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INFLUENCE OF YARN TYPES ON SINGLE-JERSEY KNITTED FABRIC PERFORMANCE

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Abstract: *Poliester and cotton fibres are the most utilized fibres by the textile and clothing sector, where ring spinning and open-end rotor spinning systems are the most widely used technologies to manufacture yarn by the sector. Also, with the increment in sustainable awareness in the sector, new approaches like use of recycled raw materials have been improved. The yarns converted from recycled fibres have been started to be intensively used in apparel and household textiles. However, recycled yarns are considered as mechanically weak. In the present study, it is aimed to how yarn type and fabric tightness affect the pilling tendency, mechanical characteristic, and vertical liquid transfer behaviour of knitted fabrics. For this purpose, six different knitted fabrics with different loop lengths were manufactured in single jersey construction using different yarn types. The selected yarns are 100% poliester (PES) ring carded, 100% cotton (Co) ring carded, and recycled polyester/cotton open-end rotor yarns in 35/65 proportion. In this direction, pilling resistance, bursting strength, and wicking tests were performed. It was observed that the knitted fabrics using PES ring carded yarns have medium to light pilling tendency, while the knitted fabrics using PES/Co blended open-end yarns show serious to medium pilling tendency. In addition, loose fabrics with higher loop length have no pilling tendency. Tight fabrics have the highest strength, whereas the fabrics from recycled open-end rotor yarns have poor strength. In both wale and course direction, the fabrics knitted using PES ring carded yarns displayed better wicking behaviour.*

Key words: *Ring carded yarns, open-end rotor yarns, recycled yarns, bursting strength, pilling resistance, wicking*

1. INTRODUCTION

Today, poliester, cotton, and poliester/cotton blended fibres are those that the textile and clothing sector relies on. It is reported that textile fibre production exceeds 113 million metric tons by 2021, 88.2 million of which is accounted for chemical fibres including synthetic fibres and cellulose-based fibres, where 25.4 million metric tons of which were reached by natural fibres such as cotton and wool [1]. In total fibre manufacturing volume, the ratio of recycled fibre was reported as ~7.6% recycled bottles, ~0.5% recycled pre- or post-consumer textiles and other non-bottle feedstock. In the case of cotton and poliester fibres, the recycled fibre ratio was reported~ 0.96% and ~15% respectively [2]. These fibres are mostly handled by ring spinning and open-end rotor spinning systems, which are the most commonly accepted yarn spinning systems. Besides, open-end rotor system has been widely used to convert recycled fibres to yarn with the increment of awareness of sustainability concept in the sector. The systems have unique economical and feasible strengths. High production rate recycled raw material usage, commercial production of coarse yarns, and low-end breaks are the advantages of rotor spinning systems. Flexibility in yarn count and low maintenance cost advantage are the strengths of ring spinning systems [3-8]. Nonetheless, ring and open-end rotor spinning systems are the most utilized systems, the advancements in both spinning systems keep carrying on. The recent developments in ring systems concentrate on high efficiency, high-speed winding operation efficiency, removing yarn residual torque, reduced ring-traveller friction, low twist systems, controlling spinning triangle, and modifications for reduced hairiness [9-12]. On the other hand, reduction in capital cost, reduced rotor diameter, low power consumption, magnetic bearing, quality monitoring system, and cooling systems are the concepts that are focused on advancements in rotor system [9].

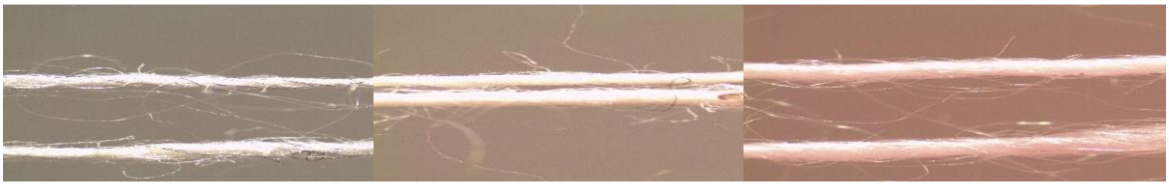
Besides the economical distinctions of spinning systems, characteristics of ring spun yarn and rotor spun yarns differ as well. Ring spun yarns are well known for high strength and denser structure, where rotor spun yarns stand out including less irregularities, better evenness, low count variations, and less hairiness [4, 8, 10, 13]. It is reported that fibre and yarn type impact the physical, mechanical, thermal, and comfort behaviour of the fabrics [14]. Hailemariam and Muhammed (2022) investigated and compared tensile and tear strengths, abrasion resistance, pilling resistance, and air permeability properties of 3/1 twill fabrics manufactured from ring spun yarns or rotor spun yarns [3]. Akhtar et al. (2020) investigated tensile and tear characteristics and pilling behaviour of woven fabrics manufactured from ring spun, ring compact spun, rotor spun, and air-vortex spun poliester and cotton yarns [8]. Gedilu et al. (2022) analysed the physical and comfort properties of single jersey, rib, and interlock knitted fabrics manufactured from ring-spun and rotor-spun yarns [15]. Kathirvelu (2018) examined bursting strength, abrasion resistance and pilling characteristic of single jersey fabrics manufactured from ring-spun and rotor-spun yarns [16]. Keskin et al. (2014) investigated and compared absorbency properties of two group fabrics, one of which included plain, twill (2/1 Z), peshtamal fabrics, and the other one of which included different terry towels [17].

In this study, it is aimed to investigate the effect of yarn type and fabric tightness on pilling tendency, mechanical characteristic, and vertical liquid transfer behaviour of knitted fabrics. For this motive, six different knitted fabrics having different loop lengths were manufactured in single jersey construction. In this direction, pilling resistance, bursting strength, and wicking tests were performed.

2. MATERIAL - METHOD

2.1 Material

In the study, 100% poliester (PES) ring carded yarns, 100% cotton (Co) ring carded yarns, and recycled poliester/cotton open-end rotor yarns in 35/65 proportion were used. All yarn counts are Ne 20. Figure 1 displays differences of fibre alignment in yarn structure.



(a) **(b)** **(c)**

Fig. 1: Close vieew of the yarns (a) PES/Co open-end rotor yarns (b) 100% Co ring carded yarns (c) 100% PES ring carded yarns

A laboratuary-sized circular knitting machine was utilized to manufacture single jersey fabrics with different tightness. The tightness of the fabrics was adjusted by manipulating the loop length. Technical properties of the knitted fabrics used in the study are given in Table 1.

Table 1: Technical properties of the fabrics

Fabric code	Fibre/yarn type	Wale density	Course density	Areal density (gr/m^2)	Loop length (mm)
F1	PES-Co/Open-end rotor	12	11	140	3.46
F2	100% Co/Ring carded	12	13	154.5	2.9
F3	100% PES/Ring carded	11	12	138	2.7
F4	PES-Co/Open-end rotor	7	9	90.5	5.24
F5	100% Co/Ring carded	7	11	112.5	4.45
F6	100% PES/Ring carded	7	10	115.5	4.24

2.2 Method

In the experimental works of the study, to evaluate the pilling tendency of the fabrics, Martindale abrasion and pilling tester was performed in 2000 and 4000 cycles. The test was carried out according to ISO 12945-2 standard and evaluated according to pilling grade scale of the Martindale standard test (Figure 2).

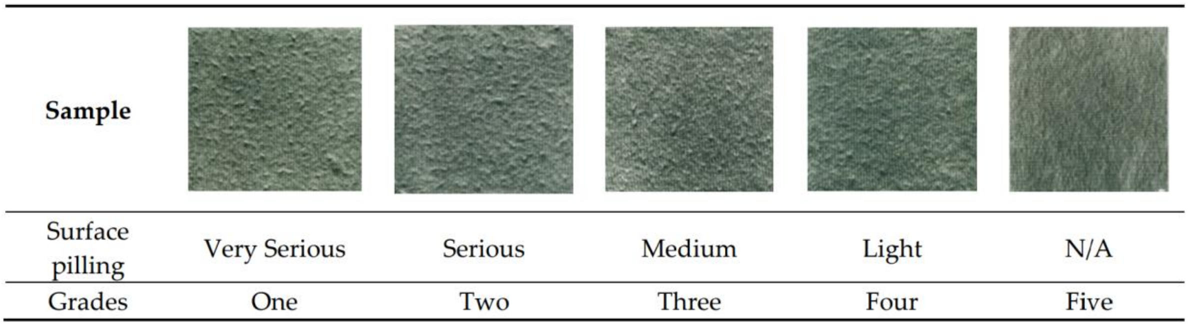


Fig. 2: Five grades of pilling detection

According to ISO 13938-1 standard, bursting strength test was carried out on SDLATLAS M229P PnuBurst Tester to determine mechanical characteristic of the fabrics. To assess the vertical liquid transfer behaviour of the fabrics, in-house wicking test was achieved.

3. FINDINGS

3.1 Pilling Properties

Concerning the number of abrasion cycles on Martindale measurement device, any pilling propensity was observed in all six fabrics by the end of 2000 cycles, whereas pillings are observed by the end of 4000 cycles depending on yarn type and loop length. It was seen that loose fabrics with higher loop length do not show high pilling tendency. As compared yarn types, F3 and F6 fabrics made of 100% PES ring carded yarns have medium to light pilling grades of 3 and 4 respectively. F1 and F4 fabrics made of PES-Co open-end rotor yarns have serious to medium pilling grades of 2 and 3 respectively. Pilling propensity of the fabrics manufactured from rotor yarns could be attributed to weak initial fibre orientation. Another possible reason is that short fibres are used in rotor yarn spinning and hence short fibres are protruded on the fabric surface. These migrated fibres could be considered as a contributor for the pilling in the fabrics. Also, high pilling tendency in PES-Co blended fabrics can be attributed to the presence of PES fibres in the yarn content. In such a situation, PES fibres with high strength and long length prevent the breaking of pillings that are built up by recycled short lengthed cotton fibres.

3.2 Bursting Strength

The bursting strength values of the fabrics are displayed in Table 2. As seen in the table, F1 and F4 fabrics made of recycled open-end rotor yarns have the weakest bursting strength. It can be ascribed that fibres expose the mechanical forces during the mechanically recycling process and thus converted yarns from recycled raw materials lose their strength. Another possible reason for poor strength is that the fabrics manufactured from open-end rotor yarns that have a high content of short fibre.

Table 2: Bursting strength values of the fabrics

Fabric code	Bursting strength (KN/m^2)	Fabric code	Bursting strength (KN/m^2)
F1	576.46	**F4**	430.46
F2	665.16	**F5**	577.56
F3	1017.06	**F6**	858.13

In terms of fibre type, high strength of poliester fibre, is reflected in the fabric and thus poliester fabrics of F3 and F6 displayed the best performance among all fabric types.

Also, it can be seen in Table 2, the loose fabrics with the high loop length resist the lower pressure as compared to the tight fabrics with the low loop length, which can be attributed that loose fabrics have less number of yarn intersections, low wale and course density in unit area, and inherently low areal weight.

3.3 Wicking Properties

The wicking test results in wale and course direction are displayed in Table 3. In wale direction, F3 fabrics manufactured from PES fibres have the strongest wicking ability, where F2 fabrics manufactured from cotton yarns have the poorest wicking ability. In course direction, F3 fabrics have the best wicking ability, where F5 fabrics have the weakest wicking ability. In terms of tightness or looseness of the fabrics, tight fabrics having short loop length were observed to absorb more liquid in both wale and course direction.

Table 3: Wicking test results of the fabrics

Fabric code	Time (minute)	Wicking height (cm)	
		Wale direction	Course direction
F1	5	11.66	17.00
	10	25.33	37.00
	15	39.33	48.66
F2	5	3.00	0.00
	10	5.00	2.33

	15	10.00	9.66
F3	5	45.33	44.33
	10	67.33	62.00
	15	83.66	77.33
F4	5	6.33	6.33
	10	11.66	13.00
	15	22.00	19.66
F5	5	1.00	0.00
	10	2.66	0.66
	15	4.66	5.00
F6	5	9.66	12.00
	10	24.33	20.33
	15	39.00	30.33

4. CONCLUSION

In this study, pilling tendency, mechanical characteristic, and vertical liquid transfer behaviour of single jersey knitted fabrics manufactured using ring spun and open-end rotor spun yarns were investigated and compared. Three types of fibre including poliester, cotton, and poliester/cotton blend were selected. In addition, the fabrics were designed in tight or loose construction manipulating their loop length. In the frame of the experimental work, the extracted conclusions are followed as:

- The fabrics from poliester ring carded yarns have medium to light pilling tendency, while the fabrics from poliester/cotton open-end rotor yarns show serious to medium pilling tendency. High pilling tendency in PES-Co blended fabrics can be explained with the presence of PES fibres in the yarn content. PES fibres with high strength and long length prevent the breaking of pillings that are built up by recycled short lengthed cotton fibres. From the view of fabric tightness, loose fabrics with higher loop length do not have pilling tendency.
- Among the fibre types, poliester fabrics displayed the best performance. On the other hand, since blended yarn is recycled yarn, bursting strength of the poliester/cotton fabric yarn show poor bursting strength level. The tight fabrics have higher bursting strength than loose fabrics, since tight fabrics have higher number of yarn intersections.
- In both wale and course direction, the fabrics knitted from poliester ring carded yarns displayed better wicking behaviour.

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