Advances in Flexographic Printing Inks Technology. A Re-solubility Study on BOPP film.

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Objective

- The objective of this work was to study the effect of anilox cylinder cell size (with associated volumes) on ink resolubility.
  - What is the difference between a larger and smaller cell for resolubility.
  - How do various ink resin formulations affect resolubility.
  - Develop a quantifiable test method to measure resolubility.
Introduction to Flexographic Printing and its use in packaging.

- 25 years of growth and improvements
  - Anilox
  - Plate
  - Inks

- Heavily connected to packaging
  - 60% of packaging is printed flexo *
  - 92% of flexo workflow is packaging *
  - Packaging growth up to $587.19 Billion by 2020**

- Flexographic Printing is taking market share from other printing methods.
  - Increase in speed and quality

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Flexo Printing Methods

- Enclosed chamber / Metering Roll
- Anilox cylinder
- Doctor Blade(s)
- Raised print surface
Anilox Cylinders

- Anilox cylinders are ceramic coated metal rolls with etched cells
- “Lower” Lines per Inch (lpi) anilox
  - Coatings
  - Spot Colors
    - Custom colors i.e. CocaCola® Red, Pepsi® Blue
- “Higher” lpi anilox
  - Process Printing (CMYK)
  - Detailed printing
What is Resolubility?

- Resolubility is the ability of the “dried” ink on the Anilox cylinder or on the plate to be “re-wetted”

- Poor resolubility leads to:
  - Less ink transfer from anilox cylinders to plates
  - Dried ink on the print plate leads to dot gain:
    - when a printing dot gains size due to dried ink around the dot
    - causing larger than desired dots
    - which negatively affects color strength and image resolution.
  - Down time
Inks

- Inks for film printing must:
  - Form a film on top of the substrate
  - Be fast drying
  - Have resolubility
  - Have resistance properties:
    - Scuff Resistance
    - Block Resistance
    - Resistance to water and other chemicals
    - Cold/Hot Applications

- Two Ink types in today’s market
  - Solvent based
  - Water based
Solvent-Based Ink

- Leads market for plastics film based printing

- Known for:
  - High speed printing
  - Demanding applications (freezer to microwave)
  - Quick resolubility

- Waste Concerns
  - Disposal
  - Wasted ink

- High in Volatile Organic Compounds
  - Shift to move away from VOC
  - Work on alternative methods i.e. Water-based and Ultraviolet-based

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Water-Based Ink

- Desirable to brand owners and converters
  - Friendlier to environment
  - Easier to handle
  - Non-flammable

- Advancements and growth since 1980’s

- Still faces challenges
  - Resolubility and Printability
  - High speed considerations
  - Print defects
Equipment and Materials

- Mark Andy 2200XL Flexo Press
- 120 Gauge BOPP substrate, 16” width
  - Treated with in-line corona treater (2000 watts)
    - 36 dyne level before corona treatment, 44 dyne level after 2kW corona treatment.
- Full coverage (smooth, no print design) printing plate (polyurethane sheet)
  - 20 Inch repeat (circumference of cylinder)
- Banded anilox cylinder
  - 300 lpi (4.8 bcm) → 600 lpi (2.5 bcm)
Equipment and Materials

- X-Rite 508 Spectrodensitometer

- Pantone Color viewing light box
  - D65 Illuminate (standard daylight)

- Zahn Cup #2 – Ink Viscosity
  - Inks adjusted to a viscosity between 25 and 30 seconds (~50-70 cP)
    - Adjusted using 60% water and 40% dispersion mixture.
## Ink Formulations

<table>
<thead>
<tr>
<th>Formulations (%)</th>
<th>Resin #1</th>
<th>Resin #2</th>
<th>Resin #3</th>
<th>Resin #4</th>
<th>Resin #5</th>
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<tbody>
<tr>
<td>Pigment Dispersion</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>42.9</td>
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<tr>
<td>Acrylic Emulsion Resin*</td>
<td>38.9</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>50.4</td>
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<tr>
<td>Wax</td>
<td>3.3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4.2</td>
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<tr>
<td>Surfactant</td>
<td>0.9</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Defoamer</td>
<td>0.010</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Water</td>
<td>16.9</td>
<td>6.9</td>
<td>6.9</td>
<td>6.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Viscosity (Zahn #2, seconds / Brookfield Equiv. in cP)</td>
<td>30 (70)</td>
<td>24 (50)</td>
<td>29(70)</td>
<td>27(60)</td>
<td>26. (60)</td>
</tr>
</tbody>
</table>

*All resin formulations listed are “different” proprietary recipes*
Experimental Methodology

- **Step One:** Set Impression
  - Impression is the action of setting “optimal” pressure of printing plate to both substrate and anilox cylinder
  - Low speed to produce “best” possible image
  - Too much pressure pushes ink outwards (see “L L” below)

- **Step Two:** Press run for one minute @ 210 fpm

- **Step Three:** Turn off press, disengage anilox cylinder from press
  - Move carriage back, preventing rotation/rewetting of ink in the anilox
  - Allow press to sit idle for two minutes
Experimental Methodology (cont.)

- **Step Four**: Re-Start press
  - Move carriage back into place, re-engaging anilox cylinder
  - Re-start at 50 fpm

- **Step Five**: Insert tags into rewind roll at specific time markers
  - Initial print (0 seconds)
  - Print at 30 seconds
  - Print at one minute
  - Print at each additional minute up to nine minutes.
Experimental Methodology (cont.)

- **Step Six**: Measure and average density of lighter blue “dried” area at each tag marker.
  - X-rite Spectrodensitometer 508
  - D65 Illuminated light box.
  - Nine measurement points in each dried section.
Results: 300 Line vs 600 Line Anilox Density Recovery

Notice “not much” differentiation in densities ( % recovery) for any formulation

Testing showed ink resin formulation #2 to be a very good “performer, i.e. fast recovery, and #4 to be a poor performer
Results – Profile of all six anilox bands tested, for one ink

The 300 lpi anilox was generally NOT effective for showing density recovery.
The 600 lpi proved VERY effective for density reduction AND recovery.

A light water spray of the banded anilox cylinder immediately following the test showed “dried ink” that couldn’t easily be “re-wetted” in the 600 lpi band.
Conclusions

- We have developed a new, quantifiable test method using Banded anilox cylinders for comparing resolubility of water based ink formulations.

- Density measurements have proven to be effective for quantifying percent recovery of ink after drying.

- Formulations containing styrene, acrylic acid and a “base” tend to be “more” resoluble when there are more acid groups (and in turn more salt) present.
Conclusions (cont.)

- Resolubility is more of an issue with higher lpi cylinders (600 lpi, 2.5 bcm) than with lower lpi cylinders (300, 4.8 bcm) for a given ink formulation
  - because ink will completely dry in a smaller cell quicker than a larger cell (since there is less to dry).
  - Higher lpi anilox cylinders are desirable for best quality.

- This test methodology helps us differentiate between our ink formulations and also helps us specify ideal anilox cylinders for selected applications.

- Good resolubility is key for high performing water based inks.

- Next:
  - Testing plate drying
    - Halftones
  - Testing to continue with higher lpi anilox cylinders
    - 700 through 1400 lpi
    - Improve abilities to differentiate ink formulations