Inkjet in Coatings & Complex Shapes: Technologies & Processes

Debbie Thorp, Business Development Director
Global Inkjet Systems Ltd

Chicago – May 2019
Agenda

- Brief introduction to GIS
- Overview of Direct to Shape (DTS)
- Challenges
  - What are the problems?
- Tubes, cones & tubs
  - Well established
- More complex shapes
  - A generic approach, applied to a sphere
  - Some new challenges
Global Inkjet Systems

• Leading independent developer of inkjet technology
  • Supply critical inkjet technology and components to OEM system builders, specialist integrators and end users
• Support a broad range of inkjet printheads in wide range of applications and industries
  • Fujifilm Dimatix, Konica Minolta, Kyocera, Ricoh, Toshiba Tec, Xaar

• Based in Cambridge, UK
  • 12+ years of growth & technology innovation
  • 70+ employees
  • 130+ customers world-wide
  • Support offices in UK, Japan and China

Image source: GIS
GIS – Products

Used in broad range of applications – textiles, labels, security printing, décor, spot varnish, product decoration, corrugated, ceramics, functional coatings, materials deposition, 3D, robotics and more

From pixels to droplets: we supply technology for the whole data pipeline – from image to print
Disclaimer

Global Inkjet Systems supplies inkjet technology and components to 130+ original equipment manufacturers world-wide. As a matter of policy, we do not disclose our customer relationships.

Some of the following slides contain images chosen to illustrate the range of inkjet print systems which are available in the market. The presence, or absence, of any manufacturer’s products in these images does not in any way imply a commercial relationship between that manufacturer and GIS.
Inkjet DTS Development Timeline

Flat & Semi-Flat

Tubes/Cylinders

Cones

Tubs

Complex shapes

Image source: Mimaki, InkCups Now, EPS, Krones, Machines Dubuit, Nakan, ITW, Martinenghi, Plastic-Molds, Wifag
Tubes

- **Well established/well understood technology**
  - Fixed radius of curvature
  - Cylinder unwraps to a rectangle or square
- **Flight time differences become more complex as print speed is increased, and/or radius of curvature decreased**
  - Printheads with slim format/two rows of nozzles popular
  - Flight time difference can be significant for multi-column print heads
Cones

- Cones or cone sections are useful for many applications
  - Unfolds to an arced rectangle / section of a circle
  - Corrections are relatively straightforward, provided heads are narrow and mounted symmetrically – more complex for larger heads

- Challenges
  - Nozzle alignment
  - Density correction
  - Dot gain management
  - Avoid screening artefacts
Tubs

- Mixture of cone sections and flat surfaces
- Required corrections change during the print
  - Often from pixel to pixel
- Print system is more complex
  - No longer rotating about a single axis
  - Transport design may require a synthetic encoder

Image source: GIS software, Wifag
Inkjet Challenges – Curved Surfaces

<table>
<thead>
<tr>
<th></th>
<th>Flat Surfaces</th>
<th>Curved Surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density Correction</strong></td>
<td><img src="image1.png" alt="Flat Density" /></td>
<td><img src="image2.png" alt="Curved Density" /></td>
</tr>
<tr>
<td><strong>Throw Distance &amp; Flight Time</strong></td>
<td><img src="image3.png" alt="Flat Flight" /></td>
<td><img src="image4.png" alt="Curved Flight" /></td>
</tr>
<tr>
<td><strong>Nozzle Alignment &amp; Interleaving</strong></td>
<td><img src="image5.png" alt="Flat Interleaving" /></td>
<td><img src="image6.png" alt="Curved Interleaving" /></td>
</tr>
<tr>
<td><strong>Screening</strong></td>
<td><img src="image7.png" alt="Flat Screening" /></td>
<td><img src="image8.png" alt="Curved Screening" /></td>
</tr>
</tbody>
</table>
More Complex Shapes

- Many complex shapes have eluded inkjet printing & coating
- Analogue technologies dominate
- Inkjet moving from partial to full coverage printing / coating of any object

Photo credit: © Upper Austrian Research, Hartwig Zörgl

Other images from YouTube, Airbus & Ritzi (Heidelberg)
## Inkjet Challenges – Navigation & Motion Control

<table>
<thead>
<tr>
<th></th>
<th>Flat Surfaces</th>
<th>Curved Surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geometry</strong></td>
<td>2 Dimensions</td>
<td>3 Dimensions</td>
</tr>
<tr>
<td></td>
<td>2 Degrees of Freedom</td>
<td>6 Degrees of Freedom</td>
</tr>
<tr>
<td><strong>Print Path</strong></td>
<td><img src="image" alt="Flat Surface Print Path" /></td>
<td><img src="image" alt="Curved Surface Print Path" /></td>
</tr>
<tr>
<td><strong>Shape Data</strong></td>
<td><img src="image" alt="Flat Surface Shape Data" /></td>
<td><img src="image" alt="Curved Surface Shape Data" /></td>
</tr>
<tr>
<td><strong>Motion Control</strong></td>
<td><img src="image" alt="Flat Surface Motion Control" /></td>
<td><img src="image" alt="Curved Surface Motion Control" /></td>
</tr>
</tbody>
</table>
Inkjet Challenges - Jetability

• **Viscosity**
  • Most drop on demand printheads require fluids with viscosities in the range 7-15 centipoise (cps) at jetting temperature
  • Higher viscosity fluids can be heated to reduce viscosity to be jettable
  • Some new printhead developments will enable higher viscosities

Image source: JetXpert
Inkjet Challenges – Throw Distances

- **Inkjet typically designed to throw ink drops a distance of 1 – 2mm to the surface**
  - Produces sharp, detailed graphics and text – down to 2pt @ 1200dpi
  - Also works well even when the head or surface are moving at up to 5m/s relative speed
  - But has created a perception that greater throw distances are a problem
- **In fact, nozzle drop velocities are in the range 5-8m/s**
  - Medium to large drops will travel over 20mm
  - Placement accuracy does degrade with range, so a trade-off must be found
    - Fine detail can be achieved on near-flat surfaces with shorter throw distances
    - Coating coverage can be achieved even in concavities up to ~25mm depth
Disadvantages of Spray

- Typical interior trim part
- With high gloss piano black coating
Case Study – Cyan Tec

- Typical spray path
- Two passes overlap
- Begins & finishes off the part
- Can’t be controlled over gaps
Case Study – Cyan Tec

- Product surface: 575 cm²
- Spray pattern: 2,243 cm²
- Waste: 1,668 cm²
- Waste: 74%
Case Study – Cyan Tec

The Robotic Digital Deposition Process

- Complete piano black facia
- Scratch resistant coating
- Zero overspray
- Virtually zero waste
- 70% material reduction
- >70% VOC emissions reduction

Permission granted by Cyan Tec
Complex Shapes - From Concept To Reality

- Starting with a sphere
- Using a robot to position the shape under the printheads
- We built a test print rig
Mesh & Texture

- Many tools available for wrapping
  - Well established technologies from gaming, augmented reality industries, etc.
  - Many different ways to wrap, edit directly on to 3D surfaces
  - Result is expressed as a texture map

Image source: GIS
• **Design a print path**
  • Taking into account the constraints of the object to be printed, inkjet printhead, capability of the robot
Positioning Accuracy

Industrial robots have sufficient accuracy for many industrial applications ...

... but printing requirements are tight

- Typical industrial robots can achieve absolute pose accuracy, with calibration, of 200-500 µm
- Inkjet printing requirements for graphics are typically 5-10x finer, but not so precise for coating
- Robot repeatability is better than absolute accuracy, so further calibration is possible

Image source: ABB and Fanuc
All manufactured objects have tolerances

- E.g. Polypropylene sphere
- Inexpensive consumer product

Nominal: 75 mm radius

Structural errors
Assembly of two hemispheres

1-1.5mm

Precision errors
Limitations of process

~0.25 mm
Stitching

• **Stitching is a key area where inaccuracies will show**
  • Positioning errors cause gaps or overlaps, familiar from 2D printing

• **Careful control is required of multiple factors:**
  • Accuracy of transport, especially robots near to singularities
  • Print synchronisation
  • Variation of the target shape from nominal dimensions

Image source: GIS
Shape Accuracy Compensation

- **Measure the target shape accurately**
  - Mechanical profile gauges
    - Adequate, but rather slow
    - Contact with target shape may be a problem
  - **Laser triangulation sensors**
    - Resolutions down to $10^{-6}$m, sample rates 1-100kHz
    - Non-contact

- **Apply measurements as corrections to the mesh model**
  - For per unit variations this can be done as a late stage delta
  - Output adjusted swathe data
Create Tools

Import Mesh & Texture

Swathe Decomposition

Swathe paths

Transport Control

Measure & Correct

Colour Separation

Density Correction & Screening

Unwrap

Print Control

Image source: GIS
Result: a printed polypropylene spheroid
- CMYK 1200 dpi
- Latitude swathes
- 300dpi native x 4 interleave
Summary - Implications & Opportunities

• Inkjet already being used in many decorative and functional coating applications

• Advances in printhead technologies, software and fluids continues
  • Some highly viscous fluids for coatings remain a challenge
  • Ink jettable fluids - key to unlocking more applications

• Inkjet no longer constrained to flat surfaces
  • Precision positioning is vital, and is much more complex than for 2D

• Great potential for further usage – particularly in industrial products
Contacts

**Nick Geddes**, CEO  
nick.geddes@globalinkjetsystems.com

**Debbie Thorp**, Business Development Director  
debbie.thorp@globalinkjetsystems.com

**Phil Collins**, Director – Advanced R&D  
phil.collins@globalinkjetsystems.com

**Global Inkjet Systems Limited**  
Edinburgh House  
St Johns Innovation Park  
Cowley Road  
Cambridge CB4 0DS

Tel: +44 (0)1223 733 733  
Web: www.globalinkjetsystems.com

Technical support offices in UK, Japan and China