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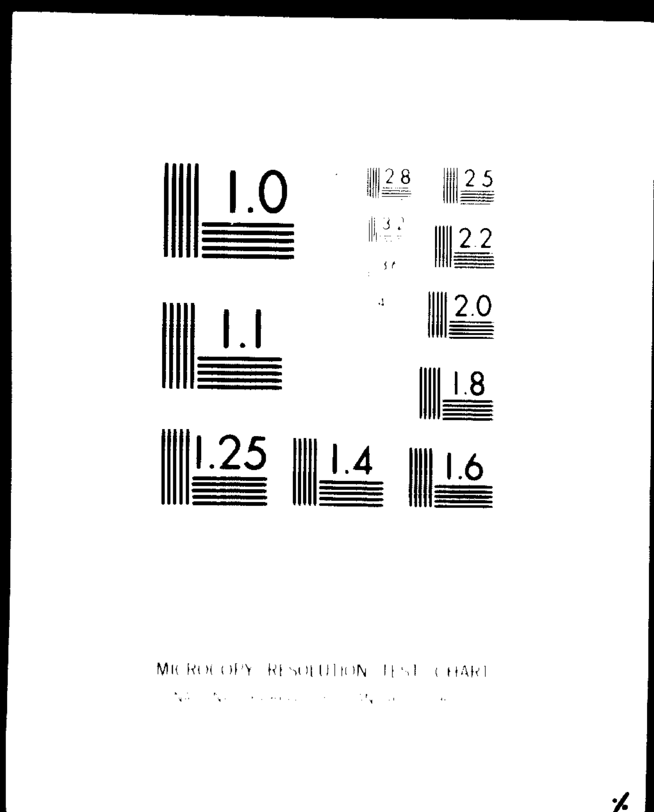

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FINISHING OF COTTON KNITS 1/

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FINISHING OF COTTON KNITS

The term "knit" covers an enormous range of products, each of which may require a different approach from the finisher, and to condense this subject into a relatively short presentation has presented a significant problem. Some consideration must be given to warp knits as woll as weft knits; weft knits can themselves be divided into flat and tubular knit fabrics; there is also the important sector of fully fashionod garments. The whole subject can be further sub-divided to take account of end-use underwear or outerwear, casual or high fashion.

The finisher has to take into account these various factors in deciding on a suitable processing sequence. The machinery to be used will depend on whether the fabric is to be processed tubular or at open-width. The treatments to be applied will depend on the requirements and specificatione for the finished fabric or garment. The ability to confer softness and absorbency on cotton makes it the ideal fibre for underwear, while the ability of these fabrics to stretch and conform to the natural body shape has led to an upsurge of interest in recent years in knitted cotton fabrice in sophisticated constructions for outerwear, which will require good stretch properties, probably also attractive draping characteristics and almost certainly a degree of "easy-care", that is, freedom from creasing during wear and in washing or cleaning. Above all others, however, the most desirable property to be conferred on a knitted fabric for any of these end-uses is that of dimensional stability. Stability in the dry state means good recovery after stretching, and in the wet state, good control of shrinkage in laundering.

From the finisher's point of view, the achievement of dimensional stability is assisted by an understanding of the causes of shrinking and distortion in the knitted structure.

Causes of Distortion in the Knitted Structure.

Table I shows typical values of shrinkage shown by various knitted structures, each in a range of stitch lengths. In each case, as the knitted structure becomes looser and more open (stitch length increases) the length shrinkage increases and the width shrinkage decreases. The fabric may even start to show an extension in width as the stitch length increases.

It has been shown that the stitch length, that is the length of yarn which is fed in during knitting to make one stitch, is the parameter which determines the structure of the fabric in the fully relaxed state. Although the tension applied to the fabric in knitting may vary, leading to considerable variations in knitted cloth weight, this does not affect the structure of the relaxed fabric. Table II shows what happens when variations occur in the take-down tension applied to the fabric in the knitting machine. These particular results are taken from a paper by Black (1). The stitch length was held at a constant level by the use of positive feed,and the construction of the fabric after wet relaxation remained constant.

Thus, we can see that although the dimensions of the grey fabric are affected by the tensions applied in the process of knitting, the final dimensions, after a wet relaxation treatment, are quite independent of those tensions and are determined only by the stitch length, the amount of yarn fed in to make one stitch.

The finisher of woven fabrics has some degree of freedom to control the dimensions of the finished cloth. He is able to stabilise the fabric to a desired width (within limits) by adjusting the length, allowing the interchange of crimp between warp and weft to release the strains which would otherwise be set up and thus maintain a condition of minimum energy, which is another way of describing the fully relaxed state.

The knitgoods finisher, however, does not have the same freedom. As the results in table III show, the ratio between the course and wale spacings in the wet relaxed structure is more or less constant, fixed by the requirements of the minimum energy configuration of the knitted loop. In fact, the dimensions of the wet relaxed fabric have already been determined by the knitter in his selection of the factors, such as machine gauge and yarn tension, which control the stitch length of the fabric.

The finisher does have one or two tricks up his sleeve, however, and these will be described later. First, some consideration might be given to the achievement of that condition in the fabric which has already been mentioned several times, the fully wet relaxed state.

Relaxing the Fabric.

The cotton knitgoods finisher has the choice of two main courses of action in the selection of machinery and processes to achieve a dimensionally stable finished product. He can either:-

a) ensure that the fabric is wet processed and dried under completely tensionless conditions, with mechanical agitation to accomplish the relaxation, or

b) process the fabric without regard to the effect of tension, relying entirely on a final stabilising treatment.

In practice, method (a) is used only in the processing of garments and garment blanks, which can be fully relaxed by steaming and tumble drying. Tumble dryers fitted with steam injection are available for the treatment. For piece goods, the finisher usually adopts a compromise between methods (a) and (b). Some tension is inevitably developed during finishing operations, as, for example, when wet fabric is pulled from a winch or drawn through a drying machine, but methods of reducing tension during finishing treatments have pre-occupied machinery builders for many years now. In addition, mechanical methods for compacting the fabric structure have been developed.

The machinery and mothods chosen will depend to a large extent on whether the fabric is to be processed in the tubular state or in the open-width. Warp knits and some weft knitted fabrics are knitted in the flat form. Usually, of course, the finishing of these fabrics is carried out in the open-width and in fact, warp knits can often be processed on woven fabric finishing equipment, as their tendency to stretch in length is normally less than that of weft knitted fabrics.

Apart from lengthwise stretching, there is one other major problem in open-width finishing and that is edge-curling. Many knitted structures are unbalanced, that is the structure appears different on the two faces of the cloth and this leads to a strong tendency for the fabric to curl at the edges, especially when it is wet. For this reason, a jig is an unsuitable machine for handling knits, and open-width dyeing is carried out on beam-dyeing equipment.

Some knitted fabrics, notably interlock and some rib constructions, are balanced and do not have this tendency to curl at the edges. In general, however, it is easier to process knitted fabric in tubular form than in the open-width and it is a good general rule that tubular knits should be processed as far as possible in tubular form. For instance, plush fabrics, which are very popular at the moment, must be opened out into a flat state for the shearing operation, but bleaching and dyeing can, and should, be carried out on the tubular fabric before it is slit. The fabric will then be almost fully relaxed before it is presented for shearing.

Tubular Processing.

Almost all underwear fabric is knitted in tubular form. Often, different diameters of knitting machines are used to produce a range of tubular widths to suit all body sizes; thus making up can be carried out using circular fabric and this, of course, means that the entire finishing operation is carried out on tubular cloth. Standard equipment for processing underwear fabric would then include:-

Ropa Washer .... for scouring and washing.

J-box or Pad Batch Equipment for tubular goods

Winch .... for dyeing and application of softener

Detwisting Equipment

Centrifuga or Vacuum Extractor

Drum Dryer

Steam Calander

Compactor

The pad-batch technique is preferred to the winch for bleaching for reasons of economy. Winch bleaching of knitgoods must be carried out at high liquor-to-goods ratio to ensure low fabric tension in running. This can make the winch an expensive machine in terms of steam consumption. On the other hand, winches are widely used for dyeing as padding methods tend to produce edge-lines. The technique of vacuum impregnation is said to overcome this difficulty and may influence the development of pad-batch dyeing on tubular cloth.

To ensure as far as possible that dimensionally stable fabric is produced at the end of the processing, samples should be taken from each batch of grey cloth, marked with measured lengths in both directions, washed and tumble dried and the relaxation shrinkage of the fabric calculated. The cloth can then be finished to a stable condition by utilising the overfeed and width control facilities of the dryer and calender, if necessary making a final correction with the compactor. Details of a suitable test method for relaxation shrinkage are given in the appendix.

Increasingly, underwear garments are being produced using the cut-and-sew technique, so that while the tubular methods of finishing can still be applied, the fabric may be opened out by slitting before making-up.

Open Width Processing.

In recent years, machinery builders have concentrated much of their activities into the development of equipment for finishing knitted goods at open-width.

This has been important, particularly for printed goods, now increasing in popularity for underwear as well as outerwear.

Printing of knitted cotton is best carried out on a flat screen machine which minimise fabric distortion. The fabric is slit before printing and usually gummed at the edge. The subsequent washing and drying is, of course, carried out at open-width and this has led to the development of edge uncurlers, fabric straighteners, tensionless washers and specially constructed knitgoods stenters with overfeed facilities to obtain the relaxed dimensions indicated by the laboratory tests. It may also be worth noting here that if a tubular fabric is going to have to be slit into open-width at any stage, the knitter can assist the finisher by "dropping a stitch", which can then be used as a guide in the slitting operation.

Setting Treatments

So far, we have only considered the techniques available for obtaining the wet relaxed state, as determined by the knitter. As already indicated, there are ways by which the finisher can control the relaxed dimensions to his own requirements using methods which are well known to the processor of woven fabrics, but which have only recently been taken up by the knit-goods finisher, who is finding that these techniques enable him to meet the more stringent market requirements for knitted shirtings and outerwear.

Crosslinking

This technique has been described in detail by earlier speakers with reference to woven fabrics; the essential difference for knitted fabric finishing lies in the objectives of the treatment. For woven goods, the prime objective is easy-care, while for knits it is again dimensional stability. Knitted fabrics in general possess better natural easy-care properties than wovens, and require a much lower level of crosslinking to achieve a good easy-care result.

By a pad-dry cure application of crosslinking agent, only about 2% of the crosslinker is required to give good easy-care together with a very much improved dimensional stability.

The effect of crosslinking treatments on two interlock fabrics of different stitch lengths is shown in Fig. 1. Treatments were carried out on partially pre-relaxed fabric (dotted lines) as well as on unrelaxed fabric (solid lines). In each case, about half of the potential shrinkage before crosslinking is eliminated by a 2% addition of crosslinking agent (DMDHEU).

Fig. 2 shows the results of a similar series of trials, this time carried out on single jersey, using urea-formaldehyde. Urea-formaldehyde is a resin, not a true crosslinking agent, and rather more is required to achieve good stability. However, an add-on of only 4% was sufficient to reduce the potential shrinkage in length from 20% to 8%.

Additives can be incorporated into the easy-care recipe to improve handle, softness and also elasticity. Trials which we have carried out with some of the new silicone additives indicate that these can be of considerable assistance in developing resilience, good elastic recovery and resistance to bagging. Another advantage of a crosslinking treatment is that it reduces the imbibition and therefore also reduces the drying time required by the wet fabric, an important point for the busy housewife (Fig. 3).

Fig. 4 shows how the fully relaxed fabric structure can be controlled by various additions of crosslinking agent. As with woven fabrics, crosslinking and resin treatments have an adverse effect on strength and resistance to abrasion. These losses are, in general, not as serious as those which occur on woven fabrics, partly because less chemical is used, and partly because the knitted structure is much more mobile and resilient.

Mercerisation

This subject has been dealt with at length by earlier speakers, though again, mainly with reference to woven fabrics. Piece mercerising of knitgoods has developed only recently on a commercial scale. Initially, the objectives of the treatment were to enhance the fabric appearance by taking advantage of the improvements in lustre and dye affinity which result from the process.

Also to take advantage of the much lower processing costs of piece mercerising in comparison with yarn mercerising.

The equipment generally used is based on the well-known chainless merceriser and several machinery makers are developing mercerisers designed to process fabric at the lower tensions required for knitgoods. Some examples of commercial machines are given in the Appendix. The economic advantages of mercerising in the piece compared to yarn mercerising become more apparent as the volume of production increases. Yarn mercerising is a relatively slow, low production batch treatment, while piece mercerising is essentially a high production, continuous or semi-continuous process. The high capital cost of a fabric mercerising machine demands its full utilisation; for this reason, most commercial installations are capable of handling both woven and knitted fabrics.

A comparison of costs of various methods for producing and finishing single jersey fabric, using yarn of Ne 30 resultant count, gave the following relative figures:-

Unmercerised, 2-fold yarn	100
Piece-mercerised, 2-fold yarn	117
Mercerised yarn, 2-fold	139
Piece-mercerised singles yarn	94

These figures are, of course, only an approximate guide, as many variables are involved. They do, however, indicate that for medium to large production runs at least, piece-mercerising offers considerable savings on yarn mercerising while the use of singles yarn in fabric production could markedly broaden the potential of the knit-mercerising process. A technical examination of a range of mercerised knitgoods, carried out recently by IIC in co-operation with two French companies, S.A.F.A.T. and Gillet-Thaon, has shown that fabrics with good lustre, stability, handle and dyeability can be produced by piece-mercerising fabric made from singles yarn. A possible disadvantage, however, in comparison with two-fold yarn is the tendency for the fabric to become rather "hairy" on repeated laundering, but it should be possible to prevent this by a crosslinking treatment.

Mercerising the fabric before easy-care treatments might be expected, as with woven fabrics, to result in improved strength retention. The results shown in Table IV on 28 gauge single jersey fabric tend to confirm this prediction. The mercerising process was a commercial treatment, carried out in the piece; the chemical treatment was a pad-dry cure process using urea-formaldehyde. In these results, the strength loss due to resin treatment is roughly halved by mercerising, but abrasion resistance is unaffected.

Examples

Three examples of finishing sequences will help to illustrate the principles to be followed in the processing of cotton knitgoods.

Example 1 Tubular underwear fabric, white or dyed.

1. Measure relaxation shrinkage.
2. Scour and bleach or dye and wash in winch. In general, it is not necessary to bleach before dyeing.

   Recipes.

   Scour

   5grm/litre non ionic detergent) 90-100°C, 60 mins.
   5g/1 sodium carbonate)

   Bleach

   7g/1 sodium silicate
   0.5g/1 sodium hydroxide
   1.8g/1 sodium carbonate (anhydrous)
   7.5g/1 35% hydrogen peroxide
   Wetting agent.
   Raise temperature to 80-85°C. Run 1 hour.

   Dye

   Use dye manufacturers recommended recipes.
3. Hydroextract
4. Check fabric construction. Usually, it will be found that the course count has become more open and the wale count tighter.
5. Detwist and calender wet. Set the stretcher board of the calender at, or just above, relaxed width. Allow as much overfeed as possible.
6. Re-check fabric dimensions and construction.
7. Dry in drum dryer with overfeed.
8. Re-check fabric dimensions and construction.
9. Steam and calender with overfeed, having adjusted stretcher board to desired final cloth width.

10. Measure relaxation shrinkage by a laboratory test.
11. If necessary, compact to obtain lengthwise stability within the desired limit.

Example 2 Tubular shirting, white or dyed, resin finished.

1-8 as example 1

9. Pad with:-
   80g/1 glyoxal based reactant.
   12g/1 magnesium chloride hexahydrate.Softener as required.
   Set the stretcher to just over the estimated final cloth width, assuming that resin-finishing will eliminate 50% of the potential shrinkage, and squeeze to 60-70% pick-up.
10. Dry and cure by one of the following methods:-
    a) Dry in drum dryer at 110-120°C, with overfeed, cure in second run through dryer at 150°C for 3-4 minutes.
    b) Dry and cure in one run through dryer at 155-160°C, 3-5 minutes.
    c) Dry as in (a), steam and calender with overfeed or pass through mechanical compactor, cure as in (a).
11. Measure final cloth shrinkage by a laboratory test.
12. If necessary, compact or calender to obtain required degree of stability.

Example 3 Open width printed shirting, resin-finished.

1-4 as example 1

5. Detwist and slit into flat form.
6. Stenter with overfeed.
7. Re-check fabric dimensions and construction. If an improvement in length stability is desired, damp or steam the cloth and re-stenter with overfeed, slightly increasing the width.
8. Print.
9. Wash at minimum tension.
10. Stenter dry with overfeed.
11. Re-check fabric dimensions and construction.
12. Pad with:-
    80g/1 glyoxal based reactant
    12g/1 magnesium chloride hexahydrate.Softener as required. Pick-up 60-70%.

13. Stenter dry at 110-120°C. Set width and overfeed to give desired stability, assuming that resin-finishing will eliminate 50% of the potential shrinkage.
14. Stenter cure at 150°C, 2-4 minutes.
15. Measure final cloth shrinkage by a laboratory test.
16. If necessary, damp or steam and re-stenter.

SUMMARY

The most important objective in the finishing of cotton knitgoods is the attainment of good dimensional stability. To reach this objective, the finisher must:-

a) test each fabric before processing, to establish its relaxation shrinkage,
b) process the fabric with as little tension as possible especially in the later stages of wet treatment,
c) encourage the fabric to relax in order to release the distortion due to knitting tensions.

In order to meet increasingly critical standards for dimensional stability, particularly in the outerwear field, he can stabilise the finished fabric by a mechanical compacting process, or set the fabric by a chemical treatment using a resin or crosslinking agent. This latter treatment confers additional properties, for example, easy-care, improved resistance to bagging and quicker drying. The strength loss in crosslinking can be minimised by mercerising, which itself improves the appearance of the fabric by adding lustre and improved dyeing characteristics.

It is possible that the best results will be achieved by a combination of mechanical and chemical methods.

References

1. Black D.H. "Shrinkage Control For Cotton and Cotton Blend Knit Fabrics", AATCC conference - Knit Shrinkage, Cause, Effect and Control, New York, 1973.

TABLE I

THE EFFECT OF STITCH LENGTH ON FABRIC PROPERTIES.

FABRIC	STITCH LENGTH (mm)	KNITTED WEIGHT (g/m^2)	RELAXED WEIGHT (g/m^2)	RELAXATION % SHRINKAGE LENGTH	RELAXATION % SHRINKAGE WIDTH
Interlock 20 gauge	3.30	245	291	13.1	3.0
	3.54	235	271	15.2	- 2.3
	3.86	227	266	19.3	- 5.7
	4.22	200	222	22.5	-16.3
Plain 20 gauge	3.02	110	146	4.1	21.6
	3.35	102	134	9.7	15.9
	3.61	94	124	13.3	12.6
	3.81	91	114	13.1	7.9
Piqué 20 gauge	3.19	225	293	14.8	10.0
	3.65	207	265	17.5	5.4
	3.95	180	236	21.9	2.4
	4.17	177	224	23.0	- 2.6
Jacquard 20 gauge	3.16	244	343	15.7	15.6
	3.53	217	306	18.6	12.8
	3.79	198	294	24.3	11.0
	4.26	178	253	28.0	2.2

A MINUS (-) SIGN INDICATES AN EXTENSION

YARN USED Ne 1/30 COMBED PERUVIAN, BLEACHED

TABLE II

TAKE-DOWN TENSION	UNRELAXED WEIGHT g/m^2	SHRINKAGE % LENGTH	SHRINKAGE % WIDTH	RELAXED COURSES/CM	RELAXED WALES/CM	RELAXED WEIGHT g/m^2
LOW	150	9	19	16	12	198
AVERAGE	143	19	17	16	12	198
HIGH	136	23	12	16	12	198

FABRIC:- 18 gauge single jersey

YARN:- Ne 1/20 Cotton

STITCH LENGTH:- 3.7 mm

TABLE III

STRUCTURE OF RELAXED SINGLE JERSEY FABRICS.

STITCH LENGTH (mm)	RELAXED COURSES/CM	RELAXED WALES/CM	COURSES PER CM / WALES PER CM
3.02	18.5	13.5	1.37
3.35	16.0	13.0	1.23
3.61	15.2	11.4	1.33
3.81	13.8	10.8	1.28

FABRIC:- Plain single jersey, 20 gauge

YARN:- Ne 1/30 combed Peruvian, Bleached

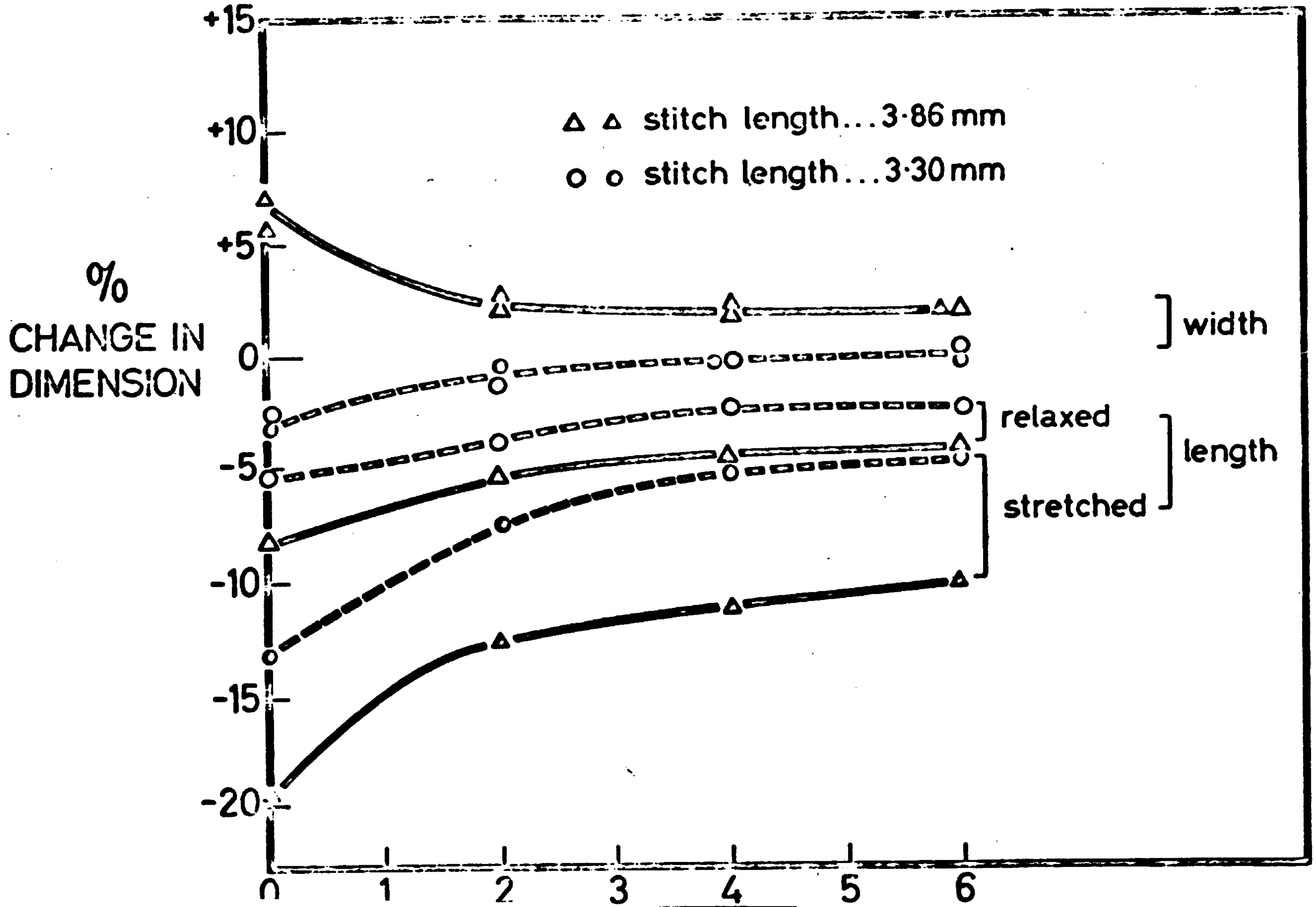
TABLE IV

THE EFFECT OF COMBINING MERCERISING AND CROSSLINKING TREATMENTS.

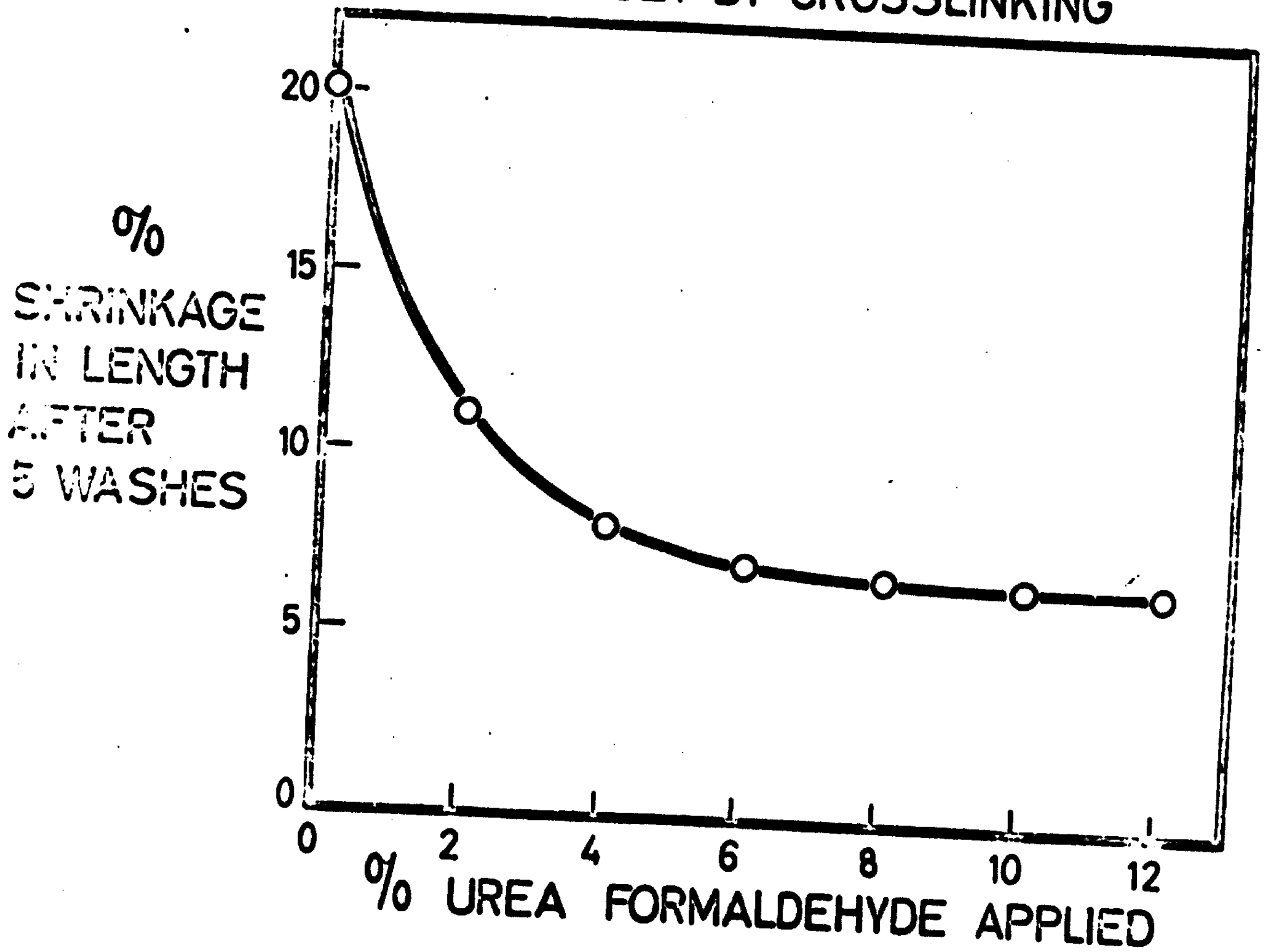
FABRIC:- 28 GAUGE SINGLE JERSEY, Ne 2/60 COTTON				
TREATMENT	BURSTING STRENGTH (kg/cm^2)	SHRINKAGE (%) LENGTH	WIDTH	ACCELEROTOR WEIGHT LOSS %
BLEACHED ONLY	7.73	20.0	2.5	4.9
BLEACHED AND MERCERISED	7.87	15.0	5.0	4.3
BLEACHED, 3% RESIN	5.84	3.0	1.0	5.2
BLEACHED AND MERCERISED, 3% RESIN	6.96	5.5	2.5	4.7
BLEACHED, 5% RESIN	5.94	6.0	1.0	8.1
BLEACHED AND MERCERISED, 5% RESIN	6.61	3.5	1.8	9.8

FIGURE I.

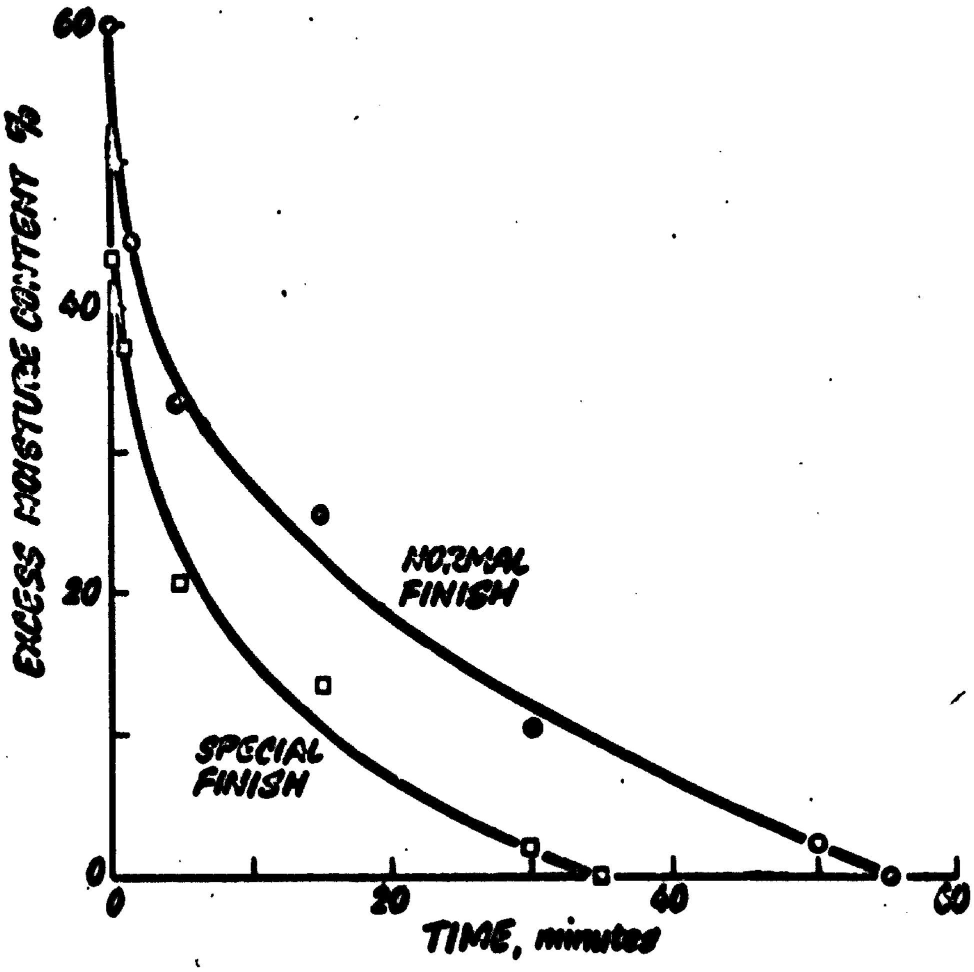
CONTROL OF SHRINKAGE OF COTTON INTERLOCK
BY RELAXATION AND CROSSLINKING

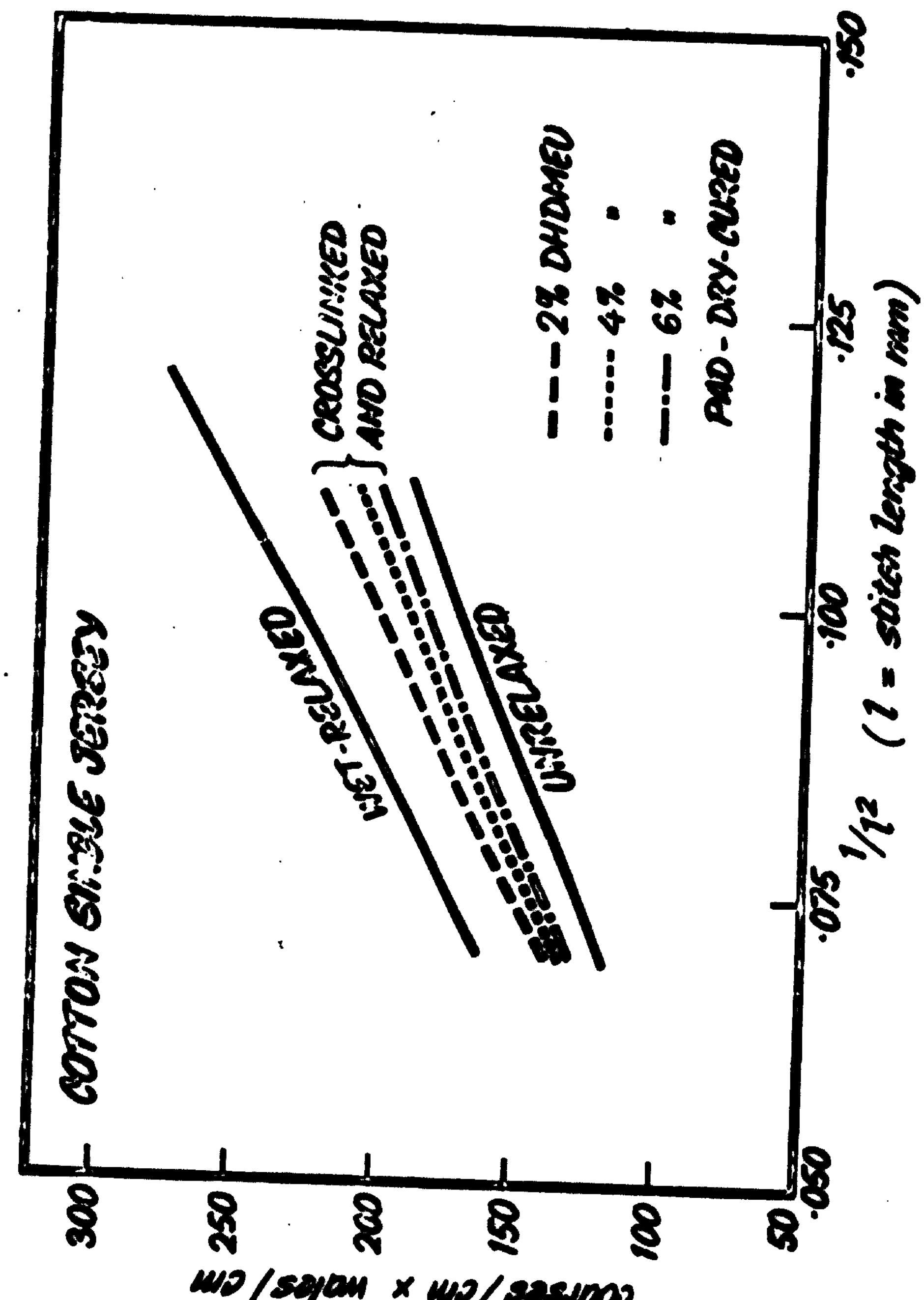


CONTROL OF SHRINKAGE OF COTTON SINGLE JERSEY BY CROSSLINKING



Rate of drying of knitted cotton terry cloth




COTTON SINGLE JERSEY
WET-RELAXED
UNRELAXED
CROSSLINKED AND RELAXED
2% DHDMEU
4% "
6% "
PAD-DRY-CURED
300
250
200
150
100
50
courses/cm x wales/cm
.050
.075
.100
.125
.150
1/l² (l = stitch length in mm)

MERCERISING MACHINES FOR COTTON KNITGOODS

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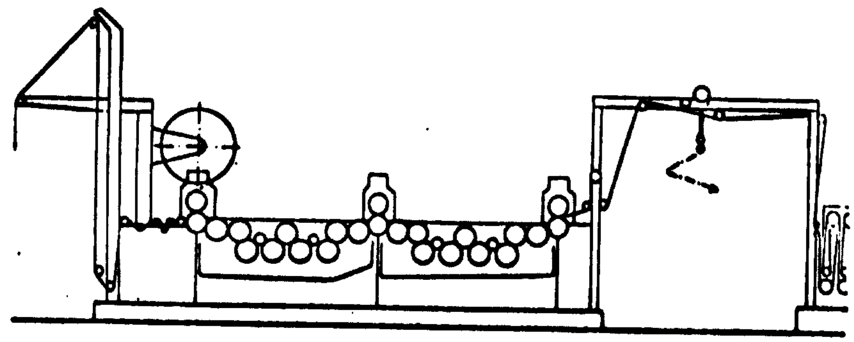

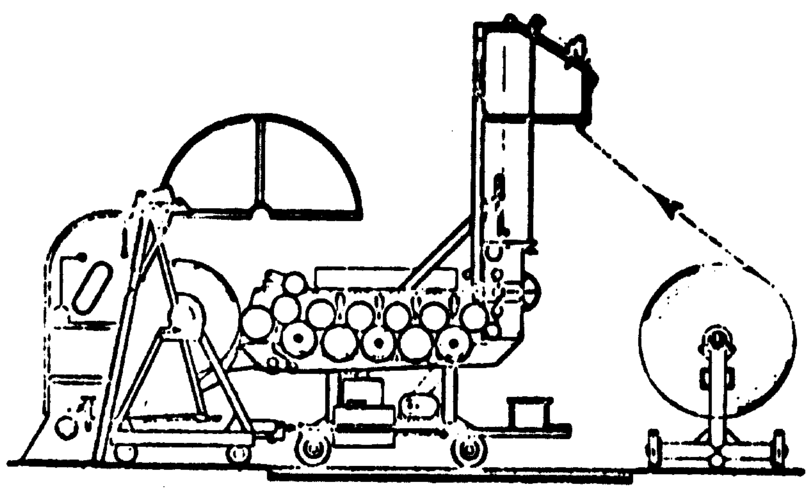

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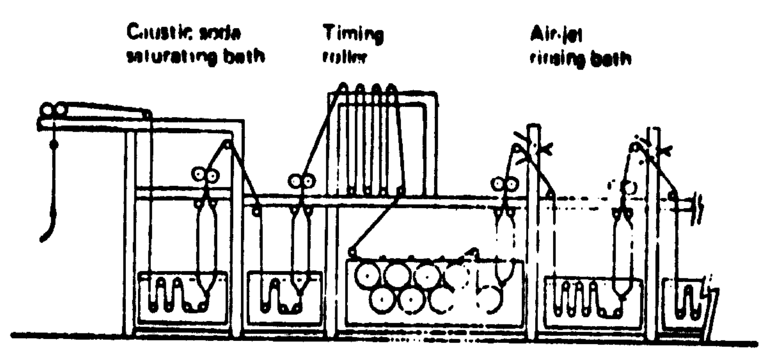

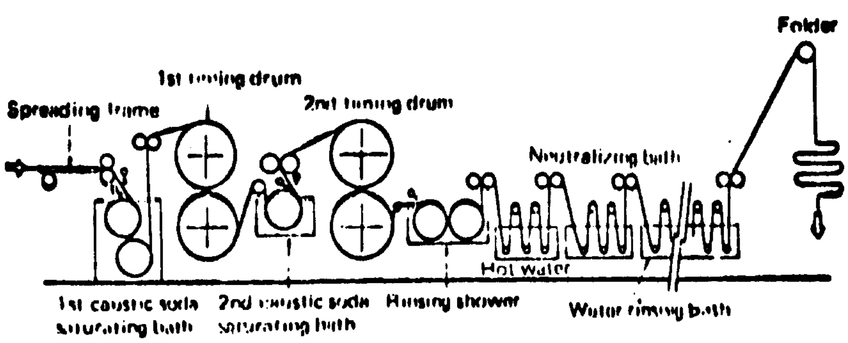

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RELAXATION SHRINKAGE TEST FOR KNITTED FABRICS.

1. Take a fabric sample measuring about 35cm x 35cm.
2. Condition the sample in a standard atmosphere for at least 4 hours.
3. Place the sample on a flat surface.
4. Indelibly mark the sample with three measured lengths of 25cm in both length and width directions. Do not distort the fabric or apply tension during this operation.
5. Wash the sample once in an automatic, domestic washing machine at 60°C and tumble dry.
6. Re-condition the sample as before.
7. Re-measure the flat sample without distorting the fabric or applying tension.
8. Measure the course and wale spacings in the flat, relaxed fabric.
9. Calculate the relaxation in length and width from the formula:-

$$\text{Relaxation Shrinkage} = \frac{\text{Average change in length (or width)}}{\text{Original length (or width)}} \times 100\%$$

Equipment required.

Scissors
Rule
Indelible Marker
Automatic Washing Machine
Household Detergent
Tumble Dryer
Atmosphere for testing: 65± 2% R.H., 20± 2°C or as otherwise specified.

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