International Institute for Cotton

Technical Research Division

Manchester

Research Record No. 86

Treatment Of Cotton Knitgoods On The Omez Tubular Mercerising Machine

Peter F. Greenwood

July 1978

Key Words: Knitgoods Finishing, Knitgoods Mercerising, Single Jersey, Interlock, Rib, Omez, Tosi, Relaxed Structure, Bursting Strength, Spirality, 24G Study, Dyeing/Colour Yield.

Digital Version: April 2009

spreadsheet is *RR86.xls*

CONTENTS

Introduction

Earlier full-scale knitgoods mercerising trials have been carried out either on modified woven fabric equipment (Gillet Thaon) or on machines designed only for open-width handling (Benninger, Kleinewefers).

The trial with Gillet Thaon showed that processing circular knit fabric through a chainless merceriser in the flat-tube form results in permanent creasing, which is undesirable and often unacceptable for making-up. Open-width mercerising, on the other hand, is probably satisfactory as a pretreatment for printing, but leads to problems of creasing and unlevel dyeing if the goods are subsequently winch dyed (although dyeing on jet machines is reported to present little difficulty).

The Omez merceriser is one of the first of a new generation of machines designed specifically for the mercerisation of tubular knitgoods. This report describes trials carried out on the Omez machine in June 1977.

The Omez Knitgoods Merceriser "Mercelux"

The machine used for the trials is installed in the finishing works of Tintoria Giuseppe Tosi in Busto Arsizio, near Milan. This was the first Omez merceriser to be built. Photographs and a diagram of the machine as it was at the time of the trials are shown in *Figures 1-10*; some modifications have since been made.

The machine consists of three main sections; impregnation, delay and washing. The approximate fabric path lengths in each section are:

impregnation	10 metres
delay	13.75 metres
wash	3.75 metres

The washing section consists of a tower through which the fabric is transported vertically downwards while being sprayed with hot water. Following the tower, there is a final water spray. About 50% of wash-water is recirculated from the bottom of the tower, together with fresh hot water.

There are four main drive points for conveying the fabric through the machine. These are nips located

(1) immediately after the impregnation section,

(2) at the top of the washing tower,

(3) at the bottom of the tower, and

(4) following the final spray wash.

Nips (1), (2) and (4) are preceded by ring expanders to open out any creases in the fabric. Over the entire distance between nips (2) and (3), during the early stages of washing, the fabric is held on a frame, the width of which is adjustable from outside, while the machine is running.

Fabrics

Ten different fabrics were included in the trial; one from our Knitting Development Department and nine from interested commercial organisations in the UK.

IIC Fabric.

The IIC fabric was a 24 gauge single-jersey, Ref. CK 191, knitted on a 1920 needle 30" diameter Monarch XL-JS machine, using Ne 24/1 combed cotton yarn supplied by Carrington Viyella.

Technical information and laboratory test results for the yarn are given below.

Evaluation of Yarn for 24g Single Jersey

Yarn Count	Ne 23.6 (25.2 tex)
Twist	17.6 t/inch (693 t/m)
Twist Factor	3.7
Breaking Load	365 g (14.5 g/tex)
Extension at break	7.80%
Coeff. of friction	0.14

Information supplied by spinner

Average Micronaire	4.0
Effective Fibre length	40/32 inch
Combing waste	18%
Twist factor	3.6

The stitch length of the grey knitted fabric was measured, and found to be 0.331 cm. With the measured yarn count being Ne 23.6 (25.2 tex), the tightness factor of the grey fabric was found to be 15.11.

Six pieces were knitted for the mercerisation trials, together with lengths of control fabric. It was hoped to process each piece under different conditions, particularly looking at the width at which the cloth is held in the washing tower.

Commercial Fabrics.

These were provided by five UK companies: Pasolds, Meridian, Tootal (Strines Printworks), Saxbys and Stevensons. They included 20 gauge interlock and 14 gauge 1x1 rib, each from three manufacturers, together with single-jersey (20 gauge), cross-tuck and fleece fabrics.

The Mercerising Treatment

The fabrics were arranged for processing in decreasing order of tubular width. (This was a guess which turned out to be wrong; the machine operator preferred to handle narrower fabrics first). The IIC fabric, being the widest, was first through the machine.

The following observations were made during the run.

Caustic concentration	27 °Bé (20.8 %)
Wetting agent (Mercerol PL, Sandoz)	10 cc/litre
Caustic temperature	22-24 °C
Wash water temperature	75 °C
Final mangle expression	136 - 138 %
Caustic content of washed fabric	14 - 16 °Bé (9.6 - 11.2 %)
Fabric speed at entry	30 m/min
Fabric speed at exit	33 m/min

Using the machine dimensions given earlier, dwell times may be calculated.

impregnation	20 sec
delay	27.5 sec
wash tower & spray	7.5 sec

Processing proceeded smoothly without any mechanical problems. The main points requiring attention were, of course, the stretcher widths - particularly the setting of the large frame in the wash tower. These were decided by inspection by the Tosi operator during the run.

With six pieces of the IIC fabric in the trial, it had been hoped that six settings of the stretcher frame could have been investigated. This plan proved to be difficult to explain to the machine operator, who was eventually persuaded, with some reluctance, to make two width changes during this part of the run.

Thus, piece No. 1 and part of piece 2 were processed at 60.0cm, the remainder of piece 2, pieces 3 and 4 and part of piece 5 at 62.8cm, and the remainder of piece 5 together with piece 6 at 65.0cm.

Most of the tower stretcher settings appear in the tables at the end of the report (unfortunately the interlock fabrics were processed during the lunch break, and the relevant details were not recorded). Subsequent examination of the *Figures* seems to indicate that the stretcher setting is about 80-85% of the unmercerised fully-relaxed width.

Editor's note: Actually, the stretcher settings for the commercial fabrics were not found in the tables (or anywhere else).

After processing on the merceriser, the wet fabric was plaited into trucks, covered with plastic film to avoid drying out, and transported to an Omez continuous washer for final washing and neutralisation with acetic acid. It was then dried on an Alea continuous drier, and calendered.

Post Treatments

Following mercerisation, the commercial fabrics were returned to their respective owners for finishing. One company (Meridian) returned samples of the fully finished fabric for our evaluation.

The IIC 24 gauge single jersey fabrics were sampled for testing, and subsequently two pieces were sent out for commercial after-treatments, one for dyeing and resin finishing at Sketchleys, the other for printing and resin finishing at Strines, in each case together with lengths of unmercerised control fabric.

Finishing at Sketchleys.

The fabrics ware separately scour-dyed in a small winch at a liquor ratio of 20:1, with -

Croscour 11 (Crosfield)	0.5 g/l
Common salt	80 g/l
Soda ash	20 g/l
Levafix Black E-B (Bayer)	
Levafix Brilliant Red E-4BA (Bayer)	

The dyeings were matched to a standard dark blue. It was found that the mercerised fabric required substantially less dyestuff to achieve the match.

Quantities required (% o.w.f.):-

	Unmercerised	**Mercerised**
Black E-B	3.25	1.9
Br, Red E-4BA	0.4	0.2

After dyeing, part of each piece was slit and resin-finished at open-width; stenter-cured using the following recipe.

Fixapret CPU (BASF)	70 g/l
Perapret PE 40 (BASF)	30 g/l
Magnesium chloride / ammonium chloride 10:1	7 g/l
DC 1111 silicone (Dow Corning)	30 g/l
Silicone crosslinker (Dow Corning)	7.5 g/l
Catalyst 2298 (Dow Corning)	1.5 g/l

The remaining part of each piece was given a treatment with softener on the winch, and dried in tubular form.

Finishing at Strines.

After a preparation treatment on a winch, the fabric was dried, slit into open-width and printed by flat screen.

Resin finishing was carried out by flash cure (60 seconds at 180°C) using the following recipe.

Fixapret CPA (BASF)	80 g/l
Siligen ECI (BASF)	20 g/l
Magnesium chloride solution	16 g/l

Evaluation Of The Mercerised Fabrics

Prior to testing, all fabric samples were subjected to a wet-relaxation treatment consisting of five machine wash (60 °C) and tumble dry cycles. During this relaxation treatment the fabric shrinkages in length and width over the five cycles were measured, and measurements on the relaxed fabrics included weight, courses and wales per centimetre, stitch length, spirality angle and bursting strength. An evaluation of uniformity of dyeing was also carried out.

IIC Fabric.

Fabric Stability

Fabric shrinkages found for the IIC single jersey in the relaxation treatment are given in *Table 1*. The conclusions which can be drawn are, of course, clouded by the possible effects of the post-mercerisation washing, drying and calendering processes, but there is an indication that the narrowest stretcher width - and therefore lowest tension - has resulted in better stability, (which vindicates the intransigence of the Tosi machine operator!).

Effects of Mercerising on Relaxed Fabric Structure

One of the objectives of this work was to try to evaluate the importance of fabric tension during mercerising in controlling the relaxed structure of the finished fabric. As the lengthwise extension of the fabric was held nominally constant during processing, by the fixed speeds of the various mangles, it was attempted to introduce tension variations by altering the stretcher width in the wash tower. For reasons already given, only three stretcher widths were examined.

Test results on the fabrics after relaxation are given in *Table 2*. In examining the effects of stretcher widths, the results for pieces 2 and 5 have been ignored, as changes took place during the processing of these pieces which make the conditions applied to the tested length somewhat uncertain. Pieces 3 and 4 were processed under identical conditions and the results for these were averaged.

Stitch Length and Yarn Shrinkage

From the stitch length measurements, it was possible to deduce that yarn shrinkage for the control fabric in the relaxation treatment was 1.2%, and the average yarn shrinkage attributable to mercerising was 5.3%. Although there was some variation in the stitch lengths of the mercerised fabrics, this could not be related to the stretcher width.

Course and Wale Spacings and Relaxed Width

There are indications that the course and wale spacings in the relaxed fabrics might be influenced by the stretcher width setting. The trends seem to show that, as stretcher width was increased, the fabric was induced to become tighter in the wale direction and more open in course spacing. Thus the Course to Wale ratio was quite markedly reduced by increasing the stretcher width and the width of the relaxed fabric was also reduced. These trends are shown graphically in *Figures 11, 12 & 13*.

This last result, which seems to be somewhat of a paradox, can be explained by considering the fabric tension at the stretcher. Lengthwise extension is fixed by the mangle speeds which remained constant throughout the trial. Increasing the stretcher width, therefore, effectively increased fabric tension, and this was not compensated by a reduction in fabric length. Hence the fabric suffered a considerable degree of distortion, and the change in Course-to-Wale ratio shows that some at least of this distortion has remained, set into the fabric structure.

Tightness Factor and "*K*" values

For the purposes of calculating tightness factors, the yarn counts of the mercerised fabrics were calculated for the initial yarn count of 25.2 tex and the measured changes in stitch length. As this was originally unscoured yarn, there is an error in this approach resulting from the loss of material in the mercerising process. However, it is considered that the error would be small and can be ignored.

From the figures given in *Table 2*, the mercerising treatment can be seen to have produced a reduction in stitch length and an increase in yarn linear density, which together have resulted in an increase in tightness factor from 15.4 (unmercerised) to 16.6 - 17.0 after treatment.

Tightness factor was not found to vary with stretcher width; not surprisingly, as no link between stretcher width and stitch length had earlier been found.

In the published literature on relaxation of single jersey fabric, some importance has been attached to certain parameters known simply as "*K*"-values; *Kc*, the product courses per centimetre times stitch length, and *Kw*, similarly calculated from the wale spacing. At one time they were thought to be constants, but it is now believed that they vary, in a more or less linear fashion with tightness factors. It is not appropriate to go into detail here, but a recent study of this subject is described by Knapton *et al* in *J. Text. Inst. 1975, 66, 413*.

To study the effect of the mercerising treatment on *K*-values, it was first necessary to establish the behaviour of unmercerised fabric. Rather than to rely on the published data in the literature, which is at best unreliable and at worst conflicting, it was decided to take some results from our own records (*Research Record No. 64*) on 24 gauge single jersey fabrics which had received a similar relaxation treatment. Some of these results are given in the *Appendix*.

Figure 14 shows the variations in *Kc* and *Kw* with tightness factor for those unmercerised single jersey fabrics. Mean values were *Kc* = 5.83 and *Kw* = 4.33 which agree fairly well with Knapton's findings although *Kw* is seen here to vary inversely with tightness factor. Knapton considered *Kw* to be independent of all variables.

The control fabric for the present trial fits fairly well within the variations shown, and the trends induced by mercerisation are clearly indicated. Mean values for the mercerised fabrics are *Kc* = 5.33 and *Kw* = 4.54; the former being much lower, and the latter somewhat higher than would be expected on unmercerised fabric with a similar tightness factor.

The ratio *Kc/Kw* has also received some attention in the literature, as it might be said to indicate the shape of the relaxed loop. Numerically, this is identical to the course to wale ratio already referred to, but in this section it is convenient to describe it as *Kc/Kw*. In *Figure 15* this is plotted against tightness factor, including the data of RR 64 from the *Appendix*.

Although the trend shown by the results on unmercerised fabric is for *Kc/Kw* to vary directly with tightness factor, nevertheless in spite of the tightness factor increase resulting from mercerising, the effect of the treatment is markedly to reduce the *Kc/Kw* ratio, suggesting that a permanent distortion of the knitted loop has taken place. Study of the results shown in *Figure 15* shows that the magnitude of this distortion has increased with increasing stretcher width, and therefore with increasing tension in the early stages of washing off.

Fabric Weight and Bursting Strength

Reference to *Table 2* shows that the bursting strength of the relaxed fabric has increased by an average of about 14 % as a result of mercerisation. However, the structure of the fabric has also been altered and the weight per unit area has increased by about 5½%. To examine the possibility that the structural changes might alone account for the strength improvements, reference was again made to the 24 gauge study results given in the *Appendix*.

The relationship between bursting strength and relaxed weight for these fabrics is shown in *Figure 16*. Results for the Omez control and mercerised fabrics are also shown. Although the Omez control is stronger than the mean 24 gauge study line, it comes within the scatter, and in any event was produced from a slightly stronger yarn (14.5 g/tex), compared with an average tenacity of 12.2 g/tex for the yarns used in the 24 gauge study of RR 64.

The graph indicates that, after taking into account the weight change resulting from the mercerisation treatment, the fabrics have increased in strength by about 7½%, but the evidence is far from conclusive.

Incidentally, in the course of testing some of the fabric finished at Sketchleys, some strength tests were carried out on yarns taken from the dyed material. The results were as follows.

unmercerised	290 g	(11.5 g/tex)
mercerised	348 g	(13.1 g/tex)

indicating a slight increase in yarn tenacity as a result of mercerisation, which would also be expected to contribute to any increase in fabric bursting strength.

Spirality and Fabric Length.

Although spirality is well-known in single jersey manufacture, especially if singles yarns are used, a reliable definition of the effects has not been established. For the purpose of this study, the angle of spirality is defined as the angle between the line of courses and the normal to the line of wales. Measurements of this angle, after relaxation, on a selection of samples taken at various stages of processing, are given in *Table 3*.

In order to establish the effect, if any, which mercerising would have on spirality, it was first necessary to calculate the change to be expected simply due to the altered fabric structure.

Without going into details here, from geometrical considerations alone it can be calculated that, for any process in which courses per cm, wales per cm, and spirality angle of the relaxed structure are altered from an initial state of C_1, W_1 and α_1 respectively to C_2, W_2 and α_2 these values should be related by the following equation.

$$\sin \alpha_2 = C_2/C_1 \;.\; W_1/W_2 \;.\; \sin \alpha_1$$

Thus, taking the results given in *Tables 2 & 3* for the control and mercerised fabrics, we have:

$$\sin \alpha_{merc} = 17.2/18.4 \;.\; 13.0/14.8 \;.\; \sin(18.1)$$

$$= 0.255$$

This gives a calculated value for the angle of spirality in the mercerised fabric of 14.8°.

As *Table 3* shows, the measured value for the mercerised fabric was 11.6°, suggesting that mercerisation may have had some effect in reducing the angle of spirality, although the magnitude of this effect is hardly large enough to result in a significant improvement; and recent evidence (*Research Record 82*) has indicated that spirality decreases as the tightness factor increases, so that the rise in tightness factor resulting from mercerisation may in itself be sufficient to explain any improvement in spirality.

Changes in spirality affect fabric shrinkage. A twisted tube which becomes less twisted also becomes longer. If it is assumed that courses remain parallel to fabric width, it can be shown that length shrinkage is dependent on two factors; the change in course spacing and the change in the cosine of the angle of spirality. In the present instance, the changes noted in these two factors indicated that the fabric has extended as a direct result of mercerising, by about 3.8 %.

Summary

A summary of the main effects observed in the comparison between mercerised and unmercerised 24 gauge single jersey fabric is given in *Table 6*.

Dyeing Properties.

It is well-known that mercerised fabric responds more favourably to dyeing processes, giving deeper shades than on the same fabric unmercerised; but of course, in order to take advantage of this effect, it must be ensured that the response is uniform and reproducible.

The trial at Sketchleys in which a full piece (No. 3) of the mercerised single jersey fabric was winch-dyed to a uniform shade, showed that uniformity of dyeing is possible provided that no changes in mercerising conditions are made. However during the mercerising of the 24 gauge single jersey, two changes were made in the stretcher width, causing tension variations. From various measurements already described, these have been shown to have affected the fabric structure; it was considered that dyeing properties might also have been influenced.

In order to examine this possibility, a series of cuttings from the mercerised fabric, together with an unmercerised control, were given a light scour and peroxide bleach, and dyed separately under identical conditions in an Ahiba laboratory dyeing machine with 4% (on weight of fabric) Procion Blue H-E6R (ICI) - a dyestuff which is known from earlier work (*Textile Institute and Industry 1976, 14, 373*) to respond strongly to mercerisation.

Measurements of the tristimulus values, *X*, *Y* and *Z* on the dyed samples and on corresponding undyed, bleached control samples were made using a Harrison Colorimeter, and the results are shown in *Table 4*. Colour differences δE were calculated according to the CIELAB formulae (*JSDC 1976*, 92, *337*). Values of δE for each mercerised sample, compared with the dyed, unmercerised, fabric are also given in this table.

The colour difference δE between the two extremes No. 1 and No. 6 of the mercerised samples was calculated and found to be 1.65 CIELAB units, which is perceptible but probably not unacceptable in most cases. Curiously, the fabric processed under lowest tension conditions appears to have dyed slightly less deeply than the others; this rather goes against the accepted behaviour of mercerised yarns and woven fabrics.

Much more work, of course, needs to be carried out on this important subject, and some of this mercerised fabric, together with control, is at present being evaluated by Bayer (UK) at their Altrincham laboratories. A report covering this work will be produced later.

Commercial Fabrics.

Table 5 compares the test results found on the fabrics supplied by the commercial co-operators. As three examples each of 20 gauge interlock and 14 gauge 1x1 rib are included in this group, some fairly superficial calculations were made which are included in *Table 6*.

However, until we know more about the relationships between weight, tightness factor and strength of these constructions, it is premature to comment.

Evaluation Of Post Treatments

Two pieces of the 24 gauge single jersey fabric were subjected to commercial finishing treatments (as described earlier). The test results for these fabrics are shown in *Table 7*.

It is perhaps unwise to make any firm conclusions on the basis of this very small number of experiments, particularly in view of the variation in the standard of finishing as shown in the degree of resin fixation (*Table 8*). However, it can be said fairly confidently that the crosslinking treatments have stabilised the fabric structure in a more open, lighter-weight configuration. They appear to have affected the course spacing, and hence improved the length stability, rather more than the wale spacing, width or width stability. The cross-linking treatment may have stabilised the unmercerised fabric slightly more effectively than the mercerised fabric, but there is very little in it.

In a superficial examination, bursting strength retention after crosslinking appears to be much better on the mercerised fabric than on the unmercerised. In fact it is better, but when the change in relaxed fabric weight per unit area is taken into account, the improvement is not quite so remarkable. (*Figure 17*).

Two rather unexpected results, unconnected directly with the mercerising process, are revealed by these figures. First is the large difference in the fully relaxed structures, particularly in the course spacings, of the grey and dyed fabrics. This has been noted before (*Research Record 82*) and clearly requires further investigation. The corresponding difference between the mercerised, and the mercerised-and-dyed, fabrics is much less marked.

The second rather surprising feature of these results is the apparent reason for the loss in bursting strength after crosslinking. From *Figure 17* it can be seen that the main cause is not embrittlement, or chemical damage, but the reduction in fabric weight. Again, a more detailed study is indicated.

In visual assessment of the finished fabrics, and also the fabrics processed at Meridian following mercerisation, it was generally agreed that the improvements in brightness and lustre resulting from the process added considerably to the attractiveness of the fabrics. Special attention was paid to the question of permanent creasing and no sign of this effect could be seen; although a curious dark lengthwise stripe could be seen in the fabric dyed and resin treated at Sketchleys, when viewed through the fabric. No corresponding mark could be seen in the fabric (from the same dyed piece) which had not been slit and resin finished. The fault was not detectable in wale spacing measurements or in colorimetric tests, and its cause remains a mystery.

Conclusions

This study has first of all shown that tubular knitgoods mercerising is a commercial proposition on the Omez machine. No serious deficiencies were found in the machine or in its operation, and a wide range of fabrics of reasonable commercial quality were obtained.

Having said this, it must be remarked that the efficiency of washing off in the tower is slightly suspect. The rather high level of residual caustic found in the fabric following the tower wash-off raises doubts about the degree of stabilisation achieved at this point. In the Mark II machine, the tower design has been improved so that the fabric moves upwards against a counter-current water flow. This should result in a better washing action.

Improved lustre and dyeing properties were demonstrated, and although some variability in dye uptake may result due to tension variations, the limited work reported here has indicated that with reasonable care, this may not present any practical problems.

The study has also shown that mercerisation produces changes in the fully relaxed fabric structure, resulting in a reduction in course spacing and an increase in wale spacing, with consequent increases in fabric length and reductions in fabric width. These effects may be controllable to a limited degree by the fabric tension during the mercerisation process and, if the principles underlying this effect can be examined and understood more fully, we may have an exciting new tool by which the finisher can control and modify knitted fabric properties to a degree which he is at present unable to achieve.

A further range of possibilities is added by a subsequent crosslinking. Mercerised and crosslinked fabrics have been shown to have better strength properties than fabrics which have only been crosslinked. Again, work needs to be done in order to establish principles, but the introduction of piece-mercerising into knitgoods finishing could well pave the way for a wider use of crosslinking treatments as well, with consequent improvements in the standards of stability and easy-care characteristics demanded by good quality outerwear.

Table 1: Stretcher-frame Width and Relaxation Shrinkage

Piece No.	Stretcher Width		Shrinkage, 5W&TD	
	Start cm	End cm	Len. %	Wid. %
Control (unmerc)	~	~	12.8	11.2
M-1	60.0	60.0	11.1	**-0.6**
M-2	60.0	62.8	14.8	4
M-3	62.8	62.8	18.6	2.9
M-4	62.8	62.8	16	3
M-5	62.8	65.0	17.5	3.1
M-6	65.0	65.0	16.8	3

Negative shrinkage indicates an Extension

Table 2: Fabric Evaluation

Fabric evaluation - 24 gauge Single Jersey (1920 needles)
Grey yarn tex (a) = 25.2; Stitch Length (b) = 0.330 cm

	Relaxed					Calculated, Relaxed					
Sample	**St. Len**	**Courses**	**Wales**	**Weight**	**Strength**	**Count**	**T.F.**	**Kc**	**Kw**	**Kc/Kw**	**Width**
	cm	/ cm	/ cm	gsm	KN / sqm	tex	K				tub.
	c	*d*	*e*			*f = a.b/c*	*sqrt(f)/c*	*d.c*	*e.c*	*d/e*	*960/e*
Control (unmerc)	0.327	18.4	13.0	190	610	25.4	15.4	6.02	4.25	1.42	73.8
Mercerised											
Piece 1	0.306	17.8	14.5	205	650	27.2	17.0	5.45	4.44	1.23	66.2
Piece 2	0.311	17.2	14.6	200	714	26.7	16.6	5.35	4.54	1.18	65.8
Piece 3	0.311	17.1	14.4	205	699	26.7	16.6	5.32	4.48	1.19	66.7
Piece 4	0.310	17.2	14.8	203	697	26.8	16.7	5.33	4.59	1.16	64.9
Piece 5	0.311	17.3	14.8	193	727	26.7	16.6	5.38	4.60	1.17	64.9
Piece 6	0.309	16.6	14.8	196	686	26.9	16.8	5.13	4.57	1.12	64.9

Table 3: Spirality

Fabric	**Relaxed Angle of Spirality** deg
Control (unmercerised	18.1
Mercerised (Piece No. 4)	11.6
Dyed	15.7
Mercerised & Dyed	12.0
Dyed & Resin-finished	17.45
Mercerised, Dyed & Resin-finished	10.2
Printed & resin-finished	15.5
Mercerised, Printed & resin-finished	4.95

Table 4: Evaluation of Laboratory Dyeings

Procion Blue H-E6R, 4% o.w.f. 20:1 Liquor Ratio

Sample	**Tristimulus Values**		
	X	**Y**	**Z**
Control (unmerc)	10.60	9.15	28.50
Mercerised:			
1	6.30	5.05	18.60
2	6.00	4.75	17.75
2*	6.20	4.90	18.15
5	6.20	4.90	18.25
6	6.00	4.70	17.40

CIELAB Colour Differences δE

	Control	**1**	**2**	**2***	**5**
1	9.74				
2	10.72	1.02			
2*	10.39	0.90	0.52		
5	10.38	0.89	0.57	0.2	
6	11.09	1.65	0.79	0.84	0.97

* other end

Table 5: Evaluation of Commercial Fabrics

Fabric & Supplier	Grey Yarn tex	Grey St. Len cm		Relaxed St. Len cm	Relaxed Courses /cm	Relaxed Wales /cm	Relaxed Weight gsm	Relaxed Strength KN/sqm
30" interlock	16.0	0.363	Control	0.363	14.4	15.6	237	706
Saxby			Merc.	0.338	12.8	15.9	231	824
28" interlock	15.5	0.333	Control	0.341	16.6	13.7	211	664
Pasold			Merc.	0.317	15.7	16.4	244	831
26" interlock	16.0	0.349	Control	0.345	16.4	14.3	228	638
Meridian			Merc.	0.323	14.4	17.0	240	842
30" 1x1 rib	19.7	0.289	Control	0.291	18.7	10.7	208	588
Meridian			Merc.	0.268	17.0	12.9	225	731
30" 1x1 rib	20.4	0.291	Control	0.290	18.7	11.1	205	601
Strines			Merc.	0.273	17.6	12.7	231	735
30" 1x1 rib	20.4	0.285	Control	0.288	18.3	11.1	211	602
Stevenson			Merc.	0.27	17.6	12.9	234	740
30", 20g s. jersey	25.7	0.308	Control	0.305	19.0	13.7	198	593
Pasold			Merc.	0.287	18.4	15.3	205	703
24" cross-tuck	31.1	0.343	Control	0.352	19.1	8.9	257	693
Meridian			Merc.	0.328	17.5	10.3	250	807
25" fleece	15.5	0.381	Control	0.399	15.9	10.4	439	612
Pasold			Merc.	0.377	14.4	12.2	469	711

Table 6: Summary of the Main Effects Shown by Mercerised Fabrics

	Percentage Change 24g s. jersey	Percentage Change 20g interlock	Percentage Change 14g 1x1 rib
Stitch Length	-5.3	-6.8	-5.2
Width	-11.1	-11.9	-19.0
Length	3.8	10.1	8.0
Weight/area	5.4	5.8	10.6
Tightness factor	8.5	11.1	10.9
Bursting strength	14.0	24.4	23.2

Table 7: Evaluation of Post-treatments

Process	Shrinkage % Length	Shrinkage % Width	St. Len. cm	Courses /cm	Relaxed Wales /cm	Weight gsm	Strength KN/sqm
Control (unmercerised)	12.8	11.2	0.327	18.4	13.0	190	610
Mercerised (Piece No. 4)	18.6	2.9	0.311	17.2	14.6	204	698
Dyed & softened	11.2	1.1	0.329	16.5	13.3	184	560
Mercerised, dyed & softened	15.3	**-4.9**	0.312	16.9	14.9	197	677
Dyed & resin-finished	10.0	2.7	0.318	15.0	13.9	161	344
Mercerised, dyed & resin-finished	12.6	3.9	0.303	15.1	14.7	183	666
Printed & resin-finished	9.0	5.6	0.324	14.6	13.7	158	470
Mercerised, printed & resin-finished	10.0	2.6	0.308	14.8	15.2	178	638

*** Negative shrinkage value indicates an extension**

Table 8: Degree of Cure in Resin-finishing Treatments

Process	% Nitrogen BW	% Nitrogen AW	Fixation %
Dyed (Sketchley)	0.526	0.226	43.0
Mercerised & dyed	0.428	0.145	33.9
Printed (Strines)	0.594	0.528	88.9
Mercerised & printed	0.588	0.460	78.2

Figure 1: The Omez Knitgoods Merceriser

Figure 2: The Omez Knitgoods Merceriser - Diagrammatic

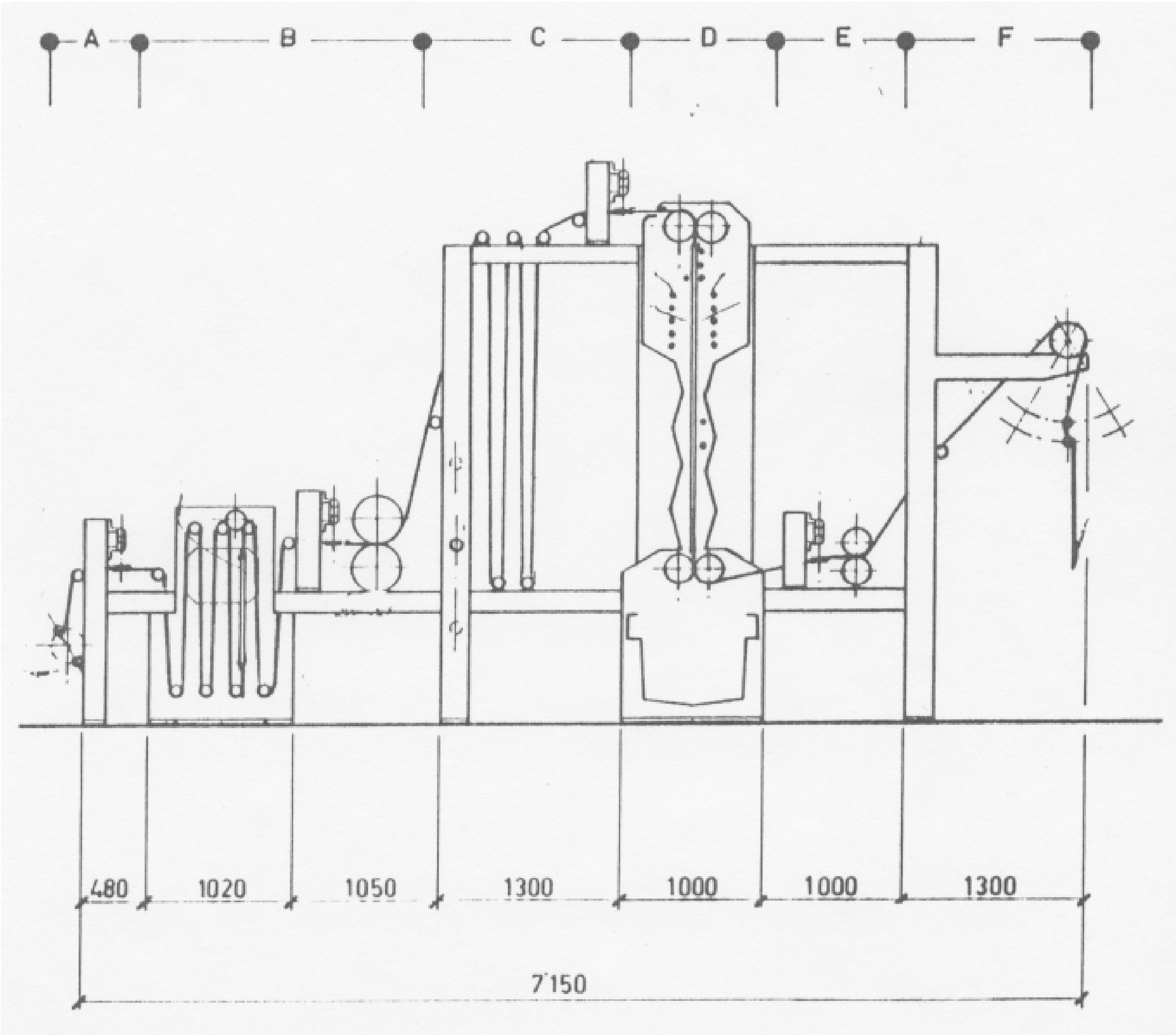


Figure 3: Overall View with Saturator in Foreground

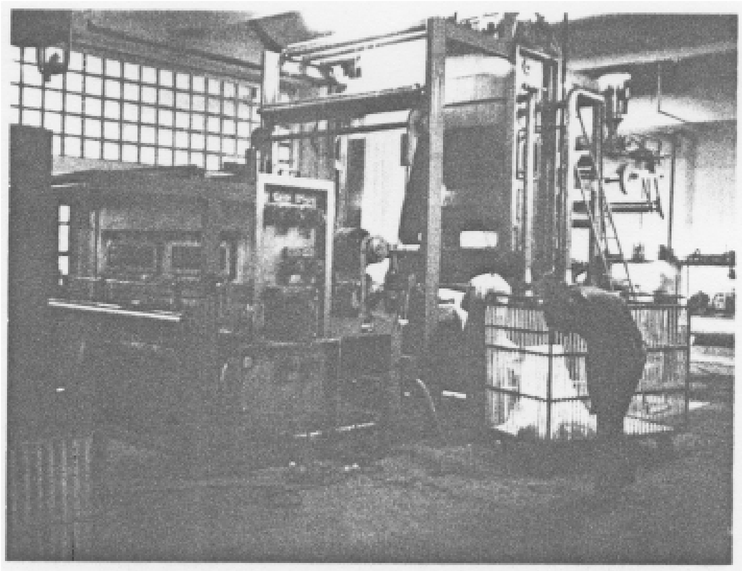


Figure 4: Fabric Entering the Saturator

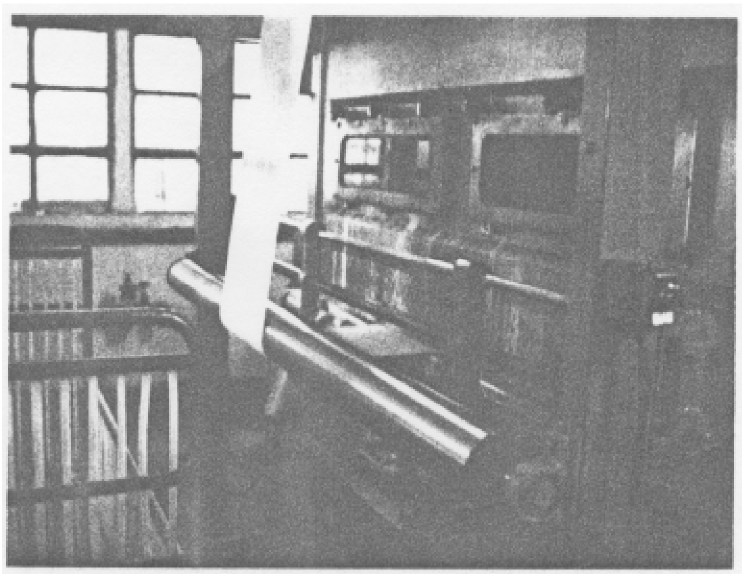


Figure 5: Saturator Exit Nip

Note ring expander to prevent creasing

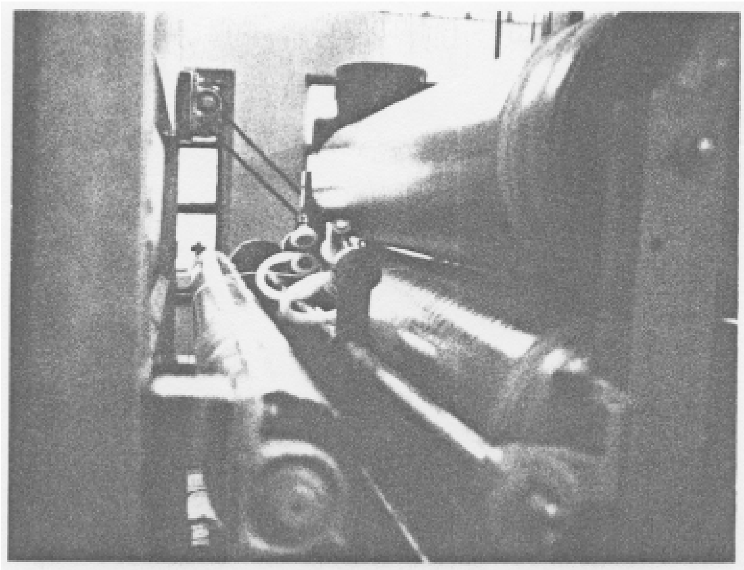


Figure 6: Delay Section

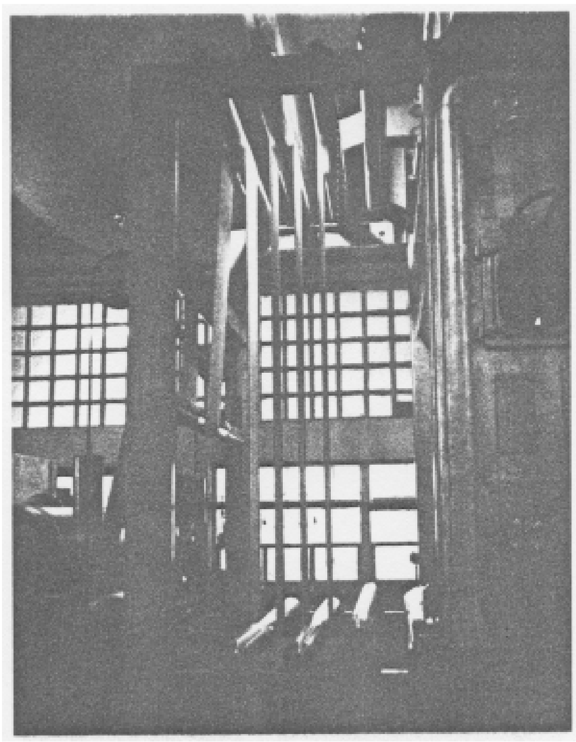


Figure 7: Washing Tower

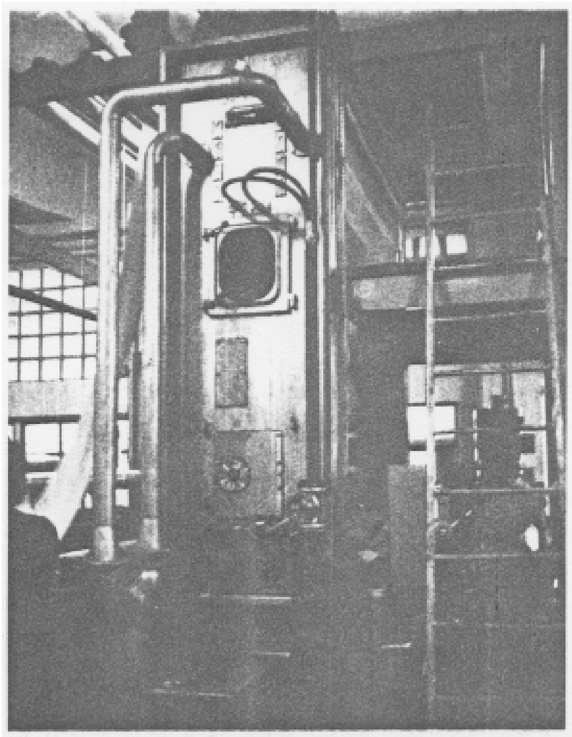


Figure 8: Exit Side of Washing Tower

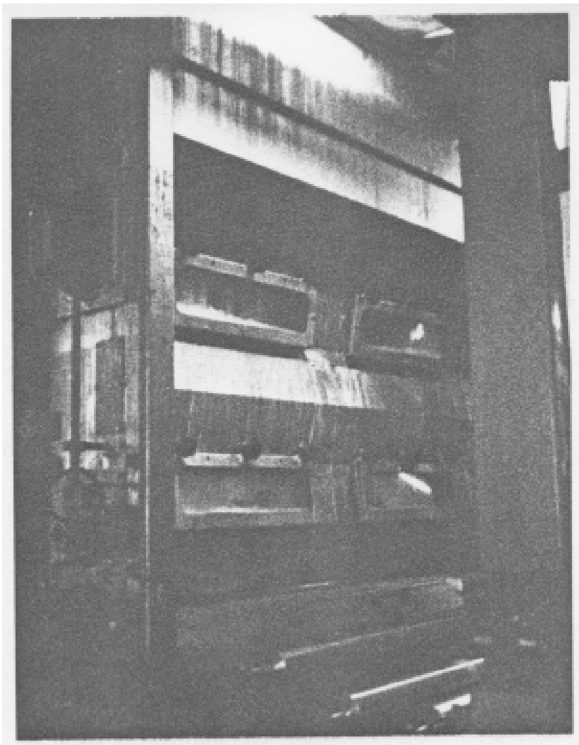


Figure 9: Delivery End

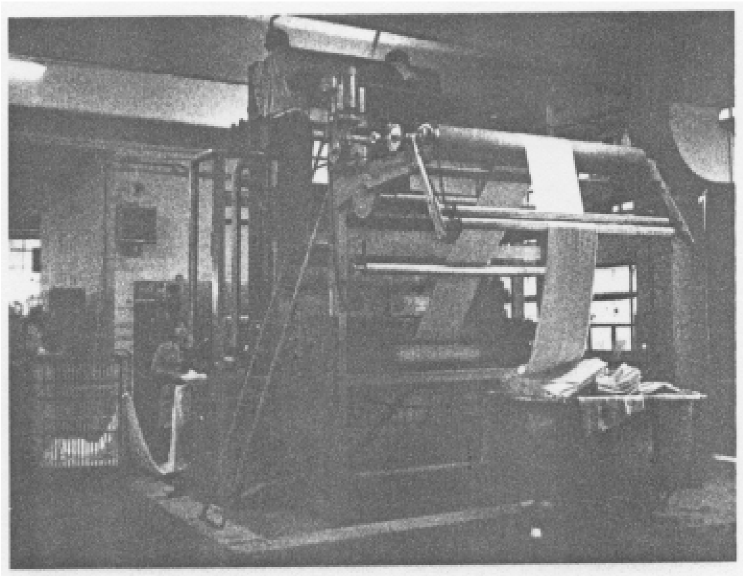


Figure 10: Control Panel

(speed controls arrowed)

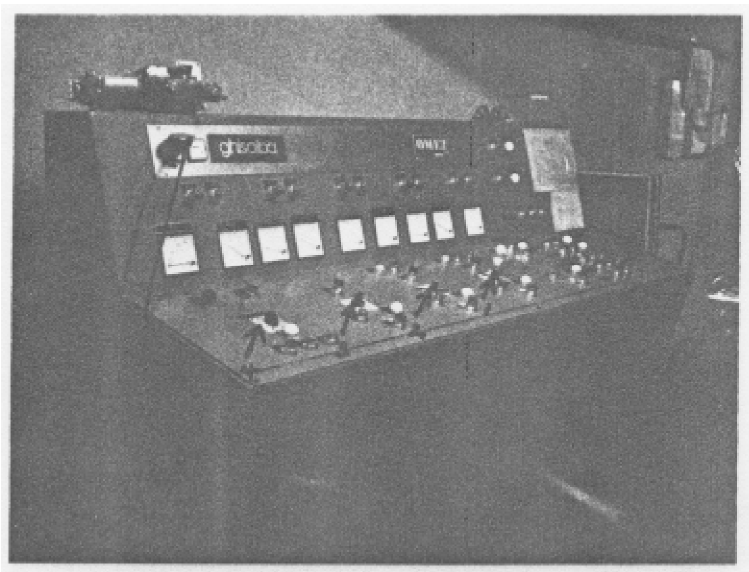


Figure 11: Effect of Stretcher-frame Width on Relaxed Structure

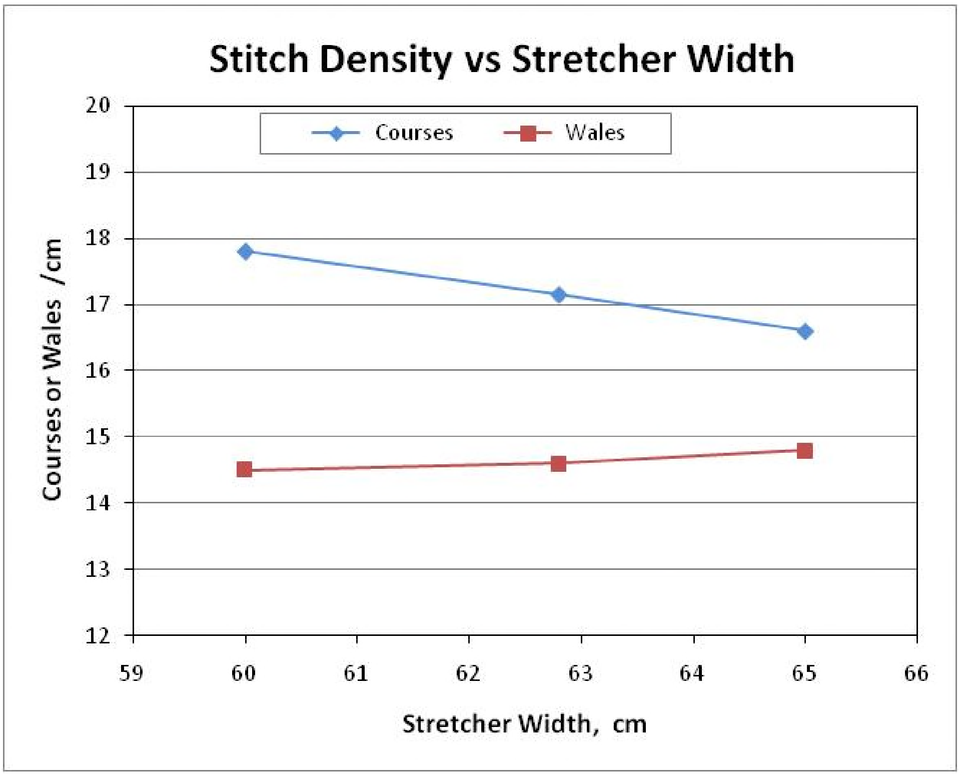


Figure 12: Effect of Stretcher-frame Width on Relaxed Structure

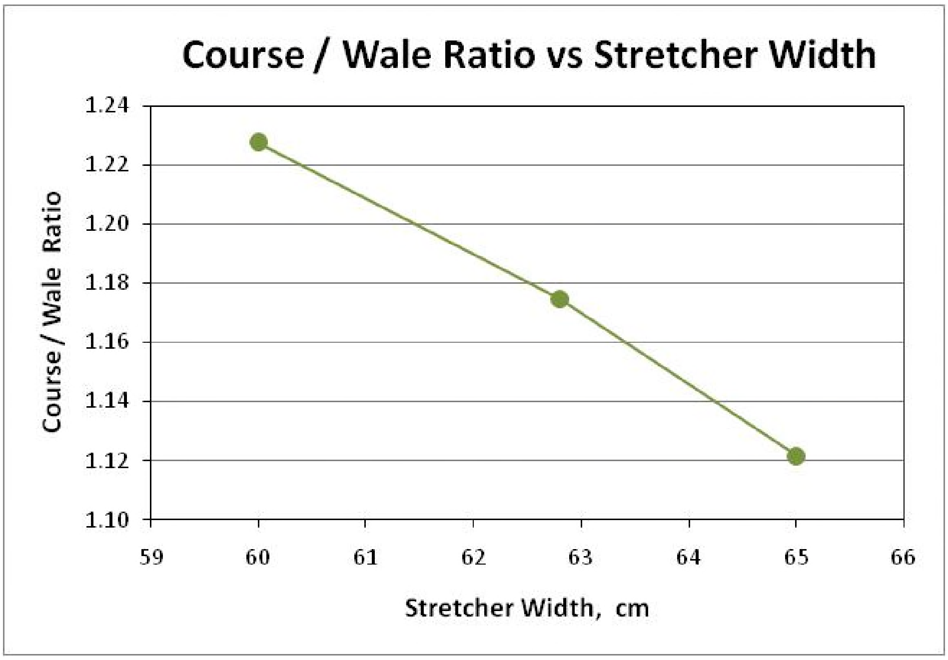


Figure 13: Effect of Stretcher-frame Width on Relaxed Structure

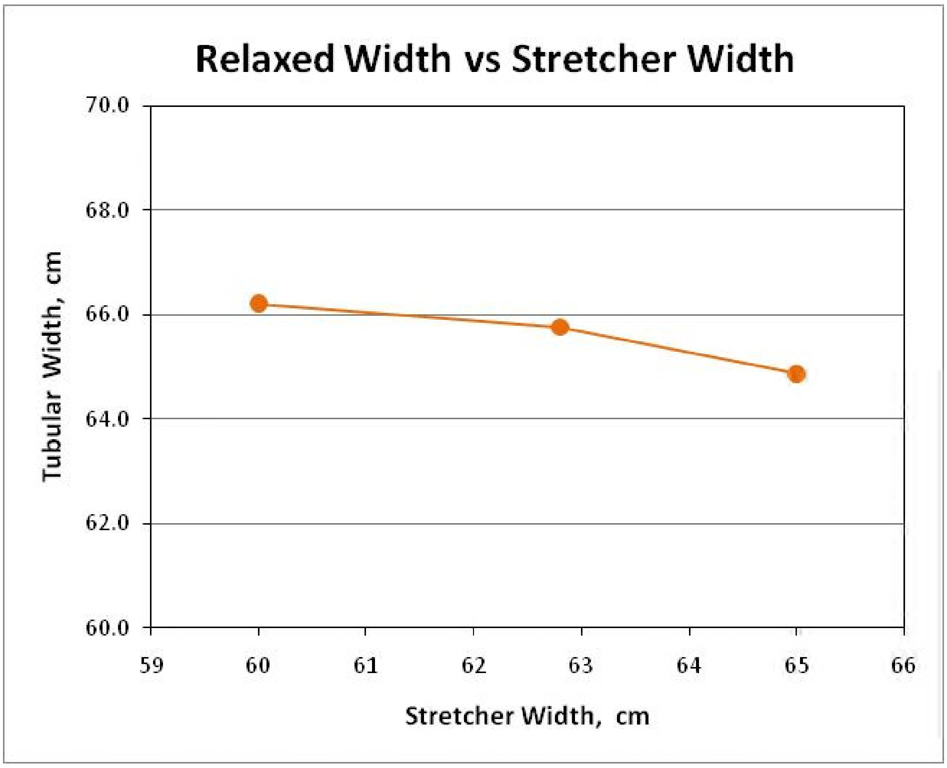


Figure 14: K-values

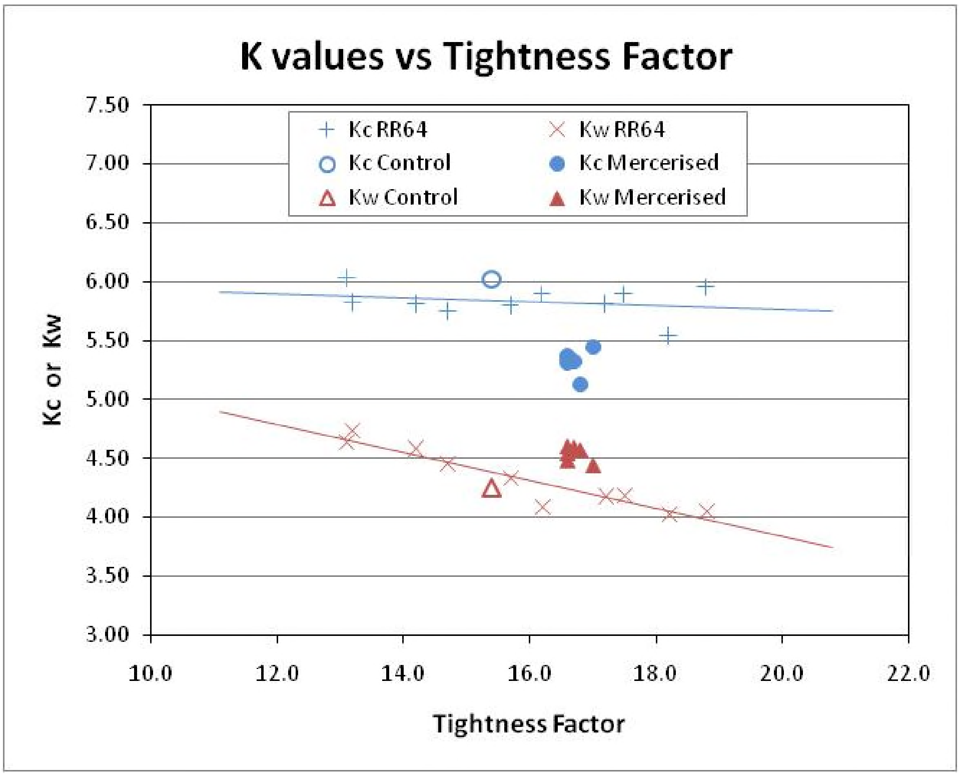


Figure 15: Course - Wale Ratio

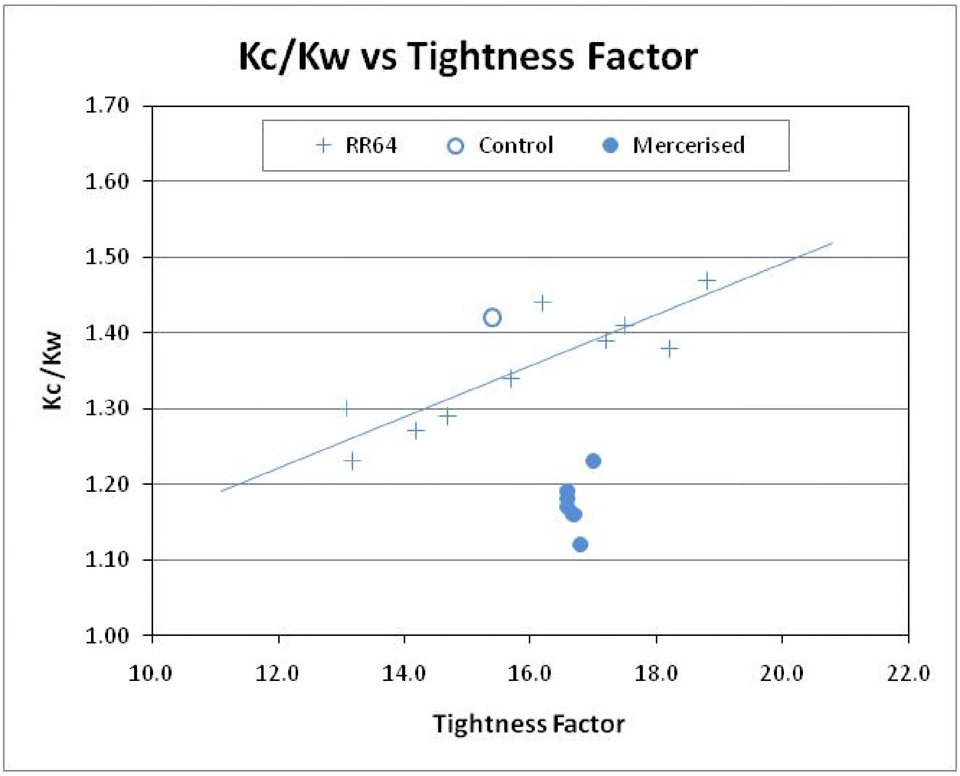


Figure 16: Effect of Mercerising on Bursting Strength

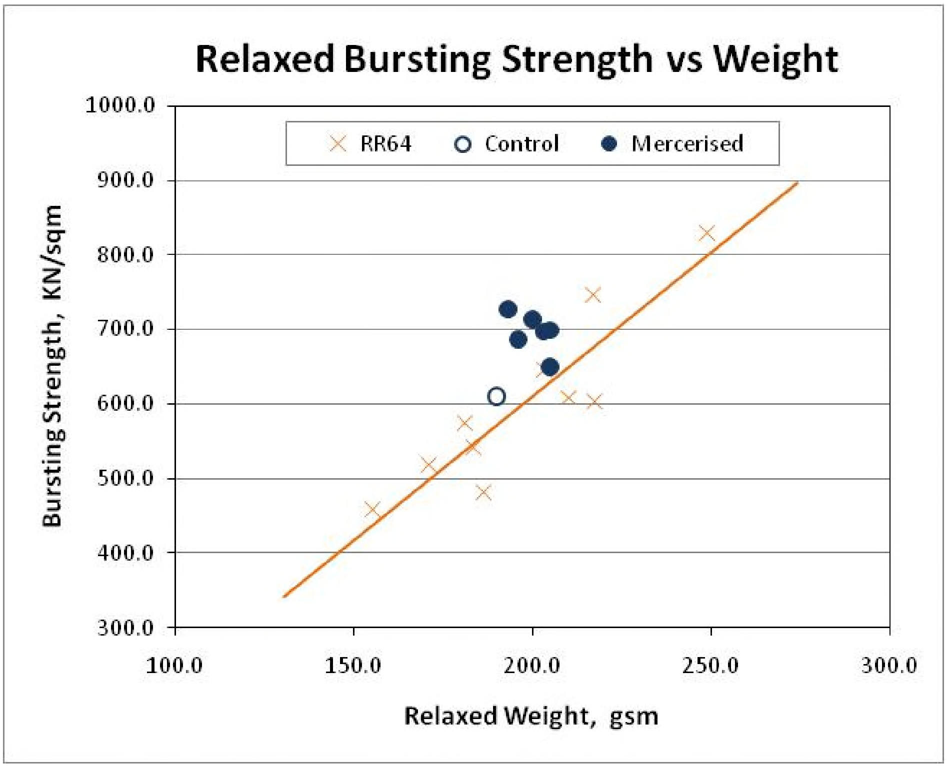
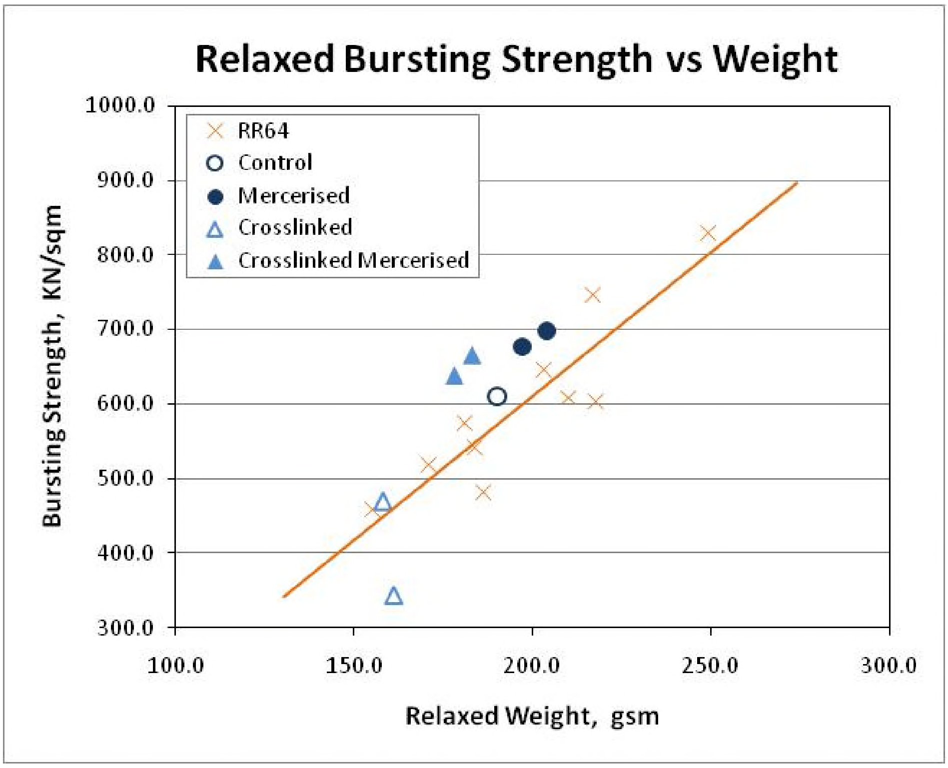


Figure 17: Effect of Crosslinking on Bursting Strength



Appendix

24g Single Jersey Study Results (Research Record No. 64)

	Grey		Relaxed						Calculated, Relaxed				
Sample	**Yarn**	**St. Len**	**St. Len**	**Courses**	**Wales**	**Weight**	**Strength**	**Yarn**	**T.F.**	**Kc**	**Kw**	**Kc/Kw**
Yarn	tex	cm	cm	/cm	/cm	gsm	KN/sqm	tex	K			
	a	*b*	*c*	*d*	*e*			*f = a.b/c*	*sqrt(f)/c*	*d.c*	*e.c*	*d/e*
20/1	29.5	0.290	0.289	20.6	14.0	249.0	830.2	29.6	18.8	5.95	4.05	1.47
20/2	29.5	0.354	0.349	16.6	12.4	217.5	602.6	29.9	15.7	5.80	4.33	1.34
24/1	24.6	0.283	0.283	20.8	14.8	216.9	746.0	24.6	17.5	5.89	4.19	1.41
24/2	24.6	0.350	0.342	16.8	13.0	186.4	481.3	25.2	14.7	5.75	4.45	1.29
26/1	22.7	0.284	0.269	20.6	15.0	210.1	608.1	24.0	18.2	5.54	4.03	1.38
26/2	22.7	0.355	0.342	17.0	13.4	181.2	575.0	23.6	14.2	5.81	4.58	1.27
28/1	21.1	0.280	0.272	21.4	15.4	203.2	645.4	21.7	17.2	5.81	4.18	1.39
28/2	21.1	0.352	0.351	17.2	13.2	171.1	517.1	21.2	13.1	6.03	4.63	1.30
30/1	19.7	0.270	0.273	21.6	15.0	183.7	542.0	19.5	16.2	5.89	4.09	1.44
30/2	19.7	0.353	0.342	17.0	13.8	155.3	457.8	20.3	13.2	5.82	4.73	1.23

24 Gauge Single Jersey Study (Research Record No. 64)