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THE CORRELATIONS BETWEEN DIFFERENT MEASURES OF WEAK PLACES IN WORSTED YARNS AND WEAVING PERFORMANCE*

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ABSTRACT

An analysis has been undertaken of the inter-correlation between various measures of weak places in yarns and their rôle in determining weavability. Three instruments were used to obtain measures of weak places, these being the Shirley Constant Tension Winding Tester, the Uster Tensorapid and a new high-speed yarn strength tester developed at SAWTRI. Multiple regression analyses showed that fits above 80% could be obtained using the data provided by any one of the three instruments in conjunction with measures of other relevant yarn properties. The important rôle played by isolated weak places in the weavability of worsted yarns once again clearly emerged. The SAWTRI instrument appears to hold great potential for providing, at very high speed, an accurate measure of yarn weak places, as well as information on the mean breaking strength, mean extension and mean work to break, and their CV's.

INTRODUCTION

It is becoming increasingly[1–9] clear that an accurate measure of the weak places in a yarn is essential if the performance of the yarn during subsequent weaving is to be predicted with any degree of reliability. This was very clearly illustrated in a recent detailed study[1] on the factors which affect the weaving performance (warp breaks) of 71 worsted yarns. In that study, a statistical fit of 83% was obtained for the data, a measure of the isolated weak places (Shirley Constant Tension Winding Test) proving to be the most important yarn property by far for explaining differences in the weaving performance of the various yarns. In practice, however, it is rather time-consuming, and often laborious to obtain an accurate measure of the isolated weak places in a yarn, since this would normally entail the testing of some 5 000 metres of yarn or more.

Recognising the need for an instrument which would enable the isolated weak places in a yarn to be determined accurately and rapidly, SAWTRI embarked upon a programme aimed at the development of such an instrument. This has now been accomplished; a high speed automatic instrument having been designed and constructed as a prototype.[10]

This paper reports on the correlation between the values obtained on the SAWTRI instrument and those obtained on other instruments, as well as the correlation between such values and the weaving performance of the above-mentioned worsted yarns as measured in a previous study[1].

* *This paper was presented at the 55th IWTO Conference in Oostende, Belgium, June 1986.*

EXPERIMENTAL

Some 71 worsted yarns (Table I)[1] comprising two-ply ring-spun, two-strand (e.g. Sirospun) and Repco self-twist (STT) yarns in wool, wool/polyester and polyester/viscose, were studied. The tensile properties of the yarns were measured on the following instruments: Uster Tensorapid — 1000 tests per sample (Table II); Uster Dynamat — 400 tests per sample; Shirley Constant Tension Winding Tester — approximately 10 000 metres per sample at a tension of 211 cN; SAWTRI instrument — 5 000 tests per sample. Except for the Shirley test, which is a continuous one, the tensile tests were carried out at a gauge (test) length of approximately 50 cm .

SAWTRI Instrument:

The SAWTRI instrument uses a novel concept to enable the tensile properties of yarns to be measured at extremely high speeds, approaching 10 000 tests per hour. This instrument, for which patents have been applied,[10] is computer controlled, and at the end of a test provides a printout of the strength, extension and work to break of weak places in the yarn as well as the average strength, work to break and extension of the yarn. The results obtained are given in Table III.

Examples of distribution curves obtained for breaking strength, extension at break and work to break are shown in Fig. 1, while Fig. 2 shows cumulative distribution curves for these same three parameters from which a measure of the tail-end of the distribution can be obtained.

Weavability Tests:

The weavability of the yarns was measured, as part of a previous study[1] on a Sulzer loom, running at 260 picks/min with fixed settings of warp tension, shed size, reed width, weave structure and fabric cover factor. A 2/2 twill suiting of a fairly heavy construction, known to give considerable trouble with end breakages during weaving, was selected and a constant weft supply at a fixed pick density was maintained throughout.

A relatively high warp tension was selected to ensure a measurable end breakage rate for all the yarns investigated and in addition, a lower warp tension was used in the case of the 40 all-wool warp samples.

The number of warp breakages was recorded and expressed as warp breaks per 1 000 ends per 100 000 picks.

RESULTS AND DISCUSSION

The inter-correlations between some selected measures of weak places in the yarns and the weavability of the yarns, are shown in Table IV. From this table it can be seen that the measures of weak places provided by the Shirley, Tensorapid and SAWTRI instruments were all similarly and highly correlated with weavability, the correlation coefficients being in excess of 0,8. This illustrates the importance of having a measure of the weak places in a yarn in order to predict its weavability.

In the light of the above findings a multiple regression analysis was carried out on the results in log form with weavability as dependent variable and various combinations of yarn properties, including different measures of weak places, as independent variables. From this analysis the following best fit equations were derived, with Y representing weavability (warp breaks per 1 000 ends per 100 000 picks):

1. Making use of results obtained on the Shirley, and Tensorapid instruments:

   $$Y = 0{,}23X_1^{2{,}15}\,X_2^{0{,}26}\,X_3^{-1{,}42}\,X_4^{0{,}50} \qquad (1)$$

   % fit = 85,1

   where

   X_1 = yarn linear density
   X_2 = objectionable faults (Classimat)
   X_3 = Tensorapid extension at break
   X_4 = Shirley breaks.

2. Making use of results obtained on the Shirley, but omitting the Tensorapid results.

   $$Y = 2{,}37 \times 10^{-3}\,X_1^{2{,}47}\,X_4^{0{,}61} \qquad (2)$$

   % fit = 81,9

3. Making use of Tensorapid results but omitting the Shirley results:

   $$Y = 6{,}2 \times 10^{6}X_5^{-2{,}26}\,X_6^{-0{,}27} \qquad (3)$$

   % fit = 76,4

   where

   X_5 = Tensorapid strength of weakest place in 1 000 tests as predicted from the mean strength and its CV.

   X_6 = Tensorapid extension of the least extensible place in 1 000 tests as predicted from mean extension and its CV.

4. Making use of the SAWTRI instrument results:

   $$Y = 1{,}42 \times 10^{9}X_2^{0{,}40}X_7^{-2{,}02}X_8^{-2{,}55} \qquad (4)$$

   % fit = 81,2

where

X_7 = SAWTRI mean extension at break

X_8 = SAWTRI strength of the fifth weakest place in 5 000 tests predicted from a regression curve fitted to the first 250 breaks of the tail end of the distribution.

Fig. 3 illustrates the correlation between the actual weavability and that predicted from equation (4).

For wool yarns only, of which there were 40, the following best-fit regression was obtained:

$$Y = 4{,}60 \times 10^{10} X_2^{0,51} X_7^{-1,67} X_8^{-4,87} X_9^{2,09} \quad \text{.......(5)}$$

% fit = 75,0

where

X_9 = Yarn-to-metal friction.

The above results once again illustrate quite clearly the important rôle played by isolated weak places in the weavability of worsted yarns, and further illustrate that a fairly accurate measure of weavability can be obtained by any one of the three instruments. Although the Shirley Constant Winding Tension Tester gave a slightly better fit than the other two instruments, it is a manual and time-consuming test, and from a practical point of view the other two instruments are preferable because they are automatic and also far more rapid. This is particularly so for the SAWTRI instrument which is extremely rapid, which means that many more tests, and undoubtedly a more accurate measure of the isolated weak places in a yarn can be obtained within a given period.

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TABLE I

DETAILS PERTAINING TO YARN PROPERTIES AND WEAVABILITY[1]

Warp No.	Fibre	Comp.	Yarn Type	Actual tex	Obj. Faults	Irreg. (CV %)	Thin/ 1000m	Thick/ 1000m	Neps/ 1000m	Hairs/m	Friction (cN)	Strength (cN)	Tenacity (cN/tex)	Extension (%)	Shirley** Breaks	Measured* Weavability
1	Wool	100%	Ring	51,6	7,5	14,1	3	1	15	33	41	399	7,7	20,5	0,15	11,00
2	Wool	100%	Siro	47,9	72,14	16,6	52	50	10	18	44	382	8,0	19.4	1,00	132,48
3	Wool	100%	Ring	49,1	6,09	14,0	11	10	5	24	45,5	402	8,2	21,7	8,32	330.86
4	Wool	100%	Ring	51,0	6,53	14,0	5	8	11	34	46	384	7,5	18,2	0,00	10.09
5	Wool	100%	Repco	48,0	18,11	16,2	25	42	4	32	38	353	7,4	21,9	8,52	141,31
6	Wool	100%	Ring	50,0	1,84	13,4	3	11	10	35	46	404	8,1	21.6	0.29	7,85
7	Wool	100%	Repco	48.7	5,77	16,6	12	11	6	36	37,5	370	7.6	21,2	4,86	43,22
8	Wool	100%	Ring	50,0	7,28	13,8	2	2	10	36	48,5	381	7,6	16,5	0,25	106,55
9	Wool	100%	Ring	51,7	14,41	13,7	1	12	14	44	27,5	345	6.7	10,3	3.23	148,04
10	Wool	100%	Ring	53,5	6,85	13,7	3	11	9	31	40	371	6,9	18,9	2,14	289,36
11	Wool	100%	Ring	52,1	13,41	13,9	3	8	8	14	36	350	6,7	11,0	0,23	14.64
12	PW	55/45	Ring	46.2	8,74	15,6	10	17	22	24	42,5	732	15,8	23,6	0,00	0,38
13	PW	55/45	Repco	42,0	10,60	16,9	61	79	23	37	27	642	15,3	23,1	0,00	6,36
14	PW	55/45	Repco	43,3	12,18	16,8	43	64	22	40	37	700	16,2	24,6	0,00	4,75
15	PW	55/45	Ring	44,0	5,54	13,9	4	3	15	22	30	768	17,5	25,5	0,00	0,96
16	PW	55/45	Repco	39,9	15.08	16,4	45	86	7	38	38	588	14,7	23,5	0,11	2,90
17	PW	55/45	Ring	44,4	8,01	14,4	15	23	18	54	42	797	17,9	24,6	0,00	4,12
18	PW	55/45	Ring	43,5	6,38	14,0	9	38	19	57	38,5	758	17,4	20,7	0,00	2,51
19	PV	65/35	Ring	31,3	14,78	11,3	0	7	61	19	44	601	21,8	14,9	0,14	10,73
20	PV	65/35	Ring	41,7	6,96	12,4	0	8	16	32	46,5	813	19,5	18,9	0.00	2,94
21	PV	65/35	Ring	41,6	15,28	12,9	3	22	34	37	48,5	811	19,5	19,8	0,09	2,02
22	PV	65/35	Ring	42,5	6,09	12,4	1	4	13	34	49	807	19.0	19,2	0,09	0,34
23	PV	65/35	Ring	42,6	9,40	12,3	0	7	22	34	50	822	19,3	19,4	0,00	2,20
24	PV	65/35	Ring	42,8	9,07	12,3	0	4	12	30	50	797	18,6	18.6	0,00	4,01
25	PV	65/35	Ring	42,6	10,48	13,9	2	9	23	28	50	718	16,8	17.3	0,00	6,62
26	PW	55/45	Ring	42,3	1,25	15,0	10	12	12	51	36	791	18,7	23,0	0,00	1,23
27	Wool	100%	Ring	43.5	2,28	14,6	6	11	19	42	45	332	7,6	21,2	2,78	76,76
28	PW	55/45	Ring	52,6	10.76	13,5	2	4	14	65	35,5	943	17,9	24,2	0,00	2,34
29	PW	55/45	Ring	53,8	7,45	14,3	2	8	20	72	38,5	1011	18,8	25,4	0,00	1,11
30	PW	55/45	Ring	50,8	2,89	13,8	1	5	7	55	37	924	18,2	22,9	0,00	0,54
31	PW	55/45	Ring	55,6	6,28	12,9	1	3	9	50	40	1075	19,3	25,8	0.00	1,00
32	PW	55/45	Ring	57.6	5,25	13,0	0	3	9	58	39	1074	18,7	26,0	0,00	0,00
33	PW	55/45	Ring	38,2	2,01	14,7	9	17	42	56	34	649	17,0	24,4	0,20	4,63
34	PW	55/45	Ring	36,9	3,37	15,2	11	14	30	52	39,5	660	17,9	21,5	0,31	3,83
35	PW	55/45	Ring	37,4	3,51	14,7	5	8	29	52	42,5	659	17,6	23,2	0,00	0,92
36	Wool	100%	Ring	48,5	3,32	14,1	1	7	11	28	29	318	6,6	11,6	1,87	120,00
37	Wool	100%	Ring	48,2	4,68	14,1	1	6	7	27	36	331	6,9	11,7	3,25	154,77
38	Wool	100%	Ring	47,5	4,45	14,2	2	12	13	37	28	331	7,0	11,5	0,67	30,70
39	PW	55/45	Ring	48,3	3,67	13,1	1	2	15	50	36	765	15,8	19,3	0,00	4,00
40	PW	55/45	Ring	49,2	2,17	13,3	1	5	7	36	48	801	16,3	23,8	0,00	0,63
41	PW	55/45	Ring	49,6	2,96	13,6	1	3	6	35	49	786	15,8	23,4	0.00	1,47
42	Wool	100%	Ring	39,3	2,80	14,6	3	8	10	30	35	268	6,8	13,3	38,83	129,64
43	Wool	100%	Ring	38,7	4,28	14,4	6	9	14	36	27,5	278	7,2	13,6	18,90	57,45
44	Wool	100%	Ring	38,2	4,40	14,6	3	9	9	38	26,5	294	7,7	17,3	11,14	144,37
45	PW	55/45	Ring	36,9	2,01	15,1	11	14	77	31	39,5	689	18,7	22,1	0,00	1,89
46	PW	55/45	Ring	38,7	37,40	15,0	6	13	50	35	40	682	17,6	24,6	0,00	0,92
47	PW	55/45	Ring	38,1	5,21	15,1	6	12	33	41	38	598	15,7	23,4	0,00	2,57
48	PW	55/45	Ring	33,8	44,62	14,8	8	9	22	30	25	603	17,8	22,3	0,00	1,45
49	Wool	100%	Ring	39,1	15,39	14,3	8	11	17	25	26	274	7,0	18,3	55,72	136,60
50	PW	55/45	Ring	44,1	5,98	14,3	2	5	12	42	29,5	754	17,1	22,8	0,00	1,85
51	Wool	100%	Ring	45,9	15,79	14,5	8	13	29	33	33	304	6,6	15,8	19,38	290,41
52	Wool	100%	Ring	47,6	0,52	13,9	1	1	4	30	48	373	7,8	23,1	0,00	0,98
53	Wool	100%	Ring	44,1	0,34	13,5	3	2	5	32	39,5	364	8,3	24,4	0,10	1,38
54	Wool	100%	Siro	46,6	44,63	15,5	17	21	7	19	40,5	370	7.9	19,4	0,70	26.91
55	Wool	100%	Siro	36,4	79,25	14,8	12	5	8	17	37	292	8,0	22,5	25.00	212,13
56	Wool	100%	Siro	45,0	93,33	15,1	16	7	8	13	32	362	8,0	23,8	3,90	33,13
57	Wool	100%	Ring	50,8	3,45	13,9	3	13	22	46	27	389	7,7	23,0	0,00	1,23
58	Wool	100%	Siro	48,9	105,16	15,1	13	26	9	24	34	415	8,5	27,6	0,30	20,72
59	Wool	100%	Ring	51;3	8,35	13,7	5	3	14	42	41	399	7,8	23,6	0,10	9,72
60	Wool	100%	Ring	37,1	4,84	14,5	7	9	10	33	25	309	8,3	24,3	6,80	21,12
61	Wool	100%	Siro	38,9	44,6	15,8	22	23	12	13	34	320	8,2	23,6	30,00	71,2
62	Wool	100%	Ring	36,3	3,17	14,1	2	11	17	13	38	288	7,9	14,5	2,60	13,47
63	Wool	100%	Siro	38,9	61,33	15,8	16	33	5	15	32	313	8,1	22,3	15,40	106,01
64	Wool	100%	Siro	39,4	60,23	16,6	45	28	9	17	28	311	7,9	21,2	20,30	220,98
65	Wool	100%	Siro	39,2	75,47	16,3	20	18	6	17	29	322	8,2	23,5	15,50	137,49
66	Wool	100%	Siro	40,9	72,15	16,6	25	52	13	14	34	296	7,2	16,9	36,90	196,43
67	Wool	100%	Siro	39,5	73,88	14,6	7	12	12	12	31	305	7,7	19,9	10,10	62,24
68	Wool	100%	Siro	38,6	83,05	15,6	22	31	25	12	30	305	7,9	20,1	16,90	111,96
69	Wool	100%	Siro	39,6	48,22	16,4	25	37	7	13	27	289	7,2	15,5	43,20	157,14
70	Wool	100%	Siro	39,0	101,78	14,5	11	20	20	13	28	309	7,9	19,7	9,10	60,4
71	Wool	100%	Siro	40,6	70,37	14,7	5	23	16	11	31	317	7,8	21,8	6.80	67,77

* End breaks per 1000 ends per 100 000 picks

** Breaks per 1000m at 211 cN

P Polyester

W Wool

V Viscose

TABLE II

TENSORAPID RESULTS

Warp No.	Breaking Strength		Tenacity (cN/tex)	Extension (%)	CV (%)	Work to Break (cN.cm)	Work to Break (CV%)	First* Weakest Place (cN)	Second* Weakest Place (cN)
	Mean (cN)	CV (%)							
1	406	9	7,9	17,7	25,6	2886	34,1	310	320
2	404	12	8,4	19,6	35,2	3313	44,9	240	260
3	421	11	8,6	21,6	30,3	3697	39,0	220	240
4	397	9	7,8	13,3	28,2	2118	37,5	220	280
5	351	11	7,3	16,6	35,0	2386	45,4	160	200
6	418	8	8,4	17,9	26,0	3047	34,0	320	340
7	374	11	7,7	17,7	34,9	2713	44,5	200	220
8	375	11	7,5	13,3	33,3	1985	44,8	240	260
9	344	10	6,7	8,1	28,8	1050	40,7	220	240
10	400	14	7,5	15,7	33,8	2486	47,5	200	220
11	355	8	6,8	9,3	22,1	1259	31,3	260	280
12	788	12	17,1	22,3	5,5	4602	13,8	400	500
13	711	13	16,9	21,5	7,7	4192	15,9	400	450
14	720	12	16,6	22,8	7,1	4480	14,6	450	500
15	824	11	18,7	24,3	5,3	5222	12,4	550	600
16	619	13	15,5	22,0	9,3	3965	17,5	300	350
17	821	10	18,5	21,2	5,6	4605	12,8	500	550
18	798	10	18,3	19,0	6,5	4073	13,4	500	550
19	774	8	24,7	14,8	5,6	2812	12,0	500	550
20	928	10	22,3	18,5	5,6	4245	12,1	500	550
21	898	10	21,6	19,0	5,5	4268	12,1	550	600
22	921	10	21,7	18,4	5,6	4259	12,4	600	650
23	917	10	21,5	19,0	5,0	4284	11,6	650	700
24	843	10	19,7	17,9	5,9	3890	12,7	500	550
25	796	11	18,7	16,7	6,3	3533	13,4	500	550
26	809	12	19,1	21,3	5,8	4488	13,8	450	500
27	344	10	7,9	15,6	28,7	2173	38,4	240	260
28	1032	10	19,6	22,9	5,0	6303	11,9	600	700
29	1057	10	19,7	24,3	4,1	6687	10,7	700	750
30	1014	9	20,0	21,8	4,6	5754	11,0	700	750
31	1153	9	20,7	24,3	4,6	7285	11,0	850	900
32	1148	9	19,9	24,5	4,3	7427	10,4	800	850
33	718	11	18,8	23,3	5,8	4594	13,2	400	450
34	674	14	18,3	19,4	8,4	3572	17,6	350	400
35	707	12	18,9	21,7	5,7	4107	13,4	500	550
36	340	10	7,0	9,3	29,3	1231	41,1	220	240
37	339	10	7,0	9,5	27,6	1263	39,0	200	220
38	335	9	7,0	9,8	25,9	1289	35,8	240	260
39	816	10	16,9	17,9	6,9	4452	13,3	400	500
40	846	10	17,2	21,9	5,1	5220	11,8	400	500
41	833	10	16,8	21,7	4,8	5187	11,2	600	650
42	275	11	7,0	10,1	31,1	1079	43,4	160	170
43	279	9	7,2	10,8	26,9	1199	36,8	190	200
44	292	9	7,7	13,1	30,3	1571	39,8	180	190
45	727	11	19,7	20,3	6,1	3886	13,8	350	400
46	721	12	18,6	23,3	5,5	4480	12,9	400	450
47	630	12	16,5	22,2	6,4	3962	13,8	300	350
48	652	12	19,3	21,0	5,4	3458	13,0	420	440
49	280	13	7,2	13,2	34,9	1459	47,2	180	190
50	847	13	19,2	21,4	8,3	4821	16,6	500	550
51	310	12	6,8	12,1	42,1	1527	56,0	140	200
52	390	9	8,2	18,1	27,3	2875	35,6	260	280

11	374	12,8	8,1	18,5	1 567	30,6	182	197	205	210
12	709	13,1	18,8	10,3	6 771	20,5	197	243	267	285
13	681	13,0	18,8	9,8	6 534	21,1	225	265	285	300
14	691	11,6	19,5	9,4	6 851	19,4	382	407	419	428
15	735	11,9	20,8	7,1	7 788	17,5	366	397	413	424
16	607	13,3	19,2	11,0	5 930	22,3	240	270	286	297
17	770	11,0	18,2	8,0	7 114	17,4	351	391	410	424
18	753	10,8	16,6	11,1	6 341	19,8	279	323	346	362
19	606	17,4	12,0	15,5	3 755	30,7	215	240	253	261
20	807	11,5	16,1	9,0	6 597	18,8	355	395	415	428
21	792	10,9	16,9	8,0	6 805	17,7	302	348	371	388
22	826	12,5	16,9	8,4	7 112	18,8	409	445	463	476
23	826	11,0	17,1	6,8	7 163	16,7	404	443	463	476
24	768	11,6	16,4	7,7	6 419	18,0	366	401	418	430
25	751	11,1	15,1	8,3	5 772	18,5	339	376	394	406
26	755	11,6	18,3	7,4	7 013	18,1	424	451	464	473
27	374	13,2	12,0	25,4	2 328	35,8	155	172	181	187
28	922	11,1	19,6	8,5	9 199	18,4	469	507	526	538
29	993	9,4	21,1	7,1	10 599	15,5	615	648	663	674
30	903	10,0	18,6	6,6	8 501	15,3	539	571	587	597
31	1067	9,4	21,1	6,9	11 416	14,9	632	672	692	705
32	1052	9,4	21,1	8,1	11 244	16,4	606	649	670	685
33	672	11,5	20,0	8,5	6 830	18,2	233	275	297	313
34	636	12,0	16,7	8,1	5 463	18,2	286	317	332	343
35	645	12,0	18,4	7,7	6 051	18,3	327	354	367	376
36	366	14,6	8,2	22,7	1 561	34,9	115	135	146	153
37	350	14,4	8,1	21,2	1 479	33,6	145	160	168	173
38	340	14,2	7,6	20,9	1 336	33,5	137	152	160	165
39	753	11,7	15,3	10,6	5 868	20,4	324	361	380	393
40	805	9,2	19,1	6,9	7 781	15,1	522	546	558	565
41	797	10,0	18,7	7,5	7 587	15,3	502	528	540	549
42	314	13,5	9,1	23,9	1 483	35,4	132	147	154	159
43	314	11,9	9,1	22,3	1 479	32,5	140	156	163	169
44	304	18,1	9,5	31,7	1 533	46,7	115	127	133	137
45	660	11,9	17,5	7,9	5 855	18,7	358	382	394	402
46	670	11,8	19,6	7,5	6 679	17,8	322	353	369	379
47	607	11,1	19,1	7,8	5 895	17,4	265	298	315	326
48	588	12,1	18,0	7,6	5 379	18,2	274	303	317	327
49	295	15,0	10,8	25,3	1 663	38,1	104	119	126	132
50	743	12,9	17,4	10,6	6 610	21,5	312	349	367	380
51	322	16,8	9,5	30,3	1 628	44,9	113	128	136	141
52	449	10,5	16,6	24,2	3 836	32,3	227	247	257	263
53	431	10,7	17,3	25,7	3 848	33,8	198	219	230	237
54	442	11,4	13,7	29,5	3 146	38,5	217	235	244	250
55	358	12,1	15,6	31,6	2 923	41,4	146	165	174	181
56	430	12,4	15,9	29,5	3 555	39,2	144	170	184	194
57	462	10,5	15,2	24,1	3 636	32,5	223	245	255	263
58	482	12,1	17,1	30,8	4 273	40,1	210	233	244	252
59	463	12,5	14,3	26,1	3 429	36,4	161	186	199	208
60	336	14,2	13,8	29,5	2 423	40,3	119	135	143	149
61	377	13,1	15,3	31,2	3 025	41,4	153	171	180	187
62	358	11,4	12,5	25,8	2 330	34,3	150	168	177	183
63	378	14,3	15,5	34,0	3 083	44,3	105	128	140	149
64	378	14,6	14,6	34,4	2 906	45,8	136	154	163	170
65	387	13,9	15,3	34,2	3 113	45,1	142	161	171	178
66	341	16,3	11,4	31,8	2 057	44,9	100	118	127	134
67	341	13,1	12,3	30,1	2 188	40,5	140	156	164	169
68	344	14,4	13,5	31,5	2 441	42,7	109	127	137	143
69	318	15,4	11,8	29,4	1 965	42,4	126	140	147	151
70	341	13,2	13,5	28,6	2 401	39,2	159	174	181	186
71	384	11,5	14,0	28,6	2 801	37,6	174	193	203	209

TABLE IV

INTER-CORRELATIONS BETWEEN WEAK PLACES AND WEAVABILITY

	Y	X_4	X_5	X_6	X_8	X_{10}
Y	1	0,89	-0,82	-0,56	-0,86	-0,82
X_4		1	-0,85	-0,49	-0,87	-0,80
X_5			1	0,61	0,94	0,90
X_6				1	0,59	0,61
X_8					1	0,94
X_{10}						1

Y = Weavability

X_4 = Shirley Breaks

X_5 = Tensorapid strength of weakest place in 1000 tests as predicted from the mean strength and its CV.

X_6 = Tensorapid extension of the least extensible place in 1000 tests as predicted from mean extension and its CV.

X_8 = SAWTRI instrument strength of the fifth weakest place in 5000 tests predicted from a regression curve.

X_{10} = SAWTRI extension of the fifth least extensible place in 5000 tests as predicted from a regression curve.

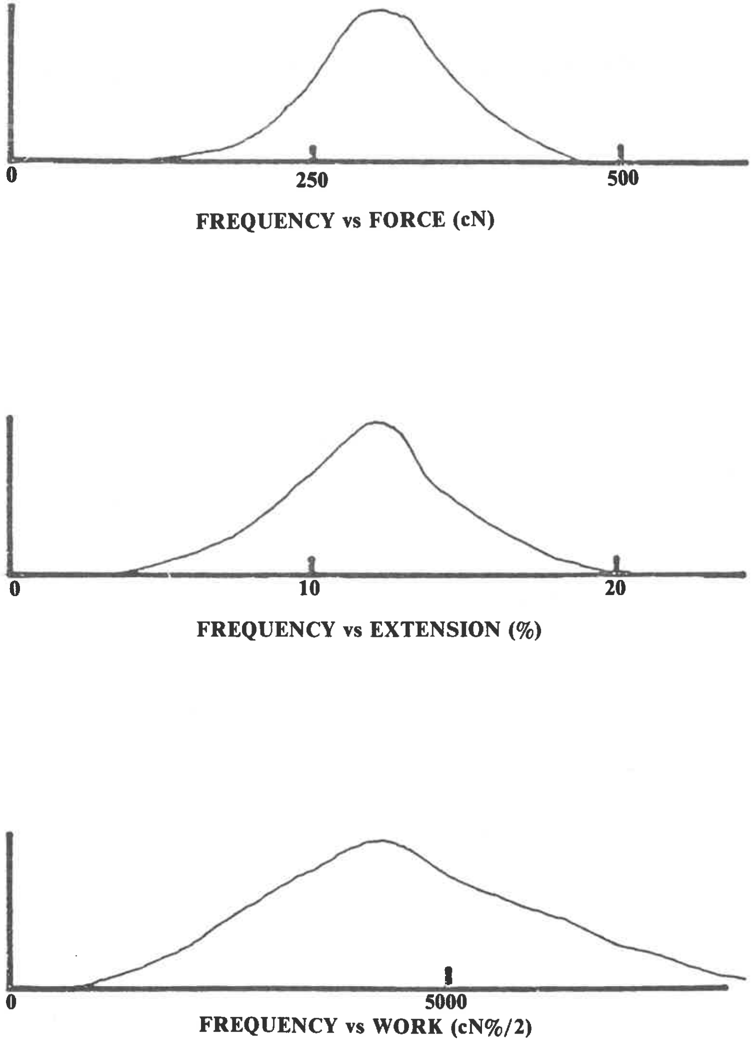
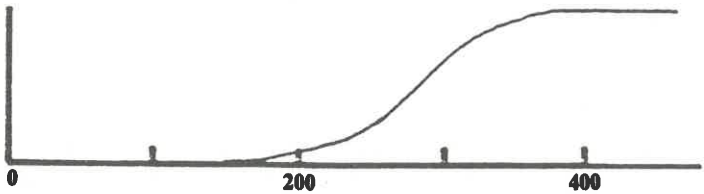
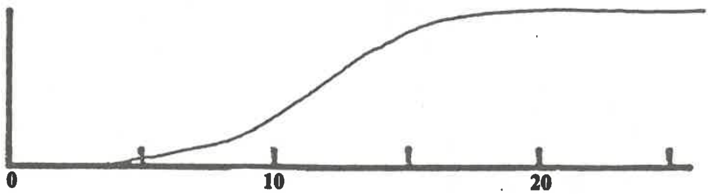


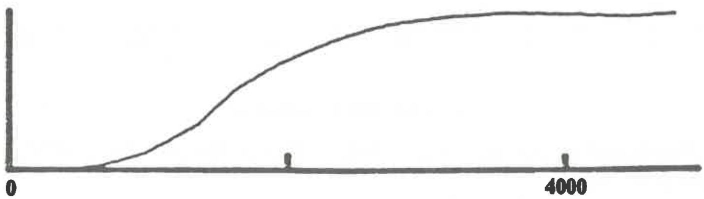
Fig. 1 – Examples of Distribution Curves for Force, Extension and Work as Obtained on the SAWTRI Instrument.



CUMULATIVE No. of BREAKS vs FORCE (cN)



CUMULATIVE No. of BREAKS vs EXTENSION (%)



CUMULATIVE No. of BREAKS vs WORK (cN%/2)

Fig. 2 – Example of Cumulative Distribution Curves for Force, Extension and Work Obtained on the SAWTRI Instrument.

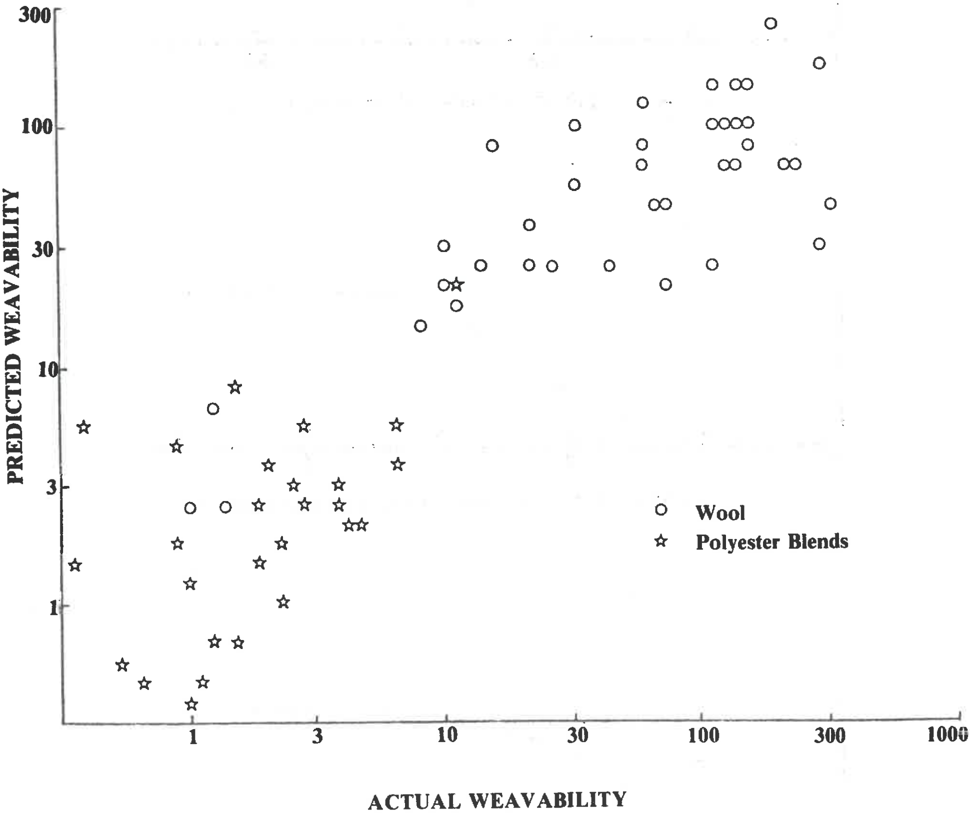


Fig. 3 – Predicted vs Actual Weavability (Warp Breaks per 1 000 Ends per 100 000 Picks).