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A Study of Dimensional Properties of some Weft Knitted Structures.

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A STUDY OF DIMENSIONAL PROPERTIES OF SOME WEFT KNITTED STRUCTURES

BY

Dr. Mostafa El-Gaiar*

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1- INTRODUCTION.

The literature of dimensional properties of weft knitted structures shows that complex structures such as rib/plain, unbalanced ribs, and cardigans have not recieved enough attention from the investigators of the field of dimensional properties of weft knitted structures. Also there is a lack of informations about fabric mechanical properties and knitting loop variables. Some work has been carried out by Smirfitt[2], and by Nutting[3] in this direction for 1 x 1 rib, and plain structures respectively.

In the present investigation a wide look on the dimensional properties of some weft knitted fabrics has been given, and the results are reported. The investigation took into consideration the study of dimensional properties of plain and 1x1 rib structures, in addition to the basic study of complex structures, i.e. 2x1 rib, 2x2 rib, half cardigan, and rib/plain. Also the investigation covered the study of the relationship between cover factor and bending stiffness of fabric. This was for three structures, namely 1x1 rib, half cardigan, and full cardigan.

2- YARNS USED

The fol... specifications of yarns used ...ructures:-

	Tex
	242
	245
	281
	230

...epart., Faculty of Engineer-

3- MACHINE USED.

The structures under investigation were produced on coarse gauge (gauge = 4) flat V-bed machines. In one of these machines the fabric take-down tension is applied by strippers fixed to the cam box, instead of the dead weight that normally used in majority of flat-bed machines. The strippers system mentioned has an advantage over thedead weight system. In the latter if the load is not distributed uniformly along the width of the fabric, many loops will drop. This in turn will cause many defects and irregularities in the produced fabric. The amount of take-down tension depends on the tighness of the structure, and the type of stitch under produotion.

4- Structures Knitted.

Figs. 1,2,3,4,5,6 and 7 show a simple illustration of the repeating courses for plain, 1x1 rib, 2x2 rib, 2x1 rib, 1x1 rib/plain, half cardigan and full cardigan respectively:-

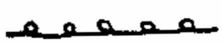


Fig.(1)

Fig.(2)

Fig.(3)

Fig. (4)

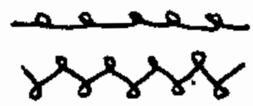


Fig.(5)

Fig.(6)

Fig.(7)

To produce the 1x1, 2x 2, and 2x1 rib fabrics, the needles in the two knitting beds were arranged as shown in Figs. 2,3 and 4. For rib/plain which is composed of two repeating courses, namely 1x1 rib, and a plain course, the needles were arranged to produce 1x1 rib, and the cam boxes were adjusted so that the cams will act only on half the number of needles, i.e. that of the front or back bed, in the second course, and miss the others existing in the other bed.

With-respect to the production of cardigan fabrics, i.e. half and full, which are structurally based on 1x1 rib, the cams were adjusted to make tucking over the needles of one of the knitting-bed, while the others knit normally. This process is accompanied in the second course by normall knitting over the needle used in the two beds. In this manner half cardigan structure is produced. For full cardigan structure tucking occurs alternatively (Fig. 7) over the needles in each bed each course. Accordingly for half and full cardigan the loops are cleared from the hook of the needle each two rows.

5- Observations on Fabrics Produced.

The fabrics produced showed the following:-

1) almost for all structures produced, fabric appearance deteriorates as the cover factor ($\sqrt{Tex}/L$) decreased. Irregular surface and many dropped loops can be easily observed, also fabric roughness increases.

2) for plain fabrics, irrespective of yarn count, yarn type, and machine type, fabrics curls. This curling starts from the face loop to the back loop, and very severe for 100% wool plain fabrics. For balanced ribs, i.e. 1x1 and 2x 2 ribs, the fabric at any cover factor is flat and no curling took place, as that founded with plain fabrics. But for unbalanced ribs i.e. 2x 1, there was severe curling at all cover factor, and starts from the face loop to the back loop. With -respect to the three other structures, i.e. 1x1 rib/plain, half cardigan, and full cardigan, no curling was observed and the fabrics at all used cover factors were flat and stable.

3) fabric thickness increases as one shifts from simple plain to rib structures, and finally to cardigans. The increase in fabric thickness may be the reason of non-curling of complex structures especially the balanced ones, i.e. 1x1, and 2x 2 ribs.

6- Relaxation Treatment.

The fabrics after being removed from the machine were left to relax in air for 24 hr., after which dimensions of the fabric have been measured.

7- Loop Length Measurment.

In the case of simple structures such as plain, 1x1 rib, 2x 2 rib, and 2x1 rib, the loop length was determined by un ravelling one course and measuring its length under the suitable tension. This length was divided by the number of needles used. For fabrics that composes of two repeating courses the total length of courses was measured and divided by the number of needles used in the repeat.

8- Results and Discussion of Results.

8.1. Plain Fabrics

The values of courses/cm, wales/cm, and stitch density for 100% wool, and polyamide-fibro yarn plain fabrics are plotted against 1/L and $1/L^2$ respectively in Figs. (8) and (9) in the dry state. Statistical analysis has shown that the correlation coefficient is very high and ranging between 0.98 and 0.995 and highly significant at the 5% level. The best fit lines for c/cm, W/cm, and S against 1/L and $1/L^2$ respectively for yarns used are given in Table (1).

Table(1)

100 % Wool fabrics	Poly-amide-Fibre Fabrics
$C/cm = \frac{4}{L} + 0.90$	$C/cm = \frac{3.23}{L} + 1.57$
$W/cm = \frac{2.3}{L} + 0.90$	$W/cm = \frac{1.71}{L} + 1.09$
$S = \frac{21.9}{L^2} - 1$	$S = \frac{15.6}{L^2} + 2.95$

From Table (1), one may observe the interceptions in the courses, wales, and stitch density equations. The interceptions in general are high and reaches to about 50% of the maximum value, especially for the wales. These interceptions can not be left out to give simple linear relationships passing through the origin. According to the previously proposed theories[4,8] concerning these interceptions the dry relaxation treatment used in the present work for relaxing the wool, and polyamide-fibro fabrics, is not sufficient to bring the fabrics to a state of minimum energy. At this state the configuration of the plain stitch is of predictable dimensions and the loop dimensions are constant irrespective of yarn, machine, and processing variables.

With respect to the constants of the loop, i.e. courses constant (K_c), wales constant (K_w), and stitch density constant (K_s), the values are given in Tables (2), and (3).

Table (2) K-Values for plain Wool fabrics

Loop length (cm)	K_c	K_w	K_s	K_c/K_w
1.17	5.67	3.51	20.01	1.61
1.36	5.05	3.67	18.54	1.37
1.45	6.10	3.71	22.50	1.64
1.49	4.82	3.73	18.00	1.29
Average	5.41	3.66	19.78	1.48

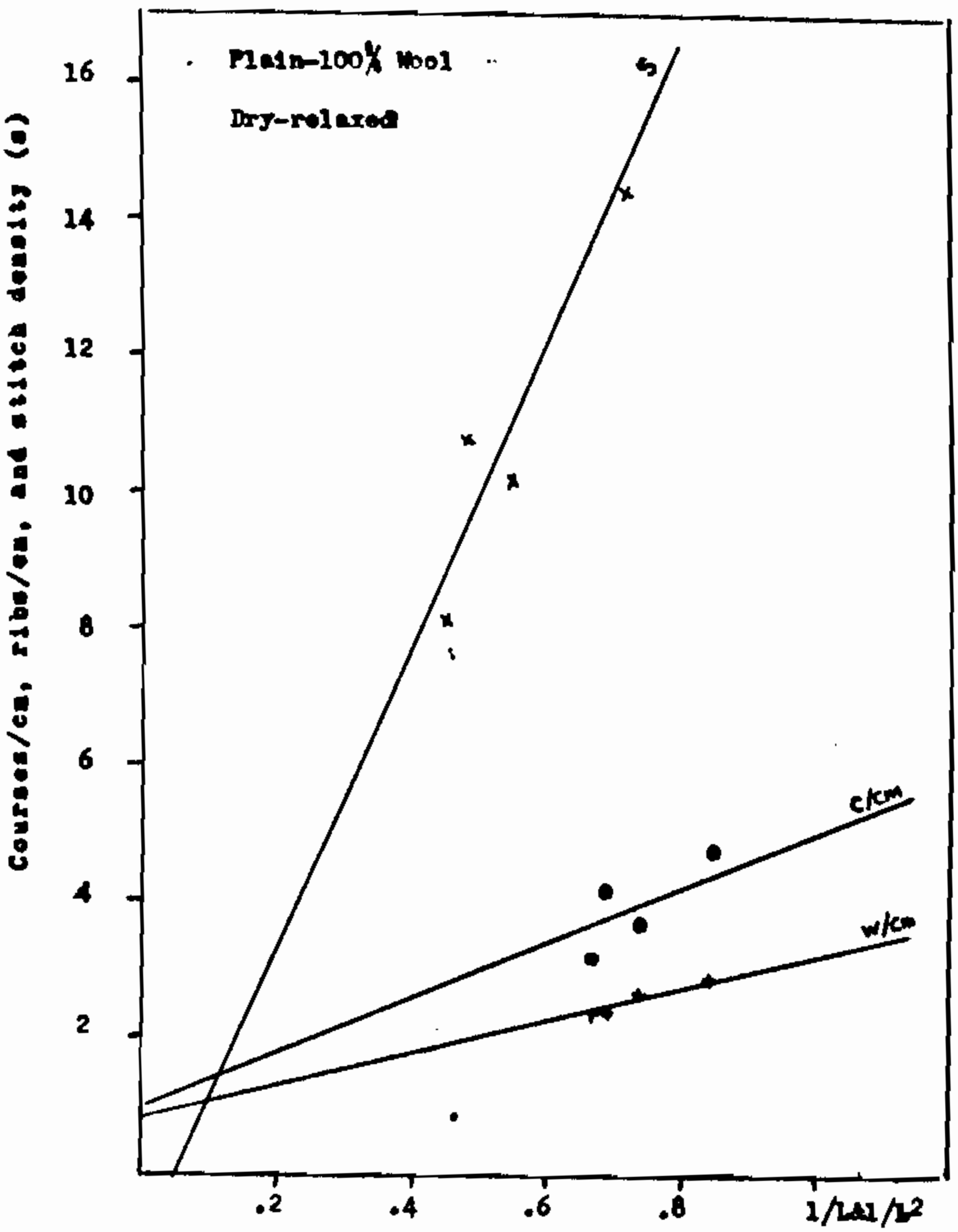

Plain-100% Wool
Dry-relaxed
Courses/cm, ribs/cm, and stitch density (s)
16
14
12
10
8
6
4
2
.2
.4
.6
.8
1/LAl/L2
c/cm
w/cm
S

Fig.8

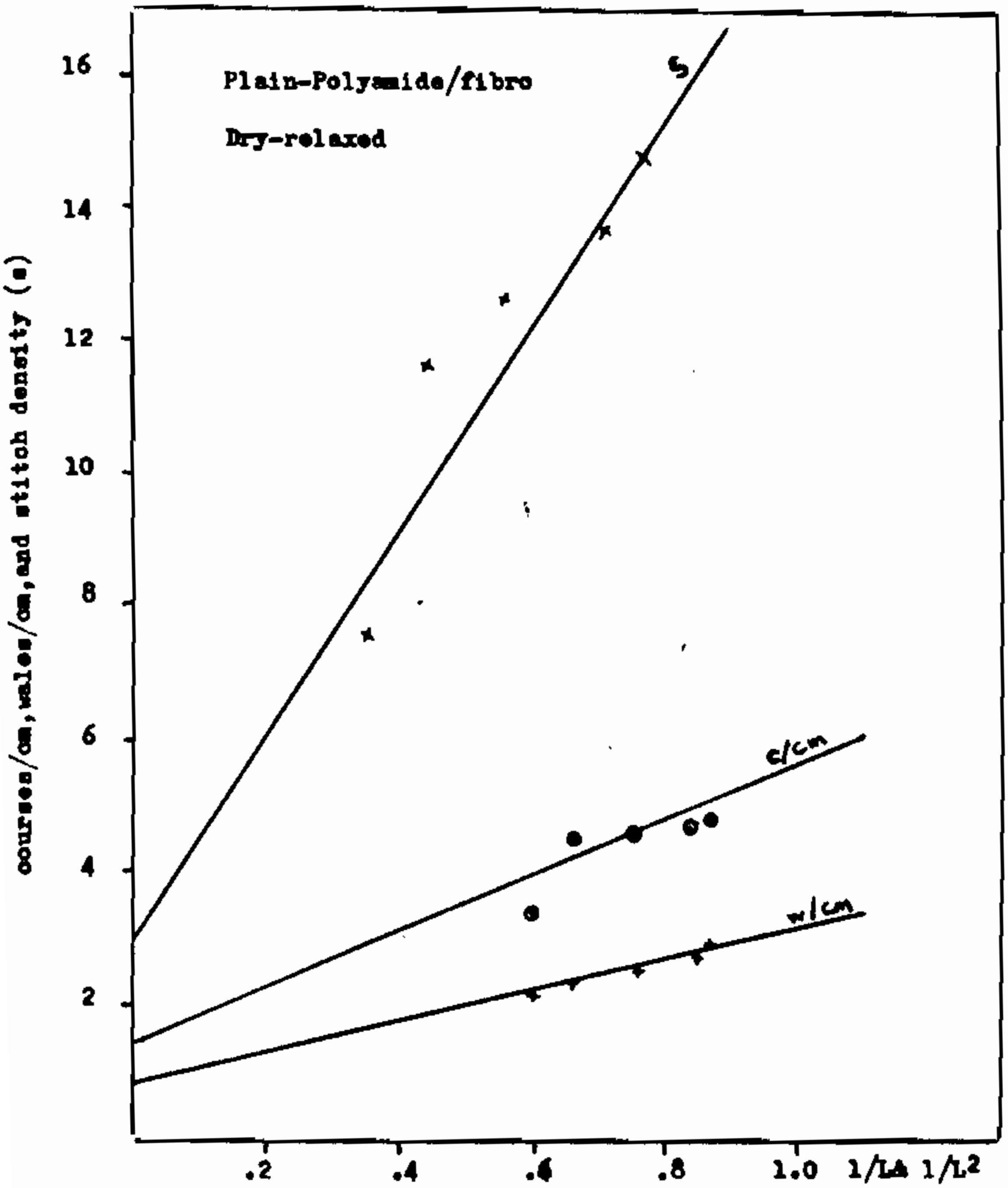

Plain-Polyamide/fibro
Dry-relaxed
courses/cm,wales/cm,and stitch density (s)
16
14
12
10
8
6
4
2
.2
.4
.6
.8
1.0
1/LA 1/L2
c/cm
w/cm

Fig.9

From Tables (2), and (3) one can observe that the K-values are not constant at any loop length, and that the average K_c, K_w, K_s, and K_c/K_w values for 100% wool fabrics are quite different from that of polyamide-fibre fabrics, knitted over the same range of cover factors.

Table(3): K-values for plain polyamide-fibro fabrics.

Loop Length (cm)	K_c	K_w	K_s	K_c/K_w
1.15	5.63	3.48	19.53	1.61
1.19	5.72	3.40	19.38	1.68
1.34	6.34	3.56	22.69	1.78
1.51	7.10	3.78	26.65	1.87
1.67	5.63	3.70	20.83	1.52
Average	6.08	3.58	21.82	1.69

In fact the K-values obtained in the present work for dry relaxed plain fabrics are different from that obtained by other investigators for the same structure. Table (4) show the results obtained by other workers for the stitch K-constants.

Table (4): K-values of plain fabrics. Knitted from different yarns. (Dry state).

Author	K_c	K_w	K_s	K_c/K_w	Yarn
Smirfitt	4.53	3.34	15.10	1.36	100% wool
Munden	"	"	19.0±0.3	"	Wool
"	"	"	19.0±0.8	"	Cotton
"	"	"	18.5±1.0	"	Regular orlon
"	"	"	18.5±1.0	"	Staple Nylon

The differences in the K-values obtained in the present work and in other works indicates that these fabrics have taken up a loop configuration different from that of the other yarns.

8.2. Rib Fabrics.

8.2.1. 1x1 Rib Fabrics.

Rib fabrics are fabrics that characterized by high stretchabilityin the courses directions. This makes it suitable

for places in the garment in which high stretchability is required to fit the body. Ribs may be balanced, as 1x 2, 2x 2, 3x 3, ...etc., or unbalanced as 2x 1, 3x 1, 3x2, 6x 10 .....etc.
To study the dimensional properties of rib fabrics (balanced and unbalanced, a series of fabrics Knitted from 100% wool, wool/acrylic, polyamide-fibro, and 100% nylon yarns were produced at cover factor ranging between 12.6 and 7.21. The average K-values of the fabric were calculated at each loop length and given in Tables (5) to (8).

Table (5): K-values of 1x1 rib wool fabric.

Loop length (cm)	K_c	K_r	K_s	K_c/K_r
1.23	5.74	3.58	20.45	1.60
1.27	5.70	3.47	18.22	1.55
1.43	5.45	3.40	18.63	1.60
1.65	5.42	3.50	19.02	1.54
1.85	5.44	3.64	19.96	1.49
2.01	5.26	3.56	18.76	1.48
Average	5.50	3.53	19.26	1.54

Table (6): K-Values of 1x1 rib-wool/acrylic fabrics

Loop Length (cm)	K_c	K_r	K_s	K_c/K_r
1.19	5.08	3.50	17.67	1.45
1.27	4.92	3.56	17.66	1.38
1.37	4.83	3.63	17.64	1.33
Average	4.94	3.56	17.66	1.39

Table (7): K-Values for 1x1 rib polyamide-fibre fabrics.

Loop length (cm)	K_c	K_r	K_s	K_c/K_r
1.17	5.96	3.30	19.79	1.81
1.31	5.48	3.17	17.41	1.72
1.45	5.85	3.17	18.43	1.85
1.61	6.29	2.45	15.60	2.50
Average	5.89	3.02	17.80	1.96

Table (8): K-Values for 1x1 rib nylon fabrics.

Loop length (cm)	K_c	K_r	K_s	K_c/K_r
1.18	5.82	3.30	19.38	1.76
1.13	5.35	3.32	17.88	1.61
1.47	6.29	3.97	25.13	1.58
1.60	5.87	4.04	23.60	1.44
1.80	6.21	4.21	26.48	1.47
Average	5.91	3.77	22.49	1.57

Table (9): Best fit lines for 1x1 rib fabrics (dryrelaxed).

100% Wool	Wool/acrylic
$C/cm = \frac{6.5}{L} + 0.69$ $r/cm = \frac{3.52}{L} + 0.02$ $S = \frac{19.5}{L^2} + 0.15$	$C/cm = \frac{9}{L} + 5$ $r/cm = \frac{7}{L} + 3$ $S = \frac{45.5}{L^2} - 17$
Polyamide-fibre	**100% nylon**
$C/cm = \frac{5.27}{L} + 0.64$ $r/cm = \frac{28.4}{L} - 18.5$ $S = \frac{44.6}{L^2} - 14.1$	$C/cm = \frac{6}{L} + 0.09$ $r/cm = \frac{0.76}{L} + 2.12$ $S = \frac{12.7}{L^2} - 4.73$

The best fit lines for 1x1 rib fabrics knitted from the four types of yarns used, and relaxed in air (dry) show that in general there is a significant interception with the courses, ribs and stitch density axes. The correlation coefficient between C/cm, r/cm, and s and 1/L and $1/L^2$ respectively are high (ranging between 0.96 and 0.98) and highly significant at the 5% level.

The interceptions are high for all fabrics other than the 100% wool fabrics, which showed lines passing near the origin with neglicible intercepts. This may be due to the high recovery of wool, which enables to get red of the strains imposed on the yarn during knitting. But inspite of this one can not say that the fabric is in a fully relaxed state, because the K-constants of the loop are still different from that obtained hy other investigators for wet, and fully relaxed 1x1 rib wool fabrics.

The various equations obtained for courses, ribs, and stitch density and 1/L and $1/L^2$ respectively are quite different from each other and from that obtained by Knapton and smirfitt for 1x1 rib wool fabrics. Given in Table (10) the hest fit lines obtained by Knapton in the dry and fully relaxed states.

Table (10): Best fit lines for 1x1 rib wool fabrics.

Best fit line	State
$C/cm = \frac{10.41}{L} - 1.76$	Dry relaxed
$r/cm = \frac{4.91}{L} + 2.13$	Dry relaxed
$c/cm = \frac{10.30}{L} + 2.13$	Fully relaxed
$r/cm = \frac{6.16}{L}$	Fully relaxed

From these regression lines it is evident that although the intercepts are clearly visible in the dry state, they are of opposite sign to those found in smirfitt's[1] equations. These intercepts were attributed to the change in processing variahles during knitting and not to the effect of yarn diameter. Similar observation were noted for the plain-knitted structure. Also from Table (10) it is clear that the fully relaxation technique proposed by knapton, and which is simply illustrated in wetting the fabrics under controlled temperature, then hydro-extracted and tumbled for 1 hr at 70°C, was capable of relaxing the fabrics more by making the intercepts of insignificant value, and in fact reduced it to zero. This is contrary to smirfitt who found that as relaxation progresses the intercepts become more significant. This disagrees with Munden's[8] plain knitted loop theory. With respect to the K-values of the structure (Tables 5 to 8), one may observe from the tables that K_c, K_r, K_s and K_c/K_r varies with the loop length. Also that the average values are quite different from each other and from that obtained by other investigators in the dry, wet, and fully relaxed states. Given in Table (11) the average K-values obtained in the present work and in other works.

Table (11)

Author	K_c	K_r	K_s	K_c/K_r	State
Smirfitt	4.53	3.34	15.13	1.36	dry
"	5.00	3.19	15.95	1.58	wet
Knapton	5.30	3.00	15.90	1.77	tumbled
Smirfitt	5.28	3.14	16.50	1.68	tumbled
Present:- 100% wool	5.50	3.53	19.26	1.54	dry
Wool/acrylic	4.94	3.53	17.66	1.39	"
Polyamide - fibro	5.89	3.02	17.80	1.96	"
100% nylon	5.91	3.77	22.49	1.57	"

8.2.2. 2x 2 and 2x 1 rib fabrics.

The method by which 2x 2, and 2x 1 rib fabrics were produced is described is section 4. In the case of the balanced rib, i.e. 2x 2, the face and the back of the fabric are identical, but this is not the case of the unbalanced rib, i.e. 2x 1.

Rib fabrics in general, when knitted from the same yarn, and at the same loop length, and over the same number of needle and fixed number of courses, have longer length than width, and also have longer length and lesser width than that of plain fabrics knitted at the same conditions and from the same yarn.

2x 2, and 2x 1 rib fabrics are not widely used in making outer wear, and this is due to their high contraction properties which result in large differential fabric distortion in the width-wise direction, it is unsuitable as an overall body covering material. Its general use is for cuffs and sweater waists where its contraction properties are used (or utilized) to ensure a snug fit. For this reason a quick and undetailed study was given to these structures.

Given in Table (12) the best fit lines for 2x 2, and 2x 1 rib wool fabrics in the dry relaxed state.

Table (12)

2x 2 rib fabrics	2x 1 rib fabrics
$C/cm = \frac{4.3}{L} - 0.46$	$C/cm = \frac{6.97}{L} - 1.16$
$r/cm = \frac{2.92}{L} + 0.01$	$r/cm = \frac{20.3}{L} - 17.8$
$S = \frac{20}{L^2} - 0.39$	$S = \frac{16.2}{L^2} - 0.29$

Plotted in Figs. (10) and (11) values of c/cm, r/cm, and S against 1/L, and $1/L^2$ for 100% wool fabrics respectively in the dry state. Statistical analysis showed that the correlation coefficients are very high and highly significant at the 5% level.

The equations obtained for 2x 2 rib fabrics are different from that obtáned by knapton for 2x 2 rib fabrics knitted from 1/26, and 2/20 yarns in the dry state. In the case of knapton the interceptions found in the courses, ribs, and stitch density equations vanished after relaxation by the method proposed in his work. It is simply illustrated in wetting the fabrics at 40°C, then hydro-extracted and finally tumble dried at 70°C for 1 hr. This led to simple equations in the form of:-

$$C/cm = \frac{K_c}{L} \qquad \text{.............(1)}$$

$$r/cm = \frac{K_r}{L} \qquad \text{.............(2)}$$

Where L is the loop length, and K_c, and K_r are the courses and ribs constants.

Given in Tables (13) and (14) the K-values of 2x 2, and 2x1 rib wool fabrics respectively in the dry state.

From the tables on may observe that the K-values, i.e. K_c, K_r, K_s, and K_c/K_r are not constant, but loop length dependent. And in general, the K_c/K_r ratio which represent the length to width ratio shrinkage tends to decrease with the decrease of the tightness of the structure.

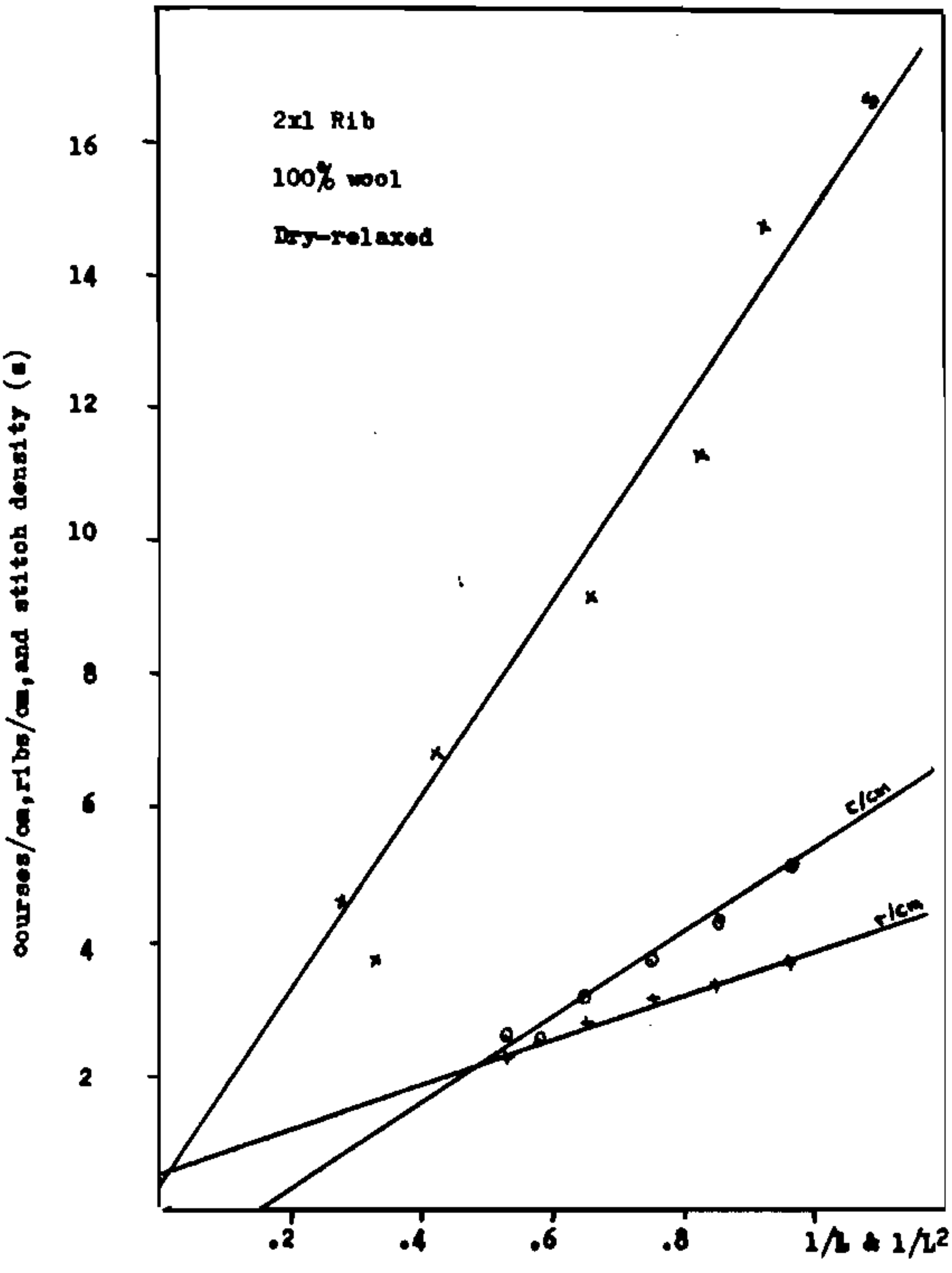

2x1 Rib
100% wool
Dry-relaxed
courses/cm, ribs/cm, and stitch density (s)
16
14
12
10
8
6
4
2
.2
.4
.6
.8
1/L & 1/L²
c/cm
r/cm

Fig.10

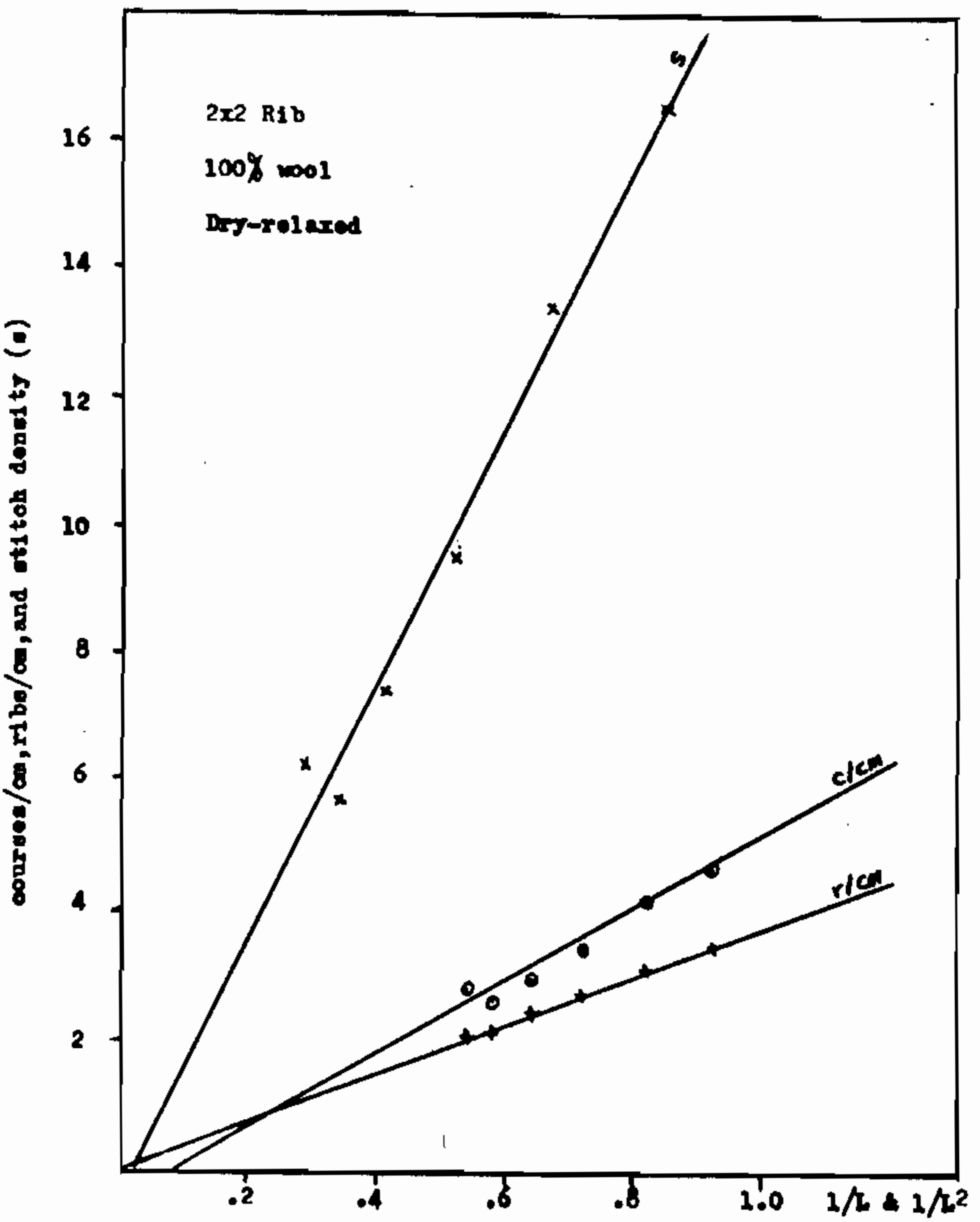

2x2 Rib
100% wool
Dry-relaxed
courses/cm, ribs/cm, and stitch density (s)
16
14
12
10
8
6
4
2
c/cm
r/cm
s
.2
.4
.6
.8
1.0
1/L & 1/L2

Fig.11

When one compares the K-values obtained for 1x 1, 2x 2, and 2x 1 rib fabrics, one would find that they are different although the basic loop formation had not changed, but it seems that in the dry stete the loop takes a different configuration in each case. This again points to an important point, and that is, more relaxation is still needed, and that the dry relaxed state is not a state of minimum energy.

Table (13)

Loop length (cm)	K_c	K_r	K_s	K_c/K_r
1.09	5.15	3.79	19.46	1.36
1.22	5.15	3.86	20.01	1.33
1.38	4.83	3.98	18.59	1.21
1.57	4.70	3.90	18.36	1.20
1.71	4.60	3.75	17.11	1.22
1.86	5.35	4.05	21.82	1.32
Average	4.96	3.89	19.23	1.27

Table (14)

Loop length (cm)	K_c	K_r	K_s	K_o/K_r
1.04	5.48	2.92	16.00	1.88
1.17	5.16	3.04	15.69	1.70
1.34	5.14	3.22	16.55	1.60
1.54	4.96	3.28	16.27	1.51
1.71	3.72	3.35	12.46	1.11
1.88	5.03	3.30	16.60	1.52
Average	4.92	3.19	15.60	1.55

8.3. 1x 1 Rib/plain fabrics

This type of weft knitted fabrics is a combination of 1x 1 rib and a plain fabric. The repeat is composed of two repeating courses, which are produced simaltanously. The fabrics were produced from repeating courses of equal cam setting. The introduction of a plain course produces fabrics that differs completely from the 1x 1 rib and the plain fabric. While 1x 1 rib structure prouides high stretchability in the cross-wise direction, the rib/plain fabric has less stretchability in the widthwise direction. This is due to the insertion of long loop-link in the plain course. The fabric exihibts lesser width than plain fabric knitted from the same yarn and at the same number of rows, and loop length.

Given in Table (15), the K-values obtained for the fabric in the dry state.

Table (15)

Loop length (cm)	K_c	K_r	K_s	K_c/K_r
1.28	8.00	3.46	27.70	2.31
1.30	6.44	3.82	25.60	1.69
1.34	6.57	4.01	26.40	1.64
1.38	6.28	3.95	24.81	1.59
1.46	6.35	3.90	24.77	1.63
Average	6.73	3.83	25.78	1.76

From the table one may observe that the K-values are not constant, but loop length dependent. Generally as the loop length increases the K-value decreases.

8.4. Cardigan Fabrics

Half and full cardigan fabrics are fabrics based structurally on 1x 1 rib. When these fabrics are produced from the same yarn, and at the same loop length, number of needles, and number of rows, they are thickner, shorter, and wider, than plain, and rib fabrics knitted from the same yarn and at the same processing conditions. These types of fabrics are widely used in outer wear garaents; because of their high bulkiness and accepted appearance. The fabric is composed of two repeating courses, i.e. 1x 1 rib, and tuck-knit course. In determining the loop length the repeating courses were unravelled and measured. The length measured was divided by twice the number of needles used, to give the average length in the repeat.

With respect to the fabric K-values, it was calculated from the simple linear relationships proposed for the plain weft knitted structure.

Given in Table (16) the average K-values obtained for the series of fabrics produced. The original K-values (not given)[10] showed that the K-value is not constant in the dry state, but loop length (or cover factor) dependent.

Table (16)

Structure	K_c	K_r	K_s	K_c/K_r
Half cardigan	9.08	3.92	35.60	2.32
Full cardigan	10.10	3.54	35.80	2.91

When these values (for wool/acrylic fabrics) are compared with that obtained for wool, and acrylic cardigan fabrics(Tables 17, 18) that have been relaxed by different methods, one would observe that the K-values obtained in the dry state are quite different from that obtained when the fabrics are well relaxed.

Table (17): K-values of full cardigan fabrics.

Yarn	K_c	K_r	K_s	K_c/K_r
2 ends of 55/2 tex, and 42/2 tex-wool.	9.63	3.63	35.04	2.65
3 ends of 63/4 tex-wool	10.21	4.16	42.50	2.39
2 ends of 74/8 tex-wool	10.45	4.06	42.50	2.57
one end of 98/2 tex-acrylic	8.14	3.73	34.14	2.45
2 ends of 49/2 tex-acrylic	8.99	3.55	31.90	2.53
one end of 59/2 tex-acrylic	8.85	3.56	31.60	2.49
2 ends of 29.5/2 tex-acrylic	8.74	3.39	29.60	2.58

Table (18): K-values of half cardigan fabrics

Yarn	K_c	K_r	K_s	K_c/K_r
2 ends of 55/2 tex-wool	8.75	3.90	34.20	2.45
3 ends of 42/2 tex-wool	8.93	4.07	36.30	2.19
3 ends of 63/4 tex-wool	9.12	4.26	38.90	2.14
one end of 98/2 tex-acrylic	8.45	3.85	32.50	2.20
2 ends of 49/2 tex-acrylic	8.30	3.75	30.00	2.15
3 ends of 29.5/2 tex-acrylic	8.65	4.13	35.60	2.10

These fabrics were relaxed by immersion in water (water temperature was controlled for 6 hrs at 40°C, and without control for 18 hrs), then left and hydro-extracted, and finally tumble dried at 72°C for 1 hr. for acrylic fabrics relaxation was carried out by tumbling the fabric (after being removed from the knitting machine) for 1 hr at 72 °C.

From the table it is evident that the dry relaxation treatment used for wool/acrylic fabrics (of the present work) was not efficient in bringing the fabrics to a state of minimum energy since the K-values are generally higher than that obtained for wool and acrylic fabrics. The observed differences between the K-values of all used fabrics may be due to yarn, and machine variables.

8.5. Bending Stiffness of 1x 1 rib, and Cardigan Fabrics

In the previous sections, the dimensional properties of some weft knitted fabrics has been examined. In the present section the bending properties of three of them, namely 1x 1 rib, half cardigan, and full cardigan, ware examined and reported.

The bending properties of textile fabric in general (woven, or knitted) play an important role in governing fabric stiffness, drape, and handle. The literature of weft knitted fabrics shows that bending properties of weft kuitted fabrics, especially those with not more tban two repeating courses, i.e. half cardigan, full cardigan,......etc. This is partly due to the complex nature of the structure of knitted fabric and also to lack of commercial concern for bending behaviour especially for outerwear fabric in which the present structures are normally used.
However fabric bending properties studies can provide many informations concerning the relationship between fabric structure, and performance.

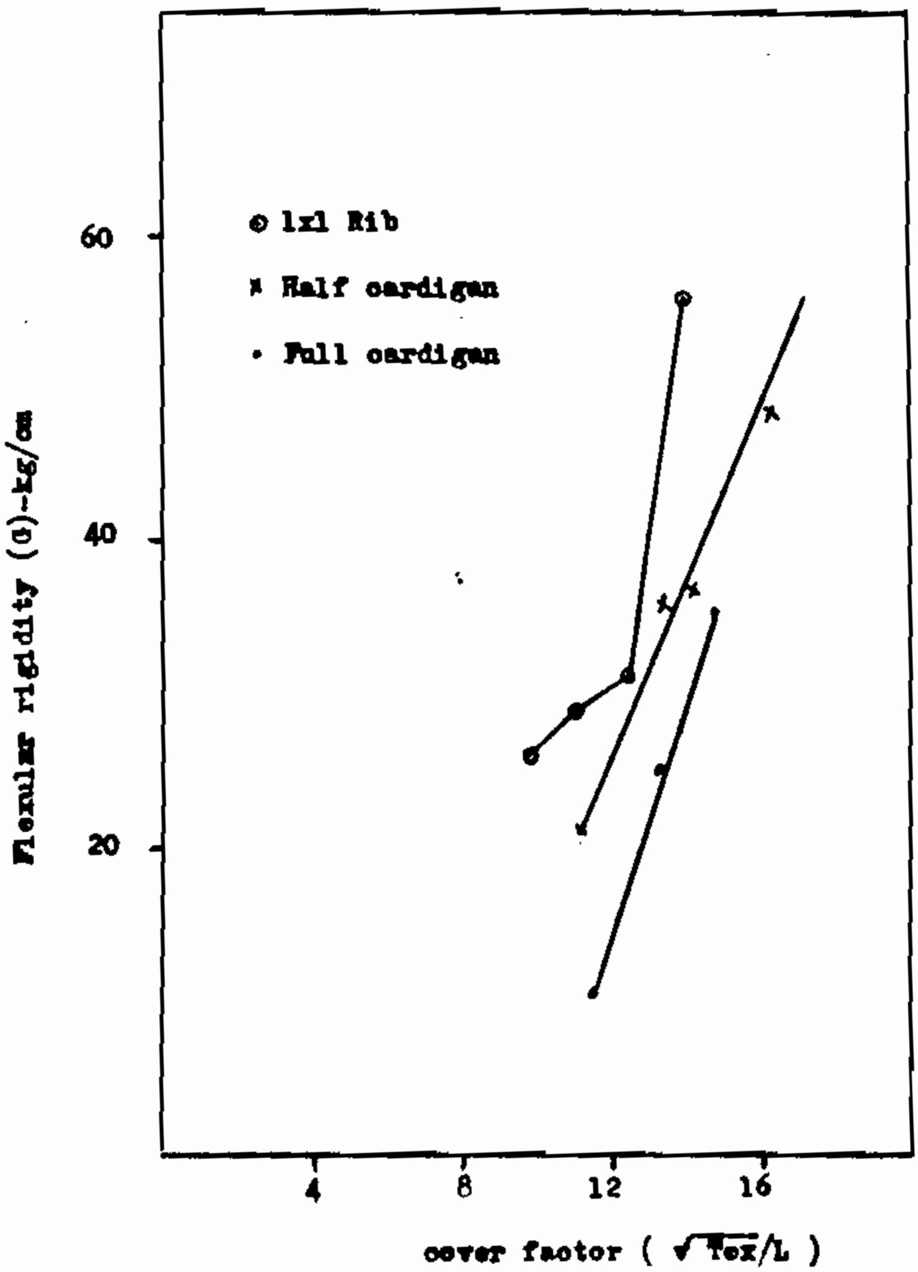
In the present experimental analysis the simple rectangular cantilever bending method[11] was adopted, and used to calculate the flexular rigidity of ths fabric. The flexular rigidity (G) is a measure of general stiffness of the fabric and is defined as the couple which must be applied to bend it to unit curvature.

The hending length (L) of the fabric was determined by the "Shierly Stiffness Tester", using strips of fabrics of 15 cm long and 2.5 cm width. The flexular rigidity was calculated using the formulae:-

$$G = W \times L^3 \times 10^3 \text{ mg/cm} \qquad \ldots\ldots\ldots\ldots\ldots(1)$$

where;
W = fabrio weight in g/m^2.
L = bending length in cm.

For each sample four readings (face and back) were recorded for the bending length, and averaged to give the bending length of the fabric.



1x1 Rib
Half cardigan
Full cardigan
60
40
20
Flexular rigidity (G)-kg/cm
4
8
12
16
cover factor (√Tex/L)

Fig.12

The values of the flexular rigidity of 1x 1 rib, half cardigan, and full cardigan fabrics knitted from wool/acrylic yarn at cover factors ranging between 9 and 16.2 are given in Table (19). These values are also plotted in Fig. (12).

Table (19): Values of flexular rigidity (G) of rib, and cardigan fabrics.

1x 1 Rib		Half cardigan		Full cardigan	
Cover factor	G(Kg/cm)	Cover factor	G(Kg/cm)	Cover factor	(G)Kg/cm
14.0	56.0	16.2	48.8	14.9	35.9
12.4	31.0	14.1	37.4	13.1	26.2
10.9	29.9	13.3	36.5	11.6	10.3
9.9	26.9	11.6	21.9	-	-

From Fig. (12), one may observe the following:-

a) for the three struotures as the cover factor ($\sqrt{Tex}/L$) increases ths flexular rigidity increases, and vice-versa.

b) 1x 1 rib fabrics have the highest flexular rigidity, and by introducing a tuok course, i.e. as in half cardigan, the flexular rigidity drops to a lesser value. When two tucking courses are used as in the case of full cardigan the flexular rigidity dropsd to about half the value of that of 1x 1 rib knitted at the same coverfactor.

The differences observed in the flexular rigidity of the three structures (using the same yarn, and all fabrios ars dry relaxed) may be explained in the light of internal friction at the cross over points and loop oonfiguration.

For ths three structures the flexular rigidity (G) increases with the increase of cover factor, because the tighter the fabric the greater the number of loops in a unit length of fabric (with a constant width),&the greater the bending force requ- ired to over come the frictional resistance at the cross-over points in the fabric. However the rate of change of (G) is considerable with the cover factor and the etructure. From the results obtained for (G) it would seem that internal friction in 1x 1 rib structure at the cross-over points is higher than that in half and full cardigan structures.

The effect of fabric thiokness on flexular rigidity is well known, i.e. thin fabrics bend easily, and hence one was expecting 1x 1 rib which is the thinnest fabric in the fabrics examined, to have the least flexular rigidity. But thie was not the case. The full cardigan which is the thickest showed the least flexular rigidity. This points to the above discussed point, i.e. the frictional resistance at the cross-over points. It seems that in the case of tuck structures, the tucking course gives the yarn more freedom to move inside the structure, and hence less bending force is required.

8.6. Conclusions

1) For plain, rib, and rib/plain fabrics in the dry state the c/cm, r/cm, and S may be related to 1/L and $1/L^2$ respectively by straight line relationships, but in general do not pass through the origin. The slope and the interception (value and sign) are machine, and yarn dependent.

2) In the dry state the K-values are not constant for the weff knitted structures examined, but machine and yarn dependente.

3) The K-values are only constant when the full relaxed state is achieved. For wool, and acrylic half and full cardigan fabrics this was achieved by wet relaxation at 40°C, followed by tubmle drying at 72°C for 1 hr, and by direct tumbling at 72°C for ½ hr, for the former and the latter respectively.

4) For 1x 1 rib, half and full cardigan fabrics, the flexular rigidity (G) increases as the cover factor increases.

5) 1x 1 rib structure is stiffer than half and full cardigan structures knitted from the same yarn and at the same cover factor.

REFERENCES

1. Smirfitt, J.A., J. Tex. Inst., 1965, 56, 248.
2. Smirfitt, J.A., J. Tex. Inst., 1965, 56, 298.
3. Nutting, T.S., J. Tex. Inst., 1958, 49, P. 490.
4. Leaf, G.A.V., J. Tex. Inst. 1961, 52, T 351.
5. Leaf, G.A.V., J. Tex. Inst. 1960, 51, T 49.
6. Centre Des Recherches de la Bonneterie, Bull. Inst. de France, No. 18, 13, 923 (1964), and No. 18, 35 (1963).
7. Munden, D.L., J. Tex. Inst. 1962, 53, P. 628.
8. Munden, D.L., J. Tex. Inst. 1959, 50, T 448.
9. El-Gaiar, M.N., M.Sc. Diss. Manchester, 1971.
10. Knapton, J.J.F., and el..., Tex. Res. J. 1968,October, 1013.
11. Booth, J.E., "Principles of Textile Testing". Heywood, 3rd edition.
12. Thomas, I.H., and Burnip, M.S., Textile progress, 3 P. 71, 1969.
13. Turner, J.D., Textile progress, 1971.
14. The Textile Institute "Studies In Modern Fabrics" 1970.
15. Gowers, C.N., and Hurt, F.N., J. Tex. Inst. 1978, 69, 108.