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The Correlation between Two Different Sewability Tests and the Effect of Certain Wool Fibre and Fabric Properties on the Sewability of Woven Fabrics

by

L. Hunter and M. P. Cawood

SOUTH AFRICAN
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INSTITUTE OF THE CSIR

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THE CORRELATION BETWEEN TWO DIFFERENT SEWABILITY TESTS AND THE EFFECT OF CERTAIN WOOL FIBRE AND FABRIC PROPERTIES ON THE SEWABILITY OF WOVEN FABRICS

*by L. HUNTER and M. P. CAWOOD**

ABSTRACT

Very high correlations were found between percentage sewability and average penetration force, as measured on an L & M Sewability Tester, for twill and plain weave fabrics woven from wools differing widely in their fibre characteristics. Lower, but still highly significant, correlations were also found between the sewability of some of the same fabrics when measured on the L & M and HatraSew testers, respectively. Fabric sewability generally deteriorated with an increase in fibre bulk resistance to compression (crimpiness) and fabric mass.

INTRODUCTION

The damage which is caused to fabrics, particularly knitted fabrics, while being sewn during garment manufacture, has long been of concern to the clothing industry. Seam damage can be a serious cost problem, often showing up only after the garment has been worn. It is not surprising, therefore, that considerable research and development effort has been directed towards the measurement and improvement of sewability, various publications having appeared in this respect. In 1979 a review[1] on sewability was published and since then further articles[2-18] have appeared, particularly on the subject of the sewability of knitted fabrics.

Two instruments are being used fairly widely to monitor the sewability of fabrics for quality control and research purposes[1]. Both provide a measure of the needle-to-yarn and inter-yarn frictional forces which play such an important rôle in determining fabric sewability and needle heat. The one instrument, the L & M Sewability Tester, is self-contained and measures the maximum penetration force, and its average, as experienced by the needle when it penetrates the fabric. The other instrument, the HatraSew, is used in conjunction with a sewing machine and measures the sewing needle temperature by means of an infra-red detector.

Most of the work on sewability to date has involved knitted fabrics and little, if anything, has been published on woven fabrics. Futhermore, no work appears to have been done to correlate the L & M Sewability Tester results with those obtained on the HatraSew or to correlate fabric sewability with fibre properties. The present report deals with a study undertaken to investigate these aspects.

*Present address: SA Nylon Spinners, Bellville

EXPERIMENTAL

Fabrics

A total of 55 wool lots, differing greatly in mean fibre diameter (18 to 33 μm), mean fibre length (48 to 113 mm), staple crimp (1,9 to 6,5 per cm) and resistance to bulk compression (13,6 to 23,8 mm compressed height), was studied. In brief, each of the wool lots was processed into 50 tex S380 and 50 tex S640 yarns, respectively, and then woven into two different structures[19,20]. In the one case, plain weave fabrics ($\simeq 200$ g/m^2) were woven using a common warp (R40 tex S520/2Z780), with each of the 50 tex S380 yarns being used in turn as weft. In the second case, cavalry twill fabrics ($\simeq 280$ g/m^2) were woven from the 50 tex S640 yarns, each fabric containing the same wool in both warp and weft, the former being sized. In total, 55 cavalry twill fabrics and 53 plain weave wool fabrics were produced, although not all were tested.

The twill fabrics were de-sized, and the plain weave and twill fabrics were crabbed (at 100°C), scoured (at 45°C), subjected to a "blank" bath reactive dyeing procedure (85°C), stenter dried (at 100°C), steamed, brushed, cropped and decatised.

Sewability Testing

The fabrics were tested for sewability on both the L & M Sewability Tester and the HatraSew. The percentage sewability and mean penetration force were measured on the *L & M Sewability Tester* at a threshold of 75g using a size 90 (14) sharp point sewing needle. These conditions were employed for both the plain weave and the twill fabrics.

The HatraSew was mounted on a Juki (DDL 555) lockstitch sewing machine and a size 90 (14) sharp point sewing needle was used throughout. The fabrics were tested with sewing thread on two plies of fabric, as well as without sewing thread on a single ply in the case of the twill fabric and two plies in the case of the plain weave fabric. The sewing thread used was a soft cotton R36 tex/3 (60). These experimental conditions were chosen since they gave readings which fell within the range of the F-index scale. A 2-metre length of fabric was sewn in the warp direction in each case where enough fabric was available. This length of fabric was required for the F-index value to reach a maximum. In each case the maximum reading on the F-index scale was taken.

The sewability results are given in Table I.

TABLE I

SEWABILITY RESULTS

BR NO.	TWILL WEAVE				PLAIN WEAVE			
	L & M % Sewability	L & M Average Penetration Force (cN)	HatraSew F-Index		L & M % Sewability	L & M Average Penetration Force (cN)	HatraSew F-Index	
			NT*	WT**			NT*	WT**
1	52,3	78,7	—	—	7,0	45,8	—	—
2	52,0	77,5	7,9	5,2	4,7	46,7	5,4	1,7
3	23,2	59,7	—	—	5,3	44,7	—	—
4	38,5	71,2	—	—	9,0	47,5	—	—
5	18,0	56,8	3,4	4,6	6,0	47,7	—	—
6	29,5	64,5	5,2	3,6	11,8	54,2	—	—
7	38,7	69,0	5,7	4,9	13,3	55,7	—	—
8	22,5	61,0	4,8	3,2	20,3	60,0	—	—
9	31,3	64,2	6,0	3,7	8,8	49,5	—	—
10	—	—	—	—	11,5	51,8	—	—
11	22,0	59,0	—	—	8,8	47,0	—	—
12	—	—	—	—	10,5	51,2	—	—
13	15,3	55,2	—	—	11,3	51,5	—	—
14	4,7	43,3	3,3	2,6	5,0	45,5	—	—
15	29,0	61,3	5,8	4,0	8,3	49,0	—	—
16	20,5	58,3	4,2	3,3	6,0	47,8	—	—
17	40,0	74,5	7,3	4,1	6,3	47,2	—	—
18	51,7	78,7	—	—	6,5	46,5	—	—
19	11,2	49,7	3,3	3,2	7,3	47,5	—	—
20	21,0	57,5	—	—	3,2	46,2	—	—
21	7,3	46,5	—	—	3,2	45,7	—	—
22	6,7	48,3	—	—	8,3	46,7	—	—
23	10,8	48,5	—	—	2,7	43,7	—	—
24	16,7	56,0	3,5	3,0	4,5	45,2	—	—
25	0,7	37,0	—	—	0,8	36,3	—	—
26	24,0	60,5	5,8	3,3	5,0	46,0	—	—
27	41,5	71,8	—	—	—	—	—	—
28	7,2	47,3	—	—	1,8	39,7	—	—
29	19,0	55,8	4,4	3,2	4,7	44,2	—	—
30	12,8	51,2	4,3	3,2	7,8	52,5	—	—

TABLE I (Cont.)

BR NO.	TWILL WEAVE L & M % Sewability	TWILL WEAVE L & M Average Penetration Force (cN)	TWILL WEAVE HatraSew F-Index NT*	TWILL WEAVE HatraSew F-Index WT**	PLAIN WEAVE L & M % Sewability	PLAIN WEAVE L & M Average Penetration Force (cN)	PLAIN WEAVE HatraSew F-Index NT*	PLAIN WEAVE HatraSew F-Index WT**
31	13,7	54,7	4,0	3,4	2,8	40,5	—	—
33	25,0	61,0	4,1	3,2	14,0	53,2	7,9	2,1
34	15,5	53,5	2,0	3,5	11,0	52,5	8,1	1,8
35	21,8	62,2	2,8	3,7	11,7	52,3	—	—
36	10,5	51,5	2,6	3,6	8,2	48,0	7,9	1,7
37	15,3	54,7	3,6	3,3	3,3	44,7	7,8	1,5
38	28,0	67,3	3,5	4,0	6,2	46,8	6,5	1,5
39	36,5	67,7	—	—	8,7	49,7	6,8	1,5
40	41,7	71,0	5,8	3,8	16,8	54,8	7,4	2,0
41	29,3	65,0	3,4	3,7	8,3	48,7	7,3	1,8
42	9,3	49,5	3,0	3,8	9,3	51,5	6,0	1,8
43	26,8	62,7	4,4	4,0	20,8	59,3	7,0	2,4
44	11,7	52,5	1,6	3,6	20,7	58,5	8,2	1,9
45	6,0	45,2	0,8	2,9	13,8	51,8	6,7	2,2
46	20,2	56,5	—	—	21,0	58,3	6,7	2,1
47	19,2	59,7	2,9	3,4	14,3	53,5	6,9	1,9
48	16,8	55,5	—	—	12,8	52,3	7,1	2,5
49	16,0	52,3	4,1	3,3	19,5	57,8	7,9	2,5
50	13,2	52,5	—	—	8,0	48,0	6,6	1,9
51	6,7	46,7	2,9	3,5	12,5	52,2	7,0	1,9
52	20,0	57,7	4,1	3,6	16,5	55,7	6,5	2,2
53	46,0	74,3	7,6	3,6	28,2	63,2	7,5	1,6
54	76,3	102,2	7,9	4,5	45,0	74,3	8,8	2,2
55	63,7	88,2	8,1	4,5	28,3	65,0	8,6	2,4
56	36,8	68,7	5,3	4,1	21,3	61,5	6,9	1,9
57	25,5	62,0	6,4	4,1	14,5	55,3	6,8	1,6

*NT : No Thread
**WT : With Thread

RESULTS AND DISCUSSION

Correlation Between Different Measures of Sewability

In Tables II and III the correlations between the different measures of sewability are given for the twill and plain weave fabrics, respectively. From these two tables it can be seen that there was a very high correlation between the % sewability and average penetration force as measured on the L & M Sewability Tester. This is illustrated in Fig. 1. There were also good correlations between the L & M and HatraSew values, these generally being slightly better when no sewing thread was used in the HatraSew test. This

TABLE II

CORRELATIONS BETWEEN DIFFERENT MEASURES OF SEWABILITY (TWILL FABRICS)

	% Sewability	Ave. Penetration Force	HatraSew (NT)*	HatraSew (WT)**
% Sewability	1	0,995	0,927	0,831
Ave. Penetration Force		1	0,900	0,825
HatraSew (NT)*			1	0,762
HatraSew (WT)**				1

TABLE III

CORRELATIONS BETWEEN DIFFERENT MEASURES OF SEWABILITY (PLAIN FABRICS)

	% Sewability	Ave. Penetration Force	HatraSew (NT)*	HatraSew (WT)**
% Sewability	1	0,980	0,748	0,728
Ave. Penetration Force		1	0,714	0,735
HatraSew (NT)*			1	0,557
HatraSew (WT)**				1

HatraSew (NT)* : No thread
HatraSew (WT)** : With thread

could be expected since no sewing thread is used in the L & M test. Fig. 2 illustrates the relationship between the L & M Sewability and the HatraSew F-values (no sewing thread) and it also illustrates that the two weaves lie on different levels, because, in the HatraSew test, two fabric layers were tested in the case of the plain weave and only one in the case of the twill weave.

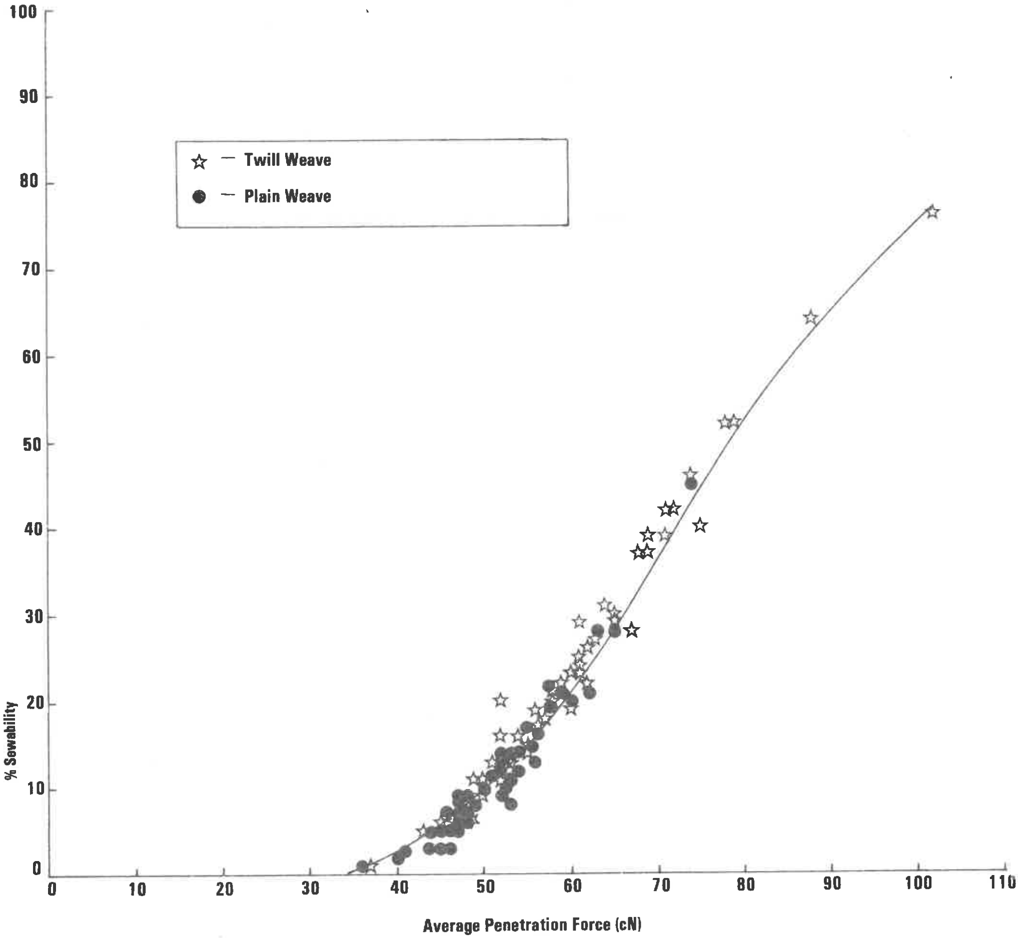

FIGURE 1

The Relationship Between % Sewability and Average Penetration Force as Measured on the L & M Sewability Tester

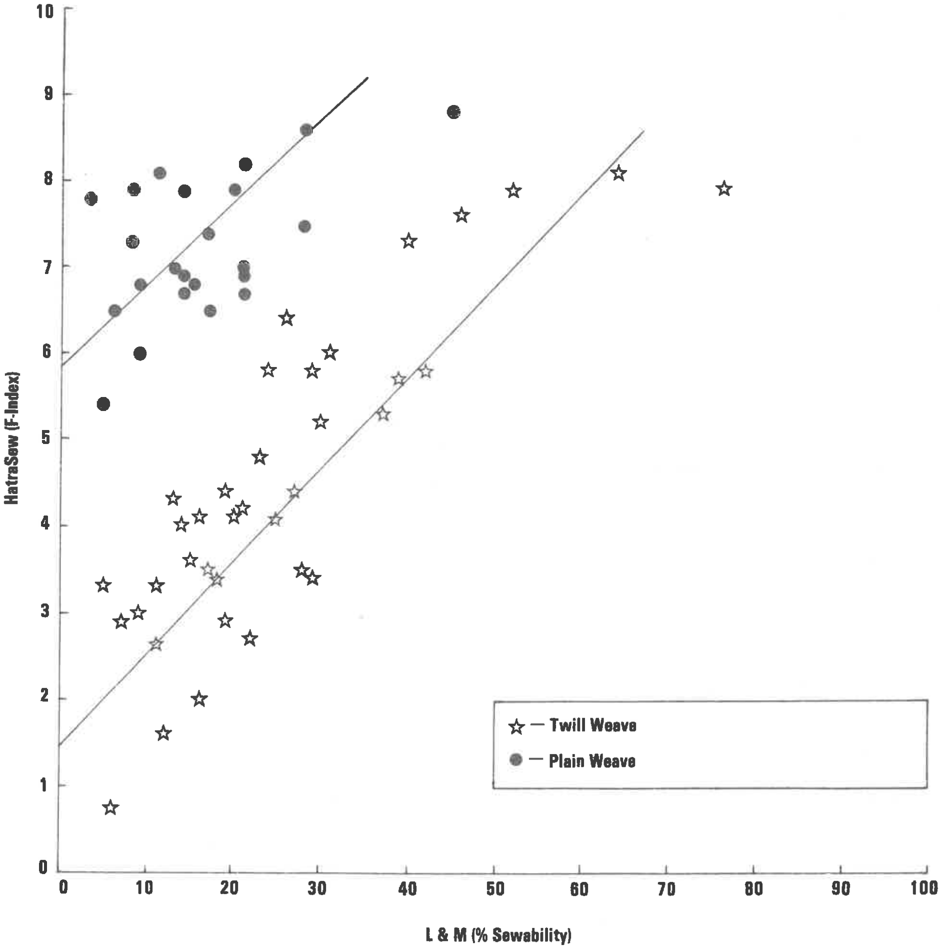

FIGURE 2

Relationship Between the HatraSew F-Index (without sewing thread) and the L & M % Sewability (Two layers of fabrics used in the HatraSew test on the plain weave fabrics)

Effect of Fibre and Fabric Properties on Sewability

L & M Sewability Results

Multiple linear regression analyses were carried out on the L & M sewability results with either the % sewability or the average penetration force as the dependent variable (Y) and the following fibre properties as independent variables:

X_1 = Fibre diameter (μm)
X_2 = CV of diameter (%)
X_3 = Mean fibre length (mm)
X_4 = CV of length (%)
X_5 = Short fibre content (%)
X_6 = Bulk resistance to compression (mm)

The analyses yielded the following significant (at 95% level) regression equations:

Twill

$$\% \text{ Sewability} = 12{,}7\, X_6 - 0{,}421\, X_1X_6 + 6{,}05\, X_1 - 169{,}2$$
$$n = 54\, ;\, r = 0{,}75$$

$$\text{Ave. Penetration Force (cN)} = 9{,}24\, X_6 - 0{,}304\, X_1X_6 + 4{,}34\, X_1 - 80{,}1$$
$$n = 54\, ;\, r = 0{,}75$$

Plain

$$\% \text{ Sewability} = 0{,}091\, X_4X_5 - 0{,}084\, X_3X_5 + 27{,}1$$
$$n = 56\, ;\, r = 0{,}61$$

$$\text{Ave. Penetration Force} = 0{,}077\, X_4X_5 - 0{,}073\, X_3X_5 + 65{,}0$$
$$n = 55\, ;\, r = 0{,}62$$

According to the above results, the trends were different for the twill and plain weave fabrics. For the *twill* weave fabrics, both the % sewability as well as the average penetration force generally increased with an increase in the fibre bulk resistance to compression and with a decrease in mean fibre diameter for the ranges of diameter and resistance to compression covered. These trends can probably be explained by the fact that wools with a greater resistance to compression produce bulkier yarns and therefore more compact fabrics which will be more difficult to penetrate by the sewing needle. Coarser fibres on the other hand, will have a lower overall surface area than finer fibres leading to a lower fibre-to-needle surface contact area and therefore to a lower fibre-to-needle frictional force.

For the *plain* weave fabrics, both the % sewability and the average penetration force increased with a decrease in mean fibre length (X_3) and with an increase in the CV of fibre length (X_4). The trend with short fibre content (X_5) depended upon the mean fibre length and CV of fibre length. According to these results it appears as if sewability could be dependent upon yarn hairiness and bulk, deteriorating as yarn hairiness or bulk increases, since mean fibre length and CV of fibre length would affect yarn hairiness and bulk.

Further analyses were carried out with the fibre properties being replaced by the following fabric properties as independent variables:

X_7 = Fabric mass (g/m^2)
X_8 = Warp crimp (%)
X_9 = Weft crimp (%)

These analyses yielded the following significant regression equations:

Twill

$$\% \text{ Sewability} = 0{,}00134\, X_7^2 - 82{,}5$$
$$n = 54 \, ; \, r = 0{,}68$$

$$\text{Ave. Penetration Force} = 0{,}560\, X_7 - 98{,}0$$
$$n = 54 \, ; \, r = 0{,}67$$

Plain

$$\% \text{ Sewability} = 0{,}948\, X_7 - 0{,}175\, X_8X_9 - 165{,}1$$
$$n = 55 \, ; \, r = 0{,}63$$

$$\text{Ave. Penetration Force} = 0{,}841\, X_7 - 0{,}166\, X_8X_9 - 104{,}9$$
$$n = 55 \, ; \, R = 0{,}67$$

The above regression equations show that, for both fabric structures, sewability deteriorated (i.e. % sewability and average penetration force increased) as the fabric became heavier and also, to a lesser extent, as either the warp or weft crimp, or both, decreased.

HatraSew Results

Analyses similar to those carried out on the L & M test results, were carried out on the HatraSew results (F – index values) and the following significant regression equations were obtained:

Twill

F (no sewing thread) = $0{,}426\ X_6 - 2{,}972$
$n = 37\ ;\ r = 0{,}51$

F (with sewing thread) = $0{,}004\ X_2X_6 + 2{,}08$
$n = 37\ ;\ r = 0{,}49$

Plain

No significant regression equations were obtained.

The above results show that, for the twill fabrics, sewability deteriorated (F-index increased) with an increase in fibre bulk resistance to compression, which is in agreement with the L & M results. Furthermore, when sewing thread was used, sewability also deteriorated (F increased) with an increase in the CV of diameter. No trends were observed for the plain fabrics.

Furhter analyses, in which the fibre properties were replaced by fabric properties, yielded the following significant regression equations:

Twill

F (no sewing thread) = $0{,}000127\ X_7^2 - 5{,}64$
$n = 25\ ;\ r = 0{,}54$

F (with sewing thread) = $0{,}042\ X_7 - 0{,}00517\ X_8X_9 + 67{,}8$
$n = 25\ ;\ r = 0{,}82$

Plain

There were no significant regression equations for the results obtained without the sewing thread.

F (with sewing thread) = $0{,}000623\ X_7X_8 + 1{,}17$
$n = 25\ ;\ r = 0{,}46$

The regression equations show that sewability, with and without sewing thread, deteriorated (i.e. F increased) as fabric mass increased which is in agreement with the L & M results. Futhermore, when sewing thread was used, there was also a trend for the sewability of the twill fabrics to improve as either warp or weft crimp or both increased. A similar trend was observed for the L & M results on the plain weave fabric.

SUMMARY AND CONCLUSIONS

The correlations between results obtained on an L & M Sewability Tester (% sewability and average penetration force) and those obtained on a HatraSew instrument (F-index without and with sewing thread, respectively), have been investigated for twill- and plain- weave fabrics woven from wool lots which differed widely in fibre characteristics. Within a structure, the fabrics were woven and finished under indentical conditions. The plain weave fabrics all had a common warp but the weft yarns were spun from a different wool lot in each case. The twill fabrics, on the other hand, contained the same wool in both warp and weft directions. More than 50 fabrics of each structure were woven but in some cases insufficient material was available for the HatraSew test which generally required a two-metre fabric strip.

A very high correlation (r = 0,98) was found between the % sewability and average penetration force as measured on the L & M Sewability Tester. There were also fairly good correlations (r $\simeq$ 0,8) between the L & M and HatraSew values, the correlation being slightly better when the HatraSew test was carried out without any sewing thread thus corresponding to the L & M test. Lower, but still significant correlations, were found between the HatraSew values obtained with and without sewing thread, respectively. In practice, the actual relationship would depend upon such factors as number of plies, the sewing conditions and on whether or not sewing thread is used in the HatraSew test, threshold level selected for L & M test, fibre type and fabric construction and mass.

The effect of wool fibre and fabric properties on sewability, as measured on both the instruments, was also investigated. Generally, different trends were observed for the twill and plain weave fabrics. For the twill weave fabrics the trend generally was for sewability to deteriorate as fibre bulk resistance to compression (crimpiness) increased. For the plain weave fabrics, the fibre properties had no effect on the HatraSew values while sewability, as measured on the L & M Tester, deteriorated with either a decrease in mean fibre length or with an increase in CV of fibre length. It was speculated that these trends were due to associated changes in yarn hairiness and bulk.

There was also a general trend for sewability to deteriorate as fabric mass increased, which was to be expected considering the principles of the two sewability tests. For the plain weave fabrics, sewability tended to improve as either warp or weft crimp or both increased. Some of the effects of fibre properties on sewability were no doubt due to the effects of the fibre properties on fabric mass and weave crimp.

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