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

Im Rangwalla
Energy Sciences Inc.
Wilmington MA 01887
Agenda

- Market Size and Market Needs
- EB CI-Flexo Technology
- Print Results
- Conclusions
- Future Developments
Global Flexible Packaging By Region 2013

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

Source: FPA 2014
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%
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
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>Developments</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&lt;br&gt;• 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 5,690,028</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 Hansens solubility parameters to form an organo gel in the applied layer</td>
</tr>
<tr>
<td>WO/2011/091364</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>Type</th>
<th>Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monomers</td>
<td>TMPTA, TMPEOTA, HDDA, TRPGDA etc.</td>
<td>40-50</td>
</tr>
<tr>
<td>Oligomers</td>
<td>Polyester acrylates, Epoxy acrylates, etc</td>
<td>8-12</td>
</tr>
<tr>
<td>Pigments</td>
<td>Yellow, Cyan, Magenta, Black, other line inks</td>
<td>20-25</td>
</tr>
<tr>
<td>Additives &amp; Dispersants</td>
<td>Tego Brands, Disperbyk</td>
<td>2-10</td>
</tr>
<tr>
<td>Gellant Polymer</td>
<td>Poly Vinyl Butyral</td>
<td>2-5</td>
</tr>
<tr>
<td>Solvent</td>
<td>Glycol Ethers like Dowanol PM</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!
EB CI Flexo Process

Small Thermal Dryer

EB Ink eliminates interstation dryers. Needs small overhead dryer
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/cm 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: Quality**

- 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%)
Quality: a closer look (2)

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

Solvent based

Gelflex-EB
QTECS: Time

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

- 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
<table>
<thead>
<tr>
<th><strong>Calculation of emission</strong></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 cm³/m²</td>
</tr>
<tr>
<td>Ink release/m²</td>
<td>1,6 gr/m²</td>
</tr>
<tr>
<td>Total transferred ink per/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: Costs

- 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>Description</th>
<th>Solvent flexo ink</th>
<th>Gelflex-EB ink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production of m²/year per machine</td>
<td>25.000.000 m²</td>
<td></td>
</tr>
<tr>
<td>Average printed area color (in %)</td>
<td>130 %</td>
<td>90 %</td>
</tr>
<tr>
<td>Volume anilox CMYK</td>
<td>5,0 cm³/m²</td>
<td>2,5 cm³/m²</td>
</tr>
<tr>
<td>Transferred wet ink on substrate</td>
<td>3,3 gr/m²</td>
<td>1,6 gr/m²</td>
</tr>
<tr>
<td>Volume anilox White</td>
<td>10,0 cm³/m²</td>
<td>5,0 cm³/m²</td>
</tr>
<tr>
<td>Transferred wet white ink on substrate</td>
<td>6,5 gr/m²</td>
<td>3,25 gr/m²</td>
</tr>
<tr>
<td>Total kg use of CMYK ink per year</td>
<td>105.625 kg</td>
<td>52.813 kg</td>
</tr>
<tr>
<td>Total kg use of white ink per year</td>
<td>146.250 kg</td>
<td>73.125 kg</td>
</tr>
<tr>
<td>Average price of ink (CMYK) per kg</td>
<td>€ 6,50*</td>
<td>€ 12,00*</td>
</tr>
<tr>
<td>Average price of ink (white) per kg</td>
<td>€ 5,00*</td>
<td>€ 8,00*</td>
</tr>
<tr>
<td>CMYK ink costs to this volume</td>
<td>€ 686,562</td>
<td>€ 633,750</td>
</tr>
<tr>
<td>White ink costs to this volume</td>
<td>€ 731,250</td>
<td>€ 585,000</td>
</tr>
<tr>
<td>Total inks costs (CMYK+White)</td>
<td>€ 1,417,812</td>
<td>€ 1,218,750</td>
</tr>
</tbody>
</table>

*Price Indication for Europe

saving per year: € 199,062
**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>Gelflex-EB ink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of solvent in CMYK ink</td>
<td>50 %</td>
<td>12 %</td>
</tr>
<tr>
<td>Amount of solvent in white ink</td>
<td>50 %</td>
<td>0 %</td>
</tr>
</tbody>
</table>

**Indication of the use of solvent per year:**

| Amount of solvent in CMYK ink | 52.813 kg         | 6.338 kg       |
| Amount of solvent in white ink | 73.125 kg         | 0 kg           |
| Amount of solvent to adjust viscosity | 12.594 kg | 634 kg         |

**Total amount solvent per year:**

| Amount of solvent | 138.531 kg | 6.971 kg |

**Average price of ethanol (mix) per kg**

| € 1,00 |

**Average price of Dowanol PM per kg**

| € 1,90 |

**Total costs of solvent per year**

| € 138,531 | € 13,254 |

**Total saving per year ink and solvent**

| € 324,348 |

**Additional costs for EB curing:**

- Cost of an EB equipment
- Costs for the use of Nitrogen

**Extra reduced costs:**

- Less or No investment and gas/power for thermal oxidizer
- Less thermal/blowing energy cost

**Reduced costs:**

| € 125,285 |
QTECS: Safe

- Food Law Compliant
  - FDA, EEC Directives, Nestle List
- Lowest odor, taint and extactable 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