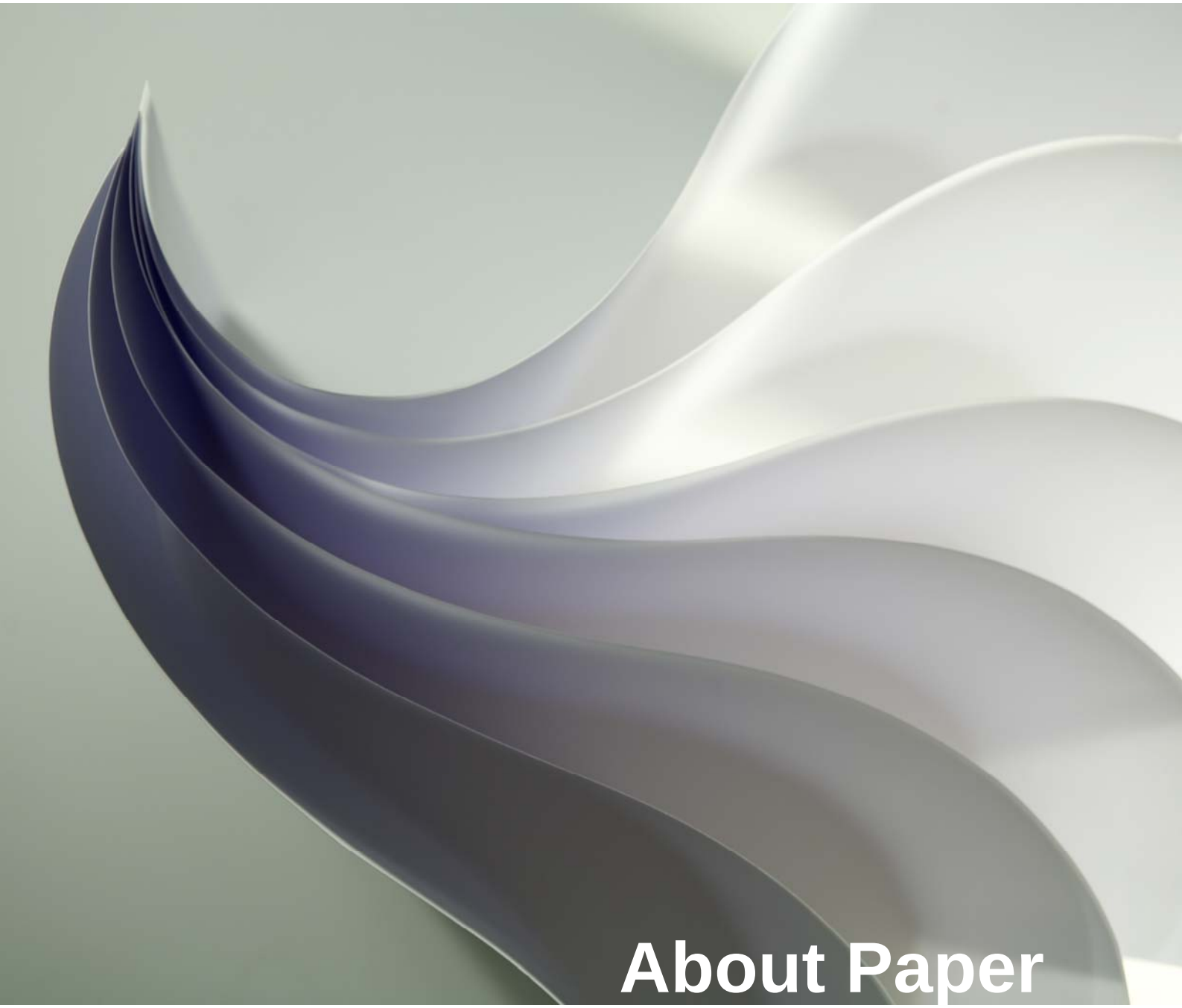

About Paper

Printing Techniques

Printing Techniques

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1. Printing

Printing is understood as those processes through which multiple reproductions of an image or text are made using a printing plate (mould) on the paper.

The largest consumer of paper is specifically the printing industry. The technique of printing is made up of three phases:

- **Composition.** These days, the original to be printed is received digitally. Before it is processed a print is made on a plotter to check that there are no errors. If the surface is correct, it can be sent directly to the plate using **CTP** technology (Computer to Plate), or to film, using **CTF** technology (Computer to Film). In the latter case, the film (called photolith) is transferred to the plate using exposure to bright light.
- **Inking.** The ink is spread over the mould.
- **Print run.** The print run is done on printing machines (presses) which press the mould strongly against the paper leaving marks on the surfaces to be printed.

The operations involved in these phases were traditionally carried out by hand, but these days they are completely mechanized.

2. The surface

In order to print a text, the first thing to be done is to make a mould which can be used for all the copies that are going to be printed.

The term **surface** is given to a mould prepared so that the inks can be transferred to a medium (paper) for the reproduction of the different texts or illustrations of an original.

The mould is placed on the printing press to print one side of the whole sheet (a signature), which could have various formats ranging from a minimum of DIN A4 (210 x 297 mm) to a maximum of 1,400 x 2,000 mm.

Two main parts can be differentiated on a surface:

- **Printing areas,** which transfer the ink and correspond to the image we wish to obtain.
- **Non-printing areas**.

2.1. Types of surface

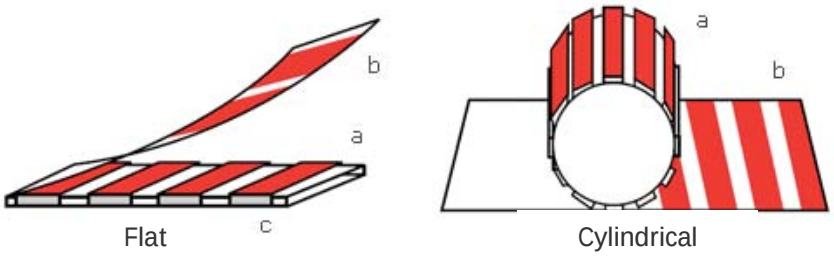
The four types of surface most used to print paper are:

- Raised surfaces.

- Planographic surfaces.
- Sunken surfaces.
- Stencils.

Raised surfaces

Raised surfaces used in relief printing are characterized by the fact that their "printing areas" are placed at a higher level than the "non-printing areas" (fig. 2), meaning that the ink extends across the printing areas only. This type of surface can be **flat** or **cylindrical.**



a. printing area
b. printed paper
c. surface

Fig. 2: Types of flat and cylindrical raised surfaces.

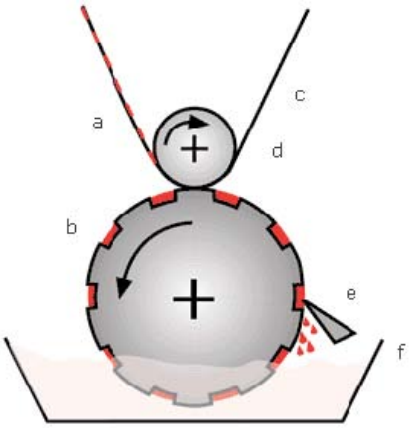
Planographic surfaces

In planographic surfaces, the "printing areas" and the "non-printing areas" are at the same level on the same plane.

The printing surface will be subject to a particular chemical treatment so that the "printing areas" accept the ink and repel water, and vice versa in the "non-printing areas". In this way, when the ink extends across the surface, it will only adhere to the printing areas due to this treatment.

Sunken surfaces

Sunken surfaces are characterized by the fact that the "printing areas" are engraved at a lower level than the "non-printing areas", or in other words, they form cavities or depressions on the surface. The ink remains in these depressions (fig. 3).

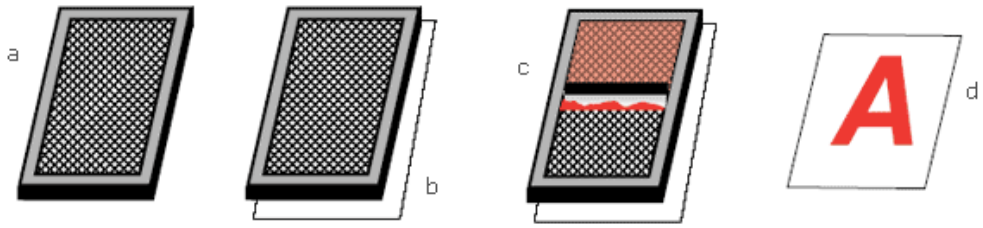


a. printed paper
b. surface cylinder
c. paper
d. printing cylinder
e. bladef
f. ink

Fig. 3: Basic diagram of printing using sunken surfaces.

Stencils

Stencils use a kind of **sieve** (in the past this was made of silk, but these days it is made of nylon) in which the "printing areas" are permeable to the ink, in contrast to the "non-printing areas" (fig. 4).



a. Filter or sieve.
b. Paper
c. Inking blade.
d. Printed paper

Fig. 4: Stencil printing.

2.2. Composition of the surface

The composition of the surface started by making the surface manually. An important advance was made by Gutenberg in passing from fixed to moveable type. The next step was hot-type composition (linotype) and, subsequently, cold composition (photocomposition).

At that time, printing surfaces were made in two different workshops. The illustrations were made up in the photomechanical workshop, and the texts in the photocomposition workshop.

Currently, with advances in computer technology everything has changed and with rare exceptions printers receive, either from pre-printing workshops or directly from the

client, the original in a digital format (normally on a CD). Before preparing the plate the printer makes a print on a plotter from this CD to see if there are errors.

The following work process is involved in the **preparation of the surface**:

- **Computer to Film (CtF).** In this case, a film (known as a photolith) is obtained using a camera. This film is like a transparent photograph, and there will be a photolith for each colour. Light is used to transfer it to the printer surface.

The transfer of the photolith to the plate is shown in the following figure:

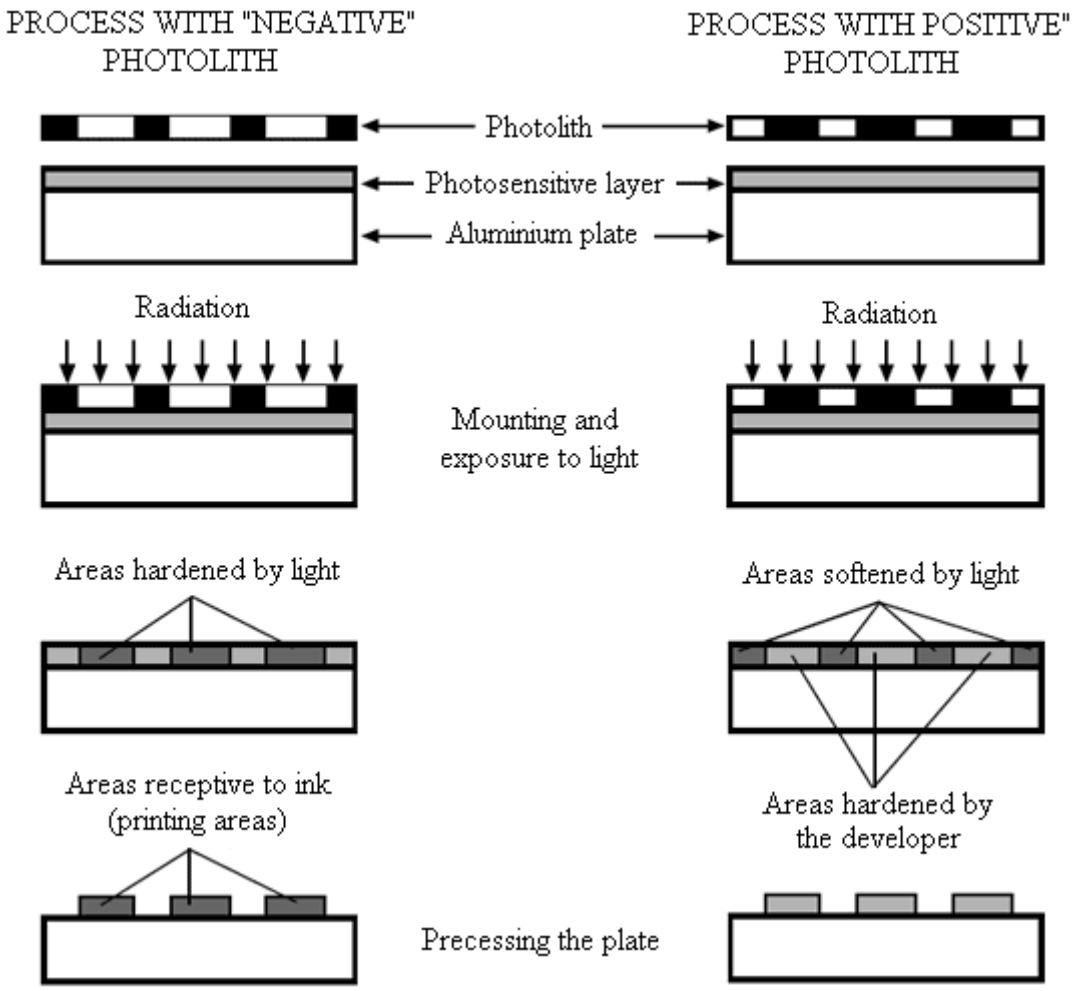


Fig. 5: Phases of creation of the photolithographic matrix (pre-sensitized plates).

The photolith is mounted on the plate, and together they are pressed into an apparatus where they are subjected to **exposure to light.** The light passes to the plate via the photolith (transparent), except in opaque areas, corresponding to the image areas in positive photoliths and non-image areas in negative photoliths.

If the photolith is **negative** (fig. 5 left), the sensitive layer sets in those parts which have been exposed to light (printing areas). In this way, on developing, the developer dissolves the areas which have not set (non-printing areas), with only sensitive material remaining in the set image areas, which will be more receptive to the ink.

If it is **positive** (fig. 5 right), the light affects the imageless areas (non-printing areas) of the sensitive layer, decomposing its molecular structure. In this case a special developer is applied which removes the sensitive material of these areas that are exposed to light, setting in the areas which are not exposed to it (printing areas).

Once the first colour is printed, the same process is used with the remaining colours.

We should mention that negative photoliths are very rarely used these days. In the past they were used mainly in America, but since the arrival of CtP they are no longer used. Whether they are negative or positive photoliths, the plate will always be seen as positive, or in other words, the text can be read normally. This is due to the fact that as it is indirect printing it is the rubber that creates the reversal of the image, being placed on the paper in positive.

- **Computer to Plate (CtP).** In this case it passes directly to the plate, or in other words, there is no film. Instead of being stimulated by the light as in the previous case, the plate does so by using heat. In other words, it will be a **thermal plate.**

- **Computer to Print.** This is similar to the previous case, but here the plate is already placed on the printing machine. This is the system known as **digital offset.**

- **Computer to Paper.** This is digital printing, or in other words, using laser or inkjet. In this case there is no visible printing surface. Instead there is an electronic image known as a **latent image.** This is what is known in the market as **non-impact printing.**

3. Printing systems

We will now look at the most commonly used systems in printing paper:

- Typography and Flexography.
- Gravure.
- Screen-printing.
- Lithography.

3.1. Typography and Flexography

Typography consists of printing based on **raised surface**. The printing surfaces have the printing areas at a higher level (raised) than the non-printing areas. The printing areas are those which transfer the ink to the paper (fig. 6).

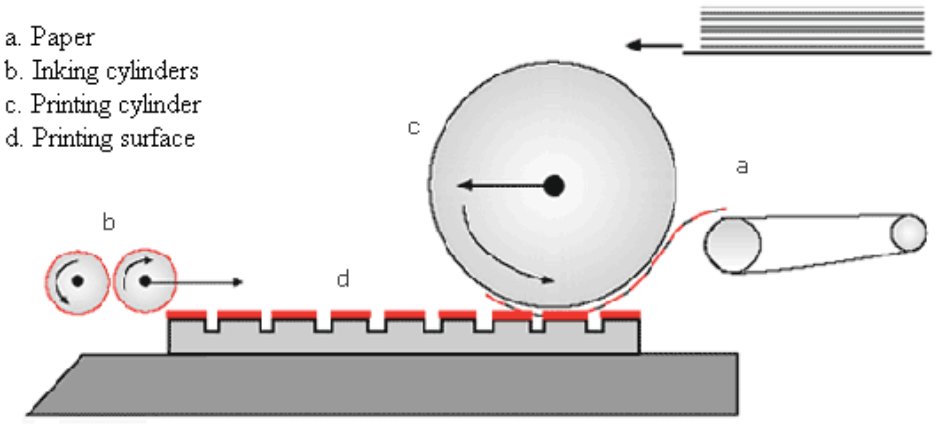


Fig. 6: Typographic press.

The paper can be fed on sheets or in reels, and the surface can be flatbed or cylindrical. The transfer of the ink takes place in the contact area between the printing cylinder and the cylinder that holds the surfaces.

Flexography is also a system of **raised** printing in which the printer surface is made of a polymer, instead of metal as in typography. It is used a lot in self-adhesive reels. In this case, the ink passes from the ink holder to the printer surface via a cylinder known as **anilox** (fig. 7). Printing is always on reels with the exception of corrugated cardboard which is printed on flexographic machines in sheets.

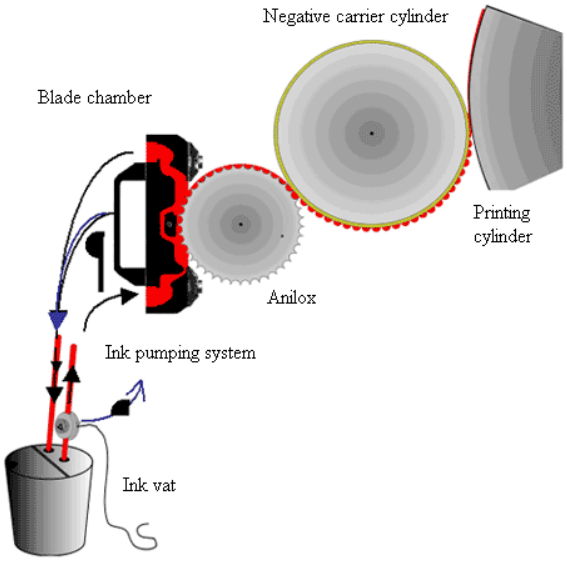


Fig. 7: System of printing by flexography.

3.2. Gravure

The system of printing by **gravure** is based on the opposite idea to that of the typography system. It uses **sunken surfaces**; in other words, the printing areas make a depression in the surface of the cylinder whilst the non-printing areas represent the outer surface of this cylinder.

The cylinder is submerged in the ink and the excess ink, or in other words, that found in the outer area (non-printing areas), is removed with a blade. The ink that remains in the depressions (printing areas) is that which is transferred to the paper creating the printing of the image (fig. 8).

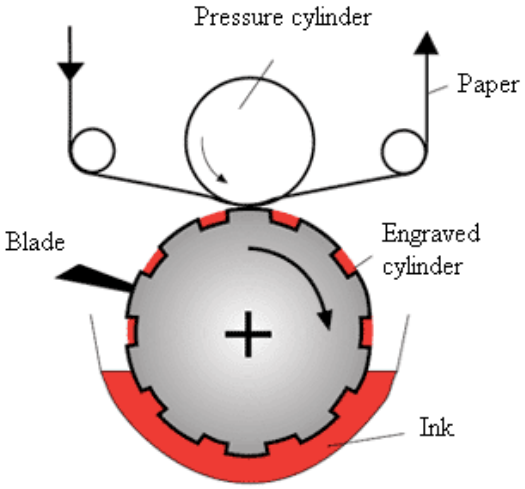


Fig. 8: Printing by rotary gravure.

Most work done using this method is carried out with rotary presses fed by reels, with the exception of corrugated cardboard plates which are printed on machines using large-sized sheets.

3.3. Screen-printing

Screen-printing is a printing system in which **stencil surfaces** are used**.** During this method the ink is applied using a type of fine and porous **sieve** placed on the paper.

In this sieve, the non-printing areas are impermeable to the ink (it cannot pass through) whilst the printing areas are permeable, meaning that the ink can pass through to the paper.

The use of this method is limited to short or medium runs due to the slow drying of the layer of ink applied.

Screen-printing is often used for advertising hoardings and printing on textiles.

3.4. Offset

Offset is a printing system which uses **planographic (flat) surfaces**. In this method there is no appreciable difference in level between the printing and non-printing areas.

During the preparation of the plates, photosensitive materials and chemical treatments are used which make the printing areas water repellent and receptive to the ink. On the other hand, these substances make the non-printing areas receptive to water and ink-repellent. Therefore, when solutions of water and ink are applied to the plates, the water covers the non-printing areas whilst the ink only adheres to the printing areas.

Offset is a system that originates from lithography. In the past, the printing surface was a stone, hence the word "litho". Subsequently, and with the aim of increasing productivity, the stone was replaced by metal, meaning that rotary presses could be used. Lithography was a **direct** printing system, given that the printing surface (firstly, stone, and later, the plate), once coated in ink, directly touched the medium (paper) to be printed.

These days lithography is used very little and has been replaced by offset, which is the system used most often on our papers.

The move from lithography to offset was pure coincidence. One day, whilst a printer was printing lithographs, a sheet went wrong and the ink remained on the rubber impression cylinder. When the sheet went through normally, it was printed on both sides, in other words, one side with the ink from the plate and the other with the ink that had remained on the rubber. He started to research

indirect printing and for this reason it was called OFF SET (out of place). Finally, the two words were joined to give one word, OFFSET.

Lithography was invented in 1775 by a Bavarian named ALLOYS SENEFELDAR.

Offset is, compared to lithography, a **system of indirect printing,** or in other words, the printing surface does not touch the paper but instead transfers the ink via an intermediate element, in this case rubber. Due to its elasticity, this passes the ink perfectly onto the paper.

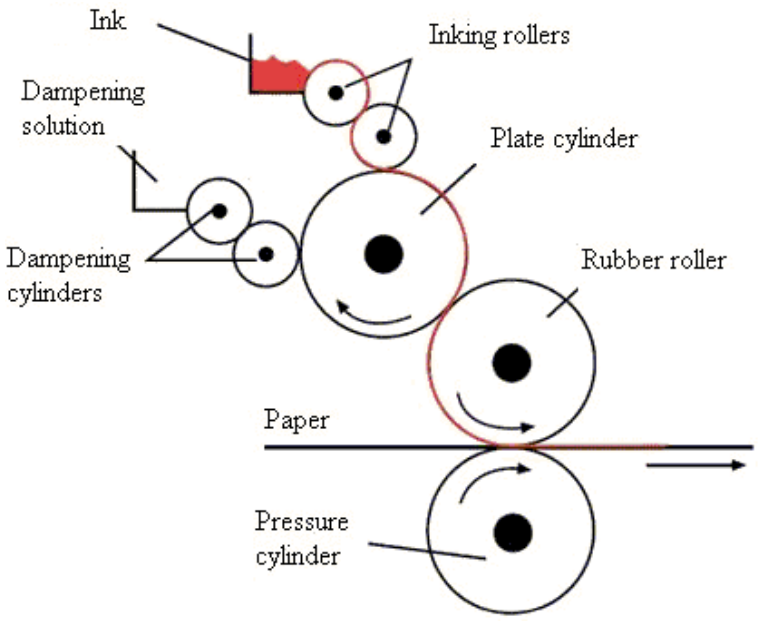


Fig. 9: Basic diagram of offset printing.

4. Colour and tone

Colour is the sensation caused by light waves or radiation, which on reflecting off an object and being received by the eye are incorporated into the brain.

Colour depends on the type of radiation reflected by objects (if they are opaque) or transmitted (if they are transparent) and perceived by the eye.

Tone is determined by the intensity of the radiation.

An object presents a certain colour when it reflects or transmits radiation of that colour and absorbs radiation different to it.

There are **three primary colours,** which are yellow, red and blue. When mixed appropriately, these give rise to the other colours. When an object absorbs all radiation without reflecting any, the colour black appears.

In printing, the basic inks or colours used are: **yellow** (red + green), **magenta** (red + blue) and **cyan** (blue + green). For printing purposes the colour **black** is also used as a fourth primary colour.

An original can be printed by preparing four surfaces, one for each primary colour. This type of printing is known as four-colour**.**

Variations in **tone** depends on the thickness of the layer of ink applied. The finer the layer, the lighter the tone, and vice versa. However the printed layers are usually of the same thickness in all areas. Therefore, to achieve different shades it is necessary to use the process known as **screening,** or in other words, obtain a screen for each primary colour.

The screen consists of breaking down the image into dots equidistant from one another. The word **ruling** is often associated with the word screen. This is because originally the screens were manual and the dots were obtained using the intersection of lines. These days the screens are electronic.

Depending on the diameter of each point we can simulate different shades for the same applied colour (fig. 10).

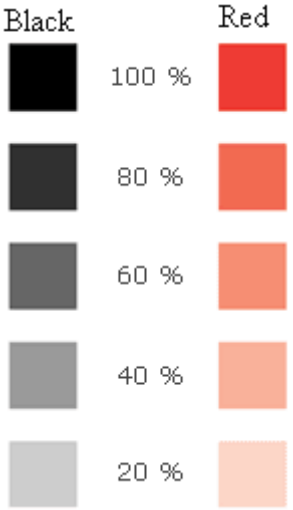


Fig. 10: Colour percentages in screens.

The screens can have different rulings (in other words, the number of lines per unit of length), depending on the quality of the printing being carried out. The more lines there are per unit of length, the more dots there will be and the more difficult it will be to perceive the discontinuity of the printed dots (the tone appears to be more continuous) and, therefore, the better the quality of the printing.

The number of dots depends on the quality of the paper. This means that a greater number of dots would be used to print on coated paper than on newspaper, for example, to print the same image. This is because during printing the point increases in proportion with the porosity of the paper.

Once the type of screen and ruling has been chosen, it should be the same for the four primary colours, but it will be necessary to orient the angle of the screen differently for each colour to avoid the dots of the different colours becoming superimposed (fig. 11).

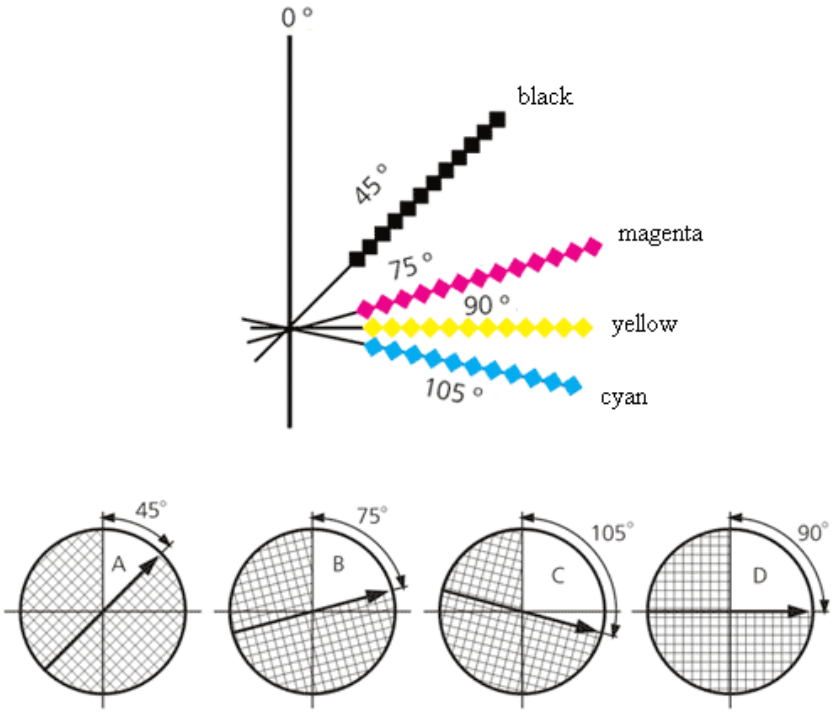


Fig. 11: Screen angles.

When printing in colour (four-colour), the vast range of colours is achieved using only four primary colours (CMYK = cyan + magenta + yellow + black). Superimposing the dots of the screen of each of these primary colours will lead to the total reproduction of the original tones and colours.

Chromatic effects (colour) are achieved by preparing a surface (plate) for each primary colour, or in other words, yellow, magenta, cyan and black. All remaining colours are achieved by mixing these four colours.

Aluminium sheets are used to make each surface, on which is applied a layer of light or heat **sensitive** material, depending on whether they are CtF or CtP, respectively. The layer of sensitive material has the property of being very receptive to the ink. Therefore, after developing the sheet this layer will need to continue to adhere to the image area in order to keep the ink on the printing areas in the inking phase.

5. Printing inks

Printing inks are all those substances that are applied to a medium (paper) to reproduce an image. These substances are transferred from the surface to the medium, where they will remain fixed thus creating the finished product.

Inks are made of two basic components: a solid part, which are the pigments, and a liquid part, known as the vehicle, varnish or binder.

5.1. Pigments

These are insoluble substances that are generally presented in the form of a very fine milled powder. The particles of these substances should be sufficiently small (giving greater shine, intensity and tone to the ink) and, furthermore, they should disperse uniformly in the vehicle.

They are divided into three major categories:

- **Blacks** (carbon).
- **Whites** (titanium dioxide).
- **Coloured** (inorganic, organic and lacquers).

Pigments give the ink its characteristics of colour (shade, intensity...) and of stability.

5.2. Vehicles

The vehicle consists of a mix of different components. It can be divided into two main groups:

- **Oil-, plant- or mineral-based vehicles, without volatile solvents.** These are used for the **greasy inks** that are used in typography and offset. The greasy inks are made of:
  - **Oils** (plant and mineral).
  - **Resins** (natural and synthetic).
- **Vehicles based on volatile solvents, without oils.** These are used for the **liquid inks,** used in gravure printing. The liquid inks are made of:
  - **Synthetic resins.**
  - **Plasticisers.** They give flexibility to the ink film.

- **Volatile** solvents. These evaporate quickly.

The functions of the ink vehicle are:

- **To bind the insoluble pigments or dissolve the soluble colorants to form a homogeneous whole.**
- **To ensure the transfer of the pigments to the medium.**
- **To fix the pigment to the medium during drying.**

6. Ink drying

Depending on the function of the type of inks used, whether greasy or liquid, different drying methods are used.

6.1. Drying greasy inks

The different drying methods that can be used for drying greasy inks are:

- **Oxidation.** When the layer of ink is placed on the medium, oxygen oxidises the plant oils and resins, thereby setting the ink layer making it resistant and flexible. There are no mineral oils in these inks (fig. 12).

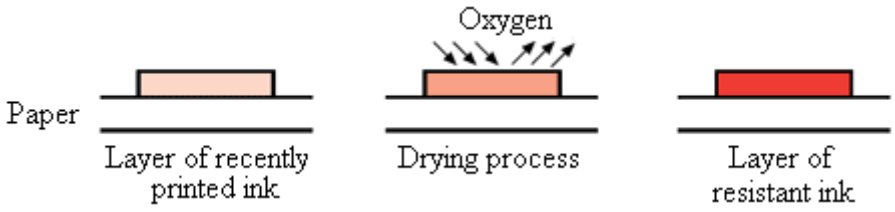


Fig. 12: Process of drying inks by oxidation.

- **Absorption.** Inks that are dried using this system have a high mineral oil content. The ink is absorbed by the medium, staying moist within it (fig. 13). This is used in **newspapers, comics, forms and other very absorbent papers.**

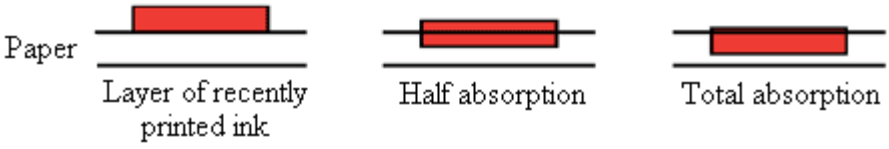


Fig. 13: Process of drying inks by absorption.

- **Selective filtration.** The layer of ink is placed on the paper and then the absorption of mineral oils begins. The ink becomes more viscous and causes the oxidation of the plant oils and resins (fig. 14).

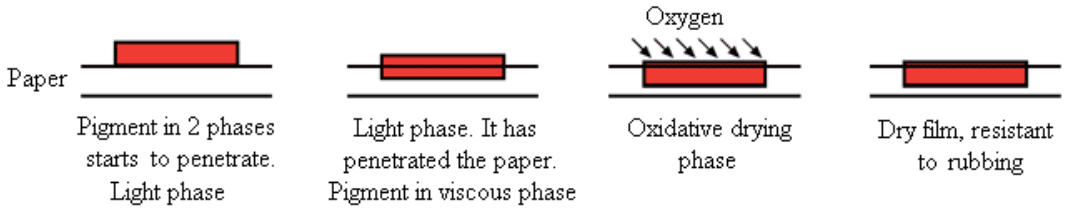


Fig. 14: Process of drying inks by selective filtration.

- **Evaporation.** There is slight absorption by the paper, although this is very low as the paper is quickly placed in the drying oven, causing evaporation. The paper then passes through coolers that set the ink (fig. 15). This is normally used in **rotary offset presses.**

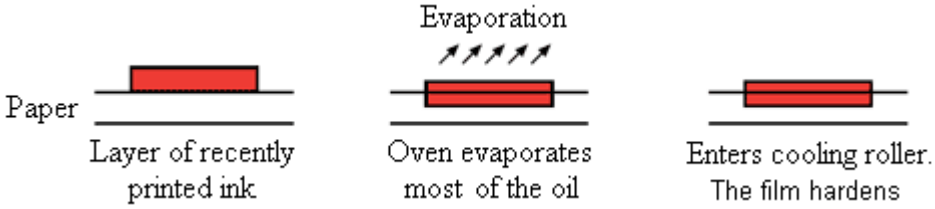


Fig. 15: Process of drying inks by evaporation.

- **Radiation.** There are two types of drying by radiation:
  - Drying by **ultraviolet.** The ink is applied and ultraviolet radiation quickly carries out the drying, leaving the ink set in tenths of a second (fig. 16). This is used mainly on **cardboard.**

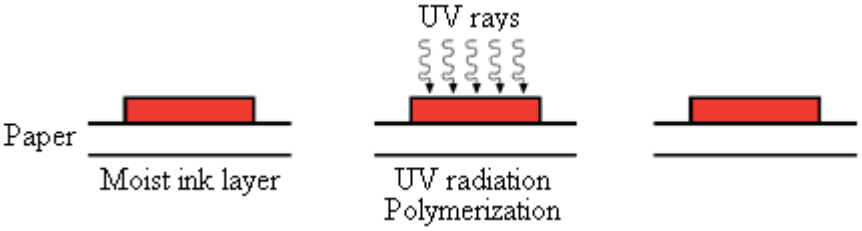


Fig. 16: Process of drying inks by ultraviolet radiation.

  - Drying by **infrared.** Reduces the viscosity of the ink, assists in its absorption and speeds up the process of oxidation. Infrared is helpful in the selective filtration system.

6.2. Drying liquid inks

Two methods are mainly used for drying liquid inks:

- **Absorption** (in absorbent products). For example, in cardboard boxes printed using flexography.
- **Evaporation** (in non-absorbent products). Evaporation in this type of ink occurs at a much lower temperature than in greasy inks. They can also be dried by evaporation even if they are absorbent products, such as paper.

7. Printing machine

Due to the widespread use of the offset system, we will focus our study on this type of machinery. Most printing machines (fig. 17) have the following parts in common:

- Marker.
- Oscillating rollers.
- Dampening system
- Ink system.
- Signature delivery.

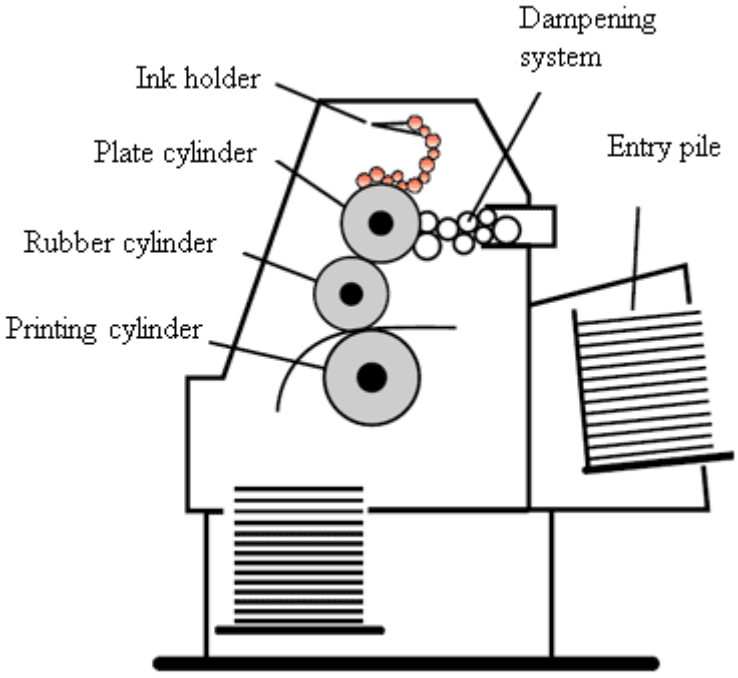


Fig. 17: Parts of the printing machine (offset)

7.1. Marker

This is the **set of mechanisms** responsible for the correct introduction of the paper in the body of the machine. Using **suckers,** adjustable to different paper sizes, the signature is lifted from the pile and moved towards the marking table with a mechanism that ensures that only one signature passes at a time. To guarantee the perfect trajectory of the signature across the marking table, a perfect marking is necessary.

7.2. Oscillating grippers

These are grippers that transfer the sheet of paper to the printing roller, once marking has been done.

7.3. Dampening system

This is the area that dampens the plates (fig. 18). (Remember that the Offset method is specifically based on the repulsion of the ink with the water in the non-printing areas).

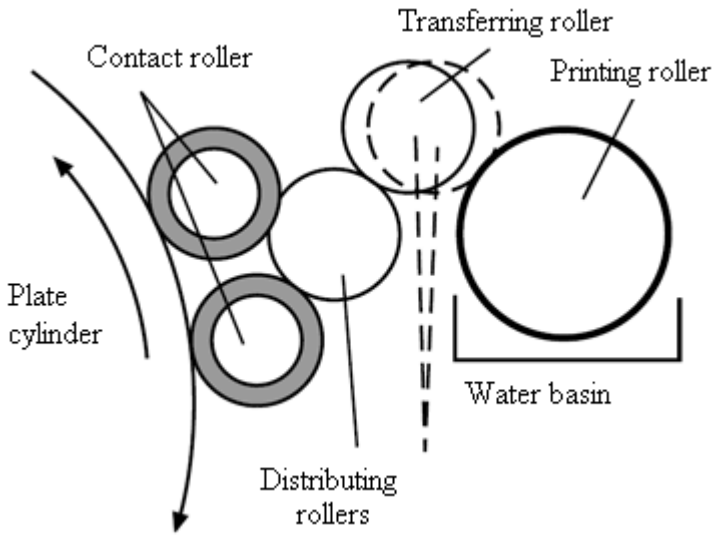


Fig. 18: Dampening system in a printing machine.

There are several dampening systems, although all of them are essentially a series of rollers (which immerse, transfer, distribute, etc) which transport the water from the tray to the plate rollers.

7.4. Ink holder

This is the area responsible for distributing the ink in the machine. As in the dampening system, it also has a series of rollers (fig. 19):

- **Transferring roller.** Takes the ink from the ink holder to transfer it to the other rollers.
- **Distributing** rollers. These distribute the ink to the different rollers.
- **Contact** rollers. These are in contact with the printing plate or roller.

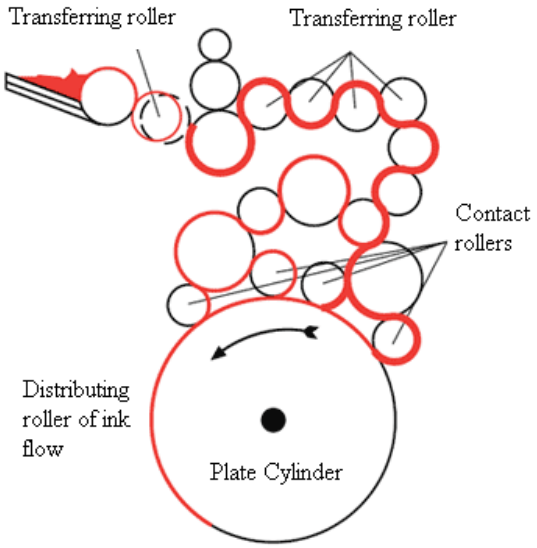


Fig. 19: Inking rollers.

7.5. Signature delivery

These are in contact with the printing plate or roller. Once the signature passes between the printing cylinder and the rubber and is printed, it passes to the receiving table via grippers.

8. Papers for printing

We are going to describe some of the types of paper used for printing depending on the system used:

- Paper for typography.
- Paper for offset.
- Paper for gravure.

8.1 Paper for typography.

This method is little used for printing. The characteristics that the paper should have to work with this system are:

- **Smoothness.**
- **Compressibility.**

The product to be printed can be absorbent or not, although it is essential that it is has compressibility. If the product is absorbent, the ink dries by **absorption,** but if the product is not absorbent the ink must be suitable for drying by **oxidation.**

8.2 Paper for offset.

The following can be used with this system:

- **Absorbent products.** These products should have the following properties:
  - Flatness.
  - Not release dust.
  - Adequate microporosity for fast drying of the ink.

For this type of products inks are used which dry by **selective filtration.**

- **Non-absorbent products** (lacking pores). With this type of products it is necessary to:
  - Control the dampening water.
  - Do not use sprays.
  - Make very small piles.

In this type of papers the ink should dry by **oxidation.**

Some absorbent products are: papers, card, white and light coloured high shine.

Some non-absorbent products are: metallic paper, extruded cardboard, plastics and strongly coloured high shine.

8.3. Paper for gravure

The drying of the ink with this method is by heat, meaning that it is not necessary that it is absorbent. It should only meet two conditions:

- **Smoothness.** This characteristic is essential.
- **Compressibility.**

Summary

Printing	Process through which multiple reproductions of an image or text are made by a printing plate (mould or surface) on the paper.
Surface	Mould made to transfer the ink to the medium (paper) to reproduce texts or illustrations of an original. The surface types most used are: ▣ **Raised** surface. The printing areas are at a higher level than the non-printing areas. ▣ **Planographic (flat)** surface. The printing areas attract the ink whilst the non-printing areas repel it. ▣ **Sunken** surface**.** The printing areas are at a lower level than the non-printing areas. ▣ **Stencil surface.** The printing areas (permeable) of a sieve let the ink pass through whilst the non-printing areas (impermeable) do not allow it through.
Printing systems	The most commonly used are: ▣ **Typography and Flexography.** They both use a raised surface. ▣ **Gravure**. Uses a sunken surface. ▣ **Screen-printing.** Uses a stencil. ▣ **Offset.** Uses a planographic surface.
Pre-printing	This is the process before making the printing surface. It is carried out digitally.
Ink drying	The systems used for drying **greasy** inks are: ▣ **Oxidation.** The oxygen oxidises the plant oils and resins in the ink. ▣ **Absorption.** The ink is absorbed by the paper. ▣ **Selective filtration.** The mineral oils are absorbed by the

paper whilst the plant oils and resins are oxidised.

- **Evaporation.** The paper goes into the drying oven causing the fast evaporation of the ink.
- **Radiation.** Using infrared or ultraviolet rays the ink sets very quickly. Infrared is helpful in the selective filtration system.

The following are used in the drying of **liquid** inks:

- **Absorption.**
- **Evaporation.**

Printing machine

The different parts of a printing machine that should be identified are:

- **Marker.** Mechanisms which correctly introduce the paper to the machine's cylinder using guides.
- **Oscillating grippers.** These transfer the sheet to the printing roller once marking has been carried out.
- **Dampening system.** This system dampens the printing plates.
- **Ink holder.** This is the space which the printing ink is kept before transferral to the printing plate.
- **Signature delivery.** This carries the printed sheet towards the receiving table.

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