The Effect of Yarn Composition and Stitch Length on Interlock Fabrics

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ABSTRACT

The comparative study of the influence of stitch length and fabric structure on the pilling, crease recovery and drape properties of 100% cotton, 50/50 and 67/33% polyester/cotton fabrics in interlock and single pique structures were studied. It was found that drape and fabric pilling increased with increase in stitch length and polyester content. The single pique fabric shows an improved performance for pilling, crease recovery and drape compared with interlock fabric.

Keywords: Stitch, interlock, pique, crease, cotton, polyester, drape

1.0 INTRODUCTION

The frequent changes in fashion and requirements of the modern way of life, both at home at work have presented the textile industry with the task of developing fabrics with better and improved washing performance characteristics such as ease of laundering, improved washing shrinkage, better pilling and other aesthetic properties. Expecting one type of fiber to provide all these qualities would be asking too much.

The introduction of synthetic fibers opened a new field and made available properties not found in natural fibers[1]. The most important of these properties were high levels of crease recovery, strength and abrasion resistance as well as easy wash and dry procedures. Like the natural fibers, the synthetic fibers could not provide all the desirable textile properties. In fact they brought along with them their own problems such as harsh handle, static build-up, hydrophobic properties and discomfort in wear[2]. In order to obtain the require fabric performance the next stage was the development of blend fabrics where fibers were blended together in an attempt to capture the best properties of both fibers and to reduce their worst features. Many blends were attempted, out of the desired properties and they soon began to find increasing market acceptance.

For over eighteen years, the weaving sector of the textile industry has dominated the production of cotton / polyester blend fabrics, particularly in shirting materials on which some work has already been carried out. Perhaps, given a similar attention, some
knitted cotton / polyester fabrics of certain composition, structures and tightness factors could be developed to compete in the areas of men’s shirting, women’s dress materials, T-shirts and sportswear [3][4].

This research is therefore an attempt to study the interaction of yarn composition, fabric structure and tightness factor on knitted fabric properties such as pilling, crease recovery, drape, elastic recovery and washing relaxation shrinkage.

2.0 EXPERIMENTAL

2.1 MACHINE AND KNITTING DETAILS

Machine type - Mettor Bromley 3/RL/3
Gauge - 20 x 20 npi
Gating - interlock
Total no. of needles - 1008 x 1008
Dial gap - 1.5mm
Timing - 10 needle delay
Diameter - 16''
Speed - 41 rpm
Positive feed - trip tape
Knitting tension - 0.015 g/dtex
Number of feeders - 12

2.2 TESTING OF YARNS

2.2.1 Composition

The analyses of the blends compositions were carried out by immersing a known weight of the dry fiber blend and stirring in 75% sulphuric acid for 20 minutes at room temperature, to dissolve out the cotton component. The polyester residue was then rinsed, bone dried, weighed and its proportion worked out.

2.2.2 Linear Density

The linear densities of the yarns were determined by reeling off a 100 meter hank of each yarn type on an automatic wrap reel. The hanks were dried and then weighed. Their appropriate regains were added and the weights in grams multiplied by 10 to obtain the linear densities in tex. Three samples taken from three different cones of each yarn type were tested and the mean of the results taken.

2.2.3 Twist test

Yarn twist analysis was based on 25 tests per yarn type using a 25cm (10”) length of yarn and the twist-untwist method. The mean of the 25 tests for each yarn type was taken.

2.3 TESTS FOR FABRICS

2.3.1 Relaxation and conditioning

The knitted fabrics were laid flat for several days on the benches of the test laboratory of RH 65 ± 2% at 20 ± 20°C to attain a dry – relaxed state before being subjecting to the various tests. This precautionary measure had to be taken because the state of relaxation of a fabric affects its properties.

2.3.2 Pilling

The pilling test for each fabric was carried out in ICI Pill Box. Four 5”x 5” samples of each stitch length (2 in course direction, 2 in wale direction) were sewn and fitted round four rubber tubes. The cut ends were sealed with sellotape to prevent them from fraying and specimens pilled in the box which rotates at 60 rev/min for 5 hours.

2.3.3 Crease Recovery

Twelve rectangular specimen measuring 2 x 4 cm ( six specimens with their short sides parallel to the wales and six with their short sides parallel to the course) were tested for each fabric on the Shirley crease recovery apparatus. The rectangular specimen was folded into halves and maintained in that state for three minutes under a load of 800 g/cm and between glass plates. The load was then removed and the sample transferred to the instrument with forceps. The grip was then rotated (keeping the free arm of the specimen hanging vertically) for three minutes and the crease angle read off.

2.3.4 Drape

Two test specimens were cut out for each fabric using template B (30cm diameter) and the test carried out on the CUSICK DRAPE TESTER. Each test consists of draping the specimen with its face uppermost followed by alternative draping with its underside
uppermost. This was repeated three times giving a total of six measurements on each specimen. The drawn shadow outline on the paper ring was cut out with scissors and the inner part of the ring weighed to the nearest 0.01g. The drape coefficient for each fabric was then calculated as follows:

$$\text{Drape coefficient} = \frac{M_2}{M_1} \times 100\%$$

Where \(M_1\) is the total mass of the paper ring and \(M_2\) is the mass of the shaded area of the paper ring.

3.0 RESULTS

3.1 FABRIC CODE NUMBERS

<table>
<thead>
<tr>
<th>Average Stitch Length (cm)</th>
<th>0.339</th>
<th>0.361</th>
<th>0.384</th>
<th>0.406</th>
</tr>
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<tbody>
<tr>
<td>Interlock A_1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A_2</td>
<td>2.0</td>
<td>58</td>
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</tr>
<tr>
<td>A_3</td>
<td>2.0</td>
<td>64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A_4</td>
<td>2.5</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single pique B_1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B_2</td>
<td>2.5</td>
<td>53</td>
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</tr>
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<td>B_3</td>
<td>3.0</td>
<td>66</td>
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<tr>
<td>B_4</td>
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TABLE A. Yarn details

<table>
<thead>
<tr>
<th>Nominal composition</th>
<th>100 % Cotton</th>
<th>50/50 % polyester/cotton</th>
<th>67/33 % polyester/cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual composition</td>
<td>-</td>
<td>55/45 %</td>
<td>67/33</td>
</tr>
<tr>
<td>Nominal linear density</td>
<td>174 dtex (1/34 cc)</td>
<td>164 dtex (1/36 cc)</td>
<td>164 dtex (1/36 cc)</td>
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<tr>
<td>Actual linear density</td>
<td>176 dtex</td>
<td>163 dtex</td>
<td>164 dtex</td>
</tr>
<tr>
<td>Actual twist (tpcm)</td>
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<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Actual twist factor</td>
<td>36</td>
<td>41</td>
<td>41</td>
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TABLE 1. Effect of Yarn Composition, Stitch Length and Fabric Structure on Pilling

<table>
<thead>
<tr>
<th>Structure</th>
<th>Yarn Type</th>
<th>Stitch Length Code Number</th>
<th>Pill Rating</th>
<th>Approximate Polyester content of Pill (%)</th>
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<td>-</td>
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<td></td>
<td></td>
<td>A_2</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>A_3</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A_4</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>50/50 % polyester / Cotton</td>
<td>A_1</td>
<td>2.0</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A_2</td>
<td>2.0</td>
<td>64</td>
</tr>
<tr>
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<td>A_3</td>
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<tr>
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<td></td>
<td>A_4</td>
<td>2.5</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>67/33 % polyester / Cotton</td>
<td>A_1</td>
<td>2.5</td>
<td>66</td>
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<tr>
<td></td>
<td></td>
<td>A_2</td>
<td>3.0</td>
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<td>3.0</td>
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<td>SINGLE PIQUE</td>
<td>100% Cotton</td>
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<td>1.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B_2</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B_3</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B_4</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>50/50 % polyester / Cotton</td>
<td>B_1</td>
<td>1.5</td>
<td>55</td>
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<tr>
<td></td>
<td></td>
<td>B_2</td>
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<td>B_3</td>
<td>1.5</td>
<td>57</td>
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<td></td>
<td>B_4</td>
<td>2.0</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>67/33 % polyester / Cotton</td>
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<td>2.0</td>
<td>50</td>
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<tr>
<td></td>
<td></td>
<td>B_2</td>
<td>2.5</td>
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<td>B_4</td>
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</table>

TABLE 2. Influence of Yarn Composition and Stitch Length on Crease Recovery
### TABLE 3. Relationship between Yarn Composition, Stitch Length, Structure and Drape

<table>
<thead>
<tr>
<th>Structure</th>
<th>Yarn Type</th>
<th>Stitch Length Code Number</th>
<th>Angular Recovery (degree)</th>
<th>Angular Recovery (degree)</th>
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<tr>
<td></td>
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<td>Walewise</td>
<td>Coursewise</td>
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<tr>
<td>INTERLOCK</td>
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<td>41</td>
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<tr>
<td></td>
<td></td>
<td>A2</td>
<td>99</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A3</td>
<td>83</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A4</td>
<td>75</td>
<td>40</td>
</tr>
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<td></td>
<td>50/50% polyester / Cotton</td>
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<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A2</td>
<td>69</td>
<td>36</td>
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<td></td>
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<td>67/33% polyester / Cotton</td>
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<td>A4</td>
<td>63</td>
<td>36</td>
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<tr>
<td>SINGLE PIQUE</td>
<td>100% Cotton</td>
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<td>112</td>
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<td>B2</td>
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<td>B4</td>
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<td>90</td>
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<tr>
<td></td>
<td>50/50% polyester / Cotton</td>
<td>B1</td>
<td>113</td>
<td>70</td>
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<tr>
<td></td>
<td></td>
<td>B2</td>
<td>105</td>
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<td></td>
<td>B4</td>
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<td>61</td>
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<td></td>
<td>67/33% polyester / Cotton</td>
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<tr>
<td></td>
<td></td>
<td>B4</td>
<td>90</td>
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</table>

### Graph 1. The Dependence of Pilling on Stitch length
**INTERLOCK**

![Graph showing the relationship between pill rating and stitch length for different blend percentages of C/P](image1)

**Figure 1**

**SINGLE PIQUE**

![Graph showing the relationship between pill rating and stitch length for different blend percentages of C/P](image2)

**Figure 2**
Graph 2. The Effect of Yarn Composition and Stitch Length on Crease Recovery

**INTERLOCK**

**Walewise**

![Graph showing the effect of yarn composition and stitch length on crease recovery for INTERLOCK Walewise.](image)

**Coursewise**

![Graph showing the effect of yarn composition and stitch length on crease recovery for INTERLOCK Coursewise.](image)

**SINGLE PIQUE**

**Walewise (face/face)**

![Graph showing the effect of yarn composition and stitch length on crease recovery for SINGLE PIQUE Walewise (face/face).](image)
Figure 4

Coursewise (face/face)

Angular recovery

Stitch Length (cm)

100% C
50/50 % P/C
67/33% P/C

Figure 5

walewise (back/back)

Angular recovery

Stitch Length

100% C
50/50 % P/C
67/33% P/C
Graph 3 The Relationship between Yarn Composition, Stitch Length and Drape

INTERLOCK

![Graph of the relationship between yarn composition, stitch length, and drape for interlock fabrics.]

Figure 6

SINGLE PIQUE

![Graph of the relationship between yarn composition, stitch length, and drape for single pique fabrics.]

Figure 7

4.0 DISCUSSION

The 100% cotton fabrics in both interlock and single pique produced the least pills, their worst grade being 1.5 which is still an acceptable level of pilling. This level of result persisted in the single pique fabrics up to stitch length B3 of 50/50% polyester/cotton (Table 1). The introduction of polyester into the structure produced a dramatic increase in pilling particularly with interlock due to the high tensile strength of the synthetic fibers which enables them to anchor the pills to the main body of the fabric \[8\]. Microscopic examinations of the pills produced by the blended fabrics revealed that majority of the fibers in the pills were polyester. However, cotton fibers due to their convolutions have relatively higher coefficient of friction and are much more difficult to pull out of their yarns than polyester fibers whose higher flexural rigidity and lower coefficient of friction make them easier to pull out of their yarns onto fabric surface especially when in a blend with cotton. The higher the percentage of polyester in the blend, the
greater the imbalance and the higher the
tendency of the fabric to form pills \cite{6}. 

Furthermore, cellulosic materials crease 
badly and blends containing cellulosic fibers 
should be expected to crease to some extent. 
It has been claimed that synthetic materials 
resist creasing which implies that they resist 
deformation and are therefore rigid but a 
product which has the ability to recover from 
deformation as well as possessing some 
degree of crease resistance is what is required 
\cite{7,10}. The fiber arrangement in the yarn and 
knitted structure all affect the crease 
resistance and recovery power of a fabric 
since the yarns used were spun on the same 
system and have roughly the same twist 
faster. The crease recovery results obtained 
here were due to mainly yarn type 
(composition), fabric tightness factor and 
structure.

More so, the drape coefficient is dependent 
on its shear stiffness as well as the blending 
stiffness and weight (mass per unit area) of 
the fabric \cite{9}. 100% cotton produced the least 
drape coefficient (DC) in both structures. The 
highest D.C results were produced by 50/50 
polyester/cotton. 67/33 % polyester/cotton 
results fell in between. This order is in 
accordance with the linear densities of the 
yarns and weight per unit area of the fabric 
(i.e. from Table A, 100% cotton – 176 dtex, 
50/50% polyester/cotton – 163 dtex, 67/33% 
polyester/cotton – 164dtex). Based on stitch 
length, the results clearly show that an 
increase in stitch length produces a decrease 
in D.C. In other words, loosely knitted 
structure will tend to drape better than tightly 
knitted ones \cite{11}. This follows since a loose 
fabric is more susceptible to deformation 
than a tight one. The relative position of 
graph nos. 3 (fig. 10 and 11) in relation to the 
D.C axis, indicate that interlock fabrics 
draped better (lower D.C) than single pique. 
This was obviously due to the tuck stitches in 
single pique which tends to stiffen the fabric 
and therefore increase the forces of 
deformation needed to drape it \cite{13}.

5.0 CONCLUSIONS

Pilling

1. Pilling increased as polyester content of 
the blends increased and the majority of 
the fibers in the pills were polyester.
2. As stitch length was increased pilling 
increased rapidly initially and less 
rapidly later.
3. Interlock in general pilled more than 
single pique of similar tightness factor in 
the loose end of the tightness range.

Crease Recovery

1. The contribution to creasing of the 
polyester component of 50/50 and 67/33 
polyester / cotton blends may not be as 
great as it has been commercially 
claimed.
2. Tightly knitted constructions tend to 
recover better from wrinkles than loose 
ones of the same type.
3. Tucking tends to improve fabric crease 
recovery.
4. Knitted structures tend to recover better 
when creased along wale than course.

Drape

1. Interlock and single pique fabrics drape 
better as their polyester content 
increases.
2. Loose interlock and single pique fabrics 
drape better than tight ones.
3. Single pique fabrics are stiffer than 
interlock of the same tightness factor.

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