Effects of Binder Solution on Color Fastness of Digital Printed Cotton Fabric

U K Sahin¹ and H Acikgoz Tufan¹
¹Istanbul Technical University, Textile Technologies and Design Faculty, Textile Engineering Department, İnönü Cad. No: 65, Beyoğlu/Istanbul, TURKEY
Email: acikgozh@itu.edu.tr

Abstract. Digital printing of textiles first appeared in early 90's, and its share in total printing market dramatically increased due to developments in the last five years and advantages of technique, but there is still much to achieve to gain a respectable place in the market. Pigments were most commonly used inks in digital printing and they have nearly no solubility in water or no affinity for any fiber, that results in a demand for binders to create a strong bond between pigment and fiber. In this study, 12 binder solution recipes were prepared with various amounts of KEOJET PGT® binder (0, 20, 25, 30%) and Catalizzatore PGT® catalyst (0, 9, 12, 15%), as well as distilled water. Then, binder solutions were applied onto 100% cotton twill fabrics before printing of Cyan (C), Magenta (M), Yellow (Y) and Black (K) colors via ink jet machine, PicassoTex. After a fixation process, color fastness to rubbing, light, washing and perspiration tests were conducted to printed fabrics. Color fastness to washing and perspiration test results were around 4/5, color fastness to light test results were 5 for all printed samples. However, color fastness to rubbing test results were observed between 3 and 4/5. When all of fastness results were taken into consideration, best results were obtained at the recipe which has 25% binder and 12% catalyst.

1. Introduction
Digital printing is based on delivering a specific design or media onto the fabric by using computerized machinery [1]. Ink jet printing technology appeared as an alternative to the conventional printing technology. It achieved to be an alternative in such ways including quick delivery, short run production, and photographic print. These features were much harder to apply in conventional printing machines [2]. There are many advantages of digital printing but there are some limitations, as well. The most important limitation is cost of printer heads. Heads are part of the machine, which are responsible for each ink droplet formation and application. In digital printing process, printer heads are moving back and forth along the face of the fabric in order to apply a tight line on the fabric with each pass. That is to say a fast-running production rate of the printer. However, most of the digital printing machines manufacturers reported that the production rate is approximately 150 meters per hour.

Bonding is achieved by attraction of colorant on fiber molecules, by using different colorant types, various bonding types can be achieved. Reactive dyeing application is done by making covalent bonds between colorant and the fiber, which is one of the strongest bond types. In order to decrease this strong bonding of electron sharing, an alkali may be used. In addition, there are ionic bonds, which can be explained as one or more electrons donating links with each other. Especially acid dyes use ionic bonds. Disperse dyes form hydrogen bonds, which are basically connecting atoms by a linking hydrogen atom.
Van der Waals forces are also available in disperse dyes, which are based on molecule attraction, and these are weaker bonds than the other type of bonds.

The most popular ink used in digital printing is pigments; however, they do not have water solubility or affinity for any fiber, and demand binders to be fixed with the fiber. Binders are typically polymers that form strong bonds with the fiber and the pigment. Thanks to these bonds, binders become materials called 'films', which are also insoluble in water and rubbing-resistant. The stability of the binder film defines color fastness and handle of the printed cloth [3-5].

Inkjet is the printing method which makes possible the delivery of liquid ink without any contact. PicassoTex is a textile inkjet printing machine produced by Optimum Digital Planet, which is based in Turkey. This machine is generally used for cotton-based fabrics in the industry.

In this study, the effects of concentration of chemicals used in binder solution on resulting color fastness of digital printed cotton fabrics are investigated.

2. Materials and method

2.1. Materials

100% cotton twill (56 ends/cm 30 picks/cm) made of ring yarns with count of Ne 46 were bleached at 98°C for one hour using 4g/L 37% Hydrogen peroxide (L.R.:1/10).

KEOJET PGT which is a special chemical that increases the performance in printing fabrics with digital pigment inks and increases the interest of the dyestuff is used as binder in this study. Keojet PGT is a white liquid which contains blend of resins in its chemical composition. Keojet PGT improves printing definition and color intensity without affecting the handle [6].

In this study, Catalizzatore PGT is used as a component of binder solution. The mission of catalyst is catalyzing the bonding of binder with the fabric. Catalizzatore PGT is a colorless liquid which is an organic acid solution containing <1% oxalic acid and 10-20% diethylenglycole.

PicassoTex is a textile inkjet printing machine produced by Optimum Digital Planet and it has eight printing heads. This machine is generally used for printing on polyester and cotton-based fabrics in the industry.

2.2. Method

Varying amounts of KEOJET PGT® binder (0, 20, 25, 30%) and Catalizzatore PGT® catalyst (0, 9, 12, 15%) were used to prepare binder solutions with distilled water. 12 binder recipes were calculated that have different amounts of binder, catalyst and distilled water. Other than binder recipes, all the parameters were identical, such as weave design, printing inks, fixation temperature and fixation time.

Each binder solution was padded on a fabric which has dimensions of 40 cm x 10 cm, followed by printing main colors (CMYK) using locally manufactured Picasso-Tex® digital printing machine equipped with Konica Minolta® 1024i printing heads, having a print resolution of 2880 dpi, and printing speed up to 420 m²/h [7]. Fixation was done in a Thermo Scientific® Hereus model drying oven at 170°C for 4 minutes.

Color fastness to rubbing, light, washing and perspiration are conducted to each of the Cyan (C), Magenta (M), Yellow (Y) and Black (K) printed fabrics according to standard test methods, ISO 105-X12, ISO 105-B02, ISO 105- C06, ISO 105- E04, respectively.

3. Results and Discussion

Results showed that all color change and staining values for washing fastness tests are 4/5. Even some color was seen in washing bath but nearly there is no penetration to the adjacent fabric. Since the dye has very limited affinity to the adjacent fabric, both acidic and basic perspiration test results follow the same trend, resulting as 4/5. Light fastness results of all samples were 5, as the pigments used are highly stable against the influence of light.

As can be seen from Figure 1., 12% of catalyst is enough to reach highest rubbing fastness value regardless of the amount of binder among the levels studied. Moreover, 25% of binder gives better rubbing fastness score than both 20% and 30%. It is assumed that 20% of binder is not enough to form a stable film, and 30% causes excessive hard print which will cause more ink loss during crocking.
As can be seen from Figure 2, 12% of catalyst and 25% binder are enough to reach highest wet rubbing fastness values, and higher amount of binder and catalyst does not further contribute to wet rubbing fastness. It is apparent from both dry and wet rubbing fastness values that for cost-effective pigment printing with better quality, investigation of interaction between binder solution chemicals and pigment type must carefully be taken into consideration.

Figure 2. Interaction plots for wet rubbing

4. Conclusion

In this study, effects of binder solution in digital pigment printing of cotton fabrics were investigated. For this aim, different amounts of KEOJET PGT® binder (0, 20, 25, 30%) and Catalizzatore PGT® catalyst (0, 9, 12, 15%) were used to prepare 12 binder solutions with distilled water, and binders were applied onto 100% cotton fabrics before digital pigment printing. While investigating for the best recipe, color fastness to rubbing, light, washing and perspiration tests were conducted to each of the Cyan (C), Magenta (M), Yellow (Y) and Black (K) printed fabrics. Color fastness to washing, perspiration and light resulted from 4/5 to 5. Dry and wet rubbing fastness results had lower fastness degrees and showed differences ranging from 3 to 4/5. When all of fastness results were taken into consideration, best results
were obtained at the recipe which has 25% binder and 12% catalyst. It is apparent from both dry and wet rubbing fastness values that for cost-effective pigment printing with better quality, investigation of interaction between binder solution chemicals and pigment ink type must carefully be taken into consideration prior to printing, and binder recipe must be carefully adjusted for every ink combination to be applied.

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