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146

CORE-SPINNING OF WOOL WITH TEXTURED FILAMENTS, A PRELIMINARY REPORT

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ABSTRACT

Core-spinning was carried out using wool and 20 denier textured multi-filament nylon. For satisfactory results the filaments had to be extended more than 20% prior to spinning. The physical properties of the core-spun yarns were considerably better than those of the 100% wool yarns. The knitting performance of the core-spun yarns was better than that of the 100% wool. Samples knitted from the core-spun yarns were better than those knitted from the 100% wool yarn as far as pilling and abrasion resistance were concerned. Comparisons of core-spun yarns with intimately blended yarns of staple nylon and wool showed that the core-spun yarns were stronger and more resistant to pilling, whereas the intimate blends showed better abrasion resistance.

KEY WORDS

Core-spinning, textured filament, physical properties, knitting.

INTRODUCTION

The use of a filament together with a staple fibre component during spinning, known as core-spinning, is a well-known technique. Some of the methods used in the manufacture of core-spun yarns and their relative merits have been discussed by Miller[1]. He investigated the properties of core-spun yarns prepared for use in conveyor belting for which high-tenacity yarns were required. Other yarns intended for fabrics for industrial clothing were made by Standring and Westrop[2] who used high-tenacity Terylene filaments. Balasubramanian and Bhatnagar[3], using a 20 denier nylon monofilament together with cotton fibres to produce fine yarns, investigated certain spinning conditions such as yarn twist, pre-tension in the monofilament and the number of rovings fed into the spinning machine. The filament they used was, however, rather thick (20 denier monofilament) and rigid (untextured).

The present report deals with an investigation in which textured multi-filaments were spun together with different types of wools. The linear density of the single filaments was approximately 3 denier. Basic spinning conditions had to be investigated before satisfactory yarns could be produced, after which physical properties of the yarns obtained under different spinning conditions were determined. Limited knitting trials were also carried out and some of the physical properties of the knitted samples were measured. The performance and properties of the core-spun yarns were compared with those of pure wool and various blends of wool/

nylon staple. Additional experiments were carried out using wools of different mean fibre lengths and diameters under different spinning conditions.

EXPERIMENTAL

Raw Material:

A 20 denier (7 filament) textured nylon multifilament with resultant torque in either S or Z directions (referred to as the S- and Z-filaments) was used as a core. Staple nylon of 3 denier (7 to 8 cm fibre length) was used for the intimate blends.

The properties of the wool tops are given in Table I.

TABLE I

PROPERTIES OF WOOL TOPS USED

	Shade	m.f.l. mm	C.V. (%) of fibre length	Fibre diameter (microns)
Lot 1	Blue	60	49	22,0
Lot 2	Undyed	47	42	21,5
Lot 3	Undyed	64	46	21,8
Lot 4	Undyed	72	48	21,9
Lot 5	Undyed	70	48	19,6

Spinning:

An SKF spinning frame with 6 spindles (57 mm rings and 32 mm diameter front rollers) and a Rieter frame with 36 spindles (62 mm and 50 mm rings, and 30 mm and 38 mm diameter front rollers) were used. Both these machines were equipped with double apron drafting systems.

A shaft, similar to the normal bottom front rollers, was mounted above the back rollers at each side of the spinning machine and standard rubber covered rollers were used as pressure rollers. This configuration is illustrated in Fig. 1. A photograph of the arrangement is shown in Fig. 2. The speed of the additional shaft (filament feed roller) could be varied by means of changeable sprockets. The filament was fed positively by this roller arrangement and, via a guide, joined the staple fibre component at the front roller nip. In order to limit the wear of the top roller covering, it was necessary to traverse the filament. The standard traversing motion of the machine (for the roving) was used for this purpose. The guides of the filament were connected to this traversing bar which kept the traversing motion of the filament synchronized with that of the staple component. Similar traversing guides behind the filament feed rollers were also necessary.

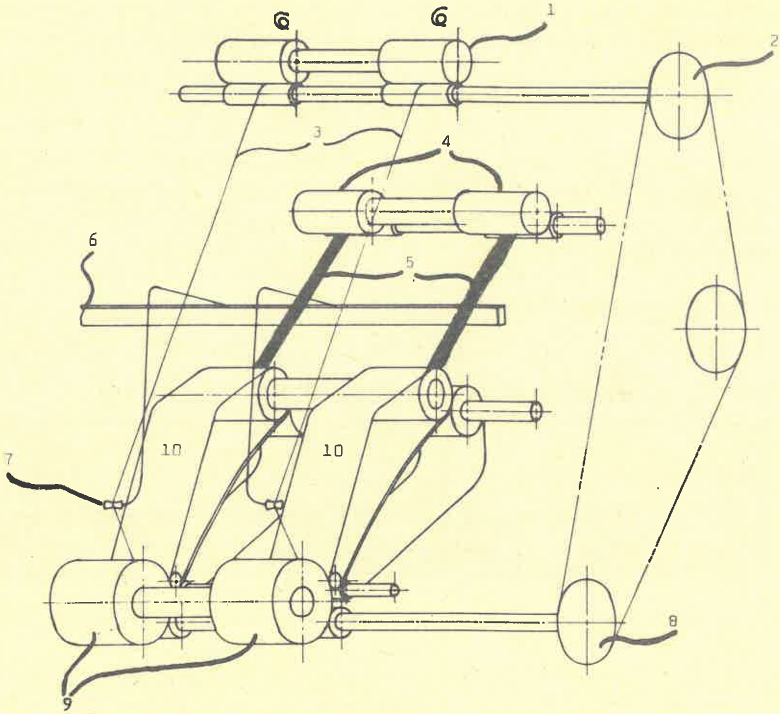


FIGURE 1

Arrangement of drives and rollers for core-spinning
1-Filament feed rollers; 2-Sprocket driving filament feed rollers; 3-filament; 4-Back rollers (feed of roving); 5-Roving; 6-Traverse bar; 7-Control guide for filament; 8-Sprocket connected to the front roller shaft; 9-Front rollers; 10-Aprons.

The speed ratio between the front rollers and the filament feed rollers could be varied from 1:1 to 1:2,5. This determined the amount of draft exerted on the filament by positive control. Before entering the filament feed system, the filament was passed over a horizontal bar mounted directly above the package or cone thereby allowing vertical unwinding and the necessary traverse motion required to prevent the filament from snarling before being fed into the feed system. The friction of the filament sliding over this guide rod caused a certain amount of extension of the filament. It was not possible to determine this amount of extension. The percentages of extension given in this report only refer to the positively controlled speed ratio between the front rollers and the filament feed rollers.

Single and double roving feeds were used in core-spinning the yarns with the 19,6 microns (Lot 5) wool.

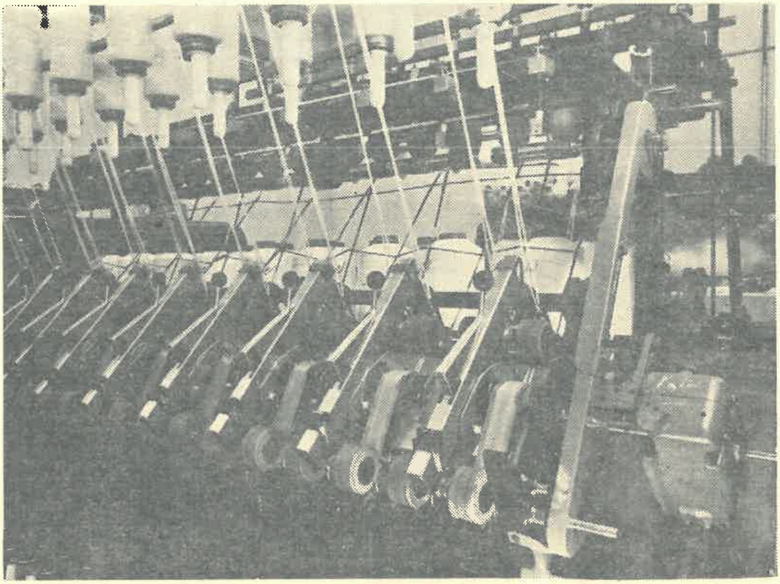


FIGURE 2

Photograph showing additional shaft mounted above the back rollers of an SKF spinning frame

Yarn testing:

Yarn breaking strength and regularity measurements were determined on an Uster Automatic Breaking Strength Tester and the "Uster" range of evenness testing equipment.

Knitting:

Samples were knitted on a 20 needle per inch Lawson Analysis Knitter and an 18 gauge Mellor Bromley circular rib machine.

Abrasion resistance of the samples was determined on a Stoll Quartermaster Wear Tester.

Pilling was determined subjectively by abrading samples on a Martindale Abrasion Tester using a crossbred cloth for a predetermined period, after which the samples were assessed subjectively by several people and classed in order of most to least pilled conditions.

RESULTS AND DISCUSSION

Resultant Torque and Extension of Filament

The first exercise was to establish whether the direction of the resultant torque existing in the textured filament, was of importance. A blue dyed wool top (Lot 1, Table I) was used to produce 22 tex yarns. The filaments of both S and Z torque were extended 10%, 20%, 50% and 150% respectively, producing core-spun yarns of R22 tex/1 with spinning twist in the Z direction (560 t.p.m.). The amount of nylon present in these yarns was approximately 10%. A 100% wool yarn of the same linear density was also produced. The white filament was clearly distinguishable from the deep blue wool fibres. In order to make a proper comparison of these yarns, samples were knitted of each and inspected visually.

Most of the samples for which the Z-filament was used, formed white pills on the surface. It was noticed that the filament coiled up, or contracted away from the cross-section of the yarn, forming a loop on the surface of the knitted sample. The higher the extension of the filament prior to spinning the less this effect became. It was severe for the 10% extension, less but still significant for 20%, just noticeable for the 50% and almost non-existent for the 150%. The samples in which the S-filaments were used did not show any of these effects.

Wherever the filament was not properly covered by the blue wool fibres it showed up as a white spot or a streak. Unevenness in shade was, therefore, an indication of the variation of the amount of covering of the filament by the wool fibres.

The samples with 10% extended filaments (both Z and S) showed large amounts of irregularity in shade. These samples were also generally of a very light shade indicating that the filament migrated more to the surface of the yarn. The samples with 20% extended filaments were significantly darker, but the irregularity in shade still persisted. It was, in fact, very noticeable in these samples due to the samples being darker. In the samples containing the 50% and 150% extended filaments only small white specks were visible, mostly at the yarn cross-over points in the knitted loop. This resulted in a uniform and pleasing shade, which appeared to be only slightly lighter than the 100% wool sample.

It was observed that the filament was sometimes forced out of the core of the yarn wherever the yarn made a sharp bend in the knitted structure. This may be due to the filament having a higher bending resistance than the wool fibres. With the filament dyed to approximately the same shade as the rest of the yarn, it will not be visible. This was, in fact, shown subsequently by core-spinning yarn from undyed wool and then dyeing it in yarn form. The filament was not visible in the knitted structure.

The samples were knitted to three cover factors, viz. 12,9, 14,7 and 16,2 (worsted cover factors 1,1, 1,25 and 1,38). There were no clear differences between these structures for those properties mentioned above.

TABLE II

AVERAGE SHADE RANKING* VALUES OF KNITTED SAMPLES

TYPE OF YARN	Cover Factor			Average for three cover factors
	12,9	14,7	16,2	
S.-Filament with extension of 10%	3,7	4,0	5,0	4,2
20%	6,3	6,7	4,0	5,7
50%	8,3	8,7	9,0	8,7
150%	9,0	8,3	6,7	8,0
Without filament	10,3	10,0	10,7	10,3
Staple spun yarns with % nylon 0	10,3	11,0	10,3	10,5
5	6,3	6,3	7,0	6,5
10	5,7	5,0	7,3	6,0
15	3,3	3,0	3,0	3,1
20	2,0	2,0	2,0	2,0
30	1,0	1,0	1,0	1,0

*Highest value means darkest shade

The knitted samples from the 100% wool yarn showed irregular stitch lengths and bars and a number of holes were present. No holes were present in the samples knitted from core spun yarns and they appeared to possess a more uniform stitch shape and size.

Comparison with staple blended yarns:

Yarns of the same linear density were also spun from intimate blends of wool and nylon staple fibre, with 100% wool, 95/5, 90/10, 85/15, 80/20 and 70/30% wool/nylon. These yarns were knitted to the same cover factors as before.

In view of the above findings the samples knitted from the core-spun yarns containing the Z-filaments were regarded as impractical and discarded. All the other knitted samples were ranked for shade. The average of the subjective assessments of three judges was used. There were eleven samples, and each judge allocated the rank 11 to the darkest shade and the rank one to the lightest shade. In Table II the averages of the three judges are given separately for each cover factor as well as the averages for the three cover factors.

The two 100% wool yarns differed only very slightly in shade. The lot of wool used for the intimate blends was the same as Lot 1, but recombed. It was hardly distinguishable in shade from the previous lot, as can be seen from the second last column of Table II, with average rankings of 10,5 and 10,3.

From Table II it is clear that the 10% and 20% filament extensions resulted in lighter shades than the 10% nylon intimate blend. The percentage nylon in the cross-section of these yarns was the same (10%). It is, therefore, clear that the filaments for 10% and 20% extensions tended to be more on the outside of the yarn. There was very little difference between the samples made from 50% and 150% extended filaments, both being darker than the intimate blends containing 10% as well as those containing 5% nylon. This shows that the filaments were well covered in those yarns for which the filament was extended 50%, or more, prior to spinning.

Yarn physical properties:

The physical properties of the core-spun yarns are given in Table III and those of the intimate blend spun yarns in Table IV. Table III shows that the irregularity improved from 21,3% C.V. for the 100% wool to 20,6% C.V. for the 50% extended filament yarn. The breaking strength improved from 113 g to 210 g, the C.V. of breaking strength decreased from 19,8 to 7%, and the extension at break increased from 10,7 to 20,0%. The yarn produced from the 150% extended yarn appeared to be better but it was suspected that sometimes single filament ends broke during spinning, and this percentage extension is, therefore, not recommended.

TABLE III

YARN PROPERTIES WITH S AND Z FILAMENTS AND DIFFERENT AMOUNTS OF EXTENSION (22 TEX YARNS FROM 22 MICRONS DYED WOOL TOP)

Resultant Filament Torque	Percentage extension during spinning	Irregularity (% C.V.)	Breaking strength (g)	C.V. of breaking strength (%)	Extension at break (%)	Neps per 1 000 m
100% wool	–	21,3	113,2	19,8	10,7	105
S	10	20,6	208,8	8,3	21,6	65
Z	10	21,5	190,4	14,0	20,8	105
S	20	21,3	192,0	10,6	20,6	45
Z	20	20,5	202,0	9,7	20,5	69
S	50	20,6	210,0	7,1	20,0	60
Z	50	20,6	220,0	7,3	20,0	62
S	150	20,4	201,2	7,4	20,0	57
Z	150	20,3	204,4	8,8	19,5	68

TABLE IV

YARN PROPERTIES OF BLENDS OF 22 MICRON DYED WOOL TOP AND 3 DENIER NYLON STAPLE (22 TEX YARNS)

% Nylon	Irregularity (% C.V.)	Breaking Strength (g)	C.V. of Breaking Strength %	Extension at break %	Neps per 1 000 m
0	19,7	102,2	16,4	8,8	17
5	19,0	136,8	14,4	15,7	14
10	19,0	156,8	15,8	17,3	10
15	18,8	180,8	16,2	20,7	12
20	19,5	183,2	19,4	20,9	14
30	18,9	236,0	16,0	22,9	21

Table IV shows that the presence of nylon generally resulted in more level and stronger yarns. The core-spun yarns (Table III) were, however, stronger than the yarns containing up to 20% nylon in the intimate blends (Table IV).

Pilling and Abrasion:

The knitted samples were all tested for pilling propensity and abrasion resistance. These results have been summarised in Table V. The intimate blends appeared to be poorest as far as pilling was concerned, but generally better for abrasion resistance. It is interesting to note that the samples made from core-spun yarns with 10% extended filaments had the least pilling propensity. The remark made above that some single filaments broke during the 150% extension of the filament is clear from Table V. This sample was the worst of the core-spun samples in respect of both pilling and abrasion. All the core-spun samples were better than the 100% wool as regards both pilling and abrasion.

CORE-SPINNING WITH OTHER WOOLS

Selecting an extension of 50% for the filament, several yarns were core-spun from the other wool lots of which the details are given in Table I.

For a comparison of the spinning performance for different mean fibre lengths, lots 2, 3 and 4 were used (all of approximately the same fibre diameter). Yarns of three linear densities were spun from these wools. The yarn properties are given in Table VI.

For the very short wool (m.f.l. 47 mm) the yarn irregularity of the 30 tex yarn improved from 22,1% C.V. to 18,5% C.V., and the breaking strength from

TABLE V

RANKING VALUES FOR PILLING AND ABRASION, AVERAGED FOR ALL COVER FACTORS

TYPE OF YARN	Ranking of Pilling Propensity*	Ranking of Abrasion resistance**	(Cycles)
S filament with extension of 10%	1	5	(428)
20%	4	3	(514)
50%	2	4	(457)
150%	5	9	(349)
Without filament	11	10	(316)
Staple spun yarns with % nylon 0	9	11	(271)
5	8	7	(366)
10	3	8	(358)
15	7	6	(423)
20	6	2	(585)
30	10	1	(777)

*Lowest value of ranking – least pilling
**Lowest value – best abrasion resistance

142 g to 251 g. In the case of the 18 tex yarn the breaking strength improved from 75 g to 162 g. The improvements in all the physical properties with the addition of the filament were overwhelming for the wools of all fibre lengths.

A 70's wool top (Lot 5) was used to spin finer yarns. It was clear that the draft during spinning had a very important influence on the regularity of the yarn. In all the previous cases two rovings were fed into the spinning machine with the filament approximately in the middle. Two yarns of 18 and 16 tex were spun using single and double rovings of 250 tex. The properties of these yarns are given in Table VII. The number of ends down during spinning was appreciably lower when the filament was present. More ends down resulted when two rovings were used, i.e. when higher drafts were required. The yarn evenness improved markedly in all cases where only one roving was used. Once again, the breaking strengths of the core-spun yarns were well above those of 100% wool, but there was little difference in breaking strength when one or two rovings were used. All these spinnings were carried out at 9 000 r.p.m.

This exercise was taken further by producing finer yarns. These results appear in Table VIII. It was possible to spin the 18 and 16 tex yarns with 100% wool at

TABLE VI

PROPERTIES OF YARNS SPUN FROM WOOL TOPS OF DIFFERENT m.f.l.'s

Yarn linear density		30 tex			22 tex			18 tex		
Wool top m.f.l. (mm)		47	64	72	47	64	72	47	64	72
Percentage nylon with filament present		7,3	7,3	7,3	10	10	10	12,3	12,3	12,3
Yarn Irregularity (% C.V.)	without filament	22,1	20,1	18,8	22,0	18,5	20,6	21,7	24,4	21,6
	with filament	18,5	16,9	17,2	21,5	19,5	19,4	19,1	19,6	20,7
Yarn Breaking Strength (gram)	without filament	142,1	192,4	197,6	103,6	131,0	129,8	75,4	97,8	111,4
	with filament	251,2	257,2	296,4	207,4	211,6	226,6	162,4	192,4	197,0
C.V. of Breaking Strength (%)	without filament	18,1	12,5	14,3	24,4	15,7	19,4	28,5	20,0	21,4
	with filament	8,5	7,9	8,7	10,4	8,5	9,9	11,4	9,9	9,6
Extension at break (%)	without filament	9,2	14,3	13,5	7,8	10,4	11,2	7,5	10,2	9,8
	with filament	21,5	23,4	24,3	20,0	21,8	23,4	19,4	22,3	22,2

TABLE VII

SPINNING PERFORMANCE AND YARN PROPERTIES WITH DIFFERENT DRAFTS AND DOUBLINGS WITH 19,6 MICRON UNDYED WOOL FIBRES

	18 Tex				16 Tex		
	With filament		Without fil.		With fil.		Without fil.
	Two rovings	One roving	Two rovings	One roving	Two rovings	One roving	One roving
No. of ends down (per 100 sp. hrs)	3,7	1,0	5,5	9,9	12,9	4,8	9,5
Draft (spinning)	29,5	15,3	25,6	12,8	36,0	16,9	14,4
Yarn irregularity (% C.V.)	21,2	20,5	22,9	20,6	24,2	20,4	21,3
Yarn Breaking Strength (gram)	190,4	190,0	104,4	109,4	163,6	185,6	91,0
C.V. of Breaking Strength (%)	7,2	10,3	17,2	17,3	12,6	7,4	16,8

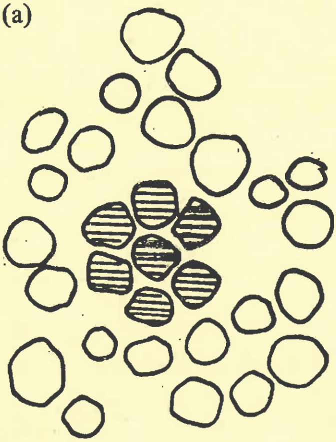
9 000 r.p.m., although the number of ends down were rather high. When a 14 tex yarn was spun, however, it was clear that 9 000 r.p.m. was too high (95 ends down) and the speed had to be reduced to 7 000 r.p.m. which still gave too many ends down. The speed of 9 000 r.p.m. was maintained throughout for the core-spun yarns. The improvements in the properties of the yarns when the filament was used are obvious from Table VIII.

Due to the fact that these tops were undyed, it was not possible to assess visually whether the filament was properly covered in the yarn. Doubt existed particularly in cases where only one roving was used. Therefore, cross-sections were made of these yarns of which two types are shown in Fig. 3(a) and (b). Most of the cross-sections were of the form shown in Fig. 3(a), demonstrating that the filaments were well covered, and probably only about 25% of the cross-sections made approached the form shown in Fig. 3(b).

A very small percentage had the filament completely on one side of the yarn cross-section. It must, however, be pointed out that these cross-sections were made from the yarns after winding. When these yarns are knitted the filaments will tend to move to the outside to a larger extent, as was shown earlier.

Preliminary tests were carried out on different spinning ring and front roller diameters. The spinning performance of core-spun yarns did not differ much when rings of 62 mm or 50 mm were used. Yarn properties were very much the same, and ends down during spinning could not be distinguished. All these trials were carried out at 9 000 r.p.m. It may be that some differences will become noticeable at higher speeds.

(a)



(b)

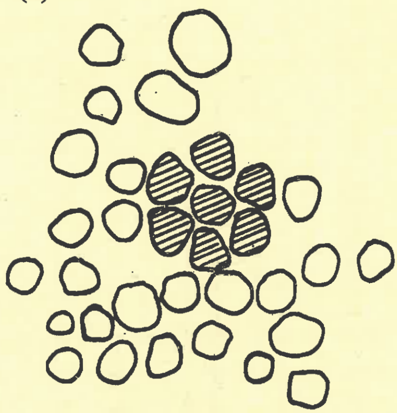


FIGURE 3

Cross section of a core spun yarn (14 tex) with a single roving feed
Magnification : 1 600

TABLE VIII

SPINNING PERFORMANCE AND YARN PROPERTIES USING ONLY ONE ROVING DURING SPINNING (19,6 MICRON UNDYED WOOL)

Yarn linear density (tex)	18		14			13	
Spinning speed (r.p.m.)	9 000	9 000	7 000	8 000	9 000	7 000	9 000
Number of ends down (per 100 Sp. hrs)							
without filament	9,9	9,5	16,4	47,0	95,0	39,0	–
with filament	1,0	4,8	–	–	4,7	–	9,1
Yarn irregularity (% C.V.)							
without filament	20,6	21,3	23,8	24,4	24,0	24,0	–
with filament	20,5	20,4	–	–	22,5	–	22,3
Yarn breaking strength (gram)							
without filament	109,4	91,0	76,0	75,2	75,4	70,2	–
with filament	190,0	185,6	–	–	168,8	–	169,2
C.V. of Breaking Strength (%)							
without filament	17,3	16,8	19,2	19,1	17,9	21,2	–
with filament	10,3	7,4	–	–	6,5	–	7,5

Front roller diameter was found to make a difference although not very substantial. The smaller front roller (30 mm) yielded better spinning results compared with the 38 mm diameter. This difference in spinning performance was more noticeable when fine yarns were spun. It appears, therefore, that the closer ratch (front roller to apron distance) in the case of the smaller front roller resulted in better fibre control during drafting and may be beneficial when spinning fine yarns.

SUMMARY

Core-spun yarns were produced from different types of wools with a nylon 20 denier textured multi-filament as core. When spinning twist was in the Z direction, only those filaments with a resultant torque in the S direction were suitable. The filaments had to be extended more than 20% prior to spinning in order to produce a satisfactory yarn. A comparison was made of samples knitted from core-spun, intimate blend spun and 100% wool yarns. It appeared that the core-spun yarns were best as regards pilling, while the intimate blend yarns with 20% and 30% of nylon had the highest abrasion resistance.

The physical properties of the core-spun yarns were significantly better than those of the other yarns. Both one roving and two roving feeds were used satisfactorily, but the lower drafts during spinning resulted in better performance. Much higher spinning speeds could be maintained with the core-spun yarns.

Spinning ring sizes did not matter much for core-spinning at a speed of 9 000 r.p.m. The front rollers of 30 mm diameter gave slightly better spinning performance than the 38 mm rollers.

ACKNOWLEDGMENTS

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THE USE OF PROPRIETARY NAMES

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