SAWTRI TECHNICAL REPORT

NO 217

A Preliminary Report on the Measurement of the Unevenness of Plain Jersey Fabrics

by

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P. O. BOX 1124
PORT ELIZABETH
REPUBLIC OF SOUTH AFRICA

ISBN 0 7988 0405 X

A PRELIMINARY REPORT ON THE MEASUREMENT OF THE UNEVENNESS OF PLAIN JERSEY FABRICS

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ABSTRACT

The variation in surface irregularity, measured by means of a stylus lightly resting on and traversed along the fabric surface as well as the variation in transmitted light measured by means of a photodensitometer, of single jersey fabrics were related to yarn irregularity. The latter method, however, appeared to be the more promising as a practical method of obtaining a measure of the unevenness of knitted fabrics. An increase in yarn irregularity was found to be associated with an increase in fabric unevenness. Subjective rankings of fabric streakiness were correlated with all these variables. The effect of an increase in stitch length on the results obtained for surface irregularity was different to that on the fabric irregularity results measured by transmitted light. In the case of the surface irregularity test the sample had to be mounted carefully since slight variations in mounting tension caused large variations in the results.

KEY WORDS

Plain jersey – fabric streakiness – yarn mass irregularity – surface irregularity – transmitted light irregularity – photodensitometer – subjective streakiness ranking – dry relaxation – steaming – pressing – wool worsted hosiery yarns.

INTRODUCTION

Streakiness often presents a major problem in fabrics knitted from staple fibre yarns and it is probably one of the most common complaints. The term streakiness, as used here, refers to that unevenness (irregularity) in the appearance of the knitted fabric which is characterised by relatively short (usually between about 1 cm and 5 cm), dark and light horizontal streaks randomly distributed over the fabric surface. It must therefore be distinguished from what is normally termed barré[1] which refers to relatively long horizontal "bars" (either lighter or darker than the rest of the fabric) and which can often extend the full width of the material. These, more often than not, repeat at regular intervals along the length of the fabric.

In contrast to streakiness, barré is more commonly associated with fabrics knitted from continuous filament synthetic yarns where it is often caused by differences in dye shade or dye uptake of yarns from different packages (due mainly to differences in either texturing or extrusion conditions) and differences in linear density (denier) and degree of texturing of yarns from different packages etc. Causes of barré common to both staple fibre and continuous filament fabrics are; incorrect yarn feed rates at different feeders (this could be due to variations in the yarn input tension, cam setting or positive feed setting), dial and cylinder not properly aligned etc. Fabric streakiness, on the other hand is mostly due to either short term variation in the yarn cross-section (i.e. yarn linear density or diameter irregularity) or unlevel (skittery) dyeing. To distinguish between these two causes yarn segments from light and dark "streaks", respectively, must be cut out and weighed. It is normal to work over a fixed number of wales and to check for any variation in stitch length as well.

In practice the appearance of a fabric, be it knitted or woven, is normally assessed subjectively by viewing it either by means of reflected or transmitted light and on this basis it is then either passed as acceptable or rejected as being too streaky. Nevertheless, in common with most subjective tests, such an assessment (evaluation) is not always reproducible or accurate. It is, for example, heavily dependent upon the particular judge (or assessor) and viewing conditions. Furthermore, this method is not only time-consuming but rather unsatisfactory when the effect of a large number of variables on fabric unevenness is to be evaluated systematically. There is, therefore, a real need for an objective method of evaluating fabric unevenness both for industrial and scientific use.

Some studies have been carried out on the effect of yarn irregularity (mass and diameter) on the appearance of both knitted and woven fabrics.

Barella *et al*[(2)] were of the opinion that the mass regularity of yarns is not of decisive importance in affecting fabric regularity and concluded that, for equal mass regularity of a yarn, the regularity of the appearance of the fabric produced from it depended directly upon the regularity of the diameter of the yarn. Rousseau and Maron[(3, 4)] also contended that faults, such as streakiness or light bars, which appear in knitted and woven fabrics were caused by a type of irregularity not revealed by evenness testers such as the Uster.

Magalhaes *et al*[(5)] found, for both woven and knitted fabrics, a close correlation between variation of reflectance as measured by a photometer and the appraisal of cloth by the human eye. They mention two other factors, the periodicity and amplitude of the variation, which will influence subjective preferences and which the simple coefficient of variation of reflectance will not take into account.

Maillard *et al*[(6)], working on jersey fabric knitted from one end of yarn, found their best fabric to be associated with good yarn regularity and their worst to have a poor yarn regularity. They weighed small discs, cut out of the fabric, and used the variation in their mass as a measure of the fabric irregularity. The use of small rectangular strips may have been more appropriate to obtain a measure of fabric streakiness. Evidence to substantiate the effect of yarn unevenness on the appearance of plain-weave fabrics (woven from 16,4 tex combed cotton yarns) appears elsewhere[(7, 8)] where it was found that the use of more even yarns resulted in more even fabric.

Hammersley[9] found that, in the case of multi-feed double jersey fabrics, evaluated subjectively by reflected light, there was little variation in fabric streakiness despite a considerable variation in the yarn irregularity parameters. When the fabrics were examined by transmitted light, however, he found the relative streakiness of the fabrics to differ considerably but the streakiness still did not correlate with yarn irregularity.

Methods which have been used to measure "streakiness" and which are particularly suitable for fabrics which are smooth and flat are; a photometric method[5] used to measure the variation in light reflectance of a cloth, photometric transparency methods[2, 10] used to measure the variation in transparency of fabrics; and a photo-electric method for evaluating the irregularity of fabric appearance[11] and seam puckering[12] in terms of the variation in either light reflected from or transmitted through a cloth scanned at a constant speed. The latter method is a continuous one in which light reflectance (or transmission) curves are obtained while in the other two methods separate readings are taken over the whole fabric area.

In the case of plain (single) jersey fabrics it is a well-known fact that short term variation in the yarn linear density (i.e. short term yarn irregularity) causes a distortion of the fabric surface resulting in a puckered (wrinkled or corrugated) appearance of the fabric. It is, therefore, conceivable that some measure of the unevenness of these fabrics, due to variation in the yarn linear density, could be obtained by evaluating the degree to which the surface has become distorted (i.e. frequency and amplitude of the distortions). This method is used to evaluate the "wrinkling severity" of woven fabrics[13, 14, 16] to which random wrinkles (creases) have been imparted under controlled conditions and it has also been used to evaluate seam puckering[15]. It was decided, therefore, to investigate the possibility of obtaining a measure of the unevenness of single (plain) jersey fabrics employing a method similar to that used by Slinger[16] to obtain a quantitative measure of the degree of wrinkling of woven fabrics. This method is, in principle, similar to that developed by Shiloh and upon which the "Wrinklemeter" is based[13–15]. This method is referred to in this report as the *mechanical* method.

The work was subsequently extended to cover a method whereby the intensity of the light transmitted through a small fabric area is measured by means of a photodensitometer and recorded. The variation in the light transmitted was evaluated and related to yarn irregularity and fabric "streakiness", the latter assessed subjectively. This is referred to as the *optical* method in this paper.

EXPERIMENTAL

Six singles wool worsted hosiery yarns with approximately the same linear density and twist, but having different yarn irregularities were selected (see Table I). Each yarn was knitted on a Lawson Fiber Analysis Knitter (220 needles – 20 n.p.i.) into plain jersey fabrics with stitch lengths of –

TABLE I

YARN PROPERTIES

YARN NO.	SHADE	LINEAR DENSITY (tex)	TWIST (t.p.m.)	IRREGULARITY (CV in %)
1	Wine Colour	28	461	18,4
2	Undyed	28	503	18,9
3	Blue Mix	27	471	19,7
4	Petale	26	493	22,4
5	Prune Mix	26	483	18,9
6	Glacier	28	494	23,6

(a) 3,0 mm;
(b) 3,5 mm; and
(c) 4,4 mm;

respectively. These correspond to tightness factors $\left(\frac{\sqrt{\text{tex}}}{\text{stitch length in cm}}\right)$ of 17,3, 14,8 and 11,8 (worsted cover factors 1,47, 1,26 and 1,00), respectively. Care was taken not to fold or distort the fabric at any time.

After allowing the fabrics to dry-relax, a profile of the surface irregularities ("wrinkledness") was obtained by means of the stylus method devised by Slinger[16] for measuring fabric wrinkledness. A low stylus pressure was used and between four and six traces were obtained for each fabric over a 9 cm length of fabric. The traces were made along parallel lines, 15 mm apart, in the direction of the wales. From these profiles the "wrinkle" parameters viz. mean wrinkle height (H) and mean wrinkle slope (T), which were previously recommended for assessing the wrinkled appearance[14, 17] or the seam puckering[15] of a fabric, were determined. The product of these two parameters, H x T (called the wrinkle severity index[18]), normally taken as an overall measure of the degree of wrinkling, was used for describing the degree of unevenness (distortion) of the fabric surface. In view of the problems caused by curling when the fabric tube was cut open the fabrics were kept in the original tubular form. It was, however, found necessary to insert a loosely fitting flat metal plate into the tube so as to weigh down the lower fabric layer and also to present a smooth, solid surface on which the top layer could rest.

It was found that H x T was dependent on the method by which the sample was mounted on the flat plate, the mounting tension being the most important factor in this respect (see Fig. 1). Tensions were applied in the wale direction during mounting. When a medium tension was applied (e.g. a total of 150 gf applied across the width of the fabric) the fabric was stretched which resulted in a rather flat (smooth) surface and differences between fabrics became too small to be accurately measurable. On the other hand when the tension was very low the effect of small variations in mounting tension became more important and was reflected by variations in the test results. Nevertheless, it was decided that a mounting method in which no tension was deliberately applied was the simplest to apply in practice and was used in subsequent work.

Certain of the fabrics were measured in three different states, viz. *dry-relaxed, steamed* and *pressed*.

The procedure for attaining the *steamed* state consisted of placing the fabric tubes on a wire mesh and allowing steam to pass through the fabric for 30 sec. No extraneous tensions were allowed to act on the fabric during steaming except for those resulting from the contact between the fabric and the wire mesh on which the fabrics were laid. The procedure for "pressing" the fabrics on a Hoffman-press was as follows

10 sec. open steaming;
30 sec. steaming with press closed;
30 sec. baking (with press closed); and
10 sec. vacuum.

The steaming temperature was about 146°C and the pressure between the head and buck, when the press was closed, varied from 8,4 kg/cm^2 at the beginning of the cycle to 7,2 kg/cm^2 at the end of the cycle. The samples, which were still in the tubular form to avoid curling of the fabric, were subjected to two pressing cycles.

The yarn irregularity was measured, in the normal manner, on the Zellweger "Uster" series of evenness testing equipment. In addition to these values, which have been termed the "average yarn irregularity", certain of the fabrics were unravelled and the irregularity of the unravelled yarns measured and related to the readings obtained on the piece of fabric from which they were unravelled. The fabrics were also subjectively ranked for "streakiness" *(surface irregularities)* by *three judges*, who, in the one case, viewed the fabrics by means of reflected light and, in the other case, by means of transmitted light (see Table II). The different appearance of the fabric irregularities at the different stitch lengths made direct comparisons between stitch lengths very difficult.

In view of the problems caused by the mounting tension in the case of the mechanical test the variation in fabric density ("streakiness" as assessed optically by means of transmitted light) due mainly to variation in the yarn linear density was also measured by means of a Hilger and Watts photodensitometer. This instrument is normally used to scan X-ray photographs. A photodensitometer amplification setting of 28 was used. The fabric was scanned (continuously) over a 10 cm length in the wale direction using a scanning speed of 2 cm/min and the fabric area covered at any one instant by the light beam was approximately 10 mm x 1 mm. The photodensitometer was coupled to a multiplier (amplifier) on which an amplification of 10 was used. A trace of the intensity of the light transmitted through the fabric was obtained on a Hitachi Recorder (QPD 53) using a range setting of 50 mV and a chart speed of 60 mm/min. Eventually the standard deviation (SD), in arbitrary units, of the recorder tracing was calculated for 27 cm of chart (representing a 9 cm length of fabric).

For the purpose of this latter experiment the fabrics were Hoffman pressed and the tubes cut open before making measurements. The fabrics were placed flat and free from tension on the traversing table of the photodensitometer. These fabrics were also ranked, by the three judges, according to their "streakiness".

RESULTS AND DISCUSSION

MECHANICAL (STYLUS) METHOD

The Effect of Mounting Tension on the H x T Values:

The H x T values have been plotted against yarn irregularity in Fig. 1. This figure shows H x T to be correlated with yarn irregularity and that even small mounting tensions, applied in the wale direction, greatly reduced H x T (i.e. the fabric surface irregularity or distortion). At the highest tension the fabric surface became so smooth (flattened) that the differences between the various fabrics became small and comparable with the experimental error and, therefore, hardly detectable. In view of this, all subsequent tests were carried out with as little tension applied to the fabric as possible. In the case of the above figure, as well as most subsequent ones, regression lines have been superimposed onto the points plotted.

The Effect of Fabric State and Stitch Length on the H x T values:

The relevant results are given in Table II while in Fig. 2 the H x T values for the dry-relaxed and pressed fabrics have been plotted against the average yarn irregularity. In the figure the flattening of the fabric by Hoffman pressing is illustrated by a large reduction in the "severity index" (H x T). The H x T values obtained on the steamed fabrics lie between those obtained on the above-mentioned two sets of fabrics. Although the scatter of the points is reasonably large, the correlation between H x T and yarn irregularity is clear. Part of the scatter can, however, be attributed to variations in the yarn irregularity along the length of the yarn seeing that the irregularity tests were carried out on a different yarn segment to that actually knitted.

In an attempt to improve the correlation (i.e. reduce the scatter of the points) certain of the fabrics were unravelled after the test and the irregularity of the yarns so obtained measured on the Uster. These results have been plotted in Fig. 3. It is clear that the scatter of the points has been reduced signifying that, in practice, a better correlation between H x T and yarn irregularity would be obtained if the irregularity of the length of yarn actually knitted were to be measured beforehand and used instead of the average value for the yarn lot as a whole.

TABLE II

THE EFFECT OF STITCH LENGTH, YARN IRREGULARITY AND FABRIC STATE ON THE RESULTS OBTAINED WITH THE MECHANICAL METHOD (NO TENSION APPLIED)

SAMPLE NO.	OPEN STEAMING				DRY RELAXED					PRESSED				
	H ($x 10^2$ mm)	T ($x 10^2$)	H x T ($x 10^4$ mm)	Visual Ranking using Reflected light*	H ($x 10^2$ mm)	T ($x 10^2$)	H x T ($x 10^4$ mm)	Visual Ranking using Reflected light*	Visual Ranking using Transmitted light*	H ($x 10^2$ mm)	T ($x 10^2$)	H x T ($x 10^4$ mm)	Visual Ranking using Reflected light*	Visual Ranking using Transmitted light*
3,0 mm														
1	–	–	–	–	26,9	8,3	223	11,7	12,3	8,1	8,1	66	5,7	10,7
2	–	–	–	–	20,8	10,6	220	10,7	11,7	14,3	12,2	174	4,3	11,3
3	–	–	–	–	25,8	12,1	312	5,7	9,7	11,6	7,9	92	7,7	6,0
4	–	–	–	–	25,0	13,1	328	4,0	4,3	9,6	7,5	72	3,3	4,0
5	–	–	–	–	26,2	9,8	257	5,7	11,0	9,2	8,3	76	8,3	12,0
6	–	–	–	–	21,7	14,3	310	1,0	1,7	15,3	16,8	257	1,0	2,0
3,5 mm														
1	22,2	13,0	289	3,3	25,3	16,4	415	11,7	13,3	11,4	8,4	96	10,0	13,7
2	25,8	12,9	333	5,7	22,9	13,9	318	7,3	10,3	10,4	4,2	44	13,7	17,0
3	25,5	14,8	377	3,7	27,6	16,4	453	8,7	10,7	11,6	9,3	108	9,7	11,0
4	24,1	17,8	429	1,3	33,2	19,0	631	2,0	3,7	11,4	12,4	141	3,7	3,7
5	21,1	11,9	251	5,3	38,3	16,3	624	10,3	12,7	8,8	6,8	60	12,3	13,0
6	30,5	17,1	522	1,7	38,0	25,3	961	4,3	1,3	17,2	15,1	260	3,0	1,7
4,4 mm														
1	–	–	–	–	25,4	13,2	335	16,3	15,3	8,8	3,9	34	18,0	12,7
2	–	–	–	–	21,6	9,9	214	17,0	13,7	8,0	6,0	48	15,3	17,7
3	–	–	–	–	27,7	10,7	296	16,0	12,7	9,2	6,8	63	15,0	10,7
4	–	–	–	–	32,6	13,1	427	10,7	7,3	8,4	4,3	36	13,7	6,3
5	–	–	–	–	22,9	9,2	211	16,7	15,0	8,1	6,4	52	17,0	10,7
6	–	–	–	–	35,8	16,1	576	11,3	4,3	13,0	8,7	113	9,3	7,3

*A low score indicates a relatively streaky appearance

H = mean "wrinkle" height

T = mean "wrinkle" slope

H x T = mean "wrinkle-severity" index, an overall measure of the surface distortion or puckering of the fabrics

In the case of the dry relaxed fabrics the results given in Table II and plotted in Figs 2 and 3 show that the tightest fabrics (i.e. those with the shortest stitch length) generally had the lowest H x T values, most probably due to the "jamming" of the loops in the tighter structure, thus not allowing the fabric to distort completely (i.e. to take up a more relaxed configuration). The fabrics of medium tightness displayed the highest H x T values suggesting that, in this case, the factors controlling the degree to which the fabric distorts were at a minimum. This is probably due to the fact that the yarns were free to move relative to each other and to take up more strain-free positions (i.e. to tend towards a minimum energy or relaxed state). The H x T values of the slack fabrics lie between the two other fabric series which can possibly be explained by the fact that, although the yarns had greater freedom to move than in the case of the other fabrics, the curvature to which the yarns was bent (and therefore the bending couple) was lower, thus reducing both the amplitude and frequency of the distortions.

From the results obtained on the pressed fabrics it is apparent that not only did pressing reduce the H x T values considerably, but it also reduced the differences between the fabrics having different tightness factors. The effect of pressing appeared to be greatest in the case of the loosely knitted (i.e. slack) fabrics and smallest in the case of the most tightly knitted fabrics. This is not surprising since the effect of pressing will, to a large extent, depend upon the freedom of the yarns to move relative to each other and, therefore, upon the magnitude of the forces preventing the yarns from moving and staying in a flat (i.e. pressed) state. Pressing also had the effect of reducing the dependence of H x T on yarn irregularity indicating that all the fabric distortions were flattened (reduced) to approximately the same level regardless of their original levels. Nevertheless, a slight dependence of H x T on yarn irregularity is still evident.

Relation between H x T and Visual Ranking:

Although it has already been found that the H x T values are correlated with the yarn irregularity it still has to be shown that they are correlated with the fabric streakiness as assessed subjectively. For this purpose three judges were asked to rank the 18 dry-relaxed and 18 pressed fabrics separately in order of decreasing "streakiness". Each judge carried out the assessment, on each of the two sets of 18 fabrics, by means of reflected light in the one case and, transmitted light in the other case. The agreement between the judges was generally very good and the ranking scores of the three judges were combined to give the final values shown in Table II. The coefficient of concordance of the rankings varied between 0,73 and 0,97 with 16,3 and 32,7 degrees of freedom. These values are well in excess of that (0,5) required for significance at the 99,5 *per cent* level and show that the consistency between the ranking scores of the three judges was very high.

In Figs 4 and 5 the H x T values have been plotted against the visual ranking values using reflected and transmitted light, respectively, for the pressed fabrics. In Figs 6 and 7 the values have been plotted for the dry-relaxed fabrics.

From Figs 4 and 5 it appears that the H x T values were better correlated with the ranking obtained when viewing the fabrics by means of reflected light than when viewing the fabrics by transmitted light. This is not unexpected in view of the fact that, when the fabrics were assessed by means of reflected light, the judges' assessment was mainly influenced by the size and frequency of the "puckers" and this is what was evaluated by the H x T values. It is apparent, too, that the relationship between H x T and ranking score is approximately independent of the stitch length of the fabric.

From Figs 6 and 7 it is apparent that, within any particular stitch length group, there was a correlation between the H x T values and the ranking score, but the relationship between H x T and ranking, whether it be by reflected or transmitted light, was influenced by the stitch length.

The above findings confirm a remark made earlier, namely that pressing tends to counteract (reduce) differences in the fabric surface distortion due to differences in the stitch length.

Relationship between Subjective Ranking and Yarn Irregularity:

In the previous section it was illustrated that there was a relationship between the H x T values and the subjective ranking score but that, in the case of the dry-relaxed fabrics, the relationship was affected by the stitch length of the fabric. It was not clear, however, whether this effect was contained in the H x T value or in the subjective ranking, or both. To investigate this the subjective ranking scores of the dry-relaxed fabrics have been plotted against the yarn irregularity in Figs 8 and 9.

From Figs 8 and 9 it is apparent that the subjective ranking of the fabrics, although correlated with the yarn irregularity, was influenced by the fabric stitch length. The looser the fabrics (i.e. the longer the stitch length) the better (i.e. the more even) the judges ranked them as exemplified by the higher ranking scores. The ranking score obtained by means of transmitted light appeared to be less dependent upon the fabric stitch length than that obtained with reflected light (compare Fig. 9 with Fig. 8). Similar trends were observed in the case of the pressed fabrics.

It, therefore, appears that, in general, ranking a fabric by means of transmitted light will be less affected by the cover factor (tightness factor) of the fabric and better correlated with the yarn irregularity than in the case of ranking the fabric by means of reflected light. Nevertheless, it is important to note the effect of stitch length on the subjective ranking, in particular when viewing the fabric by means of reflected light, since it follows that this is another factor having a bearing on the subjective assessment of the fabric "streakiness". Whether yarn linear density will influence the results in the same manner as did stitch length (both being incorporated in the tightness factor term) remains to be proved.

Relationship between Subjective Ranking Scores Obtained with Transmitted and Reflected Light:

It is of interest to investigate the correlation between the two ways of assessing "streakiness" used here, since both could be employed in practice and since Hammersley[9] reported a poor correlation between the two methods in the case of double jersey fabrics.

In Fig. 10 the values obtained by means of the two ranking methods have been plotted against each other for the dry-relaxed fabrics. It is apparent that, within a particular stitch length group, the values are correlated, but that once again, the subjective ranking of the fabrics for evenness is affected by the stitch length. Generally this appears to be due to the fact that the surface distortion (puckering) of the slacker fabrics (i.e. longer stitch length) is much less than that of the more tightly knitted fabrics with the result that the former were given a better ranking than the latter when they were viewed by means of reflected light. It therefore seems that, in practice a better correlation will exist between yarn and fabric unevenness, the latter assessed subjectively, if the fabrics are viewed by means of transmitted light rather than reflected light. Once again similar trends were observed in the case of the pressed fabrics.

OPTICAL METHOD

The Effect of Yarn Irregularity and Stitch Length on Fabric Unevenness (SD) as Assessed Optically:

The results are given in Table III and are illustrated in Fig. 11. For all the stitch lengths there was a dependence of the SD of the recorder tracing on the yarn irregularity. The greater the yarn irregularity the larger the SD (i.e. the variation in transmitted light) became. It is also clear that as the stitch length was increased the SD of the recorder tracing increased. This result, which is different from that obtained with the *mechanical* method, was probably due to the fact that, as the fabric became tighter (i.e. more compact), less light was transmitted overall and the variation in the transmitted light was therefore much smaller as well. If in some way the coefficient of variation of the intensity of the transmitted light could be calculated the effect of stitch length could possibly be reduced or even eliminated. Once again it can be anticipated that if the irregularity of the yarn segment actually knitted is measured beforehand, the correlation between yarn irregularity and the SD of the transmitted light can be improved.

Relationship between SD and Subjective Ranking:

In Figs 12 and 13 the SD of the photodensitometer trace has been plotted against the subjective ranking obtained by means of reflected and transmitted light, respectively. From these figures it is clear that, at any particular stitch length, there was a correlation between the SD values and the subjective ranking score for both

TABLE III

THE FABRIC UNEVENNESS (SD)* VALUES OBTAINED ON THE PRESSED FABRICS BY MEANS OF THE PHOTODENSITOMETER

YARN NO.	AVERAGE YARN IRREGULARITY (CV %)	STITCH LENGTH (mm)		
		3,0	3,5	4,4
1	18,4	0,658	0,785	1,190
2	18,9	0,692	0,998	1,535
3	19,7	0,726	0,994	1,455
4	22,4	0,975	1,073	1,556
5	18,9	0,636	0,716	1,213
6	23,6	0,877	1,229	1,803

*Values given represent the Standard Deviation (SD), in arbitrary units, of the recorder trace obtained by means of the photodensitometer (transmitted light).

reflected and transmitted light. It is obvious, however, that, as in the case of the H x T values, the relationship between SD and ranking was dependent upon the stitch length (i.e. the fabric tightness). Therefore, provided a constant stitch length and yarn linear density are maintained, the SD values obtained from the photodensitometer curves may be used as a measure of the subjective fabric "streakiness".

The Relationship between the H x T and SD Values:

In Fig. 14 H x T has been plotted against SD for the pressed fabrics, this being the only set of fabrics measured on the photodensitometer in view of the difficulties encountered with edge curling in the case of the fabrics which had not been pressed (i.e. the dry relaxed fabrics). It is evident, from Fig. 14, that at any particular stitch length the results obtained by means of the two different methods were correlated. This could be anticipated in view of the results obtained in the previous sections. Once again it is apparent that the effect of stitch length is of paramount importance. Only if it is *constant* can the values obtained by means of the one method be used as a measure of (or to predict) the values obtained with the other method. It may be mentioned that the two different tests were not carried out on the same piece of fabric. Had this been done, the correlation between the H x T and SD values would most probably have been even better.

SUMMARY AND CONCLUSIONS

Two continuous methods, the one employing a stylus resting lightly on the fabric surface (termed the *mechanical* method) and the other using a photodensitometer (termed the *optical* method) have been investigated as means of obtaining an objective measure of the unevenness of plain (single) jersey fabrics. In the case of the "mechanical" method the H x T value, used in the case of woven fabrics as a measure of the severity of wrinkling and called the "wrinkle-severity index", was used as a measure of the distortion (puckering) of the fabric surface. In the case of the optical method the standard deviation (SD) of the recorder trace of the intensity of the light transmitted through the fabric was used as a measure of the unevenness of the fabrics. The influence of yarn irregularity, fabric state and stitch length on the above values was investigated. The streakiness of the fabrics assessed subjectively by means of either reflected or transmitted light was also related to the H x T and SD values.

In general it was found that, although the H x T values obtained by means of the mechanical method were correlated with yarn irregularity, these values were critically dependent upon the tension under which the fabric was mounted. Pressing the fabric, as well as fabric stitch length, also influenced the relationship between the H x T values and the yarn irregularity. The correlation between the H x T values and yarn irregularity was improved if the irregularity of the yarn actually knitted was used instead of the average irregularity of the batch as a whole. The H x T values were found to be better correlated with the subjective ranking obtained by viewing the fabrics with reflected light than with that obtained by viewing the fabrics by means of transmitted light.

The subjective ranking obtained using reflected light, as well as that obtained using transmitted light, were found to be related to the yarn irregularity but the relationship was affected by the fabric stitch length. It appeared as if the subjective ranking employing transmitted light was perhaps less dependent upon the stitch length than that obtained when employing reflected light. There was a relationship between the subjective ranking, using the two different viewing conditions, but this was once again affected by the fabric stitch length. The slacker (looser) fabrics were generally ranked as being more even than the more tightly knitted fabrics, with the effect of stitch length more marked when the fabrics were ranked by means of reflected light.

The SD values obtained by means of the photodensitometer were found to be correlated with yarn irregularity but once again the relationship was greatly affected by the fabric stitch length. This also applied to the relationship between the SD values and the subjective ranking scores.

At any particular stitch length the H x T values were correlated with the SD values.

In conclusion it can be stated that the mechanical method appears to be too dependent upon factors other than yarn irregularity, such as the tension imposed upon the fabric during the test, the state of the fabric (for instance whether pressed or steamed) and stitch length, for it to be used as a practical method of obtaining a measure of the unevenness (puckering or surface distortion) of knitted fabrics. Furthermore, it would not be suitable for a balanced knitted structure such as double jersey fabrics, for instance. The optical method appears to be the more promising one and work is to continue in this direction.

ACKNOWLEDGEMENTS

The authors are indebted to the University of Port Elizabeth for the use of the photodensitometer, to Dr. I. W. Kelly for valuable suggestions and to the Department of Statistics at SAWTRI for the analysis of the data. Permission by the S.A. Wool Board to publish these results is also gratefully acknowledged.

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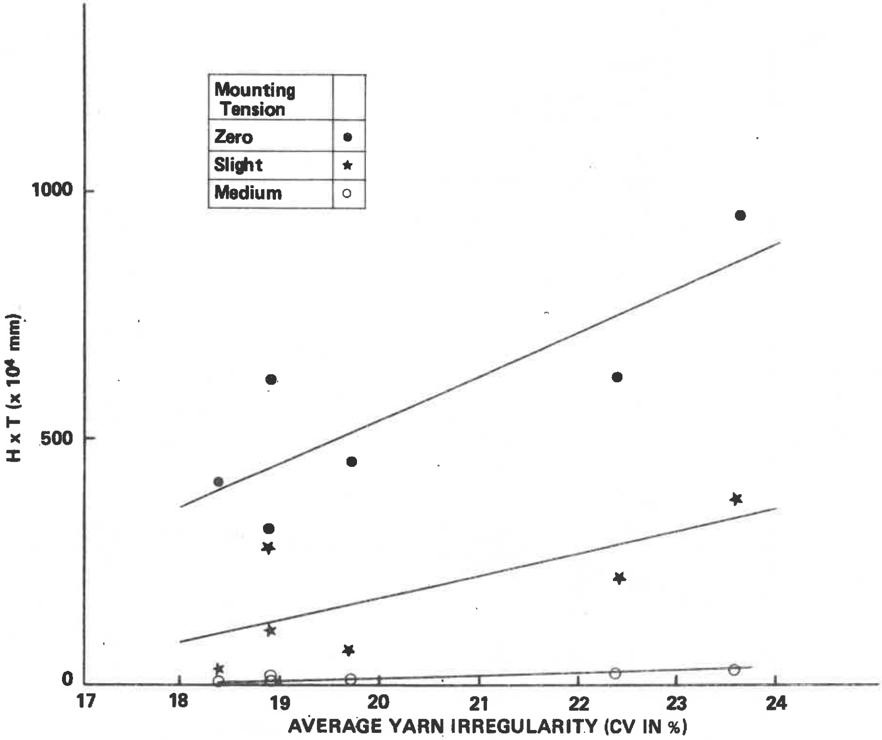

FIGURE 1

The dependence of H x T on yarn irregularity and mounting tension (dry-relaxed fabrics, stitch length = 3,5 mm)

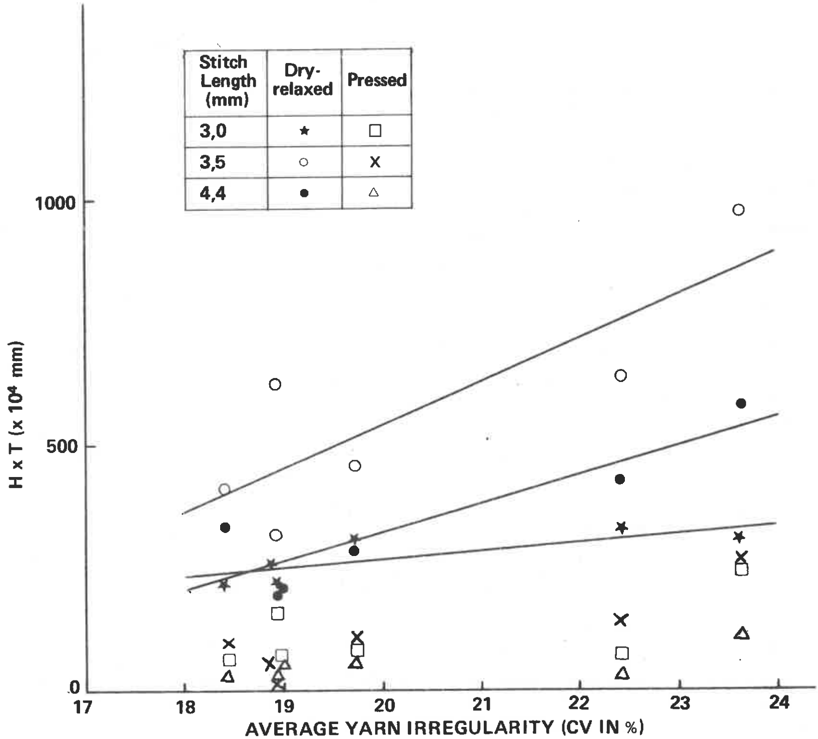

FIGURE 2

The dependence of H x T on yarn irregularity and stitch length (zero mounting tension)

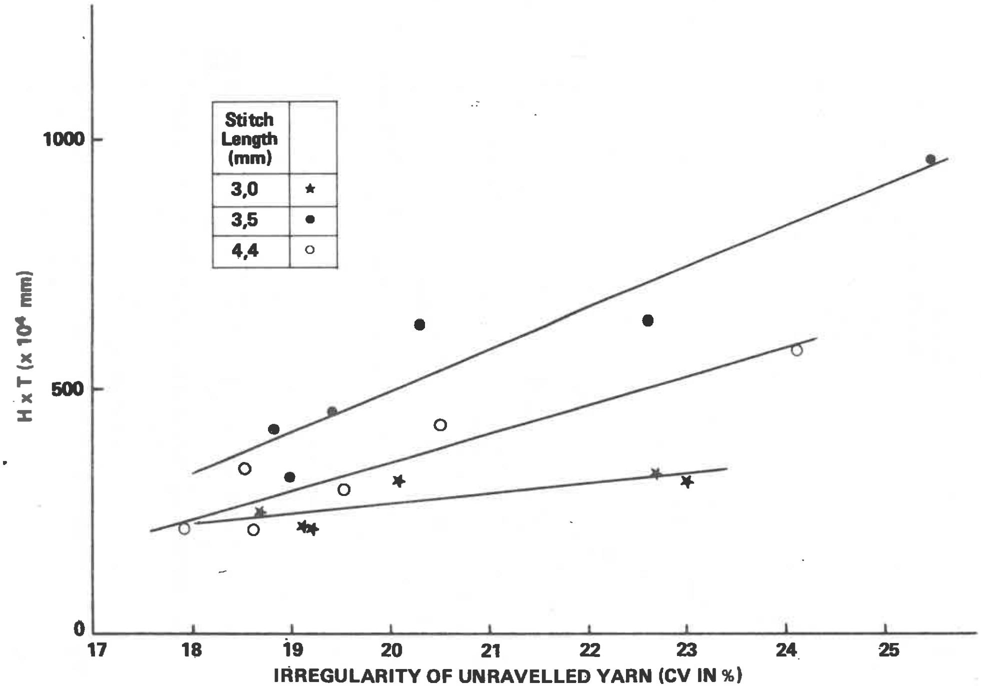

FIGURE 3

The dependence of H x T on the irregularity of the unravelled yarn and stitch length (dry-relaxed fabrics and zero mounting tension)

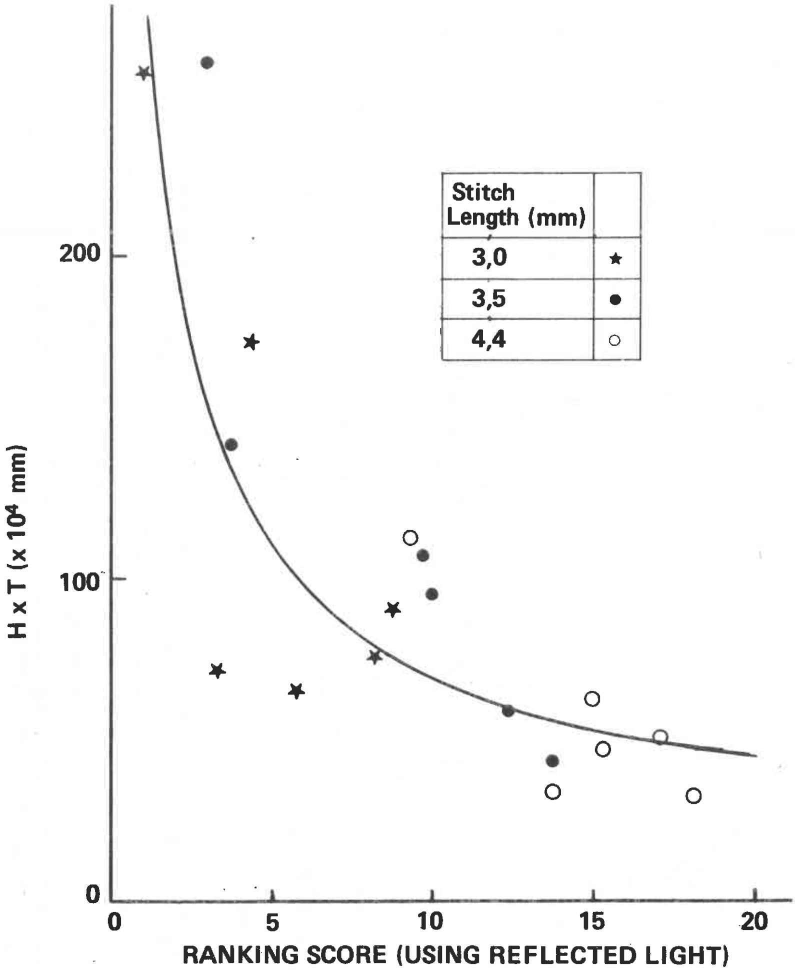

FIGURE 4

H x T values vs subjective ranking scores obtained when using reflected light (pressed fabrics)

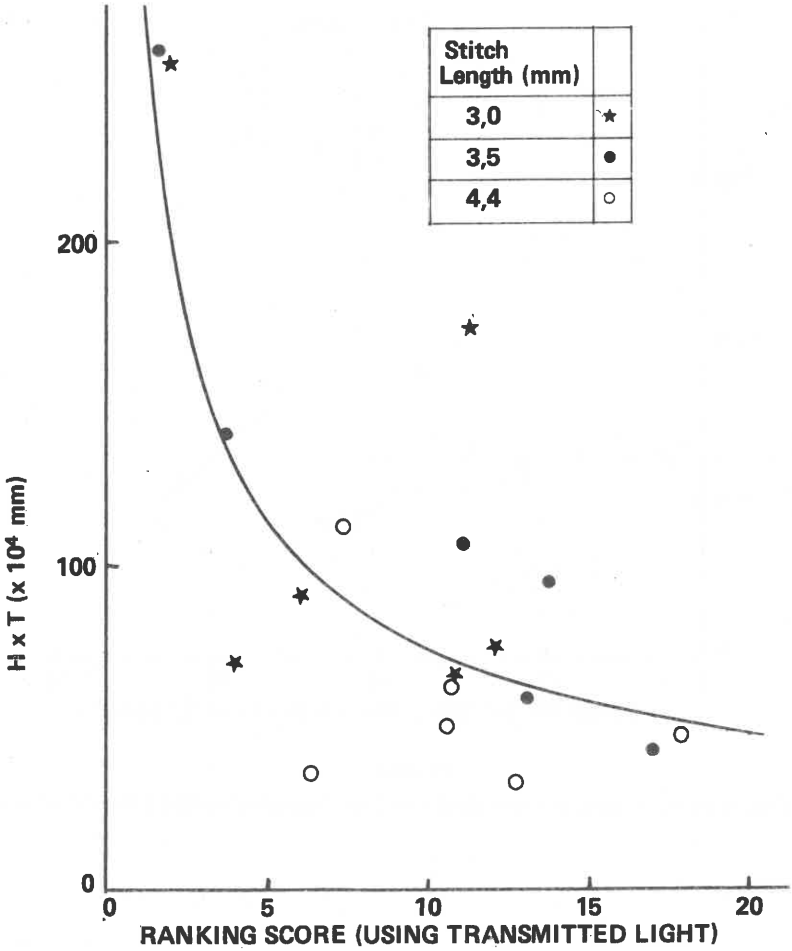

FIGURE 5

H x T values vs subjective ranking scores obtained when using transmitted light (pressed fabrics)

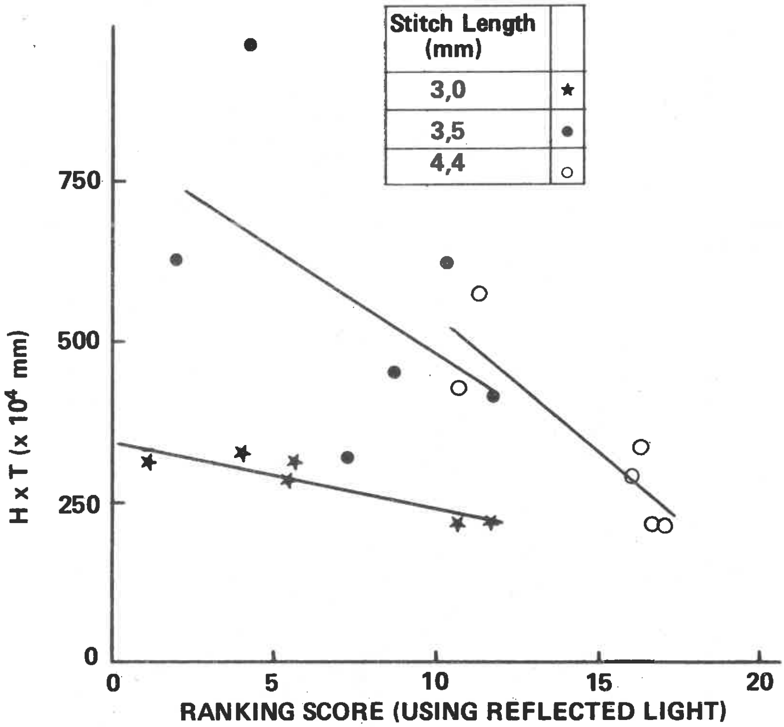

FIGURE 6

H x T values vs subjective ranking scores obtained when using reflected light (dry-relaxed fabrics)

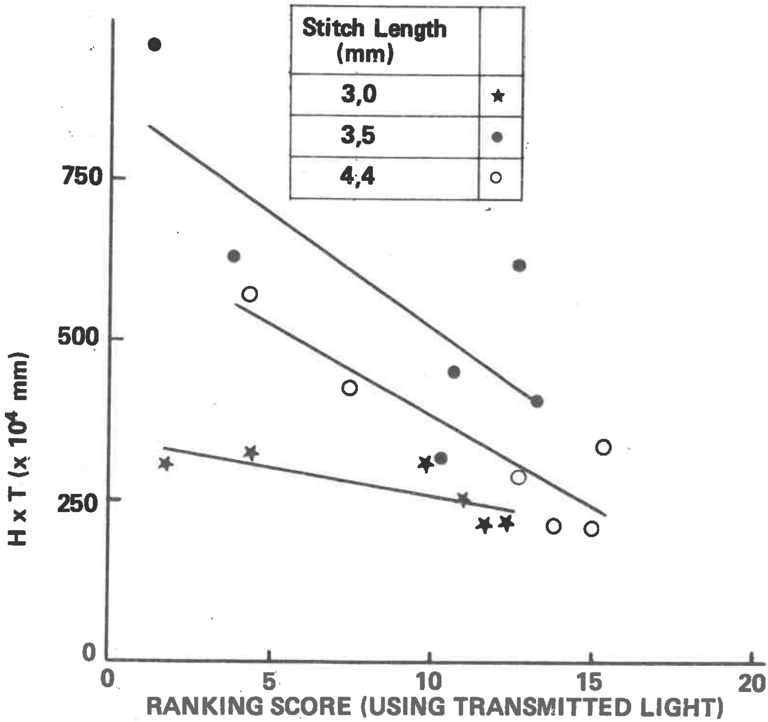

FIGURE 7

H x T values vs subjective ranking scores obtained when using transmitted light (dry-relaxed fabrics)

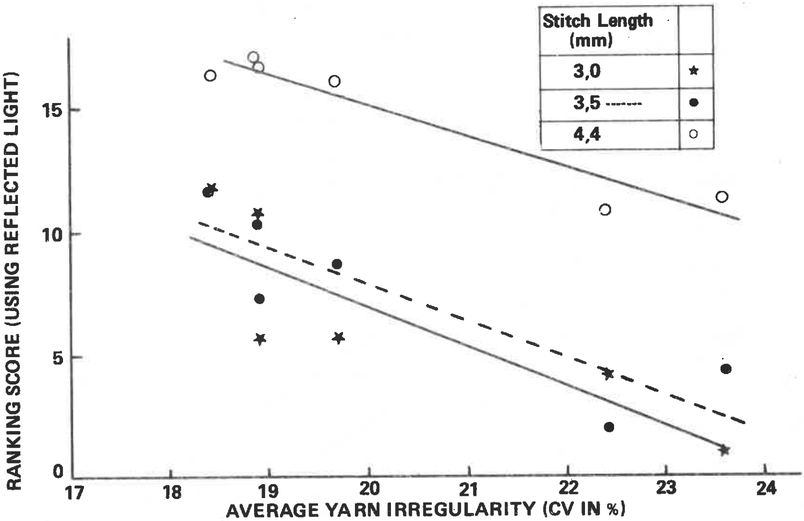

FIGURE 8

Subjective ranking score of dry-relaxed fabrics vs average yarn irregularity (reflected light used)

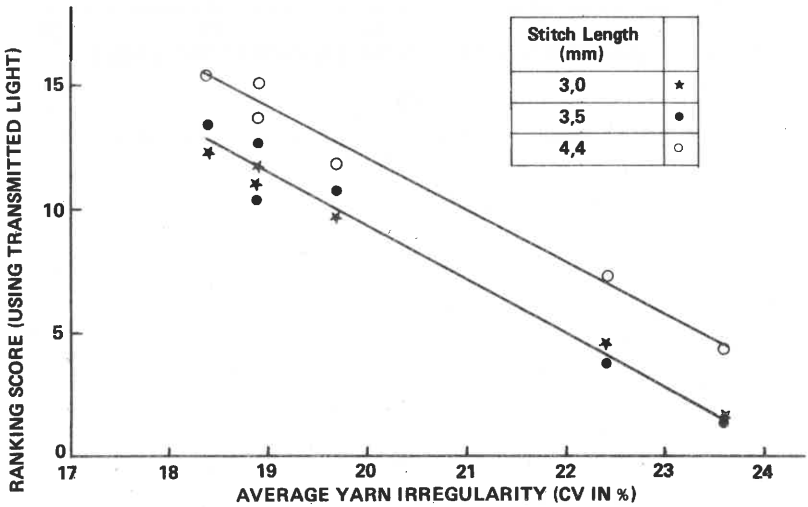

FIGURE 9

Subjective ranking score of dry-relaxed fabrics vs average yarn irregularity (transmitted light used)

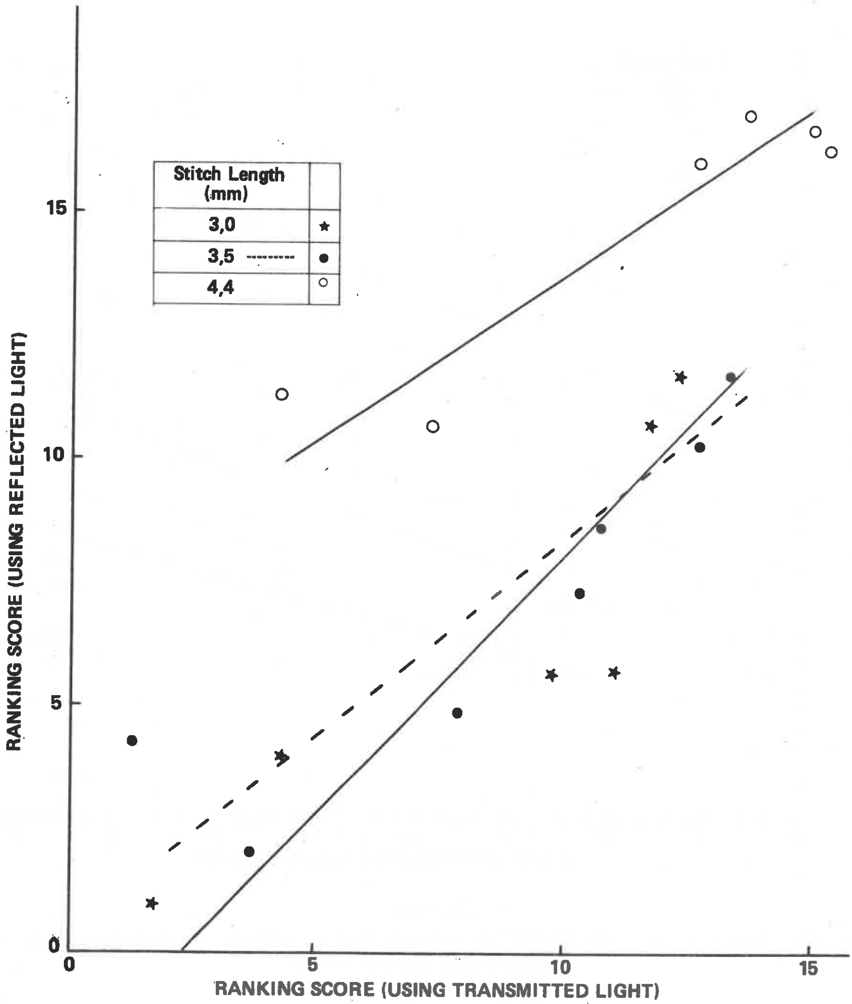

FIGURE 10

Subjective ranking scores obtained when using reflected light vs those obtained when using transmitted light (dry-relaxed fabrics)

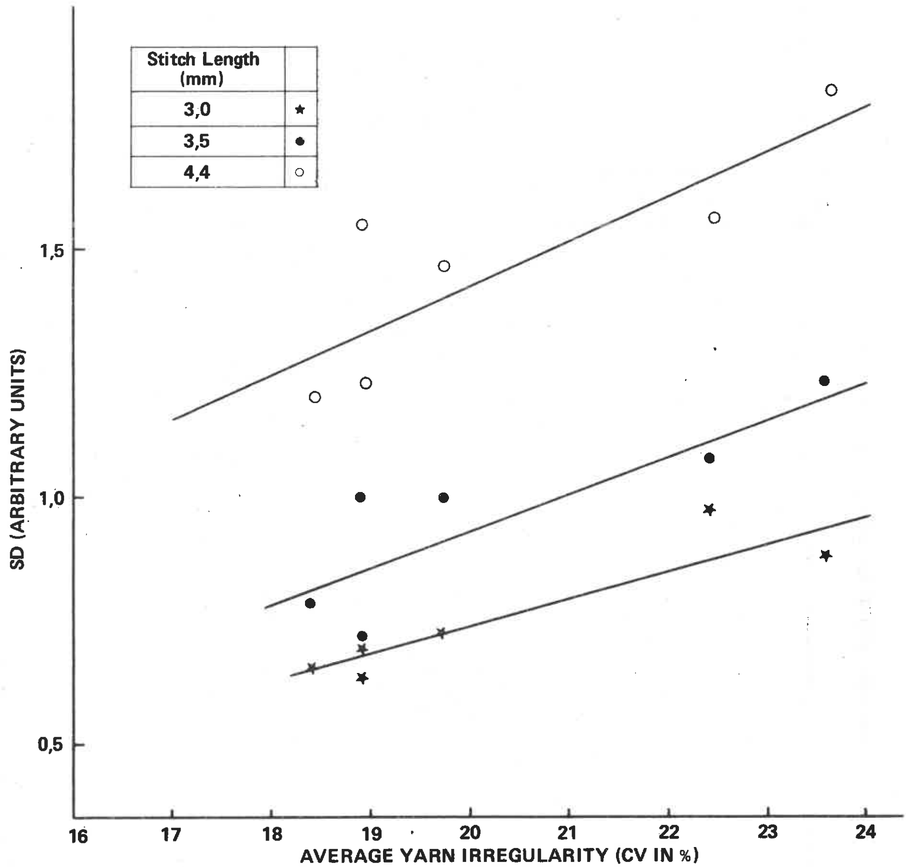

FIGURE 11

The dependence of the SD of the photodensitometer readings on yarn irregularity and stitch length (pressed fabrics)

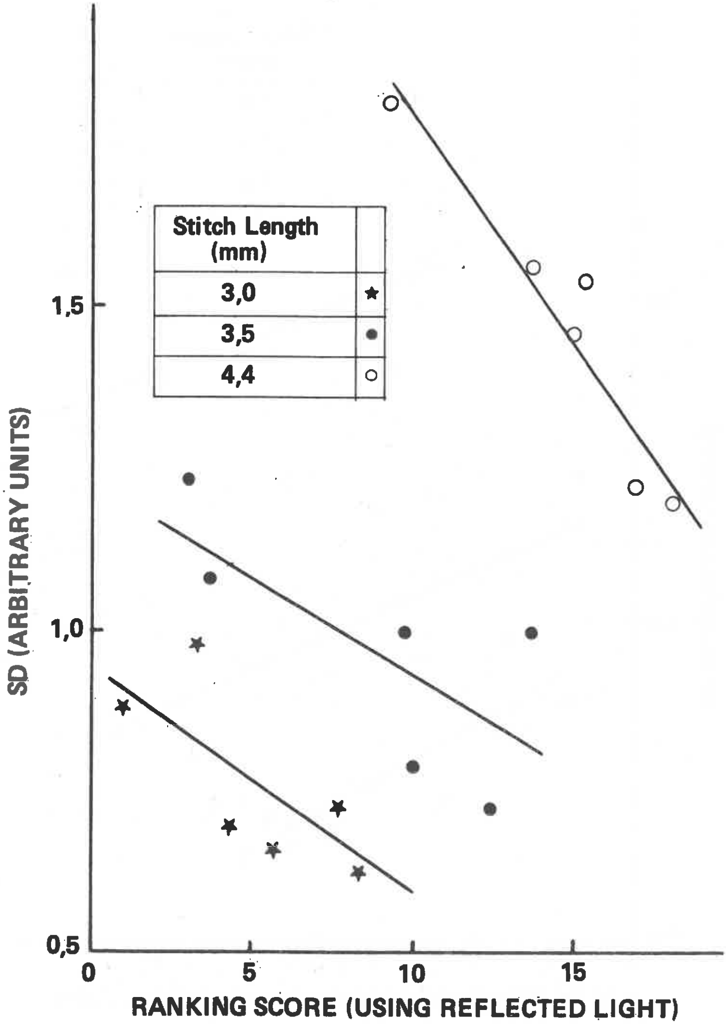

FIGURE 12

SD of the photodensitometer readings vs subjective ranking scores obtained when using reflected light (pressed fabrics)

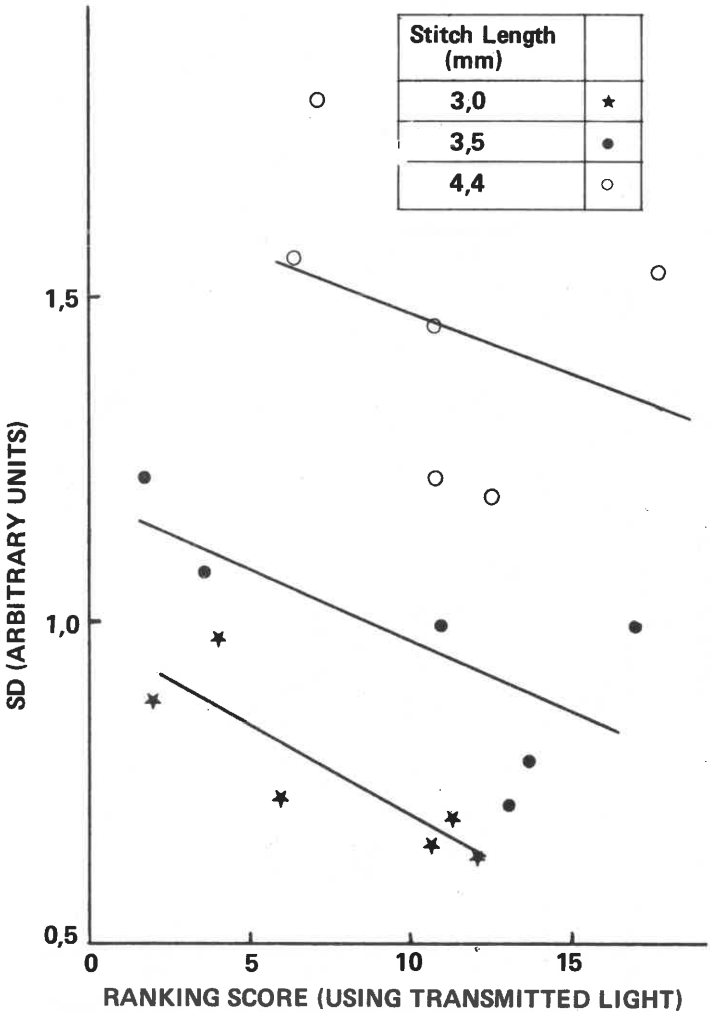

FIGURE 13

SD of the photodensitometer readings vs the subjective ranking scores obtained when using transmitted light (pressed fabrics)

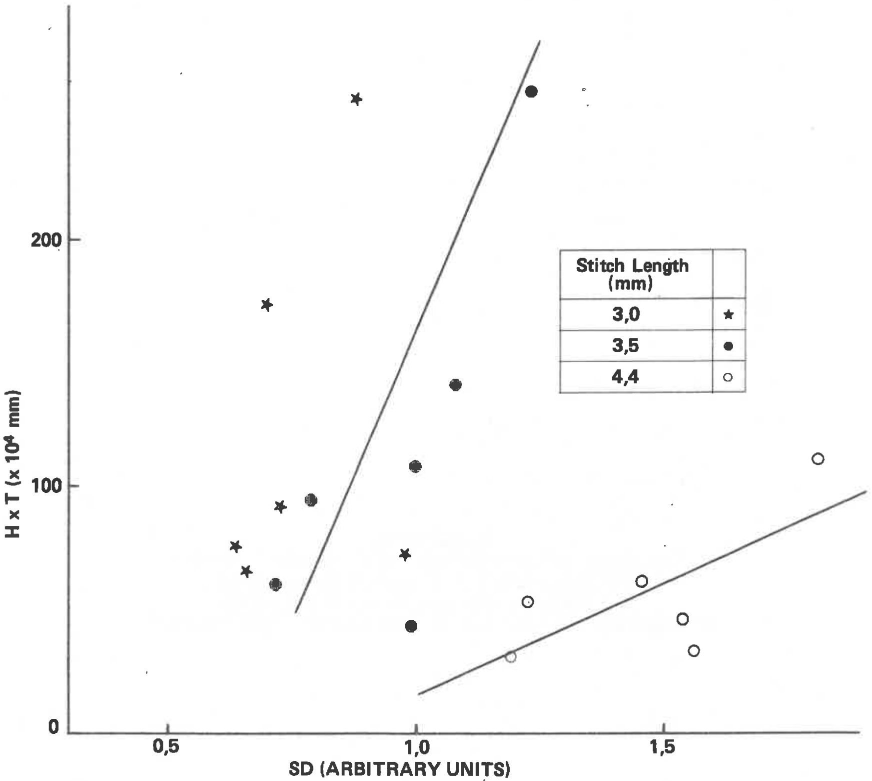

FIGURE 14

The relationship between the H x T and SD values for different stitch lengths (pressed fabrics)

Published by
The South African Wool and Textile Research Institute
P.O. Box 1124, Port Elizabeth, South Africa,
and printed in the Republic of South Africa
by Nasionale Koerante Beperk, P.O. Box 525, Port Elizabeth

ISBN 0 7988 0405 X