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Influence of Navel Type on the Hairiness Properties of Rotor-Spun Blend Yarns

Abstract
The navel, which is one of the most important items in the OE - rotor spinning system, influences yarn quality because of its surface design and structure. In this work, four different blends (polyester/cotton and polyester/viscose) and four different navels were used to produce rotor-spun yarns with the same count under the same operation conditions on a laboratory type OE - rotor spinning machine (Quickspin). The hairiness of these rotor-spun yarns were tested on Zweigle G565 and Uster 4SX testers, and an analysis of variance (ANOVA) was performed to investigate the influence of navel type on the hairiness.

Key words: *OE - rotor spinning system, rotor yarn, navel type, hairiness, statistical analysis.*

Introduction

Three spinning technologies – ring (conventional & compact), rotor and air-jet spinning- are discussed, different focusing on the entire range of their concerning fineness and imput material. A large part of the world's yarn production, 36.2 million tones (64% of the world's total yarn production), is still spun yarn. The worldwide spinning capacity of installed ring spindles was approximately 144 million and that of rotor spindles was about 3.7 million at the end of 2005 [1]. The most important raw material on rotor spinning machines is still cotton with a share of 60% [1, 2]. Modern rotor-spun yarns surpass conventional ring-spun yarns, not only in their regularity of appearance, but also due to their reduced imperfection count. They are also more abrasion resistant, more extensible and less hairy. All these favorable characteristics lead to better processing in subsequent textile operations, resulting in higher productivity and superior quality of end-products.

There are three important spinning components in OE - rotor spinning which have an influence on yarn properties, these are the opening roller, rotor, and navel. Figure 1.a. illustrates the OE - rotor spinning principal and its basic parts. The configuration of the navel has quite a considerable effect on both spinning stability and yarn appearance. It decisively determines the degree of twist present in the rotor and, therefore, the spinning conditions in the rotor groove [3, 4]. The spun yarn is withdrawn through the passage in the navel. Therefore, the yarn rolls continually on the navel. Thus, two forces affect the yarn on the navel surface (Figure1.b) [3].

These forces cause a high friction effect between the yarn and navel. It exerts some influence on the yarn character, but mainly because it generates a false twist. Moreover, the twist level rises continuously from the navel towards the rotor wall. This condition increases the performance of spinning.

Hairiness is one of the most important characteristics which affects weaving, knitting, dyeing and the finishing process in textiles. The properties of fibres and yarn production stages are known to be influential for yarn hairiness. Yarn hairiness is defined as fibre ends not embedded in the yarn body, but protruding from it at different lengths.

The material and surface form of the navel, of which there are various

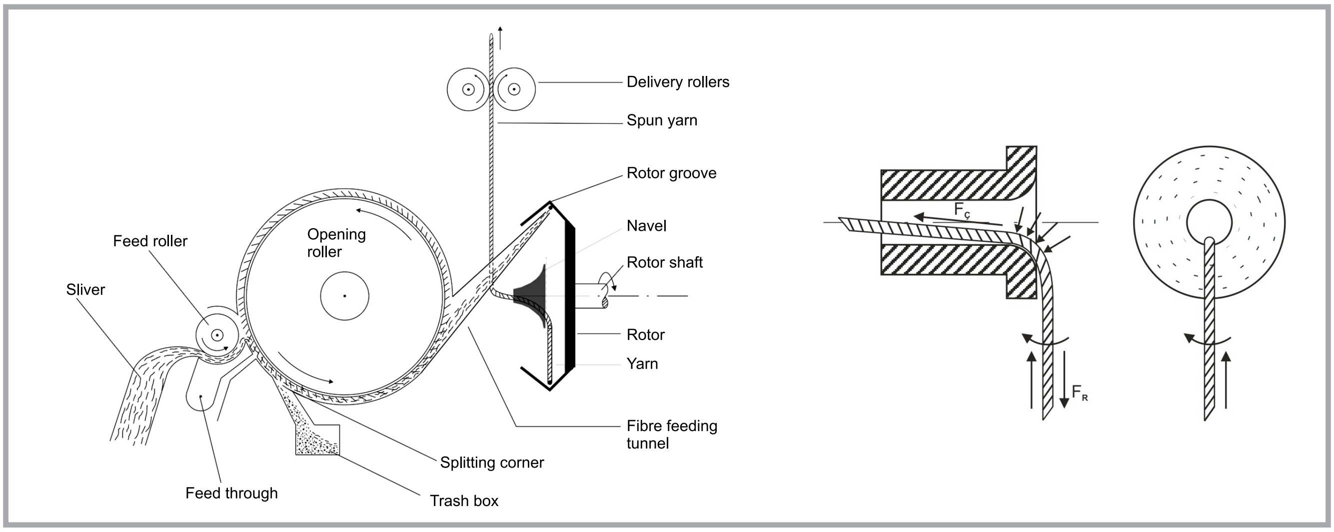


Figure 1. OE - rotor spinning components; a) and interaction between yarn and navel; b) ($F_Ç$: Pulling force, F_R: Centrifugal force).

***Table 1.** Properties of blended slivers; PES – polyester, co-cotton, CV - viscose.*

Number of sliver	Blending		Count, ktex	Fibre properties of slivers		
				Fibre	Linear density (Fineness), dtex	Length, mm
1	PES/CO	50/50	4.54	PES	1.60	33.3
2		25/75	5.37	CO	1.49	28.9
3	PES/CV	50/50	4.92	PES	1.33	38
4		70/30	4.54	CV	1.70	40

types, affect the quality properties of yarns [4, 5]. There is some information about choosing navel type in literature, especially concerning the advice of machine producers. But this information is quite general and not satisfactory.

Both the number and form of notches on the navel have an influence on hairiness. An increase in the number of notches raises hairiness (Figure 2). This study aims to investigate the influence of navel type on hairiness. Polyester/cotton and polyester/viscose blends, which play a large part in OE - rotor spinning, were used for this purpose.

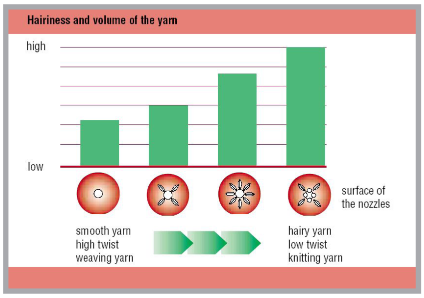


***Figure 2.** The effect of navel form on hairiness [6].*

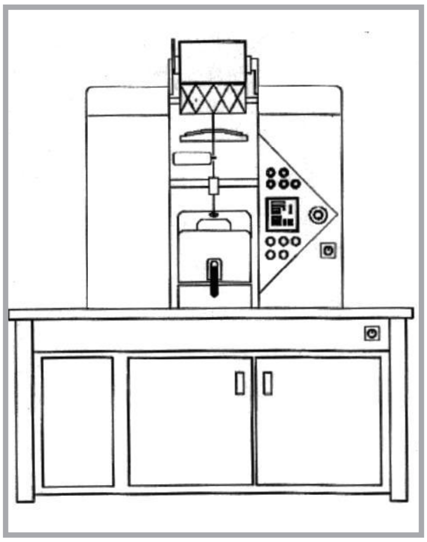


***Figure 3.** Quickspin unit [9, 10].*

Materials and method

Four different blended slivers were used in this study. Details for these slivers are given in Table 1. In addition, the navel types used in the study are listed in Table 2.

We used a Quickspin instrument with a Rieter R20 spinbox for producing rotor-spun yarns at laboratory scale (Figure 3). The spinning parameters for all yarns are listed in Table 3. Three types of navel (K4KK, K8KK and K4KS) were used for PES/CO blends. In addition to these navel types, a K6KF was used for PES/CV blends. In high-speed OE-Rotor Spinning, when producing chemical fibre blended yarns, there is the problem of the temperature between the navel surface and yarn. This high temperature can cause deformation of fibre and yarn properties. To avoid these bad effects, suitable navels must be used for chemical fibre blends [8].

We produced 14 different rotor-spun yarns from the blended slivers. The hairiness of these yarns was tested on an Uster 4SX Tester and Zweigle G565.

Ten single measurements were performed for each bobbin for both the Zweigle (per 100 meter of yarn length) and Uster Tester (per 400 meter of yarn length). Mean values of these test results were used in statistical analysis. Analysis of variance (ANOVA) and Tukey HSD (Honestly Significant Difference) tests provided an α value of 0.01. All statistical analysis steps were performed on SPSS software.

Results and discussion

Hairiness was obtained from a Zweigle test instrument as a hairiness index and S3 value, and from an Uster Tester an H value is attained. The results of variance analysis with significance values, and hairiness test results of the yarns are summarised in Tables 4, 5, 6 and 7 (see pages 33 and 34). From the test results in the tables, we can see which navel types have statistically significant difference according to hairiness. The significant values in the tables are smaller than α = 0,01, which means that the differences between the hairiness values of the yarns are, with a probability of 99%, statistically significant.

On the other hand, the averages of hairiness values according to raw material and navel types are shown in Figures 4, 5 and 6.

There is no significant difference between the S3, Index, and H values of K4KK and K8KK navels for PES/CO 50/50 yarns (Table 4). This means that the hairiness effects of these two navels are statistically similar. On the other hand, there is, with a probability of 99%, a significant difference between the K4KS navel and the two other navel types. Furthermore, the hairiness effect of K4KS is much higher than the other navels (Figures 4 - 6), and Therefore, the K4KS is more effective for the production of hairy yarns than the K4KK and K8KK.

***Table 2.** Navel types [3, 7]*

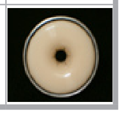
Navel types	Properties	Processed material	Front view of navel
K4KK	Ceramic, 4 notches, short	All materials	
K8KK	Ceramic, 8 notches, short	All materials	
K4KS	Ceramic, 4 notches, spiral	Cotton and blends	
K6KF	Ceramic, 6 notches, flat	Man-Made fibres and blends	

***Table 3.** Spinning parameters.*

Air conditions	
Air temperature	20 °C ± 2
Humidity	65% ± 2
Production parameters	
Type of opening roller	OS21
Opening roller speed, r.p.m.	8,000
Sliver feeding speed, m/min	0.49
Draft	184.6-218.2
Type of rotor	35 DIII BD – V
Rotor speed, r.p.m.	75,000
Delivery speed, m/min	90.5
Twist, t.p.m.	828.7
Linear density (Yarn count), tex	24.6
Twist factor, (α_m)	130

*Table 4. Comparison of Navel Types for PES/CO 50/50 Yarns; * The mean difference is significant at a level of 0.01.*

Navel type	Navel Types								
	K4KK			K8KK			K4KS		
	S3	Index	H	S3	Index	H	S3	Index	H
	741	454	5.23	833	509	5.22	1685	823	6.16
K4KK	-	-	-	0.105	0.079	0.944	0.000*	0.000*	0.000*
K8KK	0.105	0.079	0.944	-	-	-	0.000*	0.000*	0.000*
K4KS	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	-	-	-

*Table 5. Comparison of Navel Types for PES/CO 25/75 Yarn; * The mean difference is significant at a level of 0.01.*

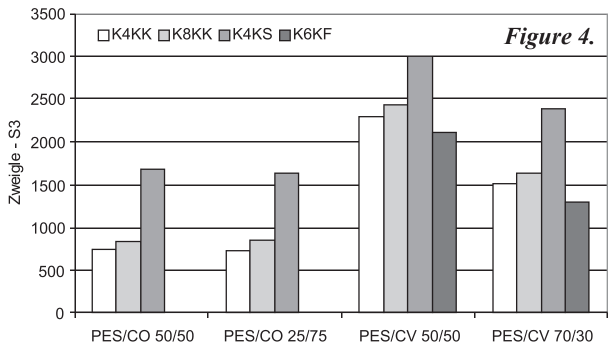
Navel type	Navel Types								
	K4KK			K8KK			K4KS		
	S3	Index	H	S3	Index	H	S3	Index	H
	728	446	4.95	862	518	5.21	1626	848	6.04
K4KK	-	-	-	0.000*	0.001*	0.000*	0.000*	0.000*	0.000*
K8KK	0.000*	0.001*	0.000*	-	-	-	0.000*	0.000*	0.000*
K4KS	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	-	-	-

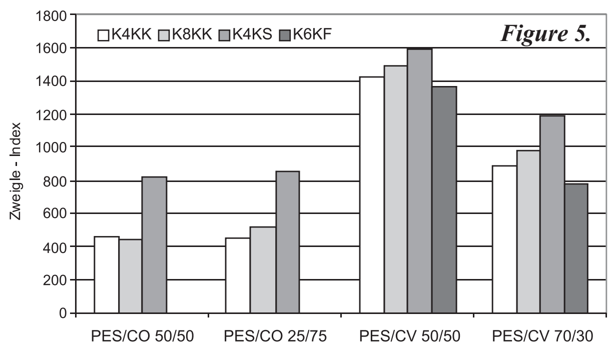
In Table 5, it appears that all three navel types are significantly different from each other for all the hairiness values of PES/CO (25/75) blend yarns. This means that K4KK and K8KK navels have different effects on cotton fibre at a 75% blend rate with polyester fibre.

As can be seen in Table 6, for PES/CV (50/50) blend yarns, the differences between all the navel types are statistically significant regarding Zweigle S3 values Minimum hairiness is obtained with the K6KF navel, whereas maximum hairiness is obtained with the K4KS navel (Figures 4 - 6). The K6KF navel has more notches than the K4KK and K4KS, but it does have a lower hairiness effect because of the suitability of its surface structure design for chemical fibres. This shows that as well as the number of notches, the surface structure and design

*Table 6. Comparison of Navel Types for PES/CV 50/50 Yarn; * The mean difference is significant at a level of 0.01.*

Navel type	Navel Types											
	K4KK			K8KK			K4KS			K6KF		
	S3	Index	H	S3	Index	H	S3	Index	H	S3	Index	H
	2292	1425	2.35	2439	1483	2.35	2997	1592	3.19	2116	1367	2.29
K4KK	-	-	-	0.001*	00.305	0.999	0.000*	0.000*	0.000*	0.000*	0.313	0.019
K8KK	0.001*	0.305	0.999	-	-	-	0.000*	0.011	0.000*	0.000*	0.006*	0.027
K4KS	0.000*	0.000*	0.000*	0.000*	0.011	0.000*	-	-	-	0.000*	0.000*	0.000*
K6KF	0.000*	0.313	0.019	0.000*	0.006*	0.027	0.000*	0.000*	0.000*	-	-	-





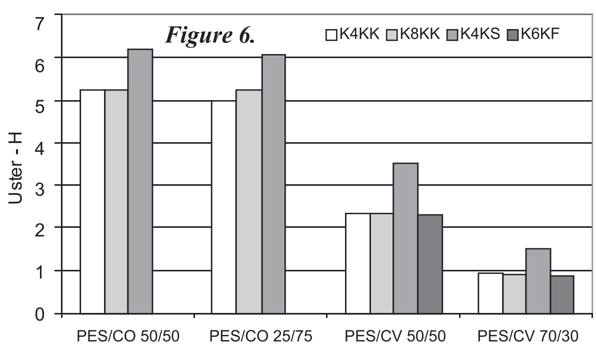


***Figure 4.** Averages of Zweigle hairiness (S3 values).*

***Figure 5.** The averages of Zweigle hairiness (index).*

***Figure 6.** Averages of Uster hairiness (H).*

*Table 7. Comparison of Navel Types for PES/CV 70/30 Yarn; * The mean difference is significant at a level of 0.01.*

Navel type	Navel Types											
	K4KK			K8KK			K4KS			K6KF		
	S3	Index	H	S3	Index	H	S3	Index	H	S3	Index	H
	1511	884	0.94	1631	979	0.92	2392	1191	1.52	1304	771	0.90
K4KK	-	-	-	0.020	0.002*	0.009*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
K8KK	0.020	0.002*	0.009*	-	-	-	0.000*	0.000*	0.000*	0.000*	0.000*	0.036
K4KS	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	-	-	-	0.000*	0.000*	0.000*
K6KF	0.000*	0.000*	0.000*	0.000*	0.000*	0.036	0.000*	0.000*	0.000*	-	-	-

also have an influence on the hairiness of yarn. For the hairiness index and H values, there is no significant difference between the K4KK, K6KF and K8KK. For the K4KK and K8KK there is a high similarity of *H* values at a level of 0.99.

For PES/CV (70/30) blend yarns (Table 7), most of the navel types have significant differences regarding yarn hairiness. There is no significant difference at a level of 0.01; only between K4KK and K8KK in S3 values and between K8KK and K6KF in H values. The hairiness is lowest for the K6KF navel for all hairiness values. The K4KS navel has the hairiest effect on the yarns.

Figure 7 presents the hairiness behaviour of the navel types used in this study. The minimum hairiness effect was obtained with the K6KF navel, and the maximum hairiness effect was obtained with the K4KS navel.

Conclusions

- Maximum hairiness values were obtained with the K4KS navel for all blends. This means that the form and structure of a navel have an important effect on hairiness, except the number of notches.
- The minimal hairiness effect of the K6KF navel on chemical blended yarns also may result from its surface construction and thermal properties.
- Chemical fibres can be affected by thermal impacts more than natural fibres. This means K6KF navel is suitable for chemical fibre blends when hairiness is not required.
- K4KK and K8KK navels are suitable for cotton blends if hairiness is not required, and there is no statistically significant difference between them.
- If the blend ratio of cotton is more than 50%, the difference between the two navels are statistically significant.
- Noticeable properties of the navels, extracted from this study, are listed below;
  - The number of notches on the navel,
  - The physical form of notches (convex/concave),
  - The structure of the navel surface (i.e. frictional and thermal properties),
  - The surface geometry of the navel (i.e. flat, spiral)

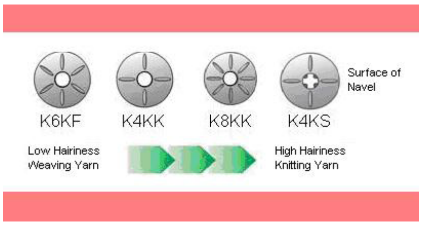


Figure 7. Hairiness behaviour of the navels.

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