Advanced Printing Technologies

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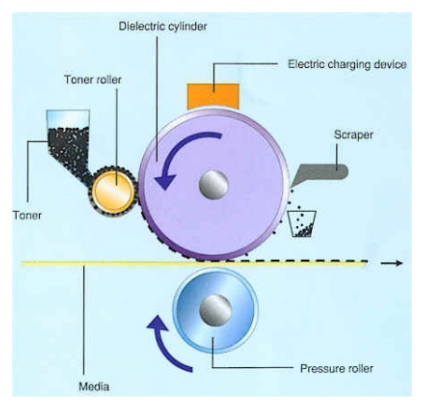

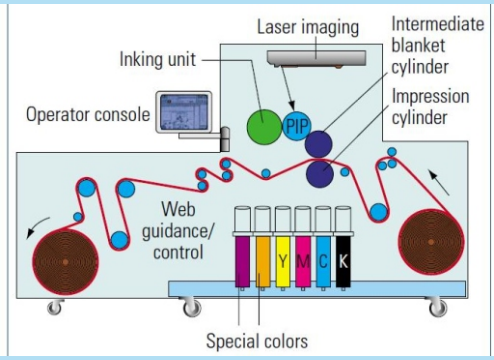

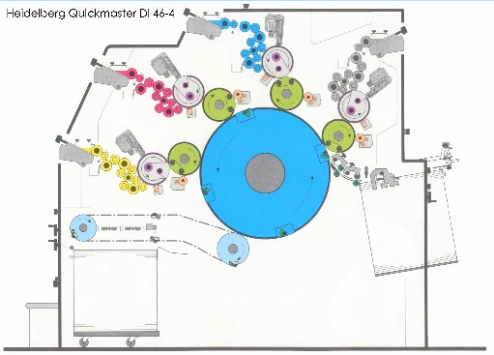

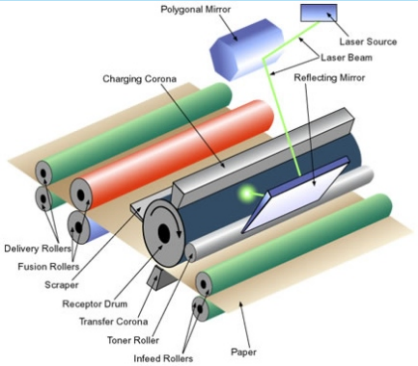

Prepared by

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ADVANCED PRINTING TECHNOLOGIES

ADVANCED PRINTING TECHNOLOGIES

Unit	Name of the Topic	Hours
I	**Digital Printing Technologies** 1.1 Digital printing – Definition, Scope and job suitability of Digital printing process. 1.2 Basic principle of Computer-to-Film, Computer-to-Plate, Computer-to-Press and Computer-to-Print. 1.3 Computer-to-Press – Working principle of Direct Imaging with once imageable master and Working principle of Direct Imaging with re-imageable master. 1.4 Computer-to-Print – Working principle.	**13 Hrs**
II	**Non-Impact Printing Technologies** 2.1 Basic principle of Non-impact printing technology, Flow chart of NIP technology and Applications of NIP technology. 2.2 Basic principle of Electrophotography – Imaging, Inking, Toner transfer, Toner fixing and Cleaning. 2.3 Basic principle of Ionography – Imaging, Developing, Toner transfer, Toner fixing, Cleaning and Erasing. 2.4 Basic principle of Thermography – Direct thermography, Transfer thermography, Working principle of thermal transfer and thermal sublimation printing systems and Properties of ink tonner for Thermography. 2.5 Basic principle of Ink jet printing - Continuous ink jet and Drop on demand ink jet, Working principles of continuous ink jet and drop on demand ink jet and Properties of ink tonner for ink jet printing.	**13 Hrs**
III	**Security Printing Features and Materials** 3.1 Security design features - Pantograph screens, Void pantograph Screen, ODT - optical deterrent technology, Guilloches, Warning bands, Code safe, High resolution graphics and Padlock icon - Application of security printing. 3.2 Security papers – Safety paper, Chemical reactive paper, Special papers, Water mark paper and Copy evident paper. 3.3 Security threads - Metalized thread, Windowed thread, Holographic windowed thread, Micro text, Clear text and Thermo text. 3.4 Watermark, Classification of watermark - Line drawing watermark, shaded watermark and Digital watermark. 3.5 Security inks – Trademark colors, Color changing ink, Magnetic ink, Copy protection ink, Erasable ink, Fugitive ink, Pen reactive ink, Heat reactive ink, Coin reactive inks, Migrating ink, Bleeding inks, Florescent ink, Metallic ink and UV ink.	**13 Hrs.**

Unit	Name of the Topic	Hours
IV	**Special Printing Technologies** 4.1 Basic principles of hybrid printing system and Application of Hybrid printing systems. 4.2 Basic principles of holograms making process, Components of hologram making system - laser, lenses, beam splitter, mirrors, holographic film and Process steps of hologram making system. 4.3 Basic principles of lenticular printing process. 4.4 Basic principles of waterless offset printing, Plate structure of waterless offset printing, Merits and Demerits of waterless offset printing.	**13 Hrs**
V	**Emerging Printing Process** 5.1 Basic principles of E-book, List of various manufactures of E-book, Application of E-book, Basic principles of E-ink and Concept of E-ink with microcapsules filled with a coloring agent. 5.2 Basic principles of “Gyricon” E-paper, Types of display of E-paper, Application of E-paper, Concepts of rewritable paper, Imaging and erasing processes for rewritable paper. 5.3 Introduction about 3D printing, Types of 3D printing - direct and binder 3D printing, Steps involved in 3D printing process and Application of 3D printing.	**13 Hrs**

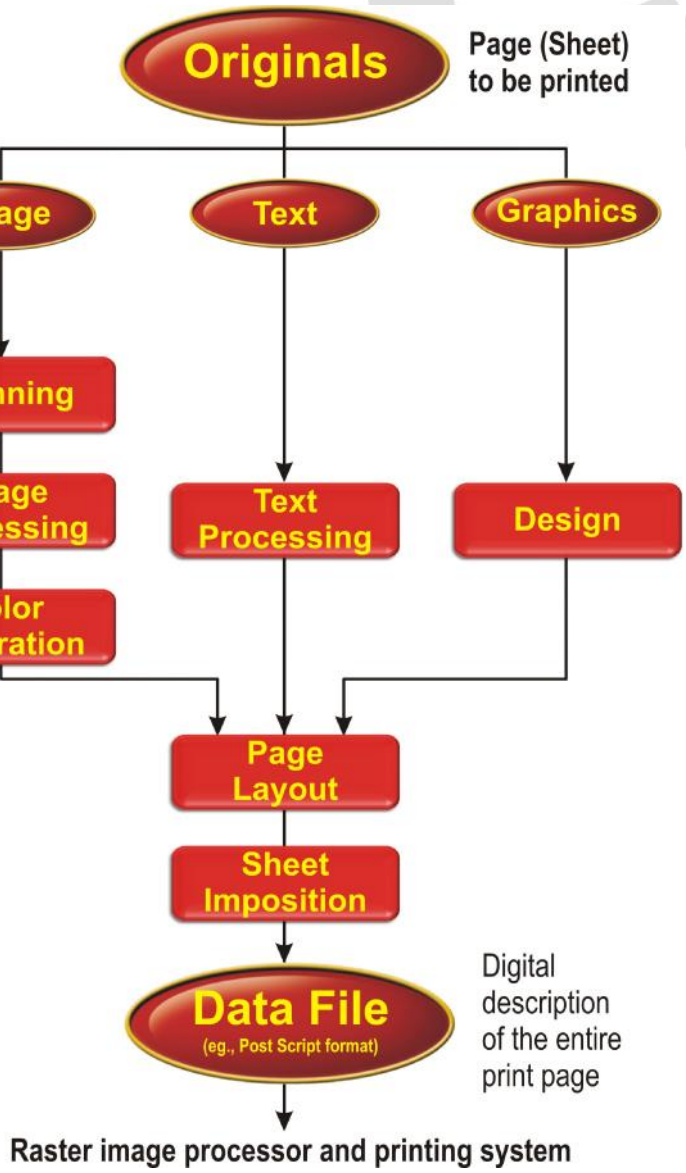
Unit - I Digital Printing Technologies

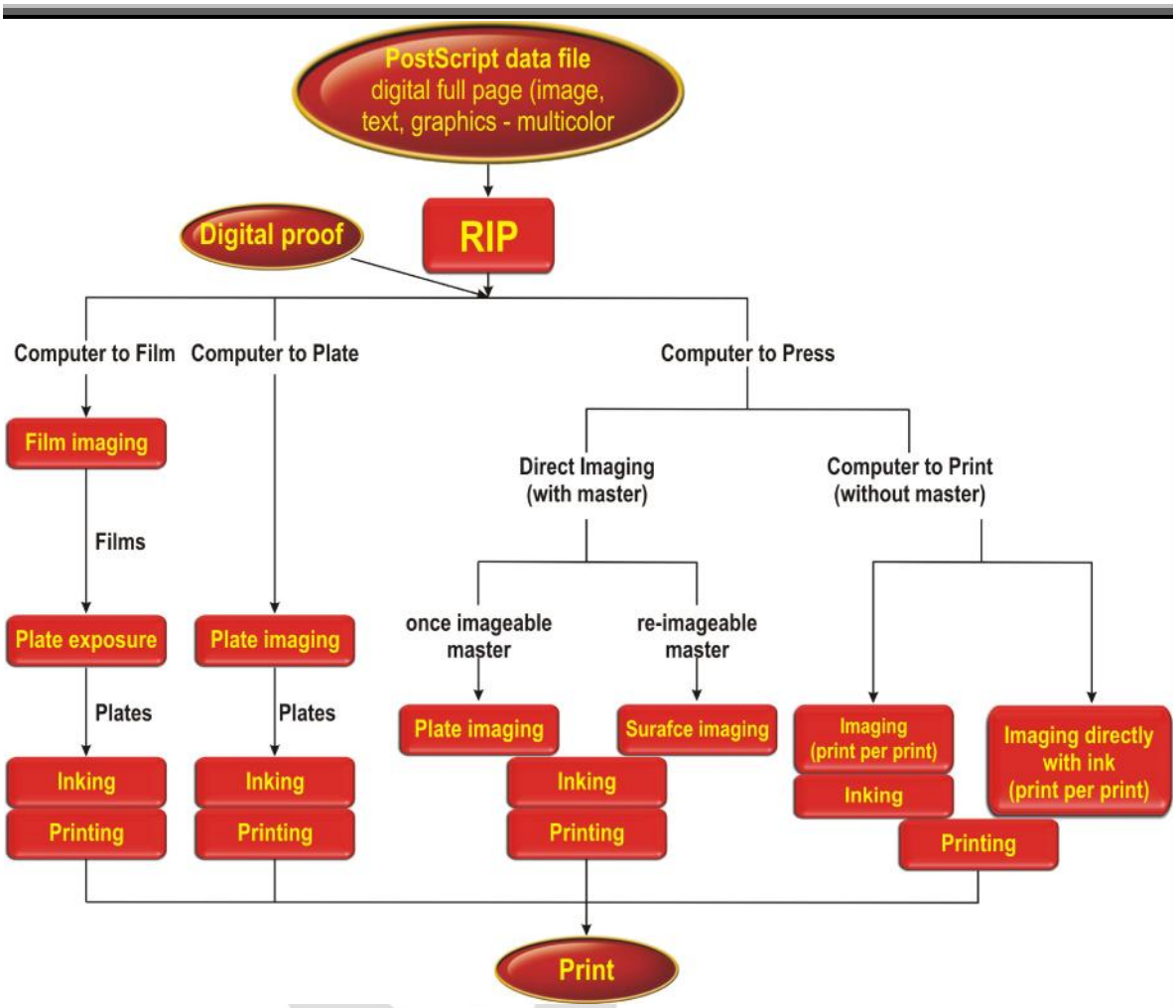
1.1 – Basic Principle of Digital Printing.

In digital printing, an image is sent directly to the printer using digital files such as PDFs from graphic software such as Illustrator and In Design. This eliminates the need for a printing plate, which is used in offset printing, which can save money and time.

Eg. Laser and Ink-jet printing.

Flow Chart of Digital Composition of a printed page





Direct Imaging (with master)

In an offset printing press, the image carrier (plate) is imaged directly on the press with built-in laser exposure units. This is called Direct Imaging.

Computer to Print (without master)

The term Computer-to-Print refers to all printing processes which do not require physical printing plates. Here the digital data is printed directly onto the substrate. This is called as Computer-to-Print.

(eg.) Laser Printing, Inkjet Printing.

Scope and Job suitability of Digital Printing Process

Digital Printing has a very bright future because

- Every print is the same till final print.
- More accurate registration.
- Less wastage.

- Cheaper low volume printing.
- Variable data printing.
- Green printing as pre-press stage is eliminated.

Digital printing is suitable for

- Short-run jobs.
- Variable data printing.

1.2 - Basic principle of Direct Imaging

Once imagebale master (Plate Imaging)

This refers to a printing press where the image carrier (plate) is imaged directly on the press.

Eg.) Heidelberg Quickmaster DI 46-4, Germany

Re-imagebale master (Surface Imaging)

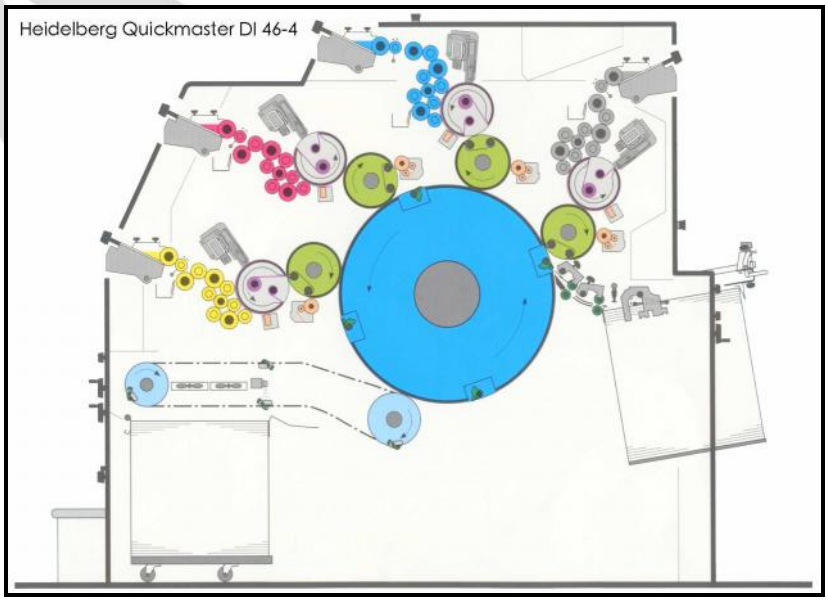
In re-imaging technology, the printing plate material can be neutralized by erasing the printing image after completion of one print job. It is then re-imaged for the next job.

E.g.) DICO Web from MAN Roland, Germany

1.3 Working principle of Direct Imaging system with Once Imageable Master

This refers to a printing press where the image carrier (plate) is imaged directly on the press.

Eg.) Heidelberg Quickmaster DI 46-4, Germany



This direct imaging press has four printing units. Each printing unit has a plate and blanket cylinder along with an inking system. There is one single large common impression cylinder at the center. This design is called as ***satellite*** design. The printing method used is ***waterless*** offset printing. This does not require a dampening system.

Each printing unit is fitted with a ***laser imaging unit***. The laser imaging unit is controlled by a ***raster image processor***. This RIP processes the job data for the direct imaging process. The laser imaging unit images the printing plates in all the units simultaneously.

This printing press works on the principle “Computer-to-Plate-on-Press”. The imaged plates can be used only for that particular job. For a new job, a new plate should be used.

Re-imagebale master (Surface Imaging)

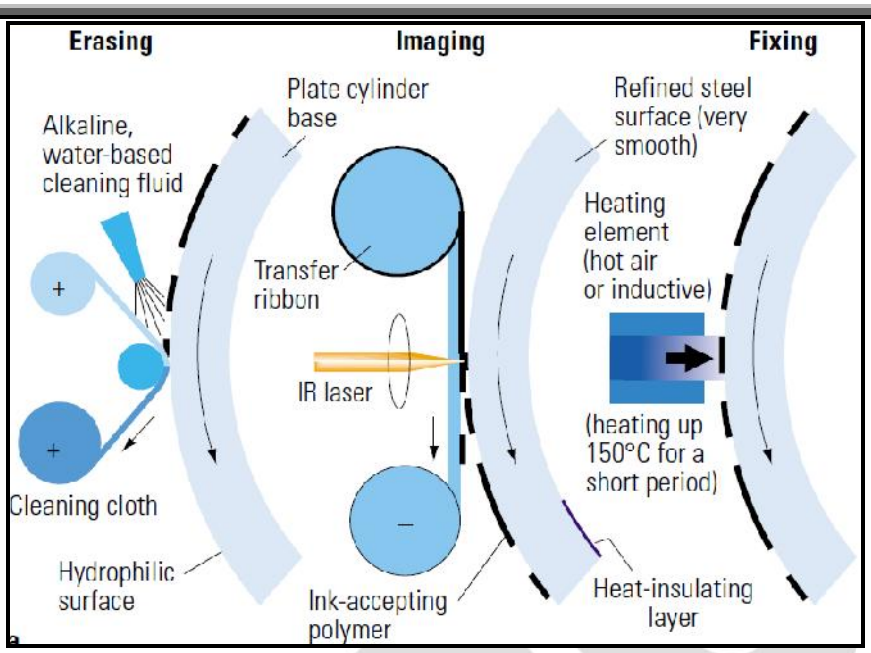
In re-imaging technology, the printing plate material can be neutralized by erasing the printing image after completion of one print job. It is then re-imaged for the next job.

E.g.) DICO Web from MAN Roland, Germany

DICO Web Press

In this technology, the image is formed on a metallic plate cylinder using a ***polymer***. The polymer is transferred ***thermally*** onto the cylinder surface. The image forming polymer is stored in a ***roll form*** in the machine. The polymer from the roll is ***fused*** on the cylinder surface by a ***thermal laser***. Thus the image is created on the cylinder surface by ***laser ablation*** technique. After imaging process, the polymer is fixed on the cylinder by supplying heat (e.g., using hot air at 150^0 C).

After the printing is over, the ink-accepting polymer material is removed from the cylinder surface by chemical and mechanical ***cleaning process***. After the cleaning process the water-accepting cylinder surface is ready for imaging the next job.



DICO Imaging Technology

1.4 Basic principles of Computer to Print

Computer to Print is a masterless printing technique. It is categorized into two types. They are,

1. Imaging on surface (print per print) E.g., Electro photography
2. Imaging directly with ink E.g., Ink jet

Imaging on surface (print per print)

Here the image is created on a charged drum/surface. Then a toner/ink is applied on the charged areas (image area). Then the toner/ink is transferred onto the substrate. After printing one sheet, the image is neutralized. Again the image is formed on the drum for printing the next sheet.

Imaging directly with ink (print per print)

Here the image is printed directly onto the substrate (i.e.) the image is printed directly onto the paper without any image carrier.

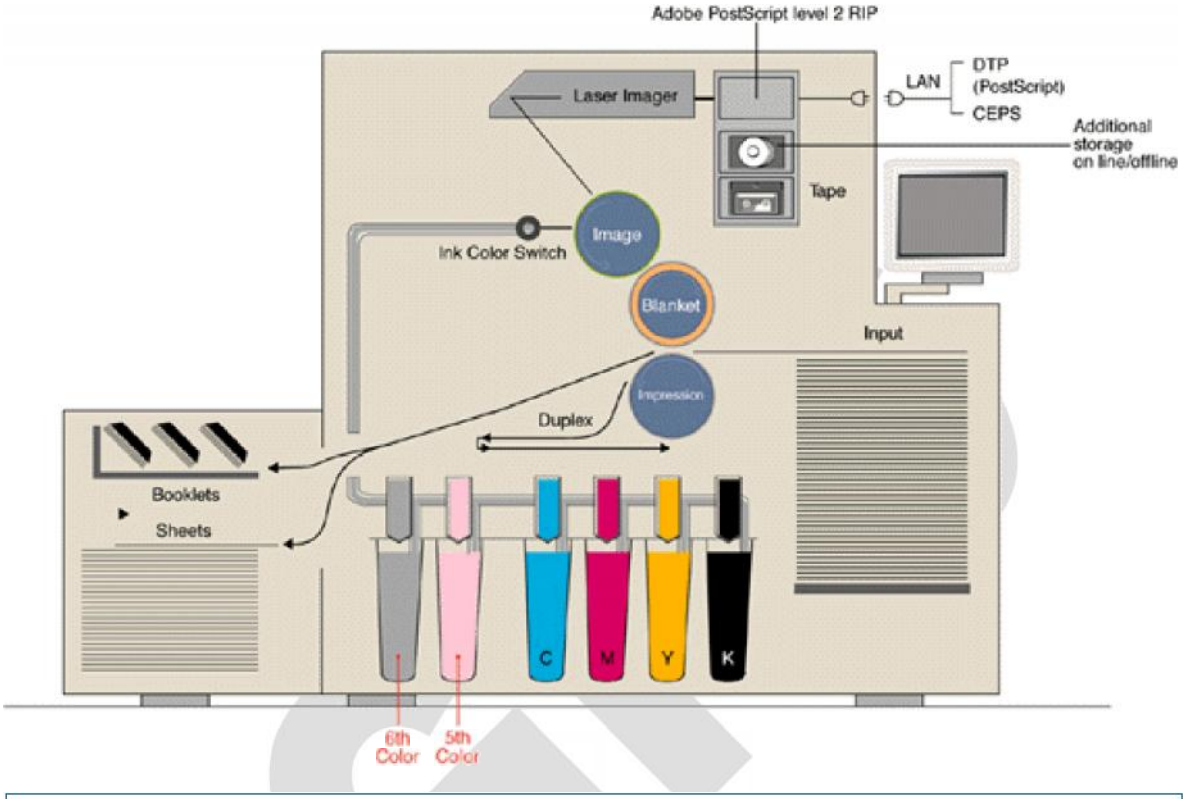
Working principles of computer to print system for printing on sheet material and web material

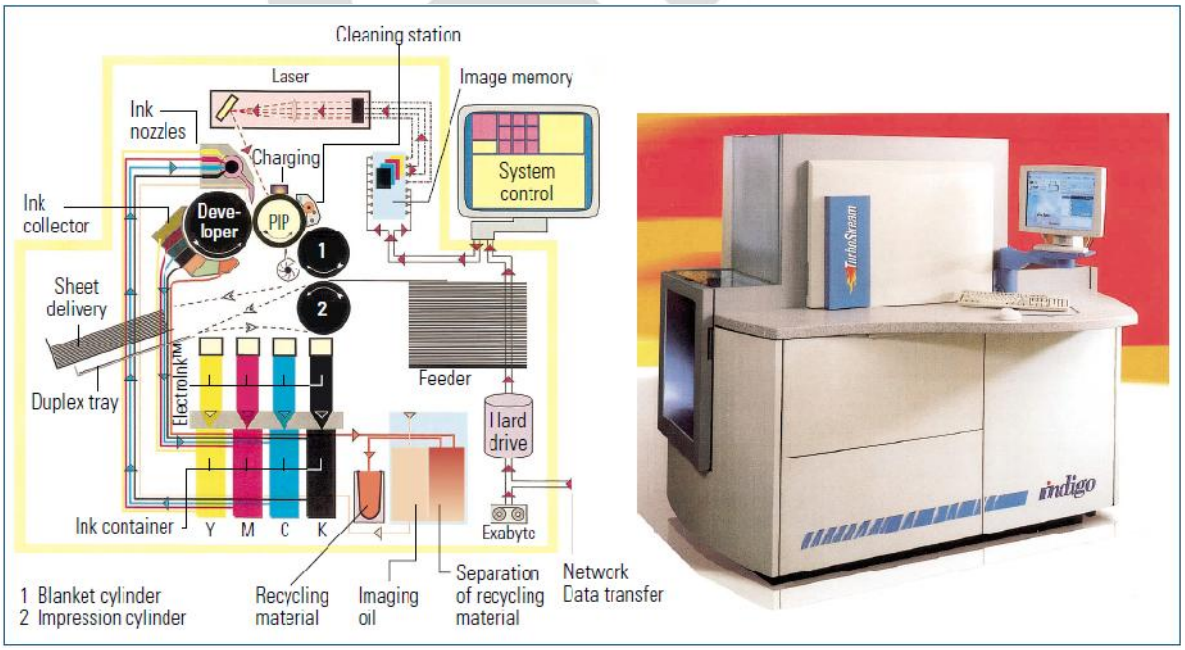
Sheet fed computer to print system

In this system the substrate used is in the sheet form. E.g., Indigo E Print 1000

This technology works on the principle of ***electrophotographic*** multicolor printing using liquid toners. Here there is only a single printing unit. This single printing unit can print four colors. The

sheet is carried by the impression cylinder for ***four revolutions*** during printing. In each revolution one color is printed. Thus after four revolutions, four colors are printed on the paper. In each rotation one of the process colors is applied on the paper by a ***blanket cylinder***.





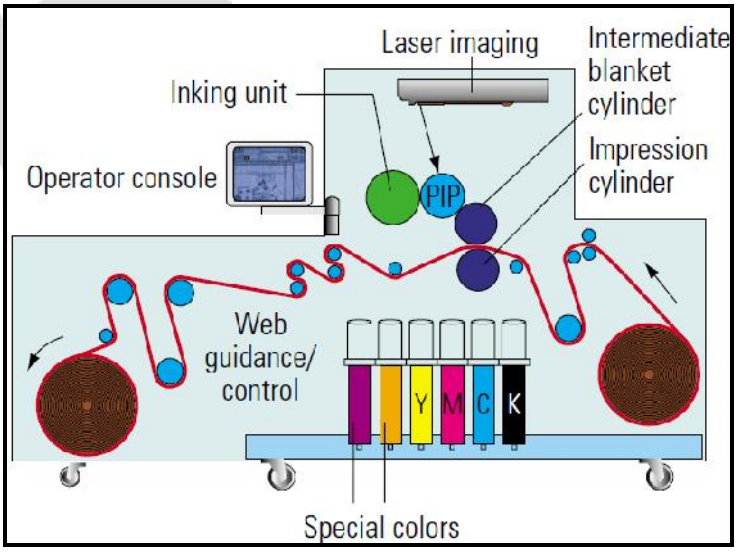
The blanket cylinder receives the colored image from a ***photo-conductor drum***. The particular color image is formed on the photo-conductor drum by a ***laser imaging head***. After imaging, a liquid toner is applied to the photo-conductor drum by means of special type of inking unit. For each revolution one color ink is applied onto the photo-conductor drum. This is then transferred

to the paper through the blanket cylinder. By this way four to six colors (six rotations of impression cylinder is needed) are printed onto the paper.

Web fed computer to print system

In this system the substrate used is in the web form. E.g., Indigo Omnius

The web fed computer print system functions similar to the sheet-fed printing system. The main difference is the impression cylinder will not rotate four revolutions for printing four color. Instead the blanket cylinder receives all the four colors onto the surface of the blanket cylinder from the imaged cylinder. Then all the four color is transferred onto the web material at a time. The quality of the image depends upon the quality of the transfer of image onto the blanket cylinder. Here the imaging is done by electrophotography and laser systems with a resolution of 800dpi.



Applications of Copy-based printing process

- Desk Top Publishing – inexpensive home and office printing.
- Variable data printing – mass personalization of printed materials.
- Print on Demand – personalized printing.
- Advertising – Used for outdoor banner advertising.
- Photos – printing photographs.

Part - A

1. What is digital printing?

In digital printing, an image is sent directly to the printer using digital files such as PDFs from graphic software such as Illustrator and In Design. This eliminates the need for a printing plate, which is used in offset printing, which can save money and time.
Eg. Laser and Ink-jet printing.

2. Write down the classifications of digital printing.

Computer to film, Computer to plate and Computer to press

3. Write down the classification of computer-to-press.

Direct Imaging (with master) and Computer to press (without master)

4. What is RIP?

Raster Image processor

5. Define variable data printing.

mass personalization of printed materials.

6. What is DI?

Direct Imaging

7. Define direct imaging with master.

This refers to a printing press where the image carrier (plate) is imaged directly on the press. Eg.) Heidelberg Quickmaster DI 46-4, Germany

8. Define computer to print without master.

The term Computer-to-Print refers to all printing processes which do not require physical printing plates. Here the digital data is printed directly onto the substrate. This is called as Computer-to-Print.

(eg.) Laser Printing, Inkjet Printing.

9. Write down the classifications of direct imaging with master.

Once imagebale master (Plate Imaging)

Re-imagebale master (Surface Imaging)

Part – B

1. Define once imageable master.

2. Define re- imageable master.

3. What is computer to press?

4. What is computer to print?

5. Give any three applications of copy-based printing system.

Part – C

1. Describe the working principle of direct imaging system with re-imageable master.

2. Describe the working principle of direct imaging system with once imageable master.

3. Explain the working principles of computer to print system for printing on sheet material.

4. Explain the working principles of computer to print system for printing on web material.

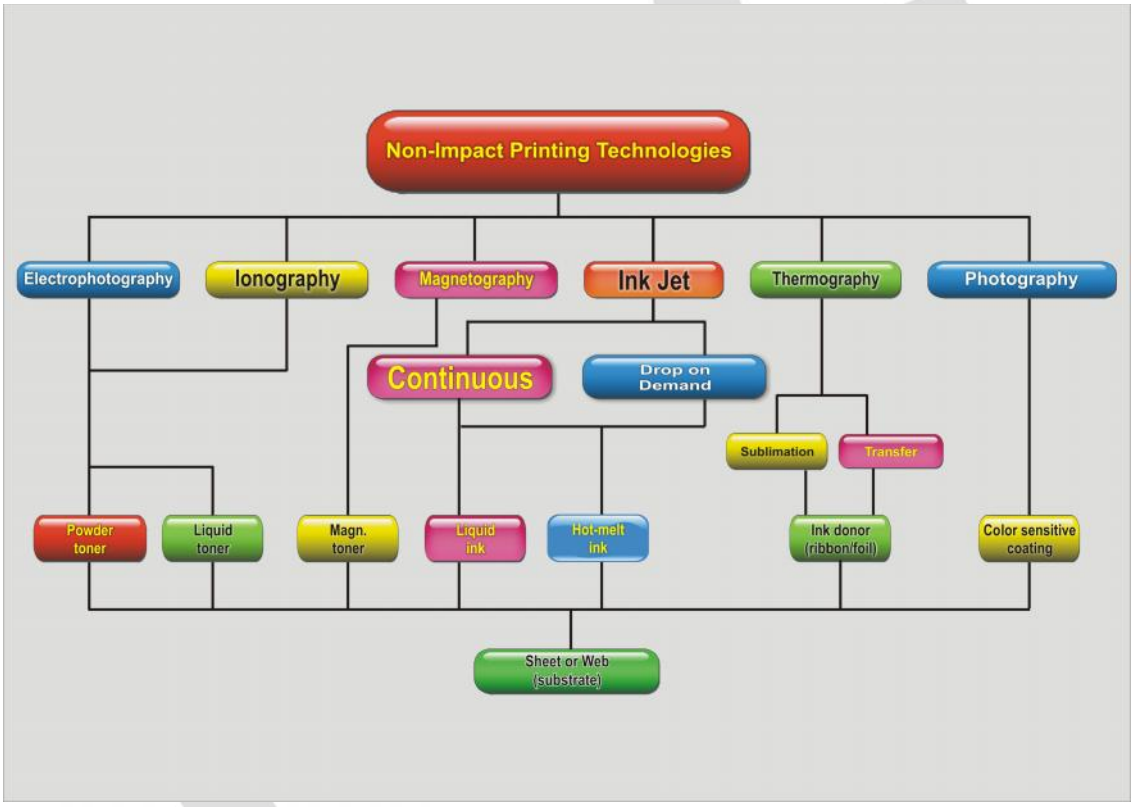
Unit - II Non-Impact Printing Technologies

2.1 – Basic Principle of Non-impact printing technology.

Non-impact printers print characters and images without any physical contact between the printing mechanism and the paper. Non-impact printers are generally much quieter than impact printers since they don't physically strike the page.

Eg. Ink-jet printing.

Flow Chart of NIP technology



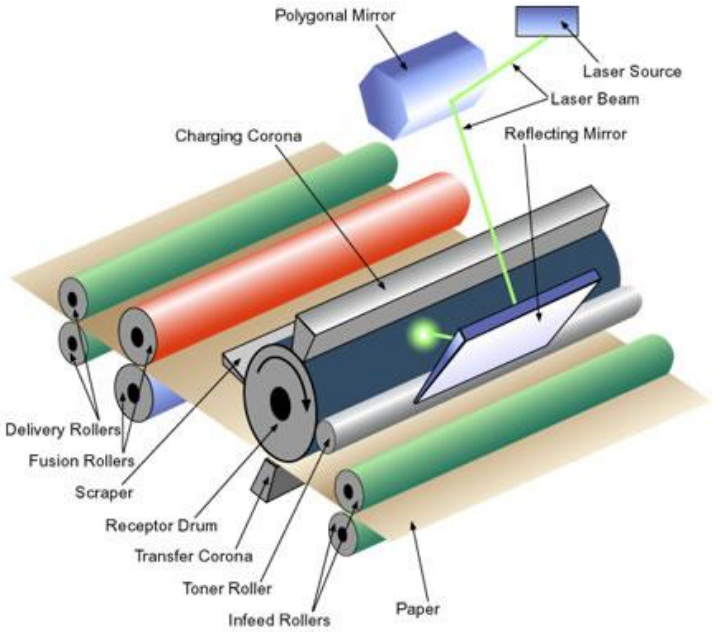
Applications of NIP technology

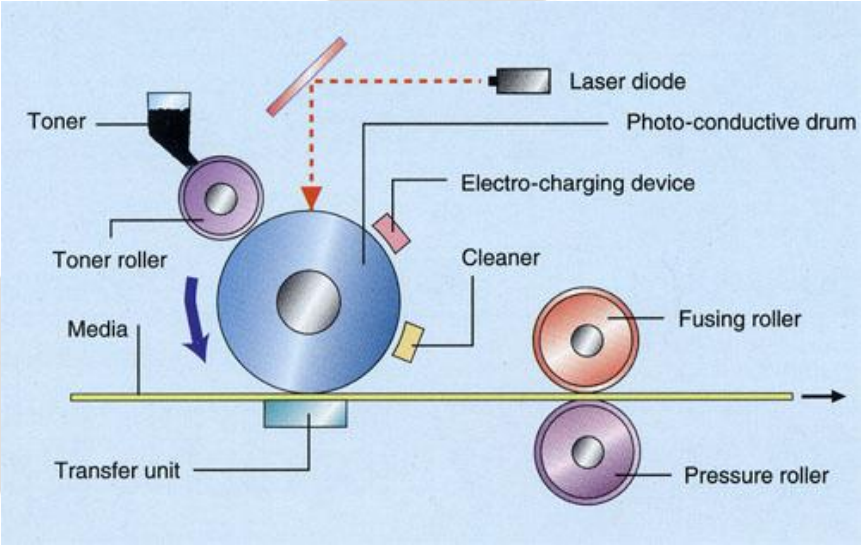
- Short run jobs.
- For printing color proofs.
- Quicker jobs.
- For smooth noiseless printing.

2.2 Basic principle of Electrophotography

Xerography, also known as electrophotography, is a printing and photocopying technique that works on the basis of electrostatic charges.

Electrophotography





Principle of Electrophotography

The process of electrophotographic printing can be subdivided into 5 stages

- Imaging
- Inking
- Toner transfer (printing)
- Toner fixing
- Cleaning (conditioning)

These five process stages are described in detail below. Short-run jobs.

The image carrier consists of an ***imaging drum***. This drum is made of aluminium and coated with a photoconductive coating. The coating may be:

- Coating with arsenic triselenide (As_2Se_3) or similar compounds containing ***selenium***
- Organic Photo Conductor **(OPC)**
- Amorphic silicon

Normally an OPC drum is used in an electrophotography printing process. The drum has a homogeneous negative charge all over the drum. There is a laser imaging head in the imaging unit. The laser diode emits imaging light. The light falls on the OPC drum. According to the image details the charge on the drum is selectively discharged. Then a toner with opposite charge is applied over the drum. The toner gets applied to only the image areas. This toner from the drum is then electrostatically transferred to the paper. The toner or the image is then fused onto the paper by heat.

Properties of ink tonner for Electrophotography.

Toner is a powder used in laser printers and photocopiers to form the printed text and images on the paper. In its early form it was a mix of carbon powder, iron oxide, and sugar. Then, to improve the quality of the printout, the carbon was melt-mixed with a polymer.

2.3 Basic principle of Ionography

Ionography is also known as "ion deposition" or electron "charge deposition printing".

This printing process consists of a series of four steps:

1. Imaging

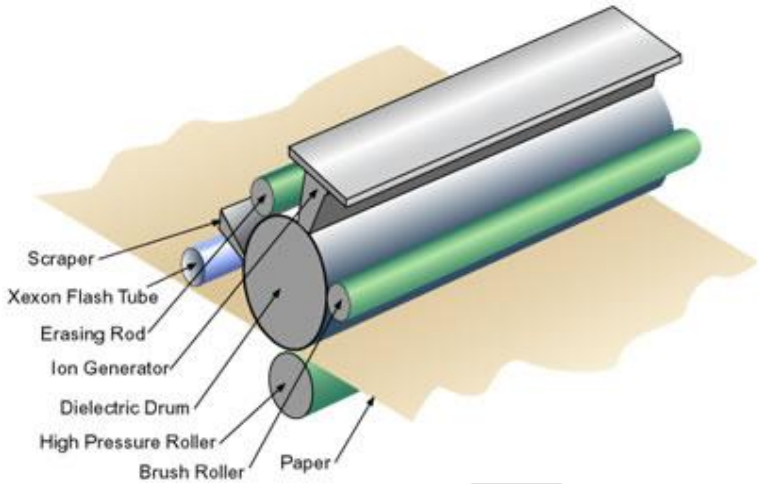
There is a cylinder with a non conductive surface. The cylinder is made of a dielectric surface of aluminum oxide. The ion generator generates controlled patterns of electronic charges on drum by the principle of corona discharge. The ionographic process creates an image with negative charge on the nonconductive surface of the cylinder.

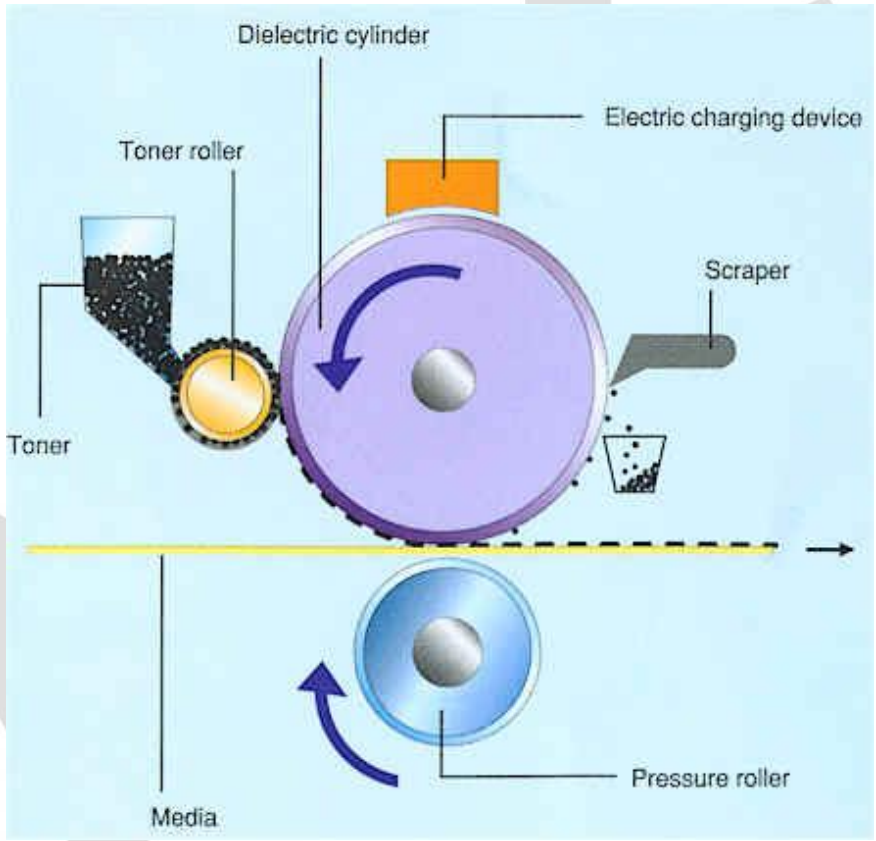
2. Toner Application

The charged surface of the transfer drum that forms the latent image attracts toner particles. The toner contains a controlled percentage of magnetite. Due to this the toner gets attracted to the latent image formed on the cylinder surface.

3. Pressure Fusing

To fuse the toner into the paper, a simple roller applies cold pressure. The roller also uses static electric charge to draw the toner from the drum onto the paper. This high pressure roller fuses the toner to the substrate.





5. Toner & Charge Removal

To prepare the transfer drum for the next print image, any residual charge is removed by the "erase rod". This neutralizes the surface of the transfer drum in preparation for re-exposure to the print head. Any remaining toner particles are removed from the drum by a simple cleaning roller.

Ionography is used only for one color printing because the high pressure cold fusion process can slightly distort the substrate, which means that multiple colors may not line up correctly. It is useful for high volume applications and for variable information printing, which allows for

changes in the content of the print application during the press run. Variable applications such as checks, statements, letters, tickets, and tags, are printed with the ionographic process. Applications printed with the ionographic process do not hold up to rough handling as well as applications printed with other processes.

2.5 Principles of Inkjet Printing

Ink-jet technology creates printed documents with streams of ink drops that are deflected to the substrate based on information in digital files. It does not require an image carrier, or plate, and it does not require equipment like a Xerographic device or a printing press. The same information can be printed throughout a print job or variable information can be printed based on the requirements of the application. The main types of ink-jet technologies are continuous jet and drop-on-demand.

Continuous Jet

With continuous jet technology, drops of ink are continuously produced and applied to the substrate to produce the image. A pump sends ink drops through a nozzle at the rate of over a million per second which can produce an image of nearly the same quality as a continuous tone image such as a photograph. There are three types of continuous jet technologies: charged drops for printing, uncharged drops for printing, and electronic deflection.

- **Charged Drops for Printing:** Drops of ink are given a charge and are deflected to the substrate to produce the image. The ink drops that are uncharged are recycled through the system to be reused.
- **Uncharged Drops for Printing:** This type of technology also applies a charge to the ink drops except that the uncharged drops are used for the actual printing and the charged drops are recycled.
- **Electronic Deflection:** This type of technology applies a charge to all of the ink drops and the application of the drops is determined by deflection, which is controlled electronically.

Drop-on-Demand

Drop-on-demand is a type of ink-jet technology in which the ink drops are formed and then applied as a response to a digital signal. There are two types of drop-on-demand printer systems: piezoelectric and thermal ink-jet.

- **Piezoelectric:** A piezoelectric crystal is given an electric charge, which produces a pressure pulse in the imaging head. This produces the emission of an ink droplet onto the substrate.
- **Thermal Ink-Jet Systems:** There are two types of printer systems using thermal ink-jet technology: liquid thermal/bubble jet and solid ink-jet:

- **Liquid Thermal/Bubble Jet:** Heat produced from an electrical resistor vaporizes the moisture in the ink which causes an ink bubble to form. The expanding bubble creates pressure inside the ink nozzle which propels the ink to the paper. The ink bubble then contracts which lowers the pressure causing more ink to be drawn into the printing head. The entire process occurs very rapidly in the printing device. In fact, the process is repeated thousands of times per second, producing high quality results.
- **Solid Ink-Jet:** A solid ink-jet printer is also known as a "phase change ink-jet printer". The ink begins as a solid and is heated to convert it to a liquid state. The ink is propelled as drops onto the substrate from the impulses of a piezoelectric crystal. Once the ink droplets reach the substrate, another phase change occurs as the ink is cooled and returns to a solid form instantly. The print quality is excellent and the printers are capable of printing on almost any type of paper and transparency substrates.

Functioning principles for ink jet technologies

The basic variants of the process are continuous ink jet and drop on demand ink jet.

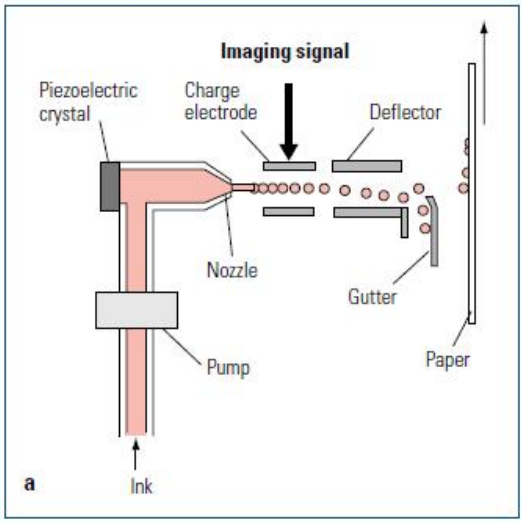
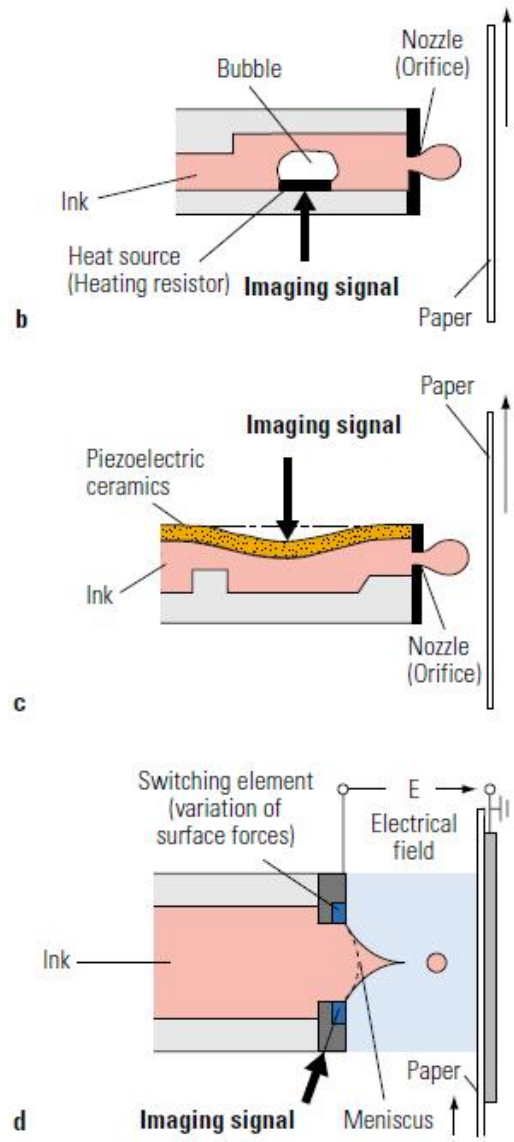


Fig 5.5.2 Continuous ink jet

Process Variants

Whereas in the continuous ink jet process, only part of the continuously generated flow of small ink drops is directed onto the paper during printing in accordance with the image, in drop on demand ink jet processes drops of ink are only generated if the information to be printed requires them.



Continuous ink jet can be subdivided into the process variants of binary deflection and multi-deflection. The binary deflection variant, in which the drop has one of two charge states (namely uncharged for conveyance to the paper and charged for deflection in an electrical field) has been described in preceding sections. In the multi-deflection process the drops receive different charges, so that as they pass through the electric field they are deflected in different directions and are transferred to different positions on the substrate.

Drop on demand ink jet processes can be classified according to the way that the individual ink drop is generated.

In the **thermal ink jet process** this is done by heating the liquid ink until it vaporizes, whereupon a certain quantity of ink is ejected from the nozzle as a result of the pressure exerted by the vapor bubble, hence the name “bubble jet”.

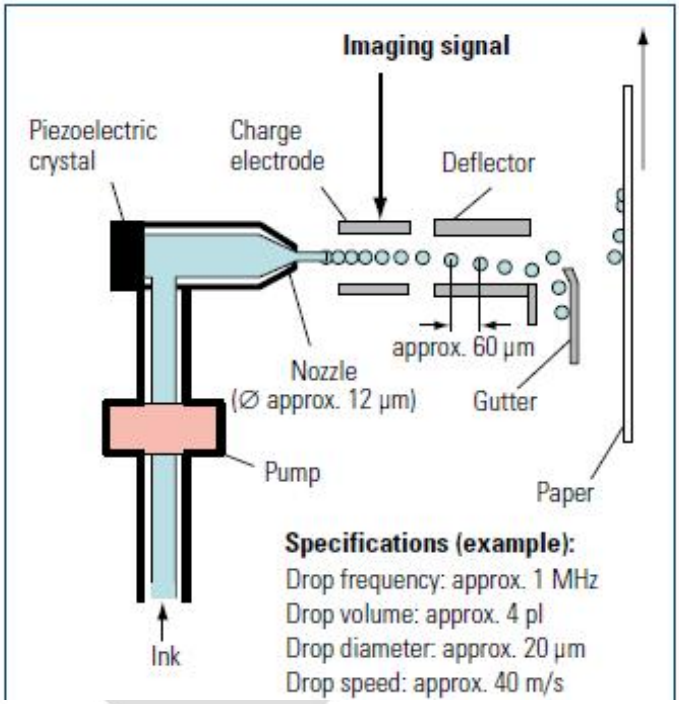
In piezo ink jet systems, the drop is generated as a result of a change of volume within the ink chamber due to piezoelectric effects, which leads to the drop of ink being ejected from the nozzle system.

There are different process variants, but common to all of them is the fact that an electrical field exists between the ink jet system and the surface to be printed, and that by means of image-dependent alterations in the ink jet nozzle system, either the forces can be balanced or the surface tension ratios between ink and outlet nozzle can be changed, so that a drop of ink is released as a result of the field forces. Withdrawal of ink from the nozzles is prepared via the electrical field, and a control pulse (e.g., electric signal or the supply of heat) then enables the release of a drop.

5.2.1 Continuous Ink Jet

Binary Deflection Continuous Ink Jet

Figure 5.5-4 shows the underlying principle of a nozzle system based on Hertz technology, which enables a high frequency stream of drops (of 1 MHz or more) to be created. The pressurized liquid is pressed out of the nozzle. The high-frequency excitation via a piezo oscillator results in the constriction of the stream due to fluid dynamics-related effects and the separation of individual drops from the stream.



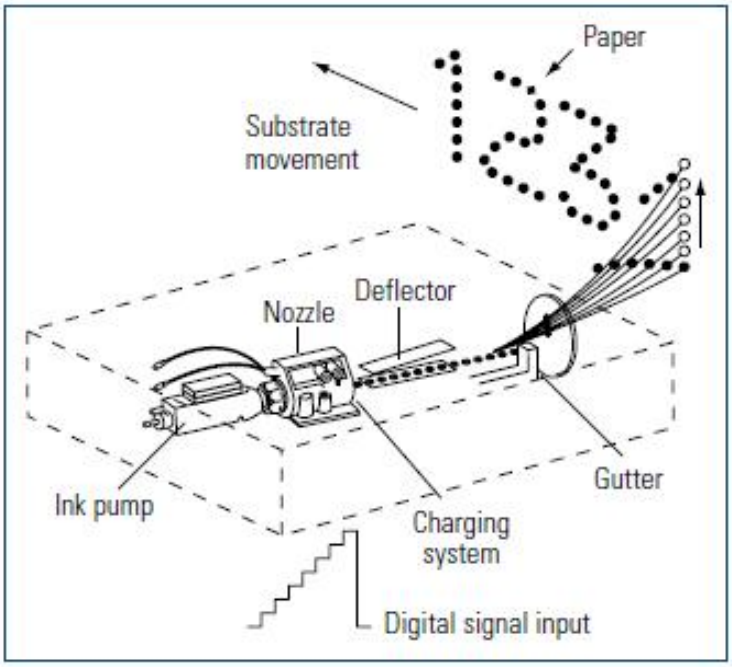
Drop size and interval basically depend on the nozzle diameter, and the viscosity and surface tension of the liquid, as well as the frequency of the excitation.

The individual drops are electrically charged by an electrode in accordance with the image just before separation from the jet. The charged drops are deflected in a subsequent electrical field (plate capacitor, deflector) and fed to a collecting device. The uncharged drops reach the paper.

So-called satellite drops are produced during the drop formation process, which should then merge with the main drop. The quality of the print depends on the quality and continuity of the drop stream generated.

Multi-Deflection Continuous Ink Jet

With the multi-deflection ink jet, the drops can be given different charges in the charging system and, as a result of this, they can be deflected more or less strongly between the deflector plates, depending on the intensity of the charge



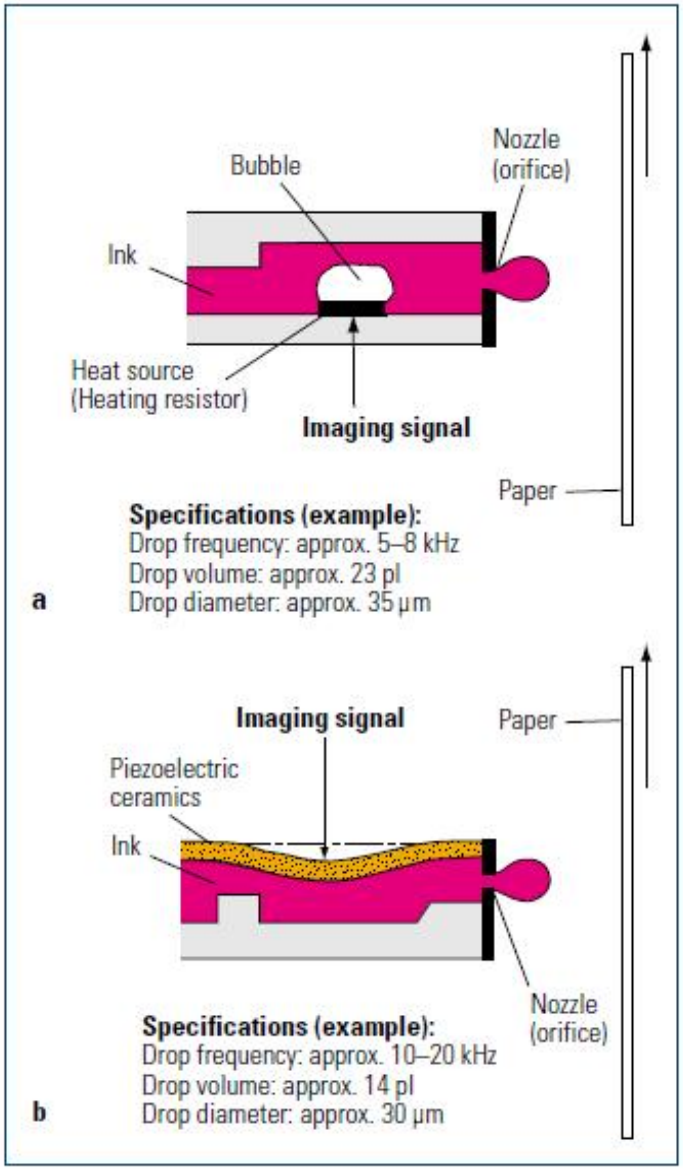
Consequently, one nozzle system can be used to image a short line (e.g., 10 mm in height). The jet can be deflected in approximately sixteen reproducible positions. The height of a line written in this way depends on the distance between the ink jet head and the paper surface. The writing height increases as the spacing increases, although the resolution will be reduced. The resolution in the direction of printing is determined by the speed of the substrate and the drop frequency.

The minimum resolution for the recognition of digitally represented characters (matrix structure) should be 7 ¥ 6 dots (height ¥ width). In principle, systems with two-dimensional jet deflection are also feasible. In this case the deflectors act in two directions so that two-dimensional characters can be printed even if the substrate is static.

5.3.1 Drop on Demand Ink Jet Technologies

With drop on demand technologies, a drop is only generated if the print image requires it.

The drop can be generated either by heat transfer (bubble jet) or by changing the chamber volume in a nozzle channel (piezo ink jet).



Thermal Ink Jet:

The sequences in figure 5.5.6 show in simplified form how an ink drop can be ejected as a result of heating and bubble formation and how the channel is then refilled with ink. Drop volumes of about 23 pl (equivalent to a representative drop diameter of about 35 µm) are possible on the basis of current thermal ink jet technologies (Hewlett Packard and Canon are the leading manufacturers in this case).

Drop frequencies are in the range of 5 to 8 kHz. The resolution must correspond to the drop volume; 600 dpi is possible with 23 pl (dot diameter in the print around 60 µm, depending on the viscosity of the ink and the absorption characteristics of the paper, etc.). Depending on the design of the jet system with regard to the direction of the drop jet discharge and the position of the heating elements, a distinction is made between “roof shooters and “side shooters”.

The color printers used in desktop-publishing or in an office environment mostly use thermal ink jet systems.

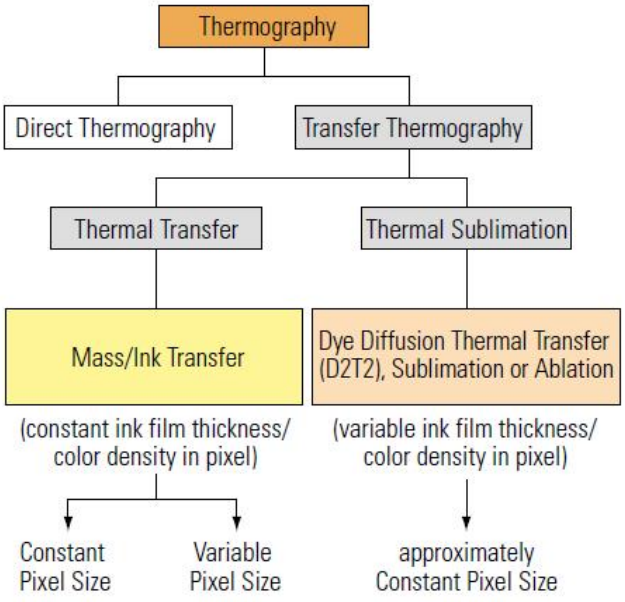
In a typical application a separate ink jet head is used for each color, although a separate head is often used for the most commonly printed color, black, and a second head for the chromatic colors, cyan, magenta, and yellow. Powerful systems are available with resolutions of 600 dpi, operating at a drop frequency of 8 kHz, and with three hundred nozzles per printing head. The nozzles are arranged in several rows and staggered to ensure the desired resolution and the space required for installation of the individually addressable nozzles.

Piezo Ink Jet:

With piezo ink jet, unlike thermal ink jet, ejection of an ink drop is generated by mechanical displacement in the ink channel, and not by heating and vaporization within the ink jet system.

Piezo-ceramic materials are ideally suited for small, electrically addressable systems. As illustrated in figure 5.5.6 materials of this type change shape or volume in the electrical field. The so-called “shear mode,” with the appropriate electrical controller, is usually used in piezo ink jet systems. In shear mode operation the material’s volume remains unchanged and the geometry is deformed.

2.6 Basic principle of Thermography



Thermography can be classified as Direct Thermography and Transfer thermography. The Transfer Thermography is further classified into Thermal Transfer and Thermal Sublimation.

Direct Thermography

In direct thermography the substrate is treated with a special coating, which changes its color when subjected to heat. This kind of special paper is often used for applications in fax machines and for labeling and coding (e.g., bar codes).

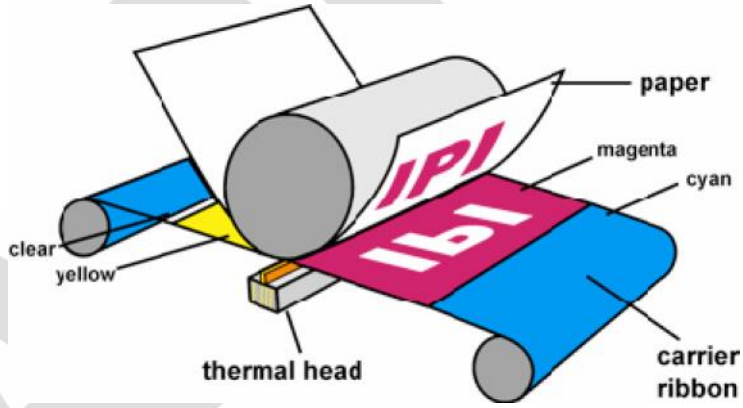
Transfer Thermography

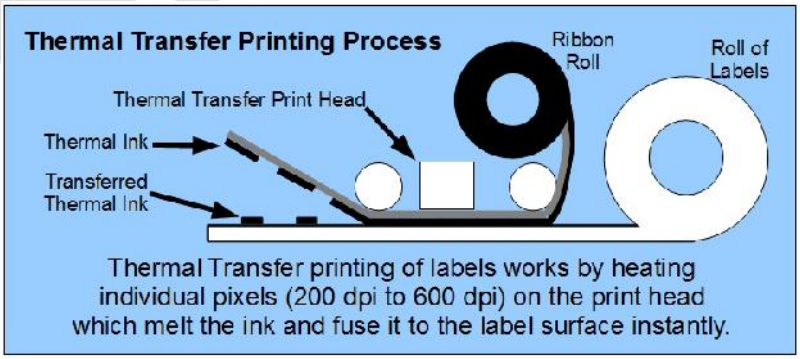
It is different from Direct Thermography. In this process, the ink is stored on a donor and is transferred to the substrate by the ***application of heat***. The ink on the donor may be wax or a special polymer. Due to this the thermal transfer is sometimes called as ***"thermal mass transfer".***

In ***thermal sublimation,*** the ink is transferred from the donor to the substrate by ***diffusion.*** The heat melts the ink and initiates a diffusion process onto the paper. For this a special coating is given on the paper. The special coating accepts the diffused colorants on the paper surface.

The physically and chemically precise term for thermal sublimation is ***"dye diffusion thermal transfer".*** The abbreviation is ***"D2T2".***

Thermal Transfer



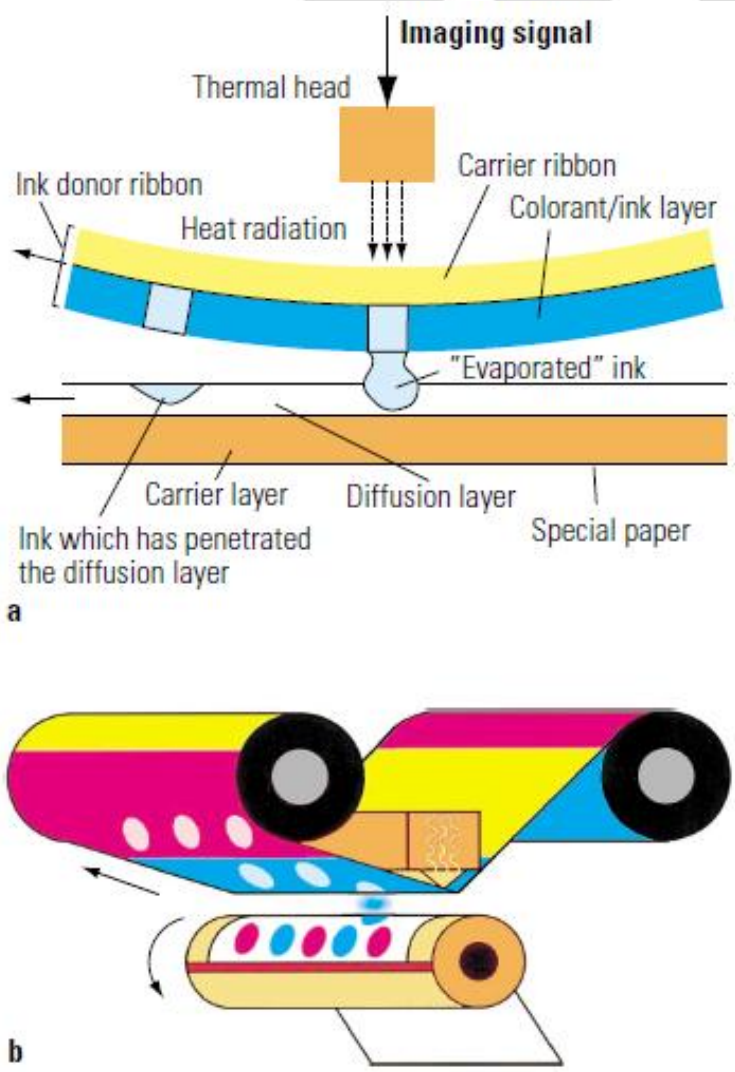


In the printing unit, a thermal printing head is in contact with the donor material. For multicolor printing, the colors black, yellow, magenta and cyan are applied to the donor. The heating element is controlled by the imaging signal from the computer. According to the imaging signal

the heating element transfers the ink from the donor to the paper. Here the donor is in ***direct contact*** with the paper. The different inks are positioned on the ink donor ribbon one after the other. The thermal transfer is based on the ink melting onto the carrier film when heated. The liquefied ink is transferred to the substrate under low pressure.

Thermal Sublimation

Thermal Sublimation or Dye Sublimation is actually ***"Dye Diffusion Thermal Transfer"*** or ***"D2T2"*** printing process. Thermal sublimation is the process where color dyes are transferred from an ink ribbon onto the substrate. The ink evaporates locally through the application of heat. The heat causes sublimation. In physical terms, sublimation is the vaporization of a solid without intermediate formation of liquid. Depending on the thermal energy supplied to the individual pixel/dot, a different amount of ink is transferred to the substrate. Here the donor is ***not*** in ***direct contact*** with the paper.



Part – A

1. What is NIP?

Non-Impact Printing

2. List down the NIP technologies.

Electrophototgraphy

Ionography

Inkjet

Thermography

Photography

3. What is OPC?

Organic Photo Conductor

4. Define electrophotography?

Electrophotography is a nonimpact printing process in which the image created on a photoconductor drum, developed with a toner and then transferred onto the substrate.

5. What is latent image?

Invisible image which becomes visible after developing.

6. Define Ionography.

Ionography is also known as "ion deposition" or electron "charge deposition printing".

Part - B

1. Define magnetic toner.

2. Write down the classifications of ink jet printing.

3. What are the classifications of continuous ink jet?

4. Write down the classifications of drop on demand ink jet.

5. Write down the classifications of thermography.

6. What are the classifications of transfer thermography.

Part – C

1. Explain the working principle of Electrophotography with a neat diagram.

2. Explain Ionography with a neat sketch.

3. Explain continuous jet inkjet printing with a neat diagram.

4. Describe drop-on-demand ink jet printing with a neat diagram.

5. Explain thermography and its types.

Unit - III Security Printing Features and Materials

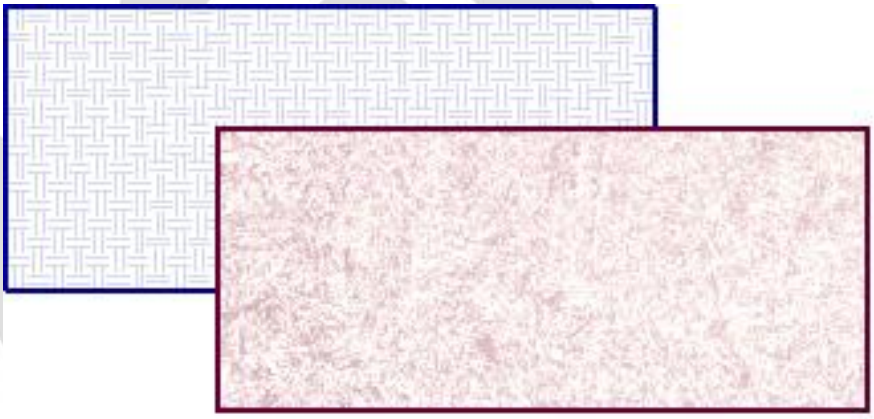
3.1 – Basic principles of security design features.

Security printing is the field of the printing industry that deals with the printing of items such as banknotes, passports, stock certificates, postage stamps and identity cards. The main purpose of security printing is to prevent forgery or counterfeiting.

Security printing is not separate printing technology. It is a combination of conventional printing technologies such as offset, gravure and letterpress. Security is not only achieved by printing alone but also through substrates, inks and special additional elements like security threads, holograms and so on.

Pantograph Screens

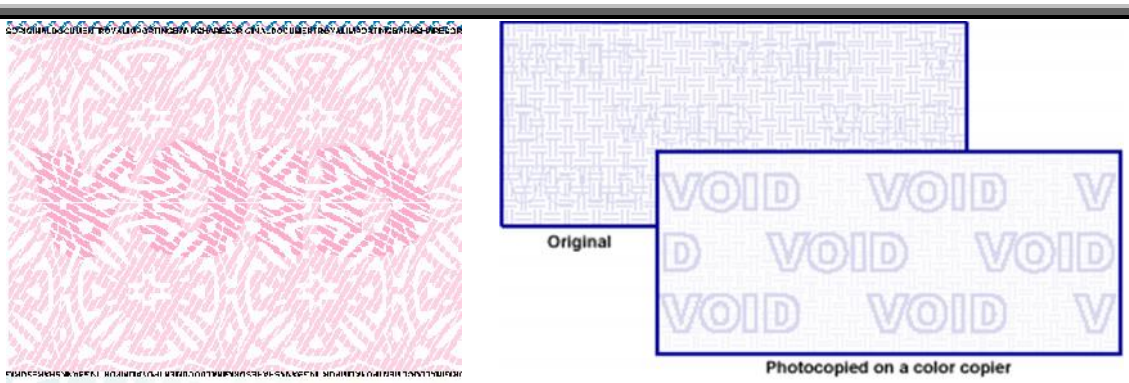
A pantograph is a ***screen*** that is printed in the background of the document. It is usually printed in a lighter color. The design of the background is hard to copy or scan. The design can be a company's name or logo.



Pantograph should be used along with other security features as it is easy to duplicate pantograph using latest scanners and copiers.

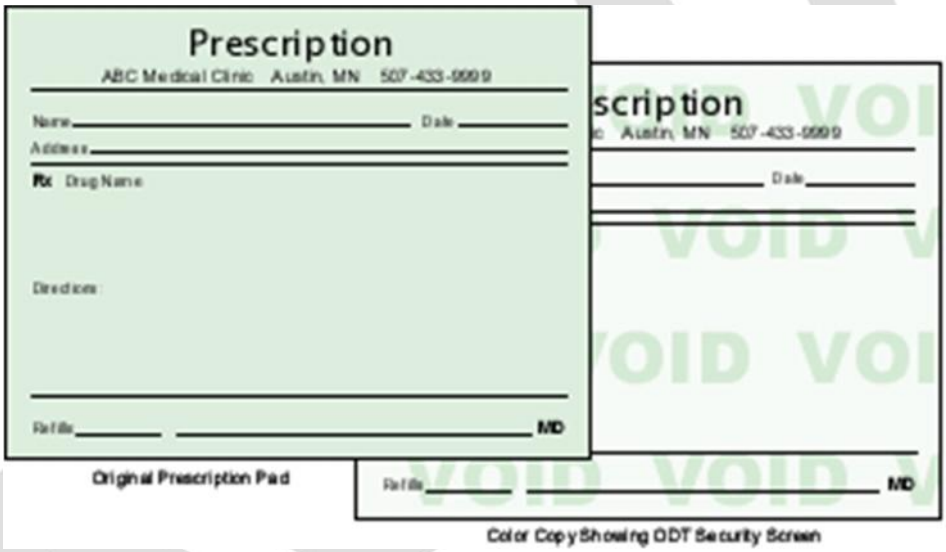
Void Pantograph Screen

This is a special pantograph screen that has the word **"VOID"** hidden in the paragraph by using special screens and background designs. When photocopied by a color copier, the word **"VOID"** appears on the copied document. The **VOID** feature makes it more difficult to duplicate than a standard pantograph. But today's higher quality scanners and copiers, the VOID pantograph can be duplicated and the word **VOID** remains hidden.



ODT^{TM} – Optical Deterrent technology

ODT uses a patented security screen which makes it difficult to duplicate secure documents on copiers and scanners. It is similar to VOID pantograph.



But the difference is, here there is no need for a pantograph to hide the word **"VOID".** Due to this the document appears cleaner without any clumsy background. ODT is best suitable for documents which are text intensive and needs better legibility. ODT works well on cheques, transcripts, medical records etc.

Guilloches

Very fine lines are printed in a mathematically generated pattern and are part of the background design. Copiers cannot reproduce the lines in the same way.

Warning bands

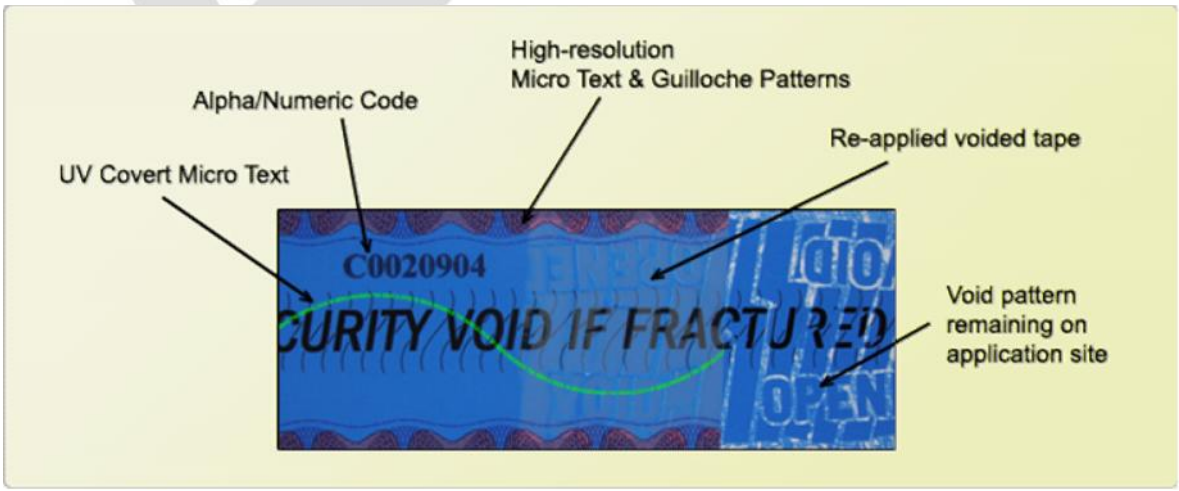
Warning Band is a border printed on the document that indicates the security features used on that document. Sometimes the warning bands explain how to detect certain features.

The band warns the document handlers as to what features should be checked to show authenticity of the document.

Code Safe ™

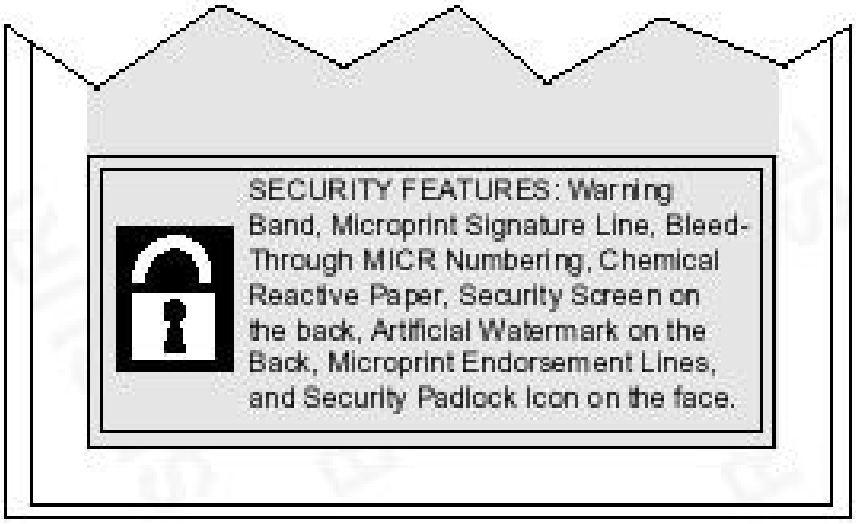
Code Safe is a patent pending technology which gives maximum security to our documents. A synthetic DNA molecular chemical code is incorporated into the document. The molecular make-up of the chemical code is very rare and creates a unique distinguishing feature. Duplicating this feature is almost impossible. The molecular make-up can be decoded and verified only with special equipment in a forensic lab.

High resolution Graphics



High resolution graphics are graphic images that contain very fine line details. This makes them very difficult to reproduce accurately on scanners and copiers. High resolution graphics are used on logos, illustrations or in borders.

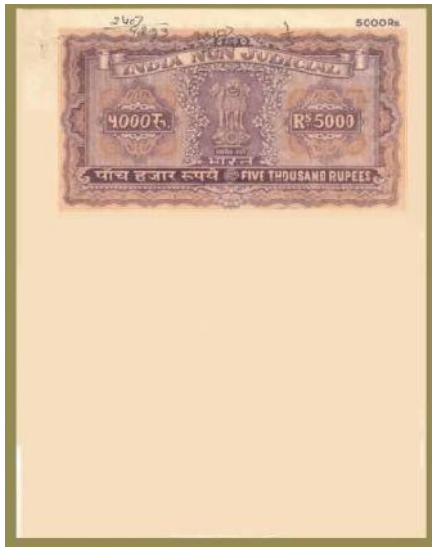
Padlock Icon



Padlock icon is printed on the face of negotiable documents. This icon indicates that two or more security features have been used on that document. An explanation of the features used, are printed on the back of the document in a padlock icon box.

3.2 Basic principles of security papers

Safety Paper



Most banknotes are made of heavy paper. The paper is made from cotton fibers for strength and durability. In some cases linen or specialty colored or forensic fibers are added to give

individuality to the paper and to protect against counterfeiting. Some countries produce banknotes made from ***polymer***, in order to improve wear and tear. The polymer also permits to include a ***small transparent window*** a few millimeters in size. This small transparent window is a security feature, which is very difficult to reproduce.

Chemical Reactive Paper

Chemically reactive security papers protect documents against forgery and tampering. The paper is treated with agents that cause spots to appear the instant anyone attempts to chemically alter the document.

Water Mark Paper

A watermark is a recognizable image or pattern in paper that appears lighter or darker than surrounding paper when viewed with a light from behind the paper. This is due to paper density variations. A water mark is made by impressing a dandy roll onto the paper during manufacturing.

Copy evident paper

Many secure documents have certain security feature. This security feature causes the photocopy of the document to appear different from the original. For example, most checks will display the word **"VOID"** when photocopied.

3.3 Types and usages of security threads

Security ***fibers*** and ***threads*** are fine fibers of paper or other material that are incorporated into the security paper during manufacturing process. These fibers are made to a ***controlled thickness*** (deciex). These fibers are cut to a specific ***length*** and ***color***. These threads are distributed with a specified frequency throughout the paper.

Metalized Thread

It is the simplest and most effective security thread. The thread is coated with highly reflective aluminium. This makes it almost invisible in reflected light. But it is visible as a distinctive black line in transmitted light.

Windowed Thread

The security thread is allowed to pass over the surface of the document at predetermined places with specific window and bridge lengths. This process is adopted in over 70 currencies and denominations. It is the most secure of all threads.

Holographic Windowed Thread

It is an alternative to simple metalized thread. With a holographic windowed thread, a customized holographic material is used that offers exceptional counterfeit protection. It is also possible to incorporate Cleartext thread by the windowing process.

Microtext

Microtext is micro-sized print on a thread. For example, the name of the issuing authority can be printed onto clear polyester, which can be examined under a magnifying glass. It is possible to register the microprint on a 1-mm thread so that the text can be seen by the naked eye.

Cleartext

Cleartext is a patented security fiber. The issuing authority's legend can be easily read in transmitted light, because the words are formed not by the use of inks but by the demetallization of the film. In a transmitted light, the thread appears as a distinctive black line with light passing through the 1-mm high demetalized characters, allowing the text to be easily read.

Thermotext

Thermotext®, a patented product of Portals Paper, consists of a thread printed with a colored script or image that is coated with a thermochromic pigment of the same color which acts as a mask. In its inactivated state, the Thermotext fiber looks like a normal colored security thread.

When warmed to the activation temperature the "mask" disappears, revealing the script underneath. A variety of colors are available and activation temperatures can be selected in 5^0C increments between - 10^0 to 40^0 C.

Activation temperatures can be mixed and matched so that different colors can be produced at differing temperatures, allowing a range of activation methods: Warming by hand, using a warm surface such as radiator, or using a simple hand-held authenticator available from the manufacturer.

3.4 Basic principles of watermark

A watermark is a recognizable image or pattern in paper that appears lighter when viewed by transmitted light.

A watermark is made by impressing a water-coated metal stamp or dandy roll onto the paper during manufacturing.

Classification of watermarks

Line Drawing Water Marks

The dandy roll is embossed with a pattern which created by winding wires or chains over the drum. In some cases if an image has to be created embossed die like pattern is created over the drum. The pattern is transferred to the pulp fibres, compressing and reducing their thickness in that area.

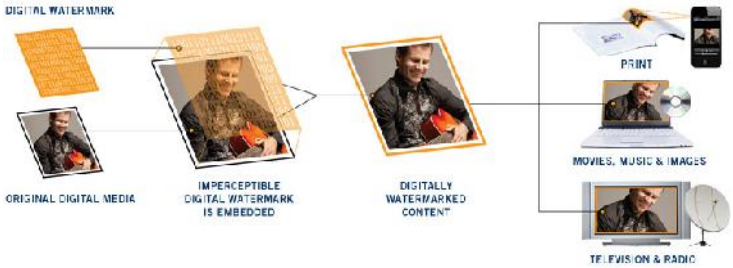
Because the patterned portion of the page is thinner, it transmits more light through and therefore has a lighter appearance than the surrounding paper. The image that is created will have uniform thickness and transmits uniform amount of light through it.

This is called as line drawing watermark.

Shaded Watermark

Shaded watermark incorporates tonal depth and creates a grayscale image. Instead of using a wire covering for the Dandy roll, the shaded watermark is created by areas of relief on the roll's own surface. This is called as shaded watermark.

Digital Watermark



Encoding an identifying code into digitized music, video, picture, or other file is known as a digital watermark. Special markings in the design of a document which can be embedded decoded and read by approved scanning systems.

A digital watermark cannot be read or decoded by a third party. The digital watermark can be designed into existing logos so that nobody can know that a watermark exists in the logo.

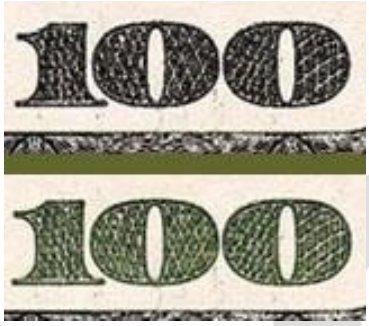
Trademark colors

Security printers use trademark colors (spot colors), metallic inks, and conventional fluorescent inks to avoid counterfeiting secured documents, packages, and labels. Trademark or spot colors are generally manufactured using single-pigment inks. These colors are most difficult to reproduce or replicate with commercially available process colors.

Metallic inks do not copy well on photocopiers and produce copies that are easily distinguishable from the original document.

Iridescent and Color-shifting ink

Iridescent inks contain metallic particles and exhibit a change of color and surface texture when viewed at different angles.



Color-shifting inks are specialty security printing inks that are used exclusively in currency printing. They are used to print the denomination amount in the lower right-hand corner on the front of the currency note. The ink changes color from black to green when the currency note is tilted back and forth.

Bleeding ink

Bleeding ink prints in black color but “bleeds”, or releases red color, when water or any aqueous solution is applied. The bleeding effect provides evidence of tampering. Bleeding ink must be printed using waterless offset. It cannot be photocopied or digitally produced.

Coin – Reactive ink

Coin Reactive ink is a security white or transparent ink. It turns gray when rubbed with the edge of a coin. The inks contain a reagent that reacts to the metallic materials contained in the coin to form a visible compound. Coin-reactive ink also provides evidence of tampering. The effect of coin-reactive ink cannot be recreated digitally or by photocopying.

Ultraviolet (UV) ink

UV-visible/daylight-invisible inks are specialty inks that are not visible in daylight. But it can be seen when illuminated by ultraviolet (UV) radiation.

Visible Fluorescent ink

Visible fluorescent inks are daylight-visible, but also absorb UV radiation and re-emit it at longer wavelengths of light in the visible spectrum. The ink will show up as an unwanted image during attempts to scan or photograph it for unauthorized. Hence fluorescent inks are also used as a security ink.

Invisible UV-fluorescent ink

Invisible UV-fluorescent inks appear colorless or transparent in visible light but glow different colors under UV illumination.

Pen-reactive ink

Pen-reactive ink is a clear ink that becomes visible when activated by a special felt-tip pen used for authentication. This ink is available only for waterless offset lithography.

Thermochromic ink

Activated by temperature, thermochromic ink changes from one color to another when exposed to body heat**.** Documents can be verified by pressing a finger over the ink or rubbing the printed area between to fingers to trigger the color shift.

Erasable ink

An erasable ink is often used to avoid the alteration of documents by mechanical efforts, such as scraping the ink images with razor blade or eraser to remove them. The ink is easily removed but leaves visual evidence of tampering after removal or alteration.

Fugitive ink

Fugitive inks are reactive to either water or solvents and usually leave an unwanted stain on the document if alteration has been attempted.

Magnetic Ink

Magnetic inks are still in use today on cheques and banknotes, although they have lost some of their strength as a counterfeit deterrent because they are readily available as photocopy toners. However, the inks contain ferromagnetic particles and they are machine-readable by Magnetic Ink Character Recognition (MICR) which provides an excellent method for machine processing of large numbers of cheques and/or banknotes and at the same time serves as a counterfeit deterrent.

Migrating Ink

The ink is printed on the front side of the document and shows as a specific color, e.g. black. The ink penetrates through the paper and appears as a different color on the reverse side of the paper, e.g. red.

Part – A

1. What is ODT?

Optical Deterrent Technology

2. What is MICR?

Magnetic Ink Character Recognition

3. What are the types of water mark?

Line Drawing Watermark

Shaded Watermark

Digital Watermark

4. Define guilloches.

Very fine lines are printed in a mathematically generated pattern and are part of the background design. Copiers cannot reproduce the lines in the same way.

5. What are warning bands?

Warning Band is a border printed on the document that indicates the security features used on that document. Sometimes the warning bands explain how to detect certain features.

6. What is padlock icon?

Padlock icon is printed on the face of negotiable documents. This icon indicates that two or more security features have been used on that document. An explanation of the features used, are printed on the back of the document in a padlock icon box.

7. Define water mark.

A watermark is a recognizable image or pattern in paper that appears lighter when viewed by transmitted light.

8. What are the types of security threads?

Metalized Thread

Windowed thread

Holographic Windowed thread

9. What is coin reactive ink?

Coin Reactive ink is a security white or transparent ink. It turns gray when rubbed with the edge of a coin.

10. What is UV security ink?

UV-visible/daylight-invisible inks are specialty inks that are not visible in daylight. But it can be seen when illuminated by ultraviolet (UV) radiation.

Part – B

1. Define Thermotext.

2. What is bleeding ink?

3. What is fugitive ink?

4. Define magnetic ink.

5. What is migrating ink?

6. Define erasable ink.

Part – C

1. Describe Pantograp, Optical Deterrent Technology, Warning bands and guilloches.

2. Explain the various types of watermarks.

3. Describe the types of security threads.

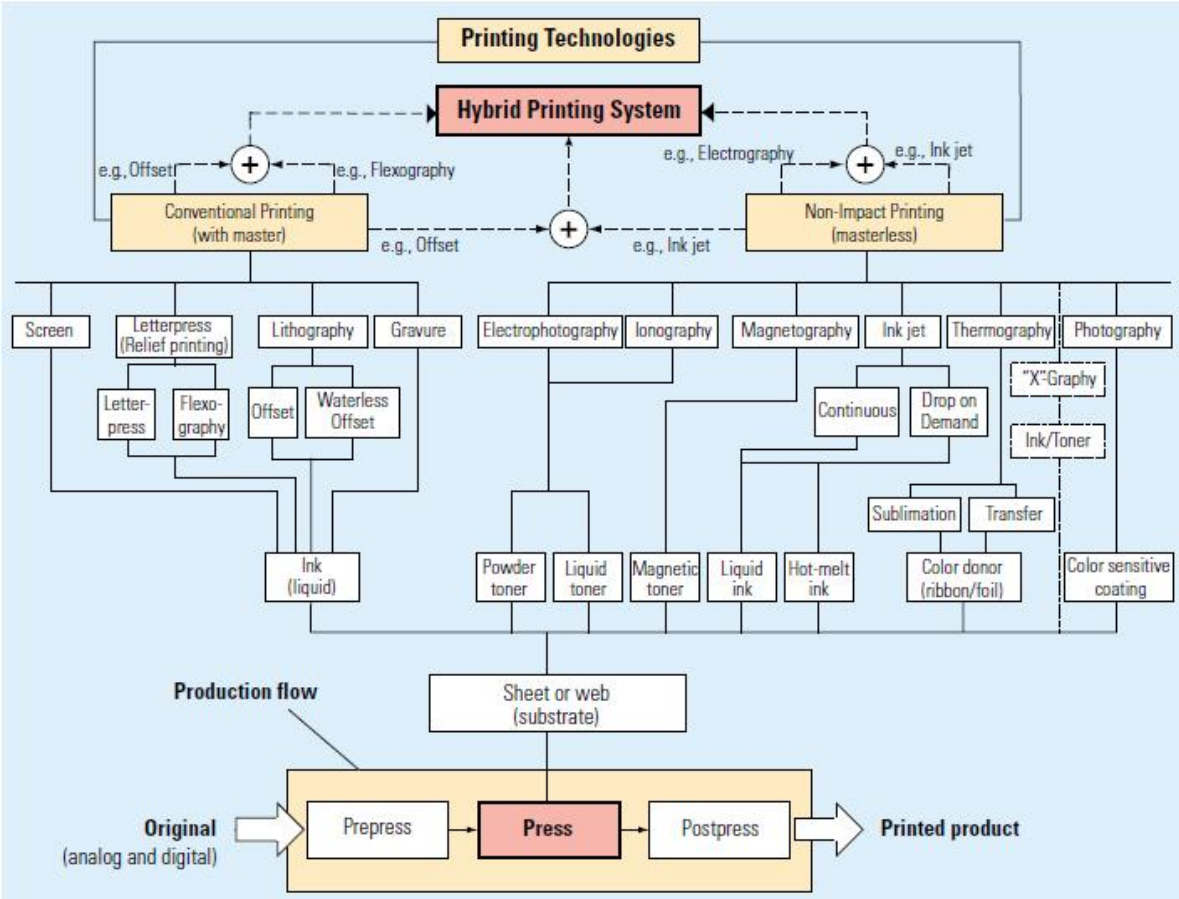
4. What are the various types of security inks?

5. Explain the various types of security papers.

Unit - IV Special Printing Technologies

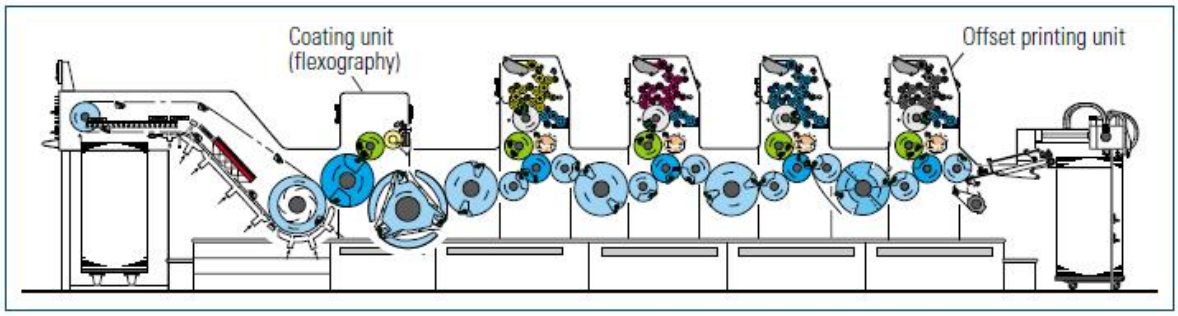
4.1 Basic principles of hybrid printing system

Flow chart of hybrid system



Hybrid printing system concepts of combining conventional printing technologies

Offset and ***Flexographic*** printing processes are combined in this type. In a multicolor offset after the final printing unit a flexographic printing unit is installed. This flexographic unit is used for the application of ***coating***. The coating may be either full sheet or spot coating process.



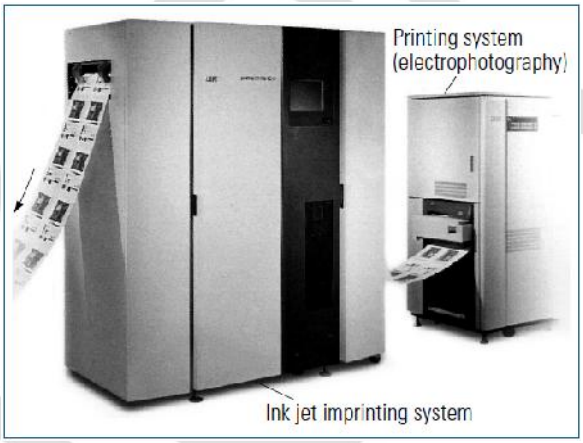
The flexographic unit may be sometimes used as an imprinting unit or printing special colors (spot colors).

Sometimes ***waterless offset printing*** and ***conventional offset printing*** are combined. In this press the multicolor work is printed with the help of waterless printing and the conventional offset technology is used for printing single color text or line art.

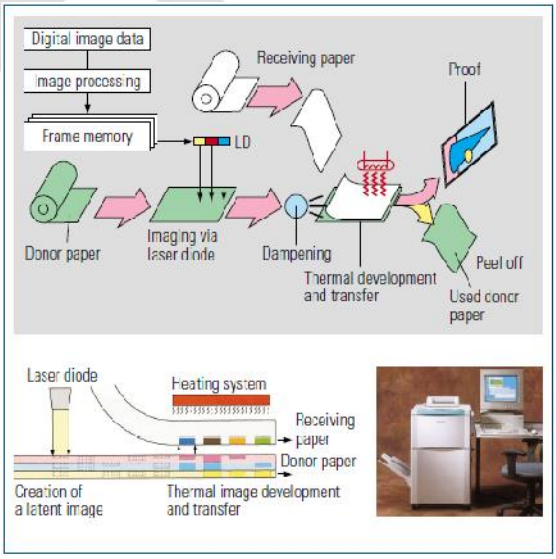
Sometimes ***offset, flexography and screen printing*** are combined for performing label printing. In some other types flexography (multicolor printing), screen printing and letterpress for embossing are combined.

Hybrid Printing Systems combining NIP Technologies

Sometimes ***non impact printing technologies*** are combined to produce hybrid printing systems for some specific purposes. For example ***electrophotography*** and ***inkjet printing technology*** are combined. Electrophotography is used for printing high speed single-color printing and inkjet printer is used for imprinting additional information in color.



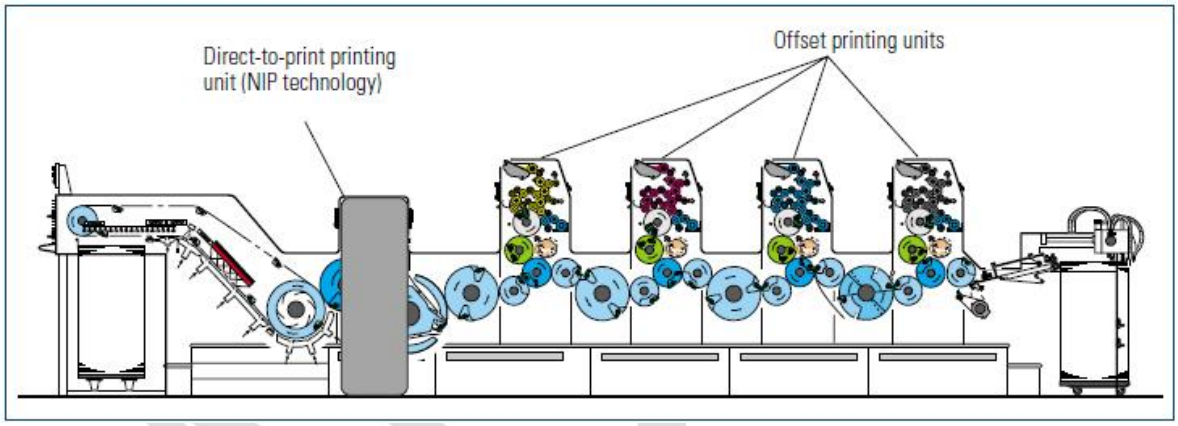
Sometimes ***photography*** and ***thermography*** are combined to produce high-quality multicolor prints.



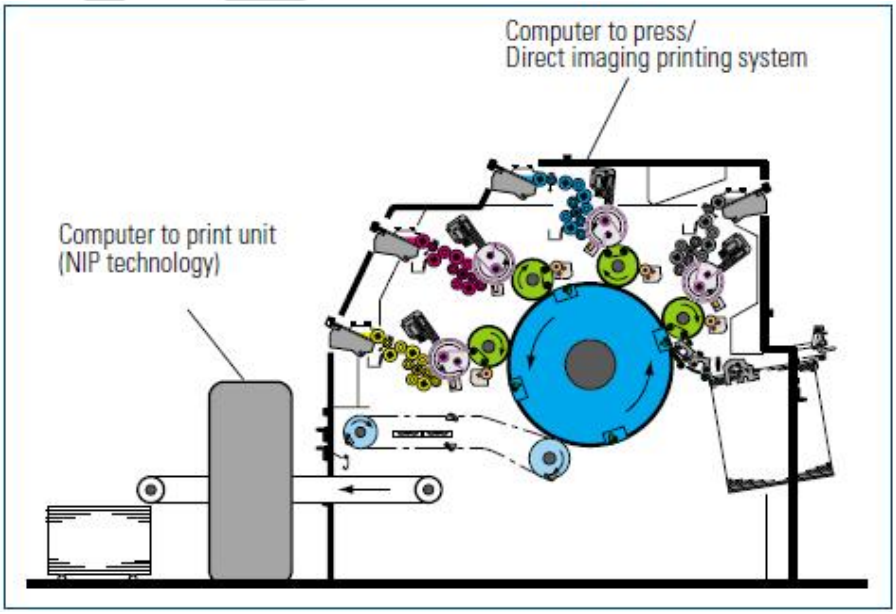
Hybrid Printing Systems combining Conventional and NIP Technologies

In this system ***conventional*** and ***Non-impact Printing Technologies*** are combined. In this system, the advantages of both technologies are optimally combined. In this system, multicolor high quality printing is done with the help of ***offset printing technology*** and with the help of an ***inkjet*** we can (add) print ***personalized information*** to the high quality print. With the help of this system, we can single color information in ***different languages*** or with ***different recipient/company address***.

This Hybrid printing system provide *production capabilities* ranging from print jobs with a fixed content throughout the entire print run (0% variable page content) to jobs with a completely variable content from page to page (100% variable page content).

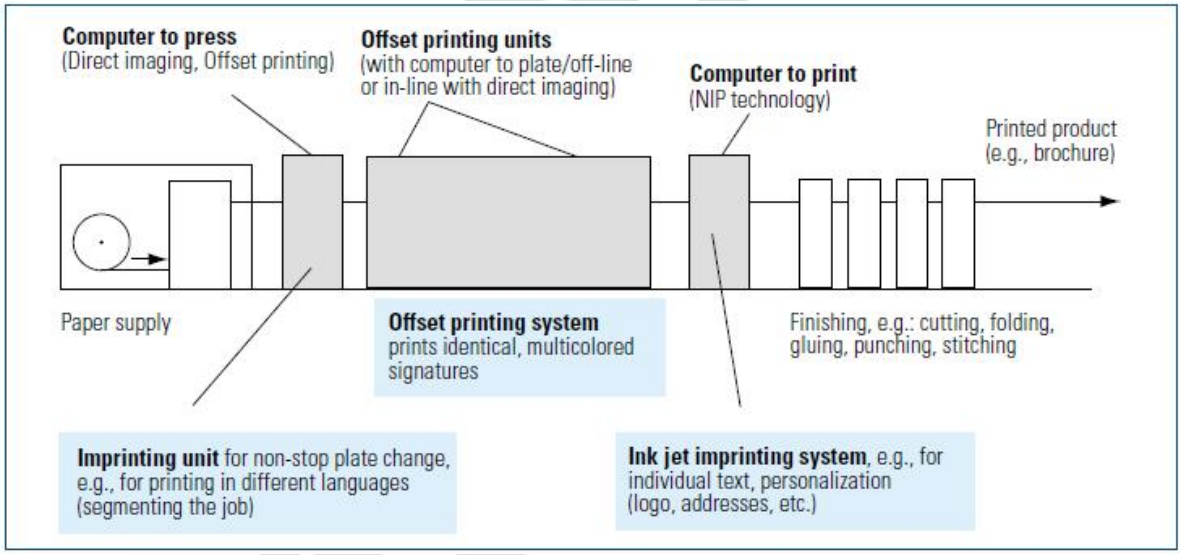


Hybrid Printing Systems combining Computer to Press/Direct Imaging with NIP Technologies



A computer to press/direct imaging press is combined with a computer to print system. High-grade printed matter of uniform high quality is produced with the direct imaging multicolor sheetfed offset press and the personalized information is printed with the computer to print NIP printing unit. Printing is carried out by means of the *offset technology* and the NIP technology is used for personalization or segmentation of the print job. NIP technologies can be used depending on the *drying process* and the degree of drying of the offset print. If the ink has not yet been dried, a non-contact printing process, such as *ink jet printing*, is advantageous. Where suitable ink and drying systems (e.g., UV inks and UV dryer) are used for offset printing, the printed image will already be dry after multicolor offset printing, and can therefore be imprinted using contact NIP techniques (the ink-carrying surface of the printing unit is in contact with the substrate) such as *electrophotography*.

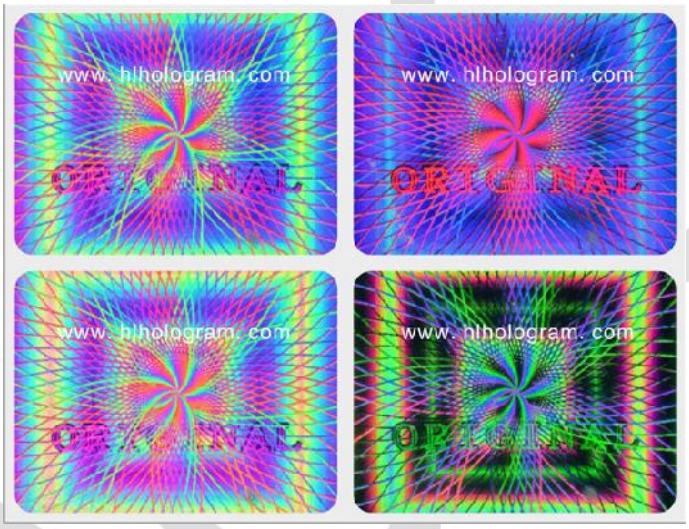
Hybrid Printing Systems combining Conventional Printing Technologies with Computer to Press Technologies



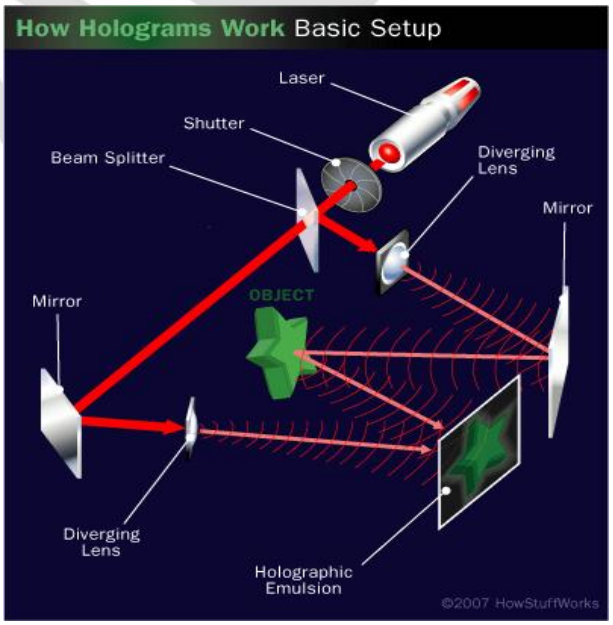
In this type the components of a hybrid printing system for the production of print media by web offset. There is an imprinting unit that can be used to print single colored text within the multicolored printed matter. By exchanging the plates it is possible to print in a different language; the complete print run is thus segmented into partial runs according to language. With a sufficiently well-designed imprinting unit, the plate can be changed without any interruption to production. The imprinting unit can be equipped with two plate cylinders, with one always in production and the other at the same time being fitted with the new plate for the next job segment. This permits an “on-the-fly” exchange of the imprint with a minimum waste rate. In principle, such an imprinting unit can be designed as a computer to press/direct imaging unit.

This provides the means for production of segmented runs according to the target group on the basis of the digital job specification. A hybrid printing system is thus set up, in which computer to press/direct imaging (digitally imaged offset master in the imprinting unit), the computer to print technology (ink jet imprinting unit), and the offset technology are combined. The printing plates for multicolor offset printing can be produced off-line using computer to plate systems. A digital printing system is therefore set up as a hybrid system and functions with varying degrees of digitization.

4.3 Basic principles of holograms making process



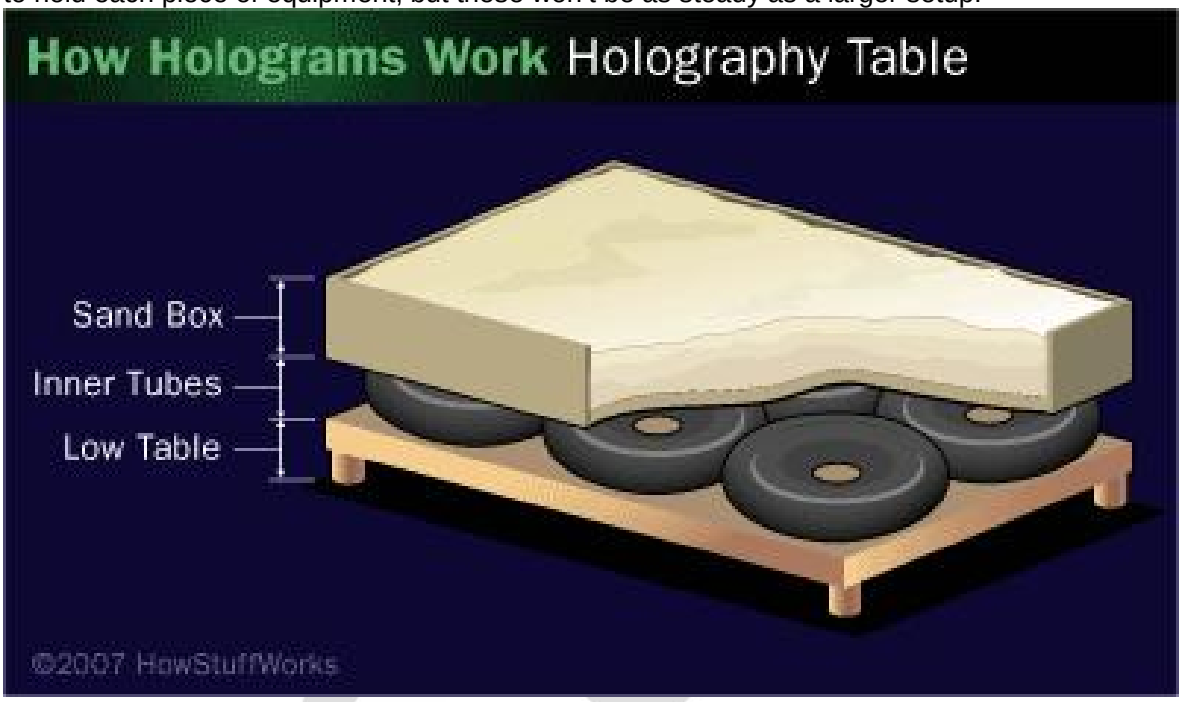
Making a Hologram



- A **laser**: Red lasers, usually **helium-neon (HeNe)** lasers, are common in holography. Some home holography experiments rely on the diodes from red laser pointers, but the light from a laser pointer tends to be less coherent and less stable, which can make it hard to get a good image. Some types of holograms use lasers that produce different colors of light as well. Depending on the type of laser you are using, you may also need a **shutter** to control the exposure.
- **Lenses:** Holography is often referred to as “lensless photography,” but holography does require lenses. However, a camera’s lens focuses light, while the lenses used in holography cause the beam to spread out.
- A **beam splitter**: This is a device that uses mirrors and prisms to split one beam of light into two beams.
- **Mirrors**: These direct the beams of light to the correct locations. Along with the lenses and beam splitter, the mirrors have to be absolutely clean. Dirt and smudges can degrade the final image.
- **Holographic film**: Holographic film can record light at a very high resolution, which is necessary for creating a hologram. It’s a layer of light-sensitive compounds on a transparent surface, like photographic film. The difference between holographic and photographic film is that holographic film has to be able to record very small changes in light that take place over microscopic distances. In other words, it needs to have a very fine **grain**. In some cases, holograms that use a red laser rely on emulsions that respond most strongly to red light.

Holography also requires a working surface that can keep the equipment absolutely still — it can’t vibrate when you walk across the room or when cars drive by outside. Holography labs and professional studios often use specially designed tables that have honeycomb-shaped support layers resting on **pneumatic** legs. These are under the table’s top surface, and they dampen vibration. You can make your own holography table by placing inflated inner tubes on a low table, then placing a box full of a thick layer of sand on top of it. The sand and the inner tubes will play the role of the professional table’s honeycombs and pneumatic supports. If you

don't have enough space for such a large table, you can improvise using cups of sand or sugar to hold each piece of equipment, but these won't be as steady as a larger setup.



To make clear holograms, you need to reduce vibration in the air as well. Heating and air conditioning systems can blow the air around, and so can the movement of your body, your breath and even the dissipation of your body heat. For these reasons, you'll need to turn the heating and cooling system off and wait for a few minutes after setting up your equipment to make the hologram.

These precautions sound a little like photography advice taken to the extreme - when you take pictures with a camera, you have to keep your lens clean, control light levels and hold the camera absolutely still. This is because making a hologram is a lot like taking a picture with a microscopic level of detail. We will look at holograms are like photographs.

4.4 Basic principles of lenticular printing process

A lenticular lens sheet consists of a linear array of thick plano-convex cylindrical lenses, Known individually as "lenticules". The lens sheet is transparent and the rear face, which constitutes the focal plane, is flat. A big advantage was it was optically analogous to the parallax barrier screen, and could therefore draw on a wealth of barrier screen research. In the 1930's

many researchers worked on advancing the British “Lenticulated screen” process, and the German “Diacor” method.

Digitally interlacing integral imagery for high-resolution color pictures was first proposed in 1990. Thousands of experimental images have been produced by a variety of methods exhibiting 3-D, animation and other effects over the years. Although integral imagery has not yet achieved significant commercial success, its use is inevitable and holds greaty promise as being a very unique display medium.

Principle of lenticular lens

A plastic lens consisting of an array of optical elements called lenticules. When viewed from different angles, different areas under the lens are magnified.

Lenticular Image

A specially prepared image to which the lens is attached. Views are arranged under lenticules so that each eye is projected a different view. The brain then processes these views to a single coherent 3D image.

Lenticular

The basic information about 3D lenticular technology should is that human’s eyes see the world in three dimensions, because each eye sees the world under its particular angle of view, in other words sees the image a little bit different not like another one. This difference is in a certain shift between the objects on a horizontal. And closer objects are shifted more, than the remote ones.

Lenticular Technology

Lenticular printing is one of the most exciting print technology to emerge in recent years. The technology converts static, two-dimensional images into dynamic educational and promotional products that leave eye catching lasting impressions. Adding the perception of motion and depth, lenticular printing creates excitement by stimulating the mind beyond the eye. The lens is a piece of ribbed plastic with lenticules running vertically - ranging from 15 lines per inch to 150 lines per inch. Each rib is a lens. Each lens is set up according to viewing distance, depth and field of view through a logarithmic process commonly known as 'interlacing'. This assists in incrementally developing the movement that the brain interprets and the eye 'appears' to see. Thicker lenses make better 3D, thinner lenses fit in more animation frames.

"Lenticular" means "relating to lenses." Lenticular graphics are made up of two components: a lenticular lens and a gital or litho produced flat printed image. The grooves and ridges of the lens are actually lenticules which focus your sight on different parts of the underlying picture. The printed picture is actually made up of multiple pictures which are printed in alternating lines. A narrow band of each image will be printed sequentially with narrow bands of each additional image. If three images will be combined, the composite print will include a narrow band of image

No.1, followed by a narrow band of image

No. 2, then followed by a narrow band of image

No. 3. That pattern of printing is continued (1,2,3,1,2,3,1,2,3) for the entire composite print. Viewed in this state, the image is fuzzy. However, viewed under the lens pattern of the lenticular screen, a different view of the image is received from different angles.

This creates the special effect. The lens pattern is described in terms of lines per inch. The composite is printed to match the lens pattern, or “pitch.” Optimum viewing distances for large format graphics are three feet to infinity. Lenticular printed images are engaging, interactive and they generate exceptionally high recall rates with consumers. Published research shows that consumers will spend substantially more time looking at an animated or three-dimensional printed image than with a typical two-dimensional image. The main message is - lenticular sells.

Interlacing

Multiple frame (image) files are interlaced (interweaved) into a single lenticular image. National Graphics developed highly-specialized interlacing software capable of generating more sophisticated imagery. The interlaced image is finely-tuned to the specific characteristics of the lenticular lens, as well as the desired viewing distance. Extreme Vision patented lenticular technologies delivers the best image quality and fidelity for lithographic lenticular printing.

Lenticular Lens

A lenticular lens is comprised of extruded clear plastic lenticules (“ribs”). Each lenticular works as a magnifying glass, revealing only portions of an interlaced image at a time. The frames of the interlaced image change as the viewer changes viewing angle of the lens.

National Graphics pioneered the method of printing directly on the reverse side of the lens material, providing accurate registration of the printed image to the lens material and making it possible to deliver images with significantly greater detail and clarity.

Uses of lenticular prints

Typically three different types of lenticular prints are used:

- Transforming prints, where the distance between different angles of view is ‘large’. Here two or more very different pictures are used, and you see a different one depending on which angle you view the print at. In order to allow people to easily see the original photos, large differences are used, so that small movement will not cause changes.

- Motion capturing prints, where the distance between different angles of view is 'medium" so that while both eyes usually see the same picture, moving a little bit more switches to the next picture in the series, creating a motion effect.
- Stereoscopic effects, where the angle position is 'small', 6-7 centimeters (2- to 2.5 inches). This causes each eye to see a slightly different view, creating the 3D effect without the use of glasses.

Lenticular images like Holograms

Holograms are made with lasers and cannot display the full colour range, the images are restricted to what you can physically put in front of the laser and they can only have a very few number of images (normally just flipping 1 image). Hence the tendency to always to appear. Lenticulars are often called holograms - don't be confused! Lenticulars utilize a grooved plastic lens to create various visual effects (you can feel the grooves when you run your finger over the surface) as opposed to a hologram, which is completely smooth and is produced from an entirely different production process. The images are actually static but appear to move as you pass the display. Lenticular images have the full colour range, can be (almost) any size, and can reproduce images that until now could only be seen on a computer.

Different Effects can be achieved

Flip Lenticular

Flip images are the most basic. They can also be the most dramatic, catching people's attention from across the room or as they walk by. The basic "flip" has two or more images printed on the same page. Once the graphic is properly aligned and laminated to the lens, the viewing angle determines which of the images is seen at any given time. The simplest and often most effective use of lenticulars can be activated side to side (horizontally - e.g. window displays) or up and down (vertically - escalators).

3D Lenticular

3D Depth images are a little more complicated. Parallax is the bio-physical phenomenon that allows us to perceive the world in three dimensions. Normally, parallax is produced by the separate viewing angles of our eyes. Our brain compares the different views, from right and left

eyes, processes the data, and creates what we see as a three-dimensional world. Think of stereoscopic viewing. Remember looking through a View Master? Each eye would see a different slide. Each slide would be a different viewing perspective of the same subject matter. We can't perceive a three dimensional field of depth with a normal image on a flat viewing monitor. 3D - creating depth (up to 2 feet) from a 5mm lens.

Animation Lenticular

Animated images are glorified flip images. However, there may be ten or more different images interlaced together. Most of the visible image will be a template used in all frames. (Think of animation cells.) The background image may remain constant, but the objects which appear to be moving will be printed at different positions. (Design hint: Create your stationary image as the background layer in Photoshop or Illustrator. Place different stages of motion on different layers. As you select different layers, motion will be perceived. That is also how the printed frames will be exported.) The multiple images are combined/interlaced in the same way described for flips. As the angle of viewing the print through the lens changes, different frames of the animation are seen. This can create a more interesting or complex transition from one image to the next.

Zoom Lenticular

This is when you look at an image and you appear to zoom in and out as you move the lenticular back and forth. Basically, the same image just gets bigger and smaller. It is a very effective and easy to produce.

Morphing Lenticular

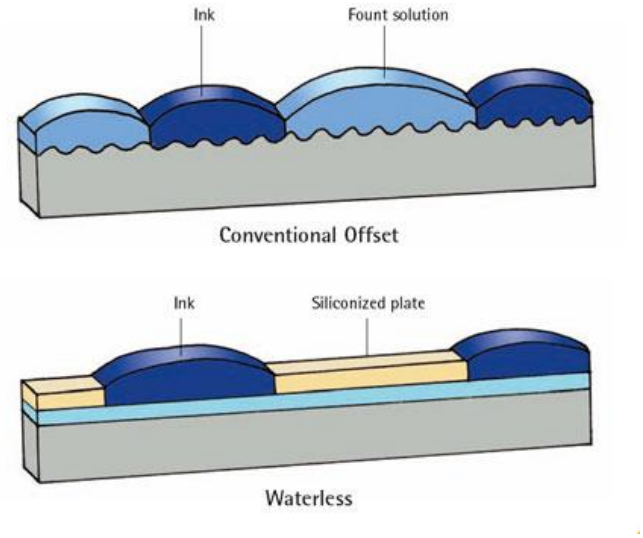
This is a multi-phase animation where the transition from one image to the next is "stepped" to give the illusion that one "morphs", transforms or changes into another image. The preparation of the art is critical to the effectiveness of this effect.

4.5 Basic principles of waterless offset printing

Waterless offset printing does not require or use dampening system. It prints without the need for a dampening to wet the non image areas. This is also called as ***Dry Offset*** printing.

Waterless is a lithographic process that does not use fount solution. It is based on repulsion between the ink and siliconized zones. When the plates are exposed to light, siliconized and nonsiliconized zones are formed according to the exposure mask. The ink deposited is repulsed from the siliconized zones towards the non-siliconized zones, thereby forming the printing and non-printing zones. The ink is then transferred onto the blanket and deposited on the substrate.

The Waterless UV process employs the same differentiation principle, but drying takes place through photopolymerisation. The UV dryer systems used are the same as those in offset with fount solution.



Advantages/Merits of Waterless Printing

Qualitative advantages:

Print quality is significantly improved by eliminating the fount solution:

• Dot sharpness (low dot gain).

• Constant reproducibility.

• Better colour density.

Production advantages:

The absence of water eliminates the need to adjust the water/ink balance, which reduces the start up and setting times and cuts waste. The elimination of the fount solution also enables other related drawbacks to be avoided: no need for a fount additive or need to maintain the fount solution tanks, elimination of problems of misting and piling, etc.

Ecological advantages:

The absence of isopropyl alcohol in the process eliminates any production of VOCs and ensures it is compliant with the objectives of the EPA (Environmental Protection Agency).

Dis-advantages/De-merits of Waterless Printing

Significant cost of consumables:

Waterless UV printing requires appropriate consumables: blanket cleaners, inks, additives, plates, etc. These are in general 2 to 3 times more expensive (than conventional products), which remains a brake to the development of this technology.

Relatively slow printing speeds:

Although Waterless UV printing do not match those obtained in conventional UV offset printing.

Demanding temperature adjustment:

Although the Waterless process makes the inking for the print run easy to set up and maintain, specific care needs to be taken as regards the printing temperature. In fact, the "printing zone" / "non printing zone" differentiation is very temperature sensitive. The temperature of the ink ducts, inking rollers and plates has to be precisely adjusted (between 18 and 23°C). Lower temperatures can lead to an "orange peel" appearance in the print and higher temperatures can cause ink misting on the plates.

Part-A

1. What is hybrid printing?

Hybird printing system is the combination of two or more different printing processes.

2. Define hologram.

a three-dimensional image formed by the interference of light beams from a laser or other coherent light source.

3. What is lenticular printing?

Lenticular printing is a technology in which **lenticular** lenses (a technology that is also used for 3D displays) are used to produce **printed** images with an illusion of depth, or the ability to change or move as the image is viewed from different angles.

4. What is waterless offset printing?

Waterless is a lithographic process that does not use fount solution.

5. Write any two lenticular effects.

Animation, Zoom, Flip, 3D, Morphing

6. What is the purpose of silicone layer in waterless offset printing plate?

To repel the ink

7. What is the other name of waterless offset printing?

Dry Offset

8. Define morphing.

Change smoothly from one image to another by small gradual steps using computer animation techniques.

Part – B

1. Define interlacing in lenticular printing.

2. What is flip lenticular?

3. What is animation lenticular?

4. Define zoom lenticular.

5. Define morphing lenticular.

6. What is 3D lenticular?

Part – C

1. Explain the hybrid printing system combining the NIP technologies.

2. Explain the hybrid printing system combining the conventional printing and NIP technologies.

3. Explain the hybrid printing system combining the conventional printing and Computer-to-press technologies.

4. Describe the preparation of holograms with a neat diagram.

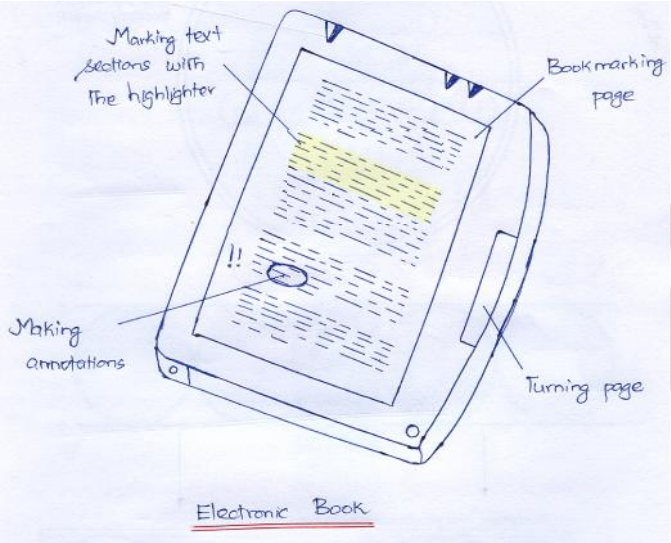
5. Explain the lenticular printing process with a neat diagram.

6. Describe the waterless printing process with a neat diagram.

Unit - V Future Printing Processes

5.1 E-Book (or) Electronic Book

An E-Book is an electronic book which can be read on **computer, laptop screen** or on a device called **E-Book reader.**



List of various manufactures of E-Book

- Rocket E-Book (Nuro Media)
- Soft book (Soft book Press)
- EB Study Model (Every Book)

The memory capacity of e-books is sufficient to store extensive electronic books. With suitable software and tools the text page can be marked with ***circling, highlighting, or pagemarkings.*** But non-flexible screen e-books do not give the same feel of reading a conventional book printed on paper. To eliminate this e-books with flexible paper like screens are developed. Electronic newspaper having double-sided flexible screen is available which can load and display texts, graphics and pictures from the Internet.

Applications of E-Book

1) Portable and no need to carry many books.
2) We can have thousands of books in a single device.
3) Saves money on buying new books.
4) Can zoom on text and graphics which is not possible on printed books.
5) Supports multiple document formats.
6) Eco friendly as it eliminates the usage of paper.

E-Ink (or) Electronic Ink

E-Ink or Electronic ink is otherwise called as electrophoretic ink. It is the optical component of a film used in electronic paper displays (EPD).

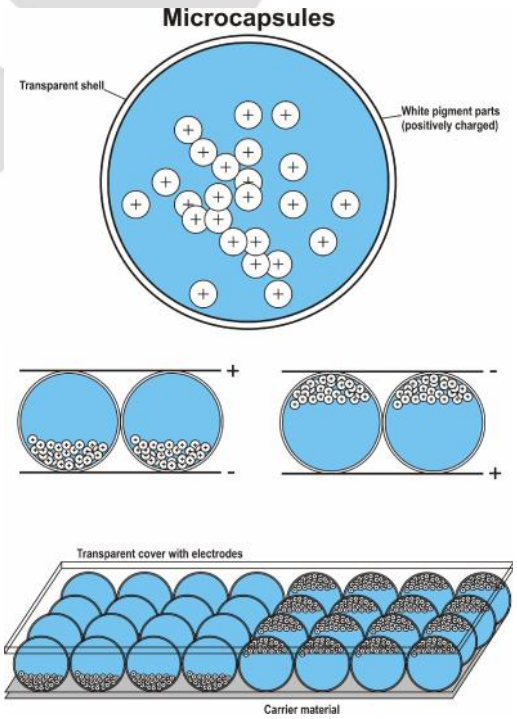
Electronic ink is a fusion of chemistry, physics and electronics. E-Ink's technology is referred to as **"bistable"**. Bistable means that the image on an E-Ink screen will be retained even when all power sources are removed. This means that the E-Ink display is consuming power only when something is changing. For example when reading on an E-Reader, power is only needed when turning to a new page but no power is consumed by the display while reading the page.

E-Ink displays are referred to as "reflective displays". LCD displays are "emissive displays". They need a backlight behind the display. But for an E-Ink display no backlight is needed/used. The ambient light from the environment is needed to read the book/display. If there is more ambient light the display looks brighter.

E-Ink displays do not have the same eye fatigue as with LCD displays when reading for long periods of time.

The backlight also consume up to 40% of the power is used in electronic displays. E-Ink displays eliminates the need of backlight and significantly increases the battery life.

Concept of E-Ink with microcapsules filled with a coloring agent



Electronic ink is made up of millions of tiny microcapsules. The diameter is equal to the diameter of the human hair. Each capsule is filled with a blue color coloring agent. Each capsule also contains positively charged white particles.

Millions of tiny microcapsules are arranged in arrays close to each other over a flexible carrier material along with electrode. Above the array of capsules a transparent cover along with electrode is mounted. When a negative charge is applied to the specific areas of top electrode, the white particle moves up and turn the paper/display into white in those areas. The other areas remain blue as the white particles move down where a negative potential is applied in the bottom electrode. This makes the surface blue and white.

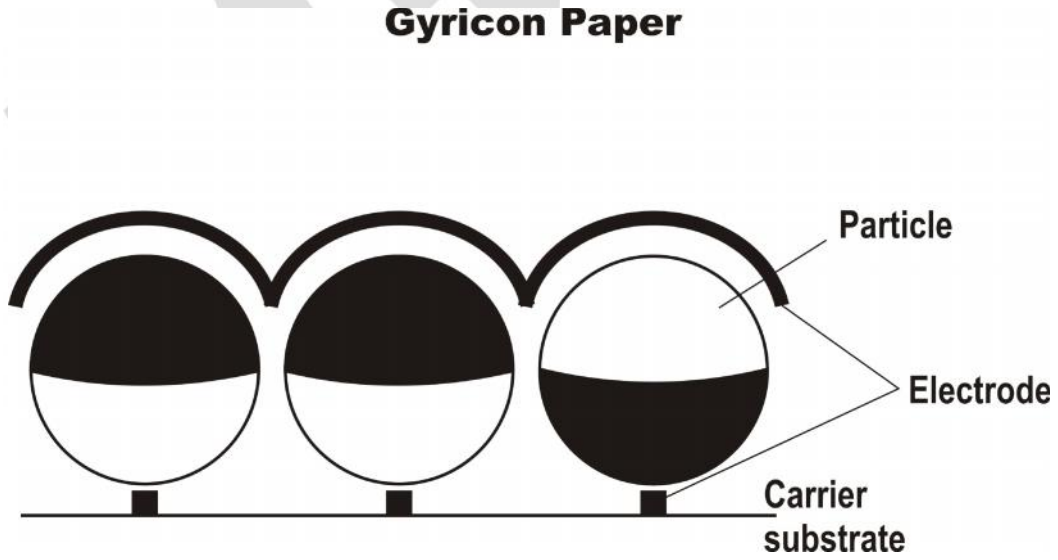
5.2 GyriconEPaper

Gyricon is the name derived from the Greek words “gyro” and “icon”

“Gyro” means ***rotate***

“Icon” means ***symbol***

Gyricon E-Paper is developed by Xerox, in Xerox-PARC (Palo Alto Research Center). Gyricon electronic paper is similar to earlier technique of microcapsules filled with coloring agent.



Here instead of microcapsules, microspheres are used. One half of these spheres are colored white and the other half is colored black. One side is charged positively and the other side is charged negatively. This type of charging is called “dipole”. The spheres are aligned in an

electric field. The image is formed by applying electric signals. The electric signals turn or rotate the spheres from black side to white and from white side to black side.

The diameter of the microspheres is 100 micrometer with these microspheres on image with a resolution of 250dpi is achieved.

Advantages of E-Paper:

- **Keeps the image in the memory until it is erased.**
  No electric power is required to maintain the image.
- **Reflective characteristics**
  As it is reflective similar to normal paper, it does not require a backlight.
- **Excellent visibility**
  Because its angle of visibility is very wide, it is easy to read under direct sunlight and puts less strain on the eyes.

Applications of E-Paper

Education: Digital School Books

E-Paper as digital school books, reduce costs and students daily burden of book.

Wristwatches

Wristwatch which has a flexible electrophoretic display consumes less power from battery and improves its life.

E-Books

E-Books are Produced with the help of E-paper and it is getting popular.

Newspapers

Electronic papers were used on a trial basis and in 2006 an electronic version of the newspaper was published.

Cell Phones

Low cost mobile phones are produced using alphanumeric black/white electrophoretic display.

Status displays

Some devices like USB flash drives use electronic paper to display status information, such as available storage space.

Rewritable Paper

Certain physic-chemical effects permit heat to produce a reversible color change in multi layered polymeric materials. This is called rewritable paper.

This paper is also called as thermally sensitive paper.

Concept of Rewritable Paper

The thermally sensitive paper (or) rewritable paper contains three layers. They are

- A Carrier Layer
- A Recording Layer and
- A Protective Layer

NIP technology is used for the imaging and erasing process. Thermal print heads (or) thermal laser diodes are used for the imaging process. When heat is applied the thermally sensitive polymers become more (or) less transparent.

When heated, the light-impermeable dark imaging layer applied to a carrier layer will become transparent and forms the image.

This process of alteration of transparency is reversible (ie) by applying heat at higher temperature levels the surface can be changed darker.

The rewritable paper can also be used in electronic books. Rewritable paper is used in E-Book with roll-out screen. Turning pages is achieved by bringing together and pulling apart both the parts of the reading device. This action enables the erasing and rewriting of information onto paper.

5.5 3D Printing

3D printing is the process of creating an object using a machine that puts down material layer by layer in three dimensions until the desired object is formed.

Types of 3D Printing

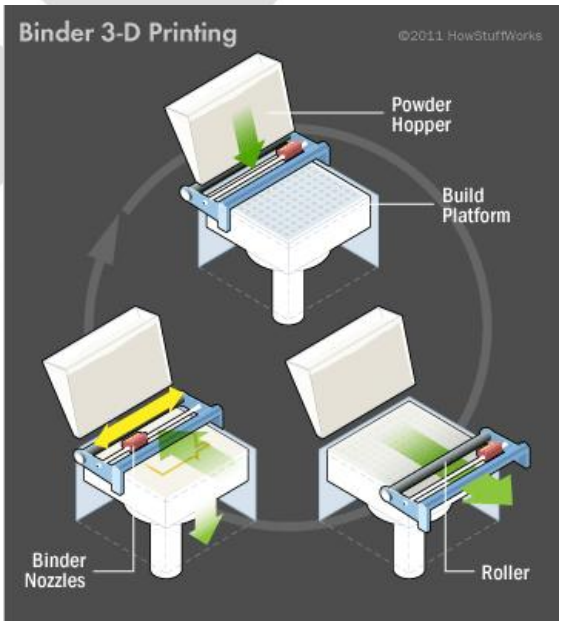
There are two types of 3D Printing. They are:

- Direct 3-D Printing
- Binder 3-D Printing

Direct 3-D Printing

Direct 3-D printing uses inkjet technology. Since 1960, Inkjet technology is used for 2-D printing. Like in a 2-D inkjet printer, nozzles in a 3-D printer move back and forth dispensing a fluid. But in a 3-D printer the nozzle or the printing surface moves up and down. Due to this multiple layers of the material is printed or deposited one over the other. Instead of ink 3-D printers use thick waxes and plastic polymers. These waxes or plastic polymers solidify to form each new cross-section of the sturdy 3-D object. Rapid Prototyping (RP) is the major factor for the development of 3-D printing. Today's advanced rapid prototyping technologies like **multi-jet modeling (MJM)** creates wax prototypes quickly with dozens of nozzles working simultaneously.

Binder 3-D printing



Binder 3-D printing, like direct 3-D printing, uses inkjet nozzles to apply a liquid and form each new layer. Binder printing uses to two separate materials that come together to form each printed layer. The materials used in a binder 3-D printer are a fine dry powder plus liquid glue or binder. Binder 3-D printers make two passes to form each layer. The first pass produce a thin coating of the powder, and the second pass applies the binder. The printing platform then lowers slightly to accommodate a new layer of powder, and the entire process repeats until the model is finished.

Binder 3-D printing has a few advantages over direct 3-D printing.

- Faster than direct 3-D printing.
- We can use wider variety of materials like metals and ceramics and color also.

Steps involved in 3-D printing process

- **Step 1: CAD --** Producing a 3-D model using computer-aided design (CAD) software.
- **Step 2: Conversion to STL --** Convert the CAD drawing to the STL format. STL, which is an acronym for **standard tessellation language**, is a file format developed for 3D Systems in 1987 for use by its stereo lithography apparatus (SLA) machines.
- **Step 3: Transfer to AM Machine and STL File Manipulation –** The STL file is copied to the computer that controls the 3-D printer. There, the size and orientation for printing is set. This is similar to the way we set up a 2-D printout to print 2-sided or in landscape versus portrait orientation.
- **Step 4: Machine Setup --** Each machine has its own requirements for how to prepare for a new print job. This includes refilling the polymers, binders and other consumables the printer will use.
- **Step 5: Build –** The building process is performed by the machine/printer. Each layer is usually about 0.1 mm thick. Depending on the object's size, the machine and the materials used, the printing process could take hours or even days to complete the job.
- **Step 6: Removal –** Then we have to remove the printed object from the machine. Safety precautions should be taken to avoid injury such as wearing gloves to protect from hot surfaces or toxic chemicals.
- **Step 7: Post processing --** Many 3-D printers will require some amount of post-processing for the printed object. This could include brushing off any remaining powder or washing the printed object with water.

Applications of 3-D Printing

- Parts of rocket engines are also manufactured and NASA has tested printed rocket engine component was tested successfully.
- Machinery parts are also being manufactured with the help of 3-D printing.
- A new and emerging concept of organ-printing in which the human organs are printed successfully.

Part – A

1. What is E paper?

Electronic paper

2. What is the name of the electronic paper created by Xerox?

Gyricon

3. What is the meaning of Gyricon?

"Gyro" means ***rotate***

"Icon" means ***symbol***

4. What is OLED?

Organic Light Emitting Diode

5. What is LEP?

Light Emitting Polymer

Part - B

1. What is rewritable paper?
2. What are the types of 3D printing?
3. Write down any two environmental friendly inks.
4. What is green printing?
5. What is 3D printing?

Part – C

1. Explain the E-Book with a neat diagram.
2. Explain Electronic Ink with a neat diagram.
3. Describe Gyricon paper with a neat sketch.
4. Explain rewritable paper.
5. Describe 3d printing and its types.