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Cockling in Fully-Fashioned Knitwear

Part 1: A Preliminary Report

by

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ABSTRACT

Different forms of loop distortion including cockling are defined with the aid of photographs.

Cockling as defined is found principally in fabrics containing wool or mohair. Even in shrinkproofed wool, although felting shrinkage is largely eliminated, cockling in a subdued form still occurs.

Twenty-seven fabrics were knitted from specially selected wool worsted yarns and the average percentage of cockled loops was 7,5 per cent. The average cockle extended over 7 to 8 loops (stitches) and it was found that cockling (significant at the 95 per cent level) was generally associated with thick places in the yarn which had a low twist.

INTRODUCTION

Cockling is a term associated with faults found in some plain single jersey fabrics, especially when knitted from wool on fully-fashioned machines. According to The Textile Institute[1] cockling is "an irregular surface effect caused by loop distortion". This definition is considered rather vague, because as Figs 1 to 5 show, loop distortion can cause four completely different irregular surface effects. For the purpose of this investigation and for the sake of clarity the various terms associated with surface distortion in knitted fabrics are defined below.

Fig 1 shows an irregular surface effect caused by the knitted loops inclining in a left to right direction due to residual torque (twist liveliness) in the yarn. The accepted term for this type of fault, usually found in single jersey circular knit fabrics, is wale *SPIRALITY* which often occurs over the full length of the fabric. In this instance, however, the fault shown in Fig. 1 was found in a fully-fashioned plain knit cardigan and only occurred in part of the garment and therefore this should be regarded as short term spirality. In contrast to this, Fig. 2 shows the more common form of spirality as would be the result of knitting a single jersey fabric from a yarn which was twist lively. This type of spirality must not be confused with pattern spirality found in certain Jacquard fabrics generally knitted on circular machines with inclined pattern wheels.

Fig. 3 shows another type of irregular surface effect found in a plain fully-fashioned single jersey fabric. This fabric was knitted from folded continuous filament yarns with a very low twist. The loop distortion which is shown in Fig. 3 is very slight and approximately within the plane of the fabric but has been accen-

tuated in Fig. 3(a) by the angle at which the photograph was taken. This type of loop distortion, which is usually associated with synthetic yarns, is defined as *FLASHING.*

Fig. 4 shows a very irregular surface effect commonly found in fully-fashioned garments associated with the change over from rib to plain, or at seams near the shoulder or collar. The degree of distortion at these points can be controlled somewhat by the ratio of the stitch length (cover factor) of the plain to that of the rib parts[2]. This irregular surface effect is defined as *PUCKERING.* It is referred to sometimes as "crow's feet".

Fig. 5 shows the fourth type of surface irregularity encountered in plain single jersey fabrics, and which consists of short term loop distortions of a few consecutive stitches in the coursewise direction. For the sake of definition this type of loop distortion will be referred to as *COCKLING.*

Having shown the basic differences between the four types of loop distortion, it becomes possible to carry out a fundamental investigation of the phenomena which fall under the general heading of loop distortion.

Various research workers have investigated the causes of irregular surface effects due to loop distortion. Kerley[2] stated that cockling is due most frequently to twist distortions, resulting from yarn irregularity. Doyle[3] observed that the yarn in the alternate links of the distorted loop apparently had a different diameter and twist. This was ascribed to the opposite directional twists imparted by the action of double bending, which on account of the assymetry of the yarn causes the twist to be increased in one limb of the loop whilst it is decreased in the other. He estimated that in his experiment the twist change taking place was of the order of 0,25 (90°) of a complete turn per half loop. This is a considerable change in twist and could be expected to have a significant effect on the behaviour of a yarn in a fabric.

Bliss[4] stated that, when some lower qualities of wool, e.g. crossbreds, were used to produce hosiery yarns, it was found that the resulting fabric cockled badly as soon as it was wetted out. A photograph very similar to Fig. 5 here illustrated this effect. Bliss[4] stated that cockling is due to unequal strains and unequal stiffness in the fibres, and to unequal thickness and twist in the yarn. He refers to a WIRA publication[5] with regard to strains in the yarn imposed during spinning and knitting being retained so long as the fabric remained dry, but the fibres recover and rearrange themselves when wetted. Workers at the Troyes'[6] knitting research centre investigating cockles, measured yarn twist and found that cockles

occurred where twist in the yarn was unduly low. By unravelling the yarn from the knitted fabric, they found that where the amount of twist in the yarn decreased to less than one turn per length of yarn in the knitted loop, cockles occurred. This implied that the amount of twist and variation of twist in a yarn, and the stitch length must be controlled, so that for an acceptable yarn irregularity the turns per stitch length never become less than unity. They showed that for a 21 gg fully-fashioned machine, the tightness or cover factor at which knitting was carried out was in this critical zone.

Hunter *et al*[7] also encountered cases of severe cockling in fully-fashioned fabrics produced from blends of wool and mohair once the fabrics had been washed. They concluded that this could be ascribed to short term variation in the torsional and flexural strains (forces) present in the fibres and yarns within the fabrics, which in turn, could have been due to short term variations in plying and singles twist (twist liveliness) and short term variations in yarn linear density. Various setting treatments, applied to the *yarn* prior to knitting, were tried *without success* but autoclave setting of the fabrics for two minutes (at a pressure of 34,3 kPa) effectively eliminated cockling although some traces of "flashing" still remained. Subsequent work[8] in which yarns were unravelled from distorted (cockled) and undistorted (normal) fabric areas indicated that cockles occurred where the yarn linear density is high and the twist (plying and singles) is correspondingly low.

Benson[9] studied the effect of yarn and fabric variables on cockling, and stated that cockling can be overcome most effectively by garment setting with bisulphite and urea. He states that loop distortion is an inherent fault of most yarns when knitted into plain structures (it is assumed that this statement refers only to wool yarns), and that the fabric becomes commercially unacceptable when washed. This statement explains why in the case of superwash[10] wool, overcoming cockling has emerged as an important problem. Extensive work has been carried out on the setting of yarns to either prevent cockling or remove cockles from a garment. Benson found that setting the yarn before knitting increased the loop distortion, with cockling increasing with the severity of setting, while yarn set in hank form (not under tension) gave the lowest loop distortion. Presetting or stabilising yarn on spinners packages, or rewinding onto cones increased loop distortion. Benson also found that a French singles Superwash yarn with a level of twist as low as one turn per centimetre (2,54 t.p.i) gave the best knitted fabric in terms of freedom from cockles. As the cover factor increased so did loop distortion.

Various anti-cockle treatments aimed at removing puckering and cockling have been used[9, 11], although it appears to be important to prevent loop distortion occurring rather than correcting it once it has appeared in the fabric[9]. It is with Benson's statement in mind that the present investigation was carried out.

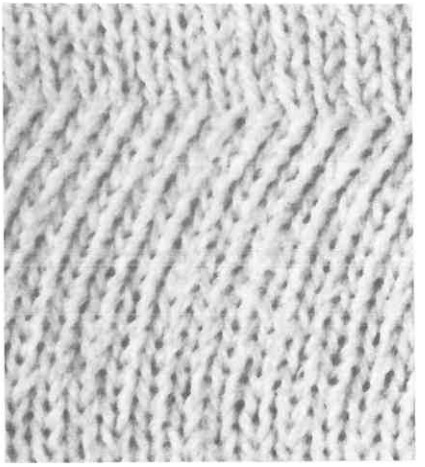


FIGURE 1
Short-term Spirality

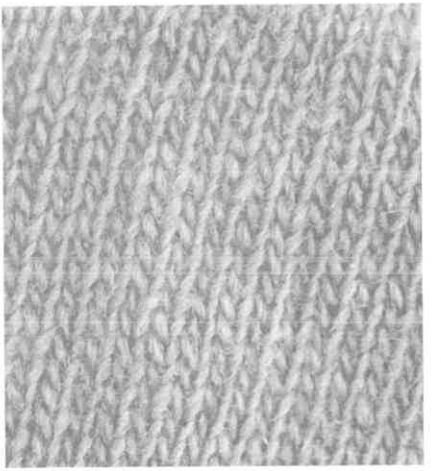


FIGURE 2
Normal Spirality

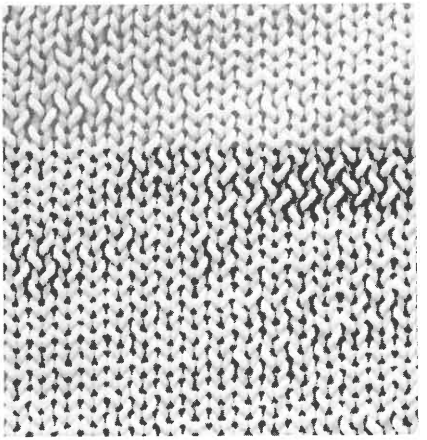


FIGURE 3
Flashing

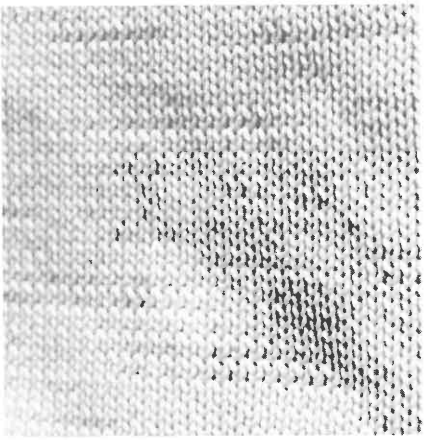


FIGURE 3(a)
Flashing – Photographed with incident light

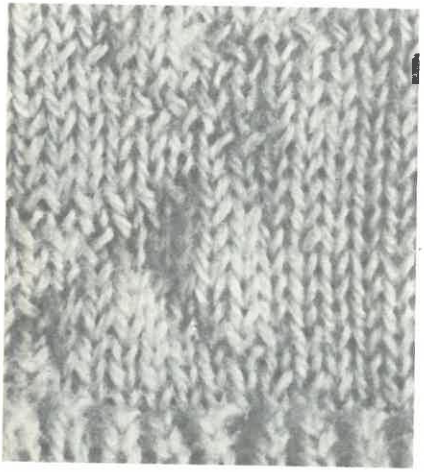


FIGURE 4
Puckering

FIGURE 5
Cockling

EXPERIMENTAL AND DISCUSSION

It was decided to carry out a preliminary study both on commercial yarns currently being knitted into fully-fashioned outerwear by local knitwear organisations, and on some SAWTRI yarns from previous work known to produce severe cockling and to establish what types of yarns were prone to cockling.

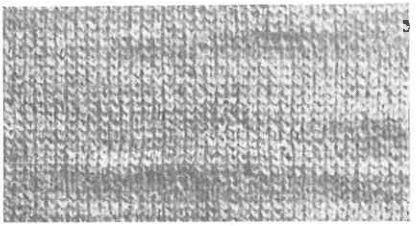
Table I lists the 20 yarns used. From each of these a number of body blanks were knitted on a Scheller 24 gg fully-fashioned machine. The knitting details were as follows:—

Machine	:	Scheller 24 gg F/F
Speed	:	44 courses per minute
Input tension	:	Low
Tightness factor	:	14,1 (CF 1,2)
Take-down tension	:	Optimum

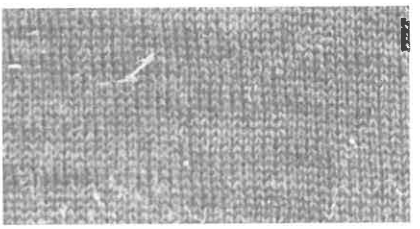
The body blanks were then subdivided into 3 groups as follows:—

Group 1	:	dry relaxed;
Group 2	:	steam relaxed without pressing;
Group 3	:	relaxed by washing.

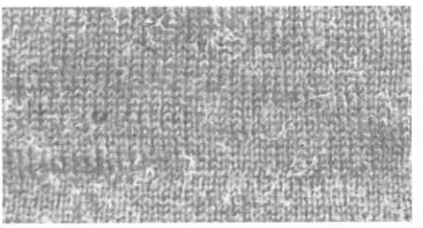
The group 1 fabrics were relaxed on gauze trays under normal conditions (65 *per cent* RH 20°C) for 48 hours. Fabrics in group 2 were placed on a Monti steam press and steam blown through the blanks for 60 seconds (without pressing), followed by blowing. Fabrics in group 3 were relaxed according to I.W.S. Wash Test



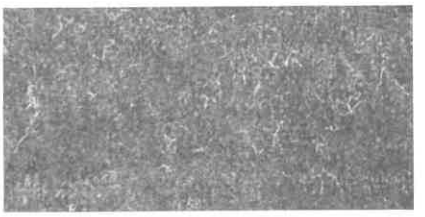
(a) Dry Relaxed (48 hrs) (e)



(b) Monti steam relaxed (60 sec) (f)



(c) Wash Relaxed (TM 9) (g)



(d) Wash Relaxed[13] (h)

Untreated Wool (Yarn 8) Shrinkproofed Wool (Yarn 7)

FIGURE 13

Photographs showing the development of cockles at each stage of relaxation

TABLE II

SOME DETAILS OF COCKLES FOUND IN ALL-WOOL GARMENTS

Actual yarn linear density	Total Number of loops per 25 cm² (w x c x 25)	Number of cockled loops per 25 cm²	Number of cockles per 25 cm²	Average extent of cockle (loops)	Percentage cockling (%)
R62 tex/2	1 209	104,9	14,6	7,2	8,7
R62 tex/2	1 160	69,8	10,3	6,8	6,0
R62 tex/2	1 160	87,0	10,9	8,0	7,5
R66 tex/2	1 064	99,1	13,4	7,4	9,3
R64 tex/2	1 160	93,5	12,2	7,7	8,1
R64 tex/2	1 073	56,3	7,0	8,0	5,3
R63 tex/2	1 064	64,0	9,2	6,9	6,0
R64 tex/2	1 073	118,2	14,3	8,3	11,0
R66 tex/2	1 110	106,2	13,2	8,0	9,6
R62 tex/2	1 160	130,5	14,6	8,9	11,3
R64 tex/2	1 147	81,6	10,0	8,2	7,1
R63 tex/2	1 240	65,6	9,2	7,1	5,3
R68 tex/2	1 112	89,4	10,5	8,5	8,1
R67 tex/2	980	55,5	7,3	7,6	5,7
R69 tex/2	1 073	49,5	6,5	7,6	4,6
R60 tex/2	1 209	117,9	15,4	7,7	9,8
R65 tex/2	1 240	101,0	10,9	9,3	8,2
R56 tex/2	1 312	138,5	12,7	10,9	10,6
R64 tex/2	1 044	74,1	9,3	8,0	7,1
R71 tex/2	969	66,1	9,7	6,8	6,8
R66 tex/2	1 044	88,1	11,9	7,4	8,4
R78 tex/2	1 003	70,5	11,0	6,4	7,0
R62 tex/2	1 280	78,5	10,0	7,8	6,1
R66 tex/2	1 015	76,2	10,3	7,4	7,5
R53 tex/2	1 215	122,6	13,3	9,2	10,1
R67 tex/2	1 015	70,2	10,2	6,9	6,9
R66 tex/2	1 064	83,6	9,2	9,1	7,9
AVERAGE	1 118	83,3	11,0	7,9	7,8

Method 9(12). The fabrics from each of the 20 lots were examined and assessed for cockling (see Table I) and it appeared that cockling only occurred in the fabrics knitted from wool yarns. Figs 6 to 12 show typical examples of the fabrics after the wash test.

A shrinkproofed wool and an untreated wool were compared. In the case of the latter it can be seen (Fig. 13) that the cockles developed and became more pronounced at each stage of relaxation. The cockles could be faintly discerned straight after knitting [Fig. 13(a)], but only became really noticeable after washing [Fig. 13(c)]. In the case of the shrinkproofed wool, it can be seen that cockles were present [Fig. 13(f)] but did not develop to quite the same extent. Fig. 13(h) shows cockling but no felting, whereas Fig. 13(d) shows signs of felting and, therefore, to some extent the cockles do not show up.

Fig. 14 is an enlarged photograph of an all-wool fully-fashioned fabric showing loop distortion. The loops appear to slant at a more acute angle in one direction, and that part of the stitch which becomes more prominent on the surface, appears to have a very low twist in the two-ply yarn.

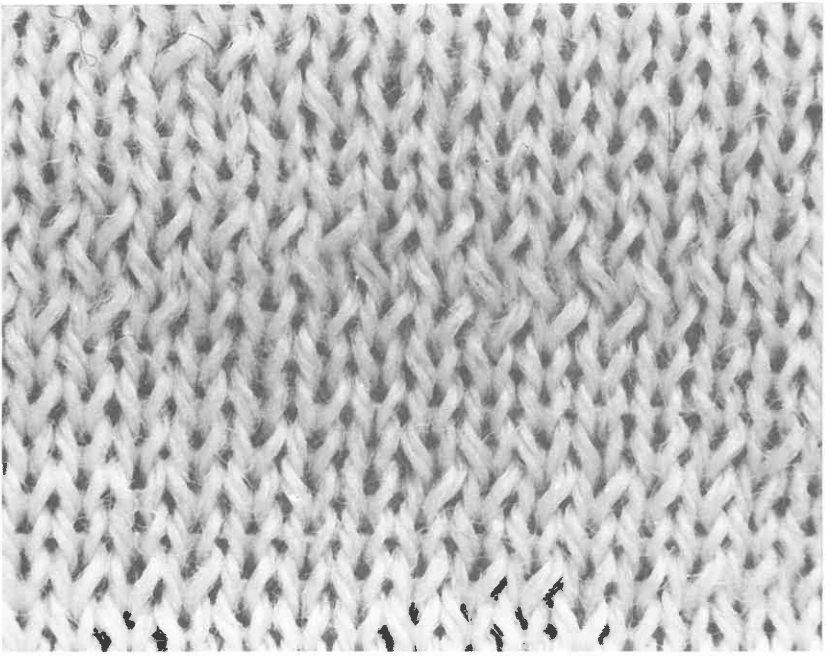


FIGURE 14

An enlarged photograph showing a portion of a cockled fabric

It was then decided to investigate the effect of twist on cockling. Twenty-seven pure wool fabrics were knitted from specially selected yarns. The yarn linear densities ranged from R53 tex/2 to R78 tex/2 and all the fabrics were knitted on a 24 gg Scheller fully-fashioned machine to a tightness factor of 14,1 (cover factor 1,2). The fabrics were washed[11], each fabric examined under magnification and the number of cockled loops per 25 cm^2 counted. This was repeated 10 times for each fabric, and the averages taken.

The wales per cm (w), courses per cm (c) and stitch length (ℓ) were measured and from this data the percentage and length of cockled loops were determined for each yarn used. The degree of cockling expressed as a percentage was defined (calculated) as follows:

$$\%\,\text{Cockling} = \frac{\text{No. of cockled loops}}{\text{Total No. of loops}} \times 100$$

The results are shown in Table II. It can be seen from Table II that all 27 wool fabrics cockled to a greater or lesser extent. The degree of cockling varied from 4,6 *per cent* to 11,3 *per cent,* and the cockling also varied in severity with some cockles being very pronounced whereas others were slight. The number of loops over which individual cockles extended varied from 6,4 to 10,9 and the mean length of the yarn in a cockle was 4,4 cm (7,9 loops).

Ten body blanks were selected at random from the 27 samples listed in Table II. Cockles in the fabric were suitably marked and the fabric cut so that the yarns could be unravelled and the various sections of the yarn, e.g. normal (N), cockled to the right (R), cockled to the left (L), slightly cockled (SL or SR) used to determine yarn linear density (tex) and twist (turns per centimetre). One set of typical individual results is shown (yarn No. 42) in Table III, and Fig. 15 shows the relationship between plying twist and yarn linear density for undistorted and cockled fabric areas.

Table IV summarises the results of the tests carried out on the 10 samples. It can be seen that in nine cases out of ten the mean plying twist of the yarn at the point at which cockling occurred was significantly lower than the average plying twist. All the 20 mean values for the twist of the singles components were lower than average, although only half of these were significantly lower at the 95 *per cent* level, and therefore the hypothesis that cockling is associated with the low twist area in the yarn is supported. This confirms the finding of other workers[6, 8].

Table V gives a summary of the linear densities (tex) of yarn removed from normal and cockled fabric areas respectively in the ten cockled fabrics. It can be seen that in eight out of ten yarns the tex of the yarn from the normal regions was significantly lower than that of yarns from the cockled regions. The same trend was also present in the case of the other two yarns, though these were not significant at the 95 *per cent* level. This is therefore in agreement with the findings of Hunter

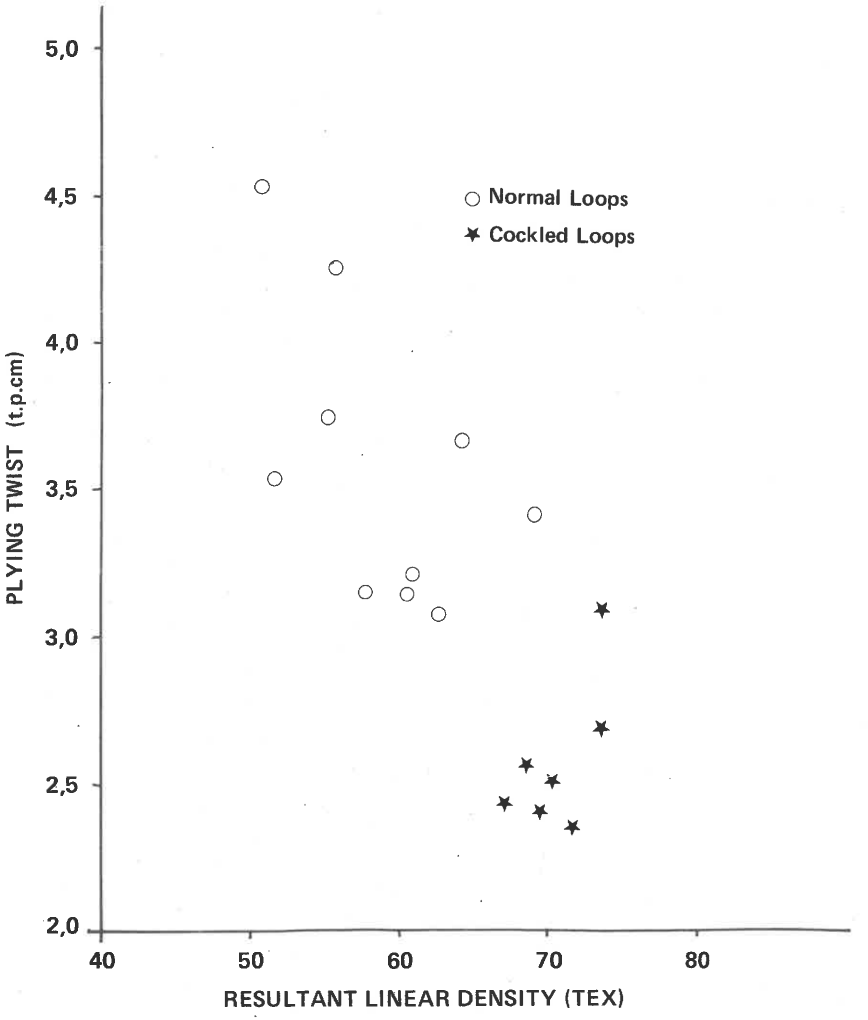


FIGURE 15

The Relationship between Plying Twist and Yarn Linear Density for Undistorted and Cockled Fabric areas respectively

et al[7, 8]. Some explanation why only wool yarns exhibited cockling can be found in Table VI which gives a comparison of the coefficient of variation (CV in *per cent*) of twist and tex in a selection of the yarns knitted. It can be seen that the

TABLE III

TYPICAL INDIVIDUAL TWIST AND LINEAR DENSITY RESULTS OF YARNS FROM NORMAL AND COCKLED LOOPS IN A SPECIMEN FABRIC (YARN NO. 42)

AREA OF TEST		RESULTANT TEX	TWIST (t.p.cm)		
			Two-ply	Single (High)*	Single (Low)*
Cockle					
1	N	64,2	3,7	5,8	5,5
	R	71,7	2,4	5,2	5,1
	SL	60,7	4,3	6,7	5,5
	R	73,6	3,1	4,8	4,0
	N	69,2	3,4	5,6	2,8
2	N	60,6	3,2	6,1	5,6
	R	69,7	2,4	6,5	3,7
	SL	55,9	3,9	5,9	4,7
	N	61,0	3,2	6,1	6,0
3	N	50,8	4,5	9,5	5,6
	SR	68,9	2,6	5,2	4,1
	L	66,9	3,1	5,5	5,0
	N	70,1	2,5	5,1	3,7
	N	55,1	3,8	6,5	6,4
4	N	57,9	3,2	6,3	4,9
	R	73,6	2,7	4,8	4,7
	SL	50,0	3,2	6,3	5,4
	N	51,6	3,5	7,0	5,7
5	N	55,9	4,3	7,9	6,7
	L	76,8	3,0	4,3	3,7
	R	67,3	2,4	6,5	3,1
	SL	63,8	3,3	6,6	5,0
	N	62,6	3,1	7,0	5,6

N = No cockle
R = Cockle inclined to the right
L = Cockle inclined to the left
S = Slight cockling

*The singles twists have been listed highest in the left hand column and lowest in the right hand column.

CV's for both plying twist and yarn linear density were considerably higher for a typical wool yarn than for the other yarns not containing wool.

TABLE IV

SUMMARY OF THE TWIST VARIATIONS FOUND IN COCKLED FABRICS

Yarn No.	Type of Twist*	MEAN TWIST (t.p.cm)		
		At Normal	At Cockle (R)	Difference**
42	P	3,57	2,58	0,99**
	SH	6,78	5,43	1,35**
	SL	5,48	4,08	1,40**
22	P	1,89	1,19	0,70**
	SH	5,45	5,24	0,21
	SL	4,61	3,98	0,63
19	P	3,22	2,38	0,84**
	SH	6,12	4,98	1,14**
	SL	4,76	3,13	1,63**
35	P	2,13	1,38	0,75**
	SH	6,40	4,38	2,02**
	SL	5,29	3,51	1,78**
2	P	2,73	2,12	0,61**
	SH	5,39	5,27	0,12
	SL	4,32	4,10	0,22
36	P	2,49	1,82	0,67**
	SH	5,87	4,68	1,19**
	SL	3,73	3,24	0,49
5	P	2,73	2,32	0,41
	SH	5,71	5,05	0,66
	SL	4,59	3,58	1,01
9	P	2,54	1,98	0,56**
	SH	5,65	4,41	1,24**
	SL	4,65	3,78	0,87**
38	P	2,87	2,03	0,84**
	SH	5,18	3,58	1,60**
	SL	4,07	2,74	1,33
20	P	2,66	2,20	0,46**
	SH	4,74	4,49	0,25**
	SL	3,95	3,33	0,62

*P = Ply
SH = Singles (high)
SL = Singles (low)

**These differences are significant at the 95 *per cent* confidence level.

TABLE V

SUMMARY OF LINEAR DENSITY VARIATIONS FOUND IN COCKLED FABRICS

YARN NO.	LINEAR DENSITY (tex)		
	Normal	Cockle	Difference**
42	58,9	70,7	11,8**
22	51,3	62,3	11,0**
19	62,1	71,2	9,1
35	69,9	84,2	14,3**
2	57,5	65,4	7,9
36	53,3	62,6	9,3**
5	59,6	69,7	10,1**
9	56,7	69,1	12,4**
38	49,5	58,3	8,8**
20	63,7	72,1	8,4**

**These differences are significant at the 95 *per cent* confidence level.

TABLE VI

A COMPARISON OF THE CV OF TWIST AND TEX OF A SELECTION OF KNITTING YARNS

Yarn No.	Composition	Linear Density (tex)	PLYING TWIST (t.p.cm)		Actual Yarn Linear Density* (tex)		Cockling
			Mean	% CV	Mean	% CV	
18	Prograde Cotton	R56 tex (R28 tex/2 X 2)	5,84	7,6	27,6	7,6	Nil
16	Orlon	R72 tex/2	3,11	7,5	72,0	13,1	Nil
12	Acrylic	R54 tex/2	3,15	5,6	55,1	10,6	Nil
15	Acrylic	R63 tex/2	2,67	8,7	60,5	7,9	Nil
11	Lambs wool/Orlon	R63 tex/2	3,03	11,1	64,5	9,8	Nil
12	All Wool	R64 tex/2	1,60	31,9	57,8	16,5	Bad

*Test Length = 2,5 cm

SUMMARY AND CONCLUSIONS

Loop distortion in plain single jersey knitting has been divided into five classes under the general description of cockling as defined by The Textile Institute in a publication "Textile terms and definitions". A more specific definition of cockling is: short term distortion of a few consecutive loops in the coursewise direction apparently caused by thick places of low twist. The differences between spirality, cockling, flashing and puckering have been illustrated by photographs.

It has been shown that out of 20 selected yarns knitted into fully-fashioned plain single jersey fabrics only the *wool fabrics* cockled to any noticeable extent. Furthermore, it was shown that even a highly shrinkresistant wool fabric still exhibited cockling.

Twenty-seven different all-wool yarns were knitted and the amount of cockling in each fabric calculated by counting the cockled (distorted) loops. It was found that, on average, 7,8 *per cent* of the fabric surface displayed cockling. The average cockle extended over 7,9 stitches but could vary between 6,4 and 10,9 stitches. The fabrics were cut at the cockles and the yarn linear density (tex) and twist were determined before, in, and after the cockle. It was shown that for all the yarns the plying twist at the cockle was lower than the average twist, and in 9 out of 10 cases it was significantly lower at the 95 *per cent* level. In eight out of ten cases the yarn linear density in the cockled region was significantly higher than that of the yarn in the normal regions. In the other two cases a similar trend was also observed although these were not significant at the 95 *per cent* level. It was shown that the coefficient of variations (CV) of both plying twist and yarn linear density were considerably lower for non-wool yarns than for all-wool yarns.

It can be concluded that thick places in the yarn are of major importance. When yarn is knitted into plain single jersey the thick places in the yarn, having lower twist levels, cause a succession of distorted loops in the fabric. This is defined as cockling.

ACKNOWLEDGEMENTS

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