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INVESTIGATION OF BASIC FABRIC PARAMETERS INFLUENCING FORMABILITY BEHAVIOR OF COTTON SHIRTING FABRICS

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Abstract: Formability of the fabric is one of the cardinal parameter that determines the Total Appearance Value (TAV) of the fabrics; it is related to maximum compression sustainable by the fabric before the onset of buckling. Formability behavior of a fabric structures is determined by the low stress mechanical properties, viz. bending rigidity and thickness. Poor formability leads to develop compression force that creates puckering at seams and affects the drape and shape retention characteristics of the finished garments. Extent of puckering is mostly determined by the fabric designed specifications and its parameters. In woven fabric structure, apart from fibre properties and fabric specifications, its parameters such as, bending rigidity, GSM, thickness of the fabric which in turn affects the fabric formability. The present paper discusses the effect of various fabric parameters, viz. GSM, bending rigidity, thickness and weave density on formability characteristics of cotton woven shirting fabrics. 100% cotton woven fabrics of varying yarn linear densities and number of plies were produced. The formability characteristics were determined using KESF evaluation system. It was interesting to note that the formability is found to be higher for shirting fabrics produced from plied yarns than that of single yarns of same linear density.

Keywords: Formability, Total Appearance Value (TAV), Bending rigidity, In-plane compression resistance.

1. Introduction

Formability of the fabric is one of the important attribute that contributes towards the appearance value of apparel garment. Lindberg defined formability as its ability to cover surfaces of various curvatures that no wrinkles or folds are formed. It is usually defined as a product of bending rigidity and longitudinal compressibility sustained by fabric before it buckles [1, 2, 3, & 4].

$$Fcr = \frac{4\pi^2 \times b}{l^2} \qquad (1)$$

Where F_{CR} = Critical Buckling Load, b = Bending Stiffness, l = Gauge Length,

Buckling occurs when $F > F_{CR}$

Bertil Olofsson and Noboru Oguchi worked on fabric buckling of woven fabric and revealed that the bending behavior of woven fabric exhibits an initial non-linearity produced by frictional restraint [5]. John Skelton's work on the bending behavior of the fabric exhibit that the suitability of a textile structure for a particular end-use is often determined by its bending behavior [6]. T. G. Clapp and H. Peng used theory of Timoshenko's elastica and studied the effect of the fabric weight on buckling behavior of the woven fabrics [7]. Several other models have been proposed to describe the basic fabric bending behavior includes, Peirce's model of constant bending rigidity [8], Grasberg's frictional couple theory [9], and the theory of bilinear moment curvature relationship [10,11]. These models allow only analytical solutions for some basic fabric buckling problems neglecting effect of fabric weight.

Low stress mechanical properties of fabrics are measured using two most important methods Kawabata evaluation system (KES-FB) and Fabric assurance by simple testing (FAST) and determines fabric formability. Kawabata correlates mechanical properties of fabric viz. formability, drape and elastic behavior with the appearance of tailored garments and determined Total appearance value of men's suit fabric.

Consumer's choice for cotton shirting is mainly attributed to its unique comfort and appearance value. Low stress mechanical properties of cotton shirting fabrics determine its comfort and appearance.

2. Materials and Methods

Experimental specimens of 100% plain woven cotton shirting fabrics were used for study. Sample fabrics were composed of different yarn linear densities, viz. 50/1, 60/1, 70/1, 100/2 & 120/2. Kawabata evaluation system KES-FB was used for determination of fabric formability. Low stress mechanical properties of fabric samples were measured and their formability F_{KES} was calculated using following equation and the tested data was analyzed using one-way ANOVA with replication method.

$$F_{KES} = \frac{EMT}{490\ LT}\ B.\frac{G}{2HG5} \qquad (2)$$

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B - Bending Rigidity, LT- Linearity of Tensile Curve, EMT-Extension at 490 N/m load, G-Shear Modulus , 2HG5- Shear Hysteresis at an angle of 5^o in N/m.

Table: 1 Specification of Experimental 100% Cotton Fabric Samples

Sr. No.	Warp Count (Ne)	Weft Count (Ne)	E.P.I.	P.P.I.	Warp T.P.I.	Weft T.P.I.	G.S.M (gm/m^2)	Thickness (mm)	Bending Length Warp (cm)	Bending Length Weft (cm)
1	50/1	50/1	144	77	28.99	27.64	117	0.214	3.89	3.025
2	60/1	60/1	180	88	34.07	32.75	119	0.179	3.87	3.065
3	70/1	70/1	190	90	34.4	37.06	100	0.177	3.635	2.795
4	100/2	100/2	148	77	29.29	31.23	123	0.208	4.005	3.365
5	120/2	120/2	188	88	36.34	35.51	120.5	0.192	3.775	3.025

3. Result and Discussion

3.1 Effect of GSM on Formability

The GSM can be affected by two factors.

1. Diameter of yarn.
2. Number of threads per unit space.

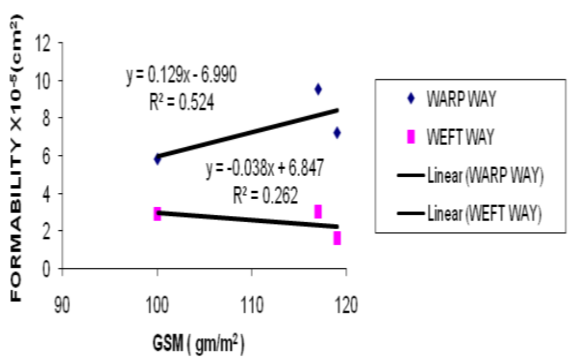

Figure1. *Effect of GSM on Formability from warp way and weft way*

As if consider the diameter of the yarn, the coarser yarn having larger diameter than finer yarn. So, due to the large diameter the area of interlacing point of warp and weft thread is more. The large interlacing point used to resist the compressive force, which prevents the fabric from buckling. Whereas, in finer yarn the area of interlacing point is less which leads to less formability.

Now if we see, in case of high GSM fabric generally we use coarser threads, hence the numbers of threads per unit space are less. When we apply force, the distribution of force per unit thread will be more hence the formability is more in high GSM fabrics. On the other hand in low GSM fabrics we use finer threads and therefore the formability is less. From figure 1, in the warp direction having 117 GSM fabric the formability is $9.542X10^{-5}$ and with 100 GSM fabric the formability is $5.839\ X10^{-5}$ and in case of weft direction in 117 GSM fabric the formability is $3.033\ X10^{-5}$ & in 100 fabric formability is $2.905\ X10^{-5}$. This indicates that as the GSM increases formability also increases.

3.2 Effect of Thickness on Formability

As the thickness increases the cross sectional area of the fabric will get increases. If cross sectional area increases then the force required to buckling the fabric will more.

From figure 2, the fabric of thickness 0.214, 0.179 & 0.177 has warp way & weft way formability as $9.542\ X10^{-5}$ & $3.033\ X10^{-5}$, $7.234\ X10^{-5}$ & $1.609\ X10^{-5}$ and $5.839\ X10^{-5}$ & $2.905\ X10^{-5}$ respectively. As per one way ANOVA with replication, thickness value of cotton shirting fabric of single yarn is significantly differing.

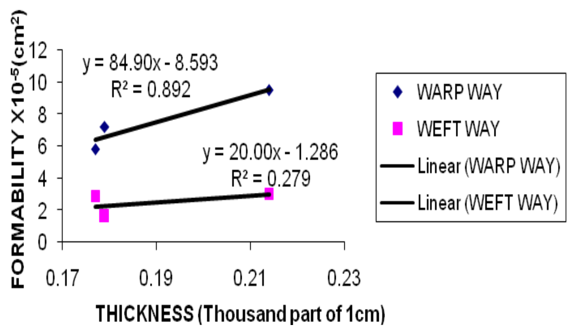

Figure2. *Effect of fabric thickness on Formability with warp way and weft way*

3.3 Effect of Bending Length on Formability

In fabric of single yarn, the fiber to fiber cohesive force within yarn is less; due to this the fabric buckles easily, so in case of a single yarn fabric the formability decreases. On the other hand in case of plied yarn the cohesive force is more due to repeated twisting of single yarn so the yarn structure becomes more compact & more force required to buckle the fabric so in this case the formability increases.

The other factor affecting bending length is stiffness of the fabric. The stiffness of the fabric depends on the stiffness of the yarn and ultimately on the twist. The single yarn is twisted once while plied yarn is twisted number of times that's why the stiffness of single yarn is less than the plied yarn. Stiffness is directly proportional to bending length. Less stiff fabric gives less bending length.

From figure 3, 50/1 fabric has bending length in warp way 3.89cm & in weft way 3.025cm and formability in warp way $9.542X10^{-5}$ & in weft way $3.033X10^{-5}$ respectively whereas in 100/2 fabric has bending length in warp way 4.005cm & in weft way 3.365cm and formability in warp way $9.849X10^{-5}$ & in weft way $4.57X10^{-5}$ respectively**.** This shows that as the bending length is directly proportional the formability. Which indicates that, as the bending length increases the formability increases.

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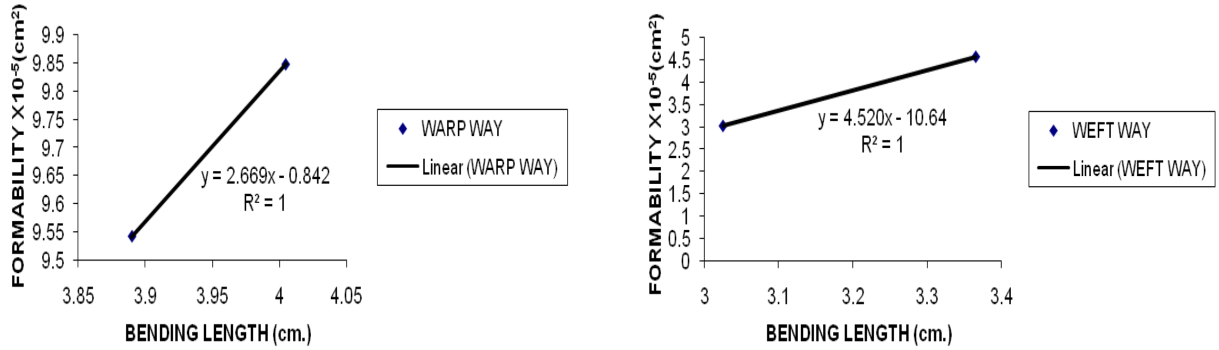

Figure3. *Effect of Bending Length on Formability with warp way and weft way*

As per one way ANOVA with replication, bending length value of cotton shirting fabric in warp way is not significantly differing, but in weft way is significantly differing.

3.4 Effect of Fabric Weave Density on Formability

The properties of the fabric depend on the density of the fabric in a warp and weft direction, which is conditioned with linear density of the yarn. Usually in fabrics with higher density we use finer yarn. The density as well as interacting points are changing according to the weave of the fabric. The higher density at the same weave of the fabric means more interfacing points. Further, a greater number of the interfacing points of fabric mean that fabric is more rigid because the yarns are close together. On the other hand, the fabrics with fewer interfacing points have some freedom of movement; therefore these fabrics are less rigid and have higher degree of formability.

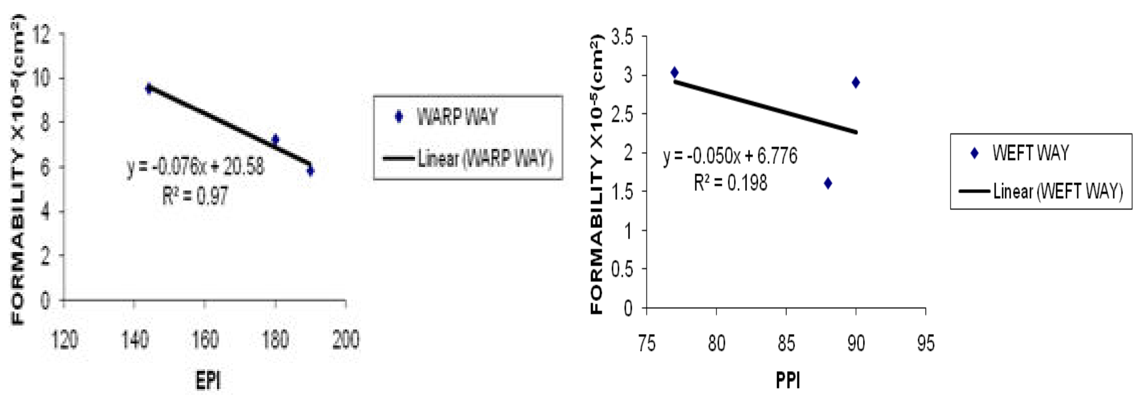

Figure 5.*Effect of Fabric Weave Density on Formability with warp way and weft way (for single yarn)*

From figure 4, Fabric of 144 EPI & 77 PPI has formability warp way & weft way 9.542X10^{-5} & 3.033 X10^{-5} respectively. Fabric of 180 EPI & 88 PPI has formability warp way & weft way 7.234X10^{-5} & 1.609 X10^{-5} respectively. Fabric of 190 EPI & 90 PPI has formability warp way & weft way 5.83X10^{-5} & 2.905 X10^{-5} respectively. It shows that as threads per inch decreases, formability decreases.

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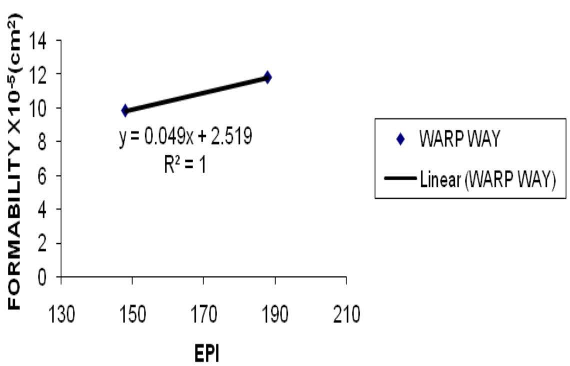
While in case of plied yarn, as the twist increases yarn becomes stiffer which requires more force to buckle. Hence formability is more. Now, because of less twist crossover points are less in coarser plied yarn. As the count is less and we already mentioned that formability of coarser plied yarn is less.
In coarser plied, as twist is less the surface characteristic is rough than the finer plied yarn. As the number of threads per inch in fabric is less the interlacing points of warp and weft is less. But due to rough surface characteristic, warp and weft threads will get resist and will not have sufficient freedom for movement, because of that the force applied is directly used for buckling of fabric. Hence no force is required for initial compactness of yarn in fabric, so formability is less. Whereas in finer fabric the yarn is smother, denser and have more crossover points gives more formability.



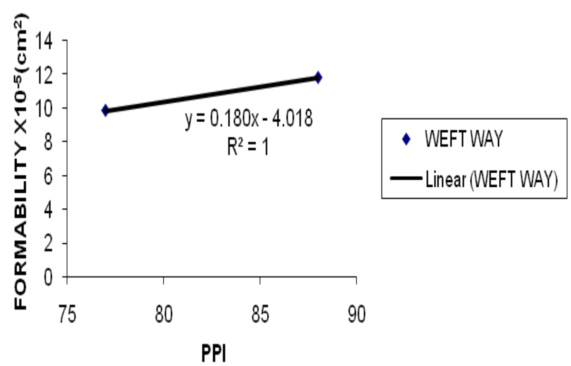


Figure 4.*Effect of Fabric Weave Density on Formability with warp way and weft way (for plied yarn)*

4. Conclusions

Based on the study of the formability behavior of different parameters of cotton shirting fabric of single yarn and plied yarn of different specification using Kawabata Evaluation System (KES-FB), the following may be concluded:

- Effect of GSM on Cotton shirting fabric composed of singe yarn has positive relation with formability it means as GSM of fabric increases formability also increase.
- For the Cotton shirting fabric composed of single yarn thickness has direct relation with formability, with increase in thickness the formability also increases.
- With increase in bending length for Cotton shirting fabric composed of plied yarn formability increases. Similar trend is there for warp & weft direction.
- As the weave density of Cotton shirting fabric composed of single yarn increases formability decreases, where this effect is reversed in case of Cotton shirting fabric composed of plied yarn i.e. with increase in weave density formability also increase.

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