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Physical properties of ink-jet printed cotton fabric

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Abstract: In recent days the most popular printing technique is ink jet printing which have the potential to meet the new market requirements. Furthermore, these techniques have the capability to produce printed fabrics with significantly reduced effluent outputs and with lower water and energy usage. Such technology is currently being explored and developed for commercial textile printing. The aim of this paper is to study the physical properties of ink-jet printed cotton fabric. 100 per cent plane cotton fabric was used for the present study. Five different solid pantone colours were selected for ink-jet printing and assessed for the physical properties. ink-jet printed fabrics were air dried and steamed with superheated steamer. The steamed fabrics were finally washed to remove unreacted dyes and chemicals. Steamed printed samples were subjected to physical standard testes. The physical properties of all the ink-jet printed samples were evaluated by standard IS testing methods before and after printing. Experimental results revealed that after printing and steaming process, there was consolidation of yarns in warp and weft directions, in turn resulting into increase in the yarn density and compactness of weave with irrespective of colours. Cloth thicknesses of printed samples were negligibly increased compared to control samples. GSM (gram per square meter) of control sample was relatively higher than printed sample. Irrespective of fibre content and type of print colours, maximum shrinkage was observed in weft direction than warp. Warp and weft way bending lengths of cotton control samples were found to be higher than printed samples. Control sample of cotton fabric showed lower crease recovery angle than print colours. Ink-jet printing processes influences the physical properties of printed cotton fabric.

Key words: Cloth count, Cloth thickness, Cotton fabric, Ink-jet printing

Introduction

Textile printing is an important technique of textile coloration. Cotton is one of the major fibres in the textile industry and more than 70% of all printed substrates are cellulosic fabrics. Printing of cellulosic fabrics with reactive dyes continues to increase, as these dyes produce brilliant shades with very good wet fastness properties. (Ahmed *et al.,* 2006)

The current worldwide production of printed textile fabrics is over 34 billion square meters per year and is dominated by rotary screen printing (Ujiie, 2006). It is estimated that around 11-13 per cent of textile products are printed each year worldwide with an annual growth rate of 2 per cent (Dominioni, 2003).The textile printing method predominantly adopted is rotary screen printing (about 58%), followed by flat bed screen printing (28%), transfer printing (5%), engraved roller printing (3%) and hand screen printing (6%). Although rotary screen printing machine are most suitable for most production but not really ideal to meet the requirement of demand activated manufacturing architecture and just-in-time concepts (Naik, 2006).

The increasing demand for environmental protection, short process runs, quick response times and mass customisation in the textile industry has increased interest in ink-jet printing technology. The advantage of ink-jet printing technology over screen-printing technology is that there is no need for the preparation of printing pastes and screens, thus decreasing the printing costs and shortening the production times for collections. Digital information can be directly transferred on to the textile surface with the aid of modern computer-aided design D computer-aided manufacturing software and ink-jet printers. The image on the textile surface is composed of droplets of four or more dyes. For textile ink-jet printing, large storage areas are not required to preserve the designs, as the design data are digitally stored. Less dye, energy and water are consumed in inkjet printing than in screen printing (Mikuz, 2010). The aim of this paper was to study the physical properties of ink-jet printed cotton fabric.

Material and methods

The tests were carried out in the testing laboratory to assess the effect of printing process on physical parameters of the digital printed cotton fabric. During the year 2012-2015 in the Dept.Textile and Apparel Designing, RHSc,UAS,Dharwad.

Fabric material

Commercially available pretreated cotton fabric with plain weave (67 ends / inch x 35 picks / inch, fabric weight 140.40 g/m^2) structure was used for the present study and it was procured from Jaysinth, Mumbai.

Printing procedure

Mimaki QualiJet HS^B device with a piezoelectric drop-on-demand print head machine provided with eight refillable colour cartridges (cyan, magenta, yellow, black, orange ,red, green and blue) was used to print the cotton material. All print outputs were obtained with the resolution 720 dpi, the CMYK system, standard head transition 4. A PC system with RIP master software.

Printing

Five pantone colours were selected to print the samples namely red (pantone Ds process cyan coated), green (green Ds 74-1c), yellow (pantone Ds process cyan coated), blue (pantone Ds 188-1c) and black (black pantone Ds process).

Post-treatment

Printed fabric samples were air dried at room temperature for 24 hours and subjected to steam. Printed fabric samples were steamed using fabric steamer with superheated steam at 110° C for 5 min to fix the colour. The steamed fabrics were finally washed in 5g/l of nonionic detergent (Ahurachem) to remove unreacted dyes and chemicals. Steamed printed samples were subjected to physical standard testes. The physical properties of all the digital printed samples were evaluated by standard IS testing methods before and after printing. The results of the study were analyzed statistically with single factor ANOVA.

Results and discussion

Table 1 represents the cloth count of cotton fabrics printed with five colours. It is observed from the Table 1 that the warp (68) and weft (37) density of the cotton printed samples remained same despite of different colours. Warp density of control and printed samples was almost double (67, 68) than its corresponding weft density (35, 37). This indicates a compact alignment of warp compared to weft. Significant difference was found in cloth count between control and printed samples at 5 per cent level. This may be due to after printing and steeming process, there was consolidation of yarns in both the directions, in turn resulting into increase in the yarn density and compactness of weave.

Table 2 furnishes the cloth thickness values of control and ink-jeted printed cotton fabric samples. Irrespective of type of colours, the cloth thickness has negligibly increased (0.26-0.27mm) than control (0.25 mm) samples. This may be due to increase in the density of warp and weft yarns during printing process. This finding is in line with the findings of Spoorti (2011).

The weight per square meter (GSM) of samples varies with the type of fibre and fabric construction. It was observed from the Table 3 that, The total GSM of cotton control sample (140.40) was relatively higher than printed (137.16 to 138.76 irrespective of colours) samples. The warp and weft GSM of cotton control were higher (92.32, 48.08) than printed (warp-91.00 to 91.24, weft-46.08 to 47.44) samples, respectively .This may be because of presence of pretreatment coating on the fabric surface.

Shrinkage, the linear amount of fabric which contracts either warp or weft way and expressed in terms of percentage. Table 4 gives the complete information on change in dimensions of the cotton printed fabric with different colours. It is observed that maximum shrinkage was seen in weft direction than warp (0.15 to 2.70% with irrespective of colours), which indicates the relaxation was higher in weft than warp direction. The cotton fabric attained no significant difference may be because of course yarn and compact weave.

It is observed from Table 5 that warp (3.25 cm) and weft (2.23 cm) way bending lengths of cotton control samples were found to be higher than printed samples warp (2.54 to 2.69cm irrespective of colours) and weft (1.54 to 1.61cm irrespective of colour) way. The control samples were coated with pretreatment paste on the surface of fabric gives stiffness to the fabric. During printing process removal of pretreatment coating leads

Table 1. Cloth count (Numerical Expression) of control and ink-jet printed cotton fabric samples

Samples	Warp	Weft	Mean difference	
			Warp	Weft
Control	67	35	-	-
Black	68	37	1*	2*
Green	68	37	1*	2*
Blue	68	37	1*	2*
Red	68	37	1*	2*
Yellow	68	37	1*	2*
	Warp	Weft		
S.Em±	0.24	0.37		
CV	0.80	2.33		
CD	1.44	1.79		

* Significant at 5 per cent level

Table 2. Cloth thickness (cm) of control and ink-jet printed cotton fabric samples

Samples	Mean	Mean difference
Control	0.25	-
Black	0.26	0.01 NS
Green	0.26	0.01 NS
Blue	0.26	0.01 NS
Red	0.27	0.02 NS
Yellow	0.26	0.01 NS
S.Em±	0.002	
CV	0.14	
CD	1.92	

NS - Non significant

Table 3. Cloth weight (GSM) of control and ink-jet printed cotton fabric samples

Samples	Warp (GSM)	Mean difference	Weft(GSM)	Meandifference	TotalWeight	Meandifference
Control	92.32	-	48.08	-	140.4	-
Blue	91.00	1.32*	47.44	0.64*	138.44	1.96*
Black	91.24	1.08*	46.94	1.14*	138.18	2.22*
Green	91.08	1.24*	46.08	2.00*	137.16	3.24*
Red	91.20	1.12*	46.92	1.16*	138.12	2.28*
Yellow	91.24	0.36*	46.80	1.28*	138.76	1.64*
	Warp	Weft	Total			
S.Em±	0.16	0.24	0.24			
CV	0.40	1.14	0.39			
CD	0.67	0.99	0.99			

* Significant at 5 per cent level

Table 4. Dimensional stability (%) of control and ink-jet printed cotton fabric samples

Samples	Warp mean (cm)	Weft mean (cm)	Mean difference	
			Warp	Weft
Control	20.00 (00.00)	20.00(00.00)	-	-
Black	19.65(1.75)	19.77(01.10)	0.35 NS	0.22 NS
Green	19.91(0.40)	19.94(2.70)	0.08 NS	0.05 NS
Blue	19.96(0.15)	19.91(0.40)	0.03 NS	0.08 NS
Red	19.90(0.55)	19.97(0.15)	0.10 NS	0.02 NS
Yellow	19.91(0.40)	19.94(2.70)	0.08 NS	0.05 NS
	Warp	Weft		
S.Em±	0.13	0.11		
CV	6.94	5.91		
CD	1.47	1.35		

NS - Non significant

Figures in parenthesis indicates percentage

Table 5. Stiffness length (cm) of control and ink-jet printed cotton fabric samples

Samples	Warp mean	Weft mean	Mean difference	
			Warp	Weft
Control	3.25	2.23	-	-
Black	2.68	1.61	0.58*	0.62*
Green	2.66	1.61	0.59*	0.62*
Blue	2.65	1.59	0.6*	0.64*
Red	2.54	1.54	0.71*	0.69*
Yellow	2.69	1.58	0.56*	0.66*
	Warp	Weft		
S.Em±	0.04	0.03		
CV	3.90	5.61		
C.D.	0.55	0.52		

* Significant at 5 per cent level

Table 6. Crease recovery (degree) of control and ink-jet printed cotton fabric samples

Samples	Mean	Mean difference
Control	60.60	-
Black	64.52	1.79 NS
Green	64.92	1.86 NS
Blue	63.94	1.68NS
Red	65.06	1.48NS
Yellow	64.51	2.12NS
S.Em±	1.05	
CV	3.79	
C.D.	2.99	

NS - Non significant

to decreasing in bending length. Significant decrease in bending length with irrespective of colours attributed to removal of pretreatment paste during printing process.

It is perceived from the Table 6 control sample of cotton fabric showed lower crease recovery angle (60.60)than print colours (64.51 to 65.05 angle with irrespective of colours) this may be because of removal of pretreatment coating during printing process.

Conclusion

In a nutshell Ink-Jet printing processes influences the physical properties of printed cotton fabric and the printing process enhanced the cloth count of cotton fabric samples. This is mainly because of progressive consolidation of warp and weft yarns. Irrespective of printed colours, cloth thickness of printed samples was negligibly increased compared to control sample. GSM of control sample was relatively higher than printed samples because of presence of pretreatment coating on the fabric surface. Maximum shrinkage was in weft direction than warp which indicates the relaxation was higher in weft than warp direction. Higher bending length and lower crease recovery was observed in control samples than printed samples.This may be because of removal of pretreatment coating during printing process.In general Ink-Jet printing processes enhanced the quality characteristics of cotton fabric samples. Ink-jet printing is an alternative which has drawn much attention in the textile industry.

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