Printing cellulosics – current and future demands on the reactive dye printer

John Provost and Sarah Aston

Recent developments in technology are having a profound effect on the textile printing industry. John Provost and Sarah Aston give an overview of the main issues that will be influencing the textile printer in the 1990s and into the next century.

The introduction of the rotary screen printing machine in 1963 and its continued rise in popularity (to an overall share of over 60%) is one of the major factors in the continued shift of printed production to the developing and newly industrialised countries. This fact, together with the global nature of the textile world, their lower cost base, easy access to the latest print technology, and the availability of an international fashion network has enabled developing countries to increase further their market share of world printing. In their printing survey, Stork Brabants indicate that the world market for printing is approximately 18 billion linear metres with a global growth rate of 2% per annum. The market in Western Europe is a similar size to that of North America (2.8 billion linear metres per year). However, the textile recession in Europe had a serious effect on overall production in 1991–92. In contrast to Europe and North America is the relentless growth rate of the Far Eastern markets, with a market size greater than 25% of all world printing, and growth rates nearing 5%.

With the increased pressure from the developing printing markets in the Far East, textile printers must respond with both increased quality and shorter time of response. This means supplying customers with new design concepts, printed samples in a wide range of colourways and bulk prints in a time frame unheard of only a few years ago. There is equal pressure on the textile printer to produce bulk prints in an environmentally acceptable manner, to a high quality standard.

In short, forward-looking printers of the 1990s in developed markets must have a strategy to combat increasing pressures from Far East competition and to meet the ever-increasing demands of their customers. This strategy has to be based on their closeness to the market place, knowledge and the ability to form partnerships with their customers, whether local or export, and then deliver high-quality fashion designs on innovative fabrics in extremely short delivery times. In essence, the term 'high-quality fashion design' means complex designs (which means more screens), more colourways (which means more sampling) and in a shorter time frame (which means more headaches!).

To achieve this strategy, the printer must take an integrated approach to the whole printing process, and has to examine:

- The pre-printing stage (CAD/CAM)
- The production of sample prints
- Selection of the right dye range to ensure minimum transfer time from sample to bulk printing, and consequently less down-time on the bulk printing machine.

An area that has seen much development in the USA and Europe is the pre-printing and design selection process.

Prior to 1980, the majority of printers used what was essentially a totally manual approach to the production of the textile prints, from the initial design stage to the first bulk production. Figure 1 gives a summary of the position at that time.

Since the 1983 ITMA in Milan, the situation has changed with the availability of relatively low-cost and increasingly powerful PC based systems. There has been an equally dramatic increase in the associated technology, such as visual display units (VDUs), graphic controllers, scanners and, importantly, high volume data storage systems (rewritable optical discs). With the right investment, the printer can now scan designs into a CAD system where the number of colours can be reduced, designs manipulated, put into repeat, colourways created and

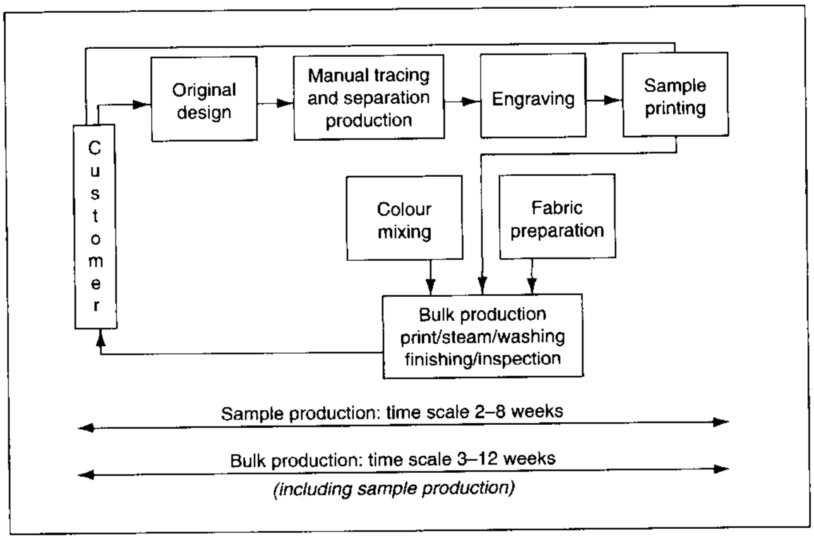

Figure 1 Textile printing by conventional methods

separations produced. The digital information generated can then subsequently be used to produce screens directly, via the latest laser engraving technology, or by conventional means using computer-produced films. Figure 2 summarises the situation for many of the systems currently available.

Obviously, many printers have not gone for the full investment in new technology, but have examined carefully their own requirements and made strategic investments in those parts that will bring them the best reward. At this point, it must be stressed that all of this technology does not replace the original designer who has the initial creative input. The majority of CAD applications start with at least an initial hand-drawn, coloured design which, after being scanned into the system, can then be further modified and coloured. All this technology does is to speed up the overall printing production time-scale, but not by much, as the customer still requires sample prints in a considerable number of colourways on his fabric. The production of these colourways at the sample print stage is still one of the major bottlenecks. Any technology that can reduce the time taken for colourway/ sample selection will greatly decrease the time taken to produce bulk prints.

After the CAD manipulation stage, it is customary to obtain a pre-print assessment via a hard copy printer. Up to a few years ago, CAD systems incorporated one of the many 'non-impact' printers available. The actual choice depended on the price level, but was normally based on ink jet printing technology (bubble jet printer) or a thermal transfer printer. The hard copy was normally on paper. A textile hard copy would obviously be more useful in design interpretation, and this has led in the past to many ambitious projects aimed at developing such output based on jet printing technology. One of the major reasons for the concentration of these extensive research programmes over the last 20 years on ink-jet printing is the realisation that the same dyestuffs could be used in this technology as those used in conventional screen or roller printing. The possibility exists therefore to develop systems for sample printing and bulk printing that would eliminate the need for screen or roller engraving and subsequent conventional printing technology.

The concept of ink-jet printing of textiles using dyestuffs used in the textile industry was commercially launched for the first time at the 1991 ITMA exhibition at Hannover by Stork Colorproofing who introduced the Stork TruColor jet printer. For the resultant jet print to be comparable with a textile print produced by conventional screen or roller printing, the ink formulation must make use of the same dye chemistry. Stork Colorproofing and Zeneca Colours has worked closely to develop extremely high purity versions of certain Procion P dyes, and to incorporate these into formulations that satisfy and are compatible with the stringent needs of the Stork TruColor jet printer. Zeneca Colours has also developed the associated pretreatment technology required for the system. Full details of this technical development and processing methods have been published over the last few years. However, the key advance with this new technology is that we can now go a considerable way to eliminating the bottleneck of producing realistic fabric samples from which the printer can select acceptable colourways and designs.

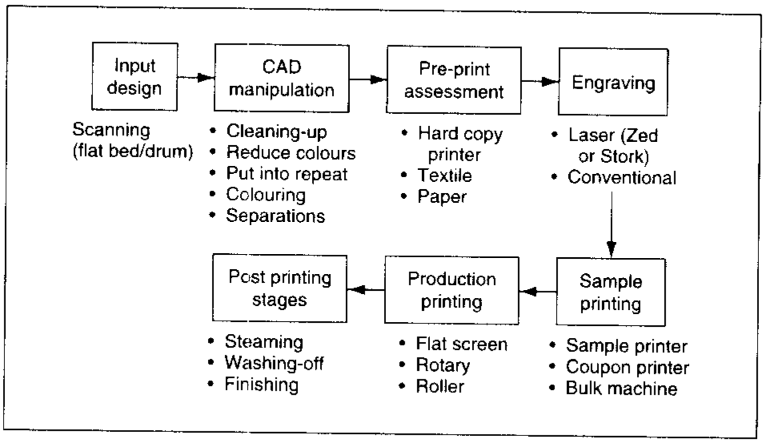

Figure 2 Integration of CAD systems into print production

Only when firm decisions have been made would screens be engraved and a conventional sample printed for final approval prior to bulk production. This stage could, as the technology develops, be eliminated, and the final approval could well come from the jet-printed sample. With the current technology, there is the added bonus that the computer systems can also drive other production functions such as laser engraving (or separation production), colour match prediction and sample (and bulk) print paste production.

However, once the sample has been accepted, the design still has to be printed in bulk. As all printers know, this is the start of a whole series of new problems.

Bulk printing

The printing of cellulosic fabrics with reactive dyes is a complex process. Individual dyes may not respond in the same manner to all the various processes. Therefore, the printer must observe several key areas of reactive dye selection in order to achieve compatible and reproducible bulk prints. By identifying these key areas, new dyes can be developed (and existing reactive dyes selected) that satisfy these selection criteria. This has been the philosophy behind the new range of Procion PX dyes, developed by Zeneca Colours, which contains a number of existing dyes and introduces six new dyes for printing cellulosics.

The key areas for which these dyes have been specifically developed are:

- Reactive dye build-up properties
- Reactive dye compatibility
- Wash-off performance.

The impact of environmental aspects on all these factors has also to be taken into consideration, particularly the current target of reducing or eliminating the urea in the print paste. The physical form is another important factor, as the availability of a high-strength liquid form compatible with the latest generation micro-value automatic colour kitchens is essential.

Build-up

Build-up curves are used by many printers to find the concentration level beyond which further dye addition makes no noticeable improvement on the visual colour value. This concentration is used by many printers as the maximum concentration in their stock pastes when they mix their colour pastes using their so-called 'standard' system. It is important therefore that the dyes build-up well and are not weak. The Procion PX dyes are mostly high-strength liquids with strengths of 40% or above. These build-up curves are obviously dependent on a wide range of factors such as the substrate (type and weight per square metre), preparation, print paste (composition and rheology) print machine (percentage pick-up), steaming and wash-off variations.

However, under constant conditions the approach does give valuable information particularly on the area of linear build-up (when the strength increases in proportion to the dye applied), the non-linear portion (where the curve starts to indicate saturation) and ultimately the full saturation portion. The concentration of maximum build-up for those specific conditions can then be assessed.

Compatibility
This is of the utmost importance in the reproduction of reactive dye prints and it is easy to visualise how mixtures of dyes with different application/technical profiles can give rise to considerable shade variations during processing. If the 'all-in' processing route is taken as:
print – dry – atmospheric steam – wash – dry
then the requirements for a compatible reactive dye range can be considered to be:
- Uniform steam profile
- Insensitivity to steam temperature and humidity variations
- Insensitivity to print-paste recipe variations.

Steam profiles
These show how the colour yield of the reactive dye varies with steaming time under atmospheric conditions and provide the key to a dye's reactivity and to the stability of the covalent bond it forms with cellulose. If dyes achieve stable maximum colour yield in times shorter that the actual time of steaming in use, mixtures of the dyes will produce consistent shades. All reactive dyes do not show the same consistent colour yield in the steam profile test and specific tests need to be carried out. Only by examining the steam profile in detail, and optimising to the ideal profile by chemical modification, can we be confident of achieving reproducible mixture shades.

Steam temperature and humidity
It is relevant to consider these two parameters together since any temperature rise will, by definition, be accompanied by a drop in relative humidity of the steam at atmospheric pressure.

Temperature control is more difficult than time control under bulk working conditions, particularly when processing viscose fabrics.

The effect of controlled variations in steam temperature and relative humidity on colour yield of reactive dyes is difficult to assess under bulk steaming conditions. Laboratory steamers have to be relied on, in which the wet and dry bulb temperatures (and consequently the humidity) can be controlled. In general, the problems with large molecular weight phthalocyanine turquoise reactive dyes are notable, but also in other shade areas (such as browns) where, by selecting dyes that have a smaller molecular weight and are less sensitive, steaming reproducibility can be improved. Phthalocyanine turquoise is always the exception to all the rules and considerable process control is needed in this shade area.

Print-paste variations
The two most common chemicals used in reactive dye printing are urea and alkali (either sodium carbonate or bicarbonate). The quantities used in the printworks tend to be worked out empirically over many years, and are the result of a compromise on the part of the printer in order to obtain an acceptable balance between storage stability of the prepared reactive dye pastes and colour yield under bulk steaming conditions.

The final recipe is usually, therefore, a compromise controlled by the spread of dye reactivity and sensitivity to urea/moisture of the dyes in use by a particular printer. By carrying out alkali/urea variations under ideal conditions, (i.e. fully conditioned prints are natural moisture regain and optimum steaming conditions), the performance of dyes can be compared.

The majority of the Procion PX dyes have a high safety factor in relation to urea/alkali variations, and can be printed from reduced urea recipes (for example 100 g/kg of urea in a cotton recipe can be replaced by 20 g/kg urea and 10 k/kg dicyandiamide).

With viscose fabrics, the print paste normally contains 200 g/kg urea. In many cases, it is causticised or pre-padded with urea to overcome the moisture sensitivity and other problems associated with printing this fabric. To replace these high levels of urea (for example 200 g/kg in the print paste), we have found 80 g/kg urea and 15 g/kg dicyandiamide can give similar results. Other approaches have been to reduce the urea by up to 50% in the print paste and apply moisture by a mechanical process prior to entering the steamer.

The whole area of urea reduction (or replacement) in the print paste is undergoing considerable study at the present time.

Zeneca Colours believes that the answer to the urea reduction problem lies in a combination of dyes which are known to be less sensitive to urea (as are the Procion PX dyes), alternative chemical additions and the mechanical application of moisture (to the natural regain of the fabric) prior to entering the steamer.

This assumes that the steamer is well maintained and operating efficiently. Whichever approach is taken, however, the turquoise/green shade area will always be the exception to the rule and careful process control will be required.

Wash-off performance
This is currently one of the major areas of concern in a printworks. Energy consumption, effluent load and water usage are high and it is frequently necessary to pass fabric twice down a continuous washing range to achieve satisfactory fastness levels. The washing stage consequently can become another major bottleneck in the printing process.

To satisfy the requirements for efficient washing-off properties, it is desirable that members of a reactive dye range should show rapid removal and low staining:
- Loose dye should be quickly washed out of the fabric to minimise washing time
- Washed-off dye must not stain back on to the fabric, so it is necessary to develop and use reactive dyes which have high fixation, low substantivity and high diffusion.

For the printer, dyes achieving the washing-off performance demonstrated by Procion PX dyes offer the potential opportunity for faster washing speeds, because of the rapid rate at which loose dye is removed, and the fact that there is less chance of backstaining during washing. The faster washing speed means high productivity and less water usage. By examining parameters such as reactive dye build-up, compatibility and wash-off performance in an analytical manner a profile of the ideal reactive dye for printing can be produced. Zeneca Colours has examined its current range of Procion P dyes and highlighted those dyes that satisfy the profile. Equally, there have been specific research targets aimed at satisfying these important selection criteria in other key shade areas. Research has produced a number of new and significant molecular developments which are now available under the Procion PX dye name. The Procion PX dyes are a major development aimed at answering the current and future demands on the printer.

This article is based on 'An integrated approach to cellulosic printing with reactive dyes' presented by J R Provost at the Clemson University Textile Conference. Clemson SC in December 1994.

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