Curved Surface Direct Product Decoration – From Prototype to Production

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GIS – Overview

- GIS Printer Drivers
- GIS Electronics
- Print Manager Boards
- Head Personality Boards
- GIS Variable Data RIP
- PC
- Printheads

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Agenda

• Direct production decoration
• Understanding shapes
  – Flat is easy; curved is....challenging
• Printing onto various shapes
  – Cylinders, cones, bottles
• Stitching
• Integration into production lines
• GIS curved surface map generator
Existing Processes

• Dominated by analogue technologies
  – Screen
  – Pad printing
  – Dry offset
Analogue Technologies

Screen printing

Dry offset printing

Pad printing

Image sources: Kase Equipment; Ink Cups Now; ITW TransTech

Pads - typically moulded silicone rubber
UNDERSTANDING SHAPES
Categories of Shapes

- The real world is made up of a variety of different shapes
- Continuity in direction of print
  - “Continuous” shapes – curvature remains constant in direction of print
    - Tube, cone (mixed resolution, but still continuous), sphere etc
  - “Discontinuous” shapes – curvature changes
    - Tub (mixture of flat edges and curved corners)
    - Correction required keeps changing
    - Discontinuity across the printhead – adds considerable complexity
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
  - Bottles & Spheres
    - Bottles & spheres cannot easily be unfolded
      - Spheres have always presented a problem
      - Bottles often highly complex
Flat Printheads and Curved Shapes

- Inkjet printheads have been designed to print well onto flat surfaces
- Some shapes are very hard to print on well
  - Drops only jet a few millimetres and decelerate quickly
  - Jet straightness
  - Larger drops jet further but smaller drops improve graphical image quality
  - Printhead dimensions
    - Reaching the nooks & crannies

- Golf ball example
  - Area of print focused in small area
  - Or - many revolutions needed
In an Ideal World....

- An interesting challenge for the industry!
- In the absence of such a product...
  - Physical characteristics of printhead in relation to curved surface
  - Image compensation
Coping with Reality

• 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 Geometry**

**Single column**
- Easiest, but lower resolution

**Dual column shared wall**
- Symmetrical, narrow is better

**Multiple columns**
- Faster, complex but some printheads have independent fire control, which helps

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CONTINUOUS SHAPES - CYLINDERS
Tube Rotation Under Printhead
Tube Array

- Open-ended tube on mandrel
- Heads in a fixed array
- Each mandrel can spin/geared
- UV lamps under each print station
- Motion control moves mandrel under 1st printhead - Cyan
- Needs 1.5 revolution per colour to print and then cure
- Whole mechanism moves along and prints each colour in turn
- Example of pipelining
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DISCONTINUOUS SHAPES
Printing onto Bottles (Lower Quality)

- Some objects cannot be printed in a single rotation
- Often highly complex
  - Neck ridges
  - Narrowing of middle section
- Multiple angles may be required to print the entire surface
  - Some areas almost impossible to reach
- Simplistic approach shown here
  - Print quality will vary dramatically – needs large drops for the throw distance
Printing onto Bottles (Higher Quality)

• Three step process (in this example)
  – Printhead printing 3 parts of the bottle and stitching image data together at software level
  – Production speed reduced
  – Mechanism needed to orientate the printhead
  – Choice of printhead can be critical
    • Ideally avoid heads with wide mounting points which can cause obstruction. Best to use a printhead with nozzles right up to the edge to get into the print areas
• Robotics a possible solution (in this example)
Robotics

- Six degrees Of freedom
- Versatile (works with most objects)
- Potentially low accuracy
- Ok for single pass
Robotics

• Can be successfully implemented/integrated with inkjet
• Depending on process, can be slow
• Appropriateness depends on application
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STITCHING
One Printhead – Two Swathes

- Need to print two swathes with one printhead
- Must print in two different locations
- Requires additional mechanical movement of printhead or bottle
- Requires stitching between revolutions
  - Wet on dry (may have to cure between sections) – creates more challenges
- Lower print quality
  - Can be overcome by advanced stitching techniques
- Lower throughput
Two Printheads – Two Swathes

- Need to print two swathes with two printheads
- Printheads correctly located
- Requires no additional mechanical movement of printheads or bottle
- Still requires stitching between revolutions
  - No longer wet on dry
- Higher print quality
- Higher throughput
Printhead Stitching

• Why is a good stitch important?
  – The human eye is very good at spotting discontinuities especially in areas of flat colour

• What needs to be controlled?
  – **Printhead alignment**: typically positioned to within <20% of the diameter of a drop
  – **Printhead calibration**: printheads ideally need to be tuned for jet straightness and drop size conformity
  – **Ink substrate interaction**: Ink moves over time creating visible artefacts – ink migration control

• 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

Source: Industrial Inkjet
GIS Stitch Generator

No /“Flat” Stitch

50% Stitch – printing with alternating lines from each printhead in the region of overlap. Simple to implement.
GIS Stitch Generator

**Moving Stitch** - Typically a saw tooth or sinusoidal stitch that disrupts the visible stitch line. Can be improved by using different frequencies for each ink.

**2D Stitch** - same as 1-D but with dithering in the print direction.
Curing and Drying

• UV curing
  – When, where and if to pin
    • On each colour?
  – When and where to cure
  – Print as quickly as possible

• Ink properties
  – Migration
  – Adhesion
  – Gamut

• Process
  – Pre-coat: primer; white
  – Colour: UV: aqueous: solvent: hot melt
  – Special Inks: metal effect: security: UV visible
  – Post-coat: varnish: lacquer
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INTEGRATION INTO PRODUCTION LINES
Production Lines

- Typically production lines run faster than inkjet can print today
- Bottles/cans in particular – very high speed e.g. 1,800/min
- Inkjet must find ways to integrate efficiently – otherwise the chance of adoption will be low
Increasing the Number of Printheads

Printing with multiple printheads

- Productivity increased
- Difficulty printing onto very small objects – moving printheads in and out as required
- Printheads are rotated
- Stitching difficult
- Faster than printing one colour at a time
- Removes the need to pin/cure after each colour
Parallelisation

- Simple built in redundancy
- Can “match” production line speeds
  - Multiple print stations – then rejoin main production line
Pipelining

- Redundancy more difficult
- Easily scalable to add more inks
- Needs pinning/curing between colours
- Ideal system has both parallelisation and pipelining
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GIS CURVED SURFACE MAP GENERATOR
Cones

Resolution changes when printing onto curved surfaces
Printing with no Correction

- Nozzle misalignment
- Time of flight differences
- Increasing Density
- Changes in dot gain
Cones
GIS Curved Surface Map Generator

![GIS Utility - Curved Surface Map Generator](image)

- **Shape Type**: Bottle
- **Property** | **Value**
  - Shape Dimensions
    - Neck Radius | 60.000000
    - Container Radius | 40.000000
    - Container Height | 60.000000
    - Taiper Height | 40.000000
    - Outer Curve | 60.000000
    - Inner Curve | 40.000000
  - Printhead
    - Invent Nozzle X | False
    - Invent Nozzle Y | False
  - Export
    - Export Folder | C:\Program Files\Global

**Status**
- Completed in 6.4 seconds
- Total shape length – 60.0 mm or 851 pixels

[Generate Correction Map]
Thank you – Any Questions?

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