SAWTRI TECHNICAL REPORT

No. 383

An Attempt to Quantify the Effect of Staple Crimp on the Measurement of the Length Characteristics of Wool Tops on the Almeter

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WOOL AND TEXTILE RESEARCH
INSTITUTE OF THE CSIR

P.O. BOX 1124
PORT ELIZABETH
REPUBLIC OF SOUTH AFRICA

ISBN 0 7988 1229 X

AN ATTEMPT TO QUANTIFY THE EFFECT OF STAPLE CRIMP ON THE MEASUREMENT OF THE LENGTH CHARACTERISTICS OF WOOL TOPS ON THE ALMETER

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ABSTRACT

The length characteristics of wool tops which had been produced from thirty different wools from a range of breeds were measured on the Almeter and compared with results obtained by the single fibre length method. Some of the raw wools conformed nearly to the Duerden standard, while others were highly overcrimped. The wools ranged in diameter from 19 to 32 μm and in crimp frequency from 2,5 to 6,5 crimps/cm. In a large number of cases serious differences existed between the data, and in some cases these differences were quite dramatic. It was concluded that the finer *the raw wool might be (with concomitant increase in crimp frequency) or the* more overcrimped *the raw wool might be, with respect to the Duerden standard, the greater the difference between the single fibre length and Almeter results for the tops produced from such wools becomes. An attempt was made to quantify some of the more important effects.*

This report contains comments by Mr. J. Grignet of Centexbel, Verviers, together with the author's reply.

INTRODUCTION

Different methods of test can be used to determine the mean fibre length of a wool top, some of the more common methods involving the use of the Almeter, the Wira Fibre diagram machine, the Wira single fibre length machine and the Schlumberger comb sorter. These different methods frequently give rise to different results being obtained, and one of the major contributing factors appears to be the crimpiness of the fibre. In the method involving the Schlumberger comb sorter, for example, the samples are prepared without any tension being given to the fibres while they are laid down in the combs, and although the mass of the fibre in each length interval is correct, the length interval into which the fibre should fall will be incorrect due to this residual crimp[1]. A difference of as much as 10% between the uncrimped and crimped length of fibres within a specific length interval has been reported[1]. The Wira fibre diagram machine is fitted with velvet friction pads whose function is to remove much of the crimp, but in the Almeter the sample is tested in a fairly untentioned state. This difference in stretching results in mean fibre length results on the Almeter which are frequently shorter than those obtained on the Wira fibre diagram machine[2].

Some authors have stated that there is fair agreement between results obtained from different test methods. In one report single fibre length measurements on 11 different tops were compared with measurements made on the Almeter and Wira fibre diagram machines, and it was concluded that the results obtained by the electronic apparatus are very strongly correlated to the single fibre length results, and that they coincide numerically to a degree which is sufficient for most practical purposes[3]. It was suggested that the degree of fibre crimp and the bias by cross-section area have an opposite effect on the mean fibre length and probably account for the small differences reported. On the other hand, other authors have discussed the correlation between the different methods of testing and have stated that, inter alia, the mean fibre length depends in the case of certain methods, on the crimp frequency of the wool[4]. The type and duration of storage have also been found to affect the Almeter measurement[5]. Consistent differences of up to 5,2 mm between various test methods have been reported, and, in addition, unexplained random differences of the order of 2,5 mm which have been ascribed to possible differences in crimp and sample preparation[6].

Of the above testing instruments the Almeter has proved very popular in industry. Preparation of the sample can be done automatically and measurement is relatively quick. It has been claimed that the machine is not sensitive to the colour of the goods, the mass of the sample, the array of fibres along the sample, nor its moisture content[7]. This machine is extensively used at SAWTRI and recently an opportunity presented itself to study the results obtained on this machine on a rather wide and perhaps unusual range of wool tops. These had been produced during an investigation in which the processing performance of thirty different wools from a range of breeds was being studied[9]. Some of these wools conformed to crimp/diameter relationships which were not far from the Duerden standard while others were considerably overcrimped. Such wools are nevertheless fairly common on the market and could quite well be processed on their own or in mixtures with other wools. (This could be done, for example, to improve the compressibility of the more flabby types for certain end uses). In view of the known variations in crimp between the various lots it had been decided to measure the length characteristics of the above tops by the single fibre length method and to take those values as being the correct ones. It was also decided, however, to measure the length characteristics on the Almeter so as to try and quantify the differences due to crimp.

EXPERIMENTAL

Thirty different lots of raw wool which could be broadly classified as comprising 12 lots of merino wools, 5 lots of Döhne merino wools, 4 lots of Letelle wools, 4 lots of German merino crossed wools, 2 lots of Gladdelyf wools and 3 lots of Corriedale wools were scoured, carded and combed under identical conditions. Some physical properties of the raw wools are given in Table I.

TABLE I

SOME PHYSICAL PROPERTIES OF THE 30 DIFFERENT LOTS OF RAW WOOL

Symbols used in statistical analysis	X_1	X_2			
Lot No.	**Mean fibre diameter (μm) (airflow)**	**Crimps/cm**	**Deviation of crimpiness from Duerden (%)**	**Average Classing length (months)**	**I.W.T.O. Scoured Yield (%)**
1	19,2	5,3	- 4	12,0	64,6
2	19,2	5,3	- 4	12,0	70,0
3	19,4	6,2	+15	12,0	65,4
4	20,1	4,4	-11	12,0	73,0
5	20,1	5,2	+ 5	12,0	67,6
6	20,4	5,2	+ 9	12,0	67,5
7	20,6	5,8	+24	11,5	68,2
8	21,1	4,0	- 9	14,0	70,1
9	21,3	4,6	+ 7	12,0	69,9
10	21,4	4,8	+13	12,0	64,6
11	21,6	4,8	+15	12,0	67,3
12	21,6	4,5	+ 8	12,0	72,0
13	21,8	3,8	- 7	12,0	70,3
14	22,0	6,5	+63	12,0	68,7
15	22,2	3,5	-10	12,0	73,8
16	22,4	3,7	+ 3	10,5	73,1
17	22,4	5,7	+50	10,5	66,6
18	22,9	5,3	+47	11,5	65,0
19	23,4	3,7	+ 8	14,0	70,7
20	24,3	4,8	+54	14,0	66,9
21	24,4	3,3	+ 7	11,5	67,9
22	24,6	3,0	- 1	10,0	74,0
23	25,1	4,1	+42	14,0	70,9
24	25,4	3,8	+36	10,0	65,1
25	25,7	3,0	+10	14,0	74,6
26	26,0	2,5	- 5	12,0	72,7
27	26,7	2,6	+ 5	11,0	70,6
28	27,8	3,6	+60	10,5	66,6
29	28,8	2,9	+41	14,0	68,9
30	31,9	2,6	+61	16,0	74,0

Samples of the tops which were produced from these wools were labelled and then draped over the edge of an empty can, and during the course of approximately the following 3 — 6 weeks were measured in the normal way on an Almeter. Four readings were taken, two in one direction and two in the other, and the mean of the 4 readings taken as the 'original' Almeter result. The actual tops themselves were stored in ball form, and six months later a second set of samples was drawn and the Almeter tests repeated. It was then decided to draw a third set of samples and to relax these by open steaming them for two minutes on a Hoffman press. These were allowed to condition over a week-end and the Almeter tests repeated a third time. The mean fibre lengths of the tops were, during this time, also measured by the Wira single fibre length method and, for the purpose of this exercise these results were regarded as representing the true values.

RESULTS AND DISCUSSION

The single fibre length results for the mean fibre length and CV are given in Table II. The 5% length or 'tail' length of the tops which is also given in the table is the length which is exceeded by 5% of the fibres. The tail length: mean length ratio has been calculated from the latter and the mean fibre length.

Results obtained on the Almeter for the mean fibre length (actually Almeter Hautere, or weight-biased mean length), CV of fibre length and 5% length or 'tail' length are given in Table III. Results for the tail length: mean length ratio are also given in the table together with values for the percentage of fibres shorter than 25 mm. In the case of all these parameters values have been given for the original measurement, after storage in ball form for 6 months, and after steam relaxation.

A comparison of the values shown in Table II and III for the same wool tops shows quite clearly that in a large number of cases serious differences exist between them, and in some cases the differences are quite dramatic. Values for mean fibre length show that the original measurement on the Almeter were, on average, about 6 mm shorter than those of the single fibre length measurement. Storage in ball form for 6 months reduced the discrepancy to about 4,5 mm on average, but if the fibres were steam relaxed the discrepancy *increased* to about 12 mm . Values for the CV of fibre length were, on average, about 3 units higher on the Almeter when comparing the original values with those of the single fibre length method. The CV did not change much with storage in ball form for 6 months, but was about 4,5 units higher after steam relaxation.

Values for the short fibre content also did not change much after storage in ball form for 6 months, but increased on average by about 2% absolute when the tops were steam relaxed. Values for the 5% length or 'tail' length of the tops were, on average, about 9 mm shorter on the Almeter than on the single fibre length method. The discrepancy was reduced to about 7 mm after storage in ball form for 6 months but increased to about 18 mm after steam relaxation.

Quadratic regression analyses were carried out using each of the Almeter parameters (excepting % short fibre) in turn as dependent variables (Y_1 to Y_4) and with the corresponding single fibre length parameter as one of the independent variables (Z_1 to Z_4). Four other independent variables were included in each analysis, namely crimp (X_2), crimp² (X_2^2), diameter (X_1) and the crimp/diameter interaction (X_1X_2). The analyses were repeated for the original measurements (suffix 'o') and for the measurements obtained after storage (suffix 'b') in ball form and after steam relaxing (suffix 's'). The symbols used in the analyses are shown for convenience in the various tables.

All of the 12 regression analyses which were carried out yielded equations which were significant at least at the 99% level of confidence. These equations were as follows:

(a) **Mean fibre length:**

$Y_{1o} = 0{,}772\,Z_1 + 0{,}687\,X_1 - 0{,}113\,X_1X_2 + 7{,}28$ ....(1)
n = 30; r = 0,93; % fit = 86,2

$Y_{1b} = 0{,}870\,Z_1 - 0{,}120\,X_1X_2 + 17{,}24$ ....(2)
n = 30; r = 0,93; % fit = 87,2

$Y_{1s} = 0{,}646\,Z_1 + 0{,}508\,X_1 - 0{,}204\,X_1X_2 + 24{,}09$ ....(3)
n = 30; r = 0,95; % fit = 90,5

(b) **CV of fibre length:**

$Y_{2o} = 1{,}109\,Z_2 - 1{,}68$ ....(4)
n = 30; r = 0,66; % fit = 43,9

$Y_{2b} = 1{,}018\,Z_2 + 2{,}65$ ....(5)
n = 30; r = 0,62; % fit = 38,0

$Y_{2s} = 1{,}165\,Z_2 - 2{,}68$ ....(6)
n = 30; r = 0,70; % fit = 48,9

(c) **5% length or 'tail' length:**

$Y_{3o} = 0{,}798\,Z_3 + 0{,}212\,X_1X_2 - 6{,}134\,X_2 + 22{,}610$ ....(7)
n = 30; r = 0,98; % fit; 97,0

$Y_{3b} = 0{,}847\,Z_3 - 1{,}882\,X_2 + 21{,}0$ ....(8)
n = 30; r = 0,99; % fit = 98,3

$Y_{3s} = 0,756\, Z_3 - 4,576\, X_2 + 33,51$ ....(9)
n = 30; r = 0,99; % fit = 97,5

(d) **Tail length : mean length ratio:**

$Y_{4o} = 1,210\, Z_4 - 0,333$ ....(10)
n = 30; r = 0,78; % fit = 61,5

$Y_{4b} = 1,155\, Z_4 - 0,238$ ....(11)
n = 30; r = 0,75; % fit = 57,0

$Y_{4s} = 1,113\, Z_4 + 0,0017\, X_1X_2 - 0,318$ ....(12)
n = 30; r = 0,85; % fit = 72,7

The independent variables, diameter and crimp were highly correlated (correlation coefficient r = 0,74) but this was neither surprising nor unexpected when viewing such a wide range of fine to coarse wools as studied here. It was realised that caution should be exercised when setting up a mathematical model in which both these variables were included in the same analysis, but it was not considered necessary to exclude them from the analysis since the correlation coefficient was well below 0,9. It can be seen from the above results that crimp played an important rôle in the relationship obtained between the values for the tail length and an important rôle in an interaction with diameter in the relationships obtained between the mean fibre length values. Neither crimp nor diameter played a rôle in the relationships obtained between the CV's of fibre length nor, with one exception, between the tail length : mean length ratios.

The apparent effect of diameter (X_1) on Almeter mean fibre length was probably due to the correlation between mean fibre diameter and crimp. An analysis of log Y_{1o} versus log Z_1, log X_1 and log X_2 appeared to confirm this since the diameter term was non-significant (see equation 13 below):

$Y_{1o} = 3,02\, Z_1^{0,788}\, X_2^{-0,182}$ ....(13)
n = 30; r = 0,91; % fit = 84

According to the log regression equation the Almeter mean fibre length was only a function of single fibre length (Z_1) and crimp (X_2).

It was considered to be of practical interest not only to the topmaker but to the producer, merchant and spinner as well, to translate some of these regression formulae into practical terminology. For this purpose several graphs have been drawn and are presented in Figs 1 to 9. In those regressions in which crimp and diameter play a rôle it was decided to draw the curves in such a manner that they represent specific relationships with the Duerden standard.

From data published by Duerden[9] the following formula was derived:

$$C_D = 7535{,}06 \ \ m^{-2{,}414} \quad \ldots\ldots\ldots\ldots (14)$$

where C_D is the number of crimps per cm in the raw wool and μm is the mean fibre diameter in micrometres. This was regarded as the Duerden standard. The number of crimps/cm corresponding to mean fibre diameter values from 20 to 28 μm are given in Table IV together with the number of crimps/cm for various specific deviations from that standard. The percentage deviation has been calculated by a formula previously suggested by the author[10], as follows:

$$D = \frac{C_A \times 100}{C_D} - 100 \quad \ldots\ldots\ldots\ldots (15)$$

where D = percentage deviation

C_A = actual number of crimps/cm

C_D = number of crimps/cm for a wool of the same mean fibre diameter conforming to the Duerden standard.

Positive values for D indicate that the wools are overcrimped and negative values for D indicate that the wools are undercrimped, both with respect to the Duerden values.

Fig 1 gives the Almeter mean fibre length corresponding to a single fibre length value of 80 mm and shows the effect of various specific relationships with the Duerden standard. (The single fibre length value of 80 mm was selected since it represents the average case in Table II). It is quite clear that for a given relationship to the Duerden standard a progressive decrease in the mean fibre diameter of the wool (with concomitant *increase* in crimp frequency) produced a progressive *reduction* in the Almeter mean fibre length value. Also, for a given diameter a progressive *increase* in *overcrimping* produced a progressive *reduction* in the Almeter mean fibre length value. Fine overcrimped wools gave results which could be up to about 15 mm less than coarse undercrimped wools.

Fig 2 gives the Almeter mean fibre length for Duerden wools having single fibre length values of 70, 80 and 90 mm . It shows that a difference to 10 mm can be expected between the Almeter values obtained for wools of 20 μm and 28 μm (provided they conform to the Duerden standard), this difference being independent of length within the range studied here. In other words for every μm *decrease* in mean fibre diameter (with concomitant *increase* in crimp frequency), the Almeter mean fibre length is reduced by just over a millimetre.

Fig 3 gives the Almeter mean fibre length corresponding to a single fibre length measurement of 80 mm and shows the effect of various states of

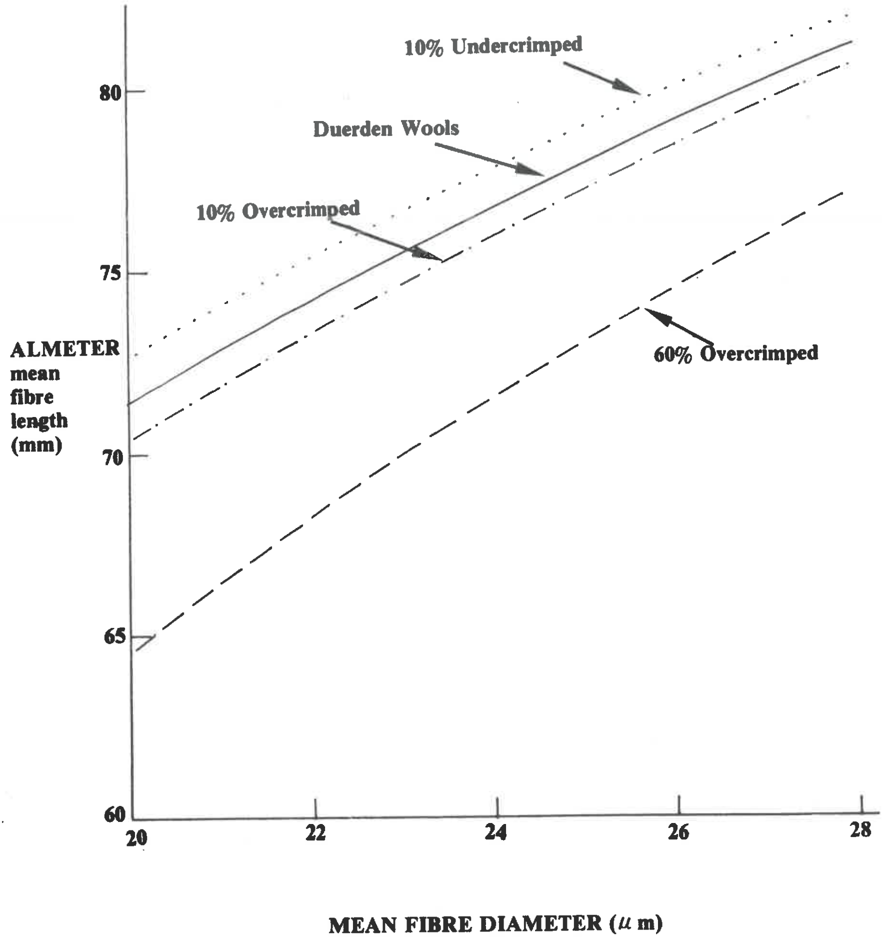

Fig. 1 Almeter mean fibre length corresponding to a single fibre length measurement of 80 mm, showing the effect of various crimp/diameter relationships

TABLE II

SINGLE FIBRE LENGTH RESULTS

Symbols used in statistical analysis	Z_1	Z_2	Z_3	Z_4
Lot No.	Mean Length (mm)	CV (%)	5% Length (mm)	Tail : Mean length ratio
1	77,9	40,7	127,0	1,63
2	78,3	42,6	126,5	1,62
3	69,7	41,9	114,5	1,64
4	79,8	44,1	140,0	1,75
5	83,6	40,3	132,5	1,58
6	75,9	40,4	121,5	1,60
7	70,0	43,8	115,5	1,65
8	87,3	40,2	135,5	1,55
9	80,0	37,9	122,5	1,53
10	76,2	47,9	135,0	1,77
11	80,0	45,8	130,5	1,63
12	75,9	42,0	124,5	1,64
13	80,0	41,2	127,5	1,59
14	69,1	48,5	115,0	1,66
15	84,3	37,6	129,5	1,54
16	77,3	38,1	121,5	1,57
17	64,5	49,8	117,5	1,82
18	81,1	41,8	128,5	1,58
19	84,2	44,4	144,0	1,71
20	81,8	45,7	142,5	1,74
21	70,5	41,0	111,0	1,57
22	71,0	38,7	109,0	1,54
23	75,9	43,8	130,5	1,72
24	76,5	43,7	122,5	1,60
25	83,3	44,0	142,5	1,71
26	82,7	34,3	122,0	1,48
27	67,6	46,9	114,0	1,69
28	77,4	45,2	125,0	1,61
29	92,8	43,9	152,5	1,64
30	113,4	46,9	200,0	1,76
Mean	78,93	42,77	129,35	1,637

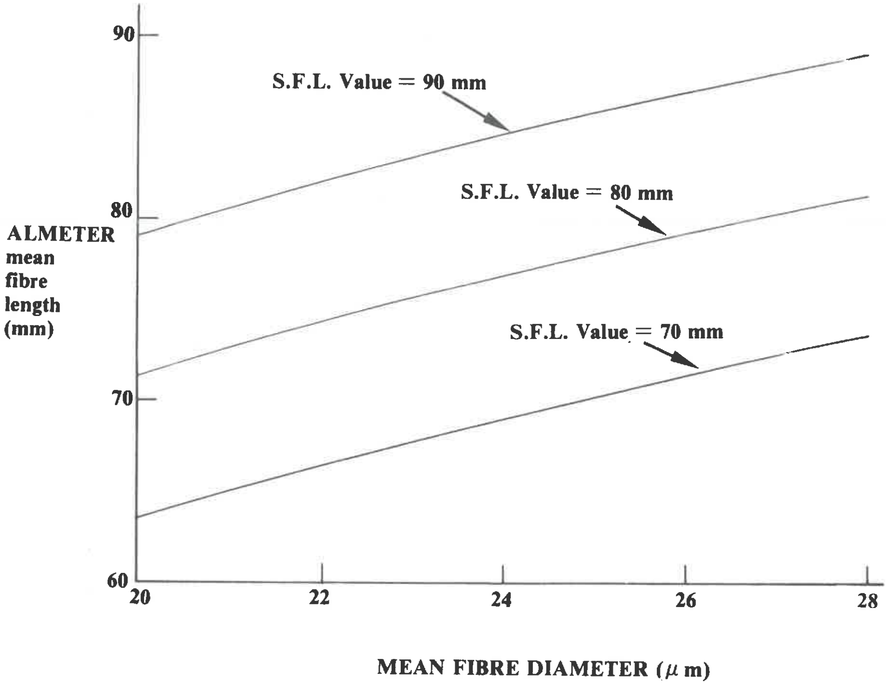

Fig. 2 Almeter mean fibre lengths for Duerden wools corresponding to single fibre length values of 70, 80 and 90 mm

relaxation on wools conforming to the Duerden standard. The fine wools appear to have benefitted most by storage in ball form, but even then were up to 5 mm shorter than the single fibre measurement would suggest. Restoration of the crimp by steam relaxation resulted in greater differences in fibre length results on the Almeter over the whole range of diameter. On highly overcrimped wools the effect was even more pronounced (Fig 4), resulting in mean fibre length values for very fine and highly overcrimped wools of up to 25 mm below the single fibre length results.

Figs 5, 6 and 7 give the values for the Almeter 5% length or 'tail' length corresponding to a single fibre length measurement of 120 mm and show the effects of variations in other parameters. The 5% length value of 120 mm was selected since it represents the average case in Table II. Here again the trends are very similar to those found with mean fibre length. Discrepancies between the two methods of measurement became more and more serious as diameter

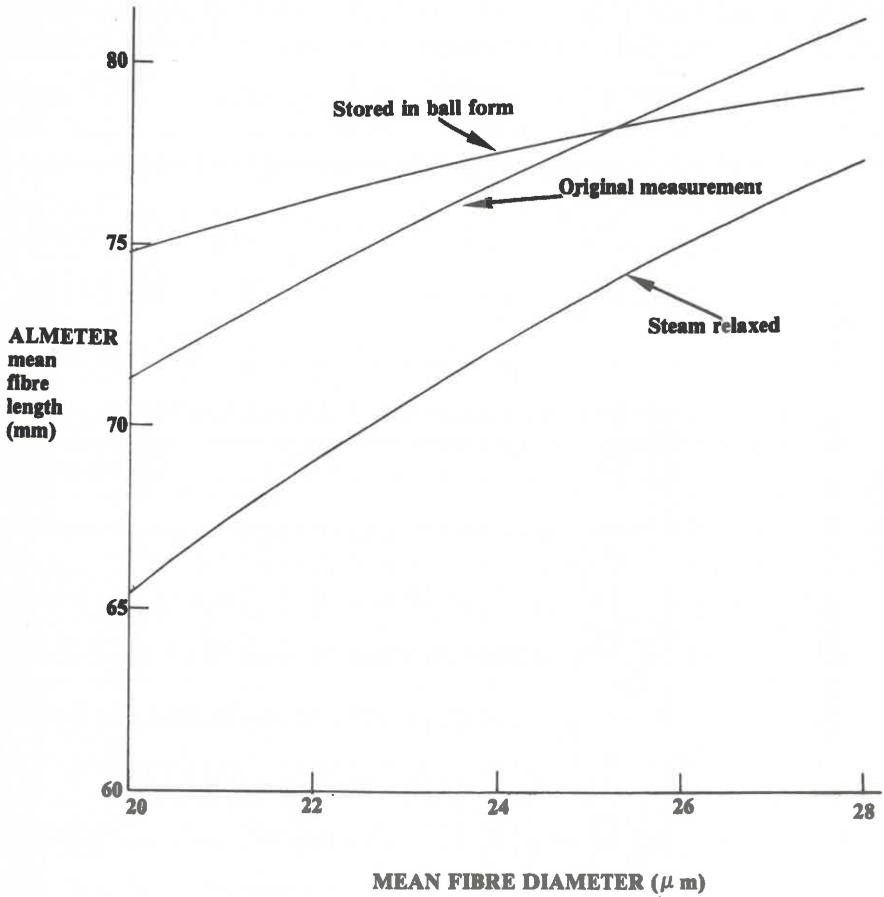

Fig. 3 Almeter mean fibre length corresponding to a single fibre length measurement of 80 mm showing the effects of various states of relaxation on wools conforming to the Duerden standard

decreased, overcrimping increased with respect to the Duerden standard, or relaxation increased. Combinations of all three of these could result in tail lengths apparently up to over 25 mm lower for the Almeter than the single fibre length method.

TABLE III

RESULTS OBTAINED ON THE ALMETER

Symbols used in statistical analysis	Y_1			Y_2						Y_3			Y_4		
LOT NO	Almeter Mean Fibre Length (mm)			Almeter CV of Fibre Length (%)			Almeter Short Fibre Content (% < 25 mm)			Almeter 5% Length (mm)			Almeter Tail: Mean Length Ratio		
	Original	Stored in balls	Steamed	Original	Stored in balls	Steamed	Original	Stored in balls	Steamed	Original	Stored in balls	Steamed	Original	Stored in balls	Steamed
1	71,7	73,8	66,1	43,7	43,5	44,6	3,3	3,0	4,5	113,7	120,0	105,9	1,59	1,63	1,60
2	71,0	73,6	66,0	44,3	44,2	44,5	3,6	2,7	5,1	113,3	118,3	105,6	1,60	1,61	1,60
3	62,4	64,3	55,8	45,3	46,3	48,2	6,2	5,7	9,3	102,0	105,3	93,0	1,63	1,64	1,67
4	73,1	75,6	66,6	44,4	44,4	47,3	2,5	2,2	4,7	124,1	127,3	115,5	1,70	1,68	1,73
5	78,5	77,3	68,8	42,3	43,6	45,4	2,8	2,9	4,9	123,2	122,7	111,1	1,57	1,59	1,61
6	65,7	69,0	58,5	45,6	46,2	47,9	4,4	3,9	8,4	107,8	114,5	98,1	1,64	1,66	1,68
7	60,0	65,5	54,6	43,7	42,7	42,6	4,6	3,0	4,6	98,2	105,6	91,0	1,64	1,61	1,67
8	84,1	85,7	78,6	37,9	39,0	39,1	1,4	1,3	1,6	125,9	128,5	119,8	1,50	1,50	1,52
9	69,7	71,6	65,9	45,1	44,7	44,7	3,7	3,4	5,0	111,1	114,2	104,8	1,59	1,59	1,59
10	69,0	68,5	60,8	52,0	52,4	53,9	7,0	6,6	10,6	123,8	124,3	110,8	1,79	1,81	1,82
11	67,6	70,5	63,5	52,0	52,3	52,0	9,1	8,5	7,9	121,3	125,9	112,3	1,79	1,79	1,77
12	68,1	72,6	65,1	47,1	45,8	47,3	6,2	4,7	7,6	112,8	119,6	107,5	1,66	1,65	1,65
13	78,9	79,4	73,5	43,0	44,4	45,1	5,1	5,7	7,1	121,2	123,8	116,3	1,54	1,56	1,58
14	60,5	60,9	53,2	52,0	52,2	53,3	9,2	9,1	12,7	109,9	110,0	96,8	1,82	1,81	1,82
15	74,1	77,9	71,9	43;0	44,2	43,1	3,5	4,5	4,2	116,6	124,0	113,0	1,57	1,59	1,57
16	74,0	73,0	67,1	40,7	41,7	43,7	4,6	5,1	7,0	113,7	113,4	105,8	1,54	1,55	1,58
17	58,9	60,1	51,2	54,3	54,5	55,5	9,2	8,9	14,3	109,3	110,6	95,8	1,86	1,84	1,87
18	73,2	72,5	61,9	45,4	45,3	48,0	6,4	6,3	9,3	119,6	118,4	102,7	1,63	1,63	1,66
19	69,8	72,3	66,7	58,2	58,4	58,5	9,3	9,1	11,0	133,0	137,3	126,3	1,91	1,90	1,89
20	68,9	72,6	64,5	55,2	54,8	54,5	10,3	9,0	11,4	126,0	132,4	118,5	1,83	1,82	1,84
21	75,9	75,0	71,6	37,3	38,1	37,7	1,5	2,0	2,3	111,9	110,5	105,9	1,47	1,47	1,48
22	70,5	70,1	65,9	40,8	42,2	41,2	6,8	7,1	7,8	106,5	106,4	100,8	1,51	1,52	1,53
23	67,9	69,3	62,1	51,5	52,9	53,8	5,1	5,7	8,9	121,7	125,2	114,0	1,79	1,81	1,84
24	76,6	76,7	69,9	37,1	37,5	41,1	3,0	3,0	6,1	113,8	113,5	106,5	1,49	1,48	1,52
25	72,1	72,7	70,4	55,8	57,3	56,1	7,9	8,1	9,4	133,5	137,5	129,7	1,85	1,85	1,84
26	81,1	81,5	77,8	33,4	34,8	33,3	1,2	2,1	1,1	118,1	119,8	113,1	1,46	1,47	1,45
27	72,2	71,5	69,5	44,0	43,2	42,9	3,8	3,8	4,1	114,9	113,2	109,2	1,59	1,58	1,57
28	75,7	76,5	67,9	46,3	45,8	49,8	8,5	7,7	12,5	122,1	122,2	113,0	1,61	1,60	1,66
29	88,6	87,9	78,4	47,2	49,2	50,8	2,2	3,1	6,0	145,5	146,2	134,2	1,64	1,66	1,71
30	112,1	112,9	101 0	43,9	43,5	48,8	1,2	1,5	5,1	185,1	185,1	174,1	1,65	1,64	1,72
Mean	73,06	74,36	67,16	45,75	46,17	47,16	5,12	4,99	7,15	119,99	122,52	111,70	1,649	1,653	1,668

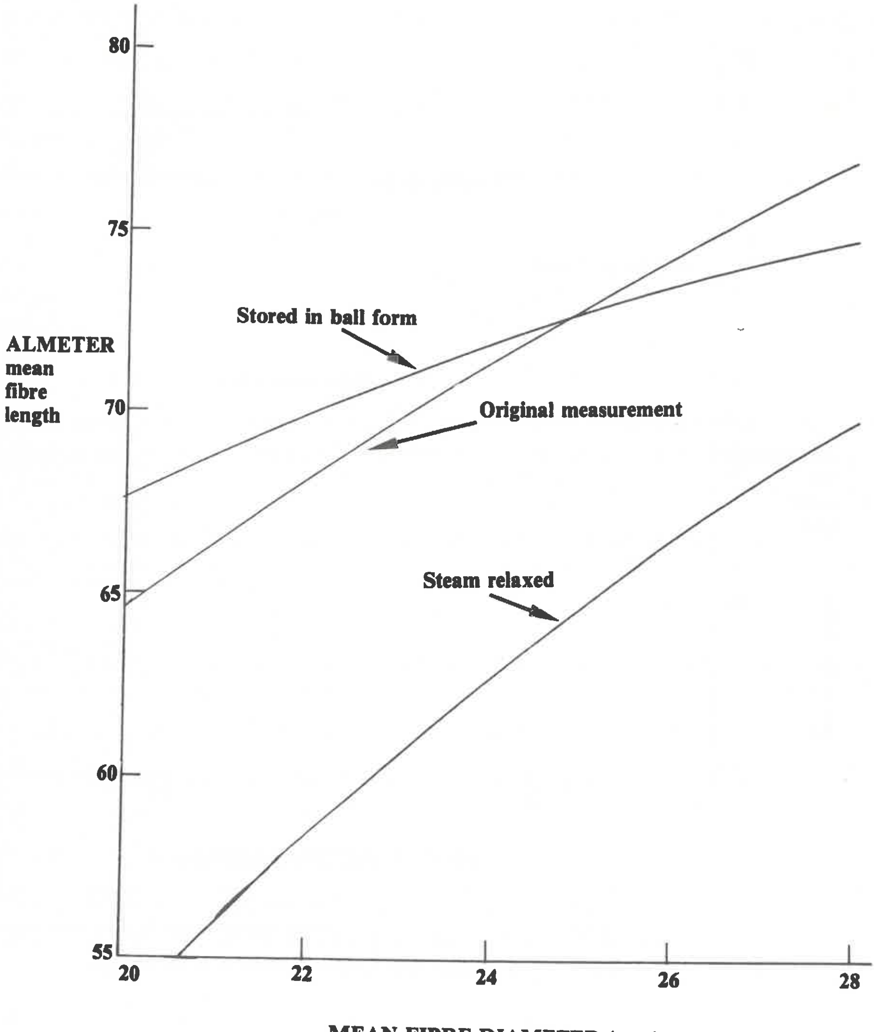

Fig. 4 Almeter mean fibre length corresponding to a single fibre length measurement of 80 mm, showing the effects of various states of relaxation on wools which are 60% overcrimped

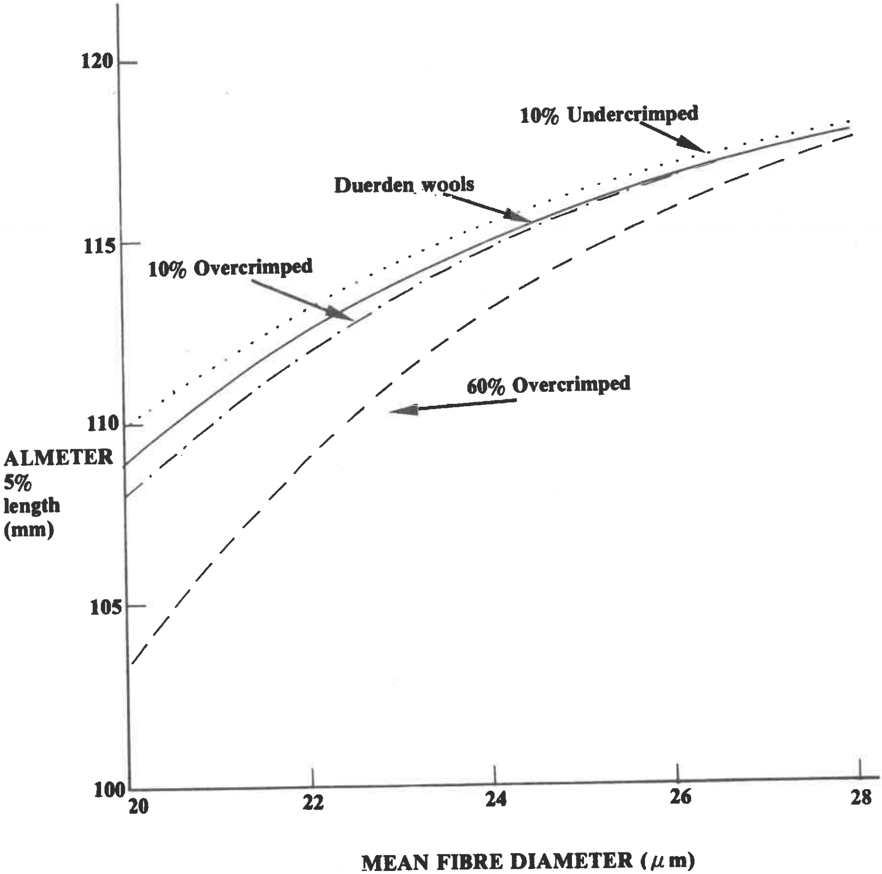

Fig. 5 Almeter 5% length ('tail' length) corresponding to a value of 120 mm by the single fibre length method, showing the effect of various crimp/diameter relationships

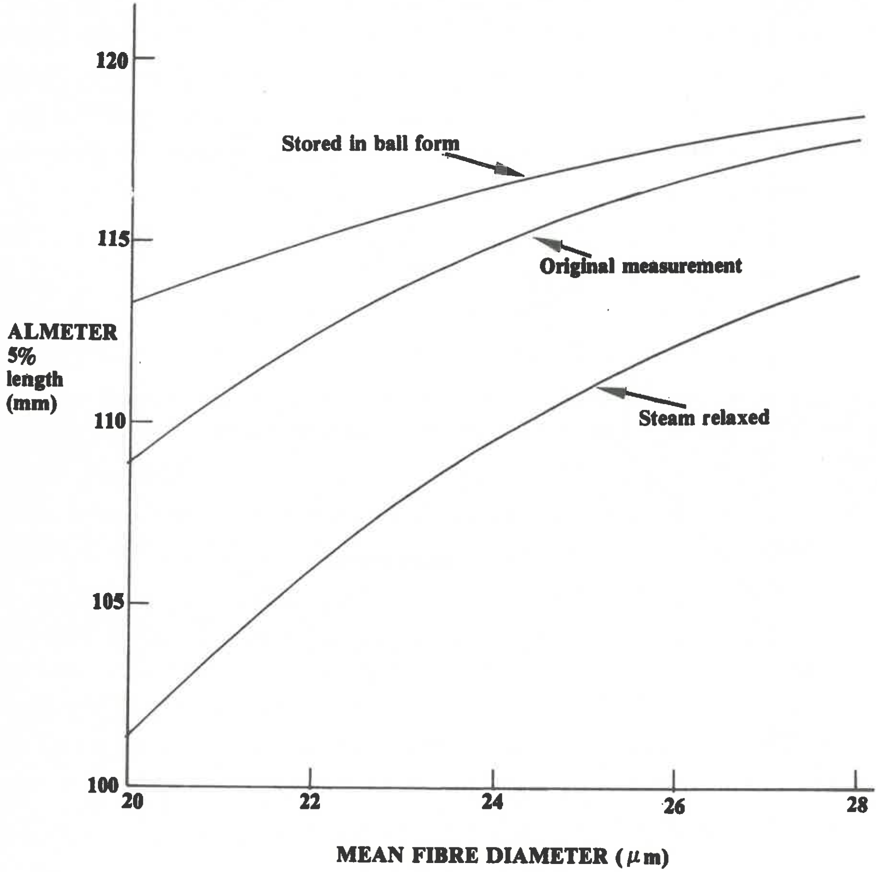

Fig. 6 Almeter 5% length ('tail' length) corresponding to a value of 120 mm by the single fibre length method, showing the effect of various states of relaxation on wools conforming to the Duerden standard

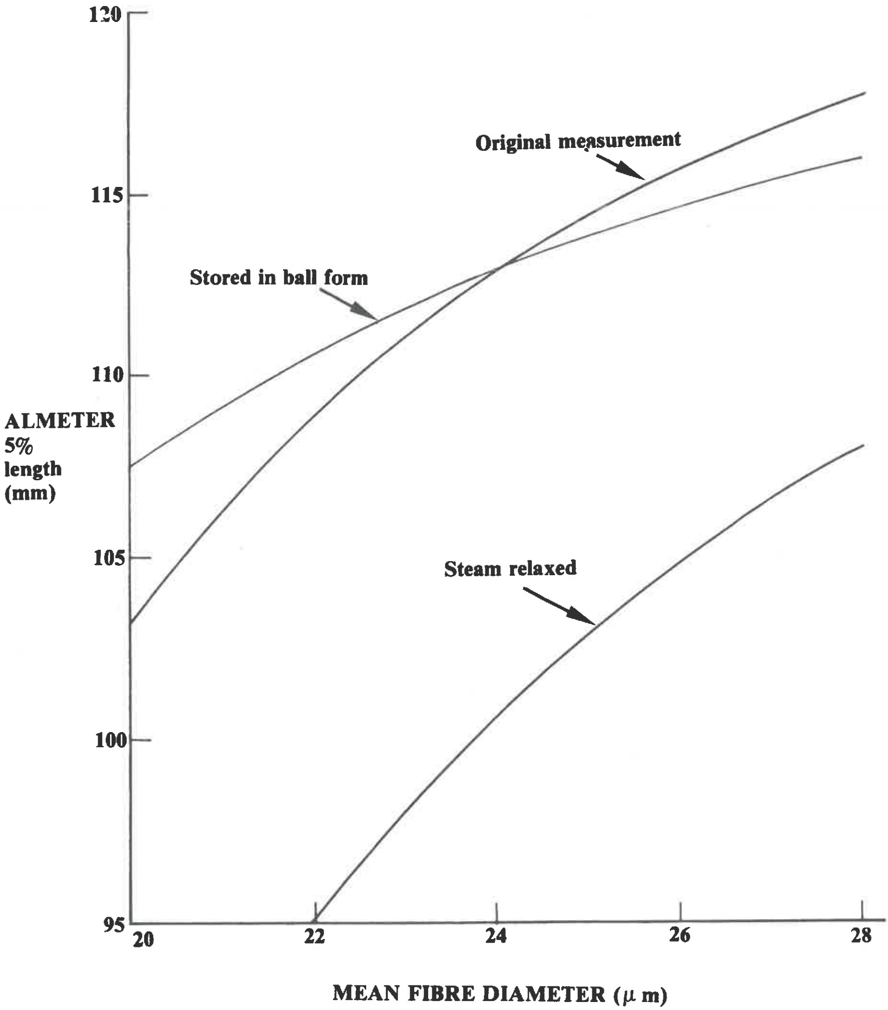

Fig. 7 Almeter 5% length ('tail' length) corresponding to a value of 120 mm by the single fibre length method, showing the effects of various states of relaxation on wools which are 60% overcrimped

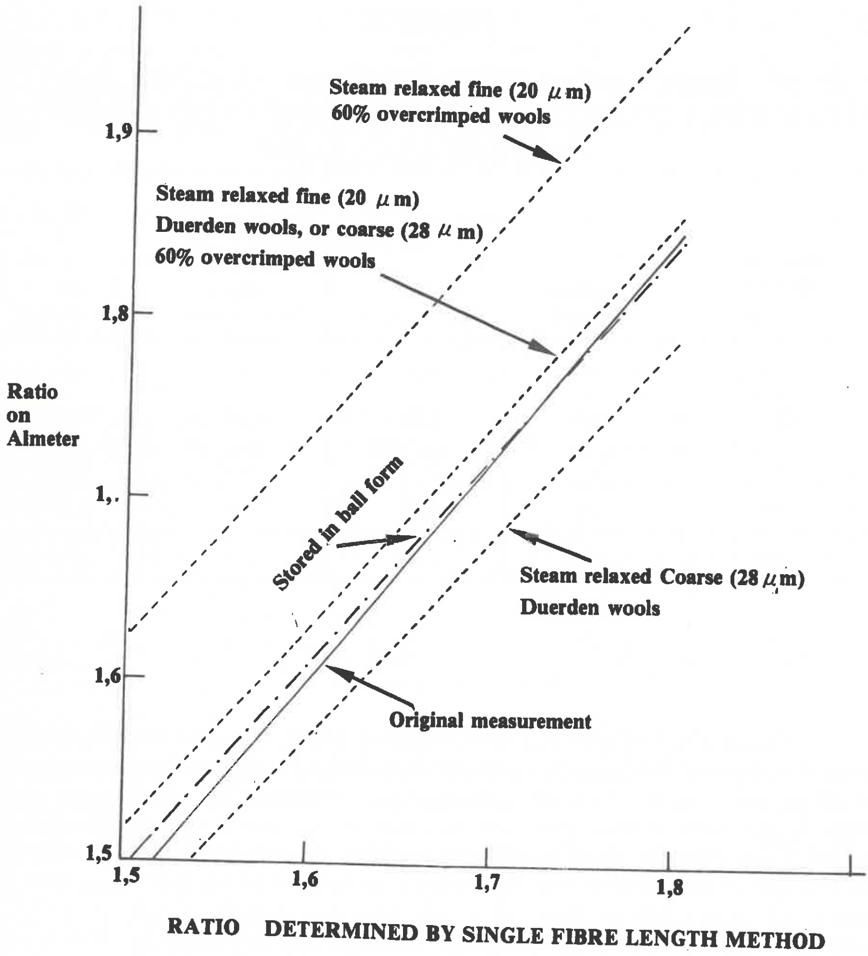

Fig. 8 Tail length: mean length ratio on almeter versus single fibre length method

Fig 8 shows that, apart from the case where the tops were steam relaxed, the tail length : mean length ratio results were in fairly good agreement when determined by the two different methods, and storage had no apparent significant effect.

TABLE IV

CRIMP FREQUENCIES PERTAINING TO VARIOUS SPECIFIC MEAN FIBRE DIAMETERS AND RELATIONSHIPS WITH THE DUERDEN STANDARD

Mean fibre diameter (μm)	No. of crimps/cm			
	Duerden Standard	10% Undercrimped	10% Overcrimped	60% Overcrimped
20	5,02	4,52	5,52	8,03
22	3,98	3,58	4,38	6,37
24	3,22	2,90	3,54	5,15
26	2,64	2,38	2,90	4,22
28	2,21	1,99	2,43	3,54

Comparison of the CV results, shown in Fig 9, indicates little effect due to different states of relaxation, but shows that all the CV results determined on the Almeter were higher than the corresponding results determined by the single fibre length method. It is fairly obvious that any change in the crimp frequency of the fibres brought about by relaxation would result in proportionate changes in the apparent length of the short fibres, as well as the long fibres so that the apparent percentage of short fibre, the apparent length of the tail and the apparent mean length will all change more or less in sympathy. This would explain the relatively narrow spread of the curves in Figs 8 and 9, particularly the latter.

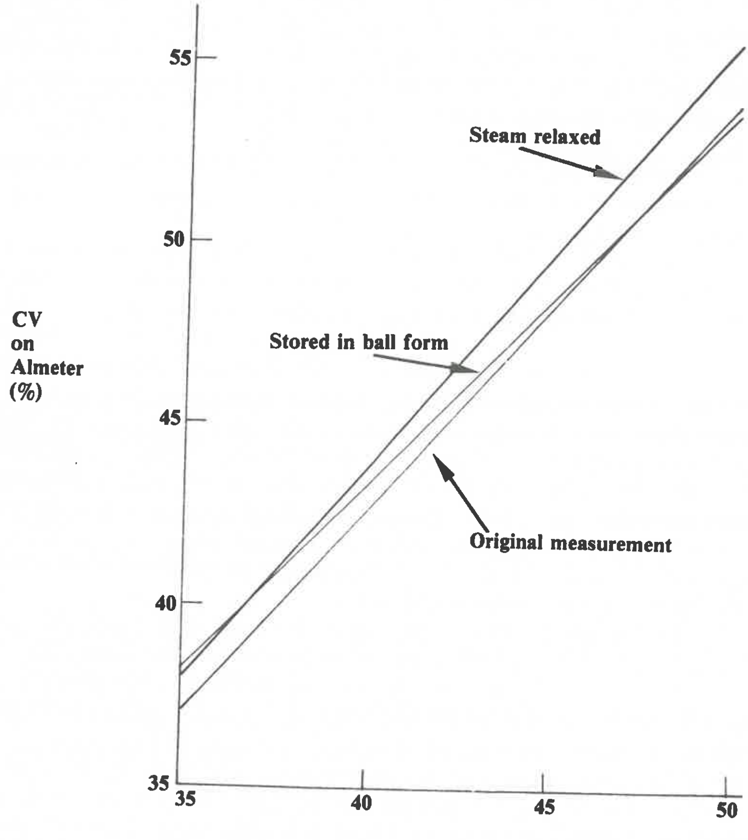

Fig. 9 CV of fibre length on almeter versus single fibre length method

SUMMARY AND CONCLUSIONS

An opportunity presented itself recently to study the length characteristics of a rather wide and perhaps unusual range of wool tops which had been produced from thirty different wools from a range of breeds. Some of these wools conformed to crimp/diameter relationships which were not far from the Duerden standard while others were considerably overcrimped. The wools ranged in diameter from 19 to 32 μm and in crimp frequency from 2,5 to 6,5 crimps/cm In view of the known sensitivity of the Almeter to crimp, measurements were made using both the Almeter and the Wira single fibre length method. The length characteristics studied were the mean fibre length (actually Almeter Hautere in the case of the Almeter), CV of fibre length, the 5% length ('tail' length) i.e. the length exceeded by 5% of the fibres, and the tail length : mean length ratio. An attempt to quantify the effect of raw wool crimp on the Almeter results was then made on the assumption that the single fibre length results represented the true values.

Almeter measurements were made for three different states of relaxation of the tops. These comprised the original state in which they were measured (some 3 — 6 weeks after combing), the state obtained after 6 months storage in ball form, and a steam-relaxed state (after open steaming on a Hoffman press).

A comparison of the values for the same wool tops showed that in a large number of cases serious differences existed between the Almeter and single fibre length data, and in some cases these differences were quite dramatic. Twelve regression analyses were carried out in which the Almeter results were expressed as a function of the single fibre length results, the mean fibre diameter and crimp frequency of the raw wool. All analyses yielded equations which were significant at least at the 99% level of confidence. Crimp played a significant rôle in the equations dealing with the mean fibre length and 'tail' length but did not play a significant rôle with regard to the CV.

For a given relationship with the Duerden standard a progressive *decrease* in the mean fibre diameter of the wool over the range 20 — 28 μm (with concomitant *increase* in crimp frequency) produced a progressive *reduction* in the Almeter mean fibre length and tail length equal to about 1 mm per micron in each case. Also, for a given mean fibre diameter a progressive *increase* in *overcrimping* produced a progressive *reduction* in the Almeter *mean fibre length* corresponding to about 1 mm per 10% change in crimp, and in the Almeter *tail length* corresponding to about 1 mm per 10% change for the finest wools and gradually reducing to practically zero for the coarsest wools. The combined effect of both fineness and overcrimping in fact could give results for the mean fibre length and tail length which were up to some 15 mm below the true value.

Steam relatation, by restoration of the crimp originally present in the raw wool, resulted in greater differences in mean fibre length results on the Almeter over the whole range of diameter values. The combined effect of both fineness and overcrimping in fact could give results for the mean fibre length after steam relaxation of up to 25 mm below the true value. On the other hand, storage of the tops in ball form for 6 months generally improved the length results on the Almeter, particularly in the case of the fine wools.

Comparison of the CV results showed that the CV as determined by the Almeter was generally from about 2% — 5% higher than the single fibre length values, depending on the state of relaxation of the fibres. The tail length: mean length ratios determined by the two different methods were generally in fairly good agreement.

In conclusion it would seem that the finer the raw wool might be (with concomitant increase in crimp frequency) or the more overcrimped the raw wool might be, with respect to the Duerden standard, the greater the difference between the single fibre length and Almeter results for the tops produced from such wools becomes. Perhaps some suitable allowance should be considered for crimp when measurements are made on the Almeter.

ACKNOWLEDGEMENTS

The author would like to express his thanks to Mr E. Gee and Mrs C. Bellingan for carrying out the statistical analyses, to Miss L.L. Oosthuizen for the Almeter measurements and Mr A.L. Braun and his assistants for the single fibre length measurements. Permission by the S.A. Wool Board to publish these results is also gratefully acknowledged.

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APPENDIX

COMMENTS BY J. GRIGNET, CENTEXBEL, VERVIERS

We have studied with great interest the report of Dr D.W.F. Turpie, which is a very valuable attempt to quantify the effect of crimp on Almeter measurements, on a very large range of wools, and particularly for a very large range of crimp values.

However, we have some important remarks to formulate. During the development period of the Almeter, in 1960, we have made a comparison between Almeter mean fibre length and single fibre mean length, for 20 industrial lots in a range of 20 to 25 micron, but without checking the crimp values. The average differences was only 3%, which we considered as practically negligible. M. Greuel and H.J. Henning (your ref. 3) arrived at about the same conclusion on 11 tops, with practically no difference on the average.

After a careful study of Dr Turpie's results, we think the discrepencies between his findings and ours are to be ascribed to the following causes:

1. The Almeter measurements called in the text "original" have not been made according to the IWTO Standard. Referring to the description on page 3: "Samples of the tops which were produced from these wools were labelled and then draped over the edge of an empty can, and during the course of approximately the following 3 — 6 weeks were measured in the normal way on an Almeter". The procedure outlined in paragraph 4.1 of the IWTO. Standard, requires immediate twisting at 24 turns of a length of 1,20 m of top and conservation of the sample in this form until it is measured. This method of preparation of the sample is very important to avoid "shortening" due to crimp, mainly in the fine and overcrimped wools. As a consequence, all the results called "original" in the report, should not be considered. (The same is true for fig. 1, and regression equations with index O in page 6).

Some figures showing the effect of twisting the sample are shown below:

(a) Reference measurement made on top twisted at 20 turns per meter for conservation, according to the IWTO. Standard, the day of the sampling at the machine. Measurement after 1 month on the same top kept in twisted form: H - 0,3%; B - 0,5%. Measurement after 1 month on the same top untwisted, kept in open form:
H - 6,7%; B - 7,5%.
Measurement after 1 month on the same top kept in ball form:
H - 0,5%; B - 1%.

(b) The best way of twisting the sample is by using a small hand-driven machine where the 1 m length of top is submitted to a tension of about 430 g during twisting, except at the beginning, and to coil the twisted sliver on a cardboard tube about 5 cm in diameter. Samples kept in this way are much less exposed to the effect of the crimp and can be measured after a long time.

2. The Almeter measurements called "aged", made on samples taken from a ball after 6 months storage, could eventually be considered as a replacement for "original" measurements, at the condition that the Almeter measurements have been made *immediately* after removal of the 1,20 m sample from the ball (but this does not seem to be the case). We have indeed observed that there is little difference between a measurement made on a sample kept in twisted form, and a measurement on a sample taken directly from a ball.

We think that what you consider as an "aging" effect is in fact the conservation of the relatively "decrimped" state of the top immediately after leaving the gills, which is obtained as well in ball form as in "twisted sample" form. If the "aged" values were accepted as original Almeter measurements, the average difference between Almeter and single fibre mean lengths on the 30 lots considered becomes (74,36 - 78,93) mm or 5,8%.

This value is still greater than the one deduced from our own and Greuel and Henning experiments, but could be explained by the following observations.

3. The lots used by Greuel, Henning and ourselves were industrial lots, generally composed of a large mixture of individual farm lots, and as a result of this mixture probably conforming to the Duerden crimp standard. On the other hand, the lots used by the author are not industrial lots, but individual farm lots, corresponding to a range of breeds, and constituting as the author admits on page 3 "a rather wide and unusual range of wool tops, some considerably overcrimped". Indeed, the average "overcrimping" compared to Duerden is 18% for the 30 lots considered.

4. To summarize our impressions, we think that Dr Turpie's work is very interesting because it is the first really systematical analysis of the causes of the differences between Almeter mean fibre length and single fibre mean length, but that the magnitude of the crimp effect, mainly on fine and overcrimped wools, has been much overestimated because of the non-observance of the preparation method for the samples.

Finally we would like to make a more fundamental point. We do not agree at all with Dr Turpie when he says that the single fibre length method gives the "correct" or "real" values for fibre length. On the contrary, we think that an

Almeter or Wira Fibre Diagram measurement is much more realistic and much more meaningful for commercial, industrial, and research purposes. The practical use of a length measurement is indeed either the choice of suitable machine adjustments (ratch in a gills, main comb setting, distances between successive rollers on a breaking machine, etc...), or the prevision of semi-finished or finished product properties related to the fibre length distribution (number of thickness faults in the yarn, unevenness, breaking load, cohesion of the top, etc...). It is thus better to measure the fibre length in a state as close as possible to the one the fibre adopts in the machine which is to be adjusted, or in the product to be evaluated.

In all these situations, the fibres always keep some amount of crimp, hooks and ondulation. On the contrary, in a single fibre measurement, each fibre is submitted individually to a relatively high tension which entirely removes the crimp and ondulation. The single fibre measurement is thus in our opinion an artificial measurement method, only suitable for reference purposes as a secondary check. The measurement on large draws of fibres also gives more extended information. For instance, on the card sliver we make two types of Almeter measurements.

(i) inserting the card sliver in the automatic grip in the same direction it will enter into the first gill (measurement A)

(ii) after preparation of the card sliver in an "opening machine" composed of a gill with back and fore draft, removing leading and trailing hooks (measurements B).

Measurement A gives the real "extent" of the fibres when they leave the card, measurement B the state they will acquire when they reach the comb. The ratio of lengths at 2,5% from measurements A and B gives a "parallelization" or "unhooking" index which describes the efficiency of carding.

Another point we would like to make is the enormous number of fibres necessary to make a valuable assessment of average fibre length on single fibres.

(a) if the variation of fibre length was purely random, the large CV of length (about 50%) would require to measure 10 000 fibres for a confidence interval of ± 1% at the 95% level and still 2 500 fibres for a ± 2% confidence interval.

(b) we have observed on many lots that there is always a systematic variation of average fibre length along the top, superimposed on the random variation. This systematic variation has about the form of a sine function, with an average period of a few tens of centimeter and an aptitude of about ± 2%. This variation corresponds probably to the oscillatory nature of the percentage of short fibres in the gilling operation, the non-controlled short fibres being delivered in a cyclic way.

We thus consider that it is necessary to make more than one measurement, with a sufficient spacing between measurements. We have not found in the report the procedure used for single fibre measurement (sampling, number of fibres, etc...)

Finally, we agree with Dr. Turpie that an indication of the fibre crimp, together with the average fibre length on draws of fibres, would give a useful information to the spinner.

REPLY BY THE AUTHOR:

The author is grateful to Mr. Grignet for being so kind as to study this paper and for providing us with his valuable comments, but would like to present the following reply in response to certain points raised by Mr Grignet.

It is frequently not easy to abide by the IWTO regulations with respect to the determination of length on the Almeter, for the simple reason that samples are often received which are not twisted or prepared in the manner prescribed. For this reason the 'original' measurements have been selected to represent the *practical* case where a sample with little or no twist is simply evaluated by testing in the Almeter without any pre-conditions being imposed. The author considers that in this respect the values obtained serve a useful purpose, as well as serving to highlight the pitfalls to those who adopt this method. Perhaps, as suggested in the article, the information provided would enable a suitable correction to be made which would be of some practical use, particularly if some knowledge of the raw wool is available.

The measurements made on the samples taken from the balls were closest to the IWTO specification, as Mr Grignet suggests, but even so crimp had a statistically significant effect and was quite appreciable on the fine overcrimped wools. The author cannot guarantee that these samples were measured *exactly* in accordance with the IWTO specification i.e. within 4 hours of sampling. To enhance the value of this report, therefore, *all the tops were re-measured in accordance with IWTO-17-67(E) after receipt of Mr. Grignet's reply.* Reference balls of tops had been retained from every experiment. The results are presented in Table V.

The results given in Table V show quite clearly that while strict adherence to the IWTO test procedure improved the length previously obtained from the balls by an average of some 1,4 mm, some very serious discrepancies still exist, and the overall mean is still some 3,2 mm below the single fibre length mean. A quadratic regression analysis using the same independant variables as before on these results, yielded the following equation, significant at the 99 per cent level of confidence:

Y_1 (As per IWTO-17-67(E)) = $0{,}790\ Z_1 + 2{,}386\ X_1 + 12{,}150\ X_2$
$-0{,}642\ X_1X_2 - 31{,}85$ ....(16)
$n = 30$; $r = 0{,}947$; % fit = 90

When the analysis was carried out in log form the following equation was found to be significant at the 99 per cent level of confidence.

Y_1 (As per IWTO-17-67(E)), $= 8{,}53\ Z_1^{\ 0{,}784}\ X_1^{\ -0{,}284}\ X_2^{\ -0{,}249}$ ....(17)
$n = 30$; $r = 0{,}913$; % fit = 83.

TABLE V

COMPARISON BETWEEN ALMETER MEAN FIBRE LENGTH, AFTER RE-MEASUREMENT OF THE BALLS IN ACCORDANCE WITH IWTO SPECIFICATIONS, AND THE SINGLE FIBRE LENGTH VALUES

Sample	Almeter mean fibre length Y_1*	Single fibre mean length Z_1*	Difference	Sample	Almeter mean fibre length Y_1*	Single fibre mean length Z_1*	Difference
1	75,6	77,9	-2,3	16	73,2	77,3	-4,1
2	75,0	78,3	-3,3	17	61,5	64,5	-3,0
3	66,4	69,7	-3,3	18	73,6	81,1	-7,5
4	77,4	79,8	-2,4	19	72,7	84,2	-11,5
5	78,3	83,6	-5,3	20	74,5	81,8	- 7,3
6	70,6	75,9	-5,3	21	76,8	70,5	+ 6,3
7	66,9	70,0	-3,1	22	70,2	71,0	- 0,8
8	88,5	87,3	+1,2	23	71,0	75,9	- 4,9
9	71,9	80,0	-8,1	24	77,6	76,5	+ 1,1
10	70,5	76,2	-5,7	25	74,0	83,3	- 9,3
11	72,6	80,0	-7,4	26	84,7	82,7	+ 2,0
12	74,0	75,9	-1,9	27	72,5	67,6	+ 4,9
13	79,9	80,0	-0,1	28	76,1	77,4	- 1,3
14	61,7	69,1	-7,4	29	89,2	92,8	- 3,6
15	79,8	84,3	-4,5	30	115,5	113,4	+ 2,1
		Mean of all results:			75,74	78,93	- 3,19

* Symbols used in statistical analysis

With regard to Mr Grignet's remarks on confidence limits, in view of the fact that 30 different wools were considered and that the true means could be above and below the observed values, it is unlikely that, on average, these confidence limits seriously affected the regression equations.

It can therefore be stated that even if the IWTO specification for the measurement of wool tops on the Almeter was strictly adhered to raw wool crimp had a significant effect on the results obtained and could be quantified by the above equations. The effect was serious, particularly on fine and overcrimped wools.

We consider it a little premature to philosophise on the merits of the Almeter in respect of its possibly better correlation with practical processing performance. The merits or de-merits of the Almeter in respect of its possibly better or worse correlation with practical processing performance however, is of much interest to us and will be considered at a later stage.

ISBN 0 7988 1229 X

Published by
The South African Wool and Textile Research Institute
P.O. Box 1124, Port Elizabeth, South Africa,
and printed in the Republic of South Africa
by P.U.D. Repro (Pty) Ltd., P.O. Box 44, Despatch