International Institute For Cotton

Technical Research Division

Manchester

Research Record No: 133

Project K2

Piece Mercerisation Of Single Jersey On The Kleinewefers Open-Width Knitgoods Mercerising Machine

A Report Of The Processing Carried Out At Joh. Mich. Engel Kg.

Peter F. Greenwood

November 1980

Classification: Fabrics/Knitted/Processing

Key Words: Engel, Dyeing, Kleinewefers, Mercerising, Single Jersey

Digital Version: February 2012

Contents

1 Introduction

As part of a continuing programme of study on the behaviour of knitted cotton fabrics in dyeing and finishing, a series of single jersey fabrics has been produced which are being subjected to a variety of dyeing and finishing treatments.

The production of these fabrics has been described in *Research Record No. 114*.

Although the full range of structures produced for this study contains 120 variants, these have not all been included in all of the finishing treatments which are being examined. The finishing programme for this full range consists of two variants, one in which the fabric is maintained in the tubular state throughout processing, while in the other the fabric is slit into open-width for final finishing. This part of the programme has been designated Project Kl.

In addition, a limited range of twenty constructional variants has been selected for study in a much more extensive programme of dyeing and finishing, which has been designated Project K2. A major section of this latter project is devoted to a study of the behaviour of single jersey fabrics when subjected to the process known as piece-mercerisation.

In recent years, machines for both tubular and open-width knitgoods mercerisation have been developed to full commercial operation. Both types of equipment have been included in the Project K2 programme, and this report describes the processing carried out, as part of Project K2 at the finishing works of Joh. Mich. Engel KG, Bad Sackingen, West Germany, where a Kleinewefers open-width knitgoods mercerising range has been in commercial production since 1977.

2 Project K2. Fabric Constructions And Coding

The twenty single jersey fabric constructions selected for study in Project K2 include both 24 and 28 gauge and both singles and two-fold yarns in each gauge. The range of 24 gauge fabrics was produced from Ne 28/1 and Ne 56/2 yarns, each in five stitch lengths, and the 28 gauge fabrics from Ne 36/1 and Ne 72/2 yarns, each again in five stitch lengths.

A fabric coding system was devised to describe the construction and finishing route for each variant. The coding consists of four sections; for example 24/1-28/291/1 refers to a 24 gauge fabric, knitted from singles 28s yarn to a stitch length of 0.291 cm and processed by finishing route #1. This coding system has been used to describe the fabrics in the tables of test results at the end of this report.

Two complete sets of fabrics, designated lots 9 and 10 were processed at the Engel finishing works. Finishing route 10 included processing on the Kleinewefers open-width mercerising range, followed by jet dyeing and open-width finishing. Lot 9 was dyed and finished in the same way, but was not mercerised. A description of the processing appears later in this report.

Because the only suitable dyeing machines available had three chambers, it was necessary to add another piece to each fabric set, so that equal lengths of fabrics could be processed in each chamber. The extra lengths produced for this purpose were of the following constructions.

Lot 9 (not mercerised) 24/2-56/354

Lot 10 (mercerised) 24/1-28/354

These codings were given the suffix "E" (for extra). The pieces were finished together with

the standard length and tested; the test data on these fabrics appear separately at the bottom of the tables in this report.

3 Processing Machinery at J.M. Engel

3.1 The Kleinewefers Mercerising Range

The open-width knitgoods mercerising machine at Engel consists of three main sections.

i) A short pin stenter with facilities for uncurling, straightening and overfeeding.

ii) A chainless merceriser of conventional design with saturator, nip and stabilising compartment.

iii) A batching unit which is transferred when full to a closed compartment in which neutralisation, washing and centrifuging are carried out.

Figure 1 shows the layout of the machine at Engel, seen from the cloth entry end, and a line drawing of the equipment.

Some of the more important dimensions of the machine are given below:-

Length of pin stenter	3.5 m
Fabric content of saturator	10.9 m
Fabric content of stabiliser	6.5 m
Capacity of batching unit	400 kg (at width of 150 cm)

For a more detailed description of the machine see the *Appendix* at the end of this report.

3.2 Dyeing and Finishing Machinery

Two Thies Roto-Stream jet dyeing machines were employed for dyeing these single jersey fabrics. It was perhaps slightly unfortunate that these were not identical, one being an atmospheric, the other a pressurised machine, although the basic design of both is the same.

The atmospheric version was used for dyeing the unmercerised fabrics. This was a Roto-Stream 100/3 with three chambers. The manufacturer's specification for this machine is given in *Figure 2*. Dyeing of the mercerised fabrics was carried out in a three-chamber Roto-Stream 140/3, as specified in *Figure 3*.

Final fabric drying and finishing was carried out on a Krantz four-bay Convey-air stenter. This was an indirect oil-fired, pin-frame, built in 1967.

4 Operational Planning

Almost all of the fabrics in this study could be described as non-standard constructions, and neither we nor any of our co-operating finishing companies could know exactly how these fabrics would behave during processing. Discovery of the means of forecasting this behaviour is, after all, one of the prime objectives of the entire project.

Guidelines for finishing these fabrics had nevertheless to be laid down before processing began and, therefore, targets were set based on certain assumptions and some educated guesswork.

The first assumption was that, in the weft knitted structure, length and width dimensions are inter-dependent, and therefore that the control of one will also give a good measure of control

to the other. Based on this, it was decided that a target should be set for the finished width of each variant based on the behaviour of the corresponding grey fabric in the IIC knitgoods relaxation test procedure (5 cycles, tumble-drying).

Earlier studies on the behaviour of knitted fabric in dyeing and finishing had indicated that relaxed fabric width tends to increase slightly after jet-dyeing, but is markedly reduced as a result of mercerisation. It was assumed that similar effects would be noted in this work on single jersey; further, and perhaps with less justification, it was also assumed that these effects would be constant across the range of fabrics in the study.

Targets for finished width were therefore calculated in the following manner.

i) Wale spacings were measured on the grey fabrics after relaxation (*Table 8*).

ii) Knowing the number of needles on the knitting machine, a figure for the width, after slitting, could be calculated for the relaxed grey fabric (*Table 26*).

iii) As width-way stretching helps to stabilise the fabric in the length direction, and as some residual width shrinkage is usually desirable, it was considered that the finished fabrics should ideally exhibit a residual width shrinkage of 10-12%. Bearing in mind the assumed effects of processing, it was decided to set target widths for fabric finishing as follows

- jet dyed, 1.17 *x* calculated relaxed grey width
- mercerised and jet dyed 0.88 *x* jet dyed target

These "target widths" are recorded in *Tables 26 and 27*.

It was realised, of course, that these targets would be reduced by any edge-trimming which would occur during processing. Discussions at Engel revealed that the normal practice was to allow 5 cm for edge-trimming loss, and to over-stretch fabrics by 4 cm during the final stentering to allow for the "creep-back" which was said to occur during transportation back to the customer.

A further restriction was placed on the finished target widths when it was considered impractical to adjust machines for each piece individually. It was decided therefore, to run the fabrics in lots, with the machine settings remaining constant throughout each lot. This is explained more fully in the next section.

5 Processing

Fabric processing at J.M. Engel took place during the week 9-13 June 1980. Members of the IIC Technical Research Division were present throughout to observe the operations.

5.1 Mercerisation

The fabrics for mercerisation were first arranged in increasing order of grey relaxed width, calculated as already described. On the basis of this arrangement, each piece was allocated a running number following the sequence M1 to M21 and the fabrics were then divided into three lots, each consisting of seven pieces. This is shown in *Table 27*.

The entry-zone pin stenter on the mercerising range was set to the following widths during processing.

lot 1 (pieces M1 - M7)	158 cm
lot 2 (pieces M8 - M14)	168 cm

lot 3 (pieces M15 - M21) 179 cm

These settings were recommended by the machine supervisor, Mr. Langer, based on previous experience. They were calculated by adding 13 cm to the original target widths.

The following observations were made during processing.

Caustic concentration	28-30° Bé
Caustic temperature	14-18 °C
Wetting agent	Mercerol SA flüssig (Sandoz)
Swelling time (impregnation + delay)	37 sec
Time in stabilising zone	28 sec
Wash water temperature	54 °C
Fabric speed	16 m/min

After stabilisation, the fabric was wound on to beams, one beam per seven-piece lot, for neutralisation and washing in the Centrifuga unit. Neutralisation was effected by the addition of 4 litres/hour of 60% acetic acid to the circulating water. The water temperature was maintained at 42-45 °C, and the fabric washed until approximately neutral (pH8 to universal indicator.) The beam was spun at 300 rpm to remove excess water, and the fabric then plaited into trucks for transportation to the dyehouse.

5.2 Dyeing

Dyeing was carried out in two Thies Roto-Stream jet dyeing machines. Although both were three-chamber machines of similar dimensions, they were not exactly identical, one being an atmospheric machine while the other was a pressurisable version for high-temperature operation.

Conveniently, as already described, the mercerised fabric had already been divided into three lots of approximately equal lengths. For dyeing these fabrics, the high-temperature jet was used, at atmospheric pressure; one lot being loaded into each chamber.

In accordance with the planned programme for project K2, the fabric was then peroxide bleached, followed by dyeing with 1.5% (on weight of fabric) of Procion Blue H-EG (ICI). A copy of the dyer's recipe sheet is shown in *Figure 5*.

The control fabrics were first arranged in a similar sequence to the mercerised fabrics, marked Cl to C21 as indicated in *Table 26*, divided into three seven-piece lots and loaded into the other Roto-Stream. The dyer's recipe sheet for processing these fabrics is given in *Figure 4*. As with all the unmercerised fabrics in Project K2, dyeing was carried out with 2% owf of Procion Blue H-EG.

Some of the additives mentioned in the recipe sheets may require explanation. Cerafil BFA (Böhme) is a stabilising agent for peroxide bleaching. Ludigol (BASF) is a product with anti-reducing properties, similar to Matexil PA-L (ICI) which has been used by other co-operators in this project. Adulcinol AL (Zschimmer and Schwartz) is a cationic softener.

The rate of fabric circulation in both machines was said to be 250 m/min Liquor ratios can be calculated from the information given in the recipe sheets as: for the unmercerised fabrics, 7.43; for the mercerised fabric, 8.91.

The higher figure for the mercerised cloth arose from the fact that it entered the dyeing machine wet, while the unmercerised fabric was, of course, still dry.

After dyeing, both batches were hydro-extracted. The unmercerised fabric which had been dyed in the tubular state was de-twisted, slit and plaited down. The mercerised fabric had already been slit into open-width prior to mercerisation; this was de-twisted by hand, and also plaited down. Both batches were end-sewn for stenter-finishing.

5.3 Stenter Finishing

The method for calculating the frame width settings for finishing these fabrics has been described in *Section 4*. On the basis of this method, the following stenter widths were recommended.

for the mercerised fabrics:

pieces	M1 - M7	134 cm
	M8 - M14	144 cm
	M15 - M21	155 cm

for the control fabrics,

pieces	Cl - C7	153 cm
	C8 - C14	164 cm
	C15 - C19	174 cm
	C20 - C21	186 cm

The fabrics were run through the stenter at a speed of 18 metres per minute, with an approximate dwell time of 50 seconds in the heated zone. The drying temperature was 120 °C. Edge gumming was carried out at the stenter entry, using Kantenstiefe FB (Böhme).

On leaving the stenter the fabric was allowed to fall into a scray and was then rolled under controlled tension on to cardboard shells using a Calator winding unit. Each piece was then marked, weighed and wrapped for transportation back to Manchester.

Fabric widths at this stage were also noted. These measurements appear in *Tables 26 and 27*.

6 Test Results

On arrival in Manchester, the fabrics were sampled for testing. The results of tests carried out on these fabrics, and on the equivalent grey fabrics, are given in *Tables 1-25*. A list of the tests carried out is to be found at the beginning of the tables.

Analysis of these results will take place over the next few months, together with data from the other finishing routes in Project K2, and therefore it is not considered appropriate to comment here, or to attempt to draw any conclusions. It should also be pointed out that these figures are at this stage to be regarded as preliminary, as re-testing and re-evaluation of these fabrics may be found to be desirable once the data analysis has begun.

One fabric property, wale spacing, will be singled out for special study. The reason for this is explained in the next section.

7 Wale Spacing - A Note

In 1975, IIC carried out a series of trials on the Kleinewefers open-width knitgoods mercerising unit Merceriser-Centrifuga MC10, at the finishing works of Pamucna Industrija

Duga-Resa, Yugoslavia. This machine, like the Engel equipment, is based on the Centrifuga beam-washing unit, but has a smaller impregnation section and no stabilising section or stenter entry.

The fabrics processed in these trials included several single jersey constructions. During the evaluation of these treated fabrics, it was noted that the wale spacing was not uniform across the fabric width, but narrowed considerably near the edges. The effect was apparent in both the unrelaxed and relaxed conditions.

Later on, samples from regular production on the machine at Engel were also found to show this effect. An example of one study of fabric from this machine is given in *Figure 6*.

The mercerised fabrics described in the present report have also been found in the unrelaxed state to show this effect quite markedly, although at the moment it is not known if, with these fabrics, the effect persists after relaxation. It is not apparent in the unmercerised fabrics.

The cause of the effect is not yet understood. One theory is that the width-way shrinkage which takes place in the mercerising liquor, which can be of the order of 30%, results in a longer path length through the machine at the fabric edges, compared with the centre. This could produce a higher tension at the edges, with consequent fabric distortion, rendered permanent by the mercerisation.

Another possible mechanism, perhaps more likely, is that the shrinkage forces in the centre of the fabric are not large enough to overcome the frictional restraints between the cloth and the roller surfaces.

A special study of this effect will be carried out on these fabrics during the next few months.

Key To Tables 1-25

1. Length shrinkage, %
2. Width shrinkage, %
3. Fabric weight, BW, gsm
4. Fabric weight, AW, gsm
5. Courses per 3cm, BW
6. Courses per 3cm, AW
7. Wales per 3cm, BW
8. Wales per 3cm, AW
9. Stitch length, BW, mm
10. Stitch length, AW, mm
11. Burst strength, BW, kN/sqm
12. Burst strength, AW, kN/sqm
13. Distension at burst, BW, mm
14. Distension at burst, AW, mm
15. Angle of spirality, BW, deg
16. Angle of spirality, AW, deg
17. Width, BW, cm
18. Yarn strength, BW, g
19. Yarn strength, AW, g
20. Yarn extension at break, BW, %
21. Yarn extension at break, AW, %
22. Yarn count, BW, Ne
23. Yarn count, AW, Ne
24. Fabric thickness, BW, mm/1000)
25. Fabric thickness, AW, mm/1000

BW Before washing, AW After washing

Table No. 1. Length shrinkage, %

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	2.69	15.63	17.85
24/1-28/306/	14.99	17.32	20.78
24/1-28/321/	13.94	18.07	23.28
24/1-28/337/	18.21	18.16	23.19
24/1-28/354/	23.13	19.93	26.18
24/2-56/291/	6.78	11.92	15.49
24/2-56/306/	11.22	11.15	18.1
24/2-56/321/	14.13	11.83	19.86
24/2-56/337/	17.12	15.02	19.51
24/2-56/354/	20.89	14.06	22.42
28/1-36/259/	15.76	17.14	21.7
28/1-36/273/	19.71	19.55	22.43
28/1-36/287/	20.02	19.88	25.73
28/1-36/301/	19.5	19.43	27.3
28/1-36/316/	21.96	22.26	28.19
28/2-72/259/	11.44	12.23	14.57
28/2-72/273/	14.35	14.68	17.39
28/2-72/287/	22.97	13.92	21.2
28/2-72/301/	21.65	14.34	19.92
28/2-72/316/	21.46	16.06	20.13
24/2-56/354/E		16.23	
24/1-28/354/E			24.68

Table No. 2. Width shrinkage, %

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	25.62	15.9	11.54
24/1-28/306/	21.15	18.98	12.6
24/1-28/321/	19.37	14.35	9.59
24/1-28/337/	18.26	15.73	12.99
24/1-28/354/	14.8	12.95	9.87
24/2-56/291/	24.72	14.92	12.21
24/2-56/306/	21.73	19.32	12.42
24/2-56/321/	21.78	15.4	11.54
24/2-56/337/	16.11	16.61	14.18
24/2-56/354/	13.61	17.63	11.32
28/1-36/259/	22.71	17.11	15.33
28/1-36/273/	20.04	12.9	10.87
28/1-36/287/	15.81	10.47	9.37
28/1-36/301/	15.73	13.99	12.1
28/1-36/316/	14.81	10.36	8.26
28/2-72/259/	23.56	18.1	14.22
28/2-72/273/	19.52	14.62	13.18
28/2-72/287/	15.69	19.96	13.91
28/2-72/301/	15.89	18.53	16.72
28/2-72/316/	13.11	14.74	12.78
24/2-56/354/E		17.34	
24/1-28/354/E			9.95

Table No. 3. Fabric weight,BW, g/sm

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	116.2	111.2	119.8
24/1-28/306/	105.3	95.8	100
24/1-28/321/	99	98.4	96.8
24/1-28/337/	94.6	90.2	88.4
24/1-28/354/	100	84.6	88.2
24/2-56/291/	115.3	114.2	112.8
24/2-56/306/	102.2	106.4	105.6
24/2-56/321/	92.2	98.6	100
24/2-56/337/	92.2	94.4	89.8
24/2-56/354/	90	86.2	86.2
28/1-36/259/	91.3	89.8	85.2
28/1-36/273/	88.5	84.4	86
28/1-36/287/	85.5	87.8	82.2
28/1-36/301/	78.4	76.2	68.4
28/1-36/316/	81	76	76
28/2-72/259/	95.8	95	99.2
28/2-72/273/	95	95	85.8
28/2-72/287/	84.8	85	86.8
28/2-72/301/	79.2	76	75
28/2-72/316/	82	79.6	80
24/2-56/354/E		83.4	
24/1-28/354/E			82

Table No. 4. Fabric weight,AW (g/sm)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	165.2	155.4	163.6
24/1-28/306/	159.6	151.6	150.2
24/1-28/321/	156	146	146.2
24/1-28/337/	152.5	138.6	~~138~~ 145.5
24/1-28/354/	145	138.2	147.8 not altered
24/2-56/291/	167.2	155.8	158
24/2-56/306/	160.6	144.6	151.2
24/2-56/321/	143.8	142.4	148
24/2-56/337/	132.4	136.4	139.6
24/2-56/354/	130	121.2	135.4
28/1-36/259/	139.4	138.8	133.6
28/1-36/273/	130	131	133
28/1-36/287/	122	126	134.6
28/1-36/301/	119.4	119	119.8
28/1-36/316/	120	111.4	118.2
28/2-72/259/	137.9	133.2	137.2
28/2-72/273/	127	126	139.7
28/2-72/287/	118	123.2	124.4
28/2-72/301/	114	117.6	118
28/2-72/316/	110	108	108.4
24/2-56/354/E		121.6	
24/1-28/354/E			144

Table No. 5. Courses per 3cm.,BW

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	61.2	49.7	47.3
24/1-28/306/	49.2	45.2	43.6
24/1-28/321/	47.1	42.3	38.6
24/1-28/337/	42.9	39.7	37.7
24/1-28/354/	37.6	37.7	34.4
24/2-56/291/	56.8	51	48.4
24/2-56/306/	49.9	46.7	43.9
24/2-56/321/	45.5	43.4	40.9
24/2-56/337/	41.1	41.1	39.1
24/2-56/354/	38.8	39	35
28/1-36/259/	56.4	53.9	42.8 49.7
28/1-36/273/	51.6	49.3	45.7
28/1-36/287/	48.5	47	42.4
28/1-36/301/	44.8	41.6	39.8
28/1-36/316/	42.8	39.3	36.8
28/2-72/259/	59.1	55.4	53.1
28/2-72/273/	53.4	51.6	47.7
28/2-72/287/	44.6	46.8	43.4
28/2-72/301/	43.6	44.7	42.4
28/2-72/316/	41	40.4	38
24/2-56/354/E		38.4	
24/1-28/354/E			34.1

Table No. 6. Courses per 3cm.,AW

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	61.4	58.2	57.2
24/1-28/306/	56.9	53.7	54
24/1-28/321/	54.1	50.3	50.1
24/1-28/337/	50.8	48.9	48.4
24/1-28/354/	48.6	45	46.2
24/2-56/291/	58.9	57.3	55.3
24/2-56/306/	56.3	51.8	52.5
24/2-56/321/	53	49	50
24/2-56/337/	49.3	47.6	46.7
24/2-56/354/	46.9	45.3	43.9
28/1-36/259/	66.2	64.2	62.7
28/1-36/273/	63.6	60.3	58.4
28/1-36/287/	59.1	56.1	55.7
28/1-36/301/	56.6	51.6	52.3
28/1-36/316/	53.8	49	49.5
28/2-72/259/	64.4	62.4	61.3
28/2-72/273/	61.8	59.7	57.4
28/2-72/287/	58.1	53.9	53.6
28/2-72/301/	55.5	51.1	51.8
28/2-72/316/	51.3	47.6	47.3
24/2-56/354/E		44	
24/1-28/354/E			44

Table No. 7. Wales per 3cm.,BW

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	33.2	36.5	39.1
24/1-28/306/	32.3	33.5	36.2
24/1-28/321/	33.1	34	37.6
24/1-28/337/	33.2	32.3	34
24/1-28/354/	32	31.4	34.9
24/2-56/291/	32.4	36	39.1
24/2-56/306/	31.6	34	39.2
24/2-56/321/	31.4	34.2	36.5
24/2-56/337/	32.2	31.9	34.6
24/2-56/354/	31.5	30.3	34.9
28/1-36/259/	38.1	39.9	~~49.7~~ 42.8
28/1-36/273/	37.8	39.4	42.5
28/1-36/287/	37.3	40.1	43.6
28/1-36/301/	38.4	38.3	38.2
28/1-36/316/	37.9	36.6	40.9
28/2-72/259/	37.4	39.4	43.1
28/2-72/273/	37.7	40.2	42.9
28/2-72/287/	38.2	37.4	41.5
28/2-72/301/	36.7	35.6	36.7
28/2-72/316/	37	36.2	37.4
24/2-56/354/E		30.1	
24/1-28/354/E			35.6

Table No. 8. Wales per 3cm.,AW

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	43.8	42.8	43.8
24/1-28/306/	42.1	42.1	41.5
24/1-28/321/	40.7	40	41.7
24/1-28/337/	39.9	38.8	39.9
24/1-28/354/	39	37.7	39.1
24/2-56/291/	42.8	42.6	43.8
24/2-56/306/	41.3	42	41.7
24/2-56/321/	40.4	40.3	41
24/2-56/337/	38.6	37.8	39.8
24/2-56/354/	36.3	35.7	38.7
28/1-36/259/	50.2	48.6	50.1
28/1-36/273/	48.4	46.6	49
28/1-36/287/	46.9	45.9	48
28/1-36/301/	46	44.8	46
28/1-36/316/	44.4	43.5	45.9
28/2-72/259/	49	48.9	49.5
28/2-72/273/	47.3	46.4	49
28/2-72/287/	45.2	45.7	46.8
28/2-72/301/	42.4	42.9	44.8
28/2-72/316/	41.4	42.7	43.4
24/2-56/354/E		35.8	
24/1-28/354/E			40.1

Table No. 9. Stitch length,BW (mm.)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	2.936	2.89	2.835
24/1-28/306/	3.071	3.042	2.965
24/1-28/321/	3.216	3.2	3.146
24/1-28/337/	3.397	3.351	3.273
24/1-28/354/	3.573	3.526	3.469
24/2-56/291/	2.91	2.867	2.802
24/2-56/306/	3.105	3.016	2.905
24/2-56/321/	3.225	3.185	3.065
24/2-56/337/	3.373	3.332	3.222
24/2-56/354/	3.538	3.479	3.401
28/1-36/259/	2.61	2.581	2.564
28/1-36/273/	2.77	2.727	2.706
28/1-36/287/	2.871	2.86	2.803
28/1-36/301/	3.046	3	2.996
28/1-36/316/	3.188	3.144	3.116
28/2-72/259/	2.55	2.542	2.463
28/2-72/273/	2.734	2.7	2.652
28/2-72/287/	2.844	2.831	2.804
28/2-72/301/	3.02	2.954	2.894
28/2-72/316/	3.192	3.118	3.052
24/2-56/354/E		3.494	
24/1-28/354/E			3.477

Table No. 10. Stitch length,AW (mm.)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	2.89	2.863	2.837
24/1-28/306/	3.015	2.957	2.981
24/1-28/321/	3.196	3.184	3.161
24/1-28/337/	3.35	3.311	3.305
24/1-28/354/	3.496	3.477	3.449
24/2-56/291/	2.906	2.82	2.809
24/2-56/306/	3.038	2.96	2.94
24/2-56/321/	3.15	3.094	3.071
24/2-56/337/	3.322	3.299	3.228
24/2-56/354/	3.512	3.373	3.394
28/1-36/259/	2.614	2.542	2.56
28/1-36/273/	2.742	2.662	2.715
28/1-36/287/	2.809	2.839	2.827
28/1-36/301/	2.976	2.963	2.98
28/1-36/316/	3.153	3.094	3.129
28/2-72/259/	2.563	2.538	2.486
28/2-72/273/	2.727	2.692	2.665
28/2-72/287/	2.833	2.809	2.786
28/2-72/301/	2.964	2.95	2.905
28/2-72/316/	3.114	3.088	3.068
24/2-56/354/E		3.444	
24/1-28/354/E			3.489

Table No. 11. Burst strength,BW (kN/sm)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	n.a.	474.9	598.6
24/1-28/306/	n.a.	458.1	529
24/1-28/321/	n.a.	422.3	526.1
24/1-28/337/	n.a.	411.7	449.2
24/1-28/354/	n.a.	386.9	445.6
24/2-56/291/	n.a.	661.6	777.8
24/2-56/306/	n.a.	625.5	681.4
24/2-56/321/	n.a.	605.5	419.7
24/2-56/337/	n.a.	573.1	619.4
24/2-56/354/	n.a.	556	597.9
28/1-36/259/	n.a.	398.9	448
28/1-36/273/	n.a.	370.5	436.2
28/1-36/287/	n.a.	387.3	451
28/1-36/301/	n.a.	321.7	368.2
28/1-36/316/	n.a.	310.3	391.6
28/2-72/259/	n.a.	535.2	630.1
28/2-72/273/	n.a.	531.3	575.9
28/2-72/287/	n.a.	497.9	504.8
28/2-72/301/	n.a.	471.1	516.1
28/2-72/316/	n.a.	458.1	490.6
24/2-56/354/E		566.6	
24/1-28/354/E			464.1

Table No. 12. Burst strength,AW (kN/sm)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	607.6	506	585.9
24/1-28/306/	575.8	493.5	567.3
24/1-28/321/	534.8	454.2	542.3
24/1-28/337/	494	427.5	496.2
24/1-28/354/	471.1	410.3	489
24/2-56/291/	761.7	671.9	795
24/2-56/306/	712.2	631.4	776.8
24/2-56/321/	702.9	588	728
24/2-56/337/	685.1	604.2	715
24/2-56/354/	653.4	578.8	681.7
28/1-36/259/	483.8	438.5	470.5
28/1-36/273/	483.5	414.8	456.9
28/1-36/287/	456.1	372	426
28/1-36/301/	412	369.3	409.5
28/1-36/316/	390.6	379	408.9
28/2-72/259/	641.6	580.3	664.3
28/2-72/273/	624.6	557.4	667.7
28/2-72/287/	620.5	547.3	605.2
28/2-72/301/	560.1	515.2	612.9
28/2-72/316/	544	493	584.3
24/2-56/354/E		549.6	
24/1-28/354/E			507.9

Table No. 13. Distension at burst,BW

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	n.a.	12.41	13.29
24/1-28/306/	n.a.	12.51	11.88
24/1-28/321/	n.a.	13.48	11.4
24/1-28/337/	n.a.	13.43	11.66
24/1-28/354/	n.a.	14	11.41
24/2-56/291/	n.a.	13.02	11.74
24/2-56/306/	n.a.	12.99	11.73
24/2-56/321/	n.a.	13.26	11.14
24/2-56/337/	n.a.	12.51	11.08
24/2-56/354/	n.a.	12.25	11.02
28/1-36/259/	n.a.	12.53	10.71
28/1-36/273/	n.a.	12.74	11.66
28/1-36/287/	n.a.	13.15	11.92
28/1-36/301/	n.a.	12.25	9.85
28/1-36/316/	n.a.	12.43	11.19
28/2-72/259/	n.a.	11.7	11.55
28/2-72/273/	n.a.	12.96	10.89
28/2-72/287/	n.a.	12.2	10.06
28/2-72/301/	n.a.	12.37	10.67
28/2-72/316/	n.a.	12.14	10.28
24/2-56/354/E		12.54	
24/1-28/354/E			10.52

Table No. 14. Distension at burst,AW

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	15.75	18.26	18.78
24/1-28/306/	18.48	18.12	19.25
24/1-28/321/	18.84	18.31	19.34
24/1-28/337/	19.31	18.77	19.37
24/1-28/354/	19.5	18.99	19.94
24/2-56/291/	15.13	18.16	17.43
24/2-56/306/	14.75	17.47	18.12
24/2-56/321/	18.77	17.61	18.62
24/2-56/337/	19.02	18.73	18.92
24/2-56/354/	18.23	18.76	18.8
28/1-36/259/	15	17.8	18.51
28/1-36/273/	18.59	18.03	18.62
28/1-36/287/	17.97	18.24	19.31
28/1-36/301/	18.87	18.23	19.41
28/1-36/316/	18.83	18.04	19.46
28/2-72/259/	14.9	17.19	17.63
28/2-72/273/	14.37	18.28	18.19
28/2-72/287/	19.18	18.22	18.26
28/2-72/301/	18.67	17.76	18.72
28/2-72/316/	17.6	18.08	18.77
24/2-56/354/E		18.11	
24/1-28/354/E			19.24

Table No. 15. Angle of spirality,BW (deg)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	13.09	6.43	4.14
24/1-28/306/	7.73	3.37	5.92
24/1-28/321/	17.54	1.44	2.16
24/1-28/337/	15.25	5.52	5.03
24/1-28/354/	11.53	7.02	4.55
24/2-56/291/	2.34	2.23	1.72
24/2-56/306/	2.63	1.73	1.4
24/2-56/321/	2.66	1.73	2.34
24/2-56/337/	1.19	1.82	1.64
24/2-56/354/	2.12	3.39	2.11
28/1-36/259/	12.67	3.38	4.45
28/1-36/273/	11.87	2.61	5.23
28/1-36/287/	17.96	5.14	4.99
28/1-36/301/	19.96	2.42	4.24
28/1-36/316/	15.39	2.22	3.77
28/2-72/259/	2.8	2.36	1.58
28/2-72/273/	3.62	3.08	2.2
28/2-72/287/	2.81	1.57	2.72
28/2-72/301/	1.42	2.37	2.1
28/2-72/316/	1.59	2.71	2.4
24/2-56/354/E		2.09	
24/1-28/354/E			6.55

Table No. 16. Angle of spirality,AW (deg)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	16.95	11.15	7.96
24/1-28/306/	18.88	13.41	9
24/1-28/321/	20.12	13.99	12.99
24/1-28/337/	21.8	16.44	11.41
24/1-28/354/	25.32	20.32	16.54
24/2-56/291/	2.47	-4.33	-6.76
24/2-56/306/	2.12	-5.23	-6.77
24/2-56/321/	-2.31	-4.66	-6.23
24/2-56/337/	-3.46	-7.26	-7.85
24/2-56/354/	-4.21	-6.19	-8.87
28/1-36/259/	20.08	11.79	10.39
28/1-36/273/	21.32	13.42	12.21
28/1-36/287/	24.53	15.66	13.82
28/1-36/301/	26.61	18.49	14.83
28/1-36/316/	26.45	20.23	19.31
28/2-72/259/	1.22	-6.9	-6
28/2-72/273/	1.25	-6.96	-7.96
28/2-72/287/	-2.39	-6.87	-7.35
28/2-72/301/	-2.92	-6	-7.6
28/2-72/316/	3.34	-7.53	-7.29
24/2-56/354/E		-8.09	
24/1-28/354/E			15.74

Table No. 17. Width,BW (cm.)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	89.37	150	133.5
24/1-28/306/	87.8	163	142.5
24/1-28/321/	88.43	161.5	141.5
24/1-28/337/	89.9	170.5	151
24/1-28/354/	89.5	172	150.5
24/2-56/291/	87.23	150	133.25
24/2-56/306/	88.3	160.5	141.5
24/2-56/321/	90.3	159	142
24/2-56/337/	88.5	170	153
24/2-56/354/	91.7	183.5	153
28/1-36/259/	82.03	150	133
28/1-36/273/	n.a.	148	132
28/1-36/287/	84.7	146	132.5
28/1-36/301/	86.2	163	141.5
28/1-36/316/	86.97	161	139.5
28/2-72/259/	83.63	151	132
28/2-72/273/	82.85	148	132
28/2-72/287/	82.13	160	140.5
28/2-72/301/	84.5	171	153
28/2-72/316/	86	163	152
24/2-56/354/E		183.5	
24/1-28/354/E			152

Table No. 18. Yarn strength,BW (g)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	270.5	276.5	307
24/1-28/306/	266.2	255.9	292.6
24/1-28/321/	271.8	253.1	286.3
24/1-28/337/	265.8	246.8	288.7
24/1-28/354/	252.6	242.1	285.8
24/2-56/291/	466	420.3	527.9
24/2-56/306/	488.2	456.2	523.3
24/2-56/321/	496.52	433.1	500
24/2-56/337/	516.14	424.2	537.3
24/2-56/354/	473.2	450.4	514.4
28/1-36/259/	191.3	203.1	221.4
28/1-36/273/	204.7	194.2	203.1
28/1-36/287/	190.69	192.7	211.6
28/1-36/301/	198.3	186	199.1
28/1-36/316/	208.7	175.8	216.2
28/2-72/259/	376.3	305	398.7
28/2-72/273/	355.4	320.6	390.7
28/2-72/287/	363.6	334.1	375.7
28/2-72/301/	352.8	335.9	395
28/2-72/316/	364.6	339.2	398.8
24/2-56/354/E		445.2	
24/1-28/354/E			269.8

Table No. 19. Yarn strength,AW (g)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	275.95	284	295.7
24/1-28/306/	256.87	303.4	305.4
24/1-28/321/	236.3	287.4	292.8
24/1-28/337/	252.08	259.8	298.6
24/1-28/354/	249.2	264.5	301.8
24/2-56/291/	453	468.4	521.4
24/2-56/306/	469.3	502.4	496.9
24/2-56/321/	440.9	456	511.9
24/2-56/337/	446.9	469.4	533.2
24/2-56/354/	470.2	493.5	545.1
28/1-36/259/	182.6	203.2	220.5
28/1-36/273/	197.6	203.4	210.4
28/1-36/287/	188.35	216.8	215.7
28/1-36/301/	184.2	204.8	210.6
28/1-36/316/	189.9	206	210.8
28/2-72/259/	325.78	358.5	371.2
28/2-72/273/	349.7	334.9	374.1
28/2-72/287/	334.9	345.6	362.6
28/2-72/301/	338.8	367.7	390.8
28/2-72/316/	354.2	363.7	378.9
24/2-56/354/E		461.4	
24/1-28/354/E			290.2

Table No. 20. Yarn extension at break,BW %

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	9.14	9.29	6.42
24/1-28/306/	7.59	6.82	5.8
24/1-28/321/	8.07	8.64	5.77
24/1-28/337/	7.76	7.31	5.77
24/1-28/354/	6.7	7.61	6.12
24/2-56/291/	7.16	7.05	7.16
24/2-56/306/	7.4	9.01	6.6
24/2-56/321/	6.94	9.03	6.63
24/2-56/337/	6.88	7.14	7.28
24/2-56/354/	6.65	7.93	6.2
28/1-36/259/	7.82	8.58	5.15
28/1-36/273/	8.1	8.86	5.24
28/1-36/287/	7.08	7.56	5.15
28/1-36/301/	8.28	7.17	4.71
28/1-36/316/	9.27	7.95	5.02
28/2-72/259/	9.02	6.73	6.56
28/2-72/273/	7.43	8.63	6.29
28/2-72/287/	8.73	6.81	5.69
28/2-72/301/	6.25	8.91	6.45
28/2-72/316/	6.7	6.98	6.13
24/2-56/354/E		7.21	
24/1-28/354/E			5.39

Table No. 21. Yarn extension at break,AW %

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	9.48	7.71	6.39
24/1-28/306/	8.94	7.99	6.4
24/1-28/321/	7.14	8.48	5.67
24/1-28/337/	9.99	7.97	6.05
24/1-28/354/	7.8	9.1	6.38
24/2-56/291/	8.911	8.98	6.76
24/2-56/306/	7.82	9.53	6.78
24/2-56/321/	9.77	9.03	6.73
24/2-56/337/	9.5	7.55	6.79
24/2-56/354/	9.42	9.43	6.51
28/1-36/259/	9.36	7.37	5.3
28/1-36/273/	9.44	8.31	5.4
28/1-36/287/	9.34	8.46	5.35
28/1-36/301/	9.71	8.71	5.15
28/1-36/316/	11.12	7.66	5.25
28/2-72/259/	9.36	7.09	6.12
28/2-72/273/	7.33	7.23	5.93
28/2-72/287/	9.46	6.8	5.74
28/2-72/301/	10.03	7.84	5.98
28/2-72/316/	9.14	8.92	5.75
24/2-56/354/E		7.43	
24/1-28/354/E			5.45

Table No. 22. Yarn count,BW (Ne)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	n.a.	29.07	28.62
24/1-28/306/	n.a.	29.81	27.82
24/1-28/321/	n.a.	29.69	28.98
24/1-28/337/	n.a.	29.41	28.53
24/1-28/354/	n.a.	29.42	28.81
24/2-56/291/	n.a.	28.5	25.93
24/2-56/306/	n.a.	28.95	27.56
24/2-56/321/	n.a.	28.54	27.46
24/2-56/337/	n.a.	28.42	27.45
24/2-56/354/	n.a.	28.48	27.97
28/1-36/259/	n.a.	38	38.23
28/1-36/273/	n.a.	39.27	38.77
28/1-36/287/	n.a.	38.41	37.19
28/1-36/301/	n.a.	38.82	37.93
28/1-36/316/	n.a.	38.9	37.82
28/2-72/259/	n.a.	37.18	35.26
28/2-72/273/	n.a.	37.84	36.42
28/2-72/287/	n.a.	37.19	36.34
28/2-72/301/	n.a.	37.06	35.78
28/2-72/316/	n.a.	37.03	36.28
24/2-56/354/E		28.86	
24/1-28/354/E			28.88

Table No. 23. Yarn count,AW (Ne)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	29.6	29.2	28.36
24/1-28/306/	29.2	28.45	28.46
24/1-28/321/	28.91	28.87	29.21
24/1-28/337/	29.11	29.36	29.02
24/1-28/354/	28.89	29.15	28.59
24/2-56/291/	27.64	29.58	27.91
24/2-56/306/	28	28.29	28.02
24/2-56/321/	27.85	28.91	27.59
24/2-56/337/	28.09	28.59	27.97
24/2-56/354/	26.97	28.31	27.99
28/1-36/259/	37.58	38.17	37.99
28/1-36/273/	37.23	37.48	38.12
28/1-36/287/	37.9	38.85	38.13
28/1-36/301/	37.96	37.96	37.66
28/1-36/316/	38.42	38.62	38.21
28/2-72/259/	36.21	37.03	36.34
28/2-72/273/	37.19	37.15	37.15
28/2-72/287/	36.22	36.91	36.84
28/2-72/301/	36.48	36.83	36.42
28/2-72/316/	37.39	35.63	36.81
24/2-56/354/E		28.71	
24/1-28/354/E			29.41

Table No. 24. Fabric thickness,BW (mm/1000)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	618	508	509
24/1-28/306/	593	488	487
24/1-28/321/	668	507	499
24/1-28/337/	650	508	486
24/1-28/354/	628	505	482
24/2-56/291/	621	502	482
24/2-56/306/	585	492	454
24/2-56/321/	574	509	469
24/2-56/337/	587	495	471
24/2-56/354/	604	508	462
28/1-36/259/	537	433	422
28/1-36/273/	517	444	432
28/1-36/287/	571	455	419
28/1-36/301/	528	450	409
28/1-36/316/	578	452	433
28/2-72/259/	559	433	420
28/2-72/273/	521	442	425
28/2-72/287/	520	433	415
28/2-72/301/	498	428	417
28/2-72/316/	521	439	412
24/2-56/354/E		488	
24/1-28/354/E			475

Table No. 25. Fabric thickness,AW (mm/1000)

Fabric	Grey	Dyed	Merc.&Dyed
24/1-28/291/	867	695	732
24/1-28/306/	952	705	728
24/1-28/321/	965	697	741
24/1-28/337/	957	724	758
24/1-28/354/	849	733	789
24/2-56/291/	789	651	707
24/2-56/306/	774	645	678
24/2-56/321/	882	653	679
24/2-56/337/	888	681	702
24/2-56/354/	836	668	706
28/1-36/259/	787	613	689
28/1-36/273/	796	628	701
28/1-36/287/	876	642	718
28/1-36/301/	869	656	717
28/1-36/316/	860	668	747
28/2-72/259/	719	572	618
28/2-72/273/	682	600	620
28/2-72/287/	812	592	649
28/2-72/301/	809	585	663
28/2-72/316/	757	598	610
24/2-56/354/E		662	
24/1-28/354/E			780

TABLE 26

CONTROL FABRICS: CALCULATED RELAXED WIDTHS,

FINISHING TARGETS AND MEASUREMENTS

unning Number	Fabric construction	Relaxed grey width (calc.) cm.	Relaxed grey width + 17% cm.	Finished width (trimmed) cm.	Width at sampling cm.
C 1	28/1-36/259	126.2	148.4	153	150
C 2	28/2-72/259	129.3	152.2	153	151
C 3	28/1-36/273	130.9	154.2	153	148
C 4	24/1-28/291	131.5	154.6	153	150
C 5	28/2-72/273	133.9	157.6	152.5	148
C 6	24/2-56/291	134.5	158	153	150
C 7	28/1-36/287	135	159	152	146
C 8	24/1-28/306	136.8	161	164	163
C 9	28/1-36/301	137.7	163.6	164	163
C 10	24/2-56/306	139.4	164	164.5	160.5
C 11	28/2-72/287	140.1	165	164	160
C 12	24/1-28/321	141.5	166.6	164	161.5
C 13	24/2-56/321	142.5	167.8	164	159
C 14	28/1-36/316	142.7	168	163.5	161
C 15	24/1-28/337	144.3	169.8	175	170.5
C 16	24/1-28/354	147.6	173.6	174	172
C 17	28/2-72/301	149.4	175.8	174	171
C 18	24/2-56/337	149.2	175.6	174	170
C 19	28/2-72/316	153	180	174	163
C 20	24/2-56/354	158.6	186.6	189	183.5
C 21	24/2-56/354E	158.6	186.6	190	183.5

TABLE 27

MERCERISED FABRICS: CALCULATED RELAXED WIDTHS

FINISHING TARGETS AND MEASUREMENTS

Running Number	Fabric construction	Jet dyed target (from Table 26) cm.	Jet dyed target - 12% cm.	Width on beam cm.	Finished width (trimmed) cm.	Width at sampling cm.
M 1	28/1-36/259	148.4	130.6	134	135	133
M 2	28/2-72/259	152.2	134	133	135	132
M 3	28/1-36/273	154.2	135.6	136	134.5	132
M 4	24/1-28/291	154.6	136	142	134.5	133.5
M 5	28/2-72/273	157.6	138.6	135	135	132
M 6	24/2-56/291	158	139	137	135	133.25
M 7	28/1-36/287	159	140	139	134	132.5
M 8	24/1-28/306	161	141.6	148	144	142.5
M 9	28/1-36/301	163.6	142.8	142	143.5	141.5
M 10	24/2-56/306	164	144.4	148	144	141.5
M 11	28/2-72/287	165	145.2	141	144	140.5
M 12	24/1-28/321	166.6	146.6	145	143.5	141.5
M 13	24/2-56/321	167.8	147.6	148	144	142
M 14	28/1-36/316	168	148	148	143	139.5
M 15	24/1-28/337	169.8	149.4	155	155	151
M 16	24/1-28/354	173.6	152.8	158	155	150.5
M 17	24/1-28/354E	173.6	152.8	156	155	152
M 18	28/2-72/301	175.8	154.6	149	154	153
M 19	24/2-56/337	175.6	154.6	154	155	153
M 20	28/2-72/316	180	158	150.5	155	152
M 21	24/2-56/354	186.6	164.2	157	155	153

Figure 1. Kleinewefers Open-Width Knitgoods Merceriser

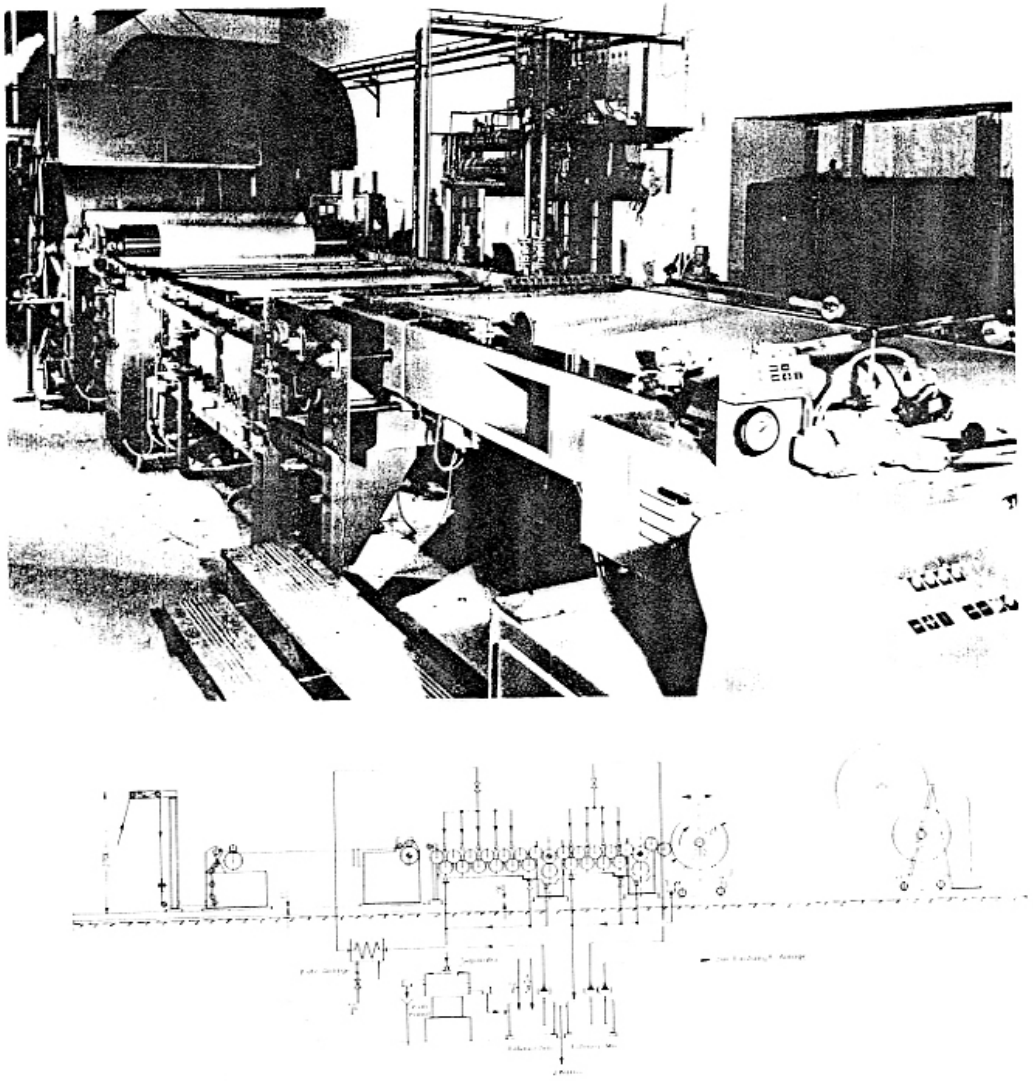
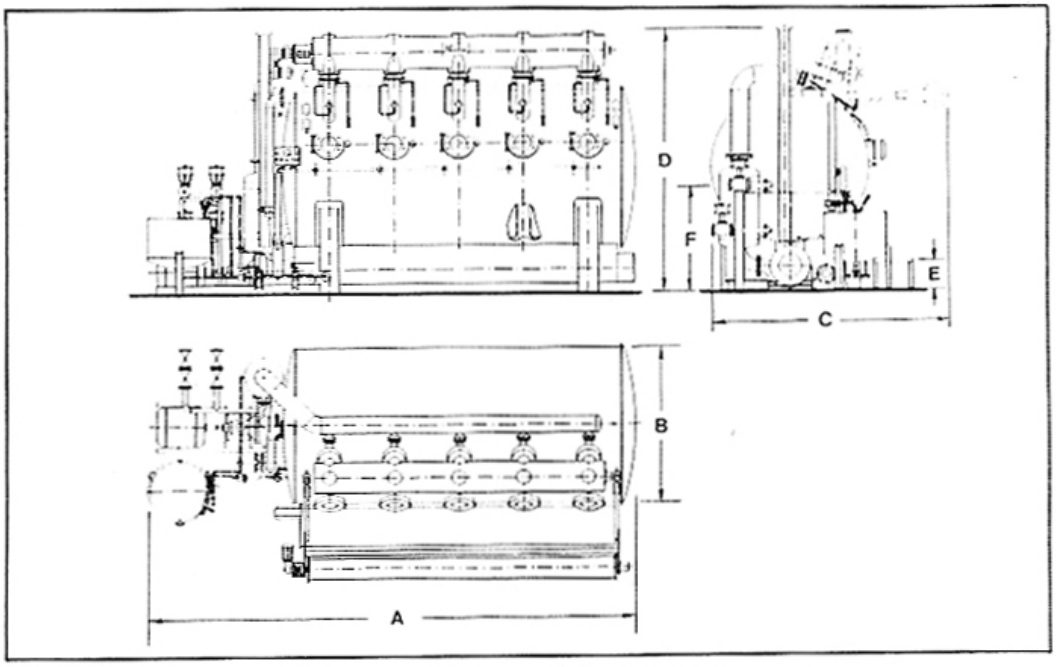


Figure 2. Thies Roto-Stream Atmospheric Jet Dyeing Machine



Short liquor dyeing machine Roto-stream 100 suitable for dyeing woven and knitted fabrics of natural and man-made fibres and their blends.

Design:
Available with 1—6 fabric stores.
Rated capacity per store: 130 kg.

High productivity. Fabric efficiently transported by adjustable geared motor that drives the winch, by the jets, and mechanically by rotation of the inner, undriven drum. Fabric speed adjustable from 55 to 400 m/min. Rate of liquor circulation 2—4 cycles/min. Reduced energy consumption through short liquor ratios (4:1 to 15:1).

Standard model consists of:
dyeing vessel with drum; winch housing with winch (driven by adjustable geared motor); circulation pump with connecting pipes; heat exchanger (choice of one or two-chamber type); loading and unloading mechanism; locking devices and controls.

Accessories: sampling device, seam locator, fabric run monitor, filter, salt dissolving device, colour shop.

Degrees of automation (control)

M = manual operation, electropneumatic temperature control
P = electropneumatic control of valves and temperature
P40 = punch card control of functions for dyeing unit, additions tank and colour shop.

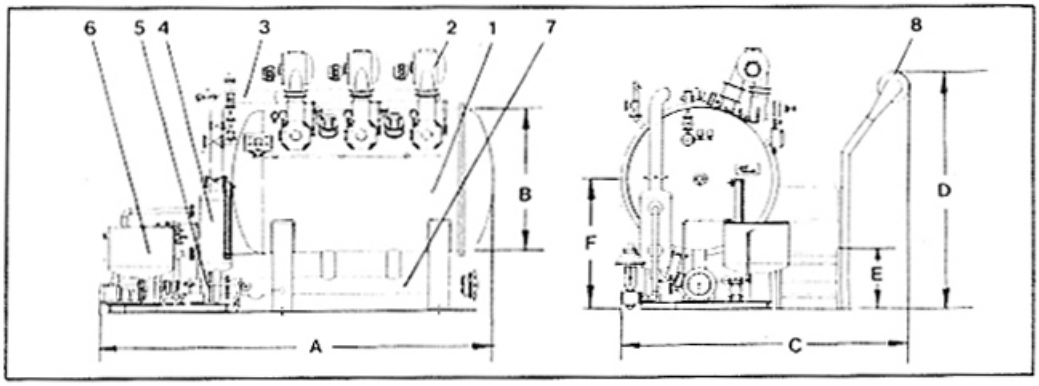
Machine sizes Roto-stream	100/1	100/2	100/3	100/4	100/5	100/6
No. of chambers	1	2	3	4	5	6
Max. load, kg *	80—130	160—260	240—390	320—520	400—650	480—780
liquor ratio	4 : 1 to 15 : 1					
required motor power (KW) 50 Hz, 1500 rpm	11	15	22	30	30	30
rate of heating with saturated steam at 4—6 bars from 20 °C to 100 °C	6 : 1 for rated capacity in median range: 4 °C/min					
rate of cooling at 3 bars cooling water pressure and 15 °C starting temperature	100 l cooling water/min/store, median range (from 100 °C to 60 °C) : 3 °C/min					
A length overall, mm	2600	3450	4350	5250	6100	6900
B drum dia., mm	2000					
C width overall, mm	3050					
D height of unloading roller, mm	2650					
E platform height, mm	400					
F water inlet valve	1100					

* depending on type of material. All details subject to design modifications.

Figure 3. Thies Roto-Stream High-Temperature Jet Dyeing Machine

roto-stream

The Roto-Stream 140 is a short liquor rope dyeing machine for woven and knitted goods. The liquor ratio can be varied to suit requirements.



Design features:

Partly flooded HT dyeing machine with 1–6 chambers. Winches driven by DC motors. Fabric transport by winch, jet and rotation of freewheeling inner drum. Liquor ratio 4 : 1 to 15 : 1. Fabric speeds up to 600 m/min. Rate of liquor exchange 2–6 circulations/min.

Operation and control

Simple operation through partial or complete automatic control. Choice of PE, P40 or P80 control unit to customer's order.

1. Pressure vessel with inner drums
2. Winch drive with DC gear motors
3. Pressure line
4. Pipe heat exchanger
5. Circulation pump
6. Addition tank
7. Suction line
8. Loading and unloading winch

Technical specification

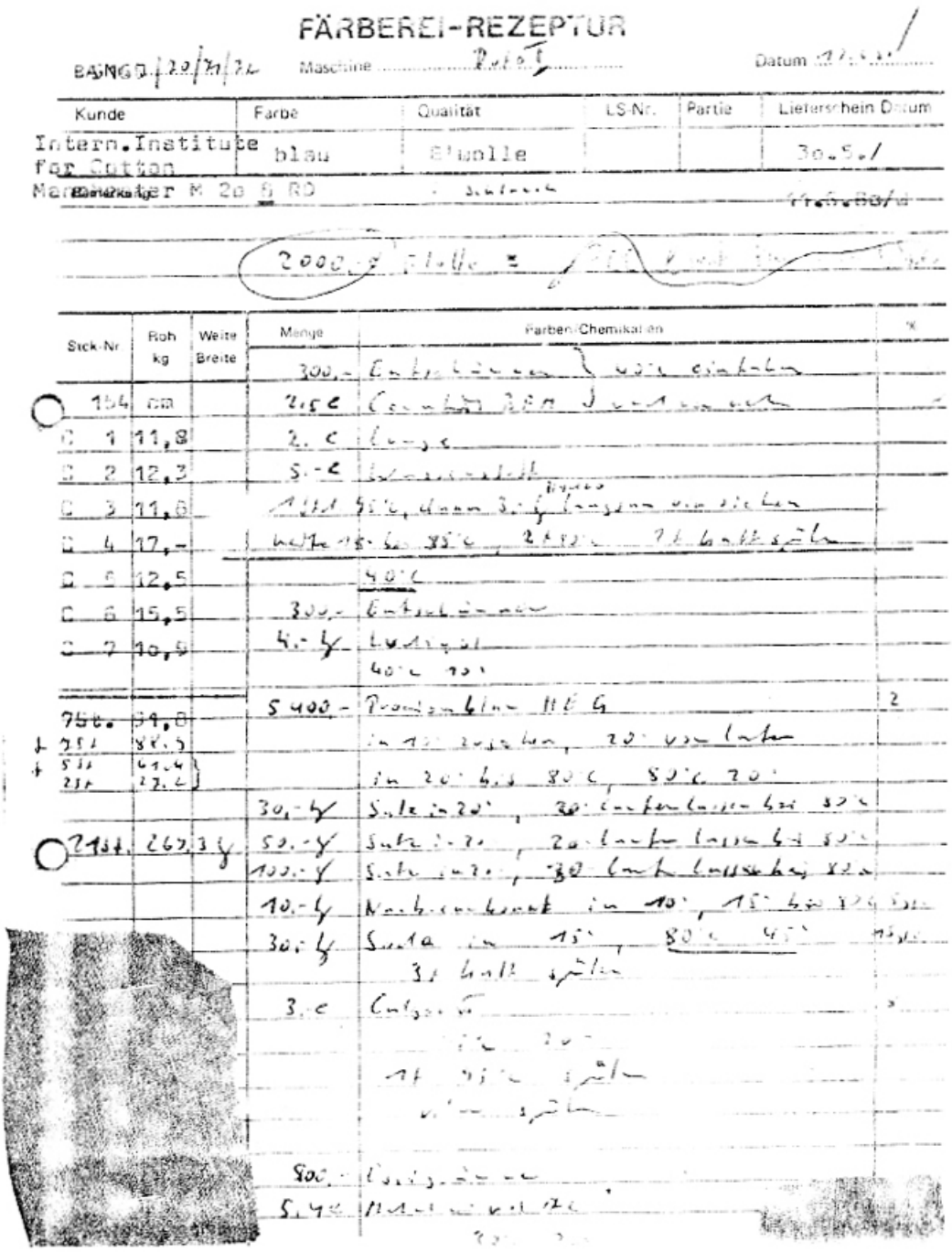
Machine size Roto-Stream	140/1	140/2	140/3	140/4	140/5	140/6
No. of chambers	1	2	3	4	5	6
Max. load, kg*	80–130	160–260	240–390	320–520	400–650	480–780
Liquor ratio	4 : 1 to 15 :1					
Max. working pressure	3.5 bar at 140 °C					
Rate of heating at 6 bar Saturated steam 20–140 °C	4 °C/min					
Rate of cooling at 3 bar Cooling water pressure at 20 °C	4 °C/min					
Motor power required kW	15	30	30	37	37	55

Space requirement	140/1	140/2	140/3	140/4	140/5	140/6
A	3400	4250	5150	6000	6900	7800
B	2000					
C	3850					
D	3100					
E	800					
F	1750					

Thies

* Load varies with type of goods. The company reserves the right to introduce modifications

Figure 4. Dyer's Recipe Sheet - Unmercerised Fabrics



FÄRBEREI-REZEPTUR

Kunde	Farbe	Qualität	LS-Nr.	Partie	Lieferschein Datum
Intern. Institute for Cotton	blau	Flanelle			30.5.71

Stck-Nr	Roh kg	Weite Breite	Menge	Farben/Chemikalien
154	cm		2,5 g	
1	11,8		2. c	
2	12,3		5.- c	
3	11,6			
4	17,-			
5	12,5			40°C
6	15,5		300.-	
7	10,9		4.- g	
				40°C
756.	94,8		5 400.-	
751	88,5			
5	41,4			
2	22,2			
			30.- g	
2151.	267,3 g		50.- g	
			100.- g	
			10.- g	
			30.- g	
			3. c	
			800.-	
			5,4 c	

Figure 5. Dyer's Recipe Sheet - Mercerised Fabrics

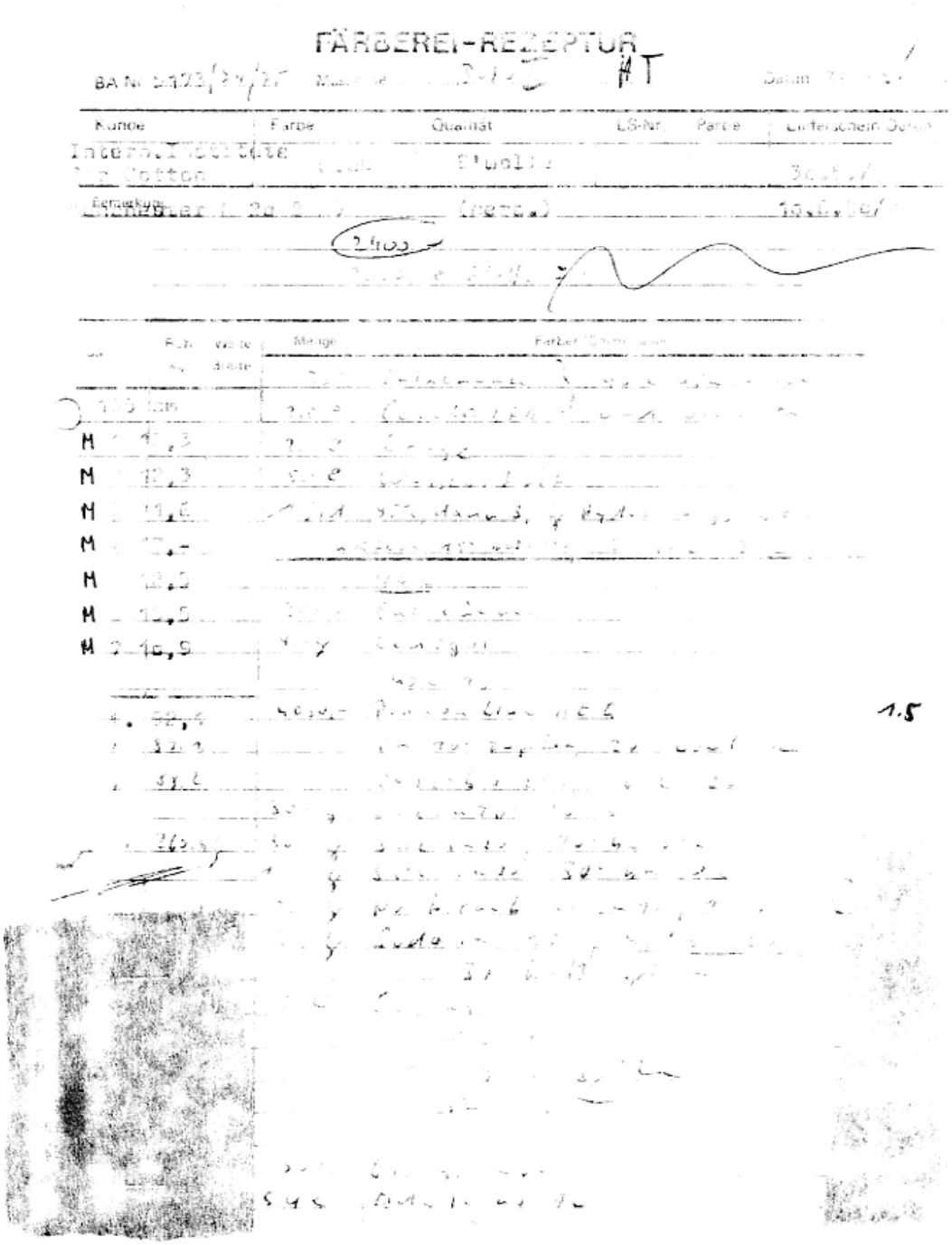
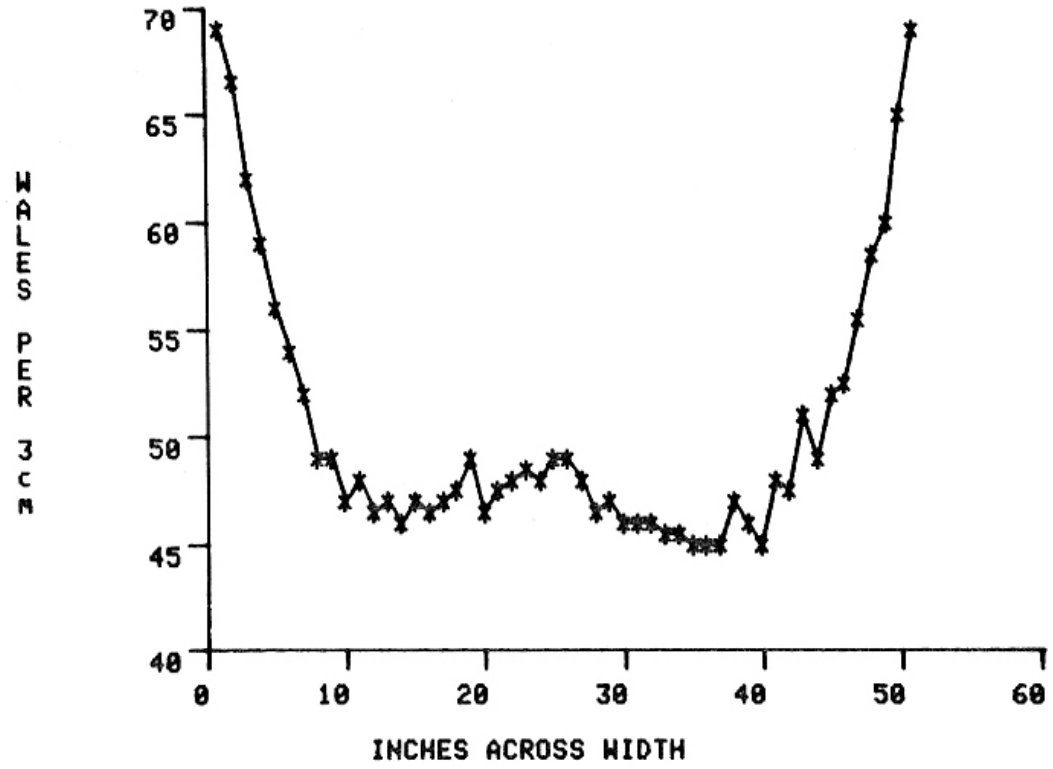
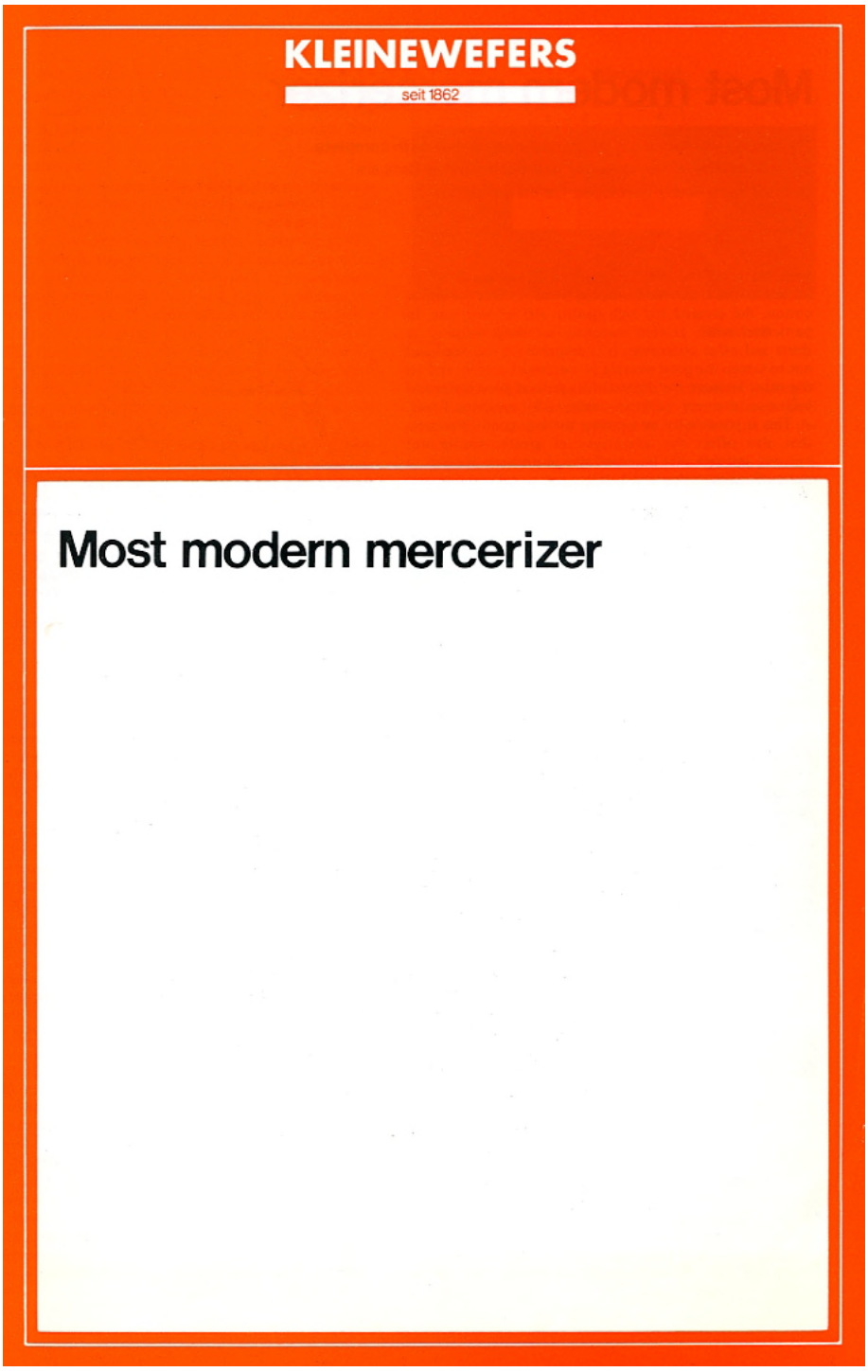


FIG.6 Open-width mercerised single jersey, (relaxed). Wale spacing variations across fabric width.



Appendix



Most modern mercerizer

Controlled mercerization of knitted piece goods with complete reproducibility of the chemical and technological data are claimed for a newly developed German machine

With the rapid rise in the production of knit goods which started in 1967, and the increasing trend towards the use of cotton, the demand for high quality articles also rose. In particular, when knitted materials are used to produce shirts and other outerwear, it is desirable on the one hand not to forego the good wearing properties of cotton, and on the other to meet the demand for fabric of good lustre and brilliance, the very qualities displayed by synthetic fibres.

This is possible by mercerizing the knit goods, a process that also offers the advantages of greater tensile and bursting strength and improved dye absorption. Savings in dyestuff consumption and better dimensional stability and shape retention result.

Owing to its high production costs, yarn mercerizing is certain to be increasingly replaced by piece mercerizing. Hitherto large quantities of yarn have been mercerized because the existing plant were not designed to meet the special requirements of loomstate knit goods, whose low dimensional stability created many problems in fabric guiding, mercerizing, stabilizing and neutralization. These had to be solved by the machine builders.

The Centrifuga mercerizing machine (Fig. 1) from Kleinewefers of Krefeld, now in production for several years, is a chainless mercerizing machine for the treatment of open knit goods which permits good length control and, as against chain mercerizing machines, reasonably good width control also. The roller surfaces hold not only the edges but the whole width of the fabric in the right position. This method of transport also keeps curling of the edges within tolerable limits.

Hitherto the Centrifuga has only used the tension created by the shrinking effect of caustic soda (26-30° Bé), no further increase in tension by mechanical means being possible. The length, width and fullness were thus limited, as these dimensions depend entirely on the shrinkage potential of the loomstate material and the shrinking effect of the caustic soda. Consequently demands for higher and reproducible lustre, greater consolidation of the fabric and perfect maintenance of elasticity in width could not be met.

In cooperation with clothing manufacturers and textile finishers Kleinewefers have now developed a new design, which is said to solve all these problems. This new plant (Fig. 2) consists of a fabric feeding unit, a tensioning field comprising vertically rotating pin chains, a fabric transfer system to the mercerizing section, a chainless mercerizing unit, a squeezing unit followed by a chainless stabilizing section, a final squeezing unit, the batching and prewashing unit and a separate Centrifuga chamber for neutralization and preparatory processes, such as bleaching with hypochlorite or peroxide.

The knit goods are guided through this plant in a tightly controlled form. Only in two places, where it cannot be avoided and over a distance no greater than 4 cm, is the fabric left loose. Hence the fabric is at all stages throughout

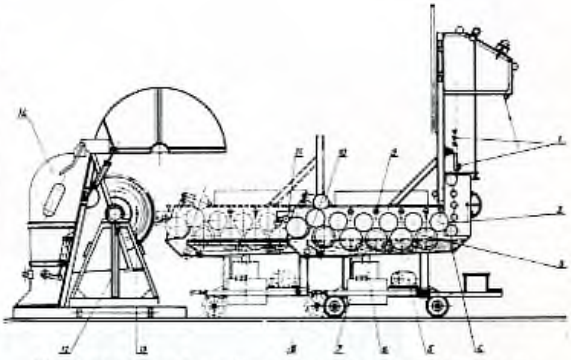


Fig. 1. Diagram of Centrifuga mercerizing plant type MC. 1, edge guider; 2, rubber covered rollers; 3, steel rollers; 4, collecting treugh; 5, drive motor; 6, liquor filter; 7, feed tank with level control; 8, pneumatic connexion; 9, jets; 10, squeezing unit; 11, pressure gauge; 12, Centrifuga carriage; 13, squeezing unit; 14, Centrifuga chamber

the process strictly controlled in respect of extension and shrinkage, length and widthwise.

The tension field presents the fabric to the mercerizing machine with pre-set width and length and corresponding shrinkage in width. Additional feed-in gadgets, such as edge uncurlers, guiders, expanders etc allow even single jersey with unglued edges to be pinned and presented to the mercerizing machine. It is important that during the transition from the tensioning field to the mercerizing section (Fig. 3) the free path of the fabric is as short as possible before it is gripped by the combination of driven rollers. This short path of not more than 4 cm prevents an uncontrolled change in dimensions and recurling of the edges. The fabric then travels tightly gripped by the combination of top and bottom rollers through the mercerizing section (Fig. 4).

This section contains six bottom steel rollers, half immersed in the mercerizing bath. Five of them are driven. Seven rubber-covered top rollers lying on them rotate freely with the bottom rollers. The fabric content of this section is 10.9 metres.

A 12-ton squeezing unit takes the fabric, still tightly held, over from the last rubber-covered top roller and transfers it to the first top roller of the stabilizing section.

There are again four bottom rollers in this stabilizing section, two of them driven, and five rubber-covered top rollers freely resting on them. The fabric content of this section is 6.5 metres. Still tightly held, the fabric is then taken over by the final squeezing unit and led to the last guide roller.

Coming from this last guide roller, the fabric is wound on the Centrifuga drum under controlled tension (Fig. 5). At this point the control of fabric tension is of vital

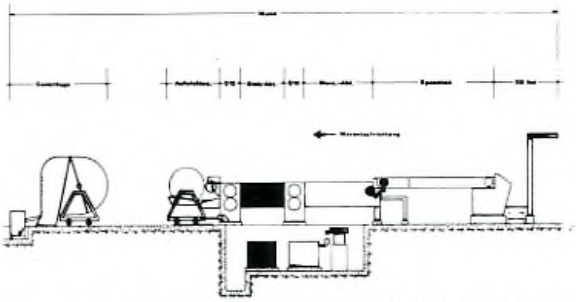


Fig. 2. Mercerizing and preparing plant for knit goods. Centrifuga: batching-up: stabilizing compartment: mercerizing compartment: tensioning field. Direction of goods

importance, since all subsequent treatments on the Centrifuga depend on it. The Centrifuga, running on rails, moves away automatically as a function of the increase in diameter of the batch. As Fig. 5 shows, the diameter of the batch is constantly monitored by a feeler. With every cm of diameter increase the feeler sends an impulse to a motor, which in turn moves the carriage 1 cm away from the last roller by means of a worm-screw. The distance of the batch can be regulated by setting the adjustable running time of the motor. This system keeps the free passage of the fabric very short, to prevent uncontrolled shrinkage and possible curling of the edges.

Pre-washing already starts during batching. When this is completed the Centrifuga carriage is moved into the

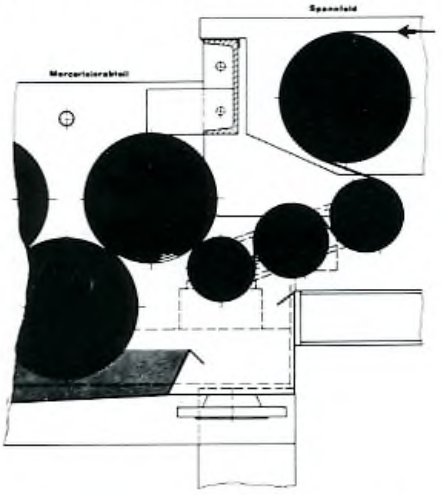


Fig. 3. Transition from tensioning field to mercerizing compartment. Mercerizing compartment: tension field

Centrifuga chamber, where all other subsequent processes, such as final rinsing, neutralization and perhaps bleaching and centrifuging, are carried out.

The whole installation is fitted with a DC multi-motor drive, thyristor-powered and with adjustable speeds of rotation. The speeds, which often vary, are set by fine adjusting potentiometers, within limits of ±10% between two adjacent drives, i.e. between tensioning field and draw-in to the mercerizing section, between the latter and the squeezing unit at the end of the mercerizing section, between this squeezing unit and the intermediate drive of the stabilizing section, between this and its squeezing unit. Picked up by differential measuring devices, this change in speeds is registered digitally on appropriate instruments.

Fig. 6 shows the path the liquor takes in the mercerizing and stabilizing sections, as well as the storage points for the chemicals required. It also shows an example of an automatic metering device. Water and caustic soda (50° Bé) flow to a metering pump from two supply tanks (top left), which are continuously refilled by level controls. The ratio of metering the two components (H_2O and NaOH) is adjusted in order to give the required concentration of

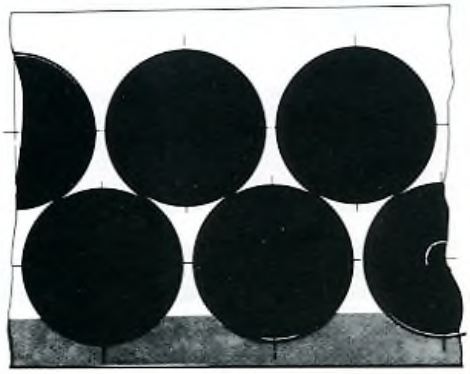


Fig. 4. Tightly controlled path of fabric in the mercerizing compartment

26-30° Bé in the mercerizing section. The two-component metering pump, regulated by a level control, delivers the liquids to a mixing tank (bottom right), from where the caustic soda, now in its correct concentration, flows through a cooling system to the spray pipes above the top rollers.

The cooling system not only eliminates the heat of dilution of the caustic but also that created by the exothermic mercerizing process, and automatically keeps the temperature of the mercerizing bath constant at the required value of 10-15°C. After the fabric has been thoroughly wetted in the mercerizing compartment, the caustic soda flows via an overflow – as already mentioned, the bottom rollers are half immersed in the batch – to an

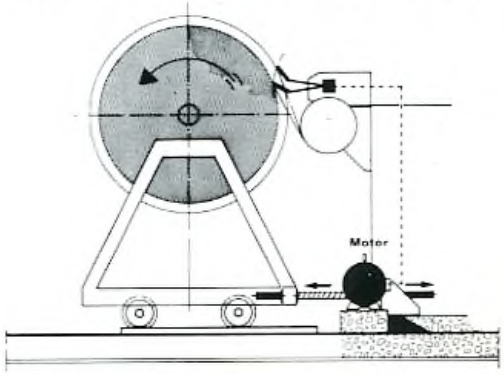


Fig. 5. Distance control between Centrifuga and mercerizing machine

oscillating sieve where it is freed from fluff, threads etc. Only then does it return to the mixing tank, and from there it flows once more in steady circulation through the cooler to the mercerizing section. The cooling water of the cooling system is utilized in the stabilizing section.

The water required for rinsing is pressed into the Centrifuga drum by a pump, passing on its way through an adjustable heat exchanger – shown left in Fig. 6 – and a liquor quantity control. Inside the drum are two rubber sleeves, which are adjusted according to the width of the fabric and inflated by compressed air to 5 atm. This guarantees the penetration of the batched up fabric over its whole width.

The water leaving the batch is collected in a trough. Part of it is returned to the mixing tank of the stabilizing section if the caustic content of the latter demands it; the rest goes to waste.

From this mixing tank, which can be heated, the water is pumped to the spray pipes above the top rollers. The water, now saturated with the caustic soda carried over by the fabric, passes over an overflow and is returned to the mixing tank. From here it either passes to a caustic soda recovery plant or is discharged to the drain. For the viable operation of a recovery plant, the concentration of the caustic soda solution should be at least 6° Bé. If no recovery plant is used, the concentration in the stabilizing section should not exceed 1-1.5° Bé in the interest of shorter rinsing and neutralizing times and in order to save water and power.

However installation of a recovery plant is generally recommended. This soon amortizes itself since, depending on the production capacity of the mercerizing plant, production costs per kg of knit goods can thereby be reduced by up to 18%.

After completion of batching and simultaneous pre-rinsing, the batch is moved into the Centrifuga chamber. Up to 400 kg of a fabric 150 cm wide can be wound on one batch. It is then tied with alkali-resistant tapes to prevent unravelling. The chamber is then closed and the fabric rinsed, neutralized and bleached. This operation can be controlled either manually or automatically by a punched card system (Fig. 7).

Rinsing water and solutions of chemicals are pumped to the Centrifuga drum from a mixing tank fitted with a heat exchanger (left). A flow meter controls the amount of liquid, and heating can be arranged in temperature intervals. The diagram of the temperature control is shown at top right. To guarantee penetration of the batch over its whole width and through all its layers, the batch rotates throughout the process at speeds from 20 to 150 rpm. For the final removal of water from the knit goods, the batch rotates at a maximum speed of 200 rpm. Depending on the type of process, the batch is either led to the drain or returned over sieves to the mixing tank, two or three-way valves being used.

The technical parameters and some typical results are:

1. Caustic soda concentration in the mercerizing compartment: Investigations carried out by Mecheels indicate that highest lustre is achieved at a caustic soda concentration of 27-30° Bé. Higher concentrations do not improve the lustre but rather reduce it. Results achieved over the years in practice confirm these findings. As it is reasonable to assume that these conditions are also valid for knit goods, all experiments were carried out at a concentration of 30° Bé.

2. Temperature of the caustic soda in the mercerizing compartment: The degree of lustre also depends on the temperature of the lye. Although lower temperatures affect wetting, especially as swelling of the fibre starts as soon as wetting begins and thus hinders further penetration by the caustic soda, best results are obtained at temperatures of 12-18°C. As knit goods, from their open structure, are less liable to be affected by this resistance to penetration, we worked at a temperature of 14°C. We also added 3 g/l of a mercerizing wetting agent to the caustic soda.

3. Reaction time: Woven goods usually require a reaction time of 50-60 seconds for optimum results. Since knit goods are more easily wetted, as mentioned, the reaction time can be reduced to 40 seconds. This increases

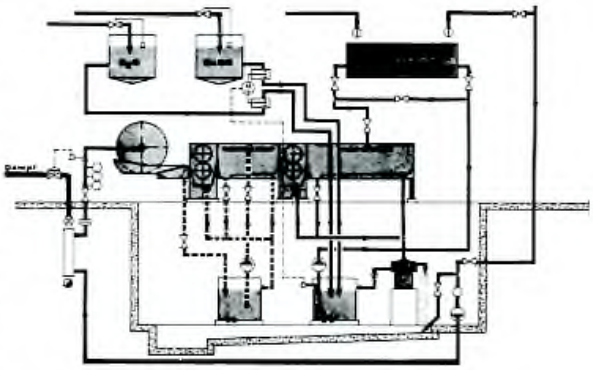


Fig. 6. Path of liquor in mercerizing and stabilizing sections. Dampf = steam

the production rate to 16 m/min. on the mercerizing plant presented here.

4. Concentration and temperature in the stabilizing compartment: As mentioned earlier, the concentration in the stabilizing compartment depends on whether or not a caustic recovery plant is used. If knit goods pass through strongly alkaline liquor at high temperature they may lose their elasticity; moreover loss of waxes can entail a harsher handle. The experiments were therefore carried out at a concentration of 1-1.5° Bé and at a temperature not over 40°C.

5. Conditions during pre-washing on batching: At first

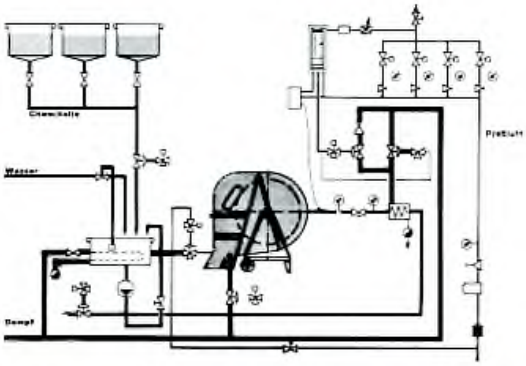


Fig. 7. Path of liquor and process control system on the Centrifuga. Chemicals: water: steam: compressed air

some 4.5 cu.m of water per hour were pumped through the Centrifuga drum during batching. This was increased with increasing diameter of the batch until at the end of the operation a quantity of 6.5 cu.m/h was put through. The temperature of the water was kept at 40°C for reasons mentioned above.

6. Conditions during washing, neutralizing and bleaching in the Centrifuga chamber: The fabric was washed for 20 minutes at 4 different r.p.m's, the water consumption being 6.5 cu.m/h. Neutralization occurred for 12 minutes at 40°C with dilute acetic acid and under circulation. The speeds of revolution were also varied. A further washing period under the conditions mentioned above and a final cold rinse for five minutes followed. Hydroextraction at 200 r.p.m. lasted 15 minutes. Processing time thus amounted to a total of 67 minutes. Centrifuging can be omitted and the washing process shortened if washing is followed by bleaching, since this treatment is after all carried out in an alkaline medium. Using peroxide for bleaching, the process would take about 60 minutes under circulation.

The mercerization of knit goods produces good dimensional stability. The subsequent processes of bleaching, dyeing etc could affect this stability and must therefore be so effected that no permanent changes in dimensions occur. Bleaching by the Centrifuga system is such a process, as it does not affect the dimensional stability fixed during mercerizing and stabilising. In any case, any subsequent operation must be carred out without excessive stretch, width or lengthwise, to maintain the improvement in stability until the treatment has ended.

7. Machine technological possibilities and their effect on the structure of the knit goods after mercerizing: Kleinewefers' new design, combining a tensioning field with a chainless mercerizer, ensures tightly controlled guiding of the fabric, and the drive described above allows great variability in respect of changes in loop structure and the production of lustre.

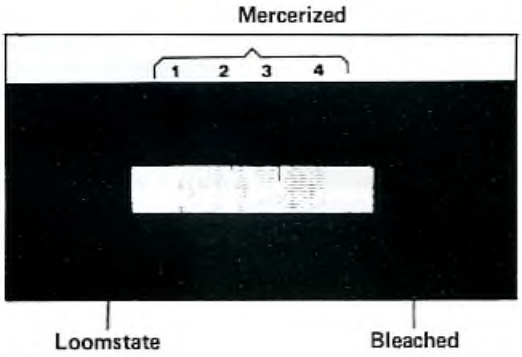


Fig. 9.

E.g. mercerization can be so conducted that the knit goods retain their loomstate width and length and hence also their number of wales and courses per cm, so that the loss in area weight is solely due to the removal of waxes and other impurities by the caustic soda. The elasticity of the fabric is fully maintained. On the other hand it is also possible to satisfy extreme demands for lustre and fabric density, by allowing full shrinkage widthways under corresponding increase in length in a reproducible manner.

With an interlock material of 147 g/sq.m loomstate weight and 190 cm open loomstate width, the following finishing requirements had to be met (Fig. 8):

Width on entering merc. compartment	Width after neutral. = width after drying	Difference between feed-in roller and tensioning field	Total difference between tensioning field and stabil. squeezing unit	g/m²	Courses/cm	Wales/cm
1 190 cm	168 cm	−5%	+8.2%	116	15.5	20.0
2 170 cm	153 cm	−6%	+4.7%	124	16.5	19.0
3 157 cm	145 cm	−8%	+7.0%	130	17.5	18.0
4 157 cm	144 cm	−8%	+7.0%	136	18.0	19.0
	Towards bleaching and dyeing					

Fig. 8. Interlock, 100% cotton, courses 15/cm, wales 23/cm, loomstate weight 147 g/m² loomstate width open 190 cm

Width on entering merc. compartment	Width after neutral. = width after drying	Difference between feed-in roller and tensioning field	Total difference between tensioning field and stabil. squeezing unit	g/m²	Courses/cm	Wales/cm
Merc. 160 cm	151 cm	−5%	+3.0%	130	15.0	18.0
Merc. & bleached 160 cm	151 cm	−5%	+3.0%	133	15.0	19.0

Fig. 10. Single jersey, 100% cotton, courses 14/cm, wales 20/cm, loomstate weight 139 g/sq.m., loomstate width open 160 cm

Width on entering merc. compartment	Width after neutral. = width after drying	Difference between feed-in roller and tensioning field	Total difference between tensioning field and stabil. squeezing unit	g/m²	Courses/cm	Wales/cm
158 cm	151 cm	−5%	+3.0%	116	14.5	15

Fig. 12. Single jersey, 100% cotton yarn dyed, courses 13.5/cm, wales 17/cm, loomstate weight 121 g/sq.m., loomstate width open 160 cm

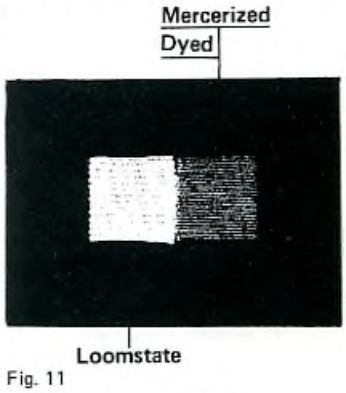


Fig. 11

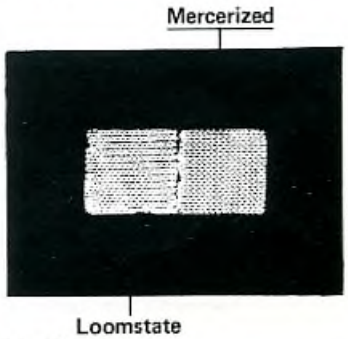


Fig. 13

Fig. 14. Centrifuga mercerizing plant type MC

- The fabric had to be as compacted as possible so as to obtain a very smooth surface with a silky lustre.
- Its elasticity in width had to be fully maintained.
- The finished width had to be 144 cm after bleaching, which meant a width shrinkage of 24%. Length stretch had to be so controlled that the area weight did not fall below 130 g/sq.m.

Experiments with this fabric established the influence on fabric width, area weight and loop structure after mercerizing of the following factors: Width on entering the mercerizing compartment of the chainless mercerizer, difference in speed between the entering rollers to the tensioning field and the chain, difference in speed of the total overfeed between tensioning field and final squeezing unit. The results appear in Fig. 8.

The narrower the fabric at constant length extension on entering the mercerizing compartment, the greater the area weight (see experiments 1 and 2, Fig. 8). Simultaneously the number of courses per cm increases while that of the wales remains almost constant. To obtain the fabric structure required, the fabric had to enter the mercerizing compartment even narrower and had to be stretched even more lengthways. The area weight then reached the required value. The additional increase in the number of courses per cm also produced the very dense appearance of the fabric. Already after mercerizing the residual shrinkage did not exceed 3.5% in length and 1-2% in width.

Experiment 4 in Fig. 8 shows the results with this fabric after bleaching in a Thies jet, type R95. They indicate a further consolidation in width and length, increasing the area weight from 130 to 136 g/sq.m. This also explains the improvement in residual shrinkage after bleaching and drying. The shrinkage tests were carried out in a standard domestic washing machine of 5 kg capacity, type Lavamat, at 60°C.

The change in the appearance of the fabric and its loop structure as a result of these four experiments is shown on the samples illustrated in Fig. 9. For photographic reasons the rows of loops are shown at right angles to their normal position. The progressing consolidation from experiment to experiment can be clearly seen.

Fig. 10 shows the parameters and results for a single jersey. Owing to the low shrinkage caused by keeping the fabric loomstate width on entering the mercerizing compartment and owing to the greatly reduced extension in length, the number of courses rose only from 14 to 15 per cm, while that of the wales fell from 20 to 18 or 19. These conditions could be considered normal, i.e. an extension in length in the mercerizing compartment of 3-5% to achieve the required lustre, combined with relatively low weight loss and maintenance of full elasticity both ways.

Fig. 11 shows the difference in structure of samples of loomstate and dyed materials. It is also significant that there are no dyestreaks along the edges, although this mercerized single jersey was dyed in a jet, with unglued edges. It is of course also possible to mercerize yarn-dyed material, provided the dyestuffs are fast to mercerizing. Fig. 12 shows the processing parameters and Fig. 13 the loop structure. The residual shrinkage of the two last named articles was below 4% in length and width.

8. Permanence of the mercerizing lustre: Knit goods from single yarns in particular used to lose lustre after a few domestic washes, accompanied by a loss of colour brilliance. This is caused by the migration of individual fibres to the surface of the yarns. As Peter F. Greenwood found in his investigations, this can be avoided by applying a suitable permanent finish, without the resin's causing any loss in strength.

9. Dyeing properties of mercerized knit goods: It is well known that mercerizing increases the dye affinity of cotton. This is due to an increase in the size of the intra-molecular and submicroscopic spaces of the native cellulose, with consequent better access to the interior of the fibre. Furthermore, in dyeings with reactive dyes by the exhaust method, savings in dyestuff consumption amounted, depending on the depth of shade, to 30-70%. Investigations carried out by Greenwood indicate that this could be the case with different and vat dyes.

SUMMARY

The machinery for the mercerization of knit goods described above allows the production of articles hardly distinguishable from those produced from mercerized cotton yarn, as far as the structure of loomstate knit goods permits. This is made possible:

- By exploiting not only the shrinkage tension caused by the action of caustic sosa, but also the additional tension which can be applied without causing uncontrolled changes in their dimensions;
- Because the combination of tensioning field and chainless mercerizer, together with the tightly controlled guiding of the fabric throughout the whole process, not only give ample scope for achieving a desired appearance of the fabric, but allow complete reproducibility at any time, and
- Because the characteristic properties of a knitted fabric are maintained. ■