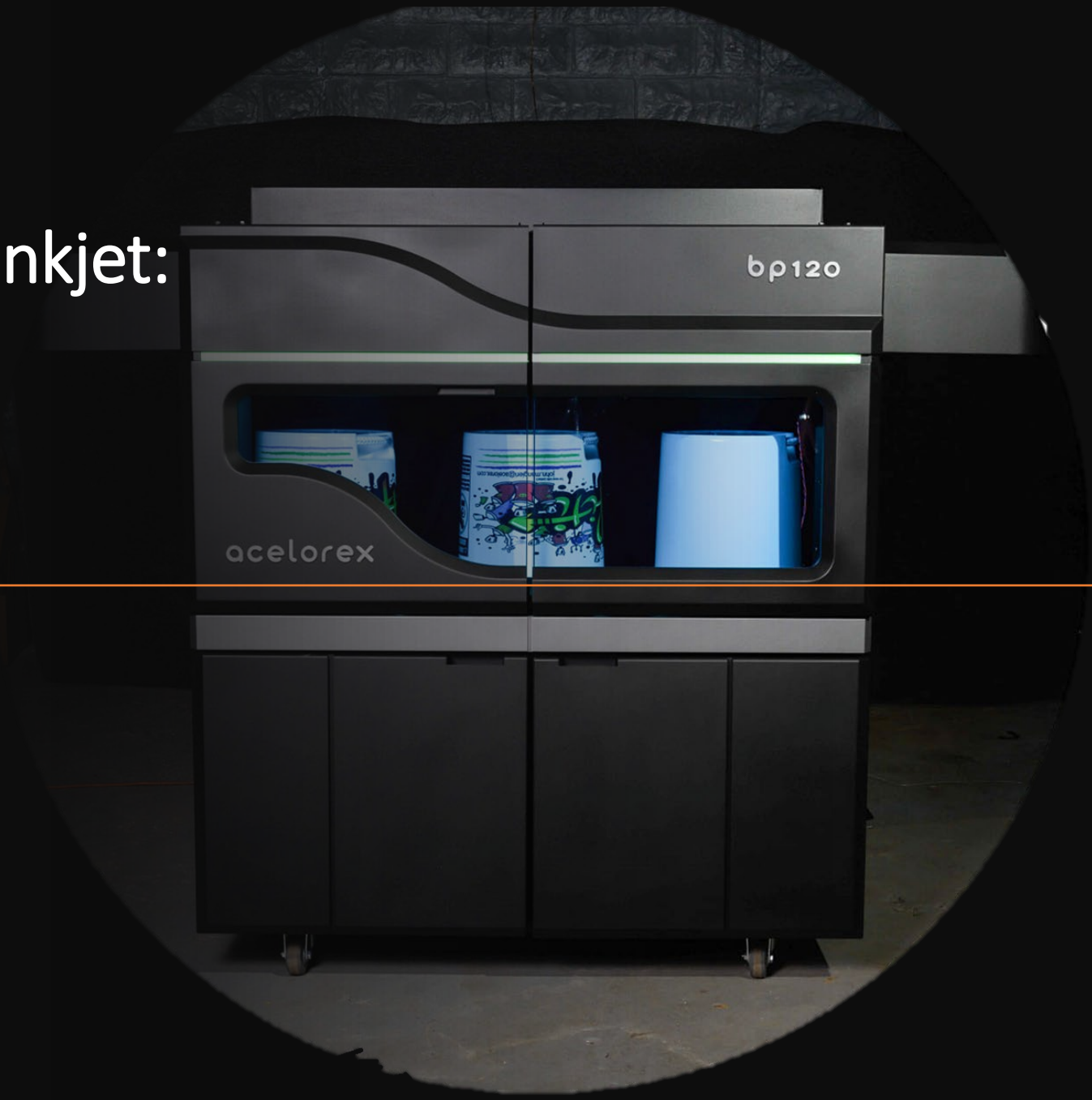
Direct-to-Object Digital Inkjet:

Process Advantages and Limitations



Terry Clayton PhD

Summit Analytical

A Little History…

British Scientist – Lord Rayleigh proposed idea of spraying ink onto paper

1878

1950s

Researchers in Germany designed Mingograph electrostatic deflection inkjet device (ECG)

Canon researchers in Japan developed a thermal inkjet printer

1970s

1984

HP releases the Thinkjet, 1st desktop thermal inkjet printer

HP releases the Deskjet 850c with a **pigmented black**

1995

Fried Eggs

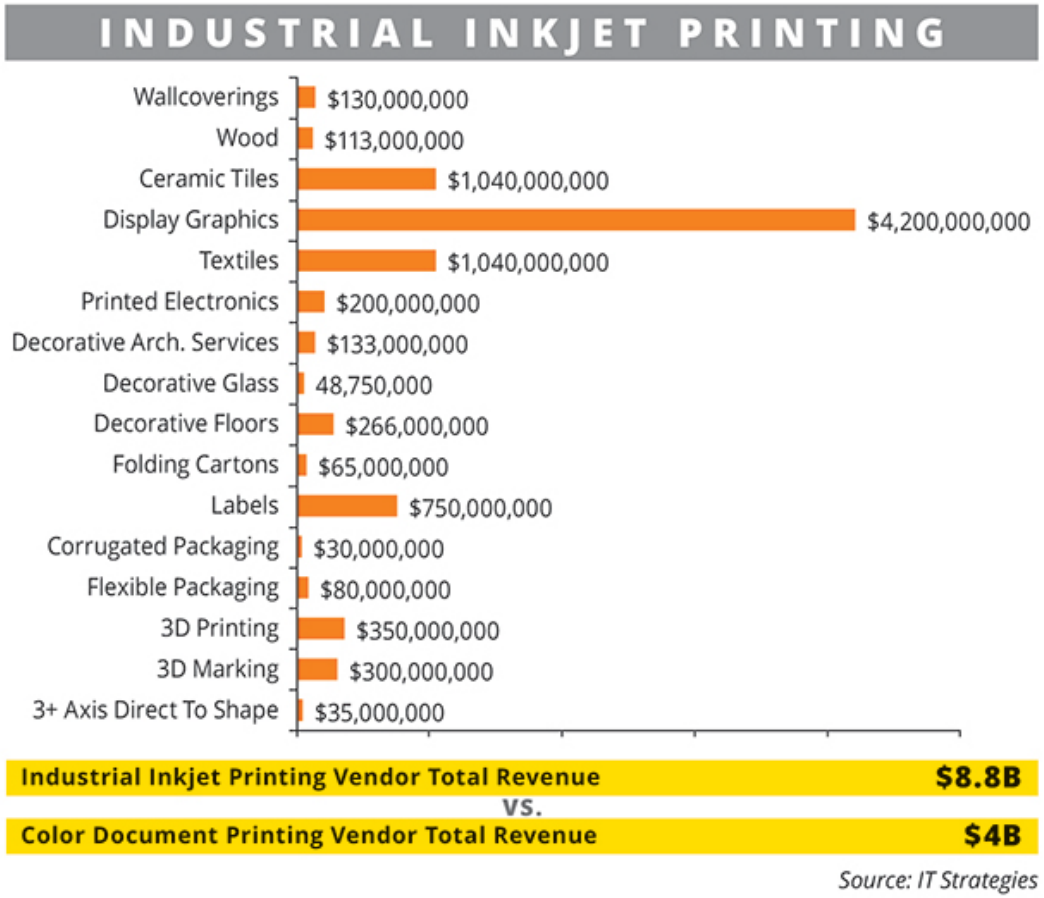
Fried Eggs in the Microwave

1. Crack two eggs into bowl.
2. Pierce the yolks with a fork/toothpick.
3. Add a pinch of salt/pepper to taste.
4. Cover the dish leaving a small vent.
5. Microwave on high for 40 seconds.
6. Let stand one minute.
7. Serve with toast.
8. Note:
    a. 600-800w – More time
    b. 900-1100w – Average
    c. 1200-1300w – Less time

Outline

- Markets & Innovation
- The Business Model
- Examples
  - Final Product
  - Process
  - Chemistry
  - Cure
  - Post Process
  - The Environment
  - Regulatory
  - Unique Customer Application/Versatility
- DTO Solution
- Integrators

Market Size by Application



2020

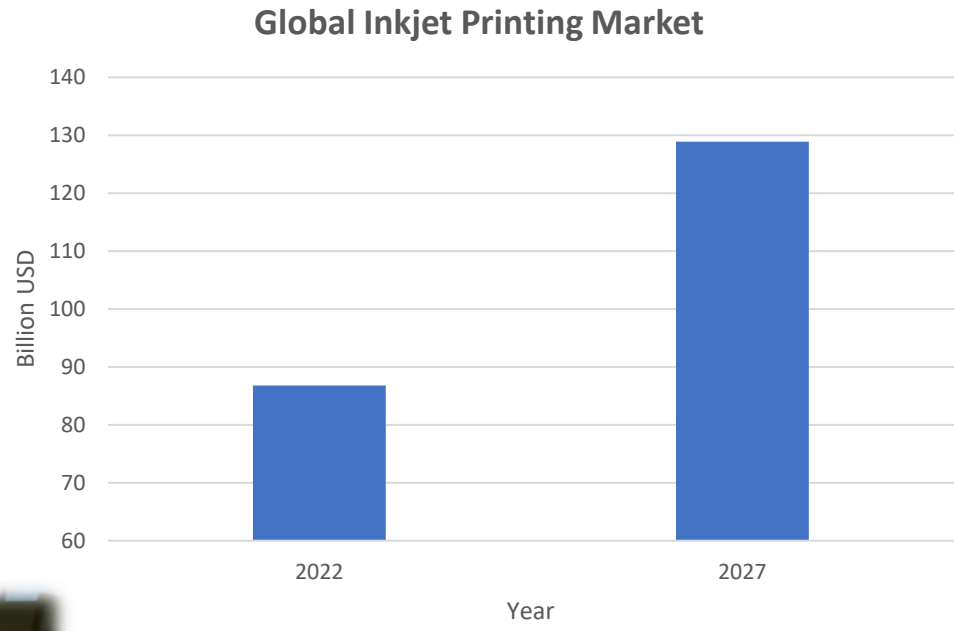
Outlook – Rising Stars

- Packaging
- Textiles
- Direct-to-Object

Global Inkjet Printing Market

- 2023 will likely be another year of recovery. The global market for inkjet printing is expected to grow from $86.8 billion in 2022 to $128.9 billion in 2027. A CAGR of 8.2%

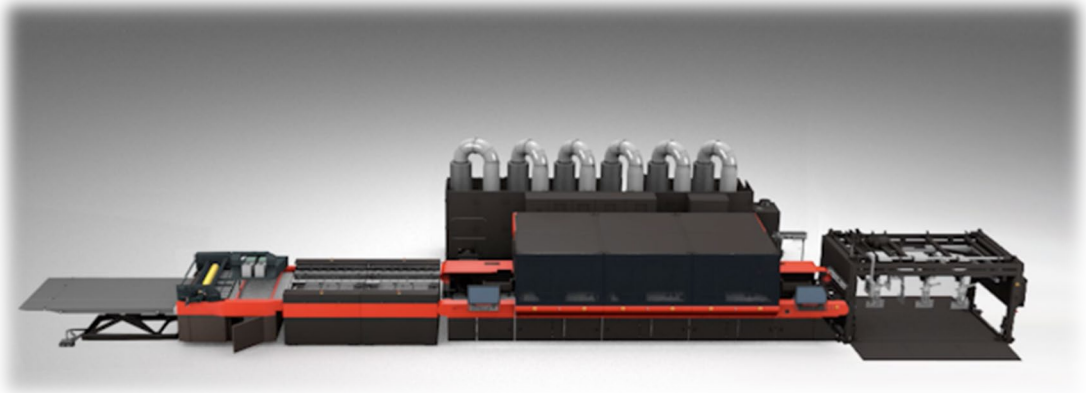
- **Major Growth Applications**
  - Corrugated
  - Carton board
  - Flexible substrates



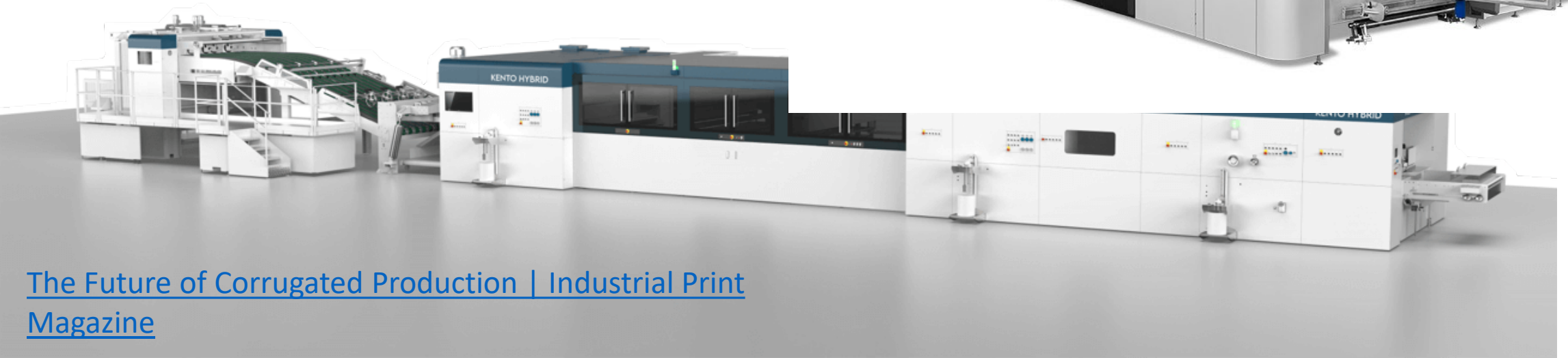
[The Future of Corrugated Production | Industrial Print Magazine](#)

Smitthers

Corrugated Packaging



- 176B Output Opportunity
- <1% Corrugated is digital today
- Ink cost is a barrier
- Automation
- Open ink systems
- Kento Hybrid



[The Future of Corrugated Production | Industrial Print Magazine]

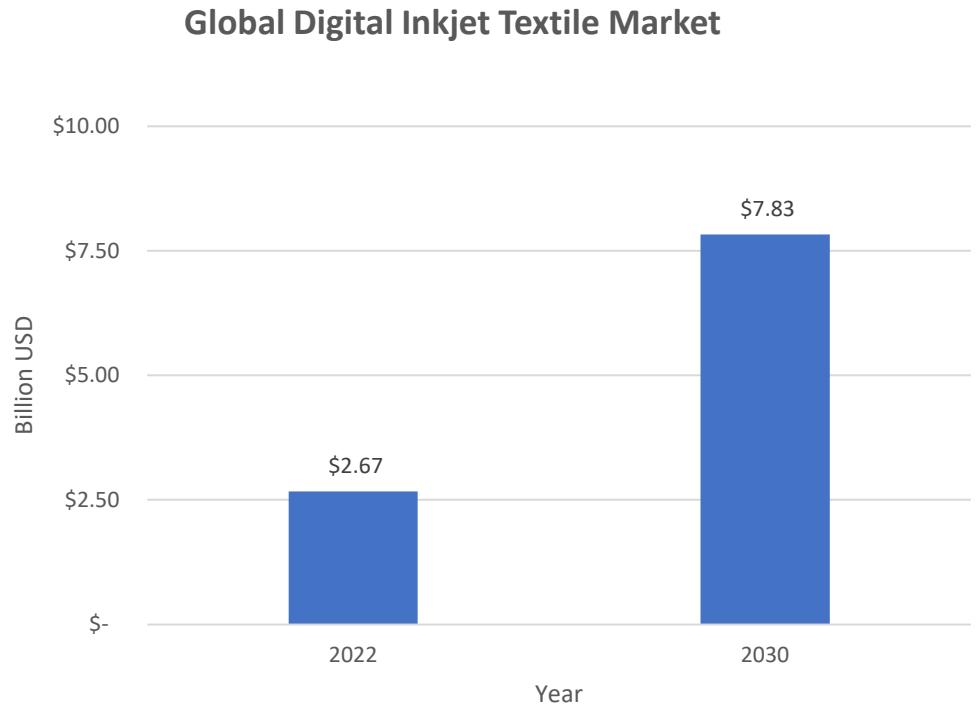
Digital Textile Market

Global digital textile market is expected to grow from USD 2.67 billion in 2023 to USD 7.83 billion in 2030. A compound annual growth rate of 14.4%.

Dye sublimation and pigment are the fastest growing segments respectively. Digital inkjet textile printing Ink market was estimated at $900 million in 2021 and is predicted to grow at a CAGR of ~20%

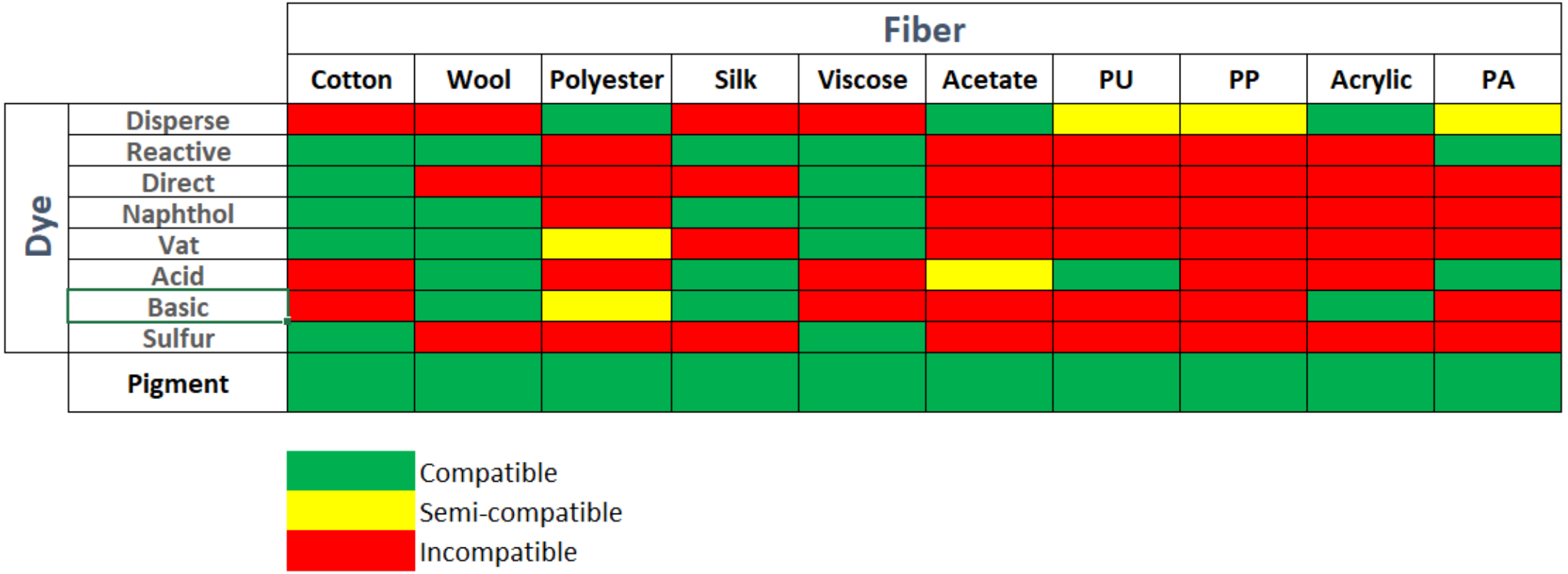
through 2027.

Today, digital represents around 5% of all textiles printed.



Grand View Research

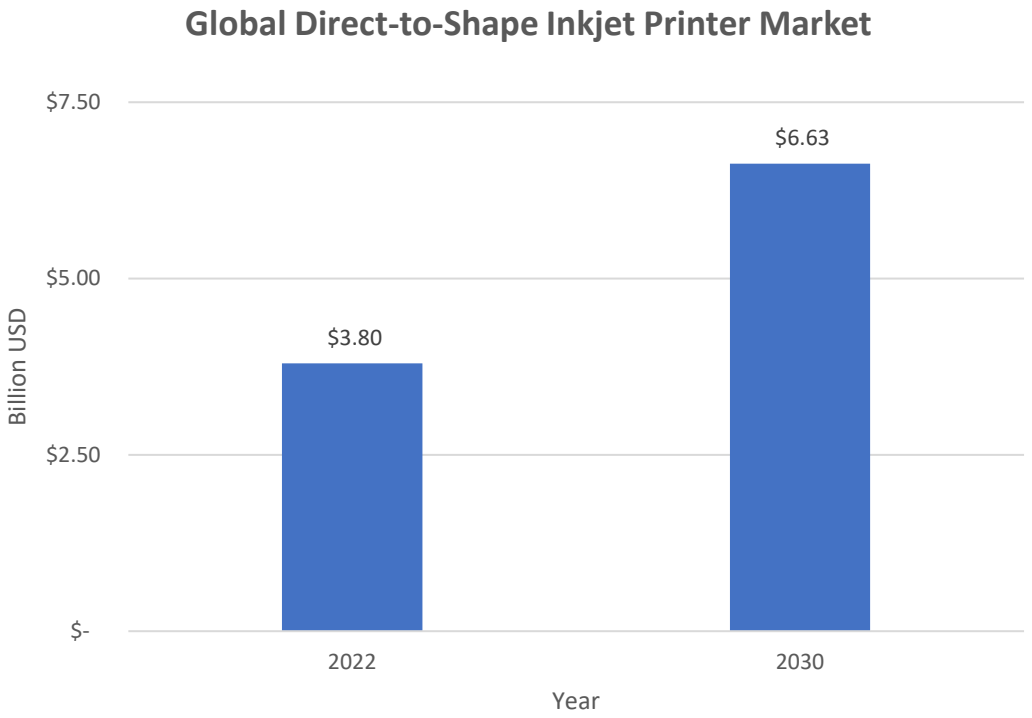
Ink & Fiber Table



Direct to Shape

- Globally, the revenue generated by the direct-to-shape inkjet printer market has been estimated to be around US$ 3.8Bn in 2022 and is projected to increase at a CAGR of 7.2%.
- Many internal production systems
- Compelling demand to ‘personalize’ product has driven inkjet implementation
- *Market penetration <5%.*

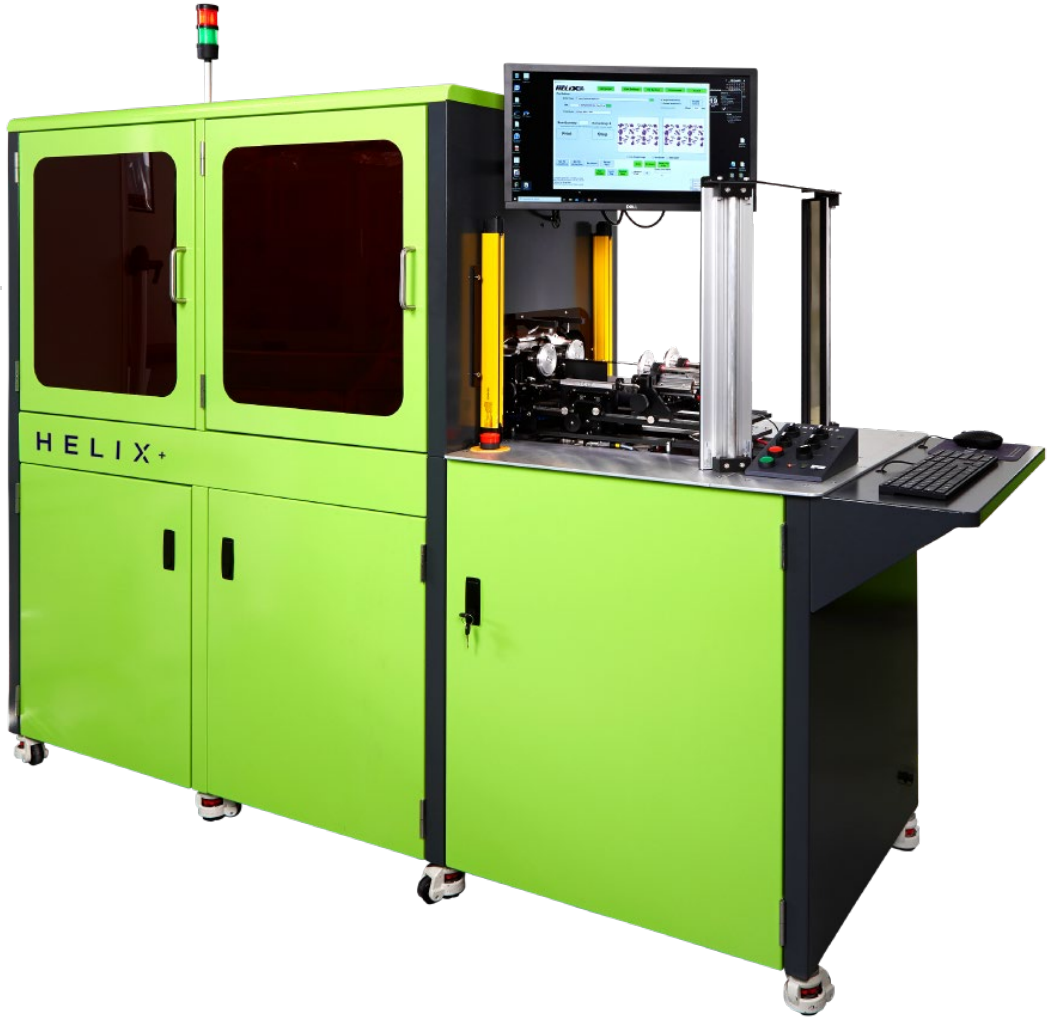
https://www.xaar.com/



https://www.futuremarketinsights.com/

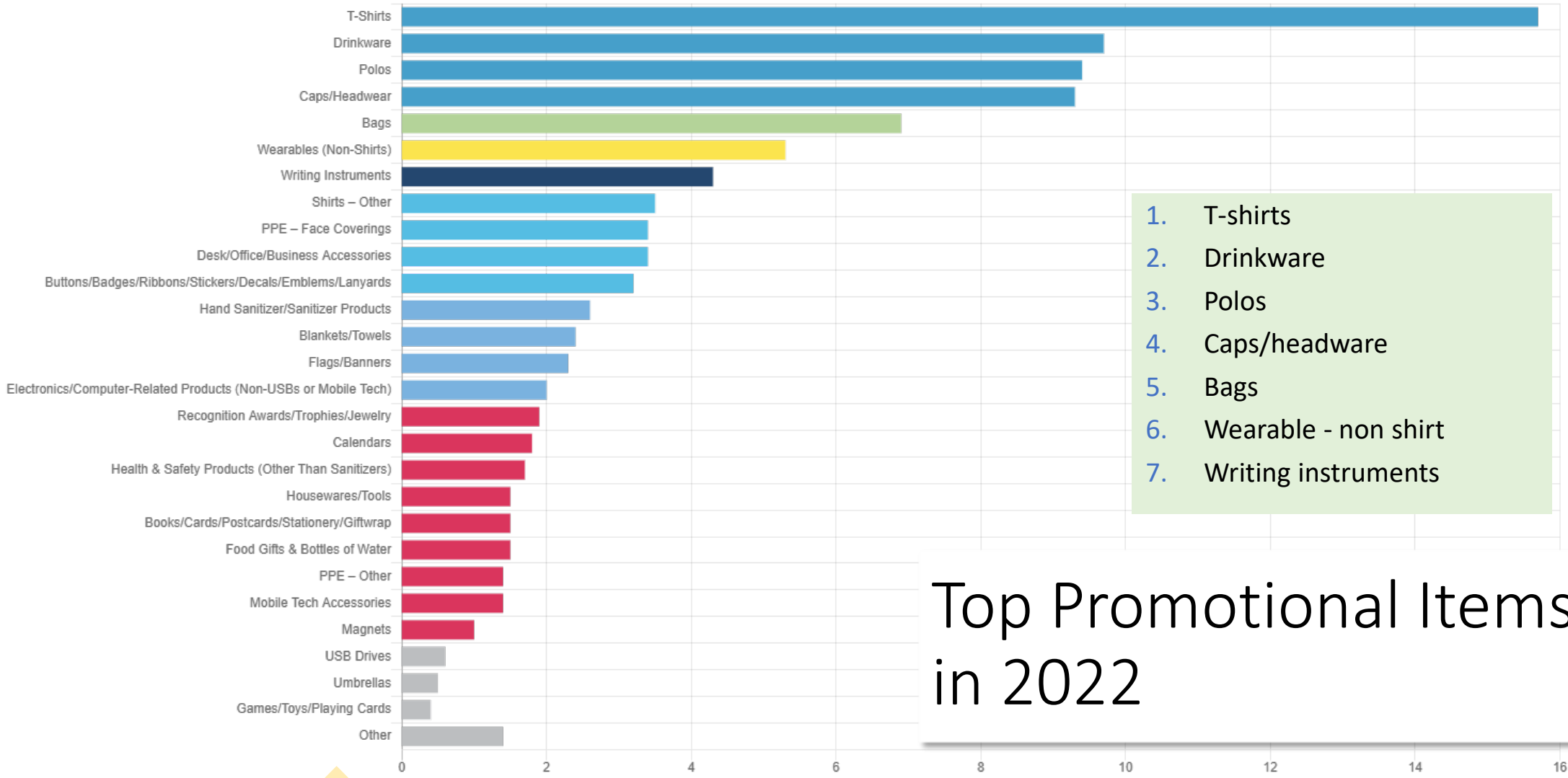
Bottled Goose, UK

- 3 Inkcups Helix
- Personalized Drinkware
- 6 PPM
- Plans to scale, be in stores
- 1- 10,000’s minimums



ESTABLISHED 2016
PROPER GOOSE™

bottled goose»



1. T-shirts
2. Drinkware
3. Polos
4. Caps/headware
5. Bags
6. Wearable - non shirt
7. Writing instruments

Top Promotional Items in 2022

[Infographic: Top Promotional Product Categories 2022 (asicentral.com)]

Digital (Inkjet) Technology Delivers Many Benefits

- The benefits of an inkjet process
  - Rapid fulfilment - ‘Amazon Generation’
  - Mass customisation possible
  - Lower inventory – make/finish on demand
  - Responsive to consumer buying patterns
  - Less materials consumption – ‘greener’ technology
  - Non-contact

- **Benefits are application-specific**

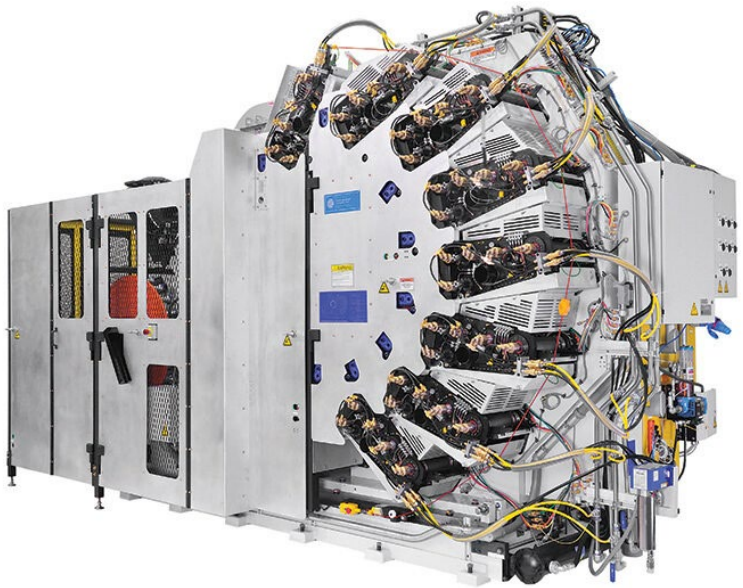
The Business Model

a. Choosing a target market
b. Understanding the whole product "specification"
c. Positioning the product
d. Building a marketing strategy
e. Selecting appropriate distribution channel
f. Deciding the proper pricing

Ceramic Tile Industry Revolutionised by Inkjet

- Traditional method – rotary screen
  - Changeover 1-2 days, $30-50K
  - 2-3 week run required to recoup set-up
  - Textured tiles difficult to print
  - 20-50% of ink is wasted
  - Significant breakage during print (10%+)
- Inkjet advantages
  - Reduction in set-up costs
  - Instant job changes, short runs, one-offs
  - Reduced inventories, shipping costs
  - Improved image quality, **less breakage**
  - Print uneven surfaces and over the edges

Speed



Stolle Decorator: 2,200 cans/min

Hinterkopf D240: 240 cans/min

"Real productivity depends on uptime..."

Reliability

i. Productivity
ii. Uptime
iii. Daily maintenance
iv. Open time
v. Sustainability

Environment

- Specifications:
  - Temperature: 68°- 86°F
  - Humidity: 40% – 80%
    - static
  - Humidity: 60%-80%

Environment

- Specifications:
  - Temperature: 68°- 86°F
  - Humidity: 40% – 80%
  - Humidity 60-80%
  - **No Particulates**

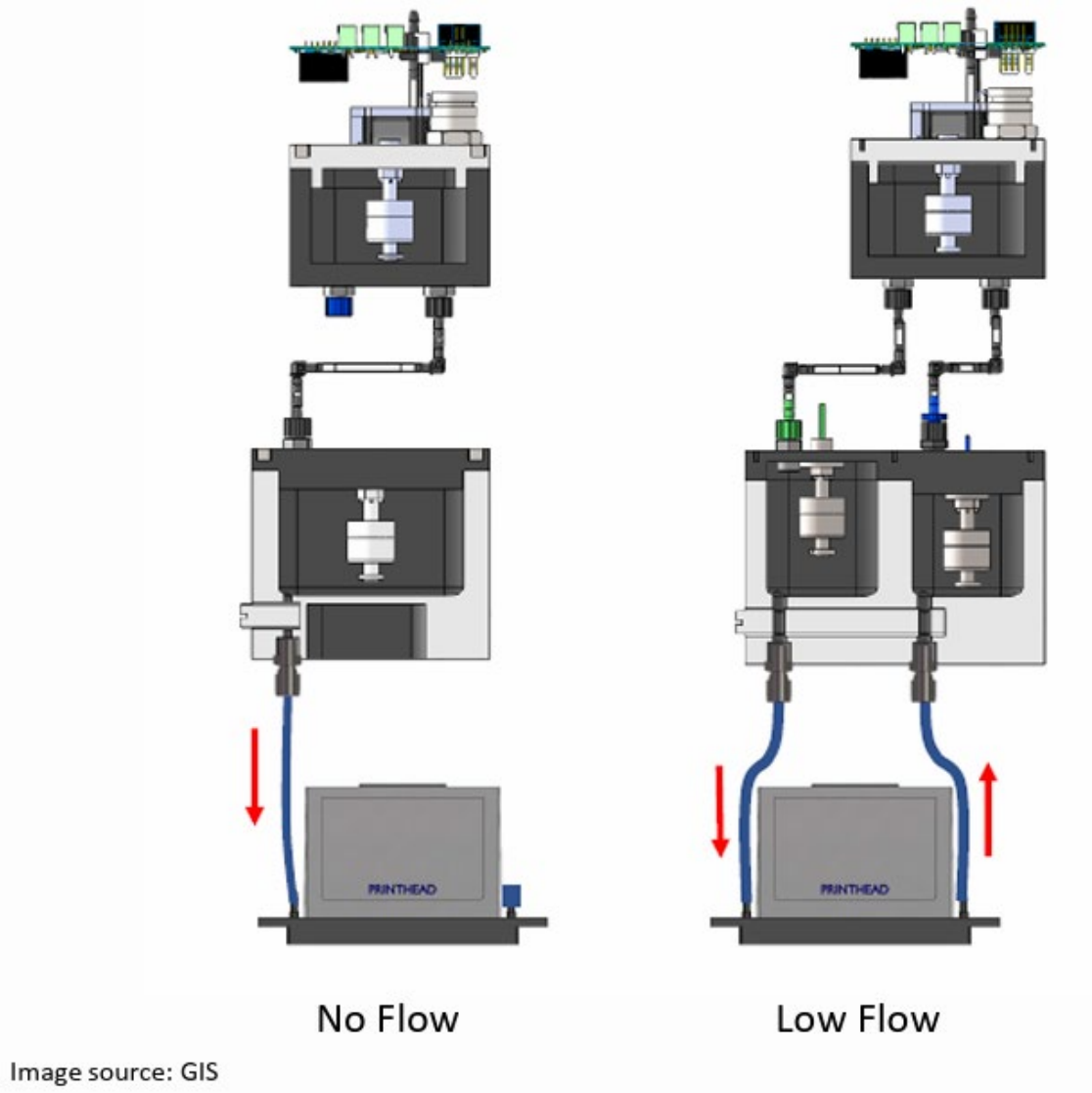
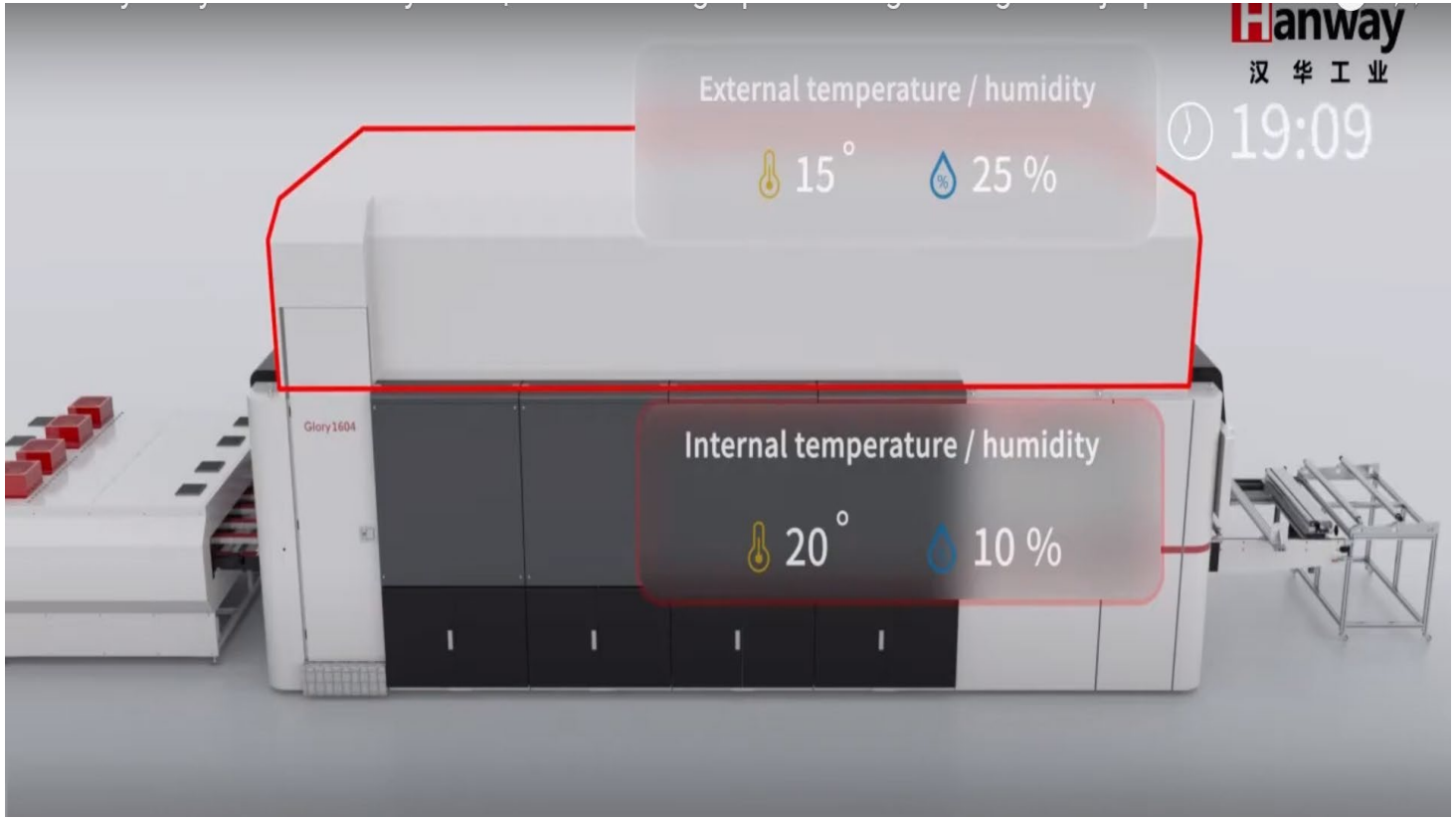


Image source: GIS

Climate Control in the Print Zone

- Temperature Control
- Humidity Control
- Particulate Control



The Environment: Plant

- Temperature
- Humidity
- Particulates
- Temp & stability, AC- rust
- Humidity >50%
- Cleanliness/dust - printheads
- Exhaust
- Compressed air, pressure volume
- Power
- Network
- Stray light
- Space
- Storage for media pre/post print
- Floor
- Water chiller
- Static bars
- Room to move
- Keep printer level

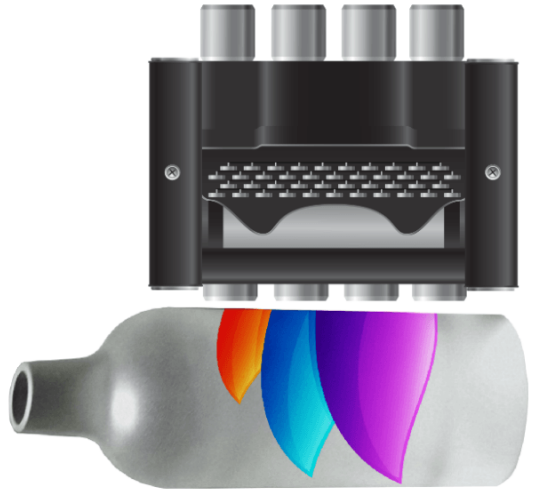
Substrate

- Warp
- Dog ears
- Absorption
- Adhesion
- Dot gain
- Feeders/manual
- Coatings
- Primer
- Porosity/hold down
- Heat sensitivity
- Treat

"Just raise the carriage…"

Print Gap - Misting and Overspray

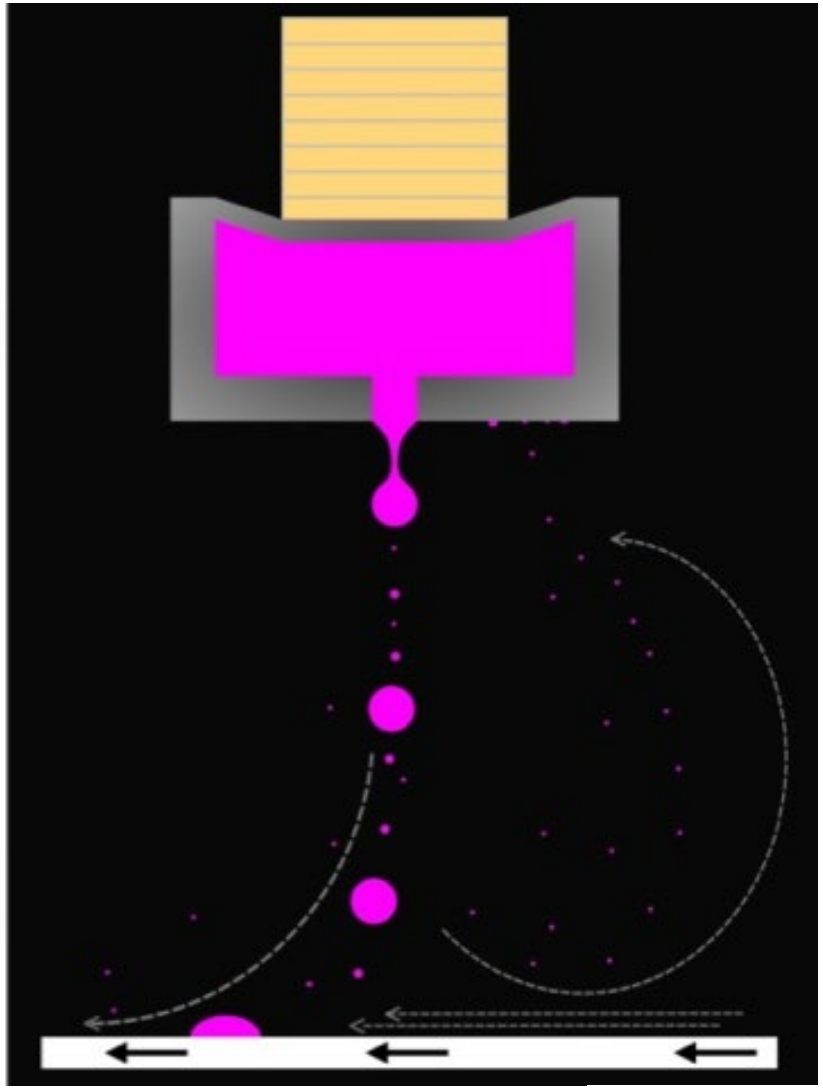
Ink overspray



Print Gap 1.5mm-2mm

What's Happening to Satellites and Mist?

- Will they make it to substrate?
- ≤ 5 pL drops carried by eddy currents, carriage turbulence
- Tall Gap
- Nozzle plate accumulation

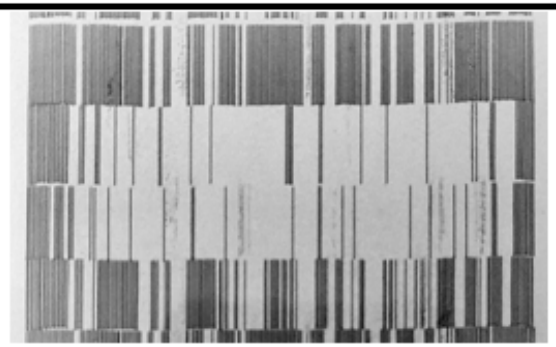
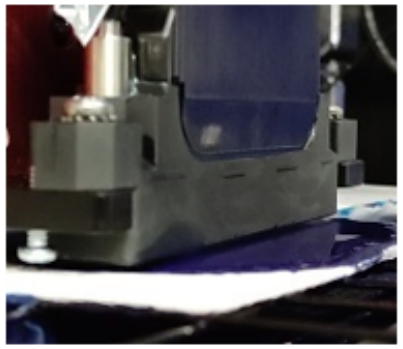
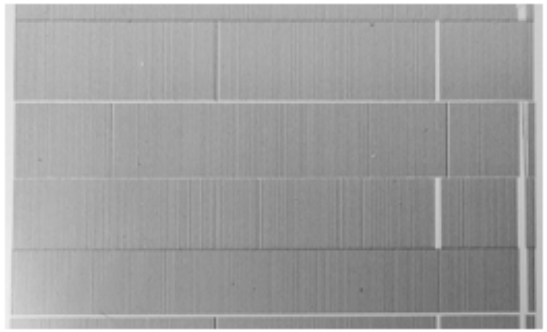


imageXpert

Reliability testing of new fluids

Example tests:

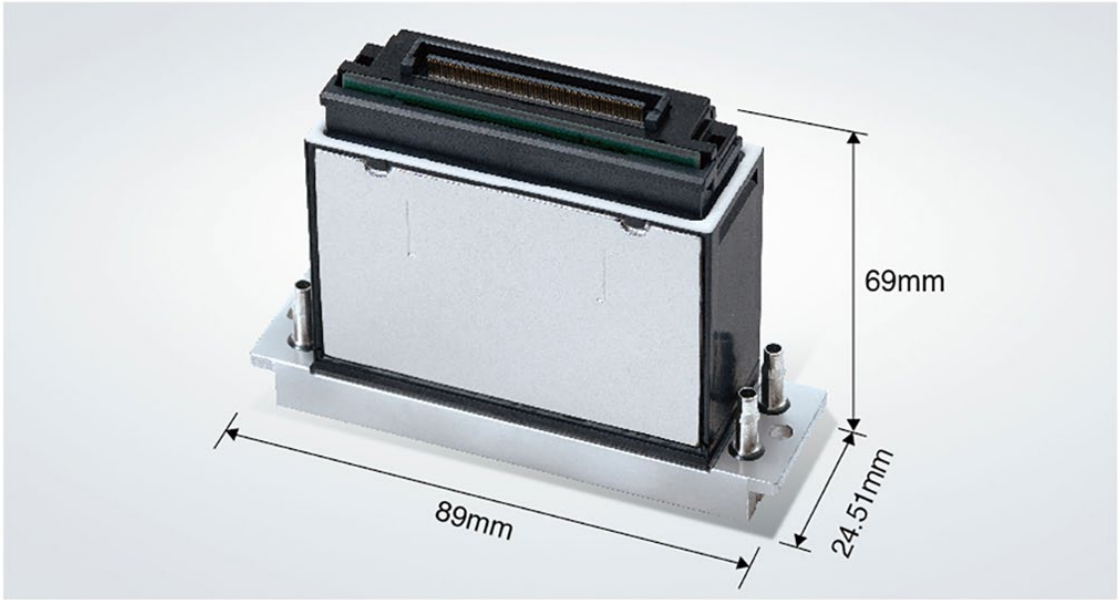
- Drive Voltage vs. Temperature
- Drive Voltage vs. Ink (Meniscus) Pressure
- Drive Voltage vs. Pulse Shape
- Drive Voltage vs. Print Frequency (Pulse Freq.)

Test Description	Set-up Photo	Print Test Result	Print Head Appearance
High Gap			
Lower Gap			

Ricoh MH5320 (Gen6)

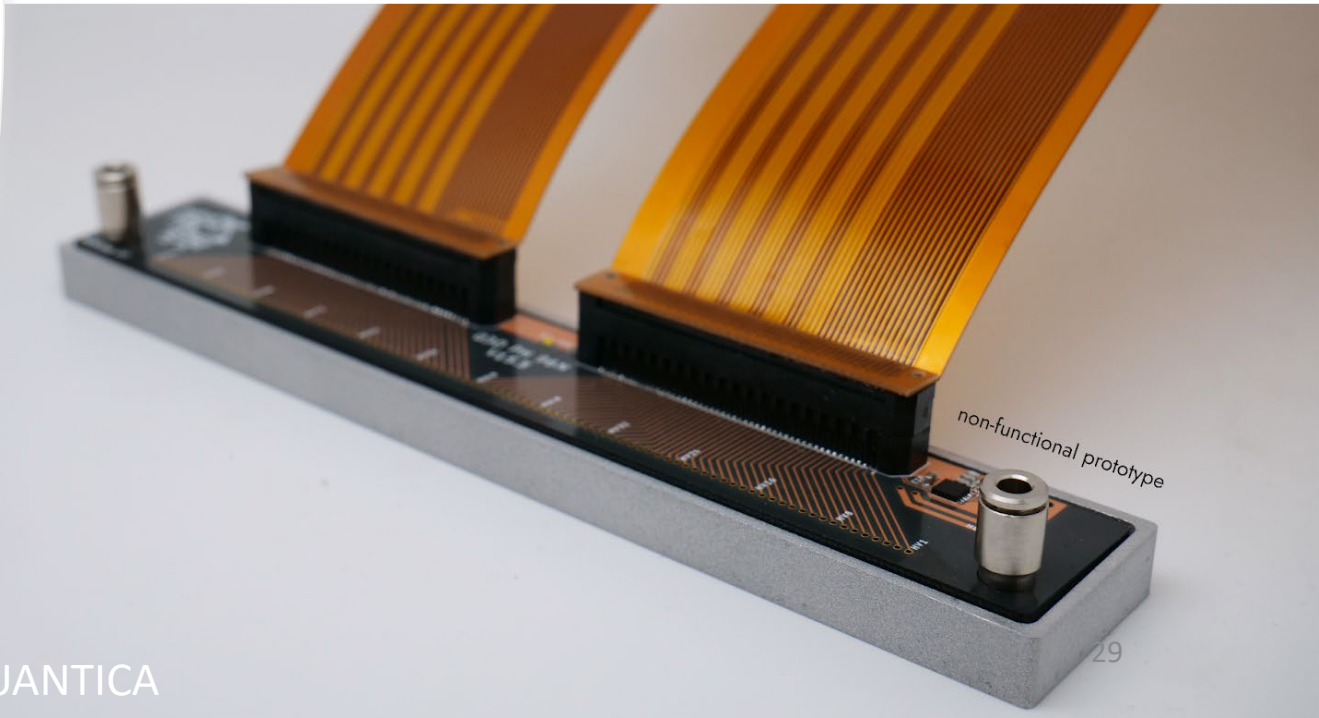
High-definition and High-productivity

A minimized 5pl droplet size and improved jetting accuracy yields excellent print quality without graininess. With 1,280 nozzles configured in 4 x 150dpi rows, this head achieves high-resolution 600dpi printing. Greyscale features a maximum frequency of 50kHz, allowing for increased productivity.

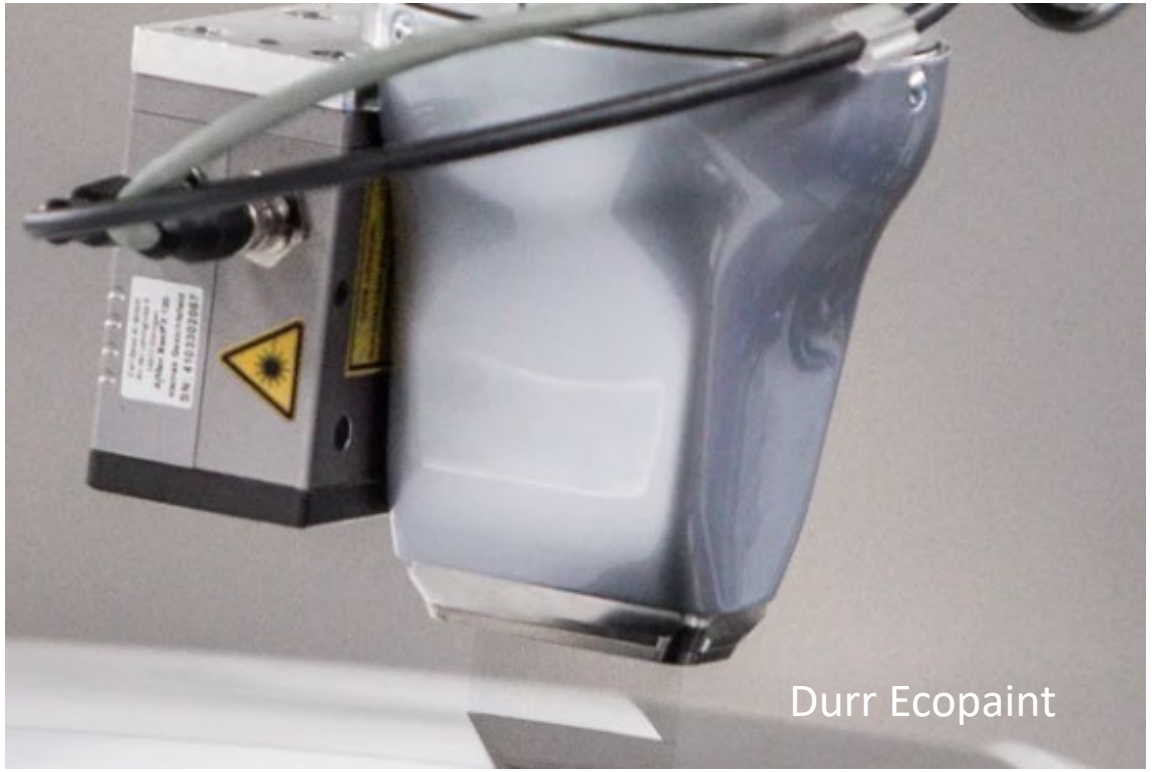


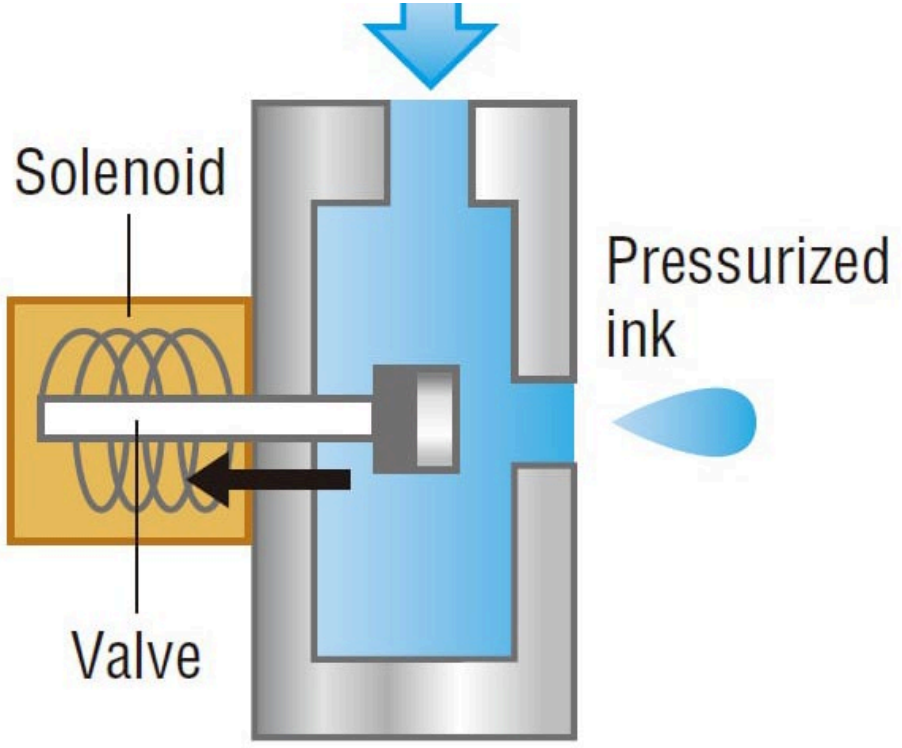
RICOH MH5320 (two color model)

New Head Tech…



Valve Jet





Chemistry

- Cost
- Custom
- One ink set or multiple

- How many applications?
- Inks: hard versus flexible
- Changeover?
- Adhesion
- Versatility
- Maintenance
- Consumables
- Light sensitivity
- Open time

Unique Customer Applications

a. Heat bending
b. 2nd surface, adhesion to wall mount
c. Caustic Wash
d. Winter Trucking
e. Solvent Welding
f. Recyclability
g. Automotive Interior

Direct to Shape

- **Key players – adopters**
  - Krones
  - Plastikpak
  - KHS
- **Suppliers**
  - Machines Dubuit
  - Inkcups
  - Industrial Inkjet (IIJ)
  - Heidelberg
  - Koenig & Bauer
  - Engineered Printing Solutions

Omnifire

Machines Dubuit

Koenig & Bauer

EPS

Inkjet Integrators

- Bringing together different elements of the supply chain to deliver a solution

  - Integrity
  - Acelorex
  - Industrial Inkjet (IIJ)
  - Cyan-Tec
  - Engineered Printing Solutions

Integrity
Industrial Ink Jet Integration

cyan tec

acelorex

ENGINEERED
PRINTING SOLUTIONS

Work Backwards!

Develop a Strategy:

- Study the End Product - SME
- Prototyping
- Regulatory
- Post Processing/ Quality Tests
- Cure
- Chemistry
- Print Gap
- Speed
- Reliability
- Substrate
- Plant Environment
- Skill Sets

Revise Business Case Continuously!

Become an expert on current and inkjet process

The Team

- **Analog & Inkjet experts**
  - Sales & Marketing
  - Operations
  - Regulatory
  - Sales
  - Engineers
  - QC
  - Don't forget the Chemistry Experts!

SUMMIT-ANALYTICAL

Terry Clayton | terry@summit-analytical.com

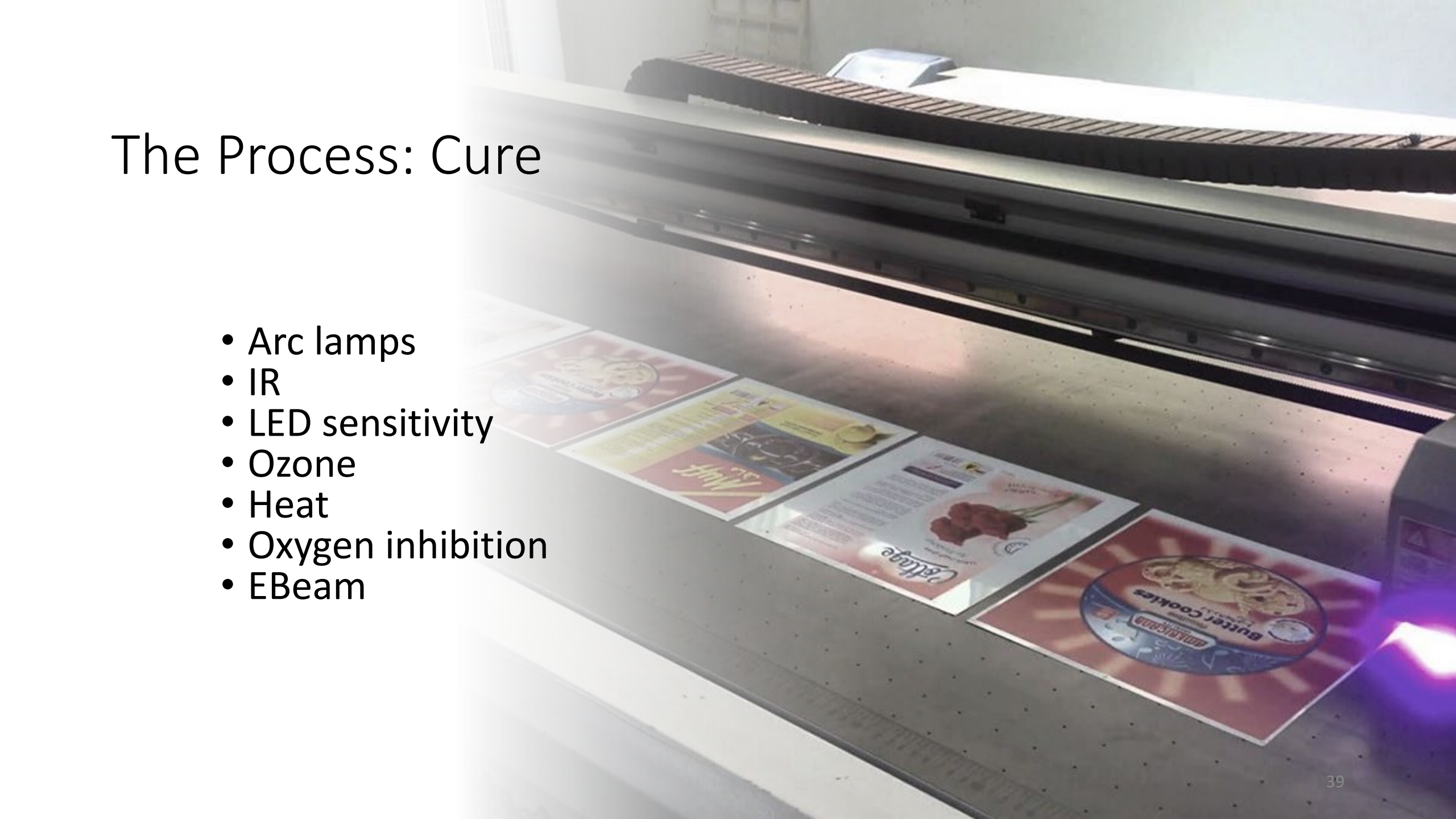
APPENDIX

Other Names to watch

- 3Sixty
- Acelorex
- Hapa
- Heidelberg
- Krones
- LSinc, Machines Dubuit
- O&PM Europa
- Velox

The Process: Cure

- Arc lamps
- IR
- LED sensitivity
- Ozone
- Heat
- Oxygen inhibition
- EBeam



Post Processing

- Media handling
- Shipping
- Construction
- Scuff (no wax)
- Folding
- Cutting
- Thermoforming
- Transportation

Regulatory

- Restrictions
- Odor
- Migration
- Indirect Food Contact
- Recycling
- PPE

Nestlé

People and Parts

Training

- Staffing
- >2 SME
- turnover

Service

- Parts
- Local FSE
- Response time
- Redundancy

The Final Product

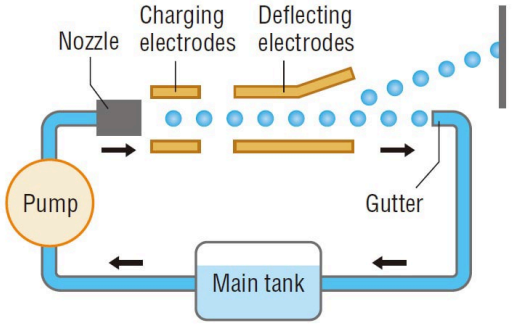
Physical Properties
- i. QC Tests
- ii. Odor

Ageing & Weathering
- i. Color
- ii. Water
- iii. Temperature
- iv. Chemical

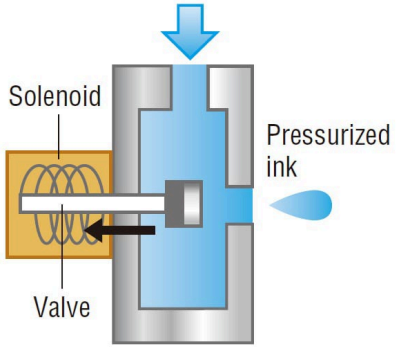
Learning Curve

Become expert in end product!

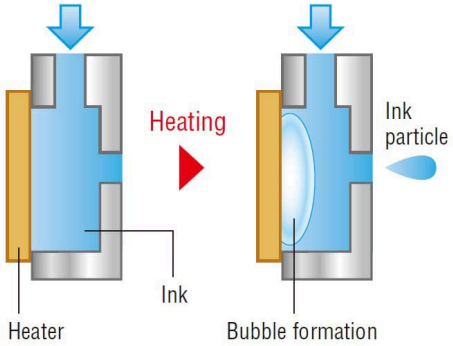
Printhead Refresher



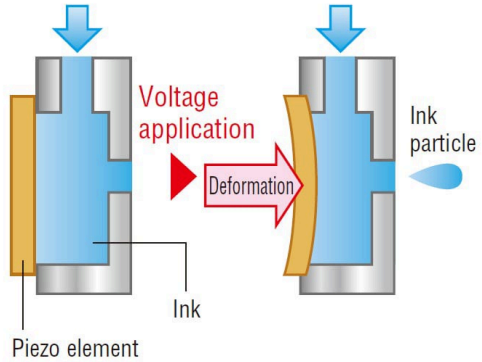
Continuous



Valve



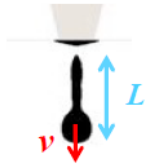
Thermal



Piezo

Misting & Overspray

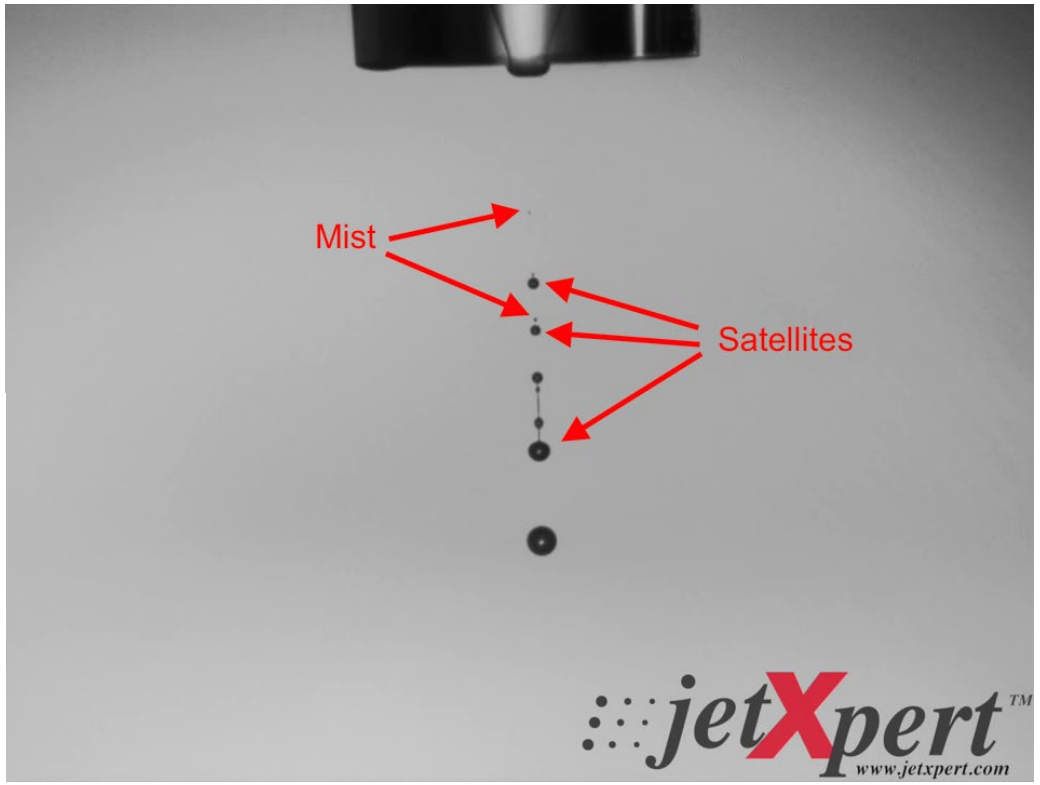
1. Viscosity
2. Surface Tension
3. Velocity
4. Pigment/Solids loading
5. Print Gap



$$L \propto \sqrt{\frac{d}{\rho\gamma^3}}\eta^2 v$$

d = nozzle diameter
ρ = density
η = viscosity
γ = surface tension
v = fluid speed

System Ceramics



Improvement of Printing Quality through Satellites Formation Control

I. Valenti et al.– 18th of April 2018, IMI.