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SPINNING MOHAIR USING THE BRADFORD (CAP, RING OR FLYER) SYSTEM AS WELL AS A COMBINED BRADFORD/FRENCH SYSTEM

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Keywords: Mohair, Bradford and French spinning, cap, ring, flyer, fibre fineness, fibre length, ends down, yarn strength, yarn irregularity, yarn hairiness

ABSTRACT

Yarns from the relatively fine mohair fibres were stronger, more regular and could be spun into finer counts. Long fibres produced stronger yarns. Cap spun yarns were more hairy, stronger and could be spun finer than ring or flyer yarns. Yarns of good regularity were spun from low twist Bradford rovings on a double apron French type ring spinner.

Yarn hairiness was influenced by spinning speed, the spinning mode, fibre fineness and length, roving and yarn twist and the use of balloon separators.

INTRODUCTION

For many years the processing of mohair was largely restricted to the Yorkshire area where the Bradford system, incorporating the draft-against-twist principle was found to be ideally suitable for the processing of long fibres such as mohair. Villers[1], in her survey of the mohair industry refers to the Bradford system only and mentions that flyer and cap spinning are used. There is evidence, however, that mohair is also spun on the French system and trials[2,3] have been conducted to investigate some aspects of mohair spinning on this particular system. This report, however, is mainly concerned with the Bradford system.

Barmby and Townend[4] investigated the hairiness and lustre of mohair fabrics and found yarn hairiness to increase with spinning speed and with the number of rewindings. Neither spinning speed nor the number of rewindings, however, seemed to affect the lustre of the finished fabric woven from the resultant yarns. In the mill, hairiness is judged visually by placing packages side by side and if further comparison is required the yarn is wound on a card of contrasting colour and compared with a standard yarn. Barella and Ruiz-Cuevas[5] found this type of visual ranking to be related to the number and projecting length of the hairs as they appear on the package. Instruments have been developed by Onions and Yates[6] and by Marouni[7] by means of which the hairiness can be measured using optical methods.

Seven lots of mohair were selected and divided into two groups of four lots, one lot appearing in both groups. The mean fibre diameters of the one group and the mean fibre lengths of the second group were similar. Spinnability tests were carried out and the physical properties of yarns spun from these lots were deter-

RESULTS AND DISCUSSION

Yarn Properties

In Table III the breaking strength, extension at break and regularity of 68 tex yarns from the seven lots as spun on the Rieter, PSS ring, PSS cap and PSS flyer are given. In the next few paragraphs the influence of the fibre properties and of the spinning mode on the yarn characteristics will be discussed and tacit reference will be made to Table III.

(a) **The influence of fibre diameter**: The fibre lengths of groups 4 to 7 are more or less comparable. Figure 1 illustrates the relationship between yarn strength and fibre diameter from which it can be seen that the coarsest fibres (Lot 5) produced yarn with low breaking strength. Yarns spun from the finer fibres of Lot 7 were not significantly stronger than those from Lot 4. This was probably due to the mean fibre length of Lot 7 being about 1 cm shorter than that of Lot 4.

The observed yarn regularity was influenced by the fibre diameter, the fine fibre yarns being more regular, due to the greater number of fibres per yarn cross-section (Table III). Yarns made from the finer fibres also seemed to have a higher extension at break.

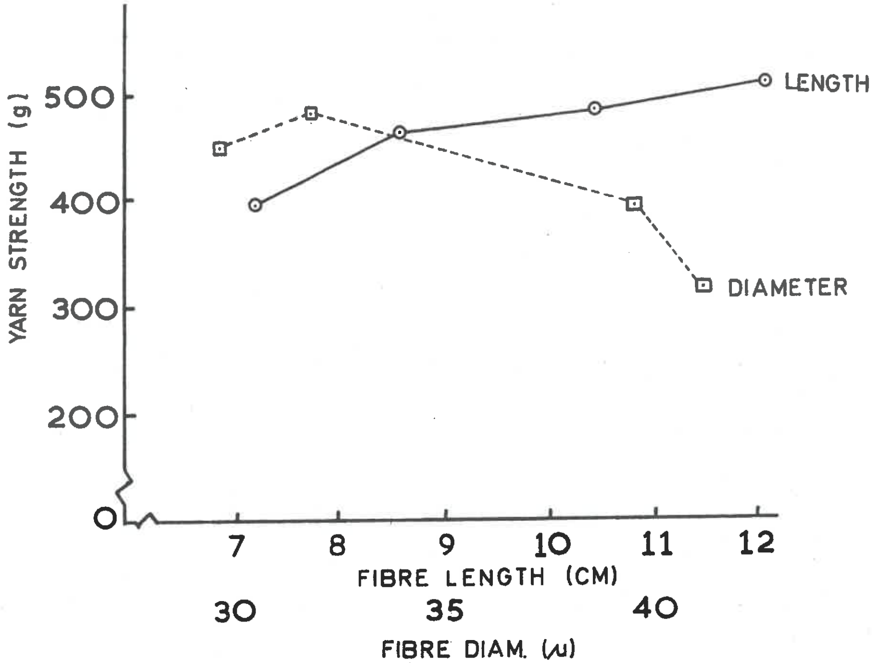

Fig. 1. Strengths of 68 tex yarns for different fibre diameters and lengths.

According to the statistical analysis (Table Vb) it appears that a yarn made from a coarser fibre is weaker than one made from a fine fibre. As to be expected the yarn irregularity was highly dependent upon fibre diameter, finer fibres causing the resultant yarn to be more regular.

(b) **The influence of fibre length**: The solid line in Fig. 1 illustrates the average breaking strengths of yarns with compatible fibre diameters (Lots 1–4), but of different fibre lengths. The Longest fibres (Lot 1), produced the strongest yarn. The extension at break (Table III) seemed to have no bearing on the fibre length, although very short fibres would, no doubt, cause a decrease in extension at break. The yarn irregularities were similar.

The statistical analysis involving fibre length confirmed most of the above and showed breaking strength to depend upon fibre length (significant at the 0.1% level) with longer fibres causing stronger yarns. Extension at break and yarn irregularity, however, were independent of fibre length.

(c) **The spinning mode**: The idea of spinning a low twist mohair roving on the double apron Rieter proved to be sound. There is more control during drafting and the regularity of these yarns was superior.

From the breaking strength data in Table III it is clear that the flyer spun yarns were consistently weaker than their ring or cap spun counterparts. The cap spun yarns tended to be the strongest followed by the PSS ring yarns.

The flyer spun yarns generally exhibited the lowest extensions at break. The amount of drag between the bobbin and the flyer will play an important rôle since the yarn has to transmit the energy necessary to rotate the bobbin resting on a felt pad and it is not unlikely that flyer spun yarns from other sources could be stronger and more elastic than the flyer yarns tested here due to the drag between washer and bobbin being less.

The covariance analysis (Table Va) confirmed differences among the four spinning modes as regards breaking strength, and yarn irregularity. The data indicated that the cap spun yarns were the strongest with the flyer yarns the weakest. The extension at break was significantly lower for flyer spun yarns. The irregularity results indicated that the Rieter yarns were the best and the flyer yarns the worst.

Comparison of Spinnability

Table IV shows the number of ends down for the seven lots, spun at 3,200 rpm for 30 min using four spindles, as well as the liner density and the number of fibres per yarn cross-section. The influence of the fibre properties and spinning mode will be discussed and the relevant information can be extracted from Table IV.

(a) **The influence of fibre diameter**: The average fibre diameters varied from 29.3 to 42 microns. The influence of the number of fibres per cross-section on spinnability is illustrated in Table IV. As the number of fibres decreased, the end breakages increased. An end breakage rate of about 10 will arbitrarily be referred to as the spinning limit. The number of fibres per yarn cross-section was mostly of the order of 20 at the spinning limit. It is interesting that yarns having such a low number of fibres per yarn cross-section could be spun at all. Apart from the low spinning speed – and, therefore, low spinning tension – the fact that the fibres were rather long probably contributed towards the spinning of a yarn with so few fibres per cross-section.

It must be stressed at this stage that the reported breakage rates are all too high for commercial purposes and the number of fibres per yarn cross-section will have to be higher during commercial spinning. For the purpose of this experiment, however, the relative spinning performance is of more importance.

In Figure 2 the linear densities at the spinning limit are plotted against the average fibre diameter for both the PSS cap and PSS ring yarns. This shows that the fine fibres could be spun into the finest yarns.

The statistical analysis (Table Vb) of the seven lots (independent of the spinning mode) showed that the spinning limit was significantly dependent upon the fibre diameter.

(b) **The influence of fibre length**: There is not much evidence that fibre length has a great influence on spinning performance. The fibre length of lot 2 was the lowest and indeed the linear density (28 tex) at the spinning limit was higher than that observed for lot 1, for example, which had a longer fibre length and which could be spun into a finer yarn.

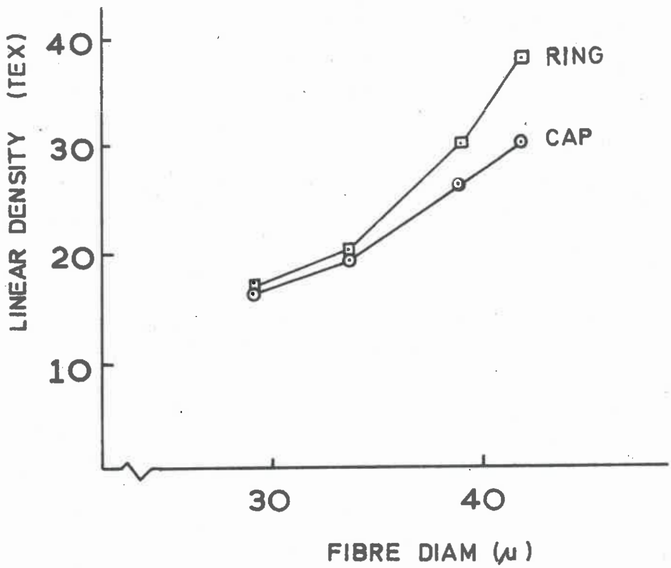

Fig. 2. Limiting yarn counts for different fibre diameters.

The statistical analysis (Table Vb) indicated a dependence between limiting count and fibre length significant at the 5% level, longer fibres making possible the spinning into a finer count.

The behaviour of lot 1 was unique in some ways. In spite of the fact that the ratches on all machines were increased to accommodate the long fibres, there was still a tendency for the yarn from this lot to form "crackers" during spinning, especially on the Rieter. The fact that the variation in fibre length of this lot was higher than that of the others, together with the long mean fibre length, could be the cause of this.

(c) **The influence of the spinning mode**: Referring to Table IV, a comparison can be made of the three spinning modes by noting the end breakage rate for the same count and lot number. The number of ends down for the cap spun yarns was consistently lower than the PSS ring reading. According to the data it seems that the PSS ring is to be preferred to the Rieter. Figure 2 shows that the cap spun yarns were finer than ring yarns, other factors being the same.

The statistical analysis (Table Va) varified the observation that the finest yarns could be spun on the cap and that the Rieter yarns were the coarsest for the same number of end breakages.

YARN HAIRINESS

Yarn hairiness can be regarded as one of the characteristic problems of mohair spinning. During this experiment the hairiness as assessed on the spinning package was used and in the majority of cases the differences in hairiness were quite obvious.

A less subjective way of measuring hairiness was also employed. The hairs removed from the spinning package were weighed and expressed as a percentage of the total yarn weight per package. This method substantiated the validity of the more subjective visual assessment. In the following paragraphs the effect of various parameters on the hairiness will be discussed and unless mentioned otherwise, the visual method was employed.

(a) **The influence of spindle speed**: During the initial stages of this investigation it became clear that a spindle speed of 6400 rpm, at which the PSS frame was running, was too high to produce an acceptable yarn and the speed was, therefore, reduced to about 3,200 rpm. The decrease in spindle speed was the first important step towards reduction of hairiness.

(b) **The influence of the spinning mode**: Generally cap spun yarns are regarded to be more hairy than ring spun yarns and mohair was no exception. For example: 0.24% of the yarn weight protruded as hair from a flyer spun yarn while correspondingly 0.80% protruded from a cap spun yarn, both yarns being spun from lot 4. The difference in hairiness between a flyer and ring spun yarn is more subtle with the flyer spun yarn being the better of the two.

Using the Rieter it was found that the pneumafil device, which collects loose fibres from underneath the bottom front rollers by means of suction, influenced yarn hairiness. Unfortunately, the PSS frame used was not equipped with similar suction devices. The least hairy ring spun yarns were produced on the Rieter with the suction in operation. The second best ring yarn was produced on the PSS frame using high-twist roving. The latter yarn was slightly better than a Rieter yarn, spun without suction. The most hairy ring spun yarn was produced on the PSS frame from a low-twist roving. The influence of roving twist will be discussed elsewhere in this paper.

(c) **The influence of fibre diameter**: Contrary to the findings of Onions[4] who investigated the hairiness of worsted wool yarns, the present evidence suggests that with mohair, fibre diameter does play a rôle. Two yarns of the same count and twist were spun from lots 4 and 5 on both the cap and the flyer. The mean fibre lengths of these two lots were similar while the mean fibre diameters differed appreciably. In both cases the yarn spun from finer fibres was less hairy. Only 0.8% of hairs was present on the package spun from lot 4 whereas 1.25% hairs were removed from the coarse fibred lot 5.

(d) **The influence of fibre length**: The fibre diameters of lots 1 and 3 were well matched while their mean fibre lengths differed appreciably. For both cap and flyer spinning, lot 3 with a lower fibre length, produced a more hairy yarn. Goswani[9], who was interested in the hairiness of cotton yarns also found that long and fine fibres produced less hairy yarns. The explanation for the dependence of hairiness on fibre length and diameter is based on the migration theory proposed by Morton[10].

(e) **The influence of yarn twist**: Packages of high twist yarn were visually less hairy than those containing low twist yarn, other factors being the same. In one instance two 68 tex yarns from lot 3 were spun having 240 and 520 tpm respectively. The amounts of hair removed were 1.00% and 0.71% respectively, confirming the above observation.

(f) **The influence of control rings and separators**: It was found that yarn hairiness improved after the removal of the separating guards between the spindles. This was especially the case with cap spinning where the balloon was inclined to be so big that is was colliding with the guard. With ring spinning, removal of the separators hardly made any difference because the heavier traveller used when spinning mohair, limits the balloon size so that no contact is made with the separator.

When the separators on a cap frame are removed, the adjacent balloons collide and control rings have to be used. The influence of the control rings was found to be marginal, possibly increasing the number of fibres pointing radially away from the package axis, but decreasing their length. Needless to say, having balloon control rings around caps will make doffing more difficult.

(g) **The influence of condensers and roving twist**: It has been found[9] that the width of the ribbon of fibres emerging from the front roller nip of the spinner is directly related to the hairiness of the yarn. Thus by using condensers behind the front roller nip to limit the width of the roving being drawn, the yarn should be less hairy. A condenser was made for the PSS frame and utilised with low twist rovings but the improvement in hairiness was not confirmed visually or by weighing.

The ribbon width can also be limited by increasing the roving twist. Several lots were spun on the PSS frame and the roving with higher twist produced a yarn that was consistently less hairy than the yarn produced by the low twist roving. For example, the hair removed from a yarn spun from a low twist roving (86 tpm) of lot 3 was 0.86% while the high twist roving (155 tpm) produced a yarn package of only 0.63% hairs. High twist rovings could not be spun on the Rieter due to the drafting forces becoming so high that slippage occurred.

(h) **The influence of traveller weight:** Experience has shown that the spinning tension must be higher for mohair than for wool spinning. The reason for this is two-fold: the tension must be high to pull cracker-like formations in the yarn apart and also to increase the traveller drag so that the hair on the spinning package cannot push the traveller ahead of its schedule.

Goswani[9] studied the hairiness of cotton yarns and found that when using heavier travellers less hairy yarns were obtained. Explaining this, he refers to the dependence of spinning tension and twist distribution on the ultimate position of the projecting fibre end. Different traveller weights were tried but for mohair the influence on the yarn hairiness was negligible.

GENERAL CONCLUSIONS

The cap spun yarns were stronger and could be spun into finer counts than ring or flyer yarns. The cap spun yarns were, however, more hairy than ring or flyer spun yarns. The flyer spun yarns were the least hairy but also the weakest and most irregular. The ring spun yarns produced from low twist rovings on a double apron ring spinner were superior as regards regularity. By and large, ring spun yarns, and probably as produced on the double apron spinner, offer the best compromise between hairiness, strength and regularity.

As regards fibre properties, the importance of fibre diameter cannot be stressed too much. The finer fibres could be spun into finer counts and yarns made from the finer fibres were less hairy, stronger and more regular than those made from coarser fibres.

SUMMARY

Seven lots of mohair were processed on the Bradford system. The mean fibre diameter of four lots and the mean fibre length of another four lots were compatible.

The finer fibres produced stronger and more regular yarns. The finest yarns could be spun from the finest fibres. Long fibre yarns were stronger.

Cap spun yarns were stronger than ring or flyer spun yarns. The finest yarns could be produced on the cap. Yarns of very good regularity were spun from low twist Bradford rovings on a double apron French type ring spinner.

Yarn hairiness was found to increase with spinning speed. Cap spun yarns were always more hairy than ring of flyer spun yarns. The difference in hairiness between ring and flyer yarns was not great with the flyer the better of the two. Hairiness can further be improved by using finer and longer fibres, increasing the yarn and roving twist, by removal of separating guards and by employing suction devices on the spinner.

ACKNOWLEDGEMENTS

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TABLE III
Yarn Details (68 tex, 360 t.p.m.)

Lot no. fibre diam. (µ) and fibre length (cm)	Spinning mode	Breaking Strength (g)	Average Breaking Strength (g)	C.V. of Breaking Strength (%)	Extension at Break (%)	Average Extension at Break (%)	C.V. of Extension at Break (%)	Regularity (C.V.%)	Average Regularity (%)
1. (33.6µ, 11.99 cm)	Rieter ring	508		13.0	22.0		25.5	19.8	
	PSS ring	507		10.4	21.9		19.8	20.7	
	PSS cap	517	502	12.3	21.2	20.4	26.2	21.1	20.7
	PSS flyer	478		14.2	16.6		31.0	21.1	
2. (32.7µ, 7.2 cm)	Rieter ring	361		19.0	20.2		34.7	19.6	
	PSS ring	411		11.7	21.1		36.0	22.2	
	PSS cap	446	392	10.2	21.3	20.6	24.6	19.9	21.4
	PSS flyer	344		21.2	19.4		33.0	22.8	
3. (32.9µ, 8.6 cm)	Rieter ring	502		10.4	25.3		18.6	17.7	
	PSS ring	446		11.1	23.3		22.0	19.8	
	PSS cap	470	456	10.5	24.2	23.3	20.8	20.0	19.7
	PSS flyer	406		12.3	20.6		25.7	21.3	
4. (33.6µ, 10.4 cm)	Rieter ring	458		32.5	27.6		28.7	19.8	
	PSS ring	511		13.0	22.4	24.2	30.7	21.2	
	PSS cap	512	476	13.7	23.3		27.6	21.1	21.2
	PSS flyer	424		19.2	19.8		27.5	22.9	
5. (42.0 µ, 10.14 cm)	Rieter ring	276		18.6	16.3		32.3	25.6	
	PSS ring	296		28.8	15.2		30.0	27.4	
	PSS cap	252	277	18.8	17.2	16.2	29.8	26.3	27.3
	PSS flyer	286		29.0	16.2		34.3	29.8	
6. (39.1 µ, 10.2 cm)	Rieter ring	338		18.5	17.8		35.5	21.4	
	PSS ring	421	394	21.3	23.8		30.6	27.6	
	PSS cap	433		15.0	19.4	18.3	27.7	23.2	23.9
	PSS flyer	385		17.9	17.2		42.0	23.7	
7. (29.3 µ, 9.3 cm)	Rieter ring	482		10.0	24.3		22.8	16.1	
	PSS ring	504	443	10.4	24.8	23.8	28.4	20.0	21.1
	PSS cap	464		12.5	23.8		32.9	20.9	
	PSS flyer	324		21.4	22.4		30.2	29.5	

TABLE IV

The number of ends down per 120 spindle min for the seven mohair lots as spun on three different spinning modes

Lot no. fibre diam. (μ) and fibre length (cm)	Rieter			PSS Ring			PSS Cap		
	Linear density Tex	No. of fibres per yarn cross-section	Ends down	Linear density Tex	No. of fibres per yarn cross-section	Ends down	Linear density Tex	No. of fibres per yarn cross-section	Ends down
1.(33.9 μ, 11.99 cm)	25	21	6	25	21	1	25	21	2
	22	19	24	22	19	12	22	19	5
2.(32.7 μ, 7.2 cm)	28	25	9	25	23	13	25	23	2
	25	23	17	22	20	20	22	20	5
3.(32.9 μ, 8.6 cm)	25	23	4	25	23	1	25	23	0
	22	20	6	22	20	19	22	20	3
	20	18	16						
4.(33.6 μ, 10.4 cm)	25	22	8	24	21	2	22	19	2
				22	19	4	20	17	1
	20	17	18	20	17	8	19	17	8
5.(42.0 μ, 10.14 cm)	38	21	10	44	24	4	44	24	2
	30	17	21	38	21	8	38	21	5
				30	17	24	30	17	10
6.(39.1 μ, 10.2 cm)	30	19	9	30	19	11	30	19	4
	26	17	6	26	19	19	26	17	6
	24	15	57				25	16	20
7.(29.3 μ, 9.3 cm)	22	25	1	22	25	5	22	25	1
	17	19	2	17	19	11	17	19	4
	16	18	12	16	18	–	16	18	15

TABLE Va

Adjusted Treatment Effects and Significance of Treatments

	Rieter	PSS Ring	PSS Cap	PSS Flyer	F
Breaking Strength	–8.2g	16.2g	39.9g	–47.9g	5.0***
Breaking Extension	0.9%	0.8%	0.5%	– 2.1%	3.4*
C of V of Irregularity	–2.2%	0.5%	– 0.4%	2.2%	4.6*
Limiting Count	1.3 tex	0.6 tex	– 2.0 tex	–	5.6***

*** significant at 0.1% level

* significant at 5% level

TABLE Vb

Regression Coefficient and t Values

	Diameter		Length	
	b_1	t_1	b_2	t_2
Breaking Strength	–12.6g/μ	–5.8***	24.6g/cm	4.0***
Breaking Extension	– 0.56%/μ	–5.5***	0.1%/cm	0.34 N.S.
C.V.	0.52%/μ	4.6***	–0.1%/cm	–0.3 N.S.
Limiting Count	1.37 tex/μ	12.3***	–0.83***	–2.6*

*** significant at 0.1% level

* significant at 5% level