Developments in Textile Ink Jet Printing with Pigment Inks

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Abstract

The analogue textile printing industry is dominated by pigment printing. One of the major reasons for such a high market share (~ 50 % of the textile printing market) is the on-going technology developments in the key component of the pigment printing system, the polymer textile "binder". The latest textile binders are complex polymer mixtures which have been developed to impart the color fastness, durability and importantly, a soft "handle" to the textile, that the final end user customer demands.

Initial developments in digital textile ink jet printing focused primarily on the development of water soluble textile inks, such as reactive and acids dyes, as dye purification and micro filtration technology was available at the colorant manufacturers. However, as textile ink jet technology develops with increased quality, production rates and new business models, the textile printing industry will require the development of textile pigment printing ink jet inks which "mirror" the conventional textile pigments/binders in technology performance.

The development of textile pigment ink solutions is very much more complex than water soluble dye systems and must be tailored to individual ink jet print head technologies. The present paper will outline developments in textile pigment ink jet printing and indicate how total textile pigment ink systems will have to be developed in the future for specific print head families.

Introduction

Detailed studies of the world analogue textile printing market have confirmed the dominance of pigment printing systems (Figure 1). The study also concluded that the dye based printing technology, such as reactive dyes will decline over the coming 10 years due to both environmental pressure to reduce water usage and increasing developments in textile pigment printing technology. The developments in conventional screen printing in the coming years will focus on both the physical form of the pigment dispersion formulations and the textile polymer (binder) components of the analogue textile ink formulation. The other major conclusion from this study is the increased printing of polyester with consequent increase in disperse dye usage.

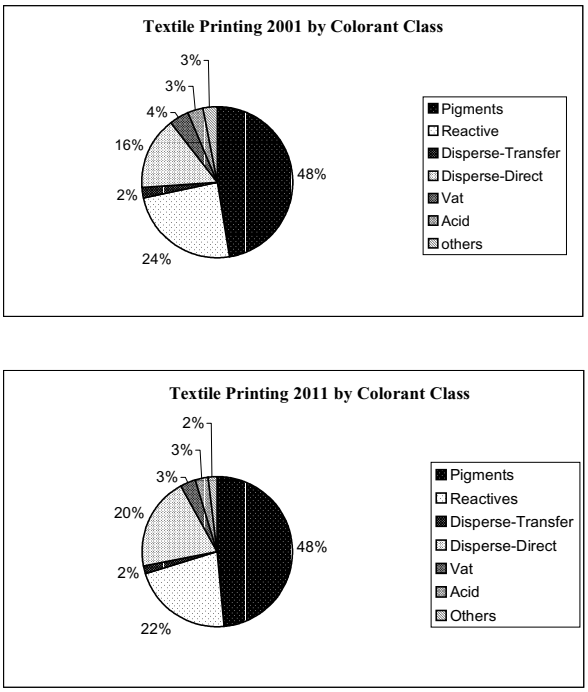

Figure 1. Textile Printing Market 2001 –2011. (© BASF AG 2002)

The overall conventional textile printing production will increase from 24 billion square metres to approximately 33 billion square metres over the next 10 years; a market growth rate of 2.7% / year.

There have been a number of optimistic forecasts of the market penetration by digital printing into the textile printing markets. Many of these market forecasts depend on future developments in areas such as print heads, business models for the inks and the ultimate acceptance of digital technology by the traditional textile printing markets. Current digital printing in the textile printing industry is still relatively small and amounts to no more than one percent, which is confined to the pre print, sample and coupon printing areas and a number of niche markets such as the flag/banner markets, sportswear and "one-off" fashion items.

As indicated in Figure 1, the major coloration method in conventional textile printing is pigment printing. For digital printing to make market penetration into the conventional textile printing market, digital systems must be developed which reproduce the accepted market standards to color fastness, "hand" and color gamut of pigment printing. The early developments in textile ink jet printing focused on water soluble dye based inks, such as reactive and acid dyes as the methods of developing inks with the required purity were relatively simple and the purification and filtration equipment was available.[1] Also, it was relatively easy to develop inks for a wide range of print head technologies based on water-soluble textile dyes. It is only recently that textile ink jet pigment printing systems have been introduced into the market and the complexity and problems of developing textile pigment ink jet ink systems have been realized.

Textile Pigment Printing Systems

Pigment printing was first introduced into the textile printing market in 1937 and since that date there have been continuing developments in the technology.[2]

Pigment textile printing can now produce textile prints with extremely soft "hand" and can comply with the majority of I.S.O. fastness tests that are required by the major retail organizations. The major textile pigment colorant suppliers have been developing ever more sophisticated polymer systems to improve the performance and at the same time simplifying the recipes for the textile printer, by incorporating many of the individual components into complex "cocktails". Behind what appears to be a simple analogue textile screen-printing recipe can be a complex blend of chemicals developed to achieve the required fastness and "hand". The textile binder blend and the printing additives, such as cross linking agents, are the key components in achieving satisfactory wash fastness results. A typical conventional printing recipe recommended would be similar to the following, where many of the components are blended into proprietary additives to simplify the system to the textile printer.

Lutexal ® HIT (Synthetic Thickener)	28 gms
Luprintol ® MCL (Printing Additives)	25 gms
Helizarin® Binder ET (Polymer Binders)	150 gms
Water to	1000 gms

Using this recipe, Figure 2 shows the importance of the textile binder amount to the fastness performance (I.S.O. Scale) in a number of very stringent fastness tests.

Test 1 - Dry Crock Fastness
Test 2 – Wet Crock Fastness
Test 3 - 100 Times Brush –Washing
Test 4 - 5 Times Domestic Laundry (60°C)

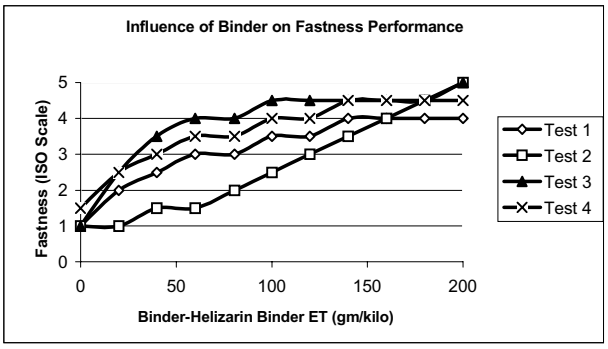

Figure 2. Effect of Textile Binder Levels on Fastness Performance (100% Cotton, Conventional Screen Printing; 2. 5% Cyan Pigment dispersion)

To achieve acceptable fastness and handle, the components of a printing recipe can be varied and optimized in conventional screen printing to specific fibers and printing machines. With textile pigment ink jet printing, the components would have to be incorporated in the ink jet formulation or applied by a separate post treatment step.

Development of Ink Jet Pigment Printing Systems

Pigment textile printing is the most important coloration group and will continue to be the focus of research by the major textile pigment colorant manufacturers. As we have shown the recipes used in conventional printing have been developed by blending many of the individual components into specific cocktails, in order to simplify the overall ink formulation for the textile printer.

In pigment ink jet printing the chemicals can either be incorporated:

- in the textile ink jet ink formulation
- by application of a textile binder after ink jet printing by a separate post treatment application stage

There is no universal textile pigment ink jet printing solution, as the process development depends very much on the print head technology selected. The most desirable approach would to be to use pigment ink jet ink formulations containing the same textile binder that are used in conventional screen printing.

There are many physico-chemical requirements to develop an acceptable textile ink jet ink formulation, one of the initial requirements is to develop ink with the required viscosity profile for the specific print head. However, the addition of textile binders with concentrations which will achieve the textile fastness levels indicated in Figure 2, produce a viscosity that is too high for many of the piezo "drop on demand" (DOD) print heads.

This can be illustrated in Figure 3, where six Helizarin® textile binders were added to a pigment ink jet formulation at various concentration levels.

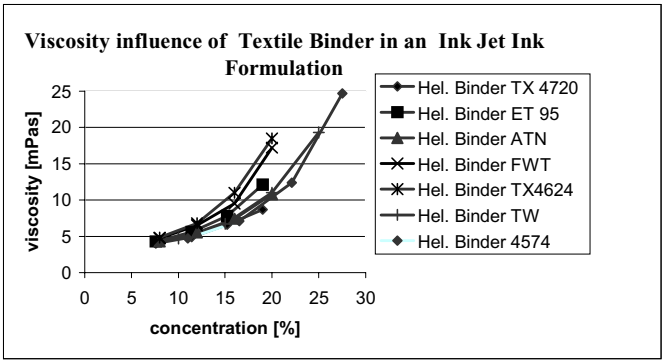

Figure 3. Influence of a Textile Binder on the Viscosity of Textile Pigment Ink Jet Ink.

The ink jet print head technology "map" is very complex with many types of print head technologies available.[3] Textile ink jet printers currently available use a wide variety of print head technologies, including both "continuous" and "drop on demand" print head types. The specific print head technology being used will determine the actual physical specification target (such as viscosity, surface tension, conductivity etc) that must be initially met in order to develop a successful textile pigment ink jet ink formulation.

Taking into account how the viscosity increases in ink jet formulations with additions of textile binder, a matrix of textile ink jet ink approaches to different print heads can be built up. Table 1 gives an indication of the possibility of developing textile pigment ink formulations containing textile binder for the different types of print head.

Table 1. Possible Textile Pigment Ink Jet Formulation Approaches to Different DOD Print Head Technologies

	Piezo Head Low Viscosity	Piezo Head Higher Viscosity	Thermal Print Head
Pigment Ink No Textile Binder	Yes	Yes	Yes
Pigment Ink with Textile Binder	No	Yes	No
Pigment Ink with non textile binder	Yes	Yes	No

With thermal DOD print heads, besides the ink jet ink viscosity requirement, the incorporation of a high amount of a polymer system into the ink jet ink is also a problem.

For example, piezo print heads which have the requirement for very low viscosity (such as the Mimaki® (Japan) printers as the JV Series or the TX Series) can not use inks with textile binder in the formulations.

Thermal print heads (such as found in the McDermid ColorSpan® DisplayMaker X11) also can not use pigment inks which contain textile binder.

Only with specific industrial type piezo print heads can pigment inks be developed which contain textile binder. With these types of industrial piezo print heads, each print head will in all probability require development of a specific textile pigment ink jet ink formulation.

With textile ink jet printing the ink formulation on the textile is deposited on the surface of the textile and does not penetrate the interstices of the textile as would be the case with conventional textile printing. Figure 4 shows a cross section through a cotton fabric, which has been ink jet printed with a piezo drop on demand printer.

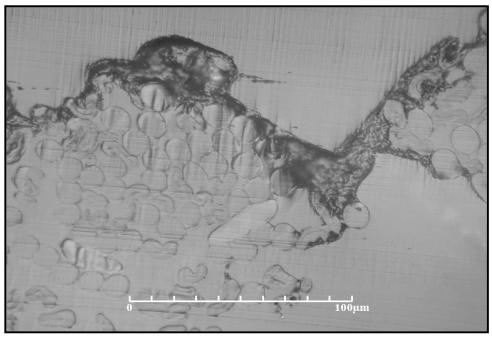

Figure 4. Photomicrograph of Textile Ink Jet Print

This surface printing effect with textile ink jet printing, which on the benefit side gives a good "hand" to the textile, also means that ink jet ink formulations and post treatment systems also have to be developed to take account of this surface print effect.

BASF Approach To Textile Pigment Ink Jet Printing

BASF, based on its knowledge of the textile printing markets world wide, have developed two ranges of textile pigment ink jet inks that contain no textile binder, for the broadest range of possibilities with different print heads.

The range consists of two ranges of ink jet ink formulations, Helizarin® P inks for low viscosity piezo DOD print heads and the Helizarin® H inks for 600 dpi thermal DOD print heads.

The number of Helizarin® P ink jet inks has now been expanded to 10 members to give the textile printer the opportunity of using the increasing number of print channels available with some of the latest textile ink jet printers.

Helizarin® ink jet inks have been specially formulated so that they can be easily used on the widest range of currently available textile ink jet printers. Based on knowledge of textile pigment printing, these pigment inks comprise all the important features required such as color

strength and gamut, runnability and fastness properties when a specific post application procedure is followed.

Helizarin® Textile Ink Jet Ink – Process Route

The general Process route is summarized in Figure 5; the post treatment is normally applied by a screen application, rather than a padding operation.

Pre-Treatment - (Optional) – Specific Recipes
Ink Jet Print
Dry
Post Treatment – Specific Recipes developed for Different Fibers
Heat Fixation (150 °C, 5 minutes)
No Wash-off

Figure 5. General Process Route for the Helizarin® Textile Ink Jet Print System

The post treatment requires the application of specially developed textile binder recipes and varies depending on the fiber being ink jet printed. Post treatments have been developed for the whole range of fiber types and adapted to many different application routes.

The BASF approach has been to develop pigment ink jet formulations, without textile binder, that will give excellent reliability for a wide range of current print head technologies. The major reason is that the current productivity levels of many of the available textile ink jet printers are aimed at the "strike-off", sampling and the coupon printing markets. The textile printer can by a "post treatment" and a heat fixation stage achieve the required soft textile "hand" and fastness performance.

The Future

In the future, as the technology develops to larger production machines, specific textile pigment ink formulations with textile binders will be developed for the different types of print head technologies. However, the textile binder in such formulations will not be just a simple addition to the ink jet formulation but will in all probably incorporate new polymer developments to overcome many of the problems highlighted in this paper.

Overall production rates greater than 100 square meters per hour will be the next target, with the ITMA 2003 Exhibition in the UK seen as a focal point for new developments.

Ink jet has already found its way into the textile printing process for use in sampling and for some short run length production. The future of ink jet in textile printing depends on many factors such as the costs per square meter and the production rate per hour of the printer.

Also the business models for the inks must be examined in the long term to follow more the business models used in conventional screen-printing. This will inevitably lead to price levels of consumables decreasing in order to make digital printing attractive to the "main stream" textile printer.

As ink jet printing speed increases, it is anticipated that ink jet printing will account for even more production processing due to the advantages over conventional textile screen printing.[4] There are so many factors that have to come together to achieve viable short run production with ink jet, it is difficult to give firm forecasts for production by ink jet in the future. However, if developments do take place, then the BASF view is that we could well be seeing ten percent textile printing production penetration by ink jet by 2011.

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Biography

Dr. Ulrike Hees received her Ph.D. degree in chemistry from the University in Mainz. (During her studies she did research at UCSB and Stanford University in the USA). In 1998 she joined BASF AG in their Research Department in Ludwigshafen and carried out research on novel polymer systems. In 2001 she joined the Global Marketing Ink Jet Team and is currently head of the Product Development team, developing industrial ink jet printing solutions, including textile applications.