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AN INTRODUCTION TO THE SAWTRI LENGTH/STRENGTH TESTER FOR RAW WOOL STAPLES*

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ABSTRACT

A staple length/strength measuring instrument has been developed for the routine automatic measurement of the cross-sectional profile and length of a wool staple, the position and cross-sectional area of its thinnest place, its tenacity and the work required to break it. The machine operation is described together with aspects regarding machine control and programming. Results of some initial studies show good correlations between the lengths measured manually and on the machine, and between the positions of the thinnest places identified by the instrument and the positions of actual break. Many different staple profiles were encountered, and not only were profound differences identified between different wool lots in respect of their strength characteristics, but also between different staples within a lot.

INTRODUCTION

It has been a well-known and accepted fact for many years that tenderness ("break") in a staple, or even an overall weakness in staple strength, will result in increased breakage during processing. Tender or weak wools are therefore subjected to a price penalty by buyers. Objective measurement of this parameter, however, was laborious until fairly recently, and was therefore seldom carried out.

In respect of the role which raw wool properties play in textile processing, it is interesting to refer to the results of research work on the topmaking and spinning performance of more than 250 widely different lots of raw wool which were presented at the Quinquennial International Wool Textile Research Conference held in Pretoria in 1980.[1] Average values and standard deviations characterising these wools were given, together with regression equations relating processing performance during scouring, carding, combing and spinning with a number of properties of either the raw wool or the tops, or both. Since the automatic routine measurement of staple strength was in its early stages of development at this time, it was not feasible, however, to carry out, manually, the large number of tests required to characterise the staple strength of the many wool lots studied. Tests were nevertheless carried out on some 49 of these lots.

***Note: This is a modified version of a paper presented to the Technical Committee of the IWTO in Paris, January 1985.**

Statistical analysis of the results of the above 49 lots failed to identify staple strength as a significant variable in explaining topmaking performance. By statistical analysis of the results of all 250 lots, without incorporating information on staple strength, it was nevertheless possible to explain some 78% of the variation obtained in percentage noil, 88% of the variation in Almeter Hauteur of the top, 93% of the variation in single fibre length of the top and 85% of the variation in the spinnability of the top. Mean fibre diameter, staple length, staple crimp, style and VM content were identified as important parameters affecting the characteristics of the tops.

Since the 1980 Conference, the processing studies at SAWTRI have continued, and the data set now covers close on 400 different lots of raw wool, and a range of different breeds, (mainly merino strains). Analyses carried out to ascertain if breed *per se* plays a role in the worsted textile performance of a wool, have been reported both at the First World Merino Conference in Australia in 1982[2] and at the Second World Congress on Sheep and Cattle Breeding in Pretoria in 1984[3]. Briefly it was found that, provided all the relevant fibre characteristic (e.g. length, diameter and crimp) of a wool are measured, it does not appear necessary to know from which breed of sheep the wool originates in order to be able to predict its worsted textile performance and the yarn and fabric properties.

Most of the work reported above[1,2,3] was carried out on wools of various class descriptions and styles normally encountered in South Africa. In view of the fact that no deliberate attempt was made to introduce tender wools, or wools having an overall weakness, the proportion of such wools would have been small in the above studies. Thus, although a highly significant proportion of the variation in percentage noil, Almeter Hauteur and spinnability could be explained[1], and conclusions reached on the question of information on breed[2,3], the work had to be extended to cover staple strength variation so as to gain a more complete picture.

At the present time, there is considerable effort being put into the development of quick and reliable routine methods for the measurement of raw wool characteristics such as staple strength and position of weakness, and to establish and quantify the effects of these parameters on the subsequent textile performance of wool[4,5,6]. SAWTRI is also involved in this research, and has developed, on behalf of the South African Wool Board, a staple length/strength measuring instrument for the routine and automatic measurement of the staple cross-sectional profile, staple length, position and cross-sectional area of its thinnest place, as well as the staple extension, tenacity and the work required to break it. This report serves to introduce this instrument, and provides results of some initial studies.

DESCRIPTION OF MACHINE OPERATION:

The SAWTRI staple length/strength tester is designed to measure various length and strength characteristics of raw wool staples. It consists principally of a feeding mechanism, a measuring mechanism, a disposal mechanism and a computer. It is programmed to test, automatically, any number of raw wool staples (usually 50 or 60), representing one wool lot, to analyse the data and to print out the results. The staples are usually selected from a grab sample using a random selection procedure, and each staple is placed by hand into individual adjacent grooves in a specially made removable loading tray with their root ends facing the open side of the tray.

A general view of the machine, and associated equipment, is shown in Fig. 1.

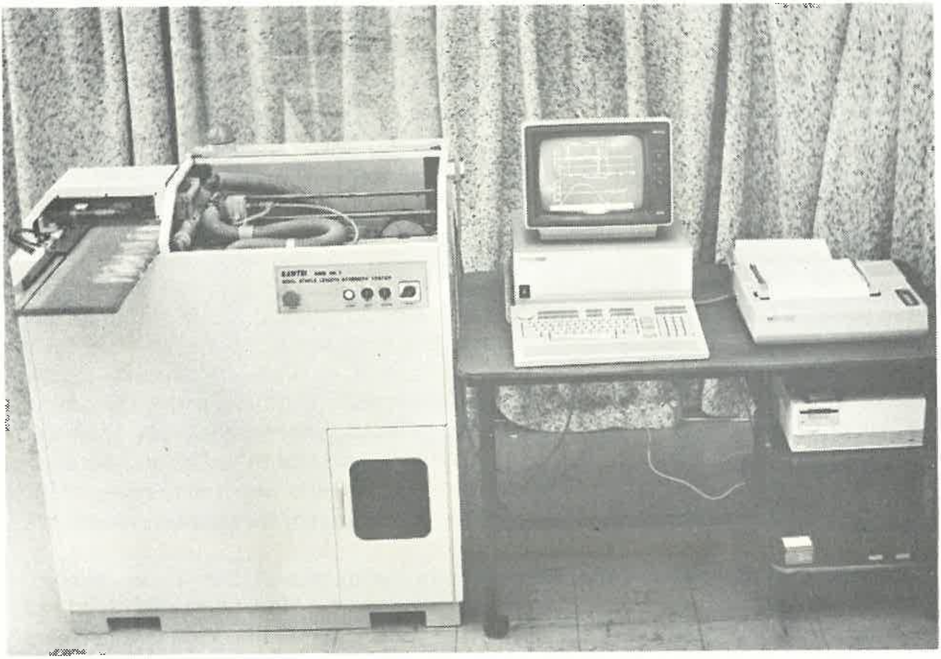

Fig. 1 – General view of SAWTRI staple length/strength tester.

A schematic diagram illustrating the passage of a staple through the machine is given in Fig. 2. The loading tray is identified 'T' in the schematic diagram, and one of the staples as 'S'. The staple 'S' is fed by means of a feeding arm 'F' into the nip of a pair of measuring wheels 'W'. A moving steel transport belt 'B' passes underneath the loading tray and between the measuring wheels, and assists in transporting the root of the staple into the nip. This steel belt moves at a constant speed which is synchronised with the speed of the measuring wheels, and performs other functions which will be described later. The measuring wheels rotate between two closefitting stationary guides which serve to confine the effective staple width to the width of the rollers.

One of the measuring wheels is in a fixed position, while the second is springloaded, and exerts a considerable force (circa 500N) on the wool. The passage of the staple through the nip of the wheels produces a vertical deflection of the movable wheel in accordance with variations in the cross-sectional profile of the staple. These deflections alter the DC output voltage of a linear transducer 'TD'. The output voltage is sampled at short regular intervals equivalent to a 1 mm movement of the transport belt, and this is converted into binary form by an analogue to digital converter, which in turn is read by a computer.

The root of the staple emerges from the measuring wheels, and is guided by means of suction into and through the open jaws of a stationary clamp 'C1', and further into and through the open jaws of a movable clamp 'C2'. (See Fig. 3 for detail). The point at which suction is applied is immediately behind the moving clamp, and the suction pipe is actually connected to the jaws of the movable clamp, so that it travels with it. The transport belt passes underneath the jaws of the stationary clamp, but through the jaws of the movable clamp, thereby assisting in transporting and guiding the staple.

The stationary clamp C1 is positioned in close proximity to the measuring wheels, and at the beginning of the extension cycle the movable clamp C2 is positioned in close proximity to the stationary clamp. Since the profile of the staple is measured at short, regular intervals, and since the distance between the measuring wheels and movable clamp is known, it is possible to programme the computer to activate the closing of the nipper jaws of the movable clamp at a pre-determined distance from the beginning of the staple root. Simultaneously, with the activation of this nipper jaw, the complete movable clamp assembly is itself clamped by a supplementary clamp onto the transport belt slightly ahead of the staple root, so that it does not clamp on to any wool. From this moment onwards until a completed break of the staple is sensed, the jaws move synchronously with the progression of the staple. Also, from this moment, due to the closing of the nipper jaws which themselves act as a closing valve, the suction applied at the movable clamp becomes de-activated, but a second suction source, positioned in front of the fixed clamp, becomes operational. Since the distance between the measuring wheels and the fixed clamp is also

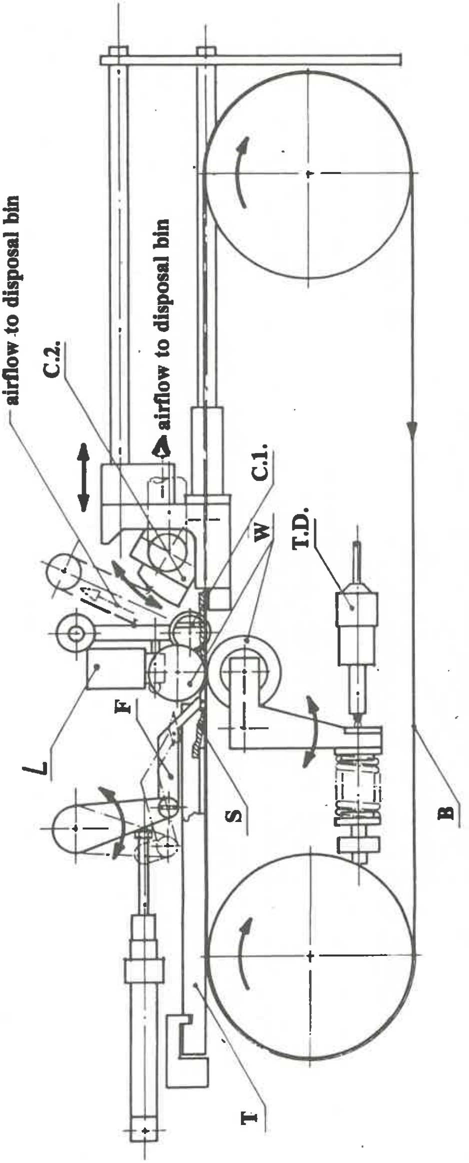

Fig. 2 – Schematic diagram of SAWTRI length/strength tester.

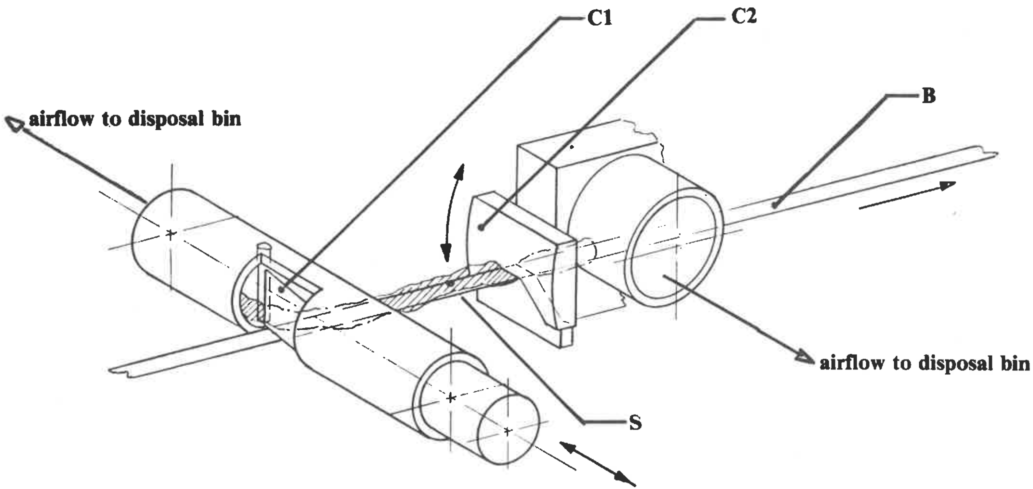

Fig. 3 – Detail of stationary and movable clamps.

known, it is possible to programme the computer to activate the nipper jaws of the fixed clamp at a pre-determined distance from the staple tip. During the short time interval between the emergence of the staple tip from the measuring wheels and the time at which the nipper jaw on the fixed clamp is activated, control of the staple is maintained by application of the second source of suction previously mentioned. This source of suction is de-activated as soon as the nipper jaw closes since this too acts as a closing valve. While the nipper jaws of the fixed clamp grip the staple, the transport belt is free to move because it passes underneath the nipper jaw. As a consequence, the staple, now positively gripped both at its root and its tip, begins to extend and continues to extend at a constant rate of 20 mm/s until it breaks. The stationary clamp is fitted with a load cell 'L' and changes in the force caused by extension of the staple, produce changes in the DC output voltage of this load cell. Here again, these changes are sampled at short regular intervals equivalent to a forward movement of the transport belt of 1 mm, and as before, this is converted into binary form by an analogue to digital converter, which in turn is read by the computer.

When the measured force approximates zero, indicating that the staple has been broken, the nipper jaws continue to move apart for a short distance to ensure that there are no isolated unbroken fibres which could cause a problem during disposal. The nipper jaw of the fixed clamp is then opened. Since the suction applied at this point is re-activated by the opening of the jaw, the tip portion of the staple is sucked away and this is then deposited into a disposal bin 'B'. At this moment, the suction applied to the fixed clamp is closed by means of a valve positioned in the disposal bin, and the nipper jaw of the moving clamp is then opened. The opening of the latter nipper jaw allows the suction applied at this point to be re-activated, and since the second source of suction has been closed, the full suction force is applied and the root portion of the staple is sucked away and deposited in the disposal bin.

After the broken portions of the staple have been sucked away and deposited in the disposal bin, the movable clamp is moved back to its original position ready for acceptance of the next staple. The loading tray is then automatically advanced by a suitable distance to allow correct positioning of the next staple, thereby completing the cycle. Such a cycle is of approximately 6 to 10 seconds duration.

CONTROL OF THE MACHINE:

A diagramatic representation of the control of the machine is shown in Fig. 4. The machine is controlled by an HP9816 Computer Controller, through an HP-IB Bus. The mechanical functions of the machine are controlled by a 12-channel digital output and a 12-channel digital input, each operating on a separate address. The digital input is provided by microswitches positioned at

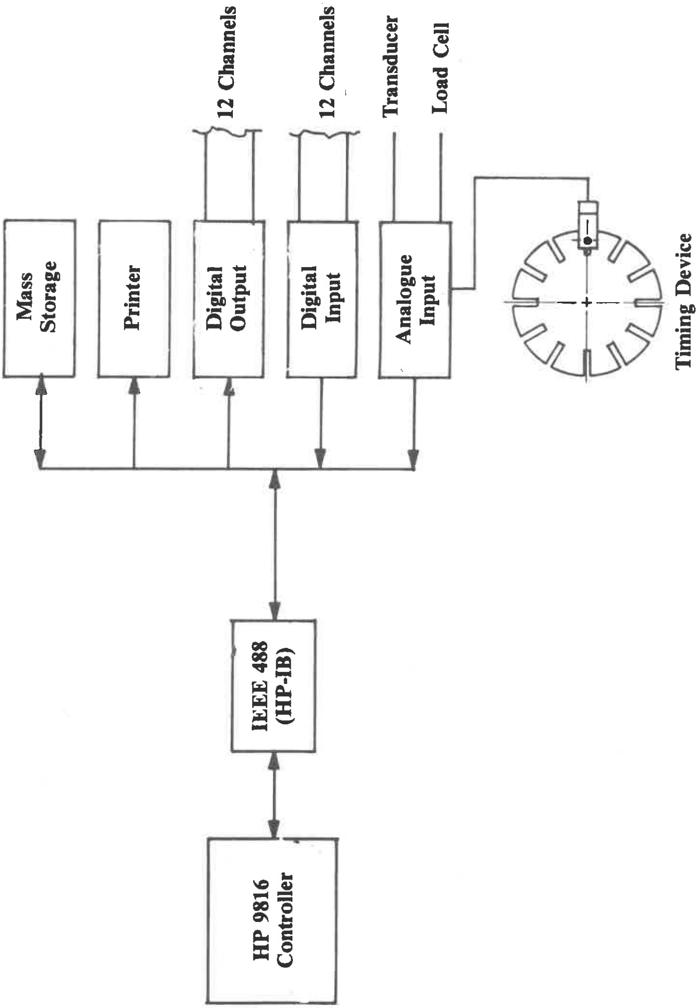

Fig. 4 – Control of the machine

suitable locations and enables the controller to read the positions of the various mechanisms. The digital output activates the solenoids and relays used in the machine for various mechanical purposes. Data acquisition is by means of a two-channel multiplexed analogue input device which is connected to a transducer on the measuring wheels of the machine, and to the load cell on the nipper jaws of the fixed clamp. A timing wheel revolves continuously in synchronisation with the linear movement of the transport belt, and using a slotted optocoupler as a sensor, provides a chain of pulses spaced every 1 mm of linear movement of the transport belt. These pulses are used to trigger analogue to digital conversion when such an input is requested by the controller.

Using the same HP-IB Bus as an interface, mass storage facilities are provided to enable subsequent data manipulation and analysis, and a printer is also provided to provide hard-copy of the results both in alphanumeric and graphics form.

PROGRAMMING:

1. Self-checking of machine at start-up:

In order to ensure proper mechanical functioning and data acquisition, it is important to establish the readings of both the transducer and load cell for zero staple cross-section and zero force respectively, since they may change slightly from test to test due to many factors such as dirt or grease accumulation on the transport belt, temperature and humidity changes, etc. The controller is therefore programmed to automatically establish the mean values of a number of transducer and load cell readings before a test commences so as to provide a base line against which to judge all subsequent readings.

2. Presence of staple in measuring wheels:

When five successive readings of the measuring wheels are higher than a pre-determined trigger level above the established zero base line, a staple is deemed to have entered the measuring wheels. The trigger level has been set at about 2% of the normal thickness of a staple. The five successive readings, together with all subsequent readings taken until the other end of the staple has been sensed, are stored in a specially allocated memory location in the computer. The above decision was made to prevent a mis-triggering of data acquisition of a non-existent staple should a particle of dirt, for example, pass through the measuring wheels.

3. Beginning and end of a staple:

There are many different views on what constitutes the "beginning" and "end" of a specific staple for purposes of establishing its length characteristics.

Staples are often "skewed" (i.e. their root ends are often not truly perpendicular to the staple axis), and also frequently have wisps of fibres protruding from either the tip or the root which could interfere with the interpretation of their true length. We have defined the beginning of the root to be a point where its thickness is half the thickness of the mean thickness of the entire staple. With respect to the tip, however, in order to cater for staples having a pronounced taper, we have arbitrarily selected the point corresponding to a thickness which is one quarter of the mean thickness of the entire staple.

4. **Positioning of the nipper jaws of both clamps:**

To avoid possible slippage which may occur if strong staples are clamped too near their ends, it is necessary to clamp the staples at some safe predetermined distances from either end. Clearly the distance between the clamps should be as high as possible within these safety limits so as to expose the maximum amount of the staple, and therefore as many weak or thin portions as there may be, to the tensile test. From experience gained during the design and construction of the machine, it was decided to programme the jaws to be activated 18 mm from the root and tip ends of the staple, respectively. A further condition which was imposed was that the minimum distance between the nipper jaws at the commencement of extension should be 14 mm, since very short distances could produce artificially high values for strength. While the instrument will measure the length of a staple, however short it may be, the minimum length it will accept for strength measurement is therefore 50 mm . (Where relatively low forces are required to break the staples, the nipper jaws could be programmed to be activated at shorter distances than 18 mm from the root or tip, if desired, thus reducing the minimum length requirement).

5. **Preliminary identification of the beginning and end of a staple for purposes of activating the nipper jaws:**

To facilitate rapid automation of the length and strength measurement functions of the machine, it is necessary to make a preliminary estimate of the position of the beginning and end of a staple before waiting for the final computer assessment. In this respect, the mean cross-sectional area of the staple is continuously computed from the data while the data is being acquired, and at the latest possible moment, this mean value is used in an initial computer assessment of the location of these points.

RESULTS OF SOME INITIAL STUDIES:

Length and Cross-sectional area of Greasy and Scoured Staples:

Ten staples were selected from each of 11 different lots of raw wool. The mass of each staple was determined by weighing, and the length of each staple was measured *manually*. The length characteristics of the raw staples were then measured on the instrument, but were deliberately *not* broken by deactivating the nipper jaws. Average properties of the different raw wool lots are given in Appendix 1.

After the length characteristics of the raw wool staples had been measured on the instrument, each staple was carefully hand-scoured, dried and conditioned, and its mass determined by weighing. Each staple was then passed through the instrument a second time to determine the length characteristics of the scoured staples.

Fig. 5 illustrates the excellent correlation between the machine measured lengths of the raw wool staples and the manually measured lengths, the percentage fit taken over 110 data points being over 97%. The machine measured length was some 11% longer than the manually measured length presumably because some of the crimp in the staple is removed when it enters the measuring wheels of the machine.

Figs. 6 & 7 illustrate that the apparent volumes of the greasy staples (as derived from displacement of the measuring wheels), were highly correlated with the mass of the greasy staples, and also with the mass of the scoured staples, in spite of the variations in the level of the contaminants in the raw wool. A logarithmic function gave percentage fits of approximately 95% to the data (110 points) in both cases, and it appeared feasible therefore to use the derived relationship for scoured staples to estimate the linear density of the wool between the measuring wheels of the instrument.

An analysis was subsequently carried out in which the cross-sectional area of each greasy staple from each lot was compared with the cross-sectional area of each equivalent scoured staple at points all along the staple from root to tip. Since some slight differences in length between the greasy staple and its scoured equivalent could occur due to handling as well as hand-scouring, it was decided, for purposes of this exercise, to normalise the results, taking 0 and 100 as the beginning (root) and end (tip) of the staple respectively.

Fig. 8 illustrates the average changes in the ratio of the cross-sectional area of the greasy staple to that of the scoured staple. The values have been averaged over 11 different wool lots and show that the scoured staples had a cross-sectional area some 93% of that of their greasy counterparts practically all the way from the root end to about mid-way along their length. The ratio is then seen to decrease progressively, finally reaching a value of about 73% at the tip. Surprisingly, in spite of substantial differences between the different wool lots, the CV of these average values was relatively low, varying from about 3% to 9%.

The average between-staple standard deviation is illustrated by the broken lines in Fig. 8, and clearly shows that, for some considerable distance along the staple, there is a zone where the scatter of the values of the cross-

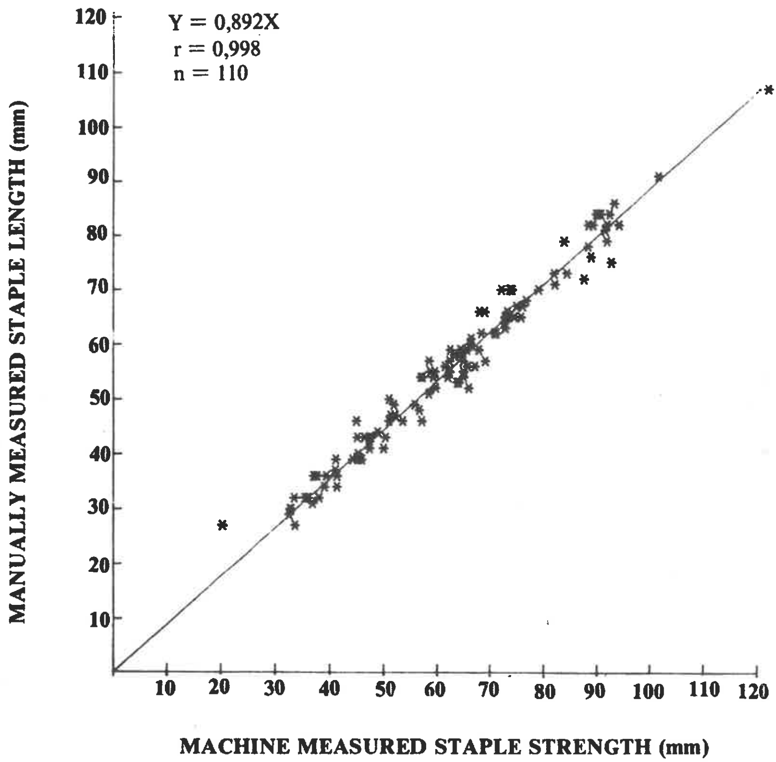

Fig. 5 – Machine measured versus manually measured staple length.

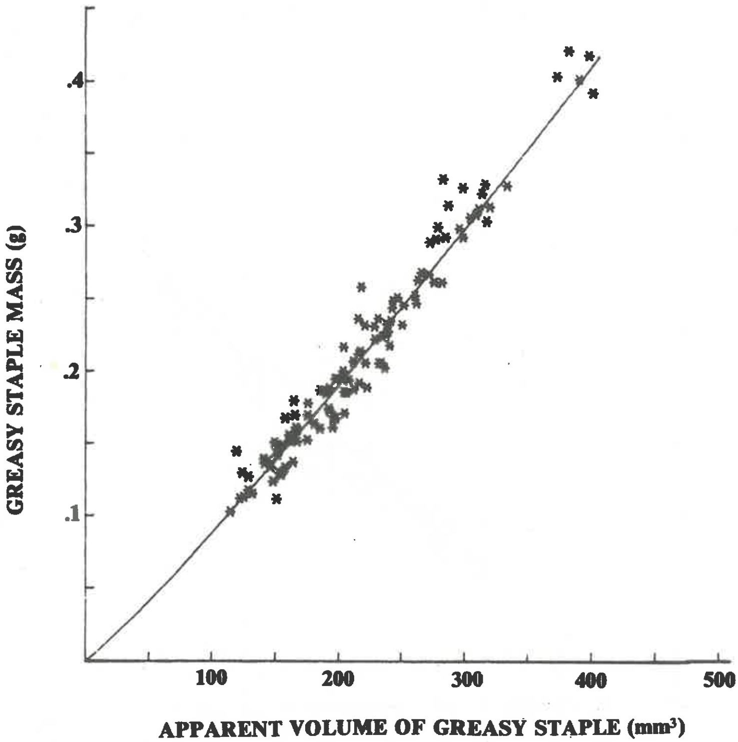

Fig. 6 – Apparent volume of greasy staple versus greasy staple mass.

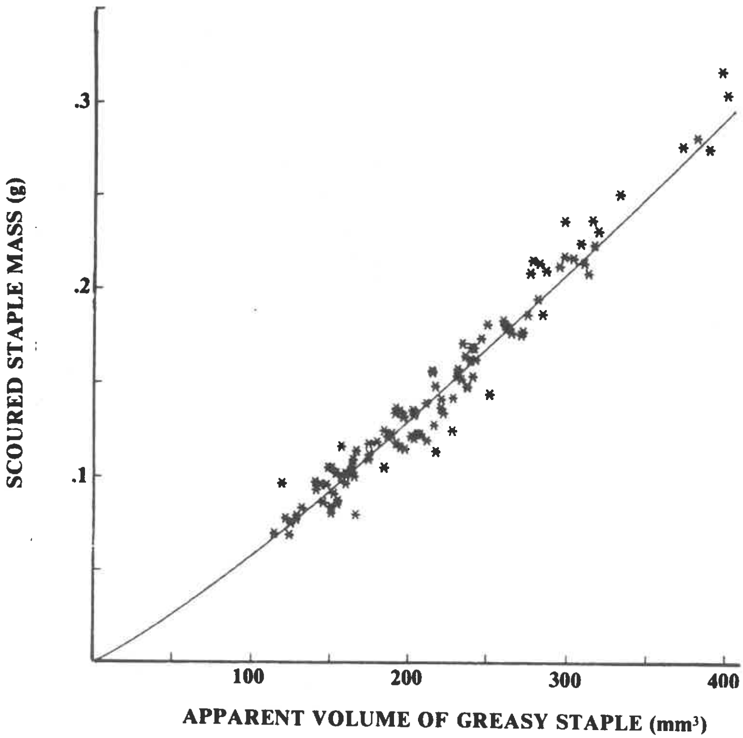

Fig. 7 – Apparent volume of greasy staple versus scoured staple mass.

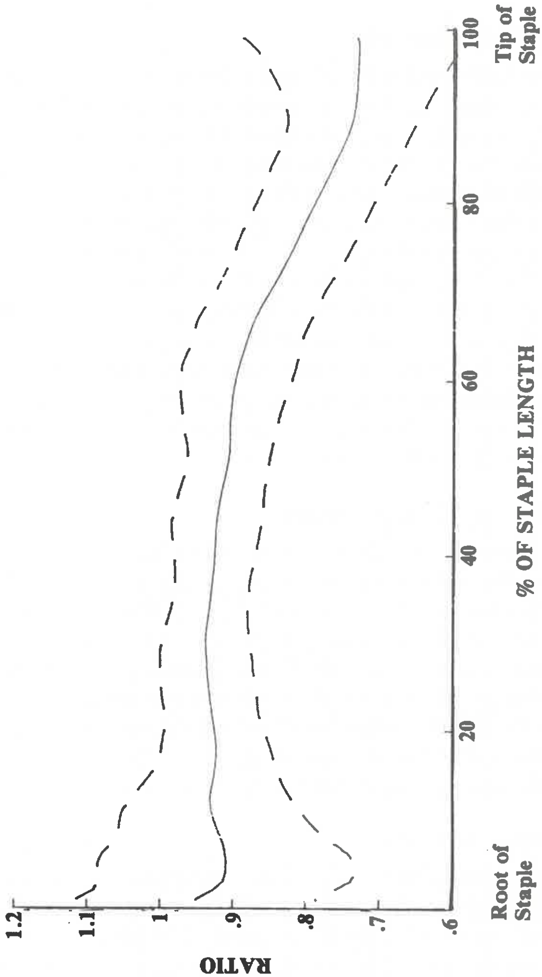

Fig. 8 – Variation in the ratio of the cross-sectional area of scoured staple to raw staple along the length of the staple (broken lines represent ± 1 standard diviation).

sectional ratio between the greasy and scoured cross-sectional areas was relatively small.

Staple profile and force/extension area:

A staple profile is illustrated in Fig. 9, and a force/extension curve in Fig. 10. Fig. 9 shows where the staple has been deemed to begin and end, and also the exact position in which the staple was clamped by the nipper jaws prior to extension and subsequent break. The uppermost of the two curves gives the profile of the greasy staple as sensed by the measuring wheels, whereas the lower curve gives the profile of the scoured staple which has been estimated using the cross-sectional ratio results reported earlier. The thinnest place between the two clamps is also shown. This has been estimated from the scoured profile, but clearly it would not have made any difference in this case had it been estimated from the greasy profile. Fig. 10 indicates the peak tenacity and the mean tenacity while the area under the curve represents the work expended in breaking the staple. These strength characteristics have been expressed on the basis of the linear density relation illustrated by Fig. 7, and are therefore based on the estimated linear density of the clean staple.

Effect of Grease and Dirt on Tenacity Results:

To ascertain whether the presence of grease and dirt in the raw staples had any adverse affect on the measurement of the tenacity of the staples, a small number of staples (3 to 5) were selected from each of six different wools. Each of these staples was carefully split by hand into two halves. One of these was measured in the greasy state, whereas the other was carefully hand-scoured and measured in the scoured state. The results of the experiment are given in Table 1, and show that in spite of fairly large variations in the levels of the contaminants on the raw wool, there was a reasonable correlation ($r = 0{,}84$) between the peak tenacities obtained on the greasy staples and their scoured counterparts.

Examination of the position of break:

The breakage of a staple of raw wool held between two clamps does not always occur at a well-defined position along the staple, except in cases where there is a very distinct reduction in staple cross-section. Where there is no such relation, the staple can break at random along its length or it need not break (sharply) at a clearly defined position. It can be expected, therefore, that the prediction from the staple profile of the position at which the staple will break and the actual position at which it breaks will be more accurate as the thinnest place becomes more pronounced.

To compare the position of the thinnest portion of the staple as assessed by the machine, with the actual position where the staple breaks during the test,

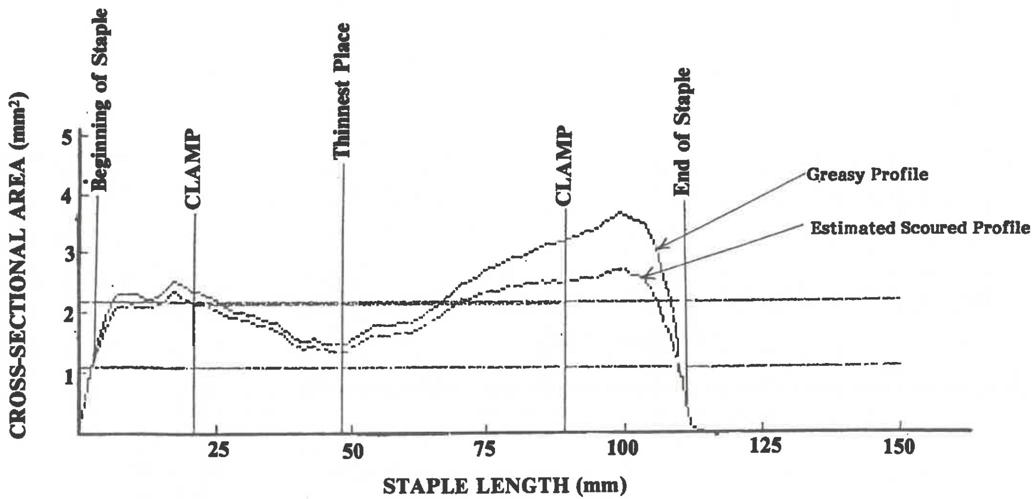

Fig. 9 – Example of a raw wool staple profile showing where it was deemed to begin and end, where it was clamped in the machine and also its estimated profile in the scoured state.

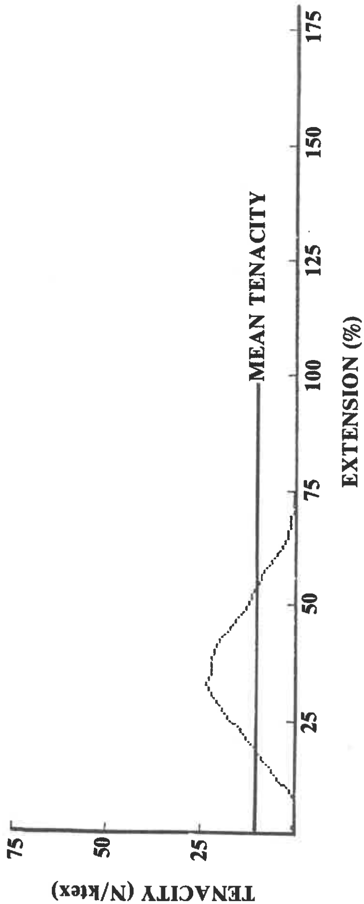

Fig. 10 – Example of a force/extension curve obtained from a raw wool staple

TABLE 1

EFFECT OF GREASE AND DIRT ON TENACITY RESULTS

Wool Lot No.	Grease Content (%)	Suint (%)	Wool Base (%)	Peak Tenacity	
				Greasy Staple	Scoured Staple
PP122	13,7	11,6	49,6	79,5	90,1
BR15	23,0	7,0	54,5	90,9	91,0
BR42	12,0	9,0	58,2	60,7	71,8
BR88	17,2	6,6	54,1	67,5	76,3
PP55	15,0	8,0	51,4	93,1	90,3
PP57	16,0	7,0	54,9	71,0	88,6
				77,1	84,7

98 staples taken from five different merino wool lots were passed through the machine, their length and strength characteristics measured, and the broken portions of each staple individually weighed.

In Fig. 11 the measured mass of the broken root portion of each staple, expressed as a percentage of the total mass of the staple, has been plotted as a function of the volume of the root portion of each staple expressed as a percentage of the total volume of the staple. The volumes were obtained by integration of the relevant portions of the greasy staple profile curves. The results clearly illustrate that there was a good correlation (81% fit) between the thinnest place identified by the staple profile measurements and the actual position of break. Indications were, however, that the lower the work to break was, the better the fit apparently became. For example, if data points representing work to break values above three arbitrarily selected thresholds of 3000, 2000 and 1000 N/ktex.mm were omitted, the percentage fit became 85%, 88% and 96% respectively. (There were, however, also fewer data points).

Data building of length/strength characteristics over a wide range:

Initially a total of 27 different lots of raw wool were selected for measurement of their staple length/strength characteristics. These were selected broadly to encompass three levels of staple length, three levels of mean fibre diameter and three levels of conversion ratio (i.e. the ratio between staple length and top mean fibre length). The lots had previously been processed into tops at SAWTRI, and reference samples of the raw wool were available. The reference

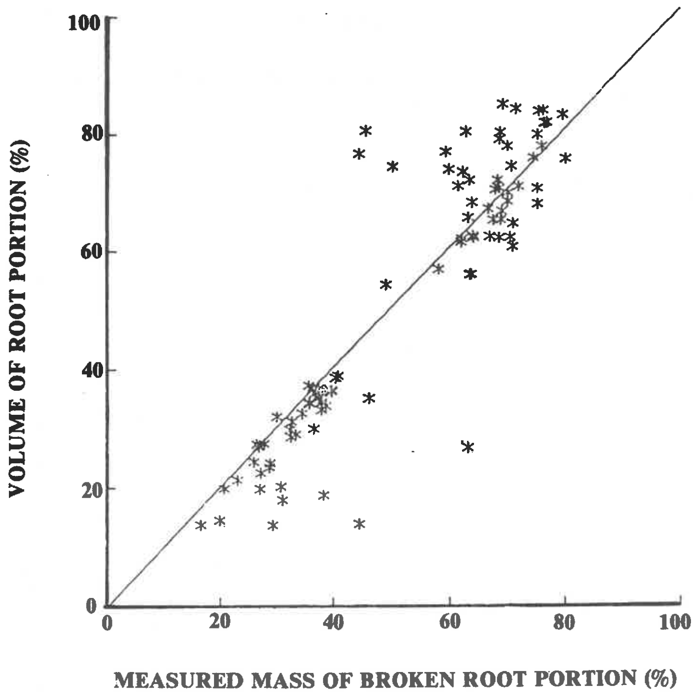

Fig. 11 – Volume of root portion up to thinnest place as % of total volume versus measured mass of broken root portion as % of total mass.

samples were spread out evenly on a table and covered with a grid containing 30 circular holes. One staple was carefully removed from each hole in the grid, and the 30 staples then used for automatic length/strength measurement. The properties of the raw wool lots, (including the staple length as determined by the simple ruler method), are given in Appendix II.

An example of the length/strength results obtained on the individual staples of one specific lot is given in Table 2. Figs. 12 and 13 illustrate two of the many different profiles encountered. A summary of the mean values obtained on all 27 lots in the study is given in Table 3.

From Tables 2 and 3 it can be seen that, not only were there profound differences between different wool lots in respect of their strength characteristics, but that there were profound differences between different staples within a lot.

TABLE 2

EXAMPLE SHOWING RESULTS OBTAINED FOR 30 STAPLES FROM ONE SPECIFIC LOT (LOT NO BR96)

Staple No.	Staple Length (mm)	Mean Cross-sectional area (mm²)	Linear Density (ktex)	Magnitude of thinnest place (%)	Position of thin-nest place (%)	Peak Tenacity (N/ktex)	Mean Tenacity (N/ktex)	Work to Break (N/ktex. mm)
1	81.1	1.2	.7	87.7	33.7	38.0	19.5	1 813
2	71.2	1.4	.9	93.3	44.8	87.9	49.0	4 751
3	87.1	1.9	1.2	80.0	20.8	38.2	20.7	1 405
4	69.0	1.5	.9	73.9	31.4	28.1	16.4	1 334
5	82.8	1.6	1.0	89.1	43.6	68.1	40.0	3 301
6	64.3	1.8	1.2	85.0	37.6	27.7	15.1	1 244
7	86.4	1.9	1.2	58.2	28.9	23.1	12.2	928
8	94.5	1.5	.9	87.5	38.6	46.8	24.7	1 519
9	74.7	1.1	.7	74.7	25.5	28.2	15.5	1 129
10	99.4	1.3	.8	88.1	20.0	35.6	20.3	1 166
11	70.6	1.7	1.0	72.6	26.4	17.8	10.3	729
12	69.1	1.5	.9	85.4	47.9	17.9	8.0	697
13	98.9	1.3	.8	66.7	29.0	22.1	13.4	585
14	86.8	1.8	1.2	81.5	21.3	50.2	26.8	1 662
15	74.8	2.1	1.4	85.7	24.2	33.9	19.6	1 696
16	102.5	2.0	1.3	77.5	38.5	29.4	14.8	1 031
17	93.2	1.4	.9	83.1	28.5	41.5	19.7	1 407
18	76.8	1.7	1.0	88.5	40.9	58.3	32.6	2 340
19	117.4	2.3	1.5	77.3	27.0	40.1	20.9	1 227
20	81.3	1.8	1.1	85.4	43.4	31.2	17.0	1 351
21	78.5	1.8	1.1	87.4	48.8	23.3	13.3	962
22	94.9	.8	.5	82.7	22.6	46.2	26.3	1 340
23	88.7	1.2	.7	55.1	43.8	20.5	9.0	592
24	78.0	1.1	.6	67.2	35.2	40.8	19.2	1 266
25	54.9	1.1	.7	92.7	34.2	2.4	2.0	329
26	87.2	1.3	.8	69.0	22.7	29.5	15.2	931
27	100.6	1.4	.9	77.4	22.4	28.1	13.7	1 007
28	98.4	1.7	1.1	50.1	18.8	15.8	8.0	412
29	93.8	2.3	1.5	89.9	39.1	61.7	33.8	2 112
30	77.9	1.8	1.2	76.3	23.1	39.0	21.0	1 333
Mean	84.5	1.6	1.0	79.0	32.1	35.7	19.3	1 387
CV	15.9	22.7	22.7	14.0	28.7	48.5	51.2	63

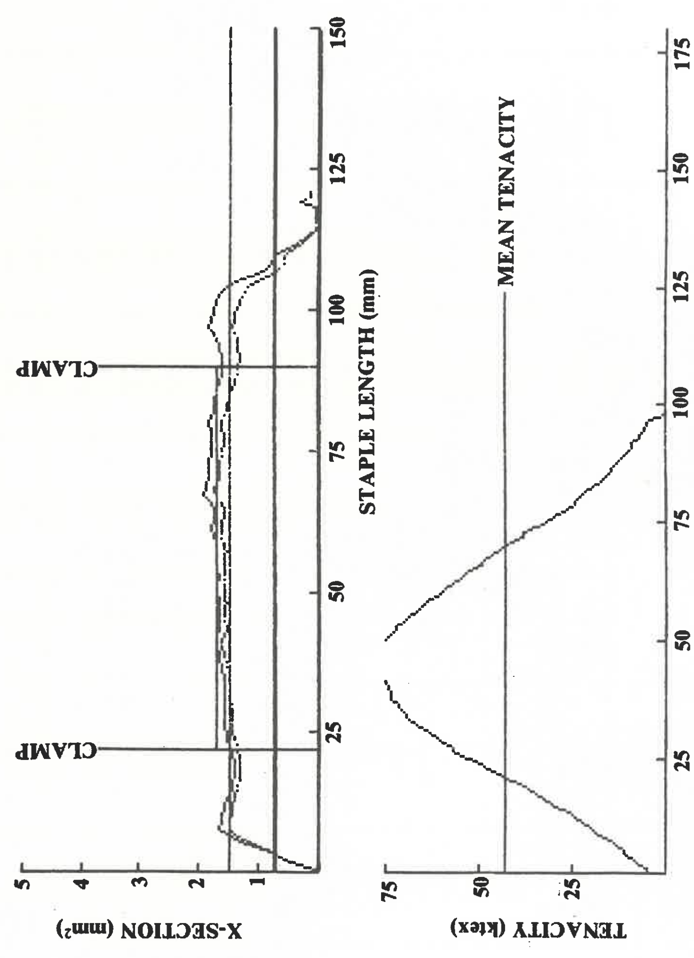

Fig. 12 – Example of profile and force/extension curve from a "high tenacity" lot (lot BR11, staple no. 19).

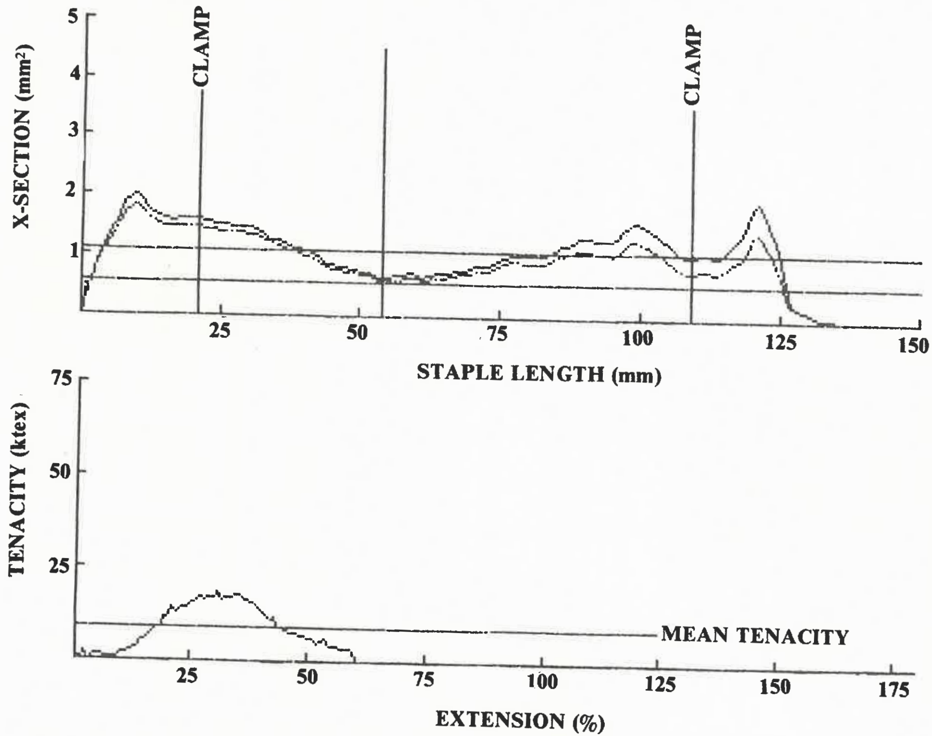

Fig. 13 – Example of profile and force/extension curve from a "low tenacity" lot (lot BR54, staple no. 14).

TABLE 3

LENGTH/STRENGTH CHARACTERISTICS OF 27 DIFFERENT LOTS OF GREASY STAPLES

Lot No. \ Property	Machine Length (mm)	CV (%)	Thinnest magnitude %	Thinnest position %	Peak Tenacity N/ktex	Mean Tenacity N/ktex	Work to break N/ktex.mm	CV of work %
BR58 *	73,0	13,4	83,1	41,8	44,4	24,6	1667	40
BR99	68,6	22,8	87,2	33,8	57,7	31,7	2825	45
BR97	70,6	20,7	81,1	31,2	44,5	24,3	1842	50
PP153	59,2	12,0	89,5	37,5	74,7	42,7	3662	40
OSP45	63,3	20,6	84,0	37,1	51,5	29,2	3034	65
BR33 *	76,6	12,0	83,2	33,7	44,8	24,0	2008	34
BR65	65,8	15,5	84,6	37,9	63,4	32,6	2542	46
PP72	70,3	11,9	84,9	31,5	70,8	39,7	4189	35
BR41 *	66,7	9,2	89,7	36,5	70,5	40,0	3922	37
BR54 *	80,5	23,4	69,6	33,7	21,9	11,2	979	50
BR35 *	80,6	23,4	78,6	37,1	33,2	18,2	1325	51
BR96	84,5	15,5	79,0	32,1	35,7	19,3	1387	63
BR42 *	80,4	12,1	76,7	30,2	52,4	29,9	3108	41
PP122	86,1	14,5	84,0	32,4	57,3	32,0	3148	48
BR88	87,8	22,3	75,5	33,0	74,2	40,6	2613	29
BR15 *	80,8	10,1	86,8	29,4	74,6	39,7	3873	28
PP55	89,1	14,2	82,0	28,1	63,7	34,9	2952	48
PP57	88,4	13,9	84,6	33,4	68,5	37,1	2816	45
PP49	86,7	14,2	76,2	32,3	43,9	22,4	2080	32
BR27 *	88,6	26,0	77,8	28,9	44,7	23,0	1885	55
BR53 *	93,8	14,6	78,4	37,6	32,6	16,9	1169	47
BR11 *	91,7	12,9	84,3	24,0	83,2	44,5	3979	28
PP101	94,2	15,3	78,4	30,3	53,4	28,1	2456	58
BR08 *	98,5	15,2	74,4	34,0	38,8	20,0	1506	61
BR09 *	93,4	8,7	84,4	23,9	67,7	35,4	3003	33
BR21 *	91,2	16,2	85,8	35,1	65,3	37,0	3589	43
BR93	94,3	14,0	74,9	29,5	51,5	26,8	1659	41

* Also tested at CSIRO

It was interesting to examine the wide variety of different staple profiles encountered during this study. Fig. 12 shows a profile of one of the "high tenacity" lots encountered, together with the force/extension curve. There was no well-defined "weak" place evident from the profile and the thinnest point between the two clamps actually coincided with the clamp on the left of the figure.

Fig. 13 shows a profile of one of the "low tenacity" lots encountered together with the force/extension curve. These curves illustrate a very marked thinning of the staple some 34% from the root-end, and extremely low values for tenacity and work to break.

A linear regression of the manually measured staple length (see Appendix II) as a function of the machine measured staple length was carried out on 810 results (30 staples x 27 lots), and the following equation was derived:

Manually measured staple length = 0,914 x (machine measured staple length).

n = 810; % fit = 91,6.

The confidence limit of the slope of the above equation was found to be ± 0.112. The equation derived from the points shown in Fig. 5 from a different selection of wool lots, is within these confidence limits.

Correlation between single fibre strength (scoured) and machine-measured staple strength (greasy):

One staple from each of the 27 different wool lots referred to previously, was selected to determine the correlation between single fibre strength, as measured on an Instron, and staple strength, as measured on the SAWTRI instrument. Each staple was carefully split longitudinally, and one portion used for each of the two different tests. In the case of the single fibre strength test, 10 fibres were withdrawn from each staple after the latter had been scoured and conditioned.

The two sets of results were significantly correlated and the following equations, significant at the 95% level, were derived:

Staple Peak Tenacity	=	0,14 x (sft x sfe) + 13,7	% fit = 57,3
Staple Mean Tenacity	=	0,07 x (sft x sfe) + 8,6	% fit = 52,8
Staple Work	=	18,6 x (sfw) - 30,6	% fit = 54,7

where sft = single fibre tenacity
sfe = single fibre extension
sfw = single fibre work

Significant correlations between single fibre strength and staple strength have also been reported previously during very early work on the SAWTRI instrument[7].

Correlation between strength results on 14 of the above lots tested at SAWTRI and at CSIRO, Australia:

Of the 27 lots selected for these experiments, 14 had been tested for their strength characteristics by the CSIRO, Ryde, Australia during the course of an earlier investigation. (The specific wool lots involved have been marked with an asterisk in Table 2). The CSIRO staple strength results were regressed against the SAWTRI results for peak tenacity, and also mean tenacity. The correlation coefficients were found to be 0,908 and 0,886 respectively.

Development of a mathematical model to predict topmaking performance:

A mathematical model to predict topmaking performance from staple length and strength data supplemented by diameter, vegetable matter content and other available data, is being developed at present.

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THE 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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APPENDIX I

AVERAGE PROPERTIES OF DIFFERENT WOOL LOTS SELECTED FOR VOLUME/MASS CORRELATION

Lot No.	BR 76	BR 34	PP 33	PP 36	PP 49	PP 52	PLS 9	PLS 31	OSP 13	OSP 22	OSP 29
Staple Length (mm)	58,7	57,0	72,0	75,0	85,0	80,0	44,0	38,9	54,8	47,8	64,4
CV (%)	12	12	15	16	18	14	13	16	12	23	14
Style index*	2,5	5	3,5	3	3,5	4,5	3	3	4	2	2,5
Mean Fibre Diameter (μm)	22,9	20,8	22,1	22,4	21,8	24,4	21,7	20,2	23,0	20,7	22,6
Crimps/cm	4,4	4,0	3,6	3,3	4,5	3,1	3,5	4,8	4,0	3,7	3,2
Grease content (%)	9,9	16,0	17,0	15,0	15,0	16,0	10,0	12,3	18,5	10,0	14,7
Wool Base (%)	51,0	57,2	48,7	49,8	54,4	54,0	54,1	48,8	52,3	45,4	46,1
VM Clean (%)	0,4	0,7	1,2	1,2	1,3	2,0	2,3	4,3	1,0	1,8	1,0
Suint Content	9,4	5,0	6,0	9,0	8,0	9,0	11,0	10,1	4,7	9,8	5,6
Class Description	Fleeces	Fleeces	Bellies	Bellies	Bellies	Fleeces	Bellies	Lambs	Backs	Bellies	Backs

* 1 = Very Poor Style, 5 = Spinners Style

APPENDIX II

AVERAGE PROPERTIES OF DIFFERENT RAW WOOL LOTS SELECTED FOR DATA BUILDING

Lot No. \ Property	Staple length (mm)		Conversion ratio		m.f.d. (m)		CV of Staple Length (%)	Style index	Crimps per cm	Grease content (%)	Wool base (%)	VM clean (%)	Suint content (%)	Resistance to Compression (mm)
BR58	LOW	68,0	HIGH	1,43	L	19,5	13,8	3	4,0	14,3	50,2	0,9	6,4	15,7
BR99	LOW	63,6	HIGH	1,27	M	22,7	25,7	2	5,7	8,5	42,2	5,6	5,4	23,5
BR97	LOW	59,4	HIGH	1,50	H	22,9	22,8	1	4,4	8,2	29,8	8,9	20,6	20,3
PP153	LOW	54,2	MEDIUM	1,06	L	19,8	12,4	3	4,1	12,6	52,1	1,1	7,0	15,3
OSP45	LOW	59,7	MEDIUM	1,15	M	21,5	23,3	2	3,7	14,2	44,6	3,4	11,1	15,3
BR33	LOW	68,5	MEDIUM	1,29	H	24,1	12,0	2	5,9	12,0	50,5	2,1	12,0	21,1
BR65	LOW	63,1	LOW	1,16	L	19,4	14,6	4	3,8	13,6	54,9	1,4	7,9	14,9
PP72	LOW	64,2	LOW	1,04	M	21,3	12,9	4	3,8	15,0	50,7	2,3	5,0	17,2
BR41	LOW	60,6	LOW	1,01	H	23,1	10,7	3	4,2	14,0	54,6	1,5	10,0	17,9
BR54	MEDIUM	71,1	HIGH	1,62	L	19,2	25,2	1	6,4	12,0	38,1	1,1	15,0	24,7
BR35	MEDIUM	74,0	HIGH	1,37	M	21,1	24,4	2	5,9	10,0	43,4	1,0	14,0	22,6
BR96	MEDIUM	72,1	HIGH	1,36	H	24,5	16,8	1,5	5,2	13,3	45,7	4,7	10,0	23,5
BR42	MEDIUM	72,9	MEDIUM	1,26	L	19,6	12,2	4	4,1	12,0	58,2	0,4	9,0	14,0
PP122	MEDIUM	78,2	MEDIUM	1,27	M	21,7	17,1	3,5	3,8	13,7	49,6	6,8	11,6	16,2
BR88	MEDIUM	81,4	MEDIUM	1,34	H	24,6	22,6	4	3,9	17,2	54,1	0,6	6,6	16,0
BR15	MEDIUM	74,4	LOW	1,13	L	19,2	10,2	5	6,2	23,0	54,5	0,2	7,0	20,7
PP55	MEDIUM	83,5	LOW	1,03	M	21,5	15,4	4	2,8	15,0	51,4	3,2	8,0	15,7
PP57	MEDIUM	82,5	LOW	1,06	H	24,9	14,9	4	2,7	16,0	54,9	1,2	7,0	14,0
PP49	HIGH	82,2	HIGH	1,28	L	19,8	14,6	3,5	4,5	15,0	54,4	1,3	8,0	17,3
BR27	HIGH	81,2	HIGH	1,31	M	22,3	26,4	2	5,2	13,0	57,2	0,3	6,0	20,6
BR53	HIGH	77,7	HIGH	1,25	H	26,4	14,7	1	5,1	11,0	52,0	1,0	14,0	22,6
BR11	HIGH	89,0	MEDIUM	1,19	L	19,5	11,9	5	5,3	20,0	58,3	0,3	5,0	18,4
PP101	HIGH	82,4	MEDIUM	1,14	M	21,7	15,2	4	3,9	15,0	57,0	0,4	6,0	15,4
BR08	HIGH	90,1	MEDIUM	1,27	H	24,3	16,5	3	4,1	15,0	59,1	0,2	8,0	18,8
BR09	HIGH	86,1	LOW	1,13	L	19,0	8,7	5	5,3	24,0	53,7	0,5	5,0	18,5
BR21	HIGH	85,7	LOW	1,07	M	21,7	14,9	4	3,8	16,0	58,3	0,6	7,0	14,6
BR93	HIGH	90,5	LOW	1,10	H	24,6	13,8	4	2,5	13,9	56,5	1,3	6,0	14,5

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