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Processing Performance of South African Wools on the Woollen System of Manufacture

Part I: The Effect of Fibre Properties on Spinnability

by

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PROCESSING PERFORMANCE OF SOUTH AFRICAN WOOLS ON THE WOOLLEN SYSTEM OF MANUFACTURE

PART I: THE EFFECT OF FIBRE PROPERTIES ON SPINNABILITY

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ABSTRACT

Sixty-eight wool blends were processed on the woollen system and were assessed for spinnability by means of a Mean Spindle Speed at Break test. Spinnability improved as mean fibre length increased but deteriorated as CV of diameter and resistance to compression increased.

INTRODUCTION

Fibre properties, such as length, diameter and crimp, not only have an important influence on the properties of yarn, but also have a profound effect on processing performance during the manufacturing stages of converting the fibres into yarn. Likewise, yarn properties have an important influence on the properties of the fabrics and on the processing performance during the conversion of the yarn into fabric. Finally, the fibre and yarn properties play an important role in the end-use of a fabric.

The inter-relationship between fibres, yarn and fabric properties, is both important and complex, and while scientific literature is plentiful on the subject for the worsted-system of manufacture, it is extremely sparse for the woollen system. It was therefore decided to study the relationships between fibre physical properties and the physical properties of the yarns produced on the woollen system of manufacture, and also to determine their effect on the physical properties of the knitted fabrics.

This paper, the first in this series of publications, deals with the effect of fibre properties on spinnability and describes the method utilised to assess spinnability.

EXPERIMENTAL

Raw Materials

Sixteen raw wool lots plus one commercially carbonised type, as well as one lot of raw karakul and a bleached lot of the same karakul type were selected for the investigation and were all processed on a full scale processing line at the Scottish College of Textiles. The ranges of the most important fibre properties spanned by the raw wool lots are given in Table 1 while the correlations between the fibre variables are given in Table 2. The wools were processed individually as well as in blends giving a total of 68 lots. The fibre properties of the individual raw wool lots are given in Appendix Table 1 while the details of the actual blending schedule are given in Appendix Table 2.

Blending, Opening and Oiling

The scoured and dyed wools were layered in a sandwich fashion and vertical cuts taken and fed to a Willey. The wool thus opened were again layered and each layer sprayed with a 50% oil in water emulsion to a total concentration of 7% ®Yarnol AS (Vickers) on a mass of wool. Vertical cuts were again fed to a Fearnought for further opening and blending.

TABLE 1
MEANS AND RANGES OF THE VARIOUS RAW WOOL FIBRE PROPERTIES

CODE	PROPERTY	MEAN	STANDARD DEVIATION	RANGE
D	Diameter (μm)	24,1	3,4	18,8 – 30,4
CV_d	CV of diameter (%)	24,7	3,9	20,3 – 43,1
L	Length (mm)	80,9	14,0	41,2 – 106,1
CV_ℓ	CV of Length (%)	33,6	7,5	22,1 – 63,9
RL	Resistance to compression (mm)	18,1	2,0	14,8 – 24,2

TABLE 2
CORRELATIONS BETWEEN THE INDEPENDENT VARIABLES (n = 68)

	D	CV_d	L	CV_ℓ	RC
D	1,000				
CV_d	0,493	1,000			
L	0,554	—	1,000		
CV_ℓ	−0,394	0,247	−0,606	1,000	
RC	−0,469	—	—	0,422	1,000

Carding

The oiled blends were carded on a one metre wide Haigh Chadwick card consisting of a breast, single part scribbler, one part intermediate and two part carder. The scribbler was connected to the intermediate by means of a broadband straight fibre feed while the intermediate was connected to the carder part by means of a broadband diagonal fibre feed. The four-height condenser delivered 80 good ends. A production rate of 5 kg/hr was maintained for the wools finer than 24 μm while the production rate was increased to 8 kg/hr and slightly more open settings were used when wools coarser than 24 μm were carded.

Spinning

All spinning experiments were carried out on a Platt's Model MWR 4 woollen spinning frame equipped with 40 spindles and 100 mm diameter rings.

Mean Spindle Speed at Break test

Since no accelerated test for the determination of the spinning performance on the woollen system could be found in the literature and because the MSS test developed for wool[1] and applied to cotton[2] appeared to have potential, it was decided to investigate the possibility of applying this technique to the woollen system.

Spinnability was assessed at a twist level where yarn strength was a maximum because the effect of the lubricant on spinnability would be smaller and less variable. For the latter purpose, nine fibre lots varying in physical fibre properties (Appendix Table 3) were individually spun into 100 tex yarns at increasing levels of twist.

A plot of yarn tensile strength against twist (Fig. 1) shows that yarn strength increased as twist increased, reaching a maximum for most of the yarns at a twist level of about 400 turns per metre. This corresponds to a tex twist factor of 40 which is in fair agreement with the twist factor of 48 arrived at for maximum yarn strength by Hearle and El-Sheikh[3]. The spinnability tests were therefore carried out at a twist level (nominal) of 413 turns per metre.

The number of end breaks that would occur during the actual spinning of a 100 tex yarn with a tex twist factor of 41 is very low and to speed up the process of end breaks, heavier travellers were used whereby spinning tension, and thus the number of end breaks at low spindle speed, was increased. The actual traveller mass was determined by trial and error. It was found that, for the specific machine and spinning conditions, a 710 mg nylon traveller was required to bring the ends down within an acceptable range of spindle speeds of 3200 to 7000 rev/min.

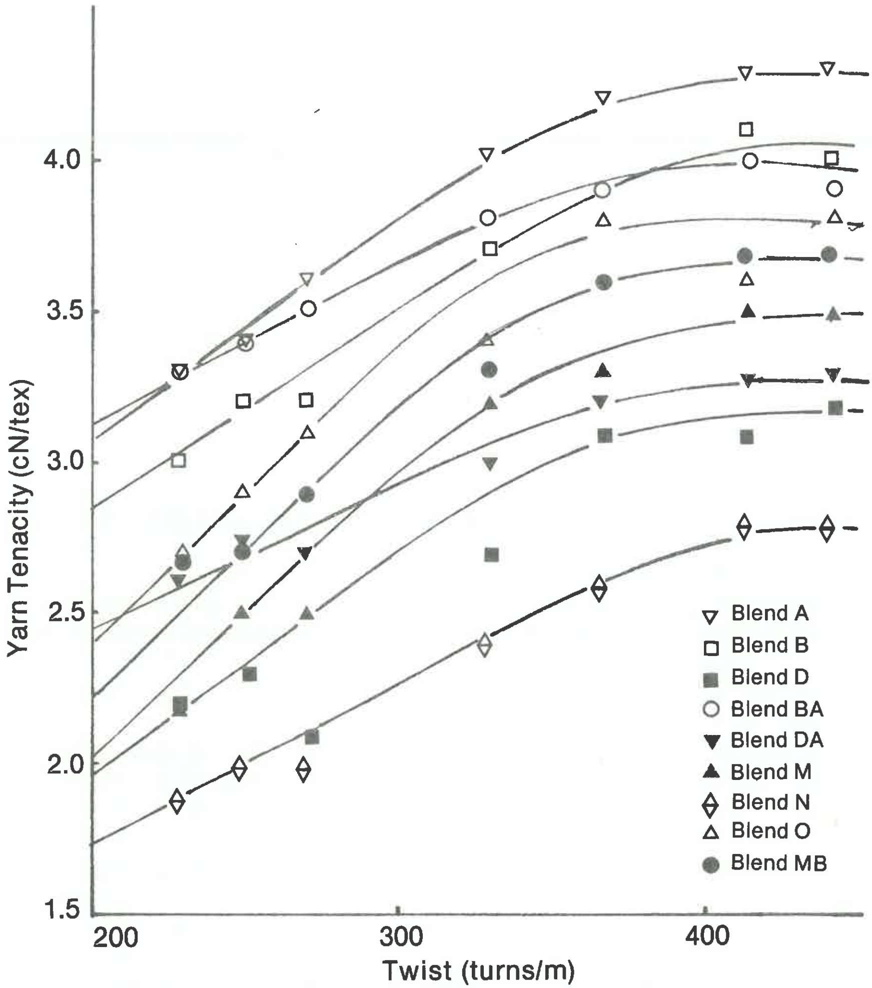

Fig. 1 — The effect of increasing twist upon yarn tenacity.

Variation in yarn tension during the building of the base of the spinning tube was another problem that had to be dealt with. This problem was overcome by building up the bases of 20 tubes with yarn until the foundation of the tube was completed. The latter was coated with resin, allowed to dry and smoothed down. Thus tension variation during the initial stages of cop building was eliminated and a considerable amount of time and yarn saved.

The actual MSS test was carried out on a Platt's Model MWR 4 spinning frame over 20 spindles. The false twist tube speed was set such that it was 1 350 rev/min at a spindle speed of 5 000 rev/min, while 710 mg travellers were fitted to the 100 mm diameter rings.

TABLE 3
EXAMPLE OF TEST RESULTS OF A MEAN SPINDLE SPEED AT BREAK TEST AND THE CALCULATION OF THE MSS VALUE

SPINDLE SPEED REV/MIN A	NO OF ENDS DOWN B	PRODUCT AB
3 200	0	—
3 500	0	—
4 000	2	8 000
4 500	4	18 000
5 000	3	15 000
5 500	6	33 000
6 000	4	24 000
6 500	1	6 500
7 000	0	—
7 500	0	—
TOTAL	20	104 500

$$\text{MSS at break} = \frac{\Sigma AB}{n} = \frac{104\ 500}{20} = 5\ 225 \text{ rev/min.}$$

(where A = Spindle speed
B = No. of end breaks at a particular spindle speed, and
n = total number of spindles in use)

Spinning was started at a spindle speed of 3 200 rev/min and spinning continued at this speed for 5 min. At the end of the 5 min period the number of ends that came down were counted and recorded. Ends that came down were not pieced. The spindle speed was then increased to 3 500 rev/min and spinning continued for 5 min at the end of which period the number of ends that came down at that speed were also recorded but not pieced up. This process was repeated, increasing the spindle speed after every period of 5 min by 500 rev/min up to a machine maximum of 7 000 rev/min. Ends that were still spinning at the end of the 5 minute period at 7 000 were taken to have come down at 7 500 rev/min.

The mean spindle speed is calculated by summation of the product of the spindle speed and the number of ends which came down at that particular spindle speed, divided by the number of spindles. An example of such a calculation is given in Table 3. Results of the MSS tests are given in Appendix Table 4.

RESULTS AND DISCUSSION

Effect of Fibre Properties on MSS

Multiquadratic analysis was performed on the results in their standard form. The individual MSS values were taken as dependent variable and regressed with fibre diameter (D), CV of diameter (CV_d), fibre length (L), CV of length (CV_ℓ) and resistance to compression (RC) as independent variables. The most significant regression equation, using the forward selection procedure is given below.

$$MSS = 64L - 3,2\,CV_d.RC - 0,4\,L^2 + 4194$$
$$r = 0,69 \,;\, n = 68$$

The equation shows that MSS increased as fibre length increased up to a mean fibre length of 80 mm after which it decreased with further increases in mean fibre length. MSS, however, decreased when CV of diameter and resistance to compression increased. The term CV_d.RC contributing 73% while L contributed 27% to the multiple correlation coefficient.

Fig. 2 illustrates the effects of mean fibre length, CV of diameter and resistance to compression on MSS.

SUMMARY AND CONCLUSION

Spinnability, on the woollen system, of sixteen virgin wools, a carbonised wool, a karakul lot and a bleached lot of the same karakul type were assessed individually as well as in blends by means of a technique based upon the Mean Spindle Speed at Break (MSS) method developed for the worsted system.

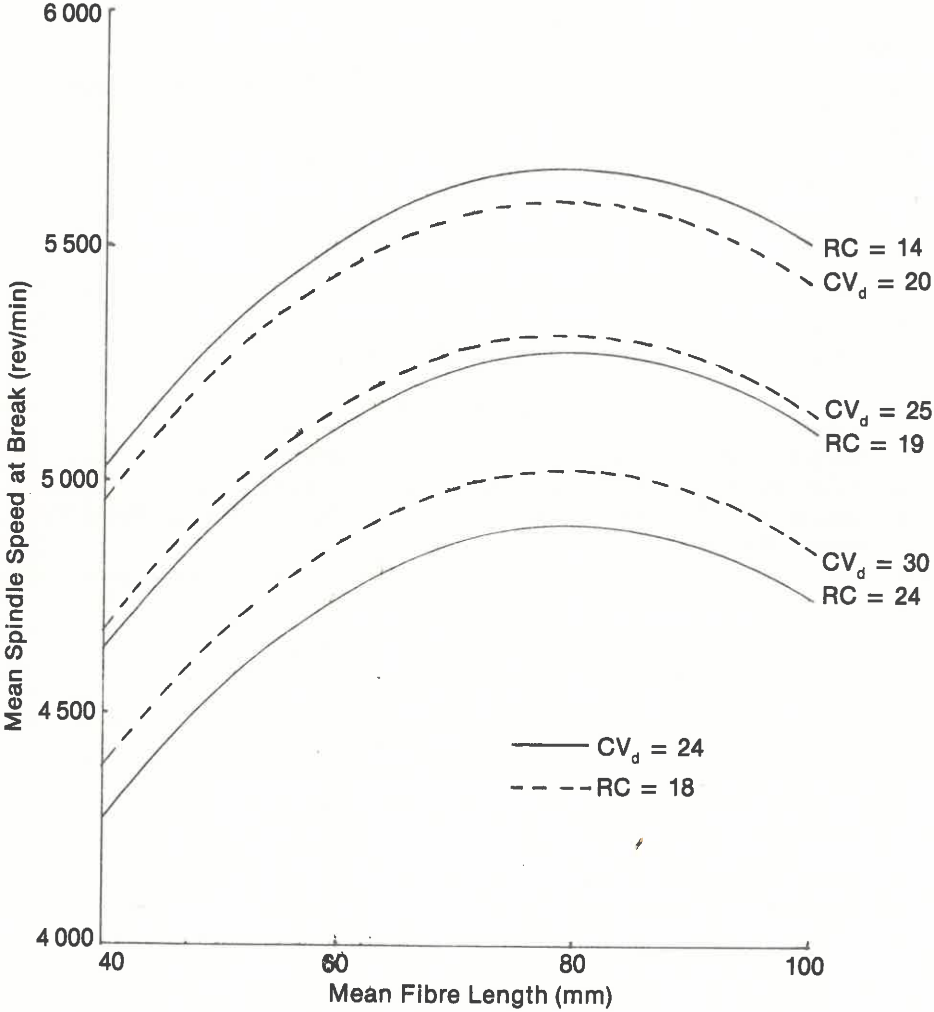

Fig. 2 — The Effect of Mean Fibre length, CV of Diameter and Resistance to Compression on Mean Spindle Speed at Break.

Multiple regression analysis of the results showed that spinnability deteriorated when CV of diameter and resistance to compression increased but improved as mean fibre length increased up to a mean fibre length of 80 mm .

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USE OF PROPRIETARY NAMES

The names of proprietary products where they appear in this report are mentioned for information only. This does not imply that SAWTRI recommends them to the exclusion of other similar products.

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1. Turpie, D.W.F., *SAWTRI Tech. Rep.* No. 240 (Feb., 1975).
2. Thierron, W., *SAWTRI Tech. Rep.* No. 555 (August, 1984).
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Appendix

TABLE 1
FIBRE PROPERTIES OF THE INDIVIDUAL BLENDS BEFORE CARDING

LOT	Fibre Diameter		Fibre Length		Staple Crimp (per cm)	Resistance-to Compression (mm)	BUNDLE TENACITY (cN/tex)	
	Mean (μm)	CV (%)	Mean (mm)	CV (%)			Scoured	Dyed
A	18.8	22.8	62.5	38.8	4.0	16.5	12.6	9.2
B	19.1	22.8	46.5	39.8	3.5	16.1	13.1	10.4
C	22.0	23.5	67.8	25.7	3.7	17.3	12.8	11.4
D	21.1	22.9	69.8	32.8	5.1	22.2	11.2	9.1
E	19.5	22.4	77.7	26.0	4.1	17.4	11.7	11.5
F	20.7	23.6	51.3	37.2	5.8	24.2	11.6	9.4
G	22.4	24.4	96.9	28.9	3.8	17.5	13.8	12.3
H	22.8	25.6	95.3	33.4	3.1	15.9	13.6	10.5
K	22.1	28.5	53.3	63.9	3.6	20.9	10.8	9.9
L	20.3	23.4	41.2	53.4	3.5	19.5	10.4	9.3
M	21.4	22.3	92.8	39.4	4.2	20.9	13.2	9.9
N	21.7	21.9	95.0	35.4	4.9	21.6	11.3	9.8
O	29.8	23.1	100.5	25.1	2.0	14.8	14.9	12.7
P	30.4	25.0	106.3	28.6	2.4	18.0	14.2	12.9
R	27.9	25.1	91.8	26.9	2.6	16.9	15.9	12.2
S	29.1	20.3	91.4	22.1	3.1	16.4	14.4	13.0
T	27.1	25.0	79.4	27.4	3.4	15.6	15.0	12.0

TABLE 2
SUMMARY OF BLENDING PLAN

Component 1			Component 2			Blend
Wool Lot	Description	Proportion of Blend	Wool Lot	Description	Proportion of Blend	
A	Fine short Lambswool	30	B C D E	Fine short	70 70 70 70	BA CA DA EA
M	Fine long	70	A B C D E	Fine short	30 30 30 30 30	MA MB MC MD ME
N	Fine long	70	A B C D E	Fine short	30 30 30 30 30	NA NB NC ND NE
O	Coarse long	70	A B D E	Fine short	30 30 30 30	OA OB OD OE
K	Fine short	50	G H	Fine long	50 50	KG KH
F	Fine short	50	G H	Fine long	50 50	KG FH
T	Coarse short	50	C D E K	Fine short	50 50 50 50	CT DT ET KT
P	Coarse long	50	C E F K	Fine short	50 50 50 50	CP EP FP KP
S	Coarse long	50	K	Fine short	50	KS
T	Coarse short	50	G H	Fine long	50 50	GT HT

Component 1			Component 2			
Wool Lot	Description	Proportion of Blend	Wool Lot	Description	Proportion of Blend	Blend
G	Fine long	50	P R S	Coarse long	50 50 50	GP GR GS
H	Fine long	50	S R	Coarse long	50 50	HS HR
T	Coarse short	50	S P	Coarse long	50 50	TS TP
R	Coarse short	50	P	Coarse long	50	RP
L	Fine short carbonised	50	C E	Fine short	50 50	CL EL

Components				
Wool Lot	Description	Proportion of Blend	Description	Blend
F G P S	Fine short Fine long Coarse long Coarse long	10 10 40 40	Four component blend	V
G P R T	Fine long Coarse long Coarse short Coarse short	20 30 30 20	Four component blend	W
Y_1 S G F	Bleached Karakul Coarse long Fine long Fine short	40 40 10 10	Four component blend containing bleached karakul	Y_3
Y_1 K P	Bleached Karakul Fine short Coarse long	40 20 40	Three component blend containing bleached karakul	Y_4
Y_2 S G F	Karakul Coarse long Fine long Fine short	40 40 10 10	Four component blend containing karakul	Y_5
Y_2 K P	Karakul Fine short Coarse long	40 20 40	Three component blend containing karakul	Y_6

TABLE 3

DETAILS OF WOOL LOTS SPUN INTO 100 TEX YARNS OF DIFFERENT TWIST LEVELS

Lot	Fibre Diameter (μm)	Single Fibre Length (mm)	Stape Crimp (crimps/cm)
A	18.8	62.5	4.0
B	19.1	46.5	3.5
D	21.1	69.8	5.1
BA	19.0	51.3	3.7
DA	20.4	67.6	4.8
M	21.4	92.8	4.2
N	21.7	95.0	4.9
O	29.8	100.5	2.0
MB	20.7	78.9	4.0

TABLE 4

Appendix

SPINNING PERFORMANCE RESULTS OF THE INDIVIDUAL FIBRE BLENDS

LOT	MSS (rev/min)	LOT	MSS (rev/min)	LOT	MSS (rev/min)
A	5325	MB	5475	GS	5500
B	5000	MC	5475	GT	5800
C	5400	MD	5220	HR	5120
D	4630	ME	5300	HS	5700
E	5975	NA	5285	HT	5235
F	4600	NB	4835	KP	5850
G	6100	NC	5300	KS	5000
H	5550	ND	4845	KT	5325
K	4650	NE	5325	OA	5700
L	4365	FG	5050	OB	5475
M	5250	FH	5460	OD	5450
N	4670	KG	5375	OE	5550
O	5310	KH	5575	RP	4950
P	5475	CT	5650	TP	5425
R	5195	CL	5700	TS	5425
S	5375	EL	5225	V	5200
T	5450	CP	5525	W	5575
BA	5335	DT	5000	Y_1	4345
CA	5400	EP	5360	Y_2	4300
DA	5100	ET	5875	Y_3	5300
EA	5900	FP	5170	Y_4	4900
MA	5625	GP	5435	Y_5	4895
		GR	5660	Y_6	5000

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