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Low-stress mechanical properties of weft knitted fabrics produced from regular and compact cotton spun yarns

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The effect of compact yarn on downstream process such as knitting has been studied. Weft knitted fabrics such as single jersey, single lacoste, double lacoste, honeycomb, popcorn, rib and interlock fabrics have been produced from regular and compact cotton spun yarns. These fabrics after dyeing and starfish relaxation treatment are investigated by Kawabata evaluation system for their low-stress mechanical properties. The results show that in a few cases the differences between regular fabric properties and the compact fabric properties are quite significant, while marginal in other cases. However, the surface roughness values show some interesting features.

Keywords: Compact yarns, Cotton, Honeycomb fabric, Interlock fabric, Lacoste fabric, Low-stress mechanical properties, Single jersey fabric, Weft knitted fabrics

1 Introduction

The quality of the textile products is directly dependent on the yarn quality and the spinning method employed. Ring spinning is the most widely used method of yarn production all over the world. The produced ring yarns are said to be perfect in terms of strength and quality, but a closer look under microscope reveals a different picture. The edge fibres are not integrated properly into the yarn structure, which results in loss of fibre strength in the resultant yarns.

Compact spinning technology introduced recently produces yarns with over all superior quality when compared with the conventional ring-spun yarns. Several studies support this conclusion[1-8]. Globally, there is a spurt in the demand for knitwear. This growth can be attributed to the basic properties of the knit fabrics, like its ability to stretch and adapt to the shape of the wearer.

Several researchers[9-16] have reported the effect of improved compact yarn quality on downstream processes such as winding, doubling, weaving and knitting. The quality of the knitted fabric produced from compact yarn, though been under much discussed, has not been investigated and reported so far. The present study is, therefore, an effort to fill up that gaps occurred in the technological end of knowledge. In this study, effect of compact yarn on low-stress properties of weft knitted fabrics has been studied.

2 Materials and Methods

2.1 Preparation of Fabric Sample

In this study, 30 Ne regular ring-spun and compact yarns were used to produce the knitted fabric samples. The 30 Ne yarns of compact and regular were tested. The characteristics of the yarns are shown in Table 1. Single jersey, single lacoste, double lacoste, honeycomb & popcorn knits and double jersey fabrics such as rib & interlock knits were produced. The grey fabrics were dyed, then subjected to relaxation treatment as per STARFISH recommendation. The details of the knitted fabrics are given in Table 2.

2.2 Testing of Knitted Fabrics Samples

The seven knitted fabrics samples were then evaluated with the help of Kawabata evaluation system (KES). The mean KES-F values of the fabrics for the evaluated 17 parameters along with their statistical evaluation using paired t-test are given in Table 3. Table 4 gives the ANOVA significance value for the 17 parameters.

The low-stress mechanical properties of fabrics in terms bursting strength and the air permeability were also tested. The air permeability of the knit fabrics

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was investigated using KES– F8–AP-1 air permeability tester. The mean of five readings was calculated.

3 Results and Discussion

3.1 Tensile Properties

The linearity of load extension (LT) of most of the compact yarn knitted fabrics shows higher values when compared with the fabric LT values of the regular yarn fabrics. The higher the value the more elastic is the fabric sample. The ANOVA analysis reveals that there is no combined significant influence in 2-way ANOVA due to difference in of yarns and fabric structures. Individually both variables influence the LT values significantly.

The tensile energy (WT) values are found to be generally higher in most of the regular yarn knitted jersey, single lacoste, double lacoste, rib and interlock fabric samples. While in the popcorn and honeycomb fabric structures, mostly the compact yarn knits show better values are compared to the conventional yarn knitted fabrics. The higher the WT values the better is the fabric elongation. The ANOVA analysis of the same shows that there is no significant relationship between the yarns and the fabric structures.

The tensile resilience (RT) study shows that in most of the knitted fabrics, except for the honeycomb and interlock knits, the regular yarns show higher readings. The higher value indicates the ability of the knitted fabric to recover after tensile stress. The ANOVA comparison indicates significant difference in RT values of the different fabric structures and the yarn types.

With regard to EMT which quantifies the elasticity of the fabric material, most of the regular yarn knits show higher values, except for compact honeycomb knit fabric in which the compact yarns fared better. The ANOVA analysis shows no combined significance, while individually the fabric structures significantly influence the EMT values.

3.2 Bending Properties

Except for the popcorn knit, in almost all the other fabric samples the compact yarn knitted fabrics show higher values of bending rigidity (B). Almost similar trend is observed for the 2HB values also. In this case, the honeycomb and popcorn knits show higher values for fabrics made from regular yarns; higher value indicates the inelasticity of the fabric.

The ANOVA analysis indicates that both B and 2HB parameters are not significantly affected by yarn type. However, the fabric structures influence both the values.

3.3 Shearing Properties

In the case of G (shear stiffness), 2HG (hysteresis of shear at 0.5°) and the 2HG5 (hysteresis of shear at

Table 1 — Characteristics of 30 Ne count yarn use

Property	Regular yarn	Compact yarn	Significance T-test
Yarn count, Ne	30	30	Not significant
Tenacity, cN/tex	14.881	16.332	Significant
Breaking elongation, %	5.166	6.010	Significant
Hairiness index H	6.5	6	Significant
U %	9.28	8.838	Significant
CV % of U %	11.67	11.12	Significant
Thin places (50%)	0	0	Not significant
Thick places (50%)	8.6	8	Significant
Neps (200%)	17.6	16.8	Significant
Yarn diameter, Mm	212	0.206	Significant

Table 2 — Fabric details

Fabric (Code)	Loop length, cm	Wales, cm	Courses, cm	Stitch density, cm^2
Single jersey regular yarn knit fabric - (JR)	0.26	18	22	396
Single jersey compact yarn knit fabric – (JC)	0.26	17	22	374
Single lacoste regular yarn knit fabric - (SR)	0.26	12	32	384
Single lacoste compact yarn knit fabric – (SC)	0.26	12	23	276
Double lacoste regular yarn knit fabric – (DR)	0.26	11	42	462
Double lacoste compact yarn knit fabric – (DC)	0.26	11	39	429
Honeycomb regular yarn knit fabric – (HR)	0.26	12	33	396
Honeycomb compact yarn knit fabric – (HC)	0.26	12	33	396
Popcorn regular yarn knit fabric – (PR)	0.26	14	30	420
Popcorn compact yarn knit fabric – (PC)	0.26	14	30	420
Rib regular yarn knit fabric – (RR)	0.26	11	17	187
Rib compact yarn knit fabric – (RC)	0.26	12	18	216
Interlock regular yarn knit fabric – (IR)	0.296	15	37	555
Interlock compact yarn knit fabric –(IC)	0.296	15	35	525

Table 3 — Mean kawabata KES-F evaluation values

Code	LT	WT	RT	EMT	B	2HB	G	2HG	2HG5	MIU	MMD	SMD	LC	WC	RC	W	T
JR	0.907	4.24	31.75	18.8	0.0192	0.0234	0.52	1.67	1.77	0.178	0.0117	3.978	0.339	0.392*	42.68	17.283	1.01*
JC	0.958	3.38	33.47	14.15	0.0288	0.0395*	0.71*	2.43*	2.34*	0.201	0.0142	2.983	0.372*	0.342	42.05	18.5*	0.917
SR	0.86	4.31*	28.33	20.08*	0.0308	0.0317	0.63	2.09	2.1	0.219	0.0331	10.847	0.348	0.328	40.97	20.588*	1.123*
SC	0.965*	2.98	22.79	12.48	0.0384	0.0441*	0.72*	2.24	2.27*	0.214	0.0325	10.317	0.343	0.312	41.39	19.87	1.087
DR	0.843	4.24	32.74*	20.2	0.0621	0.0572	0.69	2.25	2.25	0.216	0.0208	12.056	0.343	0.381	38.9	23.375*	1.34*
DC	0.858	3.83	19.35	17.85	0.0401	0.0465	0.67	2.27	2.26	0.24*	0.0227	11.81	0.402*	0.364	42.29	20.85	1.245
HR	0.915*	4.09	31.68	17.88	0.0362	0.0398*	0.54	2.02	2.24	0.214	0.0228	9.737	0.366	0.405*	41.1	21.35*	1.28*
HC	0.879	4.21	28.39	19.17	0.0268	0.0279	0.54	2.06	2.26	0.225	0.0277	10.745	0.353	0.344	42.83	21.21	1.237
PR	0.854	4.21	28.75	19.85	0.0563	0.0749*	0.65*	2.22*	2.23*	0.246	0.0242	8.907	0.494	0.461	43.28	22.936*	1.45*
PC	0.875	4.22	29.48	19.28	0.0464	0.0539	0.49	1.61	1.67	0.246	0.0223	8.454	0.593	0.748*	40.5	20.47	1.393
RR	0.9732	2.49	29.45	10.26	0.0478	0.0545	0.09	0.38	0.39	0.224	0.0145	7.841	0.348	0.399	37.95	24.543*	1.27
RC	0.994	5.52	22.93	23.88	0.0459	0.0779	0.47*	2.09*	2.01*	0.248	0.0306*	11.917*	0.344	0.398	42.79	24.19	1.283*
IR	1.014	4.7	25.81	18.74	0.1215*	0.1297	0.87	2.93	2.97	0.188	0.014	5.598	0.345	0.332	43.29*	32.397*	1.325
IC	0.999	3.79	34.87*	15.76	0.0505	0.0642	0.95	3.04	3.01*	0.219	0.0133	4.897	0.397	0.41*	36.74	32.08	1.385*
Mean	0.879	4.377	28.212	20.446	0.042	0.734	0.522	1.848	1.891	2.259	2.141	8.895	0.395	0.421	41.827	214.036	1.242
S.D.	0.086	1.756	5.706	9.717	0.033	0.898	0.189	0.589	0.566	0.352	1.505	5.893	0.082	0.124	3.326	44.338	0.147

*Significant at 0.05 level.

Table 4 — ANOVA significance value for the 17 parameter

Source	T	W	LC	WC	RC	LT	WT	RT	EMT	B	2HB	G	2HG	2HG5	MIU	MMD	SMD
Yarn type	0.320	0.000	0.000	013	0.005	0.005	0.273	0.000	0.177	0.619	0.519	0.000	0.000	0.000	0.000	0.219	0.230
Fabric structure	0.428	0.000	0.000	0.000	0.000	0.001	0.063	0.000	0.048	0.000	0.000	0.000	00.000	0.000	0.000	0.000	0.000
Yarn type & fabric structure	0.427	0.000	0.001	0.000	0.000	0.109	0.577	0.000	0.825	0.236	0.041	0.000	0.000	0.000	0.185	0.222	0.166

5°) values, the compact yarn knit fabrics mostly show higher values as compared to the conventional yarn knitted fabrics. Only the popcorn knit structure shows the inverse relationship with the regular yarn having higher value. The higher the derived values the stiffer is the fabric handle.

The analysis of the variance clearly shows statistical significance for all the above parameters. The statistical difference was caused by the different yarn types and the fabrics structures.

3.4 Surface Properties

It is observed that most of the compact yarn knitted structures show a slightly higher coefficient of friction (MIU) value. The higher value indicates higher frictional value. ANOVA analysis shows that the yarn type and the structure independently are significant. But they cause no combined effect on the MIU friction values.

The regular yarn knitted fabric structures such as single lacoste, double lacoste, popcorn and interlock knits show higher values of MMD parameter, indicating more friction. However, in jersey, honeycomb and rib fabrics the compact yarn knits show slightly higher values than the regular yarn fabrics. The ANOVA shows that the fabric structure plays some significant role in the MMD values. The yarn types show no significant results individually or in combination.

The geometrical roughness (SMD) of the fabric show a highly mixed trend with no consistent value to infer which fabric is rougher. The ANOVA findings show that the yarn types are not significant, while the fabric structure, to some significant extent, influences the resultant values.

3.5 Compression Properties

Jersey, honeycomb, popcorn and double lacoste knit compact yarn fabrics show higher linearity of compression (LC). In the rib, single lacoste and interlock knits the regular yarn knits show higher values. The higher the value the better is the bending rigidity of the fabric. The ANOVA indicates that the yarn type and fabric structure significantly influence the parameter even though a 2-way combined influence is found absent.

The compressional energy (WC) of the regular yarn knit is found slightly higher than the compact yarns knits in all the fabrics, except for popcorn knit. The higher the value the better is the fabric compression. Both the parameters (yarn type and fabric structure) influence the fabric compressional energy significantly.

The recovery of the fabric (RC) indicates that most of the compact yarn knits have better recovery values than its counterpart except in the case of popcorn and jersey knits. The ANOVA findings show that both the parameters significantly influence in combination and separately the fabric recovery values.

3.6 Fabric Weight

The regular yarn knitted fabrics generally shows a higher weight per square centimeter in most cases, except for the jersey and the double lacoste knits. The ANOVA results show that the weight obtained is largely and significantly influenced by the yarn type and the fabric structures.

3.7 Fabric Thickness

The thickness of the regular yarn knits is found generally greater than that of the compact yarn knits, except for the rib fabric. The statistical analysis of the above results shows that no parameter significantly affect the thickness value.

3.8 Total Hand Value

The total hand value (THV) of the fabrics evaluated by KES-F shows that the interlock, jersey, double lacoste, honeycomb and popcorn knits made from the regular yarn show better hand value. The fabric structures, namely rib and single lacoste made from compact yarns has better and higher hand values. The higher the value, the better is the fabric hand property (Fig. 1).

3.9 Air Permeability

A very interesting trend is observed with regard to the air permeability property (Fig. 2). All the seven compact yarn knits show higher air permeability values than the conventional yarn knits. The higher values indicate that the compact yarn knits are more porous and hence more comfortable.

3.10 Bursting Strength

The bursting strength (Fig. 3) of the compact yarn knits, such as jersey, single lacoste, honeycomb, rib and interlock fabrics, show higher values than their counterparts. The rib and double lacoste regular yarn, fabric structures show higher values, indicating the strength of the fabric.

4 Conclusion

The differences observed in the values of regular and compact yarn knit fabrics do not show any trend in most of the properties, except in the fabric mass and thickness. The compact yarn knit fabrics are found to be generally lighter and thinner than the regular yarn fabrics. The regular yarn knitted fabrics are more elastic, flexible and has better total hand value. The compact yarn knitted fabrics, on the other hand, are found to be more porous, softer, stronger, susceptible to friction, less heavy and less thick. Both the fabrics show almost equal compressibility and resiliency values.

The results clearly show that there is no significant trend observed to prove or conclude that the compact yarn knit fabrics are superior to the regular yarn knit fabrics, even though the compact yarn knits show a number of excellent characteristics.

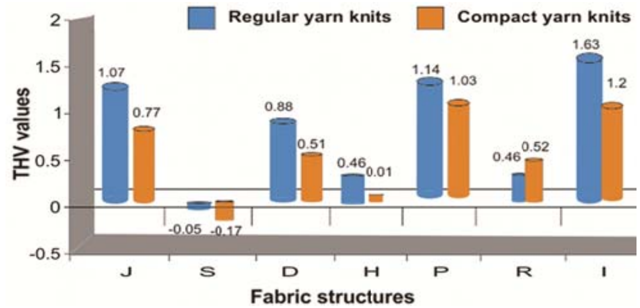

Fig. 1 — Total hand value (THV) of knitted fabrics [J-Single jersey knit, S-Single lacoste knit, D-Double lacoste knit, H-Honeycomb knit & P-Popcorn knit, R-Rib knit, and I-Interlock knit]

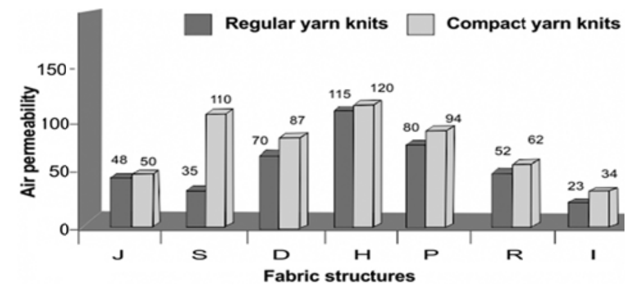

Fig. 2 — Air permeability of knitted fabrics

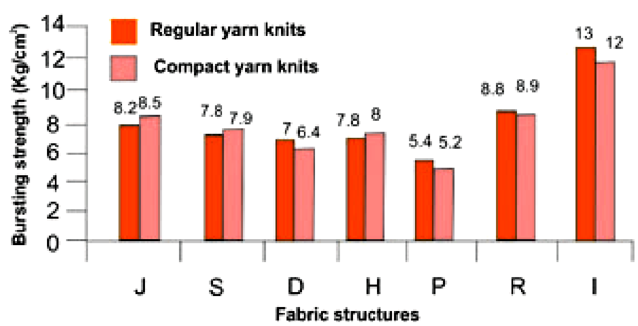

Fig. 3 — Bursting strength of knitted fabrics

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