Electron Beam Technology for Printing and Packaging Applications

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Electron Beam Technology

• Industrial uses for over 30 years
• Accelerated electrons produced using electrically operated filaments
• Low energy equipment is self-shielded
• Ionizing radiation initiates acrylate polymerization without photoinitiators
• Considered to be more food friendly compared to UV
• Very consistent output
  – Beam current ramps with line speed to give constant dose
  – Excellent cross-web uniformity
  – Output does not degrade with time
• High throughput
Presentation Outline

I. EB Printing and Packaging Applications

II. Advances in Low Energy EB Equipment
EB Technology for Printing and Packaging Applications

- Web offset printing
- Flexo printing
- Gravure printing
- EB clear coating over conventional inks
- EB laminating
- Specialty converting: holograms, transfer coating, specialty inks, etc.
EB Web Offset Printing

• Advantages
  – Commercial >25 years
  – Wet trap paste ink technology well established
  – Low plate cost
  – Low ink usage
  – High print quality
  – Variable repeat technology (VSOP)
  – Current use for cartons, labels, paper based pouches, and multi-wall bags

• Challenges
  – Extensible substrates
  – High ink coverage (first down or last down white)
  – Offset printing not familiar to most package printers
  – High capital cost of press equipment
  – Little current use in flexible packing
Central Impression Web Offset Printing

- New press technology from Comexi
- Offset stations with variable repeat sleeves mounted on a CI drum
- Combines advantages of web offset printing with ability to use extensible films
EB Flexo Printing

- Interstation EB not practical
- Need strategy to trap inks after each color
  - Wetflex (Sun Chemical)
  - EasyRad (TechnoSolutions)
  - Paste Ink System (IdeOn)
  - Dual UV-EB
Wetflex™ EB Ink Technology

- **Description/Advantages**
  - Developed by Sun Chemical
  - Allows flexo application of multiple ink colors without interstation drying
  - Curing is accomplished with a single EB unit at the end of the press
  - Inks contain limited amounts (about 20%) of water
  - Attractive for food packaging (water replaces monomer content for viscosity reduction)
  - High print quality due to low dot gain

- **Challenges**
  - Ink stability/dirty printing in long runs
  - Requires specially modified ink handing equipment
  - Wet trapping over first down white ink
  - Inks available only from Sun
EasyRad EB Ink Technology

• TechnoSolutions business venture formed by partners in Brazil
  – Antilhas (package printer)
  – Saturno (ink manufacturer)
  – Comexi (press manufacturer)
• Public announcement of demonstration at Antilhas August 2009 (www.pack.com.br/blog)
• Flexo printing with CI press platform
• Final EB cure only; no interstation drying necessary for ink trapping
• High solids solvent/EB hybrid
• Compliance with VOC emission standards?
Solvent/Water Free Paste Ink System

- Recent US Patent 7,997,194 to IdeOn LLC
  - Paste ink >5000 cps
  - Little or no VOC content
  - Apply with photopolymer based letterpress or flexo plate
  - Wet trap multiple colors and cure with single EB unit

- Ink metering system described in Patent Application publication US 2011/0192297

- No known current commercial installations
Dual UV-EB Curing of Inks

• Description/Advantages
  – Interstation UV cure with low power lamps followed by final cure by EB
  – Uses well known stable UV flexo ink technology
  – Excellent print quality due to low dot gain with 100% solids inks
  – Faster press speeds compared to UV curing alone
  – No limit on ink sequence or density of inks that may be used
  – Potential for food packing using low levels of migration resistant photoinitiators
  – EB effectively completes the cure of UV inks **without** nitrogen inverting

• Challenges
  – Higher capital costs to install both UV and EB equipment
  – Need press, EB equipment, lamp equipment, and ink supplier partners to demonstrate commercial viability

• Patent
  – US 5,407,708 covering dual UV-EB cure for CI-flexo assigned to Sealed Air expires January 2014
EB Gravure Printing

• Patent and publication by IdeOn LLC with Amgraph Packaging
• Water based EB curable inks
• Interstation drying with conventional thermal ovens
• Single EB at end of press to crosslink inks
• Advantages
  – Maintains print quality advantages of gravure
  – Eliminates VOCs from solvents
  – Food friendly: water diluent (no monomer), high molecular weight acrylated polymer dispersions
  – Crosslinked inks have superior resistance properties
EB Clear Overprint Coatings Over Conventional Inks

• Typical configuration is conventional CI press with coating station and EB after tunnel dryer

• Advantages
  – Lower cost by replacing film laminated flexible packing with surface printed and coated mono-web packaging
  – High gloss appearance
  – High heat, mechanical, and chemical resistance of cured EB coating

• Challenges
  – Matching appearance and handling of reverse printed laminated packaging
  – Odor, taint, food law compliance
  – Functional properties (COF, weatherability, ink protection)
  – Patent covering film food packaging applications (Cryovac US 6,528,127)

• Current Applications
  – Outdoor film bags
  – Multi-wall paper bags
  – Paper/foil tobacco package
  – Cold seal release coatings for confectionary packaging
EB Laminating

• Advantages
  – Stable one component adhesives
  – Bubble-free barrier-barrier lamination
  – Lamination in-line or off-line with printing
  – Instant bonding
    • Immediate QC, slitting, die cutting, shipping
    • Enables in-line processing (dye cutting, additional laminate layers)
  – FDA compliance established for select adhesives (FCN 642 -Northwest Coatings)

• Challenges
  – Higher cost compared to 2-component solventless adhesives
  – Good bonding of a limited range of inks and substrates

• Current Successes
  – Folding cartons (film-to-paperboard)
  – Non-food flexible packaging (film-to-film and film-to-paper)
  – Food packaging with foil barrier
Low Energy EB Equipment Development

- Industry defines low energy as <300 kV
- Initial self-shielded low energy beams installed in early 1980’s
- Multi-filament gun established as preferred configuration
- New generation of “lower” energy systems introduced in 2000
  - 90 to 125 kV
  - Primarily used in the curing of inks and coatings
- Modular sealed tube emitters introduced in early 2000’s
  - Performance and reliability have continued to evolve
EB User Requests

- Lower capital costs
- Improved reliability
- Lower cost of operation
- Easy and inexpensive maintenance
- Wider ranges of voltages
- Customization for new applications
- Larger range of web widths
- Non-web product handling
New Advancements in EB Equipment

- Integrated shield roll
- Low profile side fire
- Integrated converting on shield roll (4-in-1 System)
- Extended voltage range for lower energy systems
- Digital high voltage power supplies
- Sealed tube emitters
  - Narrow web curing systems
  - 3-D curing systems
  - Lab systems
- Ultra-low energy EB systems
Integrated Shield Roll

- New patented (US 8,106,369) design
- Supports the material **and** serves as a functional portion of the shielding
- Reduced machine size
- Reduced volume for inverting
- Optimum temperature control for heat sensitive substrates
- Facilitates integration of other processes on the exposed roll surface
  - Roll coaters, extruders, nips, etc.
Integrated Shield Roll
Low Profile Design

• Ideal for variable sleeve web offset presses
  – No need to raise the press or dig a pit for the beam
• Low entry height – varies with sleeve size
• New design maintains “side fire” orientation
• Easy access for foil change
• Uses integrated shield roll technology
• Allows printing on heat sensitive films such as shrink sleeve label stock
Low Profile EB on Variable Sleeve
Web Offset Press
4-in-1 Package Decorating System

• Flexo coating station and nip rolls integrated directly on EB shield roll
• Four modes of operation
  – EB coating
  – EB laminating
  – Cast & Cure (hologram embossing)
  – Cold foil transfer
• May be in-line of off-line with printing
4-in-1 Package Decorating System
Enabled by process integration with integrated shield roll
4-in-1 Package Decorating System
Examples of 4 in 1 Curing

- Coating
- Lamination
- Cold Foil Transfer
- Cast & Cure™
Extended Voltage Systems

- Same size profile as new generation lower energy EB systems
- Energy range increased up to 175 kV
- Maintains “side fire” orientation for easy foil access & changing
- Penetration up to 150 microns
  - Film crosslinking
  - Pressure sensitive adhesive crosslinking
  - Simultaneous curing of inks on the outside surface and sterilization of food contact surface
- More cost effective than current industrial EB processors
Depth/Dose Curve for Low Energy EB Up to 175 kV

For unit density g/m² = microns
Extended Voltage Low Energy Systems

175 kV system with 24 inch integrated shield roll
High Voltage Power Supply

- Newly available high frequency, switch-mode power supplies
- Power factor above 0.90
- Significantly reduced power consumption
- Integrated digital signal processors
- Configuration and diagnostics via Ethernet
- Fast (50 microsecond) control
- Replace SF$_6$ insulating gas (greenhouse gas) with silicone oil
- Compact size
- High voltage cable connection allows remote installation
High Voltage Power Supply
Sealed Tube Emitters

• Modular design
• 16 inches (400 mm) wide
• Voltage ranges of 90 to 180kV
• Speeds up to 300 ft/min (100 m/min) with 30 kGy dose
• New developments providing significant increase in foil life (over 6000 hours)
• Integrated systems based on sealed tube emitters enable new applications
  – Narrow web printing and converting
  – Curing of 3-D surfaces
  – Lab curing units
Seal Tube EB Systems
Emitter, Cable, Power Supply
EB Systems Based on Sealed Tube Emitters

Narrow web application with integrated shield roll

Custom 3-D curing application with sealed tube emitter
Narrow Web Printing Technology
Incorporating Sealed Tube Emitter Based EB System

- EB curing of thick / high density ink layers
- Supplemental curing of current UV inks
- EB inks and coatings designed for food packaging
- EB adhesive lamination
- Cold foil transfer
Narrow Web EB System
Lab EB Curing System
Ultra-Low Energy Electron Beam Systems

- Ultra-low energy range of 15 kV to 25 kV
- Compact size; widths 20 to 90+ inches
- Digital power supply
- Direct installation in vacuum coating chambers
- Elimination of the need for titanium foil as a vacuum barrier
- Cure coatings that are vacuum deposited or roll coated on a web within a vacuum chamber
- 15 kV EB generated in a vacuum will penetrate coating weights of about 4 g/m²
- Use together with other vacuum coating processes such as metallization
- EB designed to operate in $10^{-5}$ torr vacuum range
Depth/Dose Curve for 15 kV EB
(operating in a $10^{-5}$ torr vacuum)
Thank You

Questions?

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