UNIT - I – BASIC PRINCIPLES

PRINTING PROCESSES - PRINCIPLES

Lithography, letterpress, flexography, gravure and screen are the major conventional machine printing processes. Each of these processes is separate and distinct, because of the different operation of the planographic, relief, intaglio and stencil types of printing.

Image carriers in the form of plates, cylinders or stencils can be created either by exposing the assembled films onto a light sensitive image area which is then processed, or by laser engraving, digital or chemical transfer.

All printing image carriers have two separate surfaces - an image or printing area and a non-image or non-printing area. The image or printing area accepts the ink by mechanical or chemical means but the non-image area does not accept or retain ink.

1.1.A. PRINCIPLES OF FLEXOGRAPHY PRINTING PROCESS

In flexographic (Relief) printing the printing elements i.e., image area are in raised form. When the printing plate is inked, the ink adheres to the raised image area (printing parts) and is then transferred under pressure onto the printing substrate. In flexography a flexible, soft rubber or plastic plate is employed. - see Figure.

Figure 2: Flexography (Relief) printing

The principle on which a flexographic printing unit works is illustrated in figure. The low-viscosity ink is transferred to the printing plate via an anilox roller that is evenly screened with cells, the so-called screen roller/anilox roller (screen width 200–600 lines/cm, ceramic or hardchromed metal surface). The rubber or plastic plate is attached to the printing plate cylinder. Ink is transferred to the printing substrate by the pressure of the impression cylinder. The use of a blade (together with the ink supply system) on the screen roller has a stabilizing effect on the printing process resulting from even filling of the cells on the screen roller.
Using the **flexible (soft) printing plate** and the appropriate ink (low viscosity) for the printing substrate, it is possible to print on a wide range of absorbent and non-absorbent printing substrates. With the rubber plates in exclusive use earlier, only a low to moderate printing quality of solid motifs and rough line drawings could be achieved. For today's higher-quality requirements, especially in the printing of packaging, photopolymer wash-off plates are used, such as “Nyloflex” from BASF and “Cyrel” from DuPont. These allow screen resolutions of up to about 60 lines/cm (150 lines/inch).

### 1.1.A. Flexographic PRINTING Process:

Flexography is a process in which the printing image stands up in relief. Liquid inks are used which may be solvent-based, and dries mainly by solvent evaporation. Water-based inks are also widely used, and UV-cured systems for printing with UV inks are being introduced.

A low printing pressure is essential to the process because of the combination of very fluid inks and soft, flexible printing plates that are used. The process has several distinctive features.
Liquid inks are used that dry rapidly by solvent evaporation, thus enabling fast printing speeds to be achieved on non-absorbent materials such as films and foils.

‘Soft’ and flexible relief printing plates are employed that can be mounted and registered on a plate cylinder and proofs can also be obtained. Individual plates can easily be changed or rectified, and a portion of a plate can be removed to enable items such as price or expiry date to be changed.

The application of ink to the surface of the printing plate is by means of a screened (Anilox) roller. The result is a simple ink feed system that consists of not more than two rollers, or perhaps a single roller and doctor blade(s).

Although most flexographic printing is reel to reel, the machines enable changes in the print repeat length to be made simply.

1.1.B. MAIN SECTIONS OF FLEXOGRAPHY PRINTING MACHINES (PRESSES)

All flexographic presses are made up of four basic sections typically mounted in succession between sturdy side frames.

1. Unwind section
2. Printing section
3. Drying section
4. Rewind section

1. Unwind Section:

Most of the substrates come in the form of roll or webs. Firstly they are fed through infeed draw rolls, which pulls the web into press section. Now the speed of the web and press
speed should be synchronized 'to provide correct tension & register control. If the speed is more in unwind section, it is controlled by unwind breaking. An unwind section may also include a nest of internally heated steel rolls, or the rolls used for infeed tension control may be heated for a secondary purpose. This purpose is to 'open' the surface of heavily glazed or 'tight' papers by preheating, thus rendering the surface more receptive to printing ink. Preheating in this manner is also beneficial with some plastic materials, as it 'normalizes' the web, making it flatter and reducing the tendency to wrinkle.

2. Printing Section:

A single color station with the four essential rolls-fountain roller, inking roller, printing plate cylinder and impression cylinder is sufficient to constitute a press. The majority of printing presses are multi-colour; from two to eight colors in printing section. In some presses these color units are arranged horizontally, in-line, similar to a rotogravure press. Much over common is an arrangement, unique of flexography, in one or more 'stacks', with a single stack of two to four color units, each color unit arranged vertically one above another. An arrangement of color units similar to a rotary letterpress, around a single, large, common impression cylinder is also common. This arrangement is called a central impression (CI) press.

The printing unit consists of the following three basic parts:

a. the inking unit;

b. the plate cylinder;

c. the impression cylinder.

a. Inking Unit:

The function of the inking system is to meter out a fine and controlled film of liquid ink, and apply this to the surface of the printing plate.

It typically consists of an ink trough, a rubber-covered fountain roller, and a screened (Anilox) inking roller into which cells of uniform size and depth are engraved. The fountain roller lifts ink to the nip position, where it is squeezed into the cells in the screened inking roller and by a shearing action, ink is removed from the roller surface. The ink in the cells is then transferred to the surface of the printing plates. To regulate ink film thickness in printing, screened ink (anilox) rollers are available which have screens ranging from 40 to 200 cells/cm. These may be engraved or etched on metal or ceramic. The engraved cells are generally square in shape (although many other shapes are available now) with sloping side walls.

When printing halftones, the cells per centimetre of the anilox roller needs to be about 3.5 times the halftone screen ruling. The number of cells and their size regulate the volume of ink transferred. Further regulation of the ink is achieved by varying the surface speed of the fountain roller, by altering the pressure between the fountain roller and screened roller, and also
by altering the hardness of the rubber covering on the fountain roller. Despite these controllable factors it is still the basic characteristic of the anilox roller which determines the ink supply to the plate. The anilox roller is a crucial factor in achieving good-quality flexo printing.

**b. Plate Cylinder:**

The plate cylinder is usually made from steel. The printing plates, which have a thickness of up to a few millimetres are secured to the cylinder with double-sided self-adhesive material.

**c. Impression Cylinder:**

The impression cylinder is also made from steel. The substrate passes between the plate and impression cylinders, which generate light printing pressure. The ink is transferred from the cells in the screened ink roller to the plate surface, and then to the substrate, during which it reaches virtually a uniform film.

For high-quality flexographic printing the components of the printing unit must be engineered to very tight tolerances (measured in tenths of thousandths of an inch). The ability to manufacture to these standards is one of the factors which has contributed to the growth in flexographic printing, and its use for higher-quality products than was previously possible.

**3. Drying Section:**

The Drying section require an after-drier to remove the remaining solvent from all the colours before the web can be wound into a roll. The drying section may also require between-color driers between printing units on multi color presses to permit the necessary printing of color on color. The removal of solvents can be accomplished in several ways, hot air current being the most common. However revolutionary method of drying are being investigated.

An exhaust system conjunction with the after dryer prevents a build of solvent laden air that might become an explosive hazard: In between color hot air dryers it is essential that the exhaust exist the warm air supply, otherwise the location of these dryers in the very minimal space between color units would result in warm air being blown on to the inking rollers and plate cylinders. Premature ink drying would seriously interfere with the inking of the plates and printing of their image on to the web.

**4. Rewind Section:**

This section is identical to the unwind section in most respects but with some significant differences. It need be nothing more than a shaft in plain bearings holding the winding roll by means of core chucks. However, there is one important difference. The unwind shaft is braked to add necessary tension as the press pulls the web off the roll. The rewind shaft must be driven.

**Drying Systems**
The most common type dryer is the forced hot air system. There are various sources for heating the air but usually it is natural gas. Steam and electric heat exchangers are also used. It is important to define ink drying in order to better understand the function of a drying system. The drying of ink on any substrate is basically the process of attempting to eliminate the solvents from the ink.

Water or solvent molecules are held together by their potential energy bond. These molecules are not static but are always moving at a high speed and colliding with each other.

The higher the temperature of these molecules, the greater their kinetic energy, and the faster their speed of travel. If these molecules can absorb sufficient energy from hot air or other heat sources, it is possible for them to break their potential energy bond and at this point start to evaporate. Once evaporation has started, a new set of conditions arise. The molecules now in a gaseous state, must pass through a laminar layer of air that is present with a moving web. These gas molecules must be removed quickly to prevent their return to the ink surface; and heat and fresh air must be continually fed to the surface to continue the evaporation process. The basic purpose of most drying systems is to induce a faster evaporation rate of the solvents by first heating the solvents, and secondly by continuously supplying a fresh supply of non solvent laden air to the ink surface in order to absorb the evaporating solvents.

Whether the flexographic press be a stack central impression cylinder, or in-line type, all drying systems are designed to dry the ink between each color station as completely as possible before the next layer of ink is applied. After the web has been print it travels to a final drying oven to complete the solvent removal. On earlier drying systems, is was common to use one heat source for heating the supply air, one fan source for blowing the supplying the air to both the between-color and final oven, and one exhaust fan to exhaust the solvent laden air from both the between-color and final oven. Today, dual drying systems are generally used. There is a separate burner, control, and supply fan for both the between-color and the final oven drying section. The advantage of the dual drying system becomes apparent when printing is done on cellophane materials. After the initial trapping at the color station the final oven must perform the added function of providing ink adhesion by fusing the ink to the cellophane coating. This can be accomplished readily in the dual systems by increasing the oven heat.

There are many different styles of between color drying covers, but all aim at delivering the maximum amount of air with the highest possible jet velocity over the longest web travel possible. There is, however, an optimum goal for designing a jet in order to get the maximum heat transfer with high velocity air. This relation is between the air velocity, the jet opening, jet spacing, and the distance of the jets to the web. High velocity air can be defined as air movement that is always higher than 10,000 FPM when measured at a sufficient distance from the jet orifice to simulate the position of the web.

Many presses combine different drying methods. For instance, in the after-oven various temperature and velocity zones may be combined. Also, different heat sources can be
combined for different drying applications. Chill rolls are used to cool the printed web back to room temperature to prevent blocking. Single or multiple rolls in either single wall or double wall construction are presently used. It is also common to cool the non-printed side of the web first.

1.2.A. PRINCIPLES OF GRAVURE PRINTING PROCESS

In this type of printing, the printing areas are in recess - that is, on a lower level than the non-printing surface. The recesses are filled with ink and surplus ink is removed from the non-printing surface by doctor blade. The substrate is then pressed against the printing cylinder to transfer the ink onto it - see Figure. The main examples of gravure printing are Rotogravure printing and, in the area of arts and crafts, copper plate engraving and die-stamping (also security printing).

Gravure is the process which uses the intaglio principle. The shortest ink train is found in the gravure process as the gravure cylinder actually revolves in a bath of ink. The doctor blade removes excess ink, but leaves ink in the thousands of engraved cells in the copper cylinder.
The distinctive feature of gravure printing technology is the fact that the image elements are engraved into the surface of the cylinder. The non-image areas are at a constant, original level. Prior to printing, the entire printing plate (non-printing and printing elements) is inked and flooded with ink. Ink is removed from the non-image (by a wiper or blade) before printing, so that ink remains only in the cells. The ink is transferred from the cells to the printing substrate by a high printing pressure and the adhesive forces between printing substrate and ink.

Rotogravure printing is used for the economical production of long print runs. Gravure printing forms are usually cylindrical. A special feature of industrial rotogravure printing is the fact that a whole cylinder is used per color separation. This means that in a four-color press four separate cylinders have to be changed for each new job. Consequently, a company that has a lot of repeat jobs is forced to store a large number of cylinders. Depending on the printing format, gravure printing cylinders are generally rather heavy and require special conveying and handling gear systems.

1.2A. INTAGLIO / GRAVURE PROCESS

In this process a metal plate usually copper is used as a image carrier. Here, copper etching or hand engraving is carried out to form an image. Ink is applied over the image areas,
excess inks are wiped off. A sheet is laid over the plate and pressure is applied. Ink from recessed area is transferred to paper according to the width and depth of engraved lines.

**Photogravure:**

Photogravure is an intaglio process. Image areas are deeply etched below the surface of the copperised surface of printing cylinder. Liquid ink is filled in the recessed image areas and a doctor blade wipes the surface clean free from surplus ink. The cylinder is pressed on paper or other material for transferring the inked image.

**Gravure Printing:**

Gravure is the photographic version of the original “Intaglio” process and Gravure is a process which follows the intaglio principle.

In Gravure process, the printing image is engraved into a cylinder in the form of cells. The engraved cells are filled with ink and excess ink on the cylinder surface is wiped off by doctor blade. Printing is achieved by passing the substrate between the gravure cylinder and an impression roller under pressure.

![Gravure Printing Unit](image)

**Fig.: Gravure Printing Unit**

Gravure processes has a much wider application than letterpress or offset as it prints, from a low viscosity liquid ink. Coating, varnish, adhesive, hot carbon or anything that will flow on a cylinder can be printed by gravure. Plastic sheeting, curtains, linoleum, upholstery metallic foils, paper and boards can be printed. The finished materials can be passed through in-line machines for punching, cutting, folding, etc. Gravure has advantages in carton making.

Thick film of gold ink can be printed. Deep brilliant glossy solids by the slide of delicate tones of postal shades can be laid down by gravure. Printing with 100, 120, 150, 175, 225, 300 lines screens are possible. Printing using 175 line screen is popular. The greatest etching depth is 1 to 2 / 1,000 of an inch or 25 / 1000 to 50 / 1000 mm. The ratio of cell wall thickness to cell
width 1:2.25 or 1:2.5 for paper and board and 1:3 for solid areas on foil and plastic is recommended. Width increases with cell depth and cell wall becomes thinner. Ink from deep cell spreads more. The dense areas merge into one another screen pattern. Highlight cells accept little ink.

Gravure is popular for picture reproduction. Small type printing is a problem. For type matter rinco process of gravure is popular.

1.2.A. ADVANTAGES, LIMITATIONS (DISADVANTAGES) AND CHARACTERISTICS OF GRAVURE PROCESS

Advantages of Gravure:

1) The final printed images are of excellent visual quality. Due to its intaglio character, the closeness of the printing areas and different thickness of ink, gravure print displays the pleasing effect of a continuous tone image.

2) Photogravure is an exceptionally fast printing method on almost all kinds of paper and materials. Press speed attainable in web-fed presses-paper: 1,000 fpm (Feet Per Minute); Film and foil: 300 to 600 fpm. Sheet-fed presses: 3000 sheets per hour.

3) The printed sheet is usually dried, when it leaves the press, due to the volatility of the fluid ink.

4) Gravure cylinders yield very large number of impressions and under proper handling even yield several millions copies. Chrome-plated copper cylinder can print 1.5 millions revolutions without re-chroming; and can print 12 to 20 million revolutions before making new cylinders, depending on material printed.

5) Rotogravure ink, based on, fluid ink can be formulated for printing on a, variety of printing stocks- paper, paperboard, plastic films, metal foils, textiles, etc.

6) The supplementary operations like cutting, punching, creasing and stripping are done “In-line”, the end product are fabricated at the same speed at which printing press runs.

7) Cheaper paper stock can be used on gravure presses compared with other processes.

8) Quality reproductions at low cost is possible.

9) Large presses with a web width of 144 inch are used for printing of vinyl floor covering.

10) Virtually, there is no make-ready involved while printing on a Gravure press.

Limitations of Gravure:
1) Length of time to prepare and etch a cylinder. Generally, it required between three and four hours from the time resist has been applied to the copper surface until the printing form is ready to be proofed.

2) The high initial cost incurred in the cylinder preparation.

3) Type, Text matter and fine line illustrations do not reproduce as sharply in gravure as it is reproduced in offset chiefly because the rotogravure screen gives a “sawtooth” edge to vertical lines and horizontal lines while using gravure screens.

4) Minimum economical run is said to be 50,000 copies.

5) Once the cylinder has been prepared, very limited alterations or revisions alone can be made without having to prepare a new cylinder.

6) Air conditioning of the plant is necessary due to the inherent nature of the process.

Characteristics:

1) All gravure copy-reading matter as well as pictures must be screened.

2) Generally the gravure cylinder itself is etched and acts as the image carrier.

3) Gravure prints from a design below the surface of the plate or cylinder.

4) Gradations of tone are obtained by etched cells to different depths, so that more or less ink is carried by the cells and transferred to the paper according to their depth.

5) The use of the “Doctor blade” in the printing press (to remove ink from non-printing areas).

6) An interesting possibility of gravure press is the fact that a simple basic principle allows the use of cylinders of different diameters, without complicate changes in the unit gearings.

7) A continuous tone positive is used for exposing on the carbon tissue.

1.2.B. MAIN SECTIONS OF GRAVURE PRINTING MACHINE:

All gravure machines consist of following main sections:

1) Unwind section

2) Printing section

3) Drying section

4) Rewind section
1. Unwind Section:

Most of the substrates come in the form of roll or webs. Firstly they are fed through infeed draw rolls, which pulls the web into press section. Now the speed of the web and press speed should be synchronized to provide correct tension & register control. If the speed is more in unwind section, it is controlled by unwind breaking. An unwind section may also include a nest of internally heated steel rolls, or the rolls used for infeed tension control may be heated for a secondary purpose. This purpose is to ‘open’ the surface of heavily glazed or ‘tight’ papers by preheating, thus rendering the surface more receptive to printing ink. Preheating in this manner is also beneficial with some plastic materials, as it ‘normalizes’ the web, making it flatter and reducing the tendency to wrinkle.

2. Printing Section:

The printing unit of gravure machine consist of following:

a) Ink duct
b) Printing cylinder
c) Doctor blade
d) Impression cylinder

a. Ink duct

In olden days open ink trough was used. There is no control of solvent evaporation and ink is not well agitated, it was unsuitable for high speed machines. Where there is a pump which continuously agitate the ink and pump it to the ink trough in which printing cylinder rotates. Excess ink is returned back to the tank from ink trough.

Due to this enclosed system solvent evaporation is reduced. This enclosed system also employs viscosity control of the ink. In this system whenever the ink is returned from ink trough, it is filtered and solvent is added to maintain the viscosity of ink.

Further to this enclosed inking system a spray system is also used for very high speed machines, where ink pump delivers the ink to nozzles pointing at the cylinder. Due to this cylinder surface is always kept wet. It will never dry out. This system also fully enclosed.

b. Printing Cylinder:

Basically, a gravure press is still the simplest of the printing machines. Publication presses have cylinders as big as 102" with a diameter of about of 17". Generally publication presses are not built to permit inserting of cylinders varying in the diameter.

Presses for package printing can handle cylinder varying in their diameter within a given range. When variable diameter cylinders are customary, the nature of the jobs controls the dimension. Cylinders for packaging vary greatly in size from the very small, about 7" long by 2
or 3 inches diameter up to massive cylinder length of 80" or more long with a diameter of about 17".

Presses with a printing width of 200" (5 meters) and above are used for speciality printing, like printing of vinyl floor covering.

Gravure image carrier

Copper plates

Gravure plates are made from rolled copper. The ends of the plate must be carefully bent to fit in to the clamps on the cylinder. The plate covers only parts of the cylinder circumference since the plate cylinder must house the clamping system. This uncovered section must be filled in with a "gap cover" or "segment" to provide a bearing surface for the doctor blade. These type of presses (using a gravure plate) are fast becoming obsolete.

Copper cylinder

Cylinders can be made of iron, steel, copper or aluminium. Ends are usually fabricated with steel bar and plate, or steel shaft pressed through the cylinder body. Sleeves cylinders are metal tubes housed in the machine on mandrels. It is only necessary to produce a sleeve or tube with this system, for subsequent mounting on a machine mandrel. The sleeve is generally made of steel base and deposited with copper, to a diameter slightly larger than the required size. It is then turned and polished in a lathe to obtain the correct diameter and perfect stage. This system is not recommended for multi-unit web-fed presses and for large-run package printing.
In the Ballard process, a thin skin deposit of copper is loosely adhered to the bulk of the cylinder surface, but is firmly attached at the bar ends. After printing, the copper skin is removed by cutting and then pulling off. The advantages of Ballard process are elimination of grinding of the old etching and allowing exact size cylinders for color works. The thin film of copper is approximately 0.006 inch thick and is deposited in about one and a half hours. This type of cylinder is used for printing of short-run magazine and packing. On an average, to deposit one square foot of copper for 0.001 inch thick, the requirements of copper is 0.74 oz.

Solid (Integral) cylinders are invariably used on web-fed presses. The thickness of the copper deposit varies depending upon the circumference, length and construction of the cylinder. The copper deposit ranges from 0.015 to 0.050 inch thick, and copper is deposited slightly more than the required thickness. Afterwards the cylinder is taken out and brought to the required diameter by turning it on a lathe; then it is polished to a high luster. The accuracy of the cylinder is maintained within a tolerance of $\pm 0.0005$ inches.

c. Doctor blade:

The printing cylinder is flooded with ink and before impression is made on the paper, the excess ink from the cells and on the non-printing surface of the cylinder is removed by the scraping action of a flexible sheet blade, known as “Doctor Blade”. As the cylinder turns, and just before the paper makes contact with it, this doctor blade, made of fine Swedish steel (.008 inch thick) wipes off all the excess ink. The doctor blade, precision ground and hand coned (after use), is held against the cylinder under pressure, and scrapes the cylinder surface absolutely dry.

This doctor blade is assembled in such a way to ride on the surface of the cylinder and remove the surplus ink, without damaging the surface of the printing image area cells. This doctor blade is assembled as near as possible to the nip pressure, to avoid any ink evaporation and drying of ink in cells. Usually the thickness of the blade is 0.15mm to 0.25mm. The main blade is supported by backing blade of 0.76 mm thick.

The doctor blade is usually set in such a angle that must wipe excess ink from the non-image areas. If the blade angle is more steep, it gives cleaner wipe. If the blade angle is shallow it wipes less ink. Blades are ground with a bevel edge and the angle of bevel is one of the factors influencing the printing result. Doctor blades are normally made to reciprocate up to 6cm. The reciprocate action of blade makes better wiping of ink and disperse the paper fibers and any foreign particles.

High speed presses are equipped with pre-doctoring blade. This allows an ink film of 0.5mm to final doctor blade. Due to this pre-doctoring blade pressure on the second (final) doctor blade is reduced and cylinder wear is less, printed results are less affected by speed.

d. Impression roller:
This has a steel core with hard rubber covering to bear the heavy pressure. The rubber covering is of 12-20 mm thickness. Its hardness is from 60° to 100° shore. If the substrate is too rough and more compressible then hard rubber is used. Plastic films are normally printed with soft roll and with low impression pressure.

In general the pressure applied between impression roller and printing cylinder is higher than any other processes. The impression roller is oftenly supported with third roller called "BACK UP" to overcome the impression roller deflection and give sufficient pressure in the center. Another technique is "flexible" roll which can be adjusted to even out the pressure across the width of the web.

Now a days impression rollers are employed with electrostatically assisted ink transfer. To overcome the printing problem “speckle” (individual cells not printing on rough papers and non-compressible papers even if it is coated one). In this special roller during the turning (rotation) high voltage is generated. This electric field encourages the ink to leave the cells and transfer to the paper even the contact is imperfect.

3. Drying Section:

The Drying section require an after-drier to remove the remaining solvent from all the colours before the web can be wound in to a roll. The drying section may also require between-color driers between printing units on multi color presses to permit the necessary printing of color on color. The removal of solvents can be accomplished in several ways, hot air current being the most common. However revolutionary method of drying are being investigated.

An exhaust system conjunction with the after dryer prevents a build of solvent laden air that might become an explosive hazard: In between color hot air dryers it is essential that the exhaust exist the warm air supply, otherwise the location of these dryers in the very minimal space between color units would result in warm air being blown on to the inking rollers and plate cylinders. Premature ink drying would seriously interfere with the inking of the plates and printing of their image on to the web.

4. Rewind Section:

This section is identical to the unwind section in most respects but with some significant differences. It need be nothing more than a shaft in plain bearings holding the winding roll by means of core chucks. However, there is one important difference. The unwind shaft is braked to add necessary tension as the press pulls the web off the roll. The rewind shaft must be driven.
1.3.A. PRINCIPLES OF SCREEN PRINTING PROCESS

**Screen Printing:** In this type of printing, the image and non-image areas are carried on a mesh(woven) screen, the image areas being open or ‘unblocked’ in the form of a stencil. The
non-image areas are formed by ‘blocking out’ the mesh by coating. See Figure. The paper is placed under the screen. After the screen is lowered into contact with the paper, ink is passed across the upper surface of the screen. Where the screen is open, ink goes through to the paper beneath.

Screen printing is an example of the stencil printing process.

Screen printing is a process in which ink is forced through a screen. The screen printing stencil serves as a printing plate. More often than not, the screen is a fine fabric made of natural silk, plastic, or metal fibers/threads. Plastic or metal fabric is generally used nowadays. Ink is imprinted/transferred through the image-specific, open mesh that is not covered by the stencil. The screen printing plate is therefore a combination of screen and stencil.

It is the material, the fineness of the screen (the number of screen threads per centimeter of fabric length), the thickness of the screen, the distance between the top and bottom sides of the screen, and the degree of opening of the screen (the degree of screen opening areas as a percentage describes the ratio of the total of all mesh openings to the entire surface of the fabric) that determine the printing properties and quality of the fabric (screen).

Fabrics can be obtained in levels of fineness from 10 to 200 fibers/cm. The most frequently used fabrics are those between 90 and 120 fibers/cm.

The screen work and printing of very detailed illustrations necessitate the use of very high levels of fabric fineness that are matched to the resolution requirements of print image reproduction. For screen work, fabric fineness (threads/cm) should be around three to four times greater than the screening of the print image (lines/cm) — therefore nine to sixteen different screen dot area surfaces per screen cell.
The stencil on the fabric defines the actual print image. The stencil is on the side of the screen opposite the side on which the squeegee (blade) works, to avoid damage and wear to the stencil. Manual stencils, which can be produced as drawn or cut stencils and transferred to the underside of the screen, are used for simple, solid-area print work.

1.3.A. SCREEN PRINTING PROCESS

Screen printing (formerly called silk-screen printing) is a stencil process whereby ink is transferred to the substrate through a stencil supported by a fine fabric mesh of silk, synthetic fibres or metal threads stretched tightly on a frame. The pores of the mesh are ‘blocked-up’ in the non-image areas and left open in the image area. This image carrier is called the screen.

During printing the frame is supplied with ink which is flooded over the screen. A squeegee is then drawn across it, forcing the ink through the open pores of the screen. At the same time the substrate is held in contact with the screen and the ink is transferred to it. The principle is shown in Fig.

Because of their simplicity, screens can be produced cheaply and this makes it an attractive process for short-run work. Furthermore, since the image is produced through a screen rather than from a surface the impression pressure is very low. This makes it ideal for printing on fragile boxes or awkward shapes.

Irrespective of the type of machine the printing procedure is generally the same. A working supply of ink is placed at one end of the screen and the screen is then raised so that the stock may be fed to register guides or grippers on a base. The screen is then lowered and a rubber or plastic squeegee drawn across the stencil to produce the print. Ink replenishment is undertaken as necessary.

On most flat-bed machines the base to which the substrate is applied is of a vacuum type. This prevents the stock sticking to the screen and being lifted by tacky inks.
To a certain extent the thickness of the ink film printed can be controlled by the pressure, sharpness and angle of the squeegee blade.

The more upright the blade the thinner the deposit of ink. Thus, in general, fine work requires a more upright blade. However, the type of ink, stock and machine govern the blade setting also.

1.3.A. Advantages of Screen Printing Process

One of the major advantages of the screen process is the ability to obtain prints on non-flat objects. For example, printing on bottles or other cylindrical objects is achieved by using a press of the cylinder type described above but the object to be printed is placed in the machine where the impression cylinder is shown. After each impression the bottle is removed and another unprinted one substituted. There are few limitations on size or shape. Special screens and jigs are produced for printing on shaped objects such as cups with handles or tapering cylinders, and screens with high elasticity combined with shaped squeegees are used for conforming to irregular objects. Print heads can also be bolted to automatic production lines, so that printing becomes a part of the total production process of such objects as filled polythene bottles.

1.3.A. APPLICATIONS OF SCREEN PRINTING

i. Screen Printing on Flat Surfaces

Posters and Graphics Printing in Short Print Runs.

Large-format posters in particular can be produced relatively conveniently in fairly small print runs. The quite thick ink film produces coloring that is very brilliant and resistant even with halftone color impressions.

Traffic Routing Systems and Signs. Large printing surfaces for high resistance inks are found with traffic signs and routing systems. The requirements they impose are best met using screen printing.

Vehicle Fittings and Instrument Dials. With vehicle fittings a narrow tolerance range of the translucency of the impression is required in addition to its precision. For example, it must be possible for control lights to light up in precisely defined colors.

Printed Circuit Boards for Electronics. Due to its simplicity and flexibility, screen printing is an important process during the development of printed circuit boards for electronic circuits. Accurate printing onto copper-laminated hard paper or glass-fiber reinforced epoxy board with etching allowance, solder resist, or assembly designations in the necessary coating thickness is only possible in large quantities with screen printing. Restrictions are, however, imposed on the latter as a result of the extreme miniaturization of components and printed circuit boards.
Photovoltaic. Special conductive pastes are used to print on photo resistors and solar cells, which serve as the contact points for current transfer. In doing so, particular importance is placed on high coating thickness in areas that are, at the same time, extremely small and covered with printed conductors, in order to optimize the efficiency of the energy production with the solar cells as fully as possible.

Compact Discs (CD). Screen printing is one of the major processes for printing on CDs. Pad printing and more recently even offset printing are also used.

Textiles. The depth of the ink absorption in textiles calls for a large volume of ink to be supplied and screen printing is the preferable process for applying it. Clothing, canvas shopping bags, webs of material, and so on, can be printed in both flatbed and rotary screen printing.

Transfer Images. Screen printing is frequently used to produce transfer images for ceramic decoration. These images are put together from ceramic pigments for firing. The pigment’s grain size necessitates the use of a screen mesh that is not too fine. After detachment the images are removed from the base material and placed on the preburned bodies by hand. A recognizable feature of these ceramic products is the thick layer of ink. The images can be placed above or below the glazing.

Decorative Products, Labels, Wallpapers. Seamless decorations such as textile webs, wallpaper, and other decorative products, as well as labels often require rotary printing combined with reel material. Special machines are designed for this. Rotary screen printing with sheet material is used primarily for higher print runs (examples are given in sec. 2.4.3).

Surface Finishing. Transparent varnish can also be applied using screen printing technology (for spot varnishing, in particular) to finish the printed product.

ii. Screen Printing on Curved Surfaces

Almost any body that has an even, convex and concave (to a limited extent) not too structured surface can be printed using screen printing. There are virtually no restrictions with regard to the material of the body to be printed on.

Ceramics can be printed directly with screen printing. Ceramic pigment inks can be used for subsequent baking or just a low durability varnish applied to the glazed product.

It is not always possible to print directly onto plastic components. Surface treatment, for example involving flame treatment, corona charging, or the application of primer is often necessary to ensure that the ink adheres.

Bottles. Glass bottles with a baked finish or pretreated plastic bottles for the food and domestic products sector are printed using the screen printing process.

Toys. Toys, such as balls, and so forth, can be printed in full in several operational steps.
Glasses. The screen printing process is often used for drinking glass decoration, with thick coatings of all inks and also gold being applied.

Advertising Media. The type of advertising medium that can be decorated or provided with some other overprinting by the screen printing process ranges from cigarette lighters or ballpoint pens to pocket knives and pocket calculators.

1.3.B. MAIN SECTIONS OF A FLATBED SCREEN PRINTING MACHINE

SCREEN PRINTING PRESSES (MACHINES)

The screen process is one of the major printing methods used by graphic arts industry. In screen process, printing is done by forcing ink through openings in a stencil or photogravure stencil that has been attached to a fabric screen is called screen process printing. Screen Printing process is carried either by hand or manual and power operated presses.

Following are the parts of a screen printing press of hand operated one:
1. Frame
2. Base
3. Screen fabric
4. Squeegee

(1) Frame:
The frame serves as a support for the screen fabric. It can be made from wood, metal or any other rigid material.

   a) Wooden frame:
   Wood used for screen printing should be soft, straight, grained and should resist the moisture and temperature. Wooden frames are easy to handle and assemble. The cost of the wooden frame is less than metal frame. Leveling is also important for wooden frames. Coating the wooden frame by a two-component lacquer protects the wood from water and solvent.

   Pine or popular wood is usually used for making frames. Before making a frame, wood is seasoned. The corners of the frame is joined by miter, end lap, or spline joints. Angle and corner irons are sometimes used to reinforce the corners of a large screen printing frame.

   b) Metal frames:
   Steel is used for screen frames as its rigidity, life is more when comparing the wooden frames. For corrosion protection, steel frames are galvanized or coated with lacquer, sometime with stored varnish. These steel frames are available as rectangular or square section. For easier handling of large frames, steel is replaced by aluminium alloy, but care must be taken in providing rigidity. Also aluminium frames are corrosion proof when comparing steel frames.

   Leveling of metal frames is very important. This leveling is done on a special leveling slab. Twisted or warped frames can cause great trouble in printing and in registering. Before mounting the fabric, sharp edges and pointed corners should be well rounded to avoid the tearing of fabric. Metal frames should be roughened on the adhesive surface or sand – blasted, also it should be thoroughly de-greased with a suitable solvent after roughening.

(2) Base:
This is the surface upon which the substrate to be printed is positioned and held. It is usually made from a thin sheet of plywood or hardboard or table. This is longer than the frame used. Loose-pin built hinges serve to hold the frame and base together.

(3) Screen Fabric:
The screen fabric is a woven material. It is a tightly stretched across the frame. This Screen fabric serves as a carrier for stencil. The selection of fabric for particular work plays a major role. Following are the types of fabrics.
a) Silk:

Silk is a natural fiber produced by the silk worm. Hand cut and indirect stencils adhere well to silk fabrics. However, this silk is not dimensionally stable. Size variation can occur due to change in temperature and humidity. Therefore, silk is unsuitable for jobs requiring critical registration.

(b) Polyesters:

Polyesters such as darcon, Terital and polylast are man-made synthetic materials containing cellulose, resins and hydrocarbons. Polyesters fabrics are woven very uniformly and possess good dimensional stability. They are extremely strong and used for long runs. A major disadvantage is that indirect photographic stencil will not adhere so good as like in silk.

c) Nylon:

Nylon is also a man-made synthetic material having uniformly woven fabrics. This fabric is strong and durable and can be used for long run jobs. Unlike polyesters, nylon fabrics lack dimensional stability. Nylon fabrics will go on stretched and react to temperature & humidity changes. So before mounting a nylon fabric on frames, it should be wet firstly and stretched very taut, to maintain the good registration.

d) Metal fabrics:

These types of fabrics are used for only special application. Unlike the synthetic fabric, it does not absorb moisture and is therefore unaffected by changes in humidity. Also it is unaffected by temperature. As it has very good dimensional stability it is used for very precision printing like printed circuit board or very specialized application. Usually “Stainless Steel wire” is used as a metal fabric.

Stainless steel will retain its tension almost indefinitely, where as all synthetic meshes show a tendency to lose tension with use. Also stainless steel mesh allow more volume of ink to pass through. As it is electrically conductive it can be used for printing thermoplastic inks. Stainless steel screen printing fabrics are more expensive than synthetic material.

(4) Squeegee:

The squeegee performs a very important function in screen printing. It is used to force the ink through the screen mesh and stencil on to the printing stock below. Squeegee blades are made from high quality natural rubbers and synthetic material. Polyurethane squeegee blades are now-a-days used widely due to their resistance property to abrasion so there is no need for sharpening or reshaping.

Squeegees are normally supplied in three grades: Hard, Medium, Soft. The hard and medium grades are used for printing thin film inks, the soft grade is used for printing on to non-
absorbent materials such as metal & glass. During the printing action the squeegee is moved across the screen and force the ink to pass through the mesh opening.

**ADDITIONAL RELATED TOPICS**

**ADVANTAGES AND LIMITATIONS (DISADVANTAGES) OF PRINTING PROCESSES**

**Flexography Printing**

- **Advantages**
  - Changes to plates can be made relatively easily and cheaply, by just replacing the required parts of the overall image areas
  - Ideally suited to printing reel/web-fed substrates with in-line press finishing
  - An environmentally friendly process as it tends to use few chemicals, in fact is often operated as an entirely water-based process in terms of consumables, such as plate processing, inks and cleaning fluids
  - Simple, generally easy to use process
  - Variable cylinder cut-offs allow greater flexibility on the length of images that can be printed.

- **Limitations (Disadvantages)**
  - Cannot print screen halftones as fine as offset printing, requiring a smooth to coated stock to reproduce good screen detail
  - Not economic for sheet-fed printing, therefore unsuitable for short-run general commercial printed products such as booklets and leaflets
  - Although print quality has improved considerably in recent years, it is still not as high as offset lithography.

**Gravure Printing**

- **Advantages**
  - A printing process giving full colour values in reproduction, with rich tonal effects, particularly in monochrome
  - High production speeds is of great advantage in periodical, magazine, catalogue and colour supplement work printing, where very long runs are often required
  - High quality printed results, especially in colour work, on relatively inexpensive grades of substrates which cannot be matched by other printing processes
  - Variable cylinder cut-offs allow much more flexibility on available pagination range for publications compared to heat-set offset litho.

- **Limitations (Disadvantages)**
Printing cylinders very expensive
Alterations to plates or cylinders impracticable
Type matter and fine-line detail is broken up by the overall cell structure
Make-ready / set-up costs expensive, which along with high costs of printing cylinders makes gravure unsuitable for short- or medium-sized run jobs.

Screen Printing

- **Advantages**
  - Suitable for short runs multi-colour jobs.
  - Low preparatory costs
  - Light colours can be printed satisfactorily on dark materials or deep colours
  - Ideally suited for printing showcards, posters and unusual & irregular materials such as heavy gauge metal, plastic, glass, etc
  - Lays down the heaviest ink film thickness of all the printing processes, resulting in enhanced results such as very high gloss varnishing and raised printing results when required.

- **Limitations (Disadvantages)**
  - Halftone subjects are limited to coarse screens
  - Although automatic presses are now available, the process is still in the main restricted to short-run work
  - Conventional inks requires some considerable time, plus use of space consuming racking, to allow the work to dry, leading to the increased use of UV inks.

**VISUAL CHARACTERISTICS OF THE PRINTING PROCESSES**

It is undoubtedly a considerable asset to be able to determine with reasonable accuracy the printing process or processes by which an item of printed matter has been produced.

There are a number of characteristics or clues which, if they can be discerned, make identification of the process possible, but not necessarily simple. Indeed, there are some jobs where it is very difficult to identify the relevant process or processes, even to those having considerable experience, and the use of a powerful magnifying glass or ‘linen tester’ is of considerable value.

*Figure 5* and the comments which follow have been prepared to assist in this process.

**Offset Printing**
GRAVURE, FLEXO AND SCREEN PRINTING

BASIC PRINCIPLES

- Overall, smooth and even printed result
- Very wide range of substrates including coarse textures, can be satisfactorily printed, even when very fine halftone illustrations are reproduced
- Tonal effects obtained by the use of mechanical tints or halftones.

Flexography Printing

- Thickening of design under pressure, along with a general outline to the printed areas in the form of a visible halo, especially around the outer edges
- Tonal effects obtained by the use of mechanical tints or halftones
- Fine-screen halftones must have substrate with a coated surface
- Printed samples often obtained from processed material in reel-form such as self-adhesive labels, plastic and paper wrappings.

Letterpress Printing

- Thickening of design under pressure, along with a general outline to the printed areas in the form of a visible halo, especially around the outer edges
- Slight embossed effect usually detectable on reverse of sheet, especially with sheetfed printing.
- Tonal effects obtained by the use of mechanical tints or halftone dot
- Fine-screen halftones must have substrate with a coated surface.

Gravure Printing

- Wide range of tonal values is possible, giving an effect of continuous tone-like quality (especially in four-colour process work)
- Because of the screen pattern or cell structure, which appears over the whole of the printed image, fine-line work and text matter appear rough/broken at the edges when examined with a magnifying glass
- Under a magnifying glass the ‘screen pattern’ in conventional gravure is seen to be of a regular square formation (showing uniform cells).

Screen Printing

- Thickness of ink film is usually more apparent than in other processes, especially where solid colours are printed upon one another.
- Because of the use of relatively coarse screen meshes, forming the support for the stencil, small lettering and fine-line work tends to break up round the edges and this can be identified when examined with a magnifying glass.
Halftone subjects are generally reproduced with a fairly coarse screen, although with water-based UV inks 54 lpc (in excess of 133 lpi) resolution is now possible.

**JOB SUITABILITY**

**SUITABILITY OF PRINTING PROCESSES TO DIFFERENT CLASSES OF WORK**

Each of the printing processes has particular properties, characteristics and associated costs which make it more suitable for certain classes of work than others.

It has to be acknowledged, however, that there is a considerable amount of common ground where two or more printing processes may regularly be used to produce a certain printed product - eg - books printed by offset litho, flexography and letterpress, newspapers by offset litho (cold-set) and flexography, reel-fed labels by flexography and letterpress, periodicals printed by sheet-fed, heat-and cold-set web offset, also web-fed gravure.

The comments made below are given as a general guideline rather than a definitive statement on the suitability of different printing processes to different classes of work.

**Flexography Printing**

This is predominantly a reel/web-fed process, suited mainly to specialist or niche printed markets such as reel-fed labels, newspapers, flexible packaging such as food wrappings, carrier bags and rigid packaging such as cartons and collapsible corrugated cases.

**Gravure Printing**

**Sheet-fed Gravure printing**

Suited to specialist work such as printing on metallised and other substrates to produce high quality decorative effects in gold, silver and fluorescent colours.

**Web-fed Gravure printing**

This main application covers a wide range of general commercial products. Gravure is especially suited to work in four-colour process on relatively cheap, smooth mechanical papers in quantities of 250,000 or more, such as magazines, mail order and catalogues. In addition there are a wide range of specialist products such as security printing including stamps and cheques; board packaging products such as folding box cartons for food and cigarette industries, also printed video cases; flexible packaging such as printed cellophane and polythene used in food wrapping, display and protection.

**Screen Printing**

**Sheet-fed Screen printing**

As the process is best known for its ability to print a thicker ink film than any other printing process this makes it ideal for printing light coloured inks on dark coloured materials, also onto awkward, rough surfaces, uneven and moulded shape surfaces. Examples include
posters, showcards, printed circuits, T-shirts, printing on cloth, vinyl, metal, glass and plastic, etc.

**Rotary/web-fed Screen Printing**

Specialist area of the process used for self-adhesive labels, scratch-off lottery tickets, packaging, transfer printing, fabric printing, security printing, direct mail and high quality greetings cards with die-cutting and additional finishing requirements.
1. Name the printing process which utilizes intaglio principle.
   Gravure printing process

2. What is direct printing process?
   If the image is directly transferred from the image carrier to the substrate, then it is called direct printing process.
   **Eq:** Letterpress, Flexo Gravure & Screen printing process are direct printing processes.

3. State the functions of doctor blade in gravure printing. / What is doctor blade?
   Doctor blade is a thin, flexible steel, plastic or composite blade that passes over gravure cylinder to wipe off excess ink before impression is made on to the substrate.

4. What is the image carrier used in Gravure printing?
   Copper Cylinder

5. How do flexo and gravure inks dry?
   Flexo and gravure inks dry by evaporation of solvents.

6. Name the main sections of gravure printing machine.
   i. Unwind section,
   ii. Printing section - Gravure cylinder, Ink Trough, Doctor Blade, Impression Roller,
   iii. Dryer section,
   iv. Rewind section.

7. What is the earlier name of flexography printing process?
   Aniline printing process

8. State the purpose of anilox roll in flexo printing machine. / What is anilox roller?
   Anilox roll is a mechanically or laser engraved metering roll used in flexo presses to meter a controlled film of ink from the fountain roller to printing plates.

9. Name the main components of Flexography printing unit.
   Ink fountain roller, Anilox roller, Plate cylinder, Impression cylinder.
10. Name the main sections of flexography printing machine.
   i. Unwind section,
   ii. Printing section - Fountain roller, Anilox roller, Plate cylinder, Impression cylinder,
   iii. Dryer section
   iv. Rewinding section.

11. What is the principle of Screen printing process?
   In this type of printing, the image and non-image areas are carried on a mesh (woven) screen, the image areas being open in the form of a stencil. The non-image areas are formed by ‘blocking out’ the mesh by coating. The paper is placed under the screen. After the screen is lowered into contact with the paper, ink is passed across the upper surface of the screen. Where the screen is open, ink goes through to the paper beneath.

12. Name the various frames used for screen printing process.
   Wooden frame, Metal frame

13. State the different fabric materials used for screen printing.
   Silk, Polyester, Nylon, Metal fabrics

14. What is the function of squeegee?
   Squeegee is used to force the ink through the screen mesh and stencil on to the printing stock kept below.

15. What is the earlier name of screen printing process?
   Silk screen printing

16. Name the major printing processes.
   Offset, Letterpress, Flexography, Gravure and Screen printing processes.

17. Write briefly the principles of Gravure Printing process.
   In this type of printing, the printing areas are in recess - that is, on a lower level than the non-printing surface. The recesses are filled with ink and surplus ink is removed from the non-printing surface by doctor blade. The substrate is then pressed against the printing cylinder to transfer the ink onto it. The main examples of gravure printing are Rotogravure printing and, in the area of arts and crafts, copper plate engraving and die-stamping (also security printing).

18. What is Intaglio printing?
   In this process a metal plate usually copper is used as a image carrier. Here, copper etching or hand engraving is carried out to form an image. Ink is applied over the image areas,
excess inks are wiped off. A sheet is laid over the plate and pressure is applied. Ink from recessed area is transferred to paper according to the width and depth of engraved lines.

19. What is ESA?
Nowadays impression rollers are employed with electrostatically assisted (ESA) ink transfer. To overcome the printing problem “speckle” (individual cells not printing on rough papers and non-compressible papers even if it is coated one). In this special roller during the turning (rotation) high voltage is generated. This electric field encourages the ink to leave the cells and transfer to the paper even the contact is imperfect.

20. State briefly the construction of gravure cylinder.
Basically the gravure cylinder is made up of steel. Over the steel core cylinder, a nickel layer coating of 1 to 3 µm is applied. Then the cylinder receives a base copper layer of 1-2 µm. Then the application of another layer i.e., engraved copper layer of 80 to 320 µm is applied over the base copper layer.

*Construction of Gravure Cylinder*

21. What are the characteristics of prints produced from gravure printing?
- Because of the screen pattern or cell structure, which appears over the whole of the printed image, fine-line work and text matter appear rough/broken at the edges when examined with a magnifying glass.
- Wide range of tonal values is possible, giving an effect of continuous tone-like quality (especially in four-colour process work).
- Under a magnifying glass the ‘screen pattern’ in conventional gravure is seen to be of a regular square formation (showing uniform cells).
- The final printed images are of excellent visual quality. Due to its intaglio character, the closeness of the printing areas and different thickness of ink, gravure print displays the pleasing effect of a continuous tone image.
22. Describe briefly the principles of Flexography printing process.

In flexographic (Relief) printing the printing elements i.e., image area are in raised form. When the printing plate is inked, the ink adheres to the raised image area (printing parts) and is then transferred under pressure onto the printing substrate. In flexography a flexible, soft rubber or plastic plate is employed.

23. How is the ink metering done by Anilox roll in flexographic printing?

A screened (Anilox) inking roller into which cells of uniform size and depth are engraved. The fountain roller lifts ink to the nip position, where it is squeezed into the cells in the screened inking roller and by a shearing action, ink is removed from the roller surface. The ink in the cells is then transferred to the surface of the printing plates.

24. Explain briefly the principles of Screen printing process.

Screen Printing: In this type of printing, the image and non-image areas are carried on a mesh(woven) screen, the image areas being open or ‘unblocked’ in the form of a stencil. The non-image areas are formed by ‘blocking out’ the mesh by coating. The paper is placed under the screen. After the screen is lowered into contact with the paper, ink is passed across the upper surface of the screen. Where the screen is open, ink goes through to the paper beneath.

GLOSSARY

Aniline

The former term for flexography; the name was derived from aniline dyes obtained from coal tar (an obsolete technology).

Dancer Roll

A web-tensioning device in the form of a roller that uses weights or springs which monitors web tension by controlling the unwind brake or rewinding tension.

Driving Side

That side of a flexographic press on which the main gear train(s) are located; also gear side; opposite of operating side.

Dryer

That auxiliary unit of a flexographic printing press through which the printed web travels and is dried prior to rewinding. Drying units are placed as required between color stations.

Gravure

A printing process in which the image area is etched below the surface of the printing plate. The ink is carried below the printing surface in small wells or lines etched or scribed into a
metal plate. The surface of the plate is wiped clean so nonimage areas carry no ink and the image is transferred directly to the paper by means of pressure.

Infeed

A mechanism designed to control the forward travel of the web into the press.

In-Line Press

1. A press coupled to another operation such as a bag making, sheeting, diecutting, creasing, etc;
2. A multicolor press in which the color stations are mounted horizontally in a line.

Intaglio

An engraved or etched design which is below the surface as cells in an anilox roll or gravure cylinder.

Letterpress

A method of printing that uses hard-relief plates as an image carrier. The image area of the plate, raised above the nonprinting area, receives the ink and is then transferred directly to the substrate.

(Extra Questions) – 3/4/6 marks

1. Write briefly about the image carriers used for gravure printing.
   
   Gravure image carrier
   
   Copper plates
   
   Gravure plates are made from rolled copper. The ends of the plate must be carefully bent to fit in to the clamps on the cylinder. The plate covers only parts of the cylinder circumference since the plate cylinder must house the clamping system. This uncovered section must be filled in with a "gap cover" or "segment" to provide a bearing surface for the doctor blade. These type of presses (using a gravure plate) are fast becoming obsolete.

   Copper cylinder
   
   Cylinders can be made of iron, steel, copper or aluminium. Solid (Integral) cylinders are invariably used on web-fed presses. The thickness of the copper deposit varies depending upon the circumference, length and construction of the cylinder. The copper deposit ranges from 0.015 to 0.050 inch thick, and copper is deposited slightly more than the required thickness. Afterwards the cylinder is taken out and brought to the required diameter by turning it on a lathe; then it is polished to a high luster. The accuracy of the cylinder is maintained within a tolerance of + or – 0.0005 inches. (In the cylinder, image areas are on a sunken (lower) level than the non image areas).
2. Write notes on doctor blade.

The printing cylinder is flooded with ink and before impression is made on the paper, the excess ink from the cells and on the non-printing surface of the cylinder is removed by the scraping action of a flexible sheet blade, known as “Doctor Blade”. As the cylinder turns, and just before the paper makes contact with it, this doctor blade, made of fine Swedish steel (.008 inch thick) wipes off all the excess ink. The doctor blade, precision ground and hand coned (after use), is held against the cylinder under pressure, and scrapes the cylinder surface absolutely dry.

3. Write notes on dryers in flexographic presses.

The Drying section require an after-drier to remove the remaining solvent from all the colours before the web can be wound in to a roll. The drying section may also require between-color driers between printing units on multi color presses to permit the necessary printing of color on color. The removal of solvents can be accomplished in several ways, hot air current being the most common. However revolutionary method of drying are being investigated.

An exhaust system conjunction with the after dryer prevents a build of solvent laden air that might become an explosive hazard: In between color hot air dryers it is essential that the exhaust exist the warm air supply, otherwise the location of these dryers in the very minimal space between color units would result in warm air being blown on to the inking rollers and plate cylinders. Premature ink drying would seriously interfere with the inking of the plates and printing of their image on to the web.

4. Write notes on screen fabrics used for screen printing.

Screen Fabric:

The screen fabric is a woven material. It is a tightly stretched across the frame. This Screen fabric serves as a carrier for stencil. The selection of fabric for particular work plays a major role. Following are the types of fabrics.

a) Silk:

Silk is a natural fiber produced by the silk worm. Hand cut and indirect stencils adhere well to silk fabrics. However this silk is not dimensionally stable. Size variation can occur due to change in temperature and humidity. Therefore silk is unsuitable for jobs requiring critical registration.

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5. State the functions of squeegees in screen printing.

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6. What are the applications of screen printing process.

Sheet-fed Screen printing

As the process is best known for its ability to print a thicker ink film than any other printing process this makes it ideal for printing light coloured inks on dark coloured materials, also onto awkward, rough surfaces, uneven and moulded shape surfaces. Examples include posters, showcards, printed circuits, T-shirts, printing on cloth, vinyl, metal, glass and plastic, etc.

Rotary/web-fed Screen Printing

Specialist area of the process used for self-adhesive labels, scratch-off lottery tickets, packaging, transfer printing, fabric printing, security printing, direct mail and high quality greetings cards with die-cutting and additional finishing requirements.
PART - B: 12 Marks Questions

1. Describe the principles of Gravure printing process with suitable diagrams.
2. Explain the principles of flexographic printing process with necessary sketches.
3. Explain the principles of screen printing process with suitable diagrams.
4. Describe the main sections of Gravure printing machine with sketches.
5. Explain the main sections of Flexographic printing machine with diagrams.
6. Describe the main sections of screen printing machine with necessary sketches.