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Research Article

Effect of Singeing and Heat Setting on Pilling Properties of CVC Single Jersey Knit Fabric

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Abstract

Pilling affecting handle and appearance, is undesirable problem in CVC single jersey knit fabric as like any others fabric. To get rid of pilling tendency from the CVC knit fabric singeing and heat setting play a vital role. If singeing and heat setting treatment are both done for the CVC knit fabric at pre-stage of pretreatment, then there can be found a significant improvement of pilling property. In this study, practically it has been shown that the pilling tendency of CVC knit fabric can be reduced easily by singeing and heat setting keeping the other physical and chemical properties unaffected.

Keywords: *CVC knit Fabric, Pilling properties, Singeing, Heat setting.*

Introduction

Cotton is a naturally derived fabric and although it is generally preferred in terms of comfort, textile making companies frequently combine polyester with cotton for a variety of reasons. One such reason is to make clothes more durable. Cotton by itself is considered very soft, and it easily deforms and shrinks. Cotton shirts that are 100 percent cotton, for example, may be very cool to the skin and provide great comfort, but over several uses and washes, the shirts are easily deformed, and they are also more prone to shrinking. By combining polyester to the cotton fabric, garments will become more durable with less chance of deforming and shrinkage. This is also the reason many work clothes and school uniforms, for example, are best made using CVC fabric. When Cotton is blended with polyester then the fabric is called CVC (Chief Value Cotton) fabric. Everyday usage and washing puts too much stress on the fabrics, and with the presence of polyester, uniforms and clothes will become more durable and will rip less easily. With the demands of everyday activities, people will welcome clothes that can be worn for a long time. Garments made-up by cotton shrink easily to some extent due the tensions introduced by spinning, weaving/knitting. Usually, the cotton content is more than 50 percent of the total combination with polyester in CVC fabric. A CVC fabric may be made of 55 percent or 80 percent cotton with the remaining percentage indicating the amount of polyester used. The garments made from the CVC fabric will be more durable with less chance of deforming and shrinkage. But arise of polyester fiber into fabric construction causes more pilling tendency due to its greater breaking strength, lower bending stiffness and electrostatic properties. Having low twist factor and loose structure knit fabric shows more pilling tendency than woven. So, with the increasing of the use of blending natural fibers with man-made fibers causes more pilling tendency (B. P. Saville 2000; J. G. Cook 2010-11; V. R. Sivakumar *et al.* 1981).

Pilling effect arises in wear due to the formation of little 'pills' of entangled fiber clinging to the fabric surface having unsightly appearance. The pills (Fig. 1) are formed normally by a rubbing action on loose fibers which are present on the fabric surface.

Fig. 1 Pills on CVC knit fabric

The initial effect of abrasion on the surface of a fabric is the formation of fuzz as the result of two processes, the brushing up of free fiber ends not enclosed within the yarn structure and the conversion of fiber loops into

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free fiber ends by the pulling out of one of the two ends of the loop. The greater the breaking strength and the lower the bending stiffness of the fibers, the likely they are to be pulled out of the fabric structure producing long protruding fibers. Fiber with low breaking strength and high bending stiffness will tend to break before being pulled fully out of the structure leading to shorter protruding fibers. The next stage is the entanglement of the loose fibers and the formation of them into a roughly spherical mass of fibers which is held to the fabric surface by anchor fibers (B. P. Saville 2000).

S.A. Smriti et.al observed the pilling performance of cotton polyester blended yarn after mechanical singeing and they expressed that pilling grade upgrades after mechanical singeing. They also showed that presence of polyester fibre negatively affects the pilling grade (S. A. Smriti *et al.* 2015). They only observed the pilling performance after mechanical singeing but this paper also want to investigate the effect of heat setting also on the CVC fabric.

Y. Sabina et al. showed on their research that pilling properties of the single lacoste fabric demonstrates higher pilling than double lacoste conversely single jersey fabric shows lower resistance to pilling and their test was followed by ISO 12945-1:2000 method on ISI pilling box machine (S. Yesmin *et al.* 2014).

Gintis and Mead showed in their research paper that pilling attitude is biased by not only the assembly of the yarn and fabric but also by the fiber properties, e.g. tensile strength, percent elongation, flex abrasion, bending rigidity, fiber titer, shape of fiber cross-section and friction. (D. Gintis *et al.* 1959)

L. Long et al. had worked with cashmere knitted fabrics and detected the pilling rates of the fabrics for different colors and spinning methods. Samples were tested using ICI's Pilling Box and the number of the pills formed and type of fuzz for each sample were measured using an electronic balance. The pilling rate of cashmere knitted fabric of mule yarn originated higher than that of ring yarn. (L. Li *et al.* 2014)

Already there are many technical developments have been reported in the field of reducing pilling tendency. In this article, the study has been carried out about the improvement of pilling resistance of CVC knitted fabrics by subjecting to singeing and heat setting and also examined that which of them or both is more effective to improve the pilling resistance property. With pilling resistance behavior, the other physical and chemical properties of CVC fabric have also been discussed.

Materials and Methods

Materials

Recently CVC knitted fabric having the following specification was used for our current study. Fabric specifications are following:

- Fabric type: S/J
- Yarn count: 26/1
- Areal density or GSM: 160
- Course per inch: 52
- Wales per inch: 28
- Stitch length: 2.85

Chemicals and Reagents

In the current study, the used dyes, chemicals and auxiliaries are briefly shown in table 1, with their commercial name, brand name, country of origin and amount of these reagents.

Experimental Steps/Works

In the current study, the mechanical, physical and chemical properties has been recorded and discussed for four types of sample:

- **Untreated sample**- which didn't get no singeing and no heat setting before pretreatment.
- **Singed sample**- which only got singed before pretreatment.
- **Heat set sample**- which only got heat set before pretreatment.
- **Both singed and heat set sample**- which got both singeing and heat setting before pretreatment.

Singeing

The process by which the projecting or floating or hairy fibers stand out on the fabric surface are burnt off, is called singeing. The spinning process produces hairiness of the yarn and lower the yarn counts (Ne 26/1 - 36/1) greater is the degree of hairiness. The burning-off of protruding fibers results in a clean surface which allows the clean and smooth structure of the fabric. The fabric which have to be singed from an accumulator is passed through a brushing unit and then into a singeing unit. The most used singeing unit is gas flame singeing machine. In gas singeing machine both side of the fabric can be singed in same time. Two brushes are used for brushing the both sides of the fabric and two burners are used for both side singed. After singeing, the fabric is immersed into the water or desizing tank to quench any sparks and to prepare for next processes (S. R. Karmakar, 1999; J. Shore, 1995.)

In our study, the singeing operation has carried out by both side gas singeing machine or double burner. The gas burner height was 16-18cm, fabric contact with gas burner flame was for 2-3 second which was controlled by keeping the fabric speed 70 miter/min. Company: Tong Gen machine, Origin: Taiwan

Table 1: Details about the used Chemicals and Reagents

Process/Category		Commercial Name	Amount	Brand Name	Country of Origin
Pretreatment	Scouring	Jinterg KS-90 (Detergent+Wetting agent)	1 gm/Ltr	Jintex	Taiwan
		Jinsof Eco- CBA (Anticrease)	1 gm/Ltr	Jintex	Taiwan
		Caustic (NAOH) (Alkali)	2 gm/Ltr	Fresh	Bangladesh
	Bleaching	Kappazon H53-250 (stabilizer)	0.4 gm/Ltr	kapp-chem	Germany
		Hydrogen Per Oxide(H2O2) 50%	2 gm/Ltr	Samuda	Bangladesh
	Bio-polishing	Accetic Acid (Ch3COOH)	0.6 gm/Ltr	Samsung	Korea
		Jintexzyme OEM (per oxide killar)	0.4 gm/Ltr	Jintex	Taiwan
		Ecozyme LXn (Enzyme)	1.50%	Ecochem	Shrilanka
Dyeing	Auxilaries	Jintexalate SQ-117CA(sequestering agent)	1 gm/Ltr	Jintex	Taiwan
		Jinlev CL-225(dispersing &leveling agent)	1 gm/Ltr	Jintex	Taiwan
	Dyes	Sunfix Red SPD Cone	0.95%	Ohyoung	Korea
		Sunfix Blue SSR	0.32%	Ohyoung	Korea
		Sunfix Navy blue MFCN	3.00%	Ohyoung	Korea
	Chemicals	Gluver Salt(Na2SO4.10H20)	90 gm/Ltr	Sichuanxining	China
		Soda As Light (Na2CO3.10 H2O) Alkali	5 gm/Ltr	All Chem Product	Poland
		Caustic (NAOH) (Alkali)	1 gm/Ltr	Fresh	Bangladesh
	Softening & nuralising Chemicals	Accetic Acid (Ch3COOH)	0.80 gm/Ltr	Samsung	Korea
		Jinsoap AW 501 (Soaping agent)	1 gm/Ltr	Jintex	Taiwan
		Kappa Soft BD (Softener)	1.3 gm/Ltr	kapp-chem	Germany

Heat Setting

Heat setting is a thermal process with stream under vacuum. The process is mainly used for thermoplastic fibers to improve their dimensional stability in washing and drying. Heat-setting can be defined as a treatment by which shape retention, crease resistance, elasticity etc. is given to the fibers. It also changes the strength, softness and dye-ability of the material. All these changes are directly connected with the structural and chemical modifications occurring in the fiber. The stenter machine is the apparatus most frequently used to heat set all types of fabrics. It consists of three parts: (a) an entry frame and chain whereby the fabrics are dimensionally stabilized by clips or pins before heating, (b) a heating zone that varies in temperature from 140-230°C depending on the fiber type and fabric construction, and (c) a delivery system that holds the fabric under minimum tension while cooling to retain the desired dimensions (Wikipedia; S. Sardag *et al.* 2007, J. S. Heaton *et al.* 1971; T. L. Vigo, 2002).

In the current study, the heat setting was done at 180°C by stenter machine and the time for passing fabric through the 6 chambers was 1 minute controlled by keeping fabric speed 25 meter/min. Company: Tong Gen machine, Origin: Taiwan machine, Origin: Taiwan

Pretreatment

After singeing and heat setting (in which samples), the next step was pretreatment. In pretreatment section the scouring, bleaching and bio-polishing were done step-by-step. The recipes of pretreatments (scouring, bleaching and bio-polishing) are shown in Table no 1. The scouring & bleaching both were carried out at M:L=1:20 for 3.5 hours at 100°C temperature. But bio-polishing was done at 45°C for the same period of time and M:L ratio as scouring and bleaching. The pretreatment was performed for the four samples differently. All Machines were used of Tong Gen company origin of Taiwan.

Dyeing and Finishing

From the pretreatment section the four samples then need to be dyeing differently. The recipes for dyeing are shown in the table no. 1. After dyeing the samples were dried by heating at stenter.

In our current study, the dyeing parameters were: Temperature: 60°C; Time: 6 Hours; M:L=1:20. All Machines were used of Tong Gen company origin of Taiwan.

Standard Methods used

After finishing, for testing the samples to identify their physical, mechanical and chemical properties the following standard methods were used in our study:

Wash fastness: (ISO 105-C06:2010), ***Rubbing fastness:*** (ISO 105-X12:2001), ***Water fastness:*** (EN

ISO 105 E01), ***Color fastness to Perspiration:*** (EN ISO 105 E04), ***Light fastness: (ISO 12945-1), Shrinkage (ISO 6330:2012), Fabric pH: (ISO 3071:2005), Pilling test: (ISO 12945-1:2000).***

Pilling Resistance Measurement

The pilling resistance of the CVC knit fabric samples was measured by ICI recommended test method using laboratory pilling box (Fig. 2). For the test method samples each 125mmX125mm were cut. Then making tubes the samples were mounted on rubber tubes. After mounting on rubber tubes, the samples were tumbled in a pilling box. The machine was set at 60 rpm and the revolutions of pilling box were recorded on a pre-set electric counter. After required number of revolutions the pilling box was stopped. Then assessment of the samples was conducted for pilling. Four samples were tested for each types of the CVC knit fabric. The pilling resistance grades for the samples were reported based on the following table.

Table 2: Pilling grades [ISO 12945-1:2000]

Rating	Description	Points to be taken into consideration
5	No Change	No visual change
4	Slight change	Slight surface fuzzing
3	Moderate change	The samples may exhibit one or both of the following: (a) Moderate fuzzing (b) Isolated fully formed pills
2	Significant change	Distinct fuzzing and/or pilling
1	Severe change	Dense fuzzing and/or pilling which covers the samples

Results and Discussion

To investigate the effect of singeing and heat setting on the pilling properties and other physical and chemical properties of CVC knit fabric certain physical and chemical properties were determined. All the results of individual properties are organized in different tables. In the table 3, the pilling properties of different four samples have been reported. Here we can see that for untreated CVC sample fabric the pilling property is very inferior. Because after removing the untreated sample fabric from ICI pilling box, there has been noticed severe change on the fabric surface.

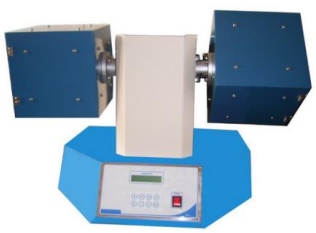

Fig. 2 A pilling box

When the untreated sample fabric gets heat set, there is a slight improved pilling property than untreated sample fabric. And after being singed the CVC knit fabric shows good pilling resistance than heat set. But the heat set fabric when get singed, there has been found excellent pilling resistance i.e. no change on the fabric surface after ICI pilling box test. The Graphical presentation of pilling grades of samples is shown in Fig. 3.

Table 3: Pilling properties of CVC knit fabric

Sample types	Grade/Rating	Description
Untreated sample	1	Severe change
Only Heat setting	2	Significant change
Only Singeing	4	Slight change
Heat setting + Singeing	5	Slight to No change

The purpose of our study is not only improving the pilling resistance of CVC knit fabric but also keeping unaffected the other mechanical, physical and chemical properties of the fabric. So, we should check the other properties of the samples after being finished by singeing and heat setting.

Firstly, in table no 4, we can see the color fastness properties of the different samples. From table 4, it can be seen easily that color fastness to wash, water, perspiration and rubbing is totally unaffected by singeing and heat setting. Rather there is a significant improved in color fastness to light after the sample get both singed and heat set together. So, having an eye to color fastness properties of the CVC knit fabric we can certainly apply singeing and heat setting together on the fabric for the betterment of pilling properties.

In table 5, the color co-ordinate values and K/S values have been shown for four samples differently. We can see that, there no considerable change in those values for singeing and heat setting. As no considerable change and thus we can get better pilling properties by both singeing and heat setting, so for pilling property improvement singeing and heat setting can apply to a CVC fabric together.

From table 6, we can see the shrinkage, spirality and pH for different four samples. Here we can see that when sample is both singed and heat set then the shrinkage and spirality is better than others keeping no considerable change pH.

As keeping unaffected the other physical, mechanical and chemical properties and some cases improvement of those properties by singeing and heat setting both together pilling property a CVC single jersey knit fabric can be improved significantly, we can apply singeing and heat setting both together to reduce pilling tendency of CVC blend fabric.

Table 4: Color fastness properties of CVC S/J knit fabric

Sample types	Grading		Color fastness properties						
			Wash	Water	Perspiration		Rubbing		Light
					Acidic	Alkaline	Dry	Wet	
Untreated sample	Color change		4-5	4-5	4-5	4-5	4-5		1-2
	Color staining	Acetate	4	4-5	4-5	4-5			
		Cotton	4	4-5	4	4			
		Nylon	4-5	4-5	4	4-5			
		Polyester	4-5	4-5	4-5	4-5			
		Acrylic	4-5	4-5	4-5	4-5			
		Wool	4-5	4-5	4-5	4-5			
Only Heat setting	Color change		4-5	4-5	4-5	4-5	4-5		2
	Color staining	Acetate	4	4-5	4-5	4-5			
		Cotton	4	4-5	4-5	4			
		Nylon	4-5	4-5	4-5	4-5			
		Polyester	4-5	4-5	4-5	4-5			
		Acrylic	4-5	4-5	4-5	4-5			
		Wool	4-5	4-5	4-5	4-5			
Only Singeing	Color change		4-5	4-5	4-5	4-5	4		4
	Color staining	Acetate	4	4-5	4-5	4-5			
		Cotton	4	4	4	4-5			
		Nylon	4-5	4-5	4-5	4-5			
		Polyester	4-5	4-5	4-5	4-5			
		Acrylic	4-5	4-5	4-5	4-5			
		Wool	4-5	4-5	4-5	4-5			
Heat setting + Singeing	Color change		4-5	4-5	4-5	4-5	4-5		4
	Color staining	Acetate	4	4-5	4-5	4-5			
		Cotton	4	4-5	4-5	4-5			
		Nylon	4-5	4-5	4-5	4-5			
		Polyester	4-5	4-5	4-5	4-5			
		Acrylic	4-5	4-5	4-5	4-5			
		Wool	4-5	4-5	4-5	4-5			

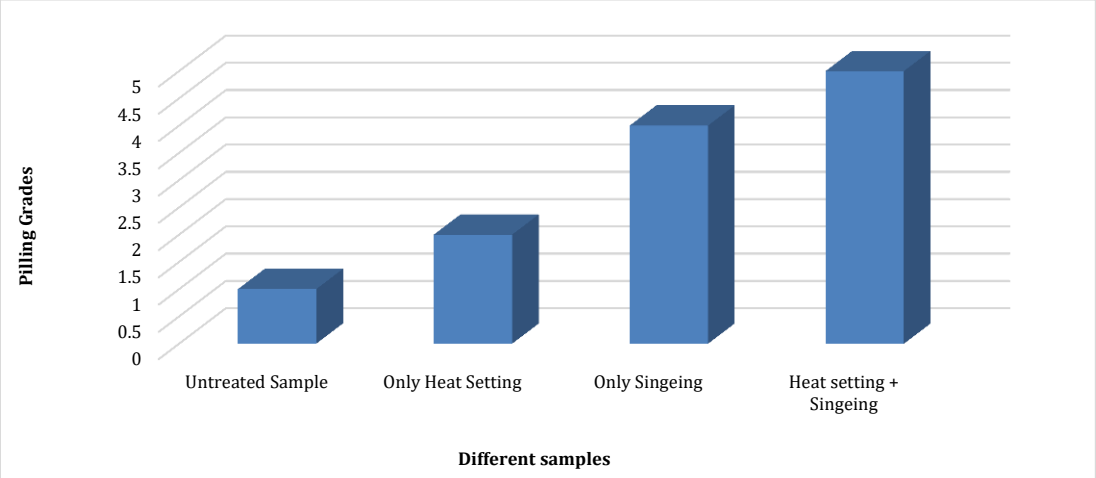

Fig. 3 Graphical presentation of pilling grades of samples

Table 5: Color co-ordinate value and K/S value

Types	**Color Coordinates value**					**K/S** (λ_{max})
	L*	a*	b*	c*	h^0	
Heat setting+ Singeing	18.37	-.36	-11.6	11.6	268.23	25.3
Only Singeing	17.93	-.49	-10.55	10.56	267.35	26
Only Heat setting	18.12	.13	-12	12	270.63	25.8
Untreated sample	17.51	.06	-11.37	11.37	270.31	26.5

Table 6: pH, Shrinkage, Spirality

Types	Length wise (%)	Width wise (%)	Spirality (%)	pH
Untreated Sample	-1.6	-2.3	2.0	6.3
Only Heat setting	-2	0	2.0	6.4
Only Singeing	-3	-2.5	1.0	5.7
Heat setting+ Singeing	-2.5	-1.0	1.0	5.9

Conclusion

The purpose of our study was to improve pilling properties of CVC knit fabric. From our current study, we can see that singeing and heat setting both are most useful in the reduction of pilling tendency of CVC knit fabric. In knitting industry, this technique can be applied for reduction of pilling tendency keeping better handle and appearance.

Competing Interests

The author declares that they have no competing interests.

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