

Colorant Selection for Commercial Ink Jet Print Technologies

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Abstract

There is increasing production and newly emerging market segments in the area of "Commercial Ink Jet Printing". Commercial Ink Jet Printing is defined as all large colour format printing not falling within the office/business/home use and Industrial Marking markets. The current paper defines and segments this growing market which includes the potentially huge area of textiles. The selection of the correct type of colorant, the print head technology, the chosen ink vehicle depends on a number of key inter-related factors such as the substrate (media) to be printed and ultimate end point of the printed product. Detailed assessment is required for each system combination and the criteria selection for the colorant/media /print head combination is outlined in the paper.

Introduction

Ink Jet Printing has become a major printing technology in both desktop and industrial marking applications. The growth of ink jet has been well documented into these markets[1,2] and the reasons for its success can be attributed to a number of factors:

- Simplistic approach-non impact ink direct to paper with no intermediate stage, giving acceptable colour quality at acceptable price levels.
- Wide range of head technologies with the ability to accommodate a considerable number of ink types, enabling the majority of the requirements in desktop and industrial marking to be met.
- Advancements in computer technology allowing high speeds /high resolution and digital colour printing to be accomplished.

These advances have allowed ink jet not only to be establish itself in desktop and industrial marking application but is now being seen as a viable alternative to many of the traditional printing applications, along with other recent non-impact technologies such as electrophotography.

The domain of 'Commercial' ink jet printing is the next area which ink jet and indeed other competing non-ink jet technologies are seeking to make a serious entry. The market for commercial ink jet printing is essentially large format colour and that not covered by desktop office/home/office and industrial marking markets. The definition also covers the emerging technologies for textile ink jet currently being actively developed.

Some authors have referred to this market as 'Industrial' ink jet but we view that this causes confusion with the industrial monochrome marking ink jet markets.

Commercial Ink Jet Technologies

The following gives some idea of the diversity of commercial applications and ink jet technologies which are now covered in this area.

Applications

* All large format/wide array technologies (greater than A2)
* Graphic Arts
  - Computer aided design
  - Indoor signage
  - Outdoor signage, posters, canvas.
* Pre-Press Printing
  - Textile proofing
  - Publication proofing
* Digital Colour Presses ('Roll to Roll' presses).
* 'On demand/Short Run printing for Textiles/Clothing, JIT Apparel, T- Shirts, Floor coverings.

Media

Paper, Textiles, Polymers.

Ink Jet Technologies

-Bubble Jet (e.g. Canon)
-Thermal Disposable (e.g. Hewlett Packard)
-Piezo DOD (e.g. Seiko Epson)
-Continuous Binary Technology(e.g. Stork, Scitex)
-Continuous Multi Level (e.g. Imaje)

Ink Systems

- Aqueous Dye based (eg direct dyes, acid dyes, reactive dyes)
- Aqueous Dispersions (eg pigment, disperse dyes, vat dyes)
- Solvent Based Dye systems (eg solvent soluble dyes)
- Non Aqueous Dispersions (e.g.pigments)

Each of these ink jet technologies and applications/end uses put special selection criteria on the colorant and formulation to be used and the media involved.

Before we go into detail inks this colorant/formulation/head technology /media matrix what is the potential size of the market?

Potential Size of Commercial Ink Jet

At the recent Giga Information Group Ink Jet Conference in Dussledorf in March 1996[3] the potential of 'Commercial' ink jet versus Industrial Marking and the office ink jet market was highlighted.

Table 1 indicates the potential of multi coloured 'Commercial' Ink Jet with the prediction that the ink volumes will exceed the combined ink volumes for both monochrome industrial and office markets within a decade.

Ink volumes will be very application specific and will only increase to the potential volumes as any of the technologies enter the production forum. The major example of this scenario is the potentially huge textile printing market, which is the singularly largest potential market.[3] The overall printing market for textiles exceeds 30 billion square metres with the usage of dye/pigments in value exceeding 1 billion US dollars (at textile dye price levels). Ink Jet has been e examined for textiles in many projects over the last 25 years.[4,5] It has long been a dream of printers to eliminate screen engraving and the time consuming proofing stage which textile prints must go through before being commercially printed in production.[6]

However it is only in the last few years that textile ink jet systems have been established in the textile proofing market.For example, there are European Union funded projects (Eureka and Brite Euram) with partners (Zeneca/ Stork/Schoeller/KBC) which have been researching textile ink jet technology.Some of the results of this collaborative research were shown at the 1995 ITMA exhibition (the Stork TCP4000), a large format textile proofer, which included the use of eight reactive dyes (to increase the CMYK gamut to the colour gamut found in conventional textile printing), together with textile pre-treatment technology and full ink re-cycling.

Table 1. Potential Size of the Commercial Ink Jet Market
(Source Giga Information Services - Dusseldorf Ink Jet Conference March 1996 (3))

	1994 Million litres	1997 Million litres	2000 Million litres	2003 Million litres	2006 Million litres
Multicolor Commercial IJ:	0	1.5	7	28	84
Office/Desktop Y, M, C, Bk IJ:	5	8	12	16	15
Industrial Marking IJ: (Black)	9	13	15	18	19

Also shown at this exhibition, based on this research, was a "technology demonstration" of a 'roll to roll' textile printer ink jet printer shown printing (four reactive colours) at approx. 7 square metres/hour.

The next evolution in textile ink jet will probably be printers capable of printing in the region of 100 square metres/hour and this is actively being pursued in a number of research projects.A printer capable of ink jet printing in this order was also recently announced in Japan.[8] If these projects are successful it will allow textile ink jet printing to compete with short production prints produced by screen print technologies (normally flat screen technologies).The ink consumption figures then will start to grow in line with some of the industry predictions.[3]

Ink Head Technology

The detailed discussion of ink head technology has been well documented. Figure 1 gives an overview of the ink jet technologies and the current types of ink systems in use with the major market segment.

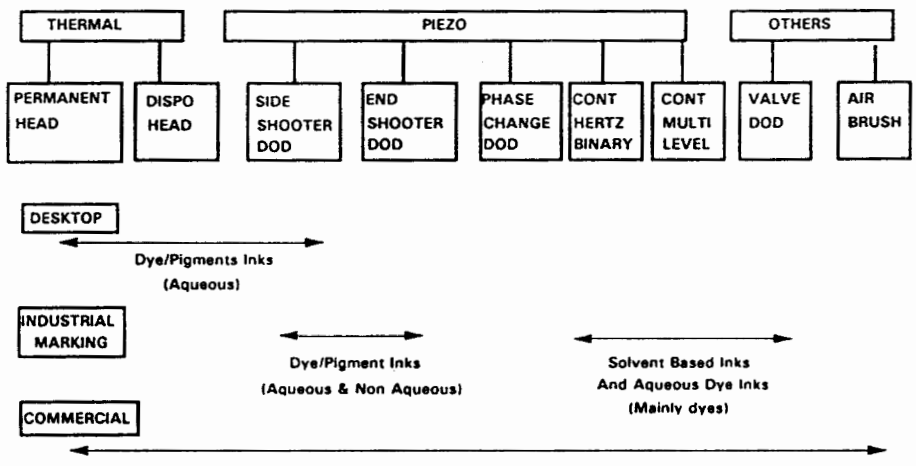

Figure 1. Ink Jet Market Segments vs Head Technologies

The desktop market is essentially aqueous based with both dye based ink systems (in the majority of head technologies) and also pigment based inks.

The Industrial marking market is predominantly monochrome systems printed from MEK based inks although there is increasing developments of alcohol based systems and aqueous based for mailing applications.

The Commercial Ink Jet area is a very much more fragmented area but predominately aqueous ink type systems (dyes, textile dyes, pigments) being used on a wide range of media and print head technologies.

The cooperation shown in the European Union funded projects briefly mentioned above has shown one approach to successfully bringing new technologies to the market place.

This type of successful relationship is shown in very simplistic form in Figure 2.

Using this "triangular" relationship we would like to highlight briefly the specific requirements of textile ink jet printing and highlight how this model is equally applicable to the large format graphic markets on special medias.

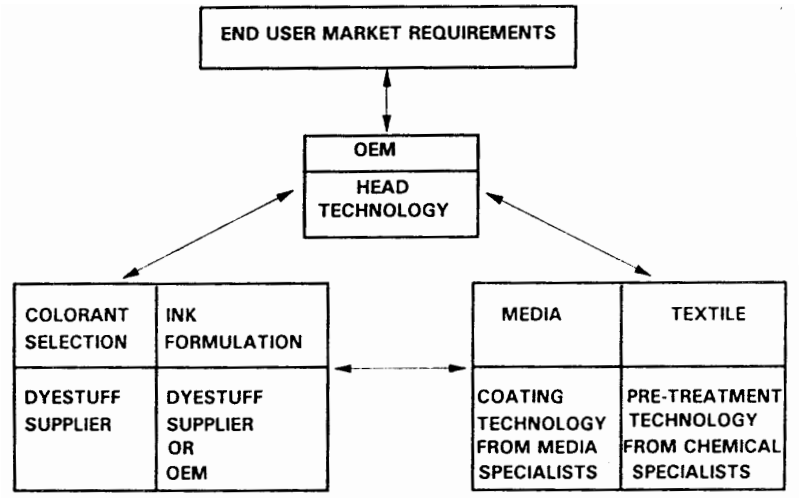

Figure 2. OEM/Colorant Manufacurer/Media Specialist Partnerships

Textile Ink Jet

Textile ink jet projects currently being examined cover a wide number of ink head technologies.[4,5,9] For example some recently published projects include;

* Continuous Binary (Hertz) Technology -STORK (Holland)

* Bubble Jet Technology (DOD) -Canon (Japan)

** Multi level Deflected Technology -TOXOT (Imaje).(France)

It is also believed that piezo drop-on-demand systems are being examined for textile ink jet in Japan.

Each of these ink head technologies present differing problems in the design of successful ink systems. For example, with the exception of the Toxot Project,[10] who have developed water based UV curable pigmented inks, the other head technologies almost exclusively use aqueous dye based inks.The inherent problems with pigments due to their particle size and susceptibility for aggregation and other problems in certain ink jet head technologies have been well documented.[4,5,10]

ZENECA as one of the partners in a European funded BRITE EURAM research project (the other partners being Stork, F. Schoeller, KBC) developed specific high purity reactive dyes for textile ink jet printing purpose.[6,7,13] At the 1995, ITMA, STORK introduced the TCP 4000 system which extended the colour gamut available by using these eight developed reactive dyes (a CMYK set plus 4 new extra colours). Reactive dyes in a high purity aqueous form manufactured to the stringent physic chemical requirements for fine jet continuous ink jet systems can match the ink head specifications, whereas pigments will have inherent problems in certain head technologies.

One of the key developments with the system recently launched was a pre treatment stage using a specifically developed cationic enhancing agent.[11,12] This is applied, together with normal chemicals used in conventional textile printing (e.g. urea, alkali, sodium alginate), in a separate stage prior to ink jet printing. This separate stage is required because of the stringent purity requirements and other key physico-chemical properties necessary for the successful performance of continuous ink jet system.[14]

As textiles also have to withstand repeated washing, a post-treatment is required to fix the dyestuffs to the fibre, followed by a subsequent washing treatment to remove unfixed dye and chemicals to ensure the final textile print meets "wash and wear" standards demanded by the consumer.

The pre-treatment of a textile in textile ink jet printing is an absolute crucial stage to achieve results that will be acceptable to the consumer.

The pre-treatment stage is essential to ensure:

- print definition on fabrics which have an inherent capilliary action.
- colour yield comparable to conventional print tech-

niques (ink jet technologies obviously deposits only a fraction of colour that conventional technology applies) Conventional technologies can adjust for the wide range of fabric types, ink jet technologies apply an equal volume of ink.

For the example discussed, Zeneca developed a pre-treatment method which following successful trials at textile printers was introduced with the system to ensure the above important criteria was met.[11,12]

Specific pre-reatments and fixation/wash-off processes in textile ink jet depends on the textile substrate to be ink jet printed and the dye type used in the ink system. Each of the various prereatments will be different and require matching to the specific textile dye used in the ink system.

To say the least, ink jet print technology for textiles, is a complex area., and there is no simple and universal solution to the many textile/colorant combinations.

From this brief overview of one of the current textile ink jet projects it is clear that the partnership of the OEM, (providing head technology and system integration), colorant supplier who in this case (Zeneca Specialist Colours) also provides the pre-treatment technology, is key to any successful project.

Large Format Graphic Ink Jet

The large format graphic ink jet is equally fragmented, with again differing requirements for different end users.

Table 2 gives a market segment breakdown on the application/ ink property and media used.

Table 2. Commercial Ink Jet -Large Format Graphics

Application	PROPERTY OF INK			Media Used
	Chroma	Light Fastness *	Wet Fastness **	
Photorealist	V High	>50hrs	to 100%	Special/ Glossy
Colour Graphic Arts	V High	> 50 hrs	to 100%	Special/ Glossy
Proofing	High	> 50 hrs	to 100%	Special/Glossy
Publishing	High	-	to 100%	Plain/ Treated/Special
Display/Signage (Indoor)	High	> 50 hrs to > 1000 hrs	to 100%	Various
Display/Signage (Outdoor)	High	> 1000 hrs	to 100%	Various

*ΔE less than 5.0 units after stated hours.

**%WF ROD measured before and after immersion for specified time in deionised water

As in the textile case there is no universal approach to all these segments but the need for optimisation of the head technology, colorant/ink formulation and media is common to all. For certain end uses e.g. outdoor permanent displays, it is clear that the light fastness requirement can only be met by the use of pigmented inks with corresponding limitations on certain ink head technologies. However in the other segments where the light fastness requirement is only 50 - 100 hours but with greater emphasis on spectral performance, soluble colorants may be required with corresponding more freedom in the choice of head technology.

The ability to match media coating to the inks used in a specific head technology brings significant print performance benefits with the correct choice of colorant and ink formulation.

For example, in the photorealist/colour graphic arts segment, where there is a requirement for very high chroma inks together with 100% wet fastness, these properties could well be achieved by examining for example aqueous dyes/ink formulations, together with specifically developed media coatings.

The model outlined in the successful project development in the textile ink jet example given in this paper could be equally used in the large format graphic arts market. Such an approach, particularly examining the interaction of soluble dyes with specific coating technologies could be one way of bringing product developments to the market.

Conclusions

Commercial Ink printing technologies are now establishing themselves as viable alternatives to traditional print technologies.

The predicted rewards are large for those partnerships that get their technology combinations and marketing policies matched to end user requirements.

In this paper we have briefly highlighted the partnership between OEM/Colorant supplier/Media chemistry specialist as a model for success using as an example the success of the introduction of a textile ink jet system based on specially developed textile reactive dyes and pre-treatment chemistry.

Finally, the introduction of ink jet technology in the textile printing industry has already led to significant ben-

efits in reducing lead times, responding quickly to fashion changes, reducing stock levels and giving increased competitiveness to printers in high cost markets such as the USA, West Europe and Japan.[15,16]

The next stage of "on demand printing" (to the 100 square metre level) if successful will, if the economics of scale are right, lead to the evolution of production ink jet technologies in the textile area. However, this will not be an over night change but a steady technology development over a number of years. The time-scale to production technologies is the all difficult unknown parameter to predict.

References

1. R. N. Mills 'Ink Jet Printing—Past, Present and Future' *IS&T 10th International Congress on Advances in Non Impact Printing* 1994 p. 410-413.
2. P. O. Silva "Consumables Technology in Non Impact Printing" IS&T *11th International Congress on Advances in Non Impact Printing* 1995 p. 7 - 11.
3. F. Noll 'Industrial Ink Jet Printing—Mix of Mature and Emerging Applications', *19th European Ink Jet Printing Conference, Giga Information Group Dussledorf,* 20 - 22 March 1996.
4. T. L. Dawson 'Jet Printing'— Review Progress in Coloration **22** (1992) 22.
5. L. Graham 'Ink Jet Print Systems for Dyeing and Printing of Textiles', *Textile Chemist & Colourist,* **21** (1988) No 6, p. 27 -32.
6. J. R. Provost 'Recent Developments in Ink Jet Printing of Textiles with Reactive Dyes', *IS&T 11th International Congress on Advances in Non -Impact Printing* 1995 p. 378-382.
7. Eureka Project EU 796 'Digital & Environmentally Friendly Printing Technology of High Quality and Productivity', ECHO: Eureka Database 1992.
8. Y. Miura 'Bubble Jet Textile Printing' *17th IFVTCC Congress* June 5 - 7th 1996 Vienna, Book of Papers p. 86 -88.
9. S. O. Aston, J. R. Provost, H. Masselink, Jet Printing with Reactive Dyes, *J.S.D.C* **109** (1993) p. 147.
10. J.- P. Stefanini 'Ink Jet Technology for Textile Printing' *17th IFVTCC Congress*, June 5 - 7 1996, Vienna, Book of Papers p. 81 - 92.
11. ZENECA, European Patent Application 534,660 A1 (14 Sept 1992).
12. J. R. Provost 'Ink Jet Printing on Textiles' *Surface Coating International* **77** (1994) No 1, p. 36 - 41.
13. BRITE Euram Project, BE 7167.
14 P. Gregory (Ed) 'Chemistry and Technology of Printing and Imaging Systems', *Black Academic*, 1996, p. 119.
15 J. R. Provost 'Integrated Digital Approach to Colour Management in Textile Printing,' *Melland Textilberichte* **77** (1996) No 6 p. 406 - 411.
16. J. R. Provost 'Dynamic Response in Textile Printing' *Textile Chemist & Colorist* **27**(1995) No 6, p. 11 - 16.

Our colorants for digital applications exceed the industry standards for color and vibrancy in process color printing using inkjet inks in digital print systems. They can be used for brand differentiation in a wide variety of consumer product applications. Our digital colorants are compatible with aqueous, energy curable and solvent inkjet inks. Sunâ€™s global footprint enables us to deliver solutions to local markets worldwide. We believe that each customer is unique and we work closely with our customers to understand their needs and help them to execute their strategies with immediate and sus