - founded by HEIDELBERG - is acting for designing a special language which allows to take over a part of the whole digital data file used for printing, also for finishing activities within the workflow. In the paper of Seydel (1996) a short description of this system is given with references for more detailed information.

8. Summary / Outlook

In Fig. 3, as explained before, an overview is given about the existing print technologies, especially digital printing equipment with some examples. The interesting part of this portfolio is the niche roughly describing the range for run lengths of 50 - 1000 prints per job - for short run color print jobs. For this niche the direct imaging printing systems and computer to print products are fastly growing and are successfully in use. This interesting market segment is the driving force for efforts of traditional printing companies as well as newcomers to gain a part of this market with products which are available, improved, newly designed or announced.

Each technology can be successful if the investments of the printing companies have a strong orientation to the customer's needs and satisfaction, based on a careful analysis of the company's goal market.

Conventional printing technologies will cover their traditional markets for high run lengths, without a danger for their survival.

The development and products for digital printing with direct imaging technologies - using a master - lead to high quality printing and relatively high productivity. Computer to press/direct imaging technology like QM-DI using a job specific master are established in the market.

Computer to print systems are prepared for "short, short run color printing" and need the acceptance for their medium print quality compared with offset in balance to their advantages, especially for personalized printed products.

The next years will show whether direct imaging printing systems with rewriteable surfaces are successful by themselves and in comparison with technical solutions using a single usable master together with automatic plate changing.

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