New EB curable CI-Flexo Ink Technology
Providing Sustainable Printing Solutions
For Packaging Applications

Im Rangwalla
Energy Sciences Inc.
Wilmington MA 01887

Global Flexible Packaging By Region 2013

Total $ 97 Billion
CAGR – 2.6 % in NA from 2003-2013

Source: FPA 2014

Market Requirements For Printing

- Runs are increasingly shorter
- Improved print quality like Gravure
- New designs with gloss and glitter
- Shorter delivery times
- Higher productivity
- Lower prices increased competition
- Higher profit margins
- Sustainable packaging
- Food Packaging Friendly

Agenda

- Market Size and Market Needs
- EB CI-Flexo Technology
- Print Results
- Conclusions
- Future Developments

2013 Flexible Package Materials
Purchase in NA
$ 15.8 Billion

Films 41%
Resin 19%
Inks 7% $1.106 Billion
Foil 6%
Ctgs&Adh 5%
Other 12%

If You Print Using Gravure

**Strengths**
- High Print Quality
- Brilliant Colors
- High Productivity For Long Runs
- Long time proven technology
- Several Established Ink Suppliers

**Disadvantages**
- Solvent Inks
- Long Lead Time for New Cylinders
- Long Time To Market
- High Cost of Cylinders
- Too Expensive For Short Print Jobs
Technical Developments

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravure for flexible packaging</td>
<td>No new developments</td>
</tr>
<tr>
<td>Flexo for flexible packaging</td>
<td>• General flexography technology. Photo polymer plate development</td>
</tr>
<tr>
<td></td>
<td>• CI-Flexo inks with EB-curing</td>
</tr>
<tr>
<td>Sheet-offset for labels and folding cartons</td>
<td>No new developments</td>
</tr>
<tr>
<td>Web-Offset for folding cartons and flexible packaging</td>
<td>Variable formats/repeat</td>
</tr>
</tbody>
</table>

Converter Printing Comparison in NA For 2013

<table>
<thead>
<tr>
<th>Print Type</th>
<th>2009</th>
<th>2011</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexo</td>
<td>64%</td>
<td>63%</td>
<td>64%</td>
</tr>
<tr>
<td>Gravure</td>
<td>10%</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Offset&amp;Oth</td>
<td>&lt;1%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Digital</td>
<td>NA</td>
<td>NA</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Unprint</td>
<td>27%</td>
<td>21%</td>
<td>23%</td>
</tr>
</tbody>
</table>

EB CI-Flexo Technology Development

<table>
<thead>
<tr>
<th>Patent or Application Number</th>
<th>Filing Date</th>
<th>Assignment</th>
<th>Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 5,096,098</td>
<td>June, 1996</td>
<td>Cavanaugh Corporation USA</td>
<td>Method of achieving wet trapping by heating the subsequent ink to reduce viscosity</td>
</tr>
<tr>
<td>US 6,772,683</td>
<td>Feb, 2002</td>
<td>Sun Chemical USA</td>
<td>Method of achieving wet trapping by evaporating non-reactive diluent and increasing viscosity of the applied layer</td>
</tr>
<tr>
<td>US 8,729,147</td>
<td>May 20, 2014</td>
<td>Technosolutions, Brazil</td>
<td>Method of achieving wet trapping by evaporating a non-reactive diluent and adjustment of Hansen solubility parameters to form an organo gel in the applied layer</td>
</tr>
<tr>
<td>WO/2011/19164</td>
<td>Jan, 2011</td>
<td>Sun Chemical USA</td>
<td>Method of achieving wet trapping by controlling the storage modulus of the ink. Each applied ink layer will have decreased modulus</td>
</tr>
</tbody>
</table>

Hansen Solubility Parameter

"Like Dissolves Like"
- d Energy From Dispersion Forces
- p Energy From Polar Forces
- h Energy From Hydrogen Bonds

Typical Formulation

<table>
<thead>
<tr>
<th>Type</th>
<th>Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monomers</td>
<td>40-50</td>
</tr>
<tr>
<td>Oligomers</td>
<td>8-12</td>
</tr>
<tr>
<td>Pigments</td>
<td>20-25</td>
</tr>
<tr>
<td>Additives &amp; Dispersants</td>
<td>2-10</td>
</tr>
<tr>
<td>Gallant Polymer</td>
<td>2-5</td>
</tr>
<tr>
<td>Solvent</td>
<td>10-15</td>
</tr>
</tbody>
</table>

How does it work?
- Gel-based multicolor flexo printing system allows single-stage EB curing
- Wet-in-wet? No!
- Gel-on-gel!
Objectives Gelflex-EB

• Significant decrease of VOC emission
• Up to 60% less ink consumption
• Higher print quality
• Highest physical properties (gloss, resistance)
• Faster time to market
• Cost reduction (improved ROI)
• Safe for operators and use

Breaking the gel

• Heating (till 35°C-95°F)
• Stirring
• Adding a small amount of solvent (needed for adjusting the solubility parameters).
• Printing with high viscosity (300-600 cP)

Our researches

• kind of flexo plates and substrates
• volumes/liniatures of aniloxes
• temperatures and viscosities of the ink
• lay down and trapping properties of the ink
• liniature of screen images and tonal curve
• consistency

What we have learned

• Up to 60% less ink consumption
• Low or no viscosity adjustments
• 5-10 times less emission of solvents
• All kinds of flexo plates suitable Kodak NX with digicap preferred
• Most kinds of substrates suitable EB conditions may need optimization
• Up to 70 l/cm (180 l/inch) is possible

60% less ink consumption

• 2.5-3.0 cm3/m2
• 1.6-1.9 BCM
• 460-500 l/cm anilox
• 1170-1270 l/inch anilox

Standard SID:
- Yellow: 1.00 – 1.10 D
- Magenta: 1.25 – 1.35 D
- Cyan: 1.30 – 1.40 D
- Black: 1.50 – 1.70 D
Last down white

- 5.0-6.0 cm³/m²  300-400 l/cm² anilox
- 3.0-4.0 BCM  750-1000 l/inch anilox
- Gelflex-EB last down white contains no solvent at all!

5-10 X less VOC emission

- a 24/7 flexo machine produces appr. 50 million m²/y, is using appr. 200 tonne solvent p/y*
- Under same conditions: Gelflex-EB has an usage of appr. 20-25 tonne p/y*
- *when printing transparent film with last down white on a 8 color CI-Flexo press

QTECS

- Quality
- Time
- Environment
- Costs
- Safety

QTECS:

- 60 l/cm (152 l/inch) as a standard
- Tonal curve like offset
- High dot quality
- Smooth vignettes
- Perfect lay down
- Good trapping properties
- High gloss

Quality: a closer look (1)

- Tonal curve like offset
- Smallest dot i.e. 4% is in print not bigger than 8%
- Smooth vignettes
- Increased details by applying i.e. 170 l/inch
Quality: a closer look (2)

- Perfect lay-down
- Excellent trapping properties (85-100%)

QTECS:

- Less or no washing times during job changes
- Faster make ready of new jobs
- Quick color matching
- Faster time-to-market

Calculation of emission (example)

<table>
<thead>
<tr>
<th>Calculation of emission</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web width flexo machine</td>
<td>1,20 meter</td>
</tr>
<tr>
<td>Printing speed</td>
<td>200 meter/minute</td>
</tr>
<tr>
<td>Ink coverage</td>
<td>130% printed design all colors together</td>
</tr>
<tr>
<td>Volume anilox</td>
<td>2.5 cm²/m²</td>
</tr>
<tr>
<td>Ink release/m²</td>
<td>3.6 gr/m²</td>
</tr>
<tr>
<td>Total transferred ink/m²</td>
<td>2.1 gr/m² total printed surface</td>
</tr>
<tr>
<td>Amount of solvent in the ink</td>
<td>12% methoxy-propanol PM</td>
</tr>
<tr>
<td>Amount of solvent to evaporate/m²</td>
<td>0.25 gr/m²</td>
</tr>
<tr>
<td>Amount solvent to evaporate per second</td>
<td>1.0 grams</td>
</tr>
<tr>
<td>Emission freight</td>
<td>3.6 kg/hour</td>
</tr>
</tbody>
</table>

QTECS:

- 5-10 less emission of solvents
- No or reduced thermal oxidizers
- Less power consumption of the press
- Less storage and transport of inks and solvents
- Green sustainable platform

QTECS:

- 50% less energy consumption
- 5-10% less down-time costs
- 5-10% less waste of substrates
- 60% less transport costs of inks and solvents
- 60% less costs of storage inks and solvents
- Less or no costs for oxidizers
### Calculation model reduced costs of inks

<table>
<thead>
<tr>
<th></th>
<th>Solvent Flexo Ink</th>
<th>Cofflex-EB Ink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume printed CMYK</td>
<td>0.2 m3/m2</td>
<td>0.4 m3/m2</td>
</tr>
<tr>
<td>Transferred on substrate</td>
<td>0.2 m3/m2</td>
<td>0.4 m3/m2</td>
</tr>
<tr>
<td>Total kg use of CMYK ink</td>
<td>105,425 kg</td>
<td>166,200 kg</td>
</tr>
<tr>
<td>Average price of ink (CMYK) per kg</td>
<td>4.59 €/kg</td>
<td>5.42 €/kg</td>
</tr>
<tr>
<td>Average price of ink (white) per kg</td>
<td>3.65 €/kg</td>
<td>4.72 €/kg</td>
</tr>
<tr>
<td>CMYK ink costs to this volume</td>
<td>634,560 €</td>
<td>717,120 €</td>
</tr>
<tr>
<td>White ink costs to this volume</td>
<td>771,350 €</td>
<td>835,000 €</td>
</tr>
<tr>
<td>Total inks costs (CMYK+White)</td>
<td>1,405,910 €</td>
<td>1,552,120 €</td>
</tr>
</tbody>
</table>

### Calculation model reduced costs of solvents at a production of 25 million m2/year

<table>
<thead>
<tr>
<th></th>
<th>Solvent Flexo Ink</th>
<th>Cofflex-EB Ink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of solvent in CMYK ink</td>
<td>57.817 kg</td>
<td>52.813 kg</td>
</tr>
<tr>
<td>Amount of solvent in white ink</td>
<td>75.175 kg</td>
<td>63.384 kg</td>
</tr>
<tr>
<td>Total amount solvent per year:</td>
<td>130.692 kg</td>
<td>116.197 kg</td>
</tr>
<tr>
<td>Average price of ethanol(white) per kg</td>
<td>1.90 €/kg</td>
<td>1.70 €/kg</td>
</tr>
<tr>
<td>Total costs of solvent per year</td>
<td>4,185,531 €</td>
<td>3,854,206 €</td>
</tr>
</tbody>
</table>

**QTECS:**

- FDA, EEC Directives, Nestle List
- Lowest odor, taint and extractable levels
- Safe for operators to handle
- No photoinitiators
- No migration of monomers at all.

### Extensive opportunities

- Avoid lamination in some cases
- In-line lamination is an opportunity
- EB coatings inline with Gelflex-EB ink with EB curable functional coatings.
- Thermal and Scratch resistance
- Excellent bond strengths using conventional adhesives

### General machine conditions

- Low Voltage EB Operating at 110-125 and 30-35 kGy of dose at < 200ppm oxygen
- ISD with just cool air. Overhead dryer at 1/3 capacity at 300-350 mpm.
- Closed and robust doctor chambers with blades used for resin based inks.
- Pumping system capable to operate in 300-600 cps viscosity ranges.
- Thermoregulation to control ink temperatures.
- Stirring devices in ink containers.

### Conclusions

- Higher productivity gains
- Faster time-to-market
- Higher print quality in comparison to solvent platforms
- Better white properties
- Better color matching
- Improved ROI
- Decreasing VOC emissions up to 90%
- The best contribution for a sustainable green platform
Future Developments

• Reduce solvent content eventually to 100% solids
• Faster Evaporating Solvent Like Ethanol
• More Special Colors
• First down white with wet trapping capability
• Faster Speeds up to 600 mpm

Thank You For Your Attention