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ON THE PROCESSING CHARACTERISTICS OF S.A. MERINO WOOLS

PART IV: PROCESSING LAMBSWOOL ON A MODIFIED WORSTED SYSTEM

by

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INTRODUCTION

Lambswool is reputed to possess certain distinctive properties which make it especially suited for selected end uses. A systematic investigation of these desirable properties has not appeared in the technical literature and a satisfactory scientific demonstration of them will, in any case, be difficult. The special features that are generally ascribed to lambswool are summarised below.

It generally possesses superior whiteness and can be readily identified in a wool store when compared with other types of raw wool.

In spite of the fact that fibre fineness is closely related to handle[1], lambswool is generally softer than its adult equivalent. Those lambswools of sufficiently soft handle to qualify for blending with cashmere are generally the more expensive types and have been found[2,3] to be of high plasticity. Whiteley's work, however, has never been followed up, probably due to plasticity determinations being so time consuming. Following another line, Venter[4] measured at 6-month intervals the crimp frequency and resistance to compression of wool grown in a merino flock from birth up to the age of 2½ years. He found the crimp frequency of the wool to remain fairly constant, diminishing by only about 0.39 crimps during this period. The resistance to compression, however, increased by about 12% during the growth period from six months to one year. This increase can be attributed to the concommitant increase in fibre diameter.

Lambswool fibres are tapered, decreasing in diameter from the root towards a pointed tip. Venter (*loc. cit.*) also investigated the variations in fibre diameter of the merino wools mentioned above. When grown on good feeding and under identical climatic conditions he found a sharp increase of about 4.8 microns in the average fibre diameter of wools shorn from sheep between the ages of six months and one year. Berek[5] found differences between the fibre fineness of lambs and adult sheep of some 2 microns. The tendency for the fibre to increase in diameter between the first and second shearing was also observed in work carried out by Slen and Banky[6].

The tip of a lambswool fibre is usually curly, but the curvature of the tip is somewhat lower than that of the crimps further down the fibre.

According to the South African Wool Commission standards, merino lambswool is graded into three main types, i.e. washing, combing and carbonising. These three groups are sub-divided according to fibre length but no distinction is made with regard to the usual concepts of quality fineness. Wool buyers, however, are cognisant of the quality differences and usually pay a premium for the soft, fine lambswool which is then blended with cashmere.

Very little has been published on the processing properties of lambswool although it is accepted that these yarns are often spun on the woollen system. The present report provides further knowledge of the processing and other properties of lambswool. The lambswool used in this experiment is followed from the scoured state to the final fabric and various physical tests are performed along the way. At the same time a modified system of worsted spinning, resembling the semi-worsted system, is introduced. The suitability of this system for processing lambswool is also discussed.

EXPERIMENTAL

A. Processing

Raw Materials

An 80-lb lot of a good length, fine type 122/129 lambswool was used. The raw wool had a mean fibre length of 5.5 cm, an average fibre diameter of 17.0 microns and the number of crimps per inch was 13.5. The grease and suint contents were 15.9% and 7.2%, respectively.

Scouring

Using Lissapol NX (I.C.I.) and soda ash the wool was scoured on a rake type four bowl Petrie and McNaught pilot plant to a residual grease content of 0.5%. In order to preserve the excellent handle of the lambswool, the scouring conditions were slightly milder than usual. The temperatures of the successive bowls were 50°, 50°, 45° and 40°C, respectively and the soda ash content in the first bowl was lower than usual (0.75 lbs/100 lbs grease wool as against 1.5 lbs/100 lbs for normal wool). The temperature in the Fleissner drier was maintained at 60°C.

(The scouring yield was 68% at 17% regain.)

Carding

Before carding, the regain of the 52 lbs of scoured lambswool was raised from 13% to 17% and 0.25% Eutectal was added.

The wool was carded on a 22″ wide Turner and Atherton card clothed with metallic clothing except for the workers. This small machine proved to be convenient for experimental purposes but was not equipped with any device for the removal of vegetable matter. This card was of the single swift type.

Initially, the wool proved difficult to card due to its slippery nature and additives had to be used to facilitate the drawing off of the web. The addition of 0.4% Leomin KP (Hoechst), a quaternary derivative of a fatty acid, rendered the inter-fibre cohesion high enough for the sliver to be drawn from the doffer

into the coiling can. Unfortunately, with the rather high carding rate of about 20 lbs per hour necessary to obtain a sufficiently strong web, the nep count became rather high and a second carding was therefore required to reduce the nep count to a more reasonable level.

Drawing, Spinning, Twisting, Steaming and Knitting

A total of 24 card slivers was put up at an auto-leveller to obtain a sliver of reasonable regularity before drawing. The auto-levelled sliver was gilled three times. Each time the draft was sufficiently higher than the number of ends up to produce a final sliver of 3500 tex (72 dr/40 yds). This sliver was suitable to be roved on a high drafter into a roving of 422 tex (8.8 dr/40 yd). The drafting procedure is set out in the draft plan (Table I).

TABLE I

Details of Drafting Sequences

Machine	Weight in	Ends up	Draft	Weight out
Gill box	16500 tex 342 dr/40 yds	4	6	11000 tex 227 dr/40 yds
Gill box	11000 tex 227 dr/40 yds	4	7	6300 tex 130 dr/40 yds
Gill box	6300 tex 130 dr/40 yds	4	7.2	3500 tex 72 dr/40 yds
Draw box	3500 tex 72 dr/40 yds	2	16.3	422 tex 8.8 dr/40 yds
Spin frame	422 tex 8.8 dr/40 yds	1	12.5	34 tex 1/26's w.c.

No problems were encountered during gilling and the high drafter handled the fibres quite well. The 34 tex (1/26's w.c.) yarn with 470 t.p.m. (12 t.p.i.) spun satisfactorily at 6000 r.p.m. The singles yarn was steam set in an Andrews Mini-setter. The yarn was exposed to two cycles each of which consisted of evacuation to 10 cm of mercury, steaming at 95°C for 10 minutes and re-evacuation.

A two-fold yarn having 250 t.p.m. (6.4 t.p.i.) was made. This yarn was steam set under the same conditions as employed for the singles. It was waxed twice on a Schweiter unit and then knitted on a Blackburn single jersey circular knitting machine to a cover factor of 1.2.

Dyeing and Shrinkproofing

Scouring

The knitted lambswool fabric was scoured for 20 min at 45°C with 0.5 g Eriopon HD (Geigy)/l and subsequently rinsed.

Dyeing

The dyebath was set with 10% sodium sulphate and 3% acetic acid (40%) and the material run at 40°C for 10 min. After addition of 2% Brilliant Alizarine Milling Blue 2RL (C.I. Acid Blue 126) the temperature was raised to 60°C over 10 min, held for 10 min, and then raised to 85°C at a rate of 1°C/min. After 45 min at 85°C the fabric was rinsed and dried.

Shrinkproofing

Wetting out was done in a winch using 10 g sodium sulphate/*l* and 0.5 g Tergitol TMN/*l* for 15 min at room temperature (± 23°C) and pH 6.0. The material was lifted and 3% dichloroisocyanuric acid (DCCA) and 2% potassium permanganate (on dry weight of fabric) were added to the bath. The material was treated for 35 min at room temperature, whereafter the temperature was raised to 35°C over 15 min and held for 20 min. The bath was drained and the fabric treated for 5 min at room temperature in a liquor containing 0.7 g sodium bisulphite/*l*. The pH was subsequently lowered to 4.5 (acetic acid) and after a further 5 min the temperature was raised to 35°C (1°C/min) and held for 20 min. The fabric was well rinsed and neutralised with 3% tetra-sodium pyrophosphate.

B. Testing Procedures

A number of mature wools of a diameter similar to that of the lambswool was also tested for purposes of comparison. In Tables II and III various physical properties of these mature wools, A – F, are given together with those of the lambswool.

Yarn properties

Yarn irregularity was recorded on the Uster irregularity tester and the breaking strength and extension at break were recorded on the Uster Dynamometer. Yarn thickness was obtained on the Reynolds & Branson tester. The friction was measured on the SAWTRI kinetic yarn friction tester before and after waxing.

Felting

The felting rate was investigated employing the standard Aachen test procedure as modified by Faure[7].

Resistance to compression

The resistance to compression of the lambswool was determined as described by Slinger and Smuts[8].

Scale structure

Consideration was given to the possibility that the scale structure of lambswool may be different from that of mature wools. With this in mind a number of fibre profiles was drawn and the scale heights were measured using a method similar to that described by Scheepers[9].

Handle

In order to establish whether the handle of lambswool was indeed superior to that of mature wools of the same fibre diameter, experienced judges were requested to rate the seven wools in order of softness.

Single fibre friction

An Instron with a capstan attached to the cell was employed to determine the coefficient of friction with and against the scales for the seven wools referred to above. The rubbing surface was an unpolished ebonite rod, 1 cm in diameter. The pull-over speed was 0.05 cm/min.

Pilling of knitted fabric

A Martindale abrader was employed to determine the difference in pilling behaviour between the shrinkproofed and untreated materials. The samples were abraded self on self. The weight of pills and pill-like ensembles was obtained and used as a measure of the pilling propensity of the fabric.

Shrinkage tests

These were done in the 50 *l* Cubex using 12.5 *l* phosphate buffer (pH 7) at 40°C and a total load of 1,000 g.

RESULTS AND DISCUSSION

Processing Performance

This experiment has shown that a lambswool of reasonable length can be processed on the worsted system without combing. The handle of the knitted piece was exceptionally soft. Due to a slight milling action during winch dyeing, yarn defects such as neps became obscured.

Since some vegetable matter may remain in the sliver if combing is omitted, it is recommended that only lambswool which contains little of this type of impurity should be considered for processing as described above. A fair proportion of the vegetable matter remaining in the slivers dropped out during drawing and spinning. These processes proceeded without undue difficulties.

Test Results

The yarn regularity (Uster) was rather worse than average (C of V% = 19.9) due to the omission of combing resulting in the presence of short fibres, vegetable matter and a very high nep count of 1,370 per 1,000 m.

Experience has shown, however, that a high incidence of neps is usually associated with a fine fibre.

The breaking strength and extension at break (Uster) of the yarn were 202.3 g and 11.6%, respectively, which are slightly lower than the average[10] for worsted yarns. The presence of short fibres and neps may contribute to such a decrease.

Yarn thickness measurements did not show any difference in diameter between the lambswool yarn (0.190 mm) and a worsted yarn (0.189 mm) of similar count and twist. However, the method of measurement which involves pressing the yarn between two contact plates may influence the results by decreasing a possible difference between the two yarns measured.

Frictional force as measured on the SAWTRI yarn friction tester was 32 g (coefficient of friction = 0.232) for the unwaxed yarn and it decreased to 17.5 g (coefficient of friction = 0.128) after two successive wax applications. These values may be considered normal for an undyed, unwaxed yarn and an undyed waxed yarn, respectively.

Data of the felting behaviour, resistance to compression and handle scores of the seven wools under consideration appear in Table II.

TABLE II

Physical Properties of a Lambswool and Selected Adult Wools

Sample No.	Diameter (microns)	Crimps per Inch	Handle Score*	Resistance to Compression (g/cm^2)	Felting density (g/cc)
Type 121/122					
Lambswool	17.0	13.5	9	50.5	0.115
A	17.0	10.2	0	45.0	0.156
B	17.0	7.5	9	37.0	0.147
C	17.6	9.2	4	42.0	0.123
D	17.2	8.8	3	54.0	0.150
E	17.9	9.6	5	46.0	0.141
F	16.2	9.4	12	40.0	0.126

* A score of 12 indicates the softest and 0 the harshest handle.

Investigations into the felting behaviour of the wool[11] indicated that the lambswool had a lower felting rate than adult merino wools of similar fibre diameter.

The relatively high resistance to compression (50.5 g/cm^2) of the lambswool can be explained in terms of the high crimp frequency relative to its particular fibre diameter[8,12].

From the results in Table II, it appears that the lot of lambswool used in this experiment was considered softer than its adult merino equivalents of similar fibre diameter.

It was noticed that when sliding the fibre against the scale, the tension built up to a certain value and then decreased suddenly as the fibre slipped. This gave a saw-tooth trace (the so-called stick-slip effect) on the Instron and the peak height is the average height of the peaks observed in this manner.

All data regarding single fibre friction of the seven wools are given in Table III.

TABLE III

Frictional Properties of a Lambswool and Selected Adult Wools

	M_A	M_W	M_A-M_W	Peak height (g)
Lambswool	0.198	0.079	0.119	0.11
A	0.246	0.079	0.167	0.28
B	0.211	0.090	0.121	0.13
C	0.200	0.087	0.113	0.13
D	0.226	0.100	0.126	0.25
E	0.193	0.103	0.090	0.15
F	0.211	0.087	0.124	0.14

Various correlation coefficients were calculated but most of these did not reach the 5% level of significance (required t = 0.754 for 5 degrees of freedom). Because the handle could not be described in terms of the resistance to compression alone, an effort was made to relate the handle to certain frictional properties, viz. M_A the coefficient of friction against the scales, M_W, the coefficient of friction with the scales, M_A-M_W which was regarded as a measure of the directional friction effect (D.F.E.) and the peak height of the recorded trace in grams tension.

Table IV gives the correlation coefficients calculated for these quantities on the data in Tables II and III.

TABLE IV

Correlation Coefficients Obtained on Various Wools

	M_A	M_A-M_W	Peak height
Felt density against	0.714	0.440	0.783*
Handle score against	– 0.549	– 0.405	– 0.770*

(*Significant at the 5% level)

For both felt density and handle score, one notices that the correlation coefficients against M_A and against M_A-M_W are not significant. It may be argued that in these cases, as with resistance to compression, significant correlation coefficients would have been obtained with a greater number of degrees of freedom or with wools not sampled from such a narrow diameter range. For these wools, however, the handle and felting behaviour seem to be explicable in terms of the stick-slip effect noticed on the Instron traces. This was confirmed by further analysis involving multiple regression analysis of handle score against the average fibre fineness and peak height. Both regression coefficients were now significant (t = 3.22 and –4.40, significant at the 5% and 1% levels, respectively) and a total correlation coefficient of 0.955 was obtained. Therefore the behaviour of the lambswool in the handle tests is in accordance with its diameter and with its fibre frictional properties.

The above relationships have been noticed on some other handle tests performed here[13] but its mechanism is not quite clear. It is possible that the reason could lie with the dimensions of the scales as suggested by McPhee[14]. However, the average scale heights of the two samples with extreme handle scores differed by only 15% (0.73 micron vs. 0.85 micron) in their scale height. This may not be sufficient to explain the large difference observed in the handle.

A multiple regression analysis of felting against the fibre crimps per inch and peak height was also carried out. The total regression coefficient was 0.899 with corresponding t values for the crimps per inch, the peak height being –1.70 and 2.68 respectively. Reference is made by Moncrief[15] to the relation between feltability and frictional properties.

Comparing the pilling behaviour of the shrinkproofed piece with the untreated piece, all pill-like ensembles were collected from the sample used in the Martindale abrader. The weight of pills removed from the DCCA-permanganate-treated sample was less (0.068 g) than the pills which formed on the control sample (0.080 g).

The shrinkage values for the knitted lambswool sample after treatment for periods of an hour and two hours were 1.5% and 9.8%, respectively. These results are based on the dimensions of the fully relaxed samples and comply with the Woolmark specifications.

SUMMARY

A lot of nine-months lambswool was satisfactorily processed on the continental worsted system omitting combing.

During carding the fibre cohesion had to be increased in order to render the card sliver strong enough to withstand the tension between the doffer and the coiler.

The yarn was knitted into fabric to a cover factor of 1.2. The knitted fabric was dyed and shrinkproofed with DCCA/permanganate. The handle of the finished fabric was very soft.

Although the original yarn was rather irregular in terms of worsted yarn specifications and contained many neps, a slight milling action during dyeing on the winch obscured these defects in the resultant cloth.

Laboratory tests showed the lambswool to have a relatively lower felting propensity than merino wools of similar diameter.

The handle of lambswool was superior to that of mature wools having the same diameter. There was strong evidence of the handle being related to both the fibre fineness and fibre frictional properties.

The incidence of pills was lower on the shrinkproofed piece than on the untreated piece.

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