8000 B.C. INVENTION OF THE PRINTING PROCESS.
The Basics of Flexible Packaging Printing

DEFINITION:
Applying ink to a substrate to produce an image or text

PRINTING METHODS:
Flexography and Rotogravure
the two most widely utilized methods for Flexible Packaging

FOCUS:
Design to Substrate; the “process” described
Structures and Print location
Understanding Ink
Substrate Surface Preparation
Methods and Equipment in detail
Reproduction Basics; line and process printing
Design to Substrate

- Preproduction Design Creation
  - Ink Management
  - Substrate Management
    - Image Preparation Color Separation
      - Cylinder or Plate Making
    - Press Make Ready
      - Printing
      - Press Cleaning and Maintenance
  - Converting
REVERSE Printing  2 Layer Structures

- Clear Oriented Polypropylene Film
- Printing Ink, formulation for laminating adhesive receptivity
- Lamination Adhesive
- Heat Sealable Metalized OPP

TWO LAYER
example - Retail Snack Bag

Clear Oriented Polypropylene Film

- Printing Ink, special formulation for metallization receptivity
- Metallization applied during a second operation
- Lamination Adhesive
- Heat Sealable Film (LDPE, EVA etc.)

TWO LAYER
example - Airplane Snack Bag
REVERSE Printing  3 Layer Structures

THREE LAYER
example - Pharma Sample Packs

THREE LAYER
example - Brick Pack Coffee / Pharma hard to hold
PRINTING INK, form & chemistry

• Physical form
  • Liquid – free flowing
  • 30% to 60% solids and 100% solids UV/EB
  • Relatively low viscosity
    (closer to water than heavy syrup)

• Chemistry
  • Solvent based – gravure, flexographic
  • Water based – flexographic, (gravure)
  • Radiation (UV/EB) cured– flexo, (gravure)
RESINS Used in Packaging Printing Inks

• Common
  • Nitrocellulose – Cellulose (cotton linters)
  • Polyamide – Rosin (crude tall oil)
  • Acrylic – Petrochemical (styrene and acrylic acid)
  • Phenolic – Rosin (gum derived)

• Specialty
  • Acrylate – used in UV/EB inks & coatings
  • Epoxy – used in UV/EB inks & coatings
  • Urethane – used in solvent and UV/EB inks and coating
## Typical PIGMENTS in Packaging Inks

### Organics:
- **Carbon** black
- **Diarylide** yellow
- **Pyrazolene** orange / red
- **Disazo** green shade yellow, red, orange
- **Naphthol** red, brown, violets
- **Pthalocyananine** green, blue
- **Quinacridone** red

### Inorganics:
- **Titanium Dioxide** white
- **Iron Oxides** yellow, red, brown
- **Metallic (Aluminum)** silver, gold
- **Clay** green, red, yellow, brown
Basic INK Formulation Examples

Water
- Water 65%
- Additives 5%
- Solution Resin 10%
- Emulsion Resin 10%
- Pigment 10%

Solvent
- Solvent 65%
- Additives 5%
- Polyamide Resin 10%
- Nitrocellulose Resin 10%
- Pigment 10%

Radcure
- Reactive Diluents Up to 30%
- Acrylate Monomer
- Additives 5%
- Acrylate Prepolymer 55%
- Pigment 20% - 25%
PRINTING INK, viscosity measurement

CENTISTOKE is the unit of reference in all viscosity cup measurements
SECONDS (time) is the Operator press side measurement

POISE is the fundamental unit of viscosity defined as the resistance of a liquid to flow
where gravity is not a factor.  **100 CENTIPOISE = 1 POISE.**
Gravity is the driving force causing liquid in a viscosity cup to flow through the orifice so a
high density material will flow from a cup in a shorter time than a low density material of
the same viscosity.

STOKE is defined as the POISE divided by density.  **100 CENTISTOKES = 1 STOKE.**

<table>
<thead>
<tr>
<th>ZAHN Cup</th>
<th>ZAHN Cup conversions</th>
<th>SHELL Cup</th>
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</thead>
<tbody>
<tr>
<td>Cup Number</td>
<td>Seconds Efflux Time</td>
<td>Centistokes Range</td>
</tr>
<tr>
<td>1</td>
<td>40-60</td>
<td>10-36</td>
</tr>
<tr>
<td>2</td>
<td>20-60</td>
<td>19 to 156</td>
</tr>
<tr>
<td>3</td>
<td>12-60</td>
<td>64 to 596</td>
</tr>
<tr>
<td>4</td>
<td>10-60</td>
<td>79-784</td>
</tr>
<tr>
<td>5</td>
<td>10-60</td>
<td>161-1401</td>
</tr>
</tbody>
</table>
PRESS SIDE Ink Management

1) PUMP & MOTOR
2) INK TANK
3) FILTER
4) PRINTING STATION
5) AUTOMATIC VISCOSITY CONTROL
TREATMENT - Substrate Surface Preparation

Most plastics such as polyethylene, polypropylene and polyester have chemically inert and nonporous surfaces with low surface tensions causing them to be non-receptive to bonding with printing inks, coatings and adhesives.

Surface Treatment Systems increase surface energy to promote adhesion for printing, coating, laminating and other converting processes.

Most all substrates including paper and foil will exhibit increased adhesion to inks, adhesives and extrusion coatings after surface treatment.
CORONA Treatment

An electrical process that uses ionized air to increase the surface tension of substrates.

Typically, corona treating systems operate at an electrical voltage of 10 kV.

The high voltage is applied across an electrode which ionizes the air in the electrode/web gap, creating a highly energized corona.
PLASMA Treatment

Like corona, plasma is the electrical ionization of a gas. Unlike corona, plasma is created at much lower voltage levels and the rate at which electron bombardment occurs is up to 100 times greater. Plasma facilitates the use of chemical gases which can produce controlled chemical reactions to functionalize surfaces.
FLAME Treatment

The process of burning away surface contaminants by forcibly spraying a flame onto a substrate surface. This is accomplished by burning an ultra-lean gas mixture, whose excess oxygen is rendered reactive by the high temperature.
TREATMENT - determining the treatment level

DYNE Test

- Solutions of various percentages of Ethyl Cellosolve, Formamide and Water
- Dyne solution levels range from 30 to 60+
- The “treatment level” is based upon the specific solution number that wets out the surface vs. the next level up that beads up
- Easy and cheap test method well suited for use on the shop floor
- Procedure can be subjective but is reasonably accurate if adequate care is taken and the solutions are kept fresh

<table>
<thead>
<tr>
<th>Material</th>
<th>Untreated</th>
<th>Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDPE</td>
<td>31</td>
<td>38-45</td>
</tr>
<tr>
<td>OPP</td>
<td>31</td>
<td>38-45</td>
</tr>
<tr>
<td>PET</td>
<td>42</td>
<td>50+</td>
</tr>
</tbody>
</table>

Reference  ASTM D2578
TREATMENT - determining the treatment level

CONTACT ANGLE

• Contact angle is the angle formed by a liquid at the three phase boundary where a liquid, gas and solid (substrate) intersect
• Very precise measurement with high repeatability
• Requires a relatively expensive test instrument that is not well suited for shop floor use
• The lower the contact angle, the higher the treatment level

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Reference ASTM D5946-04
**FLEXOGRAPHY Printing**

*Flexography: (often abbreviated to Flexo)*  
A form of relief printing where ink is applied to a rubber or polymer plate on which the printing image is raised above the rest of the surface as a 3-D positive mirrored relief.
FLEXOGRAPHY Printing - process

Three Roll Station
- Print Cylinder In Position
- Substrate
- Anilox Roll
- Ink Transfer Roller
- Rubber Inking Roller
- Doctor Blade
- Pan
- Ink
- Impression Cylinder
- Substrate

 enclosure
- PLATE
- ENCLOSED INK CHAMBER
- ANILOX
- IMPRESSION ROLL
FLEXOGRAPHY Printing - plate structure
FLEXOGRAPHY Printing - anilox rolls

The anilox roll is a steel or aluminum core cylinder with a ceramic surface that contains millions of very fine cells. They are specified by their "line screen", or the number of cells per linear inch ranging from below 250 to above 1500. Lower line screens are used to print a heavy layer of ink such as block lettering. The highest line screens produce fine detail for four-color process work such as reproducing photographs.
FLEXOGRAPHY Printing - presses
**ROTOGRAVURE Printing**

Rotogravure: (typically referred to as Gravure)
An intaglio process (in-tal-yo means engraved or cut in) in which a negative image is etched into the surface of a copper printing cylinder as tiny cells or dots of various sizes and depths. The copper is chrome plated for durability. Ink is applied to the surface and a flexible metal blade called a doctor blade removes excess ink, leaving the surface clean, with ink only in the depressions.
GRAVURE Printing - process

8 COLOR ROTOGRAVURE PRESS

Doctor Blade
Gravure Cylinder
Fluid Ink
Rubber Impression Roller
Substrate (Paper, Film, Paperboard, Foil, Etc.)

Air flow from moving web
Prewipe Device
Cylinder

Unwind
Rewind
GRAVURE Printing - cell structure

Uniform cell opening size
Varying depth of cells

(a) Conventional gravure

Varying cell opening size
Varying depth of cells

(b) Lateral hard dot

Varying cell opening size
Uniform depth of cells

(c) Direct transfer

Path of Engraving Tool Tip

100% Cells
95% Cells
50% Cells
7% Cells

Compressed.
30 Deg Cells

Elongated.
60 Deg Cells

Normal.
45 Deg Cells
**Flexible Packaging Printing Processes Overview**

**GRAVURE Printing - cylinder engraving**

**Acid Etching** (Diffusion-Etching and Direct-Transfer) – Light sensitive gelatins or photopolymers on the copper surface are exposed through a film positive of the image resulting in varying levels of acid resistance. The surface is exposed to acid, resulting in cells of the same size and cell wall thickness but varying depths.

**Electromechanical Engraving** - The original copy is scanned into a computer and digitized. The computer then controls a diamond stylus that cuts the cells into the surface of the gravure cylinder. Cell depth and cell area are varied simultaneously by using a tapered engraving head.

**Laser Engraving** – The method of choice to produce Flexo anilox rolls with some applications in gravure printing. An original is scanned into a computer, the various image densities are determined, and lasers etch the cylinder. Highly reflective copper is a poor material choice so alternative special alloys, plastics and ceramics are used.
GRAVURE Printing - electrostatic discharge ESA

1. Conductrol
2. Back-Up Roller
3. High Voltage Non-Contact Electrode
4. Variable Applicator
5. Core-Charged

(a) Impression Roller
(b) Gravure Cylinder
(c) Voltage Application
GRAVURE & FLEXO Printing - doctor blade design

- Standard
- Rounded
- 15° Bevel Angle
- 2.2° Bevel Angle
- 4.5° Bevel Angle
- 55° Bevel Angle
GRAVURE Printing - presses
LINE Printing

Single colors are printed at varying densities

Individual colors do not overlap or combine to form new colors

The number of colors in a design is limited by press capability
Flexo LINE Printing - reverse print film
Flexo LINE Printing “Screened” - surface print film
Gravure LINE Printing - surface print
Red, green and blue are the primary colors of light as perceived by the eye

When the three colors are together in a spectrum they create white
The absence of color altogether is black

This works great for digital images on computer and TV screens
It does not work well when printing colors on a substrate

The base colors for process printing are CMYK and not RGB
CMYK are subtractive colors or secondary colors of red, blue and green

Blue + Green = Cyan (B+G = C)
Red + Blue = Magenta (R+B = M)
Red + Green = Yellow (R+G = Y)
And Black = K
4 Color PROCESS Printing / CMYK
4 Color PROCESS Printing / CMYK

The image is separated into 4 different color values
Cyan / Magenta / Yellow / Black

Individual colors are printed as dots at varying densities

Individual dots combine to form additional unique colors

In Packaging printing, 4 color process is typically combined with line colors to accurately represent trademarks and logos and to maintain color consistency over large areas of solid colors

The number of final colors in a design is nearly limitless
Flexo PROCESS / reverse print film
Gravure PROCESS / reverse print film
Gravure PROCESS / surface print paper
<table>
<thead>
<tr>
<th>Comparison</th>
<th>GRAVURE</th>
<th>FLEXO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printing Press Footprint</td>
<td>larger</td>
<td>smaller</td>
</tr>
<tr>
<td>Printing Press Cost</td>
<td>much higher</td>
<td>lower</td>
</tr>
<tr>
<td>Operating Costs (utilities and overhead)</td>
<td>slightly higher</td>
<td>lower</td>
</tr>
<tr>
<td>Maintenance</td>
<td>slightly higher</td>
<td>lower</td>
</tr>
<tr>
<td>Cylinder / Plate cost</td>
<td>much higher</td>
<td>lower</td>
</tr>
<tr>
<td>Impressions per Cylinder / Plate</td>
<td>very high w/ rechrome</td>
<td>lower</td>
</tr>
<tr>
<td>Make-Ready Time</td>
<td>generally longer</td>
<td>shorter</td>
</tr>
<tr>
<td>Water Base / Solvent Base</td>
<td>solvent – water?</td>
<td>both</td>
</tr>
<tr>
<td>Substrate Flexibility</td>
<td>less</td>
<td>more</td>
</tr>
<tr>
<td>Process Flexibility (coating &amp; laminating)</td>
<td>more</td>
<td>less</td>
</tr>
<tr>
<td>Print Quality (detailed process printing)</td>
<td>exceptional</td>
<td>improving</td>
</tr>
</tbody>
</table>
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NORCROSS
First in Viscosity Control

FLYNN

ALLISON
Systems Corporation

Daetwyler
Innovations for the Printing Industry

Since 1961
ramé-hart contact angle goniometers
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