

Polymer Science

Coatings and Adhesives

Technology of printing inks

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Introduction

Inks occupy an integral and versatile position in our daily lives. Our day begins on sleepy note with newspapers and toiletries to breakfast table which is replete with several ink-labelled, packaged consumer products such as tea or coffee, bread, butter and then gradually moving to our work places –schools or offices which have myriad ink laden products be it books, calendars, photocopies, computer prints, stamps or even money, ink is found everywhere. Generally, ink is an organic or inorganic pigment or dye dissolved or suspended in a solvent. However, chemically, it is viewed as a colloidal system of fine pigment particles, coloured or uncoloured, dispersed in an aqueous or organic solvent.

The first inks were reportedly fruit or vegetable juices; protective secretions from cephalopods such as squid, cuttlefish, and octopus; blood from some types of shellfish; and tannin from galls, nuts, or bark from trees. It is believed that the appearance of the first man made ink dates back to 4,500 years in Egypt, which consisted of a mixture of animal or vegetable charcoal (lampblack) and glue [1,2]. The earliest black writing inks, developed before 2500BC, were suspensions of carbon, usually lampblack, in water stabilised with a natural gum or materials like egg albumen [3]. Modern inks are complex formulations. Along with the pigment, they also contain some additional ingredients collectively known as 'vehicle' in varying levels. These exemplify pH modifiers, humectants to retard premature drying, polymeric resins to impart binding and allied properties, defoamer/antifoaming agents to regulate foam efficiency, wetting agents such as surfactants to control surface properties, biocides to inhibit the fungal and bacterial growth that lead to fouling, and thickeners or rheology modifiers to control ink application [3]. Thus, in other words, printing of one form or the other another has been there with us for centuries; while the primary functions of decoration and information remain same, the technologies of both the printing process and the ink formulations have changed considerably.

Today's inks comprise two classes: printing and writing inks. The former is further broken down into two subclasses: ink for conventional printing, in which a mechanical plate comes in contact with or transfers an image to the paper or object being printed on; and ink for digital nonimpact printing, which includes ink-jet and electrophotographic technologies. Over 90 per cent of inks are printing inks, in which colour is imparted by pigments rather than the dyes used in writing inks. Color printing inks primarily consist of linseed oil, soybean oil, or a heavy petroleum distillate as the solvent (called the vehicle) combined with organic pigments made up of salts of nitrogen-containing compounds (dyes), such as yellow lake, peacock blue, phthalocyanine green, and diarylide orange. Inorganic pigments (used to a lesser extent) in printing inks include chrome green (Cr_2O_3), Prussian blue ($\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$), cadmium yellow (CdS), and molybdate orange. White pigments, such as titanium dioxide, are used either by themselves or to adjust characteristics of color inks. Black ink is made using carbon black. Most red writing inks are a dilute solution of the red dye eosin. Blue colour can be obtained with substituted triphenylmethane dyes. Many permanent writing inks contain iron sulfate and gallic and tannic acids as well as dyes. Ballpoint ink is usually a paste containing 40 to 50 per cent dye.

White inks usually contain titanium dioxide -rutile and anatase in tetragonal crystalline form as the pigment. However, known toxicity of heavy metals have led to the replacement of many inorganic pigments such as chrome yellow, molybdenum orange and cadmium red with organic pigments, which offer better light fastness and reduced toxicity out of growing health and environmental concerns. Spinel black, rutile black and iron black in nearly all black inks have been replaced by carbon black. Inks also contain additives such as waxes, lubricants, surfactants, preservatives, wetting and drying agents to aid printing and to impart any desired special characteristics. Other inorganic materials such as clays serve as fillers or extenders, which primarily reduces the cost of pigments, though some also improve ink properties. Metallic pigments like aluminium powder (aluminium bronze) and copper-zinc alloy powder (gold bronze) are used in novel silver and gold inks. Miscellaneous inorganic pigments provide luminescent and pearlescent effects. The major classes of printing processes are lithography or the offset process, flexography, gravure printing, screen-printing, letterpress and digital printing. The composition of printing inks depends on the type of printing process - specifically, how the ink distribution rollers are arranged in the printing press.

The principle of printing can be illustrated by simple pad operation where liquid ink is used which can wet the pad. A rubber type is first dipped in the pad, it gets wet with ink. It is now pressed against the substrate, e.g., paper and its impression is produced on the substrate. This ink should remain in liquid form when in the pad; however, it should dry fast when it has been cast over the substrate to be printed. The various printing processes differ in the way the type is impregnated with the ink, although digital printing does not involve movable types. Each process therefore demands ink that differs in its viscosity and drying efficiency, which is possible by fine-tuning the composition. Before studying each process it is important to gain a general understanding about the basic raw materials and processes involved in printing ink manufacture.

Historical Background

In about 2500BC, writing inks were first manufactured in both ancient Egypt and China. They basically consisted of paste of soot bound with gums which was formed into rods and dried, then mixed with water immediately before use. About 3000 years later, printing was invented by Chinese who used a mixture of coloured earth, soot and plant matter for pigments, again mixed with gums as a binder. The first printing press with a movable type was first invented by Johannes Guttenberg in 1440. Here, the ink was bound with either linseed or varnish materials similar to those used for black inks today. In 1972, coloured inks appeared followed by drying agents in nineteenth century.

Today's printing inks are composed of a pigment (one of which is carbon black similar to soot used in 2500BC), a binder (an oil, resin or varnish), a solvent and various additives such as drying and chelating agents. The exact recipe for given ink depends on the type of surface that it will be printing on and the printing method that will be used. Inks have been designed to print on a wide range of surfaces from metals, plastics and fabrics to papers. The various printing methods are all similar- ink is applied to a plate/cylinder made of metal or rubber, which is further applied to the surface to be printed. the image can be raised up above the surface of the

plate, in the plane of the plate but chemically treated to attract the ink or etched into the plate and the excess ink scraped off. Different inks are produced to suit these different conditions.

Raw Materials for Printing ink formulations

The raw materials for ink production are pigments, binders, solvents and additives [4].

Pigments- colour the ink and make it opaque

Resins- bind the ink together into a film and bind it to the surface

Solvents- make the ink flow so that it can be transferred to the printing surface

Additives- alter the physical properties of the ink to suit different situations

Pigments: Pigments are considered to be the chief constituent of ink and contribute about 50 per cent of its cost. A pigment is essentially any particulate solid - coloured, black, white or fluorescent - that alters the appearance of an object by the selective absorption and/or scattering of light. It occurs as a colloidal suspension in ink and retains a crystal or particulate structure throughout the colouring or printing process. Colour Index System number is generally used to identify the organic pigments in modern inks. It reflects the colour shade or hue, and structural and chronological details (order of synthesis) of the pigment. For example the well-known blue pigment copper phthalocyanine blue is PB 15. As the particle size reduces, the colour intensity (strength) of a pigment increases and the opacity peaks around a particle size of 0.3 μ m. The molecular structures of four important pigments used in ink are shown in Fig.1.

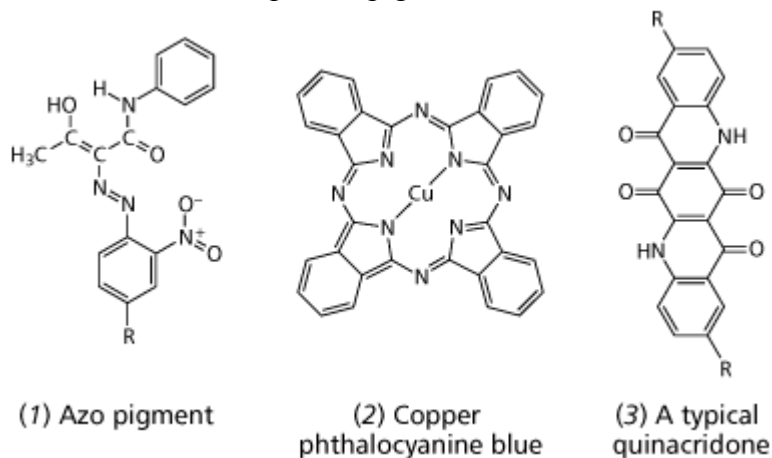


Fig. 1 Pigments used in inks

Pigments colour the ink and provide gloss, abrasiveness and resistance to light, heat, solvents, etc. Special pigments such as extenders and opacifiers are also used. Extenders are transparent pigments that make the colours of other pigments appear less intense, and opacifiers are white pigments, which make the paint opaque so that the surface below the paint cannot be seen.

Resins: Resins are primarily binders that bind the other ingredients of ink together so that it forms a film; they also bind the ink to paper. They also contribute gloss, resistance

to heat, chemicals and water. More than one resin is typically used in an ink formulation. The most commonly used resins are listed in Table 1.

Table 1. Common resins used in ink formulations

Acrylics	Ketones	Epoxides	Polyvinylbutyral
Alkyds	Maleics	Fumarics	Polyamides
Cellulose derivatives	Formaldehydes	Hydrocarbons	Shellac
Rubber resins	Phenolics	Isocyanate free polyurethanes	

Solvents: These are used to keep the ink in liquid form from the period when it is applied to the printing plate or cylinder until when it has been transferred to the surface to be printed. At this point the solvent separates from the ink to allow the image to dry and bind to the surface. Some printing processes such as gravure and flexographic require a solvent that evaporates rapidly (Table 2).

Table 2. Printing ink solvents

Solvent	Boiling point (°C)
Ethyl acetate	77
Isopropanol	82.5
n-propyl acetate	101.6
Cyclohexanone	155.6
Butoxyethanol	171-172
Aromatic distillates	240-290
Butyrolactone	89 (Boiling point at 12 torr)

High boiling point ($T_b=240^{\circ}\text{C}$ - 320°C) hydrocarbons are chosen as solvents for lithographic inks as the solvents used must be viscous and hydrophobic. Screen printing inks need to have solvents with moderately high boiling points (Table 3).

Table 3 Formulations of different types of inks for different substrates

Contents (function)	Amount (%w/w)
<u>Letterpress ink for newspaper</u>	
carbon black (black pigment)	13.00
9 poise mineral oil (wetting agent)	68.00
0.5 poise mineral oil (wetting agent)	10.00
asphaltum solution	5.00
280-320°C petroleum distillate (solvent)	2.00
<u>Lithographic ink for paper</u>	
organic pigment (colour)	18.00
quickset varnish	40.00
gloss varnish	15.00
fast setting varnish	15.00

polyethylene wax paste (prevents damage to the film against rubbing)	5.00
anti set-off paste	3.00
cobalt/manganese driers (catalyst for drying oil oxidation)	1.00
280-320°C petroleum distillate (solvent)	3.00

Flexographic ink for polyethylene film

titanium dioxide (white pigment and opacifier)	35.00
alcohol soluble nitrocellulose (resin)	5.00
alcohol soluble polyamide (resin)	15.00
dibutyl phthalate (plasticiser)	1.00
polyethylene wax (prevents damage to the film against rubbing)	1.00
amide wax (prevents damage to the film against rubbing)	1.00
ethanol (low b.p. solvent)	30.00
n-propyl acetate (low b.p. solvent)	8.00
n-propanol (low b.p. solvent)	4.00

Gravure ink for paper

C.I. pigment red 57:1 (red pigment)	10.00
alcohol soluble nitrocellulose (resin)	20.00
ketone resin (resin)	10.00
dioctyl phthalate (plasticiser)	2.00
polyethylene wax (prevents damage to the film against rubbing)	1.00
ethanol (low b.p. solvent)	30.00
n-propyl acetate (low b.p. solvent)	20.00
ethoxy propanol (low b.p. solvent)	7.00

For letterpress printing on corrugated boxes

(water reducible red)

Blance Fixe (CI Pigment White 21)	10.00
Rutile titanium white (CI Pigment White 6)	5.00
Lake red C	14.00
Varnish	54.00
Diethylene glycol	8.00
Wax paste	5.00
Amine	4.00

Varnish	
High acid value	
Maleic resin	50.00
Glycol	40.00
Amine	10.00

Black ink**(as per British Standard for letterpress inks –BS3020:1959)**

Calcium 4B toner (CI Pigment Red 57.2)	15.00
Polyethylene wax paste	3.00
Cooked quick-set vehiclea	32.5
Gloss quick-set vehicleb	28.0
Cobalt/manganese Drier	0.5
280-320°C distillate	20.0
Antioxidant	1.0

Typical formulation of an offset litho gold**suitable for sheet-fed printing on to paper and board**

Bronze lining pastea	50.0
Metallic quickset vehicleb	41.5
Cobalt driers	1.00
PE wax paste	7.5

Typical formulation for lithographic inks**for foil boards and plastic sheets**

Phthalocyanine green (OI Pigment Green 7)	20.0
Oxidation drying Vehiclea	70.0
Micronised PE wax	3.0
Micronised PTFE wax	1.0
Cobalt driers	3.0
Manganese driers	1.0
Alkali-refined linseed oil	2.0

Additives: Additives are used to alter the final properties of the formulation. These include:

- (i) Plasticisers, which enhance the flexibility of the printed film; e.g., Dibutyl phthalate
- (ii) Wax, which promotes rub resistance; e.g., Carnuba-an exudate from the leaves of *Copernicia prunifera* consisting of esters of hydroxylated unsaturated fatty acids with at least twelve carbon atoms in the acid chain
- (iii) Drier, which catalyses the oxidation reaction of inks that dry by oxidation; e.g., Salts or soaps of cobalt, manganese or zirconium
- (iv) Chelating agent, which increases the viscosity of the ink (aluminium chelate) and promotes adhesion (titanium chelate)
- (v) Antioxidant, which delays the onset of oxidation polymerization by reacting with free radicals formed during the autooxidation thus preventing them from reacting further; e.g., eugenol
- (vi) Surfactants, which improve wetting of either the pigment or substrate. They act as stabilizing agents for pigment dispersion
- (vii) Alkali, which controls the viscosity/solubility of acrylic resins in water based inks, e.g., monoethanolamine
- (viii) Defoamer, which reduces the surface tension in water based inks so that stable bubbles cannot exist; e.g., hydrocarbon emulsions
- (ix) Humectants retard premature drying

(x) pH modifiers (usually amine derivatives) and biocides and bacteriostats

Manufacturing Process

The process involves two stages: (i) varnish preparation and (ii) dispersal of pigments

(i) Varnish preparation: Varnish is principally a mixture of solvent, resins and additives. It exists as a clear liquid that solidifies as a thin film, wets the pigment particles and binds the pigment to the printed surface. There are two main types of varnishes-oleoresinous and non-oleoresinous; the former incorporates a drying oil such as linseed oil and is manufactured at much higher temperatures and under vigorous conditions than the latter.

(a) Oleoresinous varnish manufacture: This process occurs in closed kettles where the oil and solvent are heated to allow for rapid solutioning or transesterification at the temperatures ranging from 120°C-260°C for a few minutes to several hours. The rate of temperature change, maximum temperatures attained and cooking times have to be closely monitored. The whole set-up is equipped with a condensor to prevent the loss of solvent; nitrogen atmosphere is maintained to exclude the atmospheric oxygen, which may cause polymerization of drying oil.

(b) Non-oleoresinous varnish manufacture: These are simple resin solutions that do not require high temperatures during manufacture. The process usually involves breaking up the resin particles and dissolving them in a solvent in either a cavitation or a rotor/stator mixer. Cavitation mixers contain a saw tooth disc on a driven shaft and are used to produce high viscosity resin solutions. They can operate at variable speeds. Rotor/stator mixers operate at a fixed speed; the varnishes obtained here are of lower viscosity since the agitation in the mixer is less.

(ii) Dispersal of pigments: After the manufacture of varnish, the next step involves mixing or dispersal of pigments into it. Here, it is essential to observe that the pigment particles do not clump together. If the clumps are formed these have to be broken up with the help of some specially designed equipments for even dispersal of pigments throughout the resin. The choice of particular equipment is governed by the tackiness and rheology of the ink. There are three different types of equipments as discussed below.

(a) Three roll mills: It mainly consists of a series of rollers rotating in opposite directions. The pigment particles are to be fed into a hopper above the two rear-most rollers and are dispersed by the shear forces between the rollers (Fig. 2).

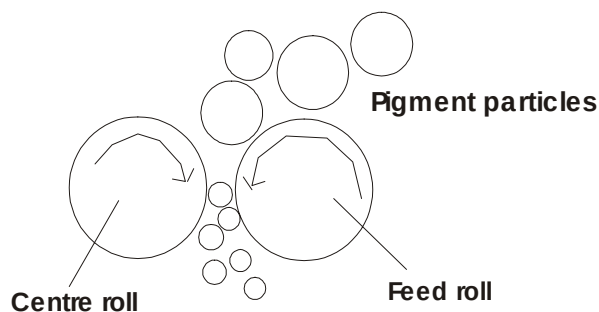


Fig. 2 Pigment particles entering a three roll mill

A doctor blade is fitted to the front roller to remove the dispersed product. For reproducible dispersion, three parameters are to be strictly controlled- the roll pressure, their speed ratios and temperature. Water-cooling of each roll is also carried out to reduce the frictional heat build-up.

(b) Bead Mill: It principally consists of beads filled cylindrical chamber surrounded by water jacket for cooling purposes. The size of the beads depends upon the viscosity and rheology of the final product, i.e., the type of ink required. For high quality low viscosity ink, e.g., gravure, typical bead size may range from 1-2 mm; for medium viscosity paste or screen ink the bead size may range upto 4 mm. These beads are usually made of zirconium oxide, glass or stainless steel. A drawback usually faced by the manufacture during this operation is that certain beads may cause discolouration of ink; thus, it is very important to test a particular type of ink with different beads before grinding for the selection of appropriate type of bead-ink combination.

In this type of dispersal operation, ink has to be pumped into the chamber and the beads (charge) are set in motion by a series of spinning discs or pins. The beads in motion break up or grind the pigment clumps and provide even dispersal of ink. The dispersed ink is then sieved out off the chamber; the beads remain behind and may be reused.

(c) Cavitation mixers: These are considered to be very efficient in dispersal of pigments such as titanium dioxide. However, in a highly viscous ink system, these may be insufficient and an additional sweeper blade is required.

Ink Colour, Drying and curing characteristics

Colour: The technology of printing ink colour is based on the Young-Helmholtz theory of three colour vision which implies that white light is composed of light from a continuous spectrum of wavelengths, humans perceive only three broad bands of this light, blue, green and red light; any other colour of light is borne by an appropriate combination of these three 'primary colours'. 'Subtractive colours' are produced by 'subtracting' one of these three primary colours from white light, e.g., red and blue light together produce. *When white light strikes an object, some of the light is absorbed and the remainder is reflected. The colour that we perceive as the colour of the object is the colour of the reflected light.*

In printing inks, four different colours of ink are employed: cyan, magenta, yellow and black. All other colours can be formed by 'overprinting' these inks, e.g., red is produced by overprinting yellow and magenta, as the yellow absorbs the blue light (because yellow is the emission of red and green light) and magenta absorbs the green light, leaving behind pure red light. Cyan, magenta and yellow add together to give brown colour usually.

In conjugated systems (one consisting of alternate single and double bonds in which π electrons are delocalised), the colour is due to light energy absorbed by the π electrons. They are characterized by a band gap, the energy of which falls in the visible region (the electrons of the second electron pair of the double bond).

Drying and curing: After its application over the substrate to be printed, the ink undergoes drying or curing phenomena involving a series of cross linking and polymerization reactions

that result in film formation thus binding the ink to the printed substrate. Ink drying or curing may occur by any one or by suitable combination of the following processes.

(i) **Evaporation**- Some inks dry or cure by the evaporation of the solvent. Generally, volatile solvents e.g., methylated spirits are used. However, solvents with boiling points above 120°C may also be used such as in screen printing inks to prevent the ink from drying during application.

(ii) **Penetration**: For porous surfaces, printing inks are designed so that the solvent penetrates into the bulk of the printing surface and the dry ink is left on the surface.

(iii) **Oxidation**: In case of inks where drying oil is used as solvent, curing occurs by the reaction of atmospheric oxygen with unsaturation of oil.

(iv) **Radiation curing**: involves a series of polymerization reactions which are instigated under the influence of radiations e.g., UV, falling on printed substrate. This process is considered as a 'green' curing route involving lesser energy and time.

(v) **Precipitation**: This process is applicable to an ink system that is only sparingly miscible in water. Here, excess water (usually in the form of steam) is added to the ink system. The sudden increase in diluent concentration causes the solubility of the resin to decrease sharply and the resin precipitates onto the printed surface; the excess water precipitates off.

Printing Processes

(i) **Letterpress printing**-Also known as typographic printing, since 13th century, it is one of the oldest printing techniques in practice. It is a commercial printing technique where many copies of an image are produced by repeated, direct impression of an inked, raised surface against sheets or a continuous roll of paper. Here, the image or printing areas are raised above the non-printing areas; the process involves printing images by the "relief" type printing plates. Rollers are laden with ink and they pass it to a separate ink bed; a fresh film is picked here for the following sheet of paper. A sheet of paper is pressed onto a type, swung back again and finally removed. A new sheet or roll of paper is again inserted at this place. Two types of letterpress printing machines are there- Flat bed cylinder Machines and Rotary letterpress printing machines.

(a) **Flat-bed cylinder**- an inking roller and an ink fountain supply ink to the plate cylinder. The plate is locked to a horizontal or vertical bed, which passes over the inking roller and then against the substrate. As the substrate moves from the feed stack to the delivery stack, it passes around an impression cylinder. In other words, a single revolution of the cylinder moves over the bed while in a vertical position so that both the bed holding the substrate and cylinder move up and down in a reciprocating motion. Either one or two-color impressions can be printed by Flat-bed cylinder presses, which operate in a manner similar to the platen press and print stock as large as 42 inches by 56 inches. These presses operate very slowly with an hourly production rate of not more than 5,000 impressions. For this reason, much of the printing initially done by this type of press is now being carried out by rotary letterpress or lithography.

(b) **Rotary Letterpress Printing**- requires curved image carrying plates. The most popular types of plates used are stereotype, electrotpe, and molded plastic or rubber. These presses use heat-set inks and are equipped with dryers, usually the high-velocity hot air type, when printing on coated papers. These are of two types- sheet-fed and web-fed. The use of the

former has been declined while the latter presses are the most popular type of letterpress printing. They are used primarily for printing newspapers. These presses are designed to print both sides of the web simultaneously. Typically, they can print up to four pages across the web; however, some of the new presses can print up to six pages across a 90-inch web. Rotary letterpress is also used for long-run commercial, packaging, book, and magazine printing. Depending on the size and image elements in the printing, Letterpress printing machines exert variable amount of pressure on the substrate. To ensure that the impression pressure is just desirable close monitoring should be accomplished and certain adjustments must be made throughout the machine run. Major chemicals used in letterpress printing are very similar to those used in lithography. They include film developers and fixers, inks, and blanket and roller washes.

Application: Letter Press printing is used in commercial operation and specialty operations including imprinting, stamping, die cutting, numbering and others. Applications of this type of printing include business cards, company letterhead, proofs, billheads, forms, posters, embossing, hot leaf stamping and others.

(ii) Screen Printing- This technique, which gained popularity during the First World War for making banners and printing flags can be traced back to the beginning of the 19th century. The printing technique creates a sharp-edged image using a porous fabric and a stencil. The screen, a piece of porous, finely woven fabric including silk, polyester or nylon is stretched over a wooden or aluminum frame, is placed on top of a piece of paper or fabric. Areas of the screen are blocked off with a non-permeable material (a stencil). Ink is placed on top of the screen, and it is further spread evenly across the screen with a rubber blade. The ink passes through the open spaces in the screen onto the paper or fabric below; the screen is then lifted off and can be re-used after cleaning. For multiple colour screen printing on the same surface, the ink is allowed to dry and then the entire process is repeated with another screen and different color of ink.

Application: Screen-printing technique finds versatile applications used in different industries, from clothing to product labels, fabric labels to circuit board printing and others due to its compatibility with a variety of materials, including textiles, ceramics, metal, wood, paper, glass, and plastic.

(iii) Flexography Printing Process: Widely used to print packaging materials, this technique is used to print on a number of materials and products including corrugated boxes, folding cartons, multi-wall sacks, paper sacks, plastic bags made up of various materials such as plastic, paper and others. The printing plates are flexible and made of rubber or plastic. The inked plates with a slightly raised image are rotated on a cylinder, which transfers the image to the substrate. These machines involve simple operation and easy adaptation for the use of water-based inks and produce high quality, finer and clear impressions on different substrates.

These machines are popularly used for printing on materials including plastic, paper, foils, acetate films, which is generally carried out by the use of rubber/plastic printing plates. Flexographic machines, due to their high speed printing process, make use of fast-drying inks. These printing machines can print on a range of absorbent & non-absorbent materials and can print in continuous patterns.

In this technique, from a roll a substrate is fed into the machine and is finally pulled off through a series of printing units and as a consequence of this action the image is printed on the substrate. Each colour is provided by a single printing unit. It finds application in high quality packaging such as milk and beverage cartons, disposable cups, containers, self-adhesive labels, adhesive tapes, envelopes, newspapers, plastic bags and food and candy wrappers.

Types of Flexographic Printing Machine: (a) Stack Type Machine

(b) Central Impression Cylinder (CIC) Machine

(c) In-Line Machine

(d) Newspaper Unit Machine

(iv) Gravure Printing Process is used for long run printing with sharper, fine and clear images. The general operation involves image preparation, cylinder preparation, printing and finishing. It is a form of intaglio printing. The image is formed on a depressed or sunken surface. The image area consists of honeycomb shaped cells that are etched or engraved into a copper cylinder. As the cylinder rotates in an ink pan (bath of ink), any extra ink is wiped off the cylinder with the help of a steel doctor blade. As the substrate passes between the plate cylinder and the impression cylinder, ink is directly transferred to the substrate and image is formed.

Applications include printing magazines, greeting cards, gift-wraps, labels, flexible packaging, cartons and others.

Rotogravure Printing Machines operate at very high speeds and are used by a number of industries for printing magazines, advertising print materials, cards etc for printing job that are long running in nature and require sharper and finer prints & images on different materials including PET, PVC, PE and paper. These machines employ turret type unwinder and rewinder; automatic splicing and web discharging can also be done. To enhance the drying performance and minimize printing defects, these machines are equipped with high speed drying systems.

Applications: Greeting Cards, magazines, advertising materials including brochures, catalogs, flexible packaging, self-adhesive labels

Future of the Printing ink Manufacturing Industry

The environmental and health problems caused by the inks containing volatile organic compounds (VOCs) call for new solutions in printing chemistry and technology. One of the approaches may be hot melt. It refers to ink, which is solid at ambient temperature and liquid at the time of printing. Such inks contain no VOCs to be trapped in the ink film or to produce VOCs. In 1990s, the European Technical Committee for Printing Inks of CEPE (*European Technical Committee for printing inks and Artists Color Manufacturers Industry*) published a guideline paper on health and safety. Since then energy curing products have gained significant growth both in coatings and printing techniques. The major energy curing processes are used: UV and EB (Ultra violet lamps and Electron Beam). Energy curing technology is important in the production of all types of printing applications where fast drying, durability and high gloss finish make them sustainable for immediate use, e.g. carton printing –Food and pharmaceutical packaging, labels plastic substitutes and metal decoration. Another development area of immense interests Development of water based

UV systems. Water is ideally suited to reduce the viscosity of ink systems. However, the main problem with water UV system is that it is inevitable to remove water completely before UV curing. Water based flex inks are being used in Naplan printing inks [NPI]. NPIs were initially formulated using petroleum-based materials. However, they left an offensive odor on printed substrates. Some printers used glycol (water washable inks) to overcome the drawbacks. The ultimate solution was the use of water based flex inks, which apart from being odor free had several other advantages. Rising petrochemical crisis and environmental concerns draw attention to vegetable oil based inks. Although vegetable oils have been used in inks for many years, the first soy bean oil based ink was developed in 1985 and was marketed in 1987. Soy inks now make up at least one third of the colored newspaper ink. Soy ink contains less VOC, less alcohol and can be washed up without solvent. Their disadvantages include their high cost compared to conventional ink as well as their disposal. For the present, UV and EB cured ink technology continues to develop. Efforts are being directed towards the use of water-based inks. Key uses presently remain in the development of vegetable oil containing inks using UV and EB cure technologies in the world of printing inks. We are destined to experience many industry innovations in this field in the next few years with almost unlimited possibilities

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