GIS – Global Inkjet Systems

• Founded November 2006
  • Privately owned
• Leading provider of technology solutions for industrial inkjet systems
• HQ in Cambridge, UK
• Technical support in UK, China and Japan
• >60 employees
• Over 150 customers

• Drive electronics for wide range of inkjet printheads
• RIP software
• Application software
• Customisable user interfaces
• Ink delivery system components
Agenda

• Main functions and basic requirements of ink delivery systems (IDS)
• Flow modes and printhead types
• Design options & challenges
  • Heating
  • Degassing
  • Customizing print bars
• Typical IDS issues
  • Diagnosing common issues
  • Troubleshooting and solutions
Main Functions of Ink System

• **Meniscus pressure**
  • Ink pressure inside the printhead
    • Meniscus is formed by a slight negative pressure at the nozzle

• **Air pressure control**
  • Negative air pressures to maintain meniscus pressure of each printhead
  • At different flow rates
  • Scanning XY systems – withstand the acceleration/deceleration of printhead carriage

• **Ink pumping**
  • Control for pumping of ink from bulk ink tank

• **Purging**
  • Positive pressure to the ink in the printhead
    • Low pressure and high pressure purge (required by some printheads)
Basic Requirements

• **Filtration**
  • Minimise chance of particles clogging the nozzles

• **Flow modes**
  • Support for recirculation or no recirculation

• **Degas**
  • Stop air bubbles reaching the printhead/nozzles
  • Avoid air pockets in ink system

• **Heat the ink**
  • For correct operating temperature (printhead dependent)
Basic Requirements

• Shared or individual pressure

Example shows shared pressure CMYK and individual pressure White
Basic Requirements

• System monitoring
• User friendly GUI
• Graphing tools – pressure, pump & solenoid activity etc.

Ultimate aim: Reliable system for production environments!

Image source: GIS
Flow Modes

No Flow

Low Flow

Controlled Flow

Image source: GIS
No Flow/End Shooter

• Basic characteristics
  • Air pressure range typically 250-500mm between header tank and nozzle plate
  • In this example, negative pressure P (-350mm) applied to balance the positive head of fluid (300mm) and provide a negative meniscus pressure of -50mm at the nozzle plate

Image source: GIS
Low Flow/End Shooter

- **Basic characteristics**
  - Height difference between the header tanks
  - Same negative air pressure applied to both tanks
  - System constantly tries to level and creates low flow through the printhead

Image source: GIS
**Controlled/Adjustable Flow**

- **Basic characteristics**
  - Two pressure values assigned
  - Printhead manufacturers tend to specify the pressure difference
  - Differential air pressure creates flow through the printhead
  - Air Pressure$^1$ and Air Pressure$^2$ are both adjustable to vary/control the flow rate

![Diagram](Image source: GIS)
# Printheads & Flow Modes

<table>
<thead>
<tr>
<th>Example Printheads</th>
<th>No Flow</th>
<th>Low Flow</th>
<th>Controlled Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fujifilm Samba G3L/G5L</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Fujifilm Starfire SG1024</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Fujifilm Sapphire 256</td>
<td>✔</td>
<td>(✔)</td>
<td>❌</td>
</tr>
<tr>
<td>Konica Minolta 1024i</td>
<td>✔</td>
<td>(✔)</td>
<td>❌</td>
</tr>
<tr>
<td>Kyocera KJ4B-QA/YH</td>
<td>✔</td>
<td>(✔)</td>
<td>❌</td>
</tr>
<tr>
<td>Kyocera KJ4A-TA/AA/RH</td>
<td>✔</td>
<td>(✔)</td>
<td>❌</td>
</tr>
<tr>
<td>Ricoh MH5441</td>
<td>✔</td>
<td>(✔)</td>
<td>(✔)</td>
</tr>
<tr>
<td>TTEC CF1/CF3</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Xaar 1003</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Xaar 5601</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
</tr>
</tbody>
</table>

**Key**
- ✔ Required
- (✔) Optional
# Ink Requirements

<table>
<thead>
<tr>
<th>Ink Type</th>
<th>Typical Ink System Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV Cure</td>
<td>• Requires heating (most printheads have heaters and/or use heated mounts)</td>
</tr>
<tr>
<td></td>
<td>• Degassing can be advantageous - best for high frequency/large number of heads. Must be used with care - can make ink over-sensitive to curing</td>
</tr>
<tr>
<td>Aqueous</td>
<td>• (Requires) degassing</td>
</tr>
<tr>
<td>Oil based</td>
<td>• None special</td>
</tr>
<tr>
<td>Solvent</td>
<td>• May require materials compatibility testing</td>
</tr>
<tr>
<td>White/ Ceramic</td>
<td>• Require special pumps due to abrasive ink pigment and particle settling</td>
</tr>
<tr>
<td>Fluid Deposition/ Functional Fluid/ Ink Development</td>
<td>• Requires materials compatibility testing</td>
</tr>
<tr>
<td></td>
<td>• Typically requires small volumes due to high value of fluid – may affect header tank design/size</td>
</tr>
</tbody>
</table>
### Heating

**Ink performance varies with temperature**
- Higher temperature
  - Reduces viscosity
  - Increases evaporation

**Inks have a recommended operating temperature window (consult your ink supplier)**

**Temperature most critical at the printhead/jetting**

<table>
<thead>
<tr>
<th>Mode of Heat</th>
<th>Comment</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-line Heaters</td>
<td>• Only work with recirculating systems</td>
<td>• Provide fast and controllable ink heating</td>
<td>• Cost</td>
</tr>
<tr>
<td>Heated Header Tanks</td>
<td>• Typically used in no flow or low flow systems</td>
<td>• Lower cost than in-line heaters</td>
<td>• Only suitable for low density printing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Temperature control less accurate</td>
</tr>
<tr>
<td>Heated Head Plates</td>
<td>• Can be used with all flow modes</td>
<td>• Provides uniform thermal environment</td>
<td>• Thermal expansion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduces workload on printhead/ink system heating improving thermal control</td>
<td>• Adds cost</td>
</tr>
</tbody>
</table>
Degassing

• (Required) for aqueous inks
  • Sometimes not used on small systems to save cost

• Recommended for some UV inks
  • Typically on large, high print frequency systems

• Contactor must be right size for flow rate and compatible with ink

• Vacuum must be applied
  • High vacuum for aqueous ink
  • Lower vacuum for UV ink
    • Risk stripping all oxygen out of the ink and cause curing

Image source: Separel web site
Image source: GIS
Larger Print Bars – Tank Options

- **Manifold system**
  - Popular design
  - Cost efficient to implement
  - Can be prone to air traps
    - Trapped air can sit at top of manifold
  - Can be difficult to fill
  - Extendable

- **Custom header tanks**
  - Header tank acts as manifold
  - Valve for each printhead
  - Equal flow resistance
  - Extendable

Image source: GIS
Typical IDS Issues
Common Issues Attributed to IDS

- Late or Grouped Jetting
- Weak Jets at Start of Swathe
- Misdirected Jets
- Unreliable Jetting
- Weak Nozzles
- Failing Nozzles During Print
- Process Direction Density Variation
- Cross Process Density Variation
- High Print Speed Variation
- Print Density Uniformity
- Air In Printhead
- Ink On Nozzle Plate
- Printhead Lifetime
- Blocked Nozzles
- Blocked Printheads
- Hard to Prime
- Drop Ejection
- ?
- ?
- ?
Common Issues with Alternative Causes

- Unreliable Jetting
- Weak Jets at Start of Swathe
- Misdirected Jets
- Weak Nozzles
- Failing Nozzles During Print
- Late or Grouped Jetting
- Drop Ejection
- Ink Delivery System
- Process Direction Density Variation
- Cross Process Density Variation
- High Print Speed Variation
- Print Density Uniformity

Waveform / Electronics
- Printhead Lifetime
- Blocked Nozzles
- Blocked Prinheads
- Hard to Prime
- Low Print Speed

Ink On Nozzle Plate
- Air In Printhead

Ink
- Environmental / Media / Mechanical

Printhead
- Lifetime
- Air In Printhead
- In-House Failure
- Printhead

Hard to Prime
- Air In Printhead
- In-House Failure
- Printhead

Ink Delivery System
- Process Direction Density Variation
- Cross Process Density Variation
- High Print Speed Variation
- Print Density Uniformity

Air In Printhead
- In-House Failure
- Printhead

Ink On Nozzle Plate
- Air In Printhead
- In-House Failure
- Printhead
Trapped Air

• **Symptoms**
  • Difficult morning start up
  • Ink dripping from nozzle plate, even when pressure set correctly
  • Intermittent printing
    • Heads may print well for short time until air moves into the head
    • Heads may print well for low density images but fail quickly for high density images

• **Solutions**
  • Ink degassing
  • Avoid tubing with uphill path or loops
  • Correct tube size (not too small or too large) – restricted flow can lead to air being sucked into the nozzle as the head fails to pull ink through the system
  • Avoid restrictions in valves & fittings
Materials Compatibility

• **Symptoms**
  • Blocked nozzles
  • Ink starvation
  • Swelling of tubes
  • Failure of the system

• **Solutions**
  • Can be difficult to fault find
  • Can cause expensive problems
  • Choose components and do sufficient materials compatibility testing
    • Material can leech into the ink
    • Use e.g. FEP or PTFE
Poor Pressure Control

• **Symptoms**
  - Ink dripping at the head or air sucking into the head
  - Variations in optical density in the image – volume of ink in each drop is affected

• **Causes**
  - Vacuum pump on continuously creates loss of pressure
  - Dirt in vacuum pump diaphragm
  - Vacuum setting incorrect
  - Pulses from pump

• **Solutions**
  - Control of vacuum pressures +/- fluctuations
  - Smooth flow control – not pulsing
  - Maintain adequate flow of ink – don’t run out

Image source: GIS
Sedimentation

• **Symptoms**
  - Heads clog
  - Parts of the ink system clog – filters etc.
  - Reduced flow to heads

• **Causes**
  - Heavily pigmented inks (pigment agglomeration)
  - Unstable/poor dispersion

• **Solutions**
  - Recirculating flow mode
  - Adjustable flow rate useful
  - Avoid pigment collection points
  - Use special pumps – resistant to abrasion which can wear internal components
  - Agitation of ink – in bulk tank
General System Unreliability

• **Causes**
  - Unsuitable components e.g. ink pump type
  - Poor quality components
  - Poor control logic/software

• **Solutions**
  - Appropriate components e.g. ink pump type
  - Good quality components
  - Tried and tested components
  - Implement industry standard control techniques/software
Summary

• Insure against future problems by careful design and planning
  • Materials compatibility, correct components, follow ink and printhead manufacturer guidelines etc.
• Over-specify on prototype
  • Simplify and cut cost when proven
• Low flow use with end shooter printheads is growing
  • No flow for CMYK
  • Low flow for W
• Recirculating/controlled flow printheads increasing
  • More demanding for IDS design and implementation
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