Color properties of disperse dye inks and pigment inks on polyester fabrics

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Abstract

*Dye inks and pigment inks are two kinds of inks for digital inkjet printing of textiles. As commercial inks, dye inks are more widely used in digital printing of textiles. But dye inks are just suitable for specific fiber fabric, such as disperse dye inks are only suitable for inkjet printing of polyester fabrics and reactive dye inks just for protein and cellulose fibers. Frequent change of inks is not only tedious and time consuming, but also wastes inks. Pigment inks are suitable for inkjet printing of all kinds of fabrics, including polyester, silk, cotton, wool, et al. But pigment inks are not widely used in textile digital printing today because there are many problems not solved such as poor fastness and less brilliant colors. In this paper, the color properties of disperse dye inks and pigment inks were investigated and compared each other. Pure colors of Cyan, Magenta, Yellow, Black, Light Cyan and Light Magenta were printed with disperse dye inks and pigment inks respectively on the same kind of polyester fabrics. The color properties such as K/S values and L*a*b* were measured. The corresponding ICC profiles were drawn respectively using the color data. Then color gamut of the two kinds of inks was calculated from the ICC profiles with RIP software. The differences of two inks printed fabrics were investigated and the reasons are analyzed. Although pigment inks exhibited poorer color property than disperse dye inks on polyester fabrics pigment inks could be used for digital inkjet printing of textiles.*

Introduction

In recent years, the application of ink-jet printing has increased. The benefits of using this method include the ease of sampling and the production of printed textiles. It has shown considerable benefit in terms of flexibility, creativity, cleanliness, strike-off, preparation of samples and recently in the production of short print-length textiles [1-5]. It is expected that with further advances in software, printer and ink technologies the ink-jet printing of textiles will increase in importance in the future.

Dyes and pigment are two kinds of inks in digital printing of textiles. As commercial inks, dye inks are more widely used in digital printing of textiles[6]. There are many different kinds of dye inks, such as reactive dye inks, direct dye inks, disperse dye inks, acid dye inks and so on. But one dye inks is only suitable for specific fiber fabric, such as disperse dye inks are only suitable for inkjet printing of polyester fabrics and reactive dye inks just for protein and cellulose fabrics[7]. So, in order to satisfy the need of different, it is necessary to change dye inks. Frequent change of inks is not only tedious and time consuming, but also wastes inks. Pigment inks are suitable for inkjet printing of all kinds of fabrics, including polyester, silk, cotton, wool, et al. But pigment inks are not widely used in textile digital printing today because there are many problems not solved such as poor fastness and less brilliant colors.

The color gamut lies on the kinds and amounts of inks colorants. Pure colors of Cyan, Magenta, Yellow, Black, Light Cyan and Light Magenta of inks are determinant of color gamut if ink jet on the same kind of fabrics with a six-color digital printing. The color properties such as K/S values and L*a*b* of every pure color were necessarily to be measured to enclose the reason of different color fields of two inks.

Experimental

Materials

The polyester fabric used in this study was commercially, 100 D(11.1 tex), 455×355, weight 155g/m^2. Transfer paper (85g/m^2) was obtained from Hangzhou Honghua digital Technology Stock Co. Ltd. The disperse inks were Dinks Cyan, Dinks Magenta, Dinks Yellow, Dinks Black, Dinks Light Cyan and Dinks Light Magenta. The pigment inks were Pinks Cyan, Pinks Magenta, Pinks Yellow, Pinks Black, Pinks Light Cyan and Pinks Light Magenta. All inks are commercial and supplied by Southern Yangtze University. Polyepoxy-emmonium Salt were commercial grade and obtained from Qingdao Haiyi Chemical Co. Ltd.

Treatment of polyester for pigment inks digital printing

Treatment was carried out by the pad-batch method on a ROACHES BVHP padder(ROACHES International Ltd) for polyester used for pigment inks ink jet printing. The Polyepoxy-emmonium Salt was used at concentrations of 15g/L, and no any other reagents added.[8,9]

Digital printing of polyester fabrics

Printing was carried out on a Mimaki Tx-1600 ink-jet printer with bidirection 8 pass and variable 720 dpi in a low speed. All prints with disperse dye ins were transferred to polyester fabrics at 200℃ for 30s. The polyester fabrics were treated with Polyepoxy-emmonium Salt before printed by pigment inks, then dried in oven at 150℃ for 3min for color fixation.

Color calibration

Color management was made on polyester used disperse inks or pigment inks respectively. First, set printer mode bidirection 8 pass and variable 720 dpi in a low speed, and use polyester as printing media whatever disperse dye inks or pigment inks, and then printing the test bar(Offered by Wasatch) which included the limit of every color inks and total inks. Secondly, inks limit were set according to test bar. Thirdly, print patches and create the ICC custom profile using X-rite MonacoProof software package, and

install it to Wasatch RIP software. So the color gamut could be seen by Wasatch RIP software.

Color yield measurements

The printed fabrics were conditioned before color yield measurement using a Macbeth Colour Eye 7000A Spectrophotometer (Gretag Macbeth, Australia). The condition for measurement was set under specular excluded with large aperture. The fabric was folded two times to ensure opacity and measured twice, i.e. measured on both the warp and weft directions to obtain average results.

The color yield (K/S value) was calculated for wavelengths of 400–700 nm at 20 nm intervals within the visible spectrum. The K/S values were calculated according to Eqn 1:

$$K/S=(1-R)^2/2R \quad (1)$$

where, K is the absorption coefficient (depending on the concentration of colorant), S is the scattering coefficient (caused by the dyed substrate) and R is the reflectance of the colored sample. The higher the K/S value is, the greater the color yield and dye uptake.

Results and Discussion

Limit inks of disperse dye inks and pigment inks

In order to investigate the color properties of the disperse dye inks and pigment inks, the pure inks patches were printed. Each fabric was printed with one pure ink at resolution 720 dpi. Polyester fabric is poor water absorption, so it is necessary for it to treatment with Polyepoxy-emmonium salt to prevent the ink colors from bleeding on the fabric before printing with pigment inks.

In fact, it is not necessary for any single inks to jet 100% during the digital printing. The color changed little with the more jetted inks. If the fabric had absorbed enough, the inks began to bleeding on the fabric. The limit of every kind inks was necessary and the results were given in Table 1.

Table 1 showed that every kind of inks has its own limit amount no whether disperse dye inks or pigment inks. It is maybe different for limit amount of inks even the same kinds inks. It lies in the different structure of dyes or pigment. Different colorant has different color saturation. When the saturation arrived to saturation, the more ink amount couldn't change color deepness. The software limited the amount of inks according the amount with saturation color deepness.

Table 1 Limit of every kind inks

	C	M	Y	K	All
Dye	90	90	92	95	300
Pig	92	90	94	96	325

It also indicate that amount of every pigment color limit inks was larger than those of dye inks. The saturation of every patch color rested with the concentration of colorants correspondingly. If the two kinds inks had the same concentration, the limit of inks maybe coursed by the different of digital printing. The disperse inks printed on transfer paper first and then transfer to polyester fabrics. The pigment inks printed directly on polyester fabrics. So, the more colorant covered on disperse inks printing polyester fabrics, that is to say, the dye ink got to saturation more easily[10].

Color properties of ink

It was well known that the pigment particle couldn't dissolve in the water. In order to form steady water-solubility pigment inks, it was necessary to add all kinds of reagents which included dispersant, antiseptics, defoaming agent and so on. So, the pigment particles were covered with the surfactant and forming to a covering layer in their surface. The covering layer covered the gloss of pigment colorant.

Color strength K/S values from Table 2 clearly demonstrate that every color of dye inks printing was higher than those of pigment inks printing correspondingly. Dispersant dye inks is an aqueous suspension, the surfactant couldn't forming a covering layer although the dispersant also exist. During the process of the disperse dye transfer to polyester from transfer paper, the dye sublimated and exhibit its brilliant color. So, K/S values of disperse dye inks is higher than those of pigment. From Table 2 it also could be found that L values of the dyes were higher than pigment L values which disclosed the lightness of color. That is to say, the disperse dye inks was really more brilliant than pigment inks[11].

Table 2 K/S value and L*a*b* of disperse dye inks and pigment inks

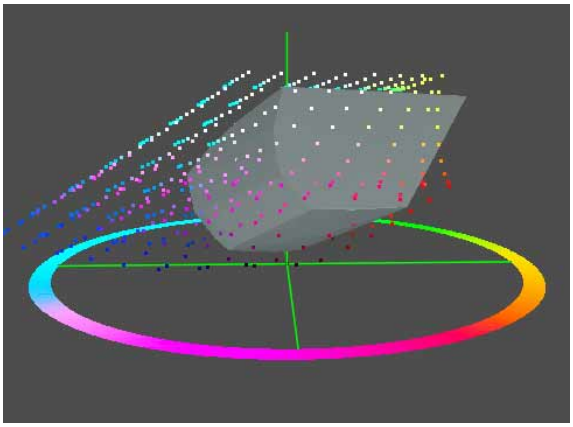
Inks		K/S	L*	a*	b*
Cyan	pig	20.160	47.87	-13.50	-34.61
	dye	25.723	50.83	-8.33	-45.89
Magenta	pig	15.990	49.45	44.06	-21.58
	dye	26.409	50.57	60.68	-3.45
Yellow	pig	23.258	73.60	-5.94	48.67
	dye	33.120	80.35	-8.55	68.88
Black	pig	28.19	32.66	2.04	-2.04
	dye	25.089	34.06	-3.38	0.04

Table 3 Color parameter of sRGB IEC61966-2.1 and Manoco Generic CMYK profile

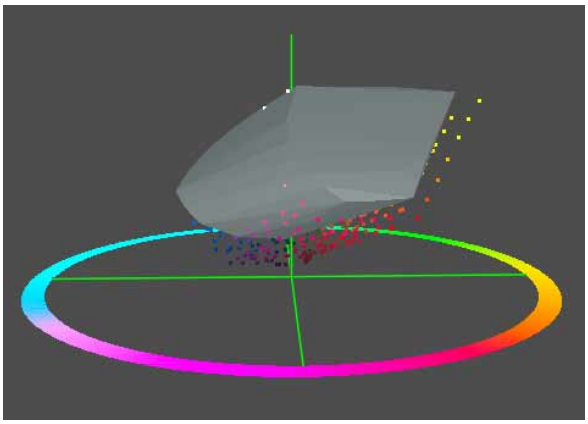
Ink	Min	Max	Max saturation	Color gamut value
sRGB IEC61966-2.1	0	100	144.675	5.93948 million delta E
Manoco Generic CMYK profile	7.484	93.096	93.7266	2.96971 million delta E

Table 4 Color parameter of sRGB IEC61966-2.1 and Manoco Generic CMYK profile

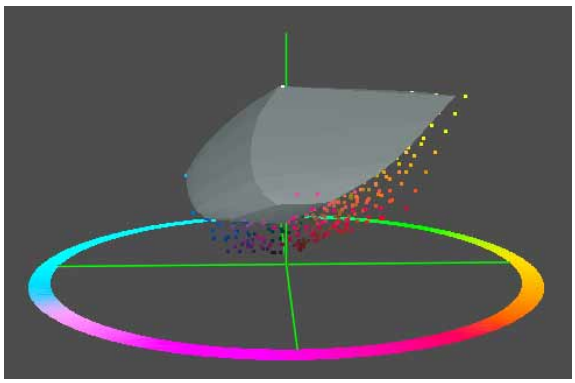
Ink	Min	Max	Max saturation	Color gamut value
Manoco Generic CMYK profile	7.484	93.096	93.7266	2.96971 million delta E
Disperse dye inks CMYK profile	20.912	95.58	85.3925	2.00328 million delta E
Pigment inks CMYK profile	26.288	89.3864	81.1599	1.45899 million delta E



Note: Dot represents sRGB IEC61966-2.1
Gray region represent Manoco Generic CMYK profile
***Figure 1** Color gamut of sRGB IEC61966-2.1 and Manoco Generic CMYK profile*



Note: Dot represents Manoco Generic CMYK profile
Gray region represent disperse dye inks CMYK profile
***Figure 2** Color gamut of Manoco Generic CMYK profile and disperse dye inks CMYK profile*



Note: Dot represents Manoco Generic CMYK profile
Gray region represent pigmmment inks CMYK profile
***Figure 3** Color gamut of Manoco Generic CMYK profile and pigment inks CMYK profile*

Contrast of color gamut of two inks

Form the Table 2, we knew that the disperse dye inks was more brilliant than pigment inks. But how its color gamut of the disperse dye inks or pigment inks? Could they use on polyester fabric? Figure 1 could give us an answer.

The display is ICC-Absolute colorimetric space. The ICC display shows L*a*b* values relative to a “perfect diffuser” or “perfect white”. The choice corresponds to the Lab spaces defined in ICC profiles. Maximum saturation shown as an indication of the brightest color. It is the maximum distance of the gamut from the gray scale. Finally, gamut volume is shown to indicate the total volume of colors that are within gamut.

The Figure 1 and Table 3 showed the color gamut of sRGB IEC61966-2.1 and Manoco Generic CMYK profile. sRGB IEC61966-2.1 is a color space often used, and the Manoco Generic CMYK profile is represent the normal color gamut that used in printing. So, as digital printing, it will be valid only compared with Manoco Generic CMYK profile.

Form the Figure 2, Figure 3 and Table 4, e could found that the color gamut of disperse dye inks is smaller than the color gamut of Manoco Generic CMYK profile, but larger than the pigment inks. In fact, the Manoco Generic CMYK profile is referable in the printing but not textile printing. Generally

speaking, the paper is more glabrous than fabrics, so it is easily to get more lighter surface, and have more expressive ability of color saturation[12]. It was also found that the different of color gamut between Manoco Generic CMYK profile and pigment inks CMYK profile lies in the deep color. That is to say, it is hard for pigment inks to get the deep color[13-15]. However, digital printing is used in individual consumption. In a general way, it could be accepted if the color gamut could is about 1.5 million delta E. So, although pigment inks exhibited poorer color property than disperse dye inks on polyester fabrics pigment inks could be used for digital inkjet printing of textiles.

Conclusion

Pigment inks exhibited poorer color property than disperse dye inks on polyester fabrics, for example, it had higher limit whatever in single color or total color limit, its K/S is more lower than that of disperse dye inks. According the pigment inks color gamut of pigment inks, it could still be used for digital inkjet printing of textiles.

References

[1] Yuen, C W M; Kan, C W. A study of the properties of ink-jet printed cotton fabric following low-temperature plasma treatment. Coloration Technology, 2007, Vol. 123 Issue 2, p96-100

[2] Hees, Ulrike; Freche, Mike; Kluge, Michae,eta. Inkjet printing: New product for pretreatment of textiles. International Textile Bulletin, May2003, Vol. 49 Issue 2, p64

[3] May-Plumlee, Traci; JiHyun Bae Behavior of Prepared-For-Print Fabrics in Digital Printing. Journal of Textile & Apparel Technology & Management: JTATM, Spring2005, Vol. 4 Issue 3, p1-13

[4] El-Hamaky, Y. M.; Nassar, S. H.; Osman, H. A.,eta. New technique for printing by ink jet process. Journal of the Textile Association, Nov/Dec2004, Vol. 65 Issue 4, p171-175

[5] Sen'i Gakkaishi. Improving the Color Yield of Ink-Jet Printing on Cationized Cotton. Journal of the Society of Fiber Science & Technology, Japan, 2004, Vol. 60 Issue 1, p40-41

[6] FANG, K.J.; FU, S.H.; ZHANG, X.. Development of digital ink jet printing. Dyeing and finishing. 2004:24, 48.

[7] By: LaPorte, Gerald M.; Wilson, Jeffrey D. etal. Mancke, S. Amando; The Forensic Analysis of Thermal Transfer Printing. Journal of Forensic Sciences, Sep2003, Vol. 48 Issue 5, p1163-117

[8] Kanik, Mehmet; Hauser, Peter J., Parillo-Chapman, Lisa;eta. Effect of Cationization on Inkjet Printing Properties of Cotton Fabrics. AATCC Review, Jun2004, Vol. 4 Issue 6, p22-25

[9] Weiguo Chen; Shichao Zhao, E.; Xungai Wang. Improving the Color Yield of Ink-Jet Printing on Cationized Cotton. Textile Research

[10] Carr, W. W.; Bucknall, D.; Morris, J. F. Inkjet deposition of complex mixtures to textiles. Annual Report - National Textile Center, 2006, p1-10)

[11] Li, Shen; Jinjin, Dai. Improvement of hydrophobic properties of silk and cotton by hexafluoropropene plasma treatment. Applied Surface Science, Mar2007, Vol. 253 Issue 11, p5051-5055

[12] Ales Hladnik and Tadeja Muck. Characterization of pigments in coating formulations for high-end ink-jet papers Dyes and Pigments, Volume 54, Issue 3, September 2002, Pages 253-263

[13] Yuen, C. W. M.; Ku, S. K. A.; Choi,eta. Study of the factors influencing colour yield of an ink-jet printed cotton fabric. Coloration Technology, 2004, Vol. 120 Issue 6, p320-325

[14] Baffoun, Ayda; Haidara, Hamidou; Viallier, Pierre. Influence of the morphological structures of alginate thickener films on the colour yield of an ink jet printed cotton fabric. Abstracts of the Fiber Society Symposium, 2005, p98-98

[15] Yuen, C. W. M.; Ku, S. K. A.; Choi, P. S. R.; Kan, C. W.. Factors Affecting the Color Yield of an Ink-Jet Printed Cotton Fabric. Textile Research Journal, Apr2005, Vol. 75 Issue 4, p319-325

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