Inkjet Printing – Flat and Container Glass

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Glassprint Conference
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Global Inkjet Systems

- Electronics, firmware, drivers, RIPs, software utilities, user interfaces and components for ink delivery systems. Our customers are primarily machine builders and integrators.
Agenda

• Introduction

• Flat glass
  • Advantages of and demands on inkjet
  • Latest developments

• Container glass
  • Understanding shapes
  • (Some of the) challenges for inkjet
  • Printing on different shapes
    • Enabling technologies
  • Next steps

Images from Dip Tech, Durst and Ferma, SMTD web sites
Industrial Inkjet Printheads

- Wide range of printheads available – different features & capabilities
  - Range of print widths/resolution/speed/drop sizes
  - Binary, greyscale
  - Ink capability
  - Recirculating ink flow
- Used in multiple different applications
  - Examples include - ceramic tile printing, laminates, textiles, labels, direct mail, 3D printing, coatings, varnishes, functional fluids (e.g. printed electronics), flat glass and direct to shape (plastics, metal & glass)
- XY scanning and single pass systems

<table>
<thead>
<tr>
<th>Fujifilm Dimatix</th>
<th>Konica Minolta</th>
<th>Kyocera</th>
<th>Panasonic</th>
<th>Ricoh</th>
<th>SII</th>
<th>Toshiba Tec</th>
<th>Xaar</th>
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**Scanning vs. Single Pass**

- **Scanning**
  - Safe and reliable
  - Errors recoverable
  - Typically lower productivity

- **Single pass**
  - No room for error
  - Defects highly visible
    - Missing nozzles
    - Jet straightness
      - Consistent jet velocity
  - High productivity
  - Reliability critical
Single Pass – Multiple Heads – Industrial Applications

- **Wide single pass inkjet** – e.g. ceramics, textiles and laminates
  - Multiple bars of printheads
  - Multiple colours
  - >100 printheads per system
  - High duty cycle environments
  - Reliability and up-time critical

- **Inkjet proven technology**
  - But can it meet the needs of the glass industry....
Flat Glass
Inkjet and Flat Glass

• Advantages
  • No screens – no storage – faster turnaround
  • Economic short runs
  • Variable data
  • Process colour printing without interim processing steps

• Vitrum news
  • Tecglass - new carriage configuration printing 1m² of a single colour design in 30 sec: multicolour design in 50 sec: graphic design in 150 sec
  • Durst - new transport suction cap system – high precision registration: surface sensors – precision positioning of round shaped glass
Demand for Glass Decoration – Flat Glass

**What product areas offer the most potential for growth in 2015?***

<table>
<thead>
<tr>
<th>Product Area</th>
<th>Growth Potential</th>
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<tbody>
<tr>
<td>Decorative glass</td>
<td>73%</td>
</tr>
<tr>
<td>Energy efficient glass</td>
<td>65%</td>
</tr>
<tr>
<td>Protective glazing</td>
<td>45%</td>
</tr>
<tr>
<td>Dynamic glazing</td>
<td>10%</td>
</tr>
<tr>
<td>Solar</td>
<td>8%</td>
</tr>
<tr>
<td>Other**</td>
<td>15%</td>
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</tbody>
</table>

“For the second consecutive year, fabricators reported that the decorative glass segment offered the most growth potential. Architects and designers increasingly demand all-glass, jumbo and custom glass for their projects, driving the decorative market.”

*Source: Glass Magazine February 2015*
Inkjet Adding Functionality

• By changing the density of patterns printed into the glass, architects can control how much natural light enters a specific room and how much solar heat gain typically occurs during the daylight hours in a site-specific location
  • November 2015 Dip-Tech launched Dip-Energy
    • Offers a printed glass performance calculator - quickly evaluates the energy performance of glass printed with Dip-Tech ceramic inks - measures the impact various designs will have on the Solar Heat Gain Coefficient and the percentage of visible light (%T) of the glass
Inkjet Printing onto Containers – Plastic/Metal

• Machines are now installed and in production
• A selection....

• Will we see the same for glass?
Container Glass - Different Shapes

<table>
<thead>
<tr>
<th>Flat</th>
<th>Cylinder</th>
<th>Conical</th>
<th>Bottles</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Flat Glass" /></td>
<td><img src="image2" alt="Cylinder Glass" /></td>
<td><img src="image3" alt="Conical Glass" /></td>
<td><img src="image4" alt="Bottle" /></td>
</tr>
</tbody>
</table>

- **Continuity of curvature in direction of print**
- **“Continuous” shapes** – curvature remains constant in direction of print
  - Cylinder, cone (mixed resolution, but still continuous), bottles etc
- **“Discontinuous” shapes** – curvature changes
  - Bottles (mixture of flat edges and curved corners and conical shapes)
  - Correction required keeps changing
  - Discontinuity across the printhead – adds considerable complexity

Source of images: internet images – none are known to be inkjet printed
Unfolding or “Flattening” Shapes

• Allows us to understand the complexities of printing onto that surface
  • Cylinders
    • Slice a cylinder down one side – unfolds/flattens to a simple rectangle
  • Cones
    • Cones unfold into “arced” rectangle
  • Tubs
    • Tubs are combinations of cones and cylinders with discontinuities
Some of the Challenges for Inkjet

- **Inks are critical**
- **Inkjet printheads**
  - Designed to print onto flat surfaces
  - Throw distance
    - Drops only jet a few millimetres and decelerate quickly
    - Larger drops jet further
    - Smaller drops improve graphical image quality
  - Distance between nozzle banks
    - Time of flight on curved surfaces
  - Printhead dimensions
    - Reaching the nooks & crannies
- **Need to manage physical characteristics of printhead in relation to curved surface**
  - Time of flight
  - Distance between nozzle banks
  - Image compensation – where applicable
Printhead Orientation

• **Orientation of the object under the printhead to get best possible print**

• **Three key issues**
  • Symmetry
  • Nozzle bank width
    • The narrower the better
  • Number of columns
    • Different times of flights
    • More complex

• **Printhead orientation**
  • Printing downwards
  • Printing sideways “skyscraper mode” (printhead dependent)
Printing onto Cylinders

- A “flat” image wrapped around a cylinder
  - No image compensation required
- Physical characteristics of the printhead
  - Geometry
  - Drop ejection
  - Time of flight
Printing Onto Bottles

• Huge range of shapes
• Printing more of the bottle presents new challenges as often different corrections required
  • Often combination of cylinder (main body of the bottle) & cones (neck)
  • Some have discontinuous shapes e.g. a tub-shaped base, ridges
Printing onto Different Shapes of Bottles

• Printing on cylinder section only

• Simplistic approach shown here
  • Print quality will vary where drop throw distance is further

Lower quality print area
Creating Wider Images

- **Decoration** – typically wider than one printhead print swathe
- **Stitches can massively improve output quality**
  - Stitched printheads do not all jet in the same place at the same time
  - Some will be printing wet on dry while others will print wet on/near wet
  - Software tools can help improve print quality

One head – wet on dry curing – lower throughput

Two heads – wet on wet printing – higher throughput

2-D Density

X & Y Dither
Full Product Height Printing

- **Cylinders**
  - Large area coverage well demonstrated

- **Conical shapes**
  - Most images are one head height and/or cover only a section of the cone requiring only minor distortion correction
  - Full height printing opens up new markets for full product decoration
Printing onto Conical Shapes

Continuous shape, but more complicated than a cylinder

• Nozzle alignment issues (as with cylinders)
• Resolution changes when printing onto curved surfaces
• Need to compensate for density increase
• Screening more complex
Printing onto Conical Shapes

- **Challenges**
  - Mechanical alignment of heads
  - Density & screening correction
  - Jetting angle variations
  - Stitching multiple heads—additional complexity
  - Software adjustment to support array of multiple printheads

- **Issues**
  - Nozzle misalignment
  - Time of flight differences
  - Increasing density
  - Screening issue - changes in dot gain

- **Images**
  - Image printed without correction
Printing onto Conical Shapes

- Technology exists
  - Correct nozzle alignment
  - Density correction
  - No dot gain issues
  - No screening artefacts

- More complex shapes also possible
  - Mixture of flat and curved surfaces
  - Required corrections change during the print (often from pixel to pixel)
  - Multi-dimensional nozzle, density and screener correction technology
    - Can be adjusted to each surface type and associated application process
Summary – Technology Enablers

• Inks/printheads
  • Drop size/ resolution/ print quality
  • Ink recirculation
  • Adhesion/process issues – ink chemistry critical
  • Recyclability
  • Reliability

• Supporting technologies
  • Pre-treatment/ curing/ post-treatment

• New processes – new market opportunities
  • Software tools – more shapes

• Synergy of inkjet with analogue print – hybrid devices

• Production systems
  • Must meet industry demands (on many levels)
  • Find applications where digital argument is compelling
  • Create new market opportunities

Images from Tecglass, Dip Tech & Fermac web sites
Inkjet Container Glass

There will be more....
Thank you – Any Questions?

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