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Compact Spinning Research for Regenerated Cellulose and Synthetic Yarns

Izvirni znanstveni članek

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Raziskava kompaktnega predenja za preje iz regenerirane celuloze in sintetične preje

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Izvleček

V tej raziskavi smo primerjalno proučevali fizikalne lastnosti kompaktnih in klasičnih predivnih prej. Za ta namen smo izdelali kompaktne in klasične prstanske preje v treh debelinah niti in s tremi stopnjami vitja. Kot surovino smo uporabili stenj iz 100 % modala, 100 % poliestra, 100 % tencela in 100 % viskoze.

Rezultati raziskave se pokazali, da so kompaktne preje v primerjavi s klasičnimi prstanskimi prejami manj kosmate, trdnejše in imajo višje vrednosti razteznega razmerja.

Razlike v kosmatosti in nateznih lastnostih med kompaktnimi in klasičnimi prstanskimi prejami so odvisne od surovine, uporabljene v postopku predenja. Z mehanskim kompaktnim predenjem se izboljšajo kakovostne lastnosti prej, ki se bolje predejo z viskoznimi štapelnimi vlakni kot z drugimi surovinami, ki smo jih uporabili v raziskavi.

Ključne besede: mehansko kompaktno predenje, klasično prstansko predenje, modal, tencel, poliester, viskoza, fizikalne lastnosti preje

Abstract

This study is a comparative study of physical properties of compact and conventional spun yarns. For this aim, compact and conventional ring yarns were produced at three yarn counts having three-twist levels. 100% modal, 100% polyester, 100% tencel and 100% viscose rovings were used as raw materials in the study.

The results showed that compact yarns have less hairiness, higher strength and higher elongation ratio values than conventional ring yarns.

The differences in hairiness and tensile properties between compact and conventional ring yarns depend on the raw material used in spinning. Mechanical compact spinning improves the quality properties of yarns, which spun with viscose staple fibres better than other raw materials used in the study.

Keywords: mechanical compact spinning, conventional ring spinning, modal, tencel, polyester, viscose, yarn physical properties

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1 Introduction

In conventional ring spinning, the zone between the nip line of the pair of delivery rollers and the twisted end of yarn is called the 'spinning triangle'. This represents the most critical part of the ring spinning system due to the critical weak spot of the ring spinning process. In this zone, the fibre assembly contains no twist. The edge fibres play out from this zone and make little or no contribution to the yarn tenacity. Furthermore, the edge fibres lead to the familiar problem of yarn hairiness [1].

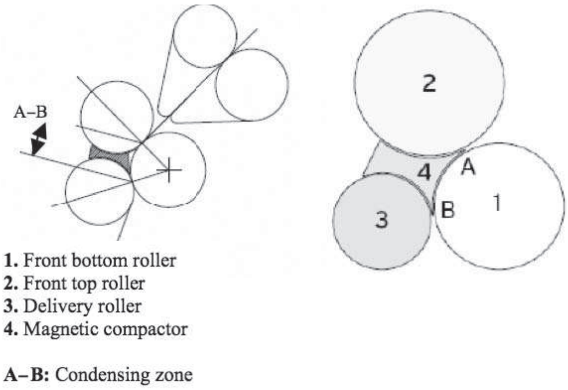

Figure 1: RoCos mechanical compact spinning principle

In compact spinning, the 'spinning triangle' is eliminated and almost all fibres are incorporated into the yarn structure under the same tension. This results in increased tenacity, as more fibres contribute to yarn tenacity, and leads to significant advantages, e.g. increasing yarn tenacity, yarn abrasion resistance and reducing yarn hairiness [2, 3].

There are different compact spinning systems in the market from different manufacturers. The main difference among these manufacturers is the condensing system. In most cases, the pneumatic compacting system is used via the perforated drums or lattice aprons over the openings of suction slots. Following the air flow, the fibres move sideways and they are consequently condensed. Nowadays, this method is widely used in compact yarn production. However, the adaptation of this system to conventional ring spinning machine is very complex and expensive. In addition, the energy consumption in the spinning process is very high. Mechanical compact spinning is an important alternative to compact yarn production. The system is cheaper and less complicated than pneumatic yarn compacting systems. Furthermore, there is no energy consumption whatsoever in the spinning process [4].

The mechanical compact spinning system which was used in the production of compact yarns for the purpose of this study is a design of Rotorcraft Company. In RoCoS compact spinning, compact yarn is produced by adding positive nip at the end of the drafting unit. The condenser is held against the bottom front drafting roller by means of a magnet. The operation brings the fibers closer and eliminates the spinning triangle [5, 6]. The view of the RoCoS mechanical compact spinning principle is given in Figure 1.

According to previous researches, mechanical compact spinning significantly improves the yarn tensile properties and reduces its hairiness [7, 8]. Numerous studies have been conducted so far concerning the compact spinning of cotton yarns. However, there are very few studies on compact spinning of 100% regenerated and 100% synthetic fibres. Consequently, in this study, we wanted to examine the effect of a compact yarn spinning system with the raw materials mentioned earlier.

2 Experimental

2.1 Yarn samples production

In the experimental part of the study, 100% modal, 100% polyester, 100% tencel and 100% viscose rovings were collected from several spinning mills located in Bursa and Kayseri. The physical properties of raw materials used in the study are given in Table 1.

The linear densities of the compact and conventional ring yarns were 29.53 Tex (Ne 20), 19.68 Tex (Ne 30) and 14.76 Tex (Ne 40). For each yarn count, twist multipliers were chosen as follows: α_e 3.4, α_e 3.8 and α_e 4.2. During the compact and convention-

Table 1: Raw material physical properties

Raw material	Roving linear density	Roving twist (turn/mt)	Fiber length (mm)	Fiber fineness
Modal	573 tex	28	38 mm	1.3 dtex
Polyester	573 tex	25.6	40 mm	1.3 dtex
Tencel	573 tex	28	38 mm	1.4 dtex
Viscose	596 tex	32	35.4 mm	1.58 dtex

Table 2: Experimental plan and yarn spinning set parameters

Technological/machine parameters	Yarn linear density								
	29.53 Tex (Ne 20)			19.68 Tex (Ne 30)			14.76 Tex (Ne 40)		
Ring yarn type	conventional & compact			conventional & compact			conventional & compact		
Twist coefficient (α_e)	3.4	3.8	4.2	3.4	3.8	4.2	3.4	3.8	4.2
Twists (turns/m)	602	667	735	735	818	902	838	947	1044
Spindle speed (rpm)	10.000			10.000			10.000		
Ring type	Orbit			Orbit			Orbit		
Ring diameter (mm)	42			42			42		
Traveller type (ISO No)	80			45			35.5		
Design and finishing treatment	SFB 2 Pm dr Saphir			SFB 2 Pm dr Saphir			SFB 2 Pm udr Saphir		
Cradle spacer thickness (mm)	3.75			3.25			2.75		
Cradle spacer colour	Cream			Yellow			Grey		

al spinning, the same rovings and the same spindles were used in order to eliminate any possible effect of roving and spindle on yarn quality properties.

It should be taken into consideration that the purpose of the study was a comparison of mechanical compact spun yarn and conventional spun yarn properties; therefore, the selected set of parameters of compact and conventional yarn spinning remained constant throughout the study.

The production of ring and compact yarns was conducted with Rieter G30 ring spinning machine in the Textile & Apparel Research and Application Centre at the Ege University. The experimental plan and the set parameters of compact and spinning systems are given in Table 2.

After a proper conditioning (65% relative humidity, 20 °C), all yarn samples were tested for single-end tensile properties with Uster® Tester 5 (UT5) and Uster® Tensorapid. We tested 10 bobbins with 400 m per bobbin on the evenness tester and 5 bobbins with 100 individual breaks per bobbin on the tensile tester.

The results obtained from the laboratory testing of yarn samples were statistically evaluated with the Factorial ANOVA method by using the SPSS statistical pocket program with the 0.05 significance level. We observed the main effect of the spinning system, the interaction effect of the spinning system & yarn linear density, and the interaction effect of the spinning system & twist multipliers on yarn quality. In some cases, despite the interaction effect of the spinning system & yarn linear density and the interaction effect of spinning system & twist multipliers being significant, the effect is irregular and the trend is too unclear to accept the presence of any meaningful effect. In consequence, this paper includes explanations only when the interaction effect had a regular trend on yarn quality.

3 Results and discussion

Table 3 represents the statistical results of the main effect of the spinning system, the interaction effect of the spinning system and the yarn linear density, and the interaction effect of the spinning system and twist. Based on the analysis results, the following conclusions can be drawn:

3.1 Yarn evenness results

Statistically-wise, the data analysis of all yarns indicated that the effect of the yarn spinning system on the evenness is significant for polyester and vis-

Table 3: F and significant analysis values

Compared pairs	Yarn property	Raw material type							
		Modal		Polyester		Tencel		Viscose	
		F	Sig.	F	Sig.	F	Sig.	F	Sig.
Spinning system	CVm (%)	1.84	.176	48.19	.000*	0,06	.797	7.08	.009*
	Thin place	1.23	.267	0.09	.755	0.78	.378	0.83	.363
	Thick place	11.60	.001*	7.09	.008*	13.33	.000*	12.31	.001*
	Neps	44.28	.000*	31.75	.000*	62.59	.000*	15.57	.000*
	Hairiness	101.72	.000*	0.94	.333	52.63	.000*	326.06	.000*
	Tenacity	14.36	.000*	146.29	.000*	0.06	.801	1.92	.000*
	Elongation	2.06	.155	138.33	.000*	0.34	.560	31.26	.000*
Spinning system* yarn linear density	CVm (%)	4.05	.019*	3.40	.035*	4.69	.010*	18.6	.000*
	Thin place	1.84	.161	0.22	.797	0.54	.584	1.64	.196
	Thick place	8.54	.000*	6.91	.001*	19.77	.000*	8.73	.000*
	Neps	20.30	.000*	41.03	.000*	47.58	.000*	9.72	.000*
	Hairiness	1.14	.320	2.95	.055	9.54	.000*	0.30	.738
	Tenacity	6.59	.002*	17.32	.000*	0.75	.472	8.29	.001*
	Elongation	6.79	.002*	6.49	.002*	4.08	.020*	0.95	.390
Spinning system* twist	CVm (%)	0.053	.948	1.59	.207	1.15	.317	11.90	.000*
	Thin place	2.30	.103	1.58	.207	0.38	.685	1.51	.222
	Thick place	2.85	.060	1.75	.177	13.48	.000*	3.34	.038*
	Neps	11.52	.000*	0.56	.569	16.79	.000*	3.70	.027*
	Hairiness	5.48	.005*	0.65	.520	0.186	.830	3.97	.021*
	Tenacity	7.49	.001*	0.12	.884	1.04	.356	7.99	.001*
	Elongation	1.87	.160	1.84	.164	4.60	.013*	0.447	.641

cose yarns. In contrast, for tencel and modal yarns, there is no significant difference between the evenness values of compact and conventional ring yarns produced from them.

The mechanical compact spinning system improves the evenness property of polyester yarns. The evenness values of polyester compact yarns are lower than the evenness values of conventional spun polyester yarns.

The effect of the compact spinning system on the viscose yarn evenness property changes according to the yarn linear density. The 29.53 tex compact yarns have higher evenness than conventional ring yarns. On the other hand, the 19.68 tex and 14.76 tex compact yarns have lower evenness values than conventional ring yarns. The latter could be explained through the control of fibres in the compacting area for coarser yarns, which is smaller.

3.2 Yarn imperfection results

There is no significant difference between the number of thin places of modal, polyester, tencel and viscose compact and conventional ring yarns.

The effect of the yarn spinning system on the number of thick places and neps of modal, polyester, tencel and viscose compact yarns is statistically significant. Compact yarns have fewer thick places and neps values than conventional ring yarns.

The effect of the interaction between the yarn linear density and the spinning system is significant for thick places and neps values of tencel yarns. While 29.53 tex and 19.68 tex compact yarns have higher thick places, 14.76 tex compact yarns have lower thick places than conventional ring yarns. The situation is similar for neps values of tencel yarns. While 29.53 tex compact yarns have higher neps values, 19.68 tex and 14.76 tex compact yarns have lower neps values than conventional ring yarns. As explained above, this result could be a consequence of a smaller control of fibres in the compacting area for coarser yarns.

The effect of the interaction between the spinning system and yarn linear density is significant for the neps values of polyester yarns. While 29.53 tex and 19.68 tex compact yarns have higher neps values, 14.76 tex compact polyester yarns have lower neps values than conventional ring yarns.

3.3 Yarn hairiness results

The hairiness values of modal, tencel and viscose compact yarns are significantly lower than the hairiness values of conventional ring yarns. However, no significant difference between the polyester compact and conventional ring yarns could be observed. The reason might be the better physical and mechanical properties of polyester and its greater bending rigidity, which reduces the fibre condensing effect [9].

The hairiness difference between the compact and conventional ring yarns are as follows: for modal yarns 4–44%, for tencel yarns 2–10% and for viscose yarns 12–20%.

For tencel yarns, the hairiness difference between the compact and conventional ring yarns increases as the yarn linear density increases.

For modal and viscose yarns, the hairiness difference between the compact and conventional ring yarns increases as the yarn twist multiplier decreases.

3.4 Yarn tenacity and elongation ratio results

The tenacity values of modal, polyester and viscose compact yarns are significantly higher than the conventional ring yarns. We could not find any significant difference between the compact and conventional ring yarns spun with tencel yarns.

The tenacity difference between the ring and compact yarns are as follows: for modal yarns 5–13%, for polyester yarns 1–9% and for viscose yarns 2–8%.

For modal yarns, the tenacity difference between the compact and conventional ring yarns increases as the yarn linear density decreases.

The elongation ratio values of polyester and viscose compact yarns are significantly higher than the conventional ring yarns. However, no difference for compact and conventional ring yarns spun with modal and tencel fibres could be found.

4 Conclusions

The hairiness values of modal, tencel and viscose compact spun yarns are significantly lower than the conventional spun yarns. On the other hand, there is no significant difference between yarn hairiness of conventional and compact spun polyester yarns. The reason might be the better physical and mechanical properties of polyester and its greater bending rigidity, which reduces the fibre condensing effect.

Due to the elimination of the spinning triangle in the compact yarn spinning system, the fly decreases and more fibres contribute to the yarn structure. Consequently, compact yarns have higher tenacity than conventional ring yarns.

The effect of the mechanical compact spinning on the improvement of yarn quality properties depends on the raw material used in the spinning. The best results are obtained in the compact spinning of viscose. It appears that the advantages of the compact spinning system are more noticeable when a fibre is shorter in length.

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