Creating Colour Profiles to Ensure Colour Reproducibility Across Different Digital Textile Printers

Ann Noonan
Sophis Systems N.V.
Belgium

Colour profiling is a necessary exercise to be able to ensure automatic process control with close colour matching, not only between coloured monitor and colour printer but also between printers and the different colour spaces of the different dyes.

The quality of colour profiling is dependent upon the number of variables, which are and which are not controlled, the way the colour calibration algorithms are calculated and implemented into the software and the starting point for the colour.

Within the textile world we have the additional factor that the substrate is not necessarily stable and the weights per square metre can be between 50 grams and 800 grams.

The Key Influences, Which Affect Us In The Textile World, Could Be Summarized As:

Printer head, droplet pattern, and the resolution or ability to manipulate 'on the fly', the levels of shades per colour

Dye types and colour space available per dye type

Substrates being used and what percentage of take-up is standard for any one substrate including whether the dye adheres on the surface or travels through the cloth structure to the other side

Tracking the variables caused by pre-preparation and the finishing of the fabrics

Receiving and converting data to fit the new process

Colour standards and translation algorithms being used in the software

Precision of the printer and how effectively the substrate is kept aligned during the process

Environment for viewing the colour matching

Colour calibration techniques used to set up the specific direct digital printer

Relationship and the integration of the key production data as a mathematical reference for the software to use when generating the printing image, to be printed out on the digital printer and to be printed later on a traditional printing table whether with rotary screens, galvano screens or flat screens.

Clear procedures need to be implemented to ensure that the new method is consistently used and it is consistently successful.

Why bother to do direct digital printing?

Printer Head, Droplet Pattern, and the Resolution or Ability To Manipulate 'On The Fly', the Levels of Shades Per Colour

To do successful process printing without manual intervention such as pre-mixing it is imperative today to have more than 4 colours as well as fine resolution prints to be able to simulate the printed production result. The minimum number of piezo based heads and resolution for fine silk printing is 6 heads and 720 d.p.i. For other fabrics there is a ratio between number of heads and the number of points per square inch. Our opinion is for automatic process control using the piezo heads today, there should be a minimum of 600 dpi and 6 heads. Otherwise unless it is flags or promotion fabrics, it is necessary to design for digital printing. This defeats the purpose in a textile market, which continues to sell mainstream their traditional style printed cloth designs. They cannot conceive of just making designs specifically for digital printing. Bubblejet follow a similar ratio of number of points versus the number of heads. For continuous drop inkjet printing, if there are not multiple levels of dots to create shaded colours, the results are limited to coarser drops. To hide the problem the cloth is saturated with dye. Sophis does not refer to the draft mode speed of a printer but to the realistic speed necessary to get an acceptable result on a specific type of fabric.

The way the droplets fall on to the cloth influences the appearance of the area of colour. Textile digital printing is a war of camouflage. The more the dots do not appear to the eye, the more acceptable the area of colour. It does not matter that in traditional printing there are dots. In digital printing, dots appearing to the viewer, must be deliberate. People are not objective in these types of judgments. Even the sequence of the colours and the way the droplets are mixed or placed together do make a difference to the appearance of the area of colour. Yellow dots within red can sometime be fatal as the eye sees the yellow immediately as a separate dot rather than a perceived orange. The way to fool the eye with paper

printing is to use micro dots and ultra micro dots which are the same number but minute dots within the same area. The eye smooths out what it sees. With textiles we have to work within the coarser limits because of the textile dyes.

Dye Types and Colour Space Available Per Dye Type

There are running reliably in the textile market today, reactive, acid, disperse and disperse transfer dyes.

Depending on the dyes used, there are definite differences in colour space possibilities with the acid dyes being extremely bright, the reactives being covering a wide range of colours and the disperse dyes generally more confined within colour space. Therefore the dye type dictates the colour range possibilities. For example if in a four colour textile printer we choose in reactive dyes, black instead of navy blue, it is possible to get a stronger black but the colour space is reduced at least by 25%.

There is also a choice between dependent and independent colour. To define dependent colours, this could be translated to a black, grey, saturated magenta, light magenta, saturated cyan, light cyan, and yellow.

We usually use dependent colours to get a good smooth appearance especially in tonal work.

However independent colours are chosen around the colour space from the dyes available and could be as one example, black, magenta, cyan, green- yellow, golden yellow, dark blue and saturated red.

The independent colours however give a wonderful range of colours ideal for the textile market in general.

Each dye type provided by each manufacturer has a colour space possibility. To define this we measure and graph these so that we can provide a sufficiently generic ideal colour standard per dye type. Within this ideal colour space, we can plot subsets of colour space per substrate, per dye type. It is also necessary to mention that different sites can get more or less colour space depending on the skill of preparing the cloth and the skill to finish the cloth.

The colour space achievable also depends on the substrate colour and this must be included in the calculation, at the time the person is coloring the print image.

Ecological demands and costs to dispose waste dyes are driving traditional printing organizations, to use complicated re-cycling systems to avoid the high expenses as well as to avoid being sued for illegal practices. Digital Printing has little waste with the ‘drop on demand’ printers.

Substrates being used and what percentage of take-up is standard for any one substrate including whether the dye adheres on the surface or travels through the cloth structure to the other side

Another key factor is the substrate(s) chosen. In this industry there are not one or two substrates per site, but it could be easily 100 or more substrates, which can vary from season to season. A set of standards for different fabrics needs to be developed and stored in the computer. The influence of how the fabric is woven, bleached and prepared prior to printing effects directly the way the dots of dye sit on the fabric. With it comes to polyester cloths the dyes flow around the threads and through to the other side. With cotton it has a habit of sinking directly into the fibres. With vicose it may travel along the threads. This influences the absorpency factor. It is a critical factor when making a colour standard.

Tracking the Variables Caused by Pre-Preparation and the Finishing of the Fabrics

There are experts in the market who know how to prepare the cloth. It is necessary that the cloth is usually padded rather than screened although there are exceptions to this rule. There are different chemicals used for different dyes; for reactive dye for example there is used sodium carbonates or bicarbonates plus urea.

For direct disperse printing as well as for many fine fabrics, it usually requires some form of alginate to stop the bleeding of the dyes.

Finishing is another expert job. Poor finishing can mean water spotted cloth, or dye not adhering to the cloth. The best recommendation we like to make is to stitch the digital printed roll onto the end of the traditionally printed roll of the same dyes stuffs so that the temperature is very even. This gives good reproducible results. However we never get any work done directly after holidays. Steamers take time to get set up to a constant atmospheric temperature controlled environment. Whether the steamer is continuous where the cloth passes slowly through a large chamber, or a rolled up fabric put into a steady state steamer like the Star Steamers, the more standardized the technique, the more consistent the result.

Disperse dyes are finished by passing these very quickly over dry heat between 210 – 230 degrees C. Cloth fixed at 210 C is passed over the heat within 30 seconds. Infra red is often used.

Receiving and Converting Designs to a Form to Fit The New Process

Designs can be sent from cad cam systems in a variety of formats. This is typical of our market sectors.

The format used to transfer the design and colour information, will eliminate or not eliminate vital information. There are some wonderful condensing formats out there, but the end result may be a design, which bears insufficient resemblance to the original design and certainly the original colours. To counteract this problem there are two key ways to prepare the print image. The print image is defined as the final design, which will be seen when printed. It is not the original design.

If the design comes in as a 24 bit file, it can be converted automatically to a 16 fit file and dumped directly to the calibrated printer. This is acceptable when there is no necessity to do colour ways. The latter demand is generally a necessity for textile printing.

Therefore the design should come in as a set of separates, or a greytone set or if a coloured design, with a predetermined way to take over the colour values. The

separations and grey tone set are recombined to make the print image using the preset up reference data for the take-up of the cloth.

A design which is only going to be digitally printed or to be used initially for marketing, can be made by using a separation program without all the technical details of engraving and recombined to fit the substrate specification. We use the SOPHIS SYMPHONY programs to do this work.

Coloration is done using the colour palettes that cover the colour space, which can be printed for a specific dye type, and which has had already calculated into the print image the factor for the behavior of the specific substrate which will be used. This is feasible today. Our customers do this.

Colour Standards and Translation Algorithms Being Used In the Software

The measurement techniques used make a big difference as to whether the printer can print within Delta E 1 – 2 for 90% of the colours; or whether there are 70% of the colours falling within this Delta E etc. We have personally found that if we start from LAB or XYZ for the input of colour specifications, instead of the spectral values the error can be immediately starting from a Delta E of 2.

The colour space is made, by measuring the possible colour space with the chosen dyes used in the printer.

The colour calibration tools will define the behaviour on the substrate (substrate profile), the effect of the preparation and the finishing, (profile of finishing), the effect when the design is printed on the final production machine (production profile). In addition there will be a coloured monitor profile and the specific digital printer profile.

To profile the digital printer for a specific dye, substrate and finished product it is necessary to calibrate for the final product. It is also possible to measure and set up for unfinished printed cloth.

To measure the basic colours for a colour standard for the digital printer there are different forms of calibration. The most common is to measure a set of representative colours with a spectrophotometer and to make a standard based on this. The measurements set the colour reference points within colour space to enable colours to be fitted from a design to the right colours. The colours are defined for the printer as a set of dye droplets placed beside each other to represent each of these colours. Sophis also uses an X-Rite Spectrofiler to make colour standards although the cloth has to be stable. In addition we use a scanner technique.

To calibrate with a scanner it is necessary to know the error so that there can be an adjustment made between the 'ideal' colour space and what the scanner is reading. The technique involves calibrating the scanner to measure the difference, as well as measuring by scanning in the printed tests. Some samples will be shown at the presentation. The printouts on the cloth are finished and measured by the scanner each time. An unsteamed colour calibrated standard or a colour calibrated finished standard can be set up. Probably the most important thing with any colour calibration is to have a good idea of the quality of the calibration. We use an in-house colour profiling technique which enables us to know what percentage of colours are within a delta e of 1 – 2 and the spread of the possible colours through the colour space.

Relationship and the integration of the key production data; as a mathematical reference for the software to use when generating the printing image, to be printed out on the digital printer and to be printed later on a traditional printing table whether with rotary screens, gravur screens or flat screens.

The production tables must be set up to run consistently to a set of standards. This involves decisions on speed, on angle of printing, the way the dye is transferred from screen to cloth, the viscosity of the dye, the drying time between putting on one colour and then the next colour and the humidity in the printing mill. The cloths must be prepared consistently to the same standard and the finishing process must be also standardized.

The production profile to simulate the way a design is traditionally printed, is specific per printing table, per fabric, per dye stuff. This we measure using a set of tests which are translated into a curve to represent the take up of the colour into the cloth. This is a representative snap shot of production. Ideally every substrate should have a specific profile. In the real world this does not happen and if there are a set of 10 curves for 70 – 100 cloth types, this appears to be a reasonable compromise. This curve when used for the separation of a design has a direct impact on the simulated print image. It is this print design image which should be used for making the colorations. For those who use engravers, the engravers endeavor to make enough tolerance to cover the way the printer prints. Sometimes this does not work and while it can be the printer changing the conditions, it may also not be reproducible because the engraver has separated the design in a way, which does not fit the way, the printing table prints. The key shades might be in a density area, which just is not achievable with the pressure, cloth etc. and the design comes out looking very flat rather than subtle.

(A sample test will be shown at the seminar to illustrate the difference between traditional sample tables and production tables)

The software can either handle this profile in a realistic manner or it can not. It is the integration of all the parameters, which makes the difference between a manually controlled system and an automatic process control system. If you can manually measure each colour, you are able to succeed with flat coloured printing. If you have mixed colours and multiple tonal work, it is impossible to do this manually without multiple tests. This is the same for digital printing. You can use a colour book printed out on the printer for the flat colours but you will have many books if you have many qualities of cloth.

The ideal work flow:- the design is imported, put into repeat, styled and separated using the production profile curve. The resulting separations are recombined using the same production profiles into a print design image. The

colorations are viewed on a calibrated coloured monitor in a room with D65 lighting.

When the design and colour ways are sent to the printer the results when viewed under D 65 by the colour calibrated monitor should be an acceptable match. This match should then be reproducible on the traditional printing tables because the digital printed cloth normally is within the same colour space as the colour space achievable with the dyes on the traditional table. For pigments there is the possibility to have a colour space mapped within the reactive dye space today, to be able to make the colour combinations which are reproducible on the printing table.

The monitors are all different. To calibrate a monitor to a known standard and to continue to recalibrate the coloured monitors, is a key to being able to view the print image in a consistent manner.

Some systems use a spectrophotometer to measure the colours on the screen and send these values with the design to the printer. We have chosen to use a feedback loop between the known behaviour of the video card and the known colour space available within a specific type of monitor. Hence per design we do not use a spectrophotometer to read the value of the colour on the screen. We prefer to use the spectral data of points within the colour space for a dye type and to translate the colours for a known colour space available on to the coloured monitor screen in the red, green and blue values. The chosen colours are re-translated from the colour standard reference in the system (not in the coloured monitor) for the colour space possible for the specific printer with the specific dyes with the specific substrate. We do this because the monitor colours vary depending on the temperature that the monitor is running at.

It is better to indicate to the user whether a colour is within a colour space and being shown correctly on the coloured monitor, or it is not shown correctly or that the colour is within the colour space achievable with the dyes and substrates. With this guideline the user can adjust for differences. We use a simple form of traffic lights to indicate this. A good colorist should not be colour blind so red and green should not be a problem!

When the colour model is being built for the printer, the dyes and the substrate, there is a different expectation for the colour matching of a single area of colour versus the tonal and mixed colours. For a flat colour the expectation is an eye match or 1 delta e colour difference unit whereas the tonal and mixed colour work may be more than a delta e of 2. As people judging colour are very subjective it is a matter of giving them the tools and letting them decide. You may have measurements that show that there is no green in the blue but if they are convinced there is green in it, there is green in it, as far as they are concerned. It is vital to look at the colours under a light box so that the results are consistently displayed. Looking at the colourway in a room looking on to a courtyard full with green grass and bright sunlight has a real effect on the perceived colours being viewed.

Clear procedures need to be implemented to ensure that the new method is consistently used and it is consistently successful.

People are not very happy with change and they are definitely not happy when their usual judgment tools are no longer valid. I have seen people using and adapting for out of date recipe colour books when they are calculating a colour combination for a design, because they have a manual input, which allows adjustment at that point. With process controls it means learning new skills. Too many firms consider the designer should set up and run these procedures. They may be able to once the system is set up but they need help from the technical people within the organization to keep the feedback sufficient to enable them to grow their knowledge. Where there are ideas to be printed so long as the results may be printable later, it is not necessary to be precise. However for industrial sampling it is crucial that the right team across divisions knows how too, and are encouraged to work together. This is also crucial to maintain the standard so that it is possible to deliver short run orders continuously without having to resort to re-colouring to match the re-orders.

People are also variable. We are not usually in the same mood every day. This means performance is variable from day to day. Unless a known effective procedure is in place, there will be variations because they have not followed for example the maintenance procedures that morning, or they are not so alert or they have not seen a variation on the cloth caused by variable pre-preparations. There are many reasons for mistakes. An effective proven set of procedures, with techniques to evaluate different behavior of the machine, support from the supplier(s) as well as the internal technical teams, with alert and curious let's get it moving people, makes the difference between failure and success.

Why Bother to do Direct Digital Printing?

So why bother? Why insist that people change and learn how to react quickly, react without all their normal controls and instead insist that they learn to trust and implement new ways of process control without their myriad of little manual checks in the current printing chain?

There is one word, economics. Without this change there is no future for the current Western world printing manufacturer. Prime money absorbers are sample costs including screen costs. If 1 metre costs at least 75 Eur when a 12 colour design is sampled the first time, and the hit rate with an idea is one (1) successful versus four (4) rejects, there is no alternative. Order runs are averaging considerably less than before. This has been a dramatic change within the last four years. This is reflected, in the lack of new traditional printing tables being sold. It is also reflected in the number of metres being printed which is down by at least 33% in overall quantity of metres compared to five years ago.

To get printing textiles back into mainstream it is necessary to create interest. It is not just to create interest against woven and piece dyed goods but to create again the desire by people to buy. Without this change there is little interest in printing for the fashion market compared to the piece dyes which can be ordered and made up within a week. Without this change the boredom level will rise to the point where people will spend their money elsewhere. They already have changed the way they

spend their income compared to ten (10) years ago. Our competition in the textile world is not textiles but other interests and leisure activities. Go to many fairs outside the textile industry and the predominant garment may be made up of plain coloured cloths including denim.

It is interesting to have a situation when there can be such a direct impact on the health of an industry. Colour profiling for this market is a key factor to people being successful. If they do not choose the right solution and set up the right teams and be very persistent as well as consistent, there could be a situation where the printing textile industry does not come back to the past level.

What I find intriguing is that the demand for short runs, the demand for having it fast, the demand to be environmentally friendly, the demand to meet price points but to have an interesting product, is dependent on people being able to implement successfully new process controls. I hope the industry is prepared to do what is necessary and to understand that by learning new disciplines they will have a viable future. Thinking 'speed' just translates to speed of machine instead of calculating the total speed from idea to ordered delivery is a key negative today for the industry. Thinking design and colour is just for the designers and they do the real work in the manufacturing part of the business is not going to revitalize the industry. Thinking they can manually adjust for the different colour profiles of the different printers under the necessary reactivity time, will be wishful. Although e-commerce has some bad press at the moment, this plus 'I want it now' mentality will have a powerful impact on our industry. We will live in interesting times!