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Textile finishing

MERCERIZATION - 2 1/

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MERCERIZATION - 2

1. Introduction

I have been invited to give you in my lecture some informations about the

"Practical aspects of modern mercerisation techniques".

Mr. Allan Heap will present very interesting informations about fundamental research work done under IIC-Contracts and its aspects. I am affraid it will be difficult to give to my lecture a similar attractivity.

We shall rather scrutinize with a critical mind our aims and work as finishers, as well as those of the machinery manufacturers, taking the present state of our knowledge into consideration. We should do this even though nobody enjoys critic and self critic is embarrassing.

Finally we have to consider the conditions of the market and the qualities it requires.

2. Practical aims

Discussions about mercerisation start normally with John Mercer's discovery in 1844. I depart from this normal way and start my exposition with a simple question:

"What do the practical men, especially the finisher, expect from the mercerisation?"

In view of the considerable investment in equipment, the processing costs and the ecological problems, this question is justified! Depending to whom you ask the question, a dyer, a printer, a finisher, or a salesman, the answer will be different. Easy dyeability, good covering of immature cotton, good dye yield, deep and brilliant colours, are important to one person, a good starting base for finishing, that is, a good pre-setting at the highest possible width, high strength in view of w+w-finishing to the other, beautiful colours, silky lustre and handle and minimum surface loss to the third.

The respective weight of the mentioned criteria is of importance because of their close connection to the equipment to be used and with the processing methods. It can be assumed that until the recent past the greatest importance has been given to the criteria of the dyer. A serious discussion about the importance of the mercerisation for the textile finishing took place only in recent times, and the practical experience and knowledge of long ago received its scientific confirmation and acceptance within the new processing methods. I think here especially of the decisive importance of the fibre structure for the technological qualities of a fabric as related to the w+w-finishing.

Every finisher knows the stored strains in the material he has to work with resulting in different and obvious consequences. Yarn and fibre internal strains are most of the time less obvious, although they have nevertheless their consequences. Let me numerate a few of the consequences we experience as finisher and consumer: shrinkage, wrinkling or misiness after wetting,

fraying, edgecurling, harshness of handle, extreme loss of tensile strength after w + w-finishing, reduced abrasion resistance, lowered crease recovery.

The formation of blocked strains is unevitable during the industrial production of yarns and fabrics. During the finishing processes we add some more; think of the modern continuous open-width treatment with its pronounced tension in warp direction, or at the stenter frames, where we try to regain the lost width and this, to often, with the fabric-chain still under tension.

PARISOT (1) has published informative date about the influence of strains due to yarn and fabric manufacturing and processing on the tensile strength. KASSENBECK (2) proved the existance of stored strains in the cotton fibre resulting from its growth and has shown their importance for the technological characteristics.

Strain conserving factors in the micro range, that is, in the fine structure of the fibre, are secondary valence forces, in the range of yarns and fabrics frictional forces. For the finisher of synthetics it is selfevident that he eliminates these strains in an early stage of his work by heating the material up to the polymer softening temperature under controlled length- and cross-tension during an exactly specified time. He calls it "setting" and has learned since a long time to carry this process out with all the due care. This simple way can unfortunately by the cotton finisher not be used for the temporary elimination of inter- and intrafibrillar secondary bonds in cotton. A close look reveals him, that the only way to eliminate these blocked fibre internal strains is a strong swelling. The known mechanical processes such as compressive shrinkage or the ML process, need for their realisation also a swelling factor, this is water. But water is a relatively weak swelling agent and is capable to eliminate the fibrillar interactions only partially. The results obtained can for this reason easily disappear in case of a later rewetting. The method of crosslinking, often used in practice, cannot be - for obvious reasons - considered

as a satisfactory solution of the problem. It cannot eliminate existing strains but, at the best, block them temporarely with a negative influence on the tensile strength.

In practice, the only effective method is the mercerisation. The caustic solution loosens, through its strong swelling action, interfibrillar and partially also intermolecular binding forces and realizes the necessary conditiones for the equalization of strains. However the success depends in practice essentially on the finally reached swelling state through to the fibre cross-section. During the deswelling under controlled conditions a new interfibrillar oder takes finally place.

Caustic soda is still the classic swelling medium, although the literature mentions a multiplicity of other products. Liquid ammonia received during the last years a great publicity, but had not the corresponding diffusion. Possibly, various reasons are responsible for this.

But let us return to our question: "Why mercerisation"?
We have considered with certainity dyeing as the main reason and as further cirterion of increasing importance the requirements for the finishing. In the expositions which follow special attention will be given to this aspect. Lustre as the third effect is remaining. We still need the silky lustre of a good mercerisation. It is asked for shirt and blouse fabrics and ladies dress goods. Optimum effects not only result from mercerisation, but also from the yarn and fibre material. Unfortunatly these are often out of the finishers control, and also often prejudice his efforts.

This statement leads us to the next question: "How does look mercerisation in practice, do we really do good work"?

3. The available knowledge is better than are the practical realisations

It is my firm conviction that the available knowledge is better than is the practical realisation, seen from the qualitative as well as economical and ecological point of view. This statement is valid for the finisher as well as for the machine manufacturer, to whom we are dedicating a special chapter.

Let us take an overall view of our work under the aspect of our earlier answer, that the dyers interests are the main reason, and that fibre and cloth setting are of secondary importance, for this finishing step. Accordingly we find that the simple caustic soda treatment at low concentration between 18 and 22°Bé, at normal temperature and with reaction times of 20 - 30 sec - but in certain cases up to several hours - is of common usage. This continuous process is done on simple roller units or on mercerising installations with little or moderate longitudinal tension. Small plants arrange often for a caustic soda impregnation on a padder, followed by batching and - after a retention time of variable duration - washing on jiggers or open-width washing machines.

For a full mercerisation is the use of installations common which are built especially for this purpose and which can be divided in two groups: the chain equipped mercerising range, and the chainless type. Each system has its devoted admirers. The caustic soda concentration is somewhere around 28 - 31°Bé, the temperature between 15 and 35°C and the time of contact with the caustic between 20 - 60 sec. Concerning tension it is more different to define the working rules. This is true especially with the chainless mercerising ranges. In contrast to the chain equipped range, which makes a well defined cross-stretch possible, the main aim is here probably to reduce as much as possible the loss in width by an adequate tension.

But the success in mercerising depends on still other decisive factors. I think here especially of the preparatory state of the cloth before mercerising. In practice we find all kind of

conditions, from the raw material to the raw cloth in a desized state, boiled-off or even bleached material, and also the mercerising of fabrics of wet or dry condition.

All these conditions are so decisive for the end result that we have to consider them a little further.

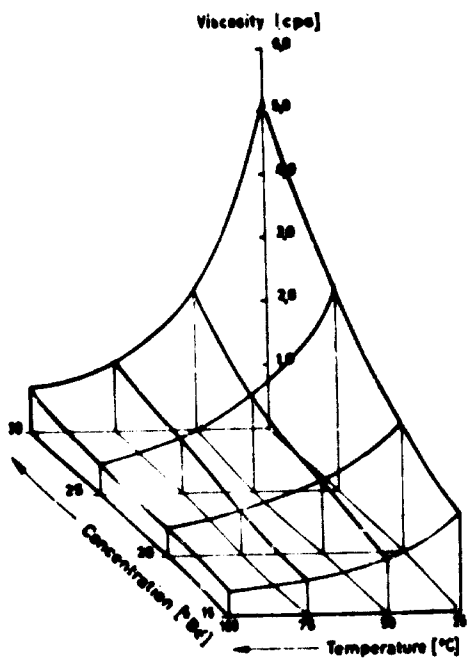
The critical textile chemist in close contact with the practice notices that the working methodes have little relation to the cloth to be treated, its condition and the expected results. A similar statement can be made concerning the manufacturers of mercerising machines. This is especially difficult to understand, because an extraordinary number of publications on basic and practical aspects of mercerisation are available. An excellent compilation of the literature until 1965 has been published in the brochure No 93 of the SHIRLEY INSTITUTE (3). Since this date interesting reports have been published by BORSTEN et al (4), KAERRHOLM and ASNES (5), MARTE and LEIMBACHER (6), FIERIEC et al and HEAP (7), BREDERECK and HEAP (8). It will be necessary, in the now following considerations about our working method and the state of our knowledge, to discuss several aspects of immediate practical importance.

Let me beginn this critical investigation about <u>impregnation</u> with the caustic soda. As a matter of course we give to this operation in the dyehouse all the attention it needs, because the consequences of a bad work become visible here. We are not used to give the same attention to a similar happening during the mercerisation. Till now, even the machinery manufacturers have neglected this important step. In most cases this neglect does not became apparent, but in view of our earlier considerations it must be comprehensible, that a bad impregnation leads to differences in swelling of yarns and fibres and thus forcibly to the formation of new strains, instead of eliminating existing ones. The effects on the technological characteristics of the cloth, especially after a easy care finishing, can only be negative.

We must therefore demand that the swelling agent, the caustic soda, comes in good and uniform contact with the fibres, and

make sure that it penetrates into the deepest capillary spaces between the fibres of our yarn. In practice, however, this demand is very difficult to satisfay. The wetting of the fibres especially if we mercerise dry grey-cloth, is already difficult. Wetting agents are offered as expedients, but a careful choice has to be made. Their presence can have unpleasant consequences in the caustic soda evaporators, through heavy, foaming, or decomposition. It is astonishing that a cheap auxiliary agent, which has still other advantages, has hardly been used: Alcohol of the aethanol or isopropanol types. The yarns of our fabrics contain an enormous number of smallest capillaries between fibres, of which it is very difficult to eliminate the enclosed air or water during impregnation. In practice, cloth tension increases the proximity of the fibres and the soaking becomes even more difficult. In addition the outer fibres of the yarn begin to swell immediately after contact with the caustic. A fact which works again, in an unfavourable direction. Impregnation of the cloth in a completely relaxed state should give better results, but a length and cross shrinkage would have to be accepted, which, at least for the chainless mercerizers, is not desirable.

We have to consider also, that the caustic soda, at the concentration and temperature for mercerisation, has already a considerable viscosity, unfavourable for the impregnation and the transport into the capillaries. But a decrease in viscosity can only be obtained through a higher temperature. This will have still other significant consequences, which have to be discussed in the next chapter.

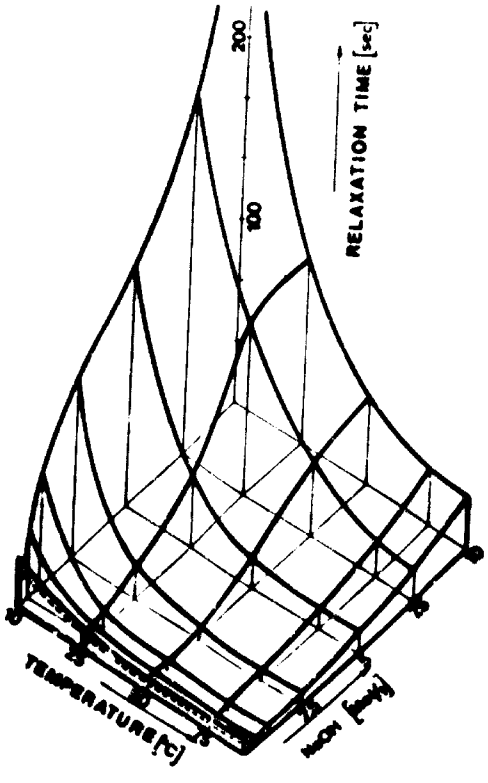


The next process controlling factor of decisive, but often misunderstood, importance, to which we will have a closer look is the swelling time. A review of the great volume of literature about swelling of cellulose with the help of swelling media, reveals that it concerns - until very recently - exclusively the static aspects of swelling and with the results obtained. This means in practice, that such an important process as mercerisation can hardly be based on any research of the kinetic of the swelling phenomenon. This is so much more astonishing, as with other stages of textile processing as for instance. The curing of w + w-finishes we have not only learned to fix a temperature corresponding to the reactant/catalyst system, but also to take the kinetic of the heat transfer into consideration. We have to consider, that the mercerisation presents a similar problem. Whereas in the case of curing we are faced with a heat flow, there ist here a material flow, that ist, the transport of NaOH into the fibre.

If we need for the mercerisation, for the optimum elimination of restored strains an equal optimum as well as homogeneous swelling, it must be comprehensible that the necessary attention has to be given to the criterion swelling speed. We are obliged to ask us the question which criteria have to be considered and which control factors are at our disposal.

Parameters / Swelling Med.	Wetting Time [sec]	Surfacetension [dyn/cm]	Relaxationst. [sec]
Water	8,5	73	12,6
NaOH 28°Bé pure	35,9	81	31,7
NaOH 28°Bé pure + wetting agent	21,3	26	23,8
Caustic leye 28°Bé from M.-M. + wetting agent	29,0	41	27,2
NaOH 28°Bé + C_2H_5OH - 5 ml/l	6,0	54	18,8

This summary of wetting times and relaxation times of the swelling of cotton with some swelling agents on dry, cleaned and bleached cotton linters shows relationships which are important in practice. The listed wetting times lead to the opinion that at least in some cases wetting is poor. When comparing these values with the surface tensious of the media, it is not difficult to recognize, that no correlation exists. If, in addition, we compare with the swelling speed, it appears that the theoretical representation of what happens during mercerisation with caustic soda must be widened, since it is evident that it is not only the wetting which is decisive. It is absolutly clear, that we have to consider diffusion as a further factor of great importance in our system. The correlation with time is therefore evident.



The present figure shows us in a three-dimensional diagramm, again measured on linters, how the swelling relaxation time is related to the caustic soda concentration and to the temperature. The deflection which shows at the concentration level of 0,2 mols of caustic soda indicates, that the diffusion is limited at the beginning by a swelling due to water, for which the inter-fibrillar

and inter-molecular bonds are responsible. But with the alcali concentration increasing, a reversal takes place. Swelling turns to be controlled by diffusion. The favourable influence of the temperature appears clearly. The increasing de-hydration of the diffusing NaOH molecules as well as of the cellulose is responsible for this phenomenon.

RELAXATIONTIMES OF SWELLING

C° TEMPERATURE	BLEACHED LINTERS		KIERED COTTON YARN		GREY COTTON YARN	
	NaOH 7,5 m	NH_3 -40 C°	NaOH 7,5 m	NH_3 -40 C°	NaOH 7,5 m	NH_3 -40 C°
25	91,4	28,0	93,7	8,3	•	4,2
90	9,5		10,5		248,5	

Caustic soda temperature gives us a possibility to control diffusion speed. In practice no use is made of it, because the necessary equipment is not in existence yet. In the earlier literature are indications that the mercerising lustre is influenced in a negative way by the caustic soda temperature. Recommendations based on exact investigations are found only in the more recent literature (6), (7), (9). Let us control this anticipation on the table shown on slide 4. For these measurements the cotton-linters have been presented in raw, boiled-off and boiled-off and bleached state. In addition to caustic soda this table shows the corresponding measurements for liquid ammonia. The comparison of liquid ammonia with NaOH of normal mercerising concentration and at the usual working temperature.

of 25°C shows that liquid ammonia has a much shorter swelling relaxation time. An increase of the caustic soda temperature can, however, as it is shown, on the second line, increase the swelling speed considerably.

One fact appears clearly from this table: the exceptional strength of the liquid ammonia process for the treatment of raw cotton, an in contrast to this, the difficulty of raw mercerisation with caustic soda. This fact seems to me important because the raw-mercerisation, seen from the point of view of the process, offers a certain number of interesting aspects, such as touch and lustre. The table shows also that the conditions are much more favourable to the caustic soda with boiled-off cloth, and this especially at a higher temperature.

Trying to interprete the information of this table, we must come to the following, for the practice important, considerations: The development in opposite directions of the relaxation times of both media, in dependence on the degree of purity of the cotton, must be attributed to different control mechanisms acting during the swell. If we keep present the fact, well known in colloid chemistry, that the solubility of a polymer depends, on one side, on the strength of the intermolecular linking forces, and on the other, on the solvatation capacity of the solvent, we arrive at the hypothesis that liquid ammonia has, compared to NaOH, a lower swelling action that enables it for this reason to penetrate extremely rapid into the cotton fibres. It seems, that it is not capable, in contrast to the caustic soda, to provoke a strong swell, even on the primary wall, with their relatively weak H-bonds, and also in the secondary layers, kept open by accompanying substances which are present in the grey cotton fibre. With an increasing degree of purity of the fibre and as a result increasing strength of the present bindung forces, the relaxation time for liquid ammonia increases; the diffusion is now limited by the swell. In opposition to this, the swell due to NaOH proceeds in a typical diffusion controlled way. The slow-down effect appears especially strong with the raw-fibres. With the elimination of the easily and stronghly swelling primary wall and the extraction of the accompanying substances out of the

secondary wall layers by a caustic boil-off, the slow-down effect goes almost completely lost. After this statement it must also be evident, that the presence of sizing agents must be the origin of additional complications during conventional mercerisation of not desized raw cloth. Under these conditions simulated swelling tests could show no penetration of the test samples even after a very long time.

Special conditions we found also for the wet mercerisation. Depending from the water content, the penetration takes place with a more or less great delay. The swelling develops strongly diffusion controlled. Based on our measurements, we can surmise that an optimal swell is far from being reached in practice with the usual caustic-contact-times.

This discussion clearly shows the importance of the control factor "swelling-time" for the practice. If in addition we take the already discussed imperfection of the impregnation into consideration, it becomes even more important.

Another, for the practice important set of problems concernes the <u>regulation of the cloth tension</u> during mercerisation. Its influence on the impregnation process has already been mentioned. We will now concern ourselves with its influence on the quality of the end-product. Its importance in the swelling zone, as well as in the succeeding stabilizing zone on lustre, setting effect, and strength has although known since a long time, been to often disregarded (10), (11). This happened in part perforce of equipment problems. So, this neglect imposes itself almost imperatively when using a chainless mercerising range, aiming at the smallest width contraction. As long as exclusively the dyers criteria are emphasized, the resulting effect may be qualified as satisfactory. However, w + w-finishing of cotton cloth started a new discussion about the importance of the cloth tension conduct in general and during mercerisation in particular. Valuable contribution have been made during the last 15 - 20 years to this problem (4), (12), (13), (14).

High strength gains have been obtained, although with somewhat varying results depending on the origin of the fibre, when mercerising bundles of parallel single fibres with full shrinkage during swelling, followed by an extension and de-caustification at constant length. The relation between strength and elongation at break is manipulated by the proportion between shrinkage and the following extension. However, such ideal geometrical conditions as with fibre bundle do not exist in yarns and even less in fabrics in practice. The axes of the fibres to be stretched are not any more in the direction of the applied, stretching forces, only components are acting. The type and quality of yarn and thread, as well as the construction and the condition of the fabric - that is in final analysis the statistical orientation of the single fibres - receive therefore forcibly an important significance. BORSTEN (4) could prove, that tension exercises further more a strong influence on the accessibility for the swelling medium and the swelling itself. In view of the extension of the swollen fibres by stretching, fibre slide has to be avoided as far as possible, whereas the mobility of the yarns within the fabric should be as great as possible.

There is no doubt that it is difficult to realize these, in part contradictory, conditions, and which are still limited further by the desired kind of weave of the fabric. Although certain fundamental rules are known since a long time (15), the weaver does not take them into consideration. The finishers task does therefore not become easier, and the result of his efforts is lessend. We have here, therefore, good possibilities of improvements.

BORSTEN (4) arrives, on the basis of his experimental work related to w+w-finishing, at the following demands:

1. Complete swelling of the fibre material through a maximum of penetration of yarn and fabric, preferably by the lowering of the viscosity and the swelling-strength of the swelling agent, during a sufficient long time and without or at the most under slight tension.

2. Limited swelling-contraction of the fabric and subsequent extension length- and cross-wise. De-caustification at constant dimensions.

Let us return to our daily routine and examine our prerequisites and working methods in the sense of the gained knowled : Type and construction of yarns and fabris are generally not at the optimum. In addition, hidden deficiencies coming from manufacturing processes are present which the finisher is not able to take into account. The qualitative variations demand in principle an adaption of his working methods, but the installations at his disposal and the pressure for a uni orm and cheap production are for him against this demand.

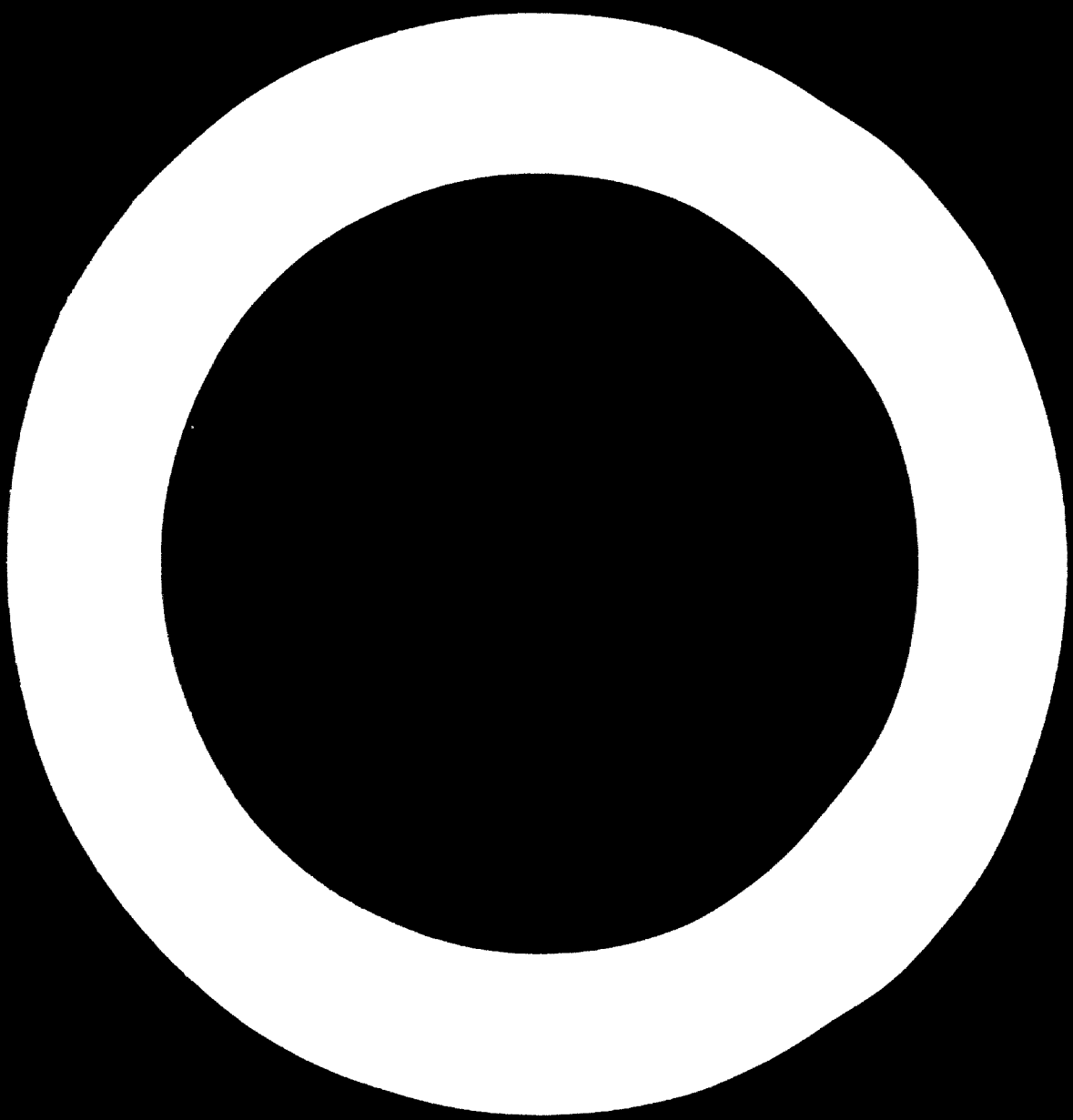
It is my opinion that simply the lacking understanding of the theoretical background lets us, again and again, disregard the demand for a complete fibre swell on the base of a good impregnation and a sufficient lon caustic contact-time. Diffusion is a time-consuming process and a non-homogeneous swelling leads forcibly to an undeseried, non-homgeneous state of the structure. Diffusion-promoting manipulations are theoretically and experimentally known today but not applied in practice.

4. Machinery

Let us take a look at the equipment which the machinery manufacturer puts at our disposal for this apparently so simple, but after a closer look at the theory, so complex proces ng stage. According to the International Textile Service, there are in the world about 25 companies offering mercerising ranges. A few companies offer chain as well as chainless mercerizers. The yearly production is estimated to be around 40 units. With ? exceptions the production of chainless machines is given preference by the european continental machinery manufacturers, whereas GB, USA and Japan are to be considered as the strongholds of the chain typ machine.

We met already repeatedly in our previous considerations some advantages and disadvantages of both systems, a few further characteristics shall be discussed now. Top models of both systems are comparable as to working speed and machine length, and both types are also offered for great widths. In contrast to the chain type machine, its competitor offers however, the possibility to work with 2 widths, side by side, or one on top of the other, increasing by the same the production by 100%. The tendency to break-downs, wear, and maintenance may also be smaller with the chainless version. Undisputed is, however, the advantage of the chain when it comes to an exact control of the length and cross-tension as prerequisite for a high quality mercerisation in the sense of our earlier theoretical introduction. In finishing, this advantage may eventually reduce the cost, and definitly influences favourably the technological qualities of the final product.

In the following exposition I would like to consider briefly a few typical characteristics of both systems in general, as well as the special features of some makers, but always with regard to the already mentioned demands. A compilation of the products built by the most important machinery manufacturers which has been kindly placed at my disposal by the International Textile Service, Zurich, may serve to communicate an overall view.



Fabric mercerising machines

		● Artos Dr. Maier-Windhorst KG D-2000 Hamburg 1 Germany	● Benninger AG CH-9240 Uzwil Switzerland	● Brugmon N. V. Almelo Netherlands	● Ets. A. Deck F-68 Mulhouse France	● Farmer Norton & Co. Ltd Salford 5 Manchester M 60 8 HH England	● Geller, M D-6075 Schwarzenbach/Saale Germany	● Kleinewefers Söhne, J. D-415 Krefeld Germany
1.	Type	type 4850	MGA	M 54 and M 2317	AD 2281	—	MA	M extendable by units of 1.5 m capacity
2.	Design a) with chain b) without chain	yes	 yes	— yes	yes —	yes —	— yes	— yes
3.	Smallest type with open-width washer a) length in m b) mean output, single pass m/min (at 50 sec reaction time)	32 25	6.94 6	10.50 9	35 35	30 35	12 8.15	13 9.50
4.	Largest type with open width washer a) length in m b) mean output, single pass m/min (at 50 sec reaction time)	58 75	63.85 extendable on modular system 120	36.50 41	65 with sky run 80	55 90	48 88.1	67 144
5.	Working width in mm a) minimum, single pass b) maximum, single pass	1000 mm 3000 mm	1000 mm 3800 mm	1600 mm 3000 mm	600 mm 3800 mm	45 mm 3800 mm	900 mm 3400 mm	848 mm special model, narrower 3800 mm
6.	Machines with chains a) caustic soda impregnation, once b) caustic soda impregnation, twice	yes	— —	— —	yes yes	once, smallest model twice, largest model	— —	— —
7.	Machines without chains a) caustic soda impregnation tandem b) caustic soda impregnation spray c) caustic soda impregnation tandem and spray		— — yes	— — yes	— — —	— — —	— — yes	— — yes
8.	Ratio of impregnation to setting zone a) smallest type b) largest type	2 : 1 3 : 1	standard machine 2 : 1, freely adaptable by modular system	100 : 75 75 % of impregnation zone, 100 : 75	— —	expressed in m fabric length 100 : 75 100 : 40	1 : 1 75 % of impregnation zone	1 : 1 1.51 : 1 flexibility through modular system
9.	Caustic soda removal by a) hot water b) steam c) steam and hot water	yes	— — yes	— — yes	— — yes	— — yes	— — yes	— — yes
10.	Which open-width washing units are required for rinsing? Type and number of tanks	3 to 7 enclosed wash tanks as required by layout of mercerising process	roller vats, freely adaptable by modular system	3—4 closed wash tsks	3—6 enclosed wash tanks	4 roller vats type R 10 7 roller vats type R 16 according to machine size	3—8 roller vats (inc. steam lye extractor) vat capacity 17 m	roller vats (10, 15, 25 + 30 m capacity) inc. steam lye extractor. No. varies with type of washer + max. fabric weight
11.	Type of lengthways and widthways shrinkage control	quotient measuring device, width indicator	fabric tension control + combined extension measurement + tension control (psl)	quotient measuring device	quotient measuring device	chain tension regulator	quotient measuring device, overstretching zone, specially shaped rollers in impregnation and stabilising compartment	quotient measuring device, biaxial stretching zone
12.	Accessories for standard type	caustic soda cooling plant, caustic soda seperators	caustic soda cooling plant, recovery plant, pump system, concentration control for strong and weak caustic soda and acid, acid control, temperature control, fabric tension control for 2 pass working (pat.) MYCOCK open width stabilising compartment	caustic soda cooling plant, remoistalize control, caustic soda separator, pumps	caustic soda cooling plant, caustic soda separator, recovery plant, metering device	caustic soda cooling plant	caustic soda cooling plant, caustic soda dissolver, caustic soda purification plant, measuring and metering devices	concentration plant, temp. + steam control, lye density measurement, caustic soda cooling plant, separator, purifier, density measuramant, conductivity measu't for weak lye and acid
13.	Special equipment available	caustic soda concentrating plant	caustic soda preparation plant with dissolver	level and concentration control, caustic soda preparation plant, heat exchanger	3-bowl impregnating padder sky run over 1050 mm dia. rollers	fully autom. ctl. of all processes, caustic soda recuperation plant, separation	batch changer device for gradual enrichment of stabilising lye	special inlead for overstretching goods before mercerising compartment, autom. width ctl. caustic soda dissolver, all autom. measuring and control apparatus

		● Marshall & Williams Co Providence, R.I. USA	● Mather & Platt Ltd Manchester M 10 6BA England		● Morrison Machine Co. Paterson 3, N.J. USA	● Nisso Iron Works Co. Ltd. Osaka Japan	● VEB Robur-Werke Zittau DDR-88 Zittau GDR	
1.	Type	M-2	chain mercerising machine	chainless merc. machine	Morrison - 8 A	—	8241	
2.	Design a) with chain b) without chain	yes	yes	— yes	yes —	yes —	— yes	
3.	Smallest type with open width washer a) length in m b) mean output, single pass m/min (at 50 sec reaction time)	12.20 55	12.20 33.50	15 10	30 7—60	7.80 40	17 30	
4.	Largest type with open width washer a) length in m b) mean output, single pass m/min (at 50 sec reaction time)	36.60 120	60 70	33.20 54	60 30—140	14 80	32 80	
5.	Working width in mm a) minimum, single pass b) maximum, single pass	1060 mm 3050 mm	900 mm 3800 mm	900 mm 3800 mm	700 mm 3800 mm	1200 mm 3800 mm	1000 mm 3400 mm	
6.	Machines with chains a) caustic soda impregnation, once b) caustic soda impregnation, twice	yes	yes, for small outpout yes, for large output	— —	— yes	— yes	— —	
7.	Machines without chains a) caustic soda impregnation, tandem b) caustic soda impregnation, spray c) caustic soda impregnation, tandem and spray		— — —	yes — —	— — —	— — —	— — yes	
8.	Ratio of impregnation to setting zone a) smallest type b) largest type	2 : 1 3 : 1	— —	1 : 1 1.65 : 1	variable depending on specification	— —	7 : 6 9 : 8.5	
9.	Caustic soda removal by a) hot water b) steam c) steam and hot water	yes — —	— — yes	yes — —	— — yes	— — yes	— — yes	
10.	Which open-width washing units are required for rinsing? Type and number of tanks	4—8 open width wash tanks with squeeze rolls	open cascade washers 3—6 open width wash tanks with squeezing arrangement open width overstretching	2—4 open width wash tanks	4—6 open width wash tanks	5—10 open width wash tanks	4—6 open width wash tanks	
11.	Type of lengthways and widthways shrinkage control		tensioning and measuring device	tension measurement	special expanding device, measuring device	—	electrical slip measuring device	
12.	Accessories for standard type	caustic soda saturator, measuring and metering device	caustic soda cooling plant, chemicals measuring and metering device, caustic soda recuperation	expanding device caustic soda cooling plant, chemicals measurement caustic soda recuperation, metering device	caustic soda cooling plant, automatic controls, caustic soda recuperation	automatic controls, centrifugal pumps, air compressor, caustic soda cooling device	caustic soda cooling device, giant batch winding, pre-wetting boxes with squeeze rollers, lye preparation tank, lye concentration control	
13.	Special equipment available			—	—	—	—	

The ringed numbers ● above each column correspond to the pictures overleaf

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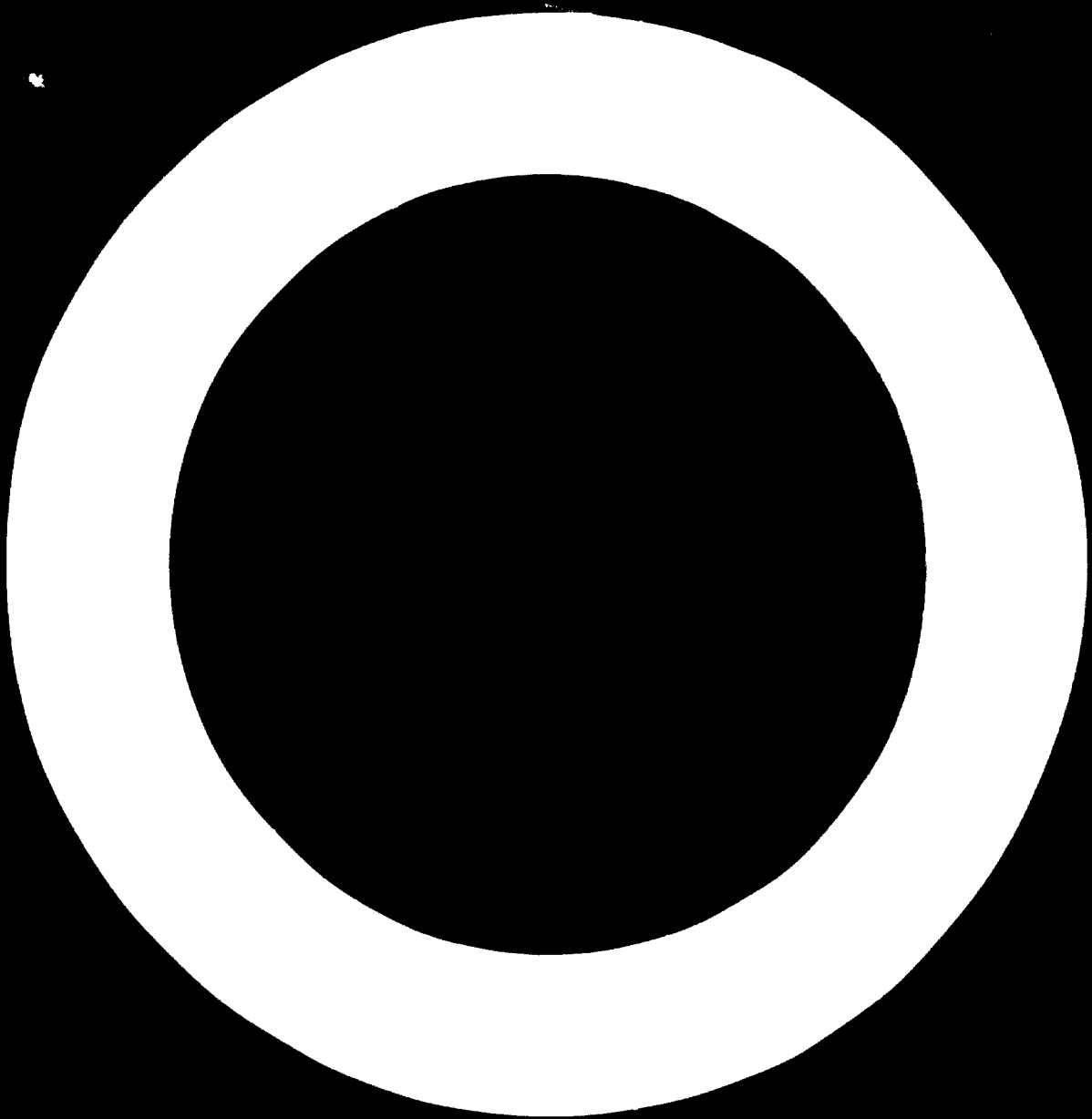


From this abundant information we will consider especially the lines 2, 4 a + b, 9, 10 and 11, further the important position and finally the lines 12 and 13.

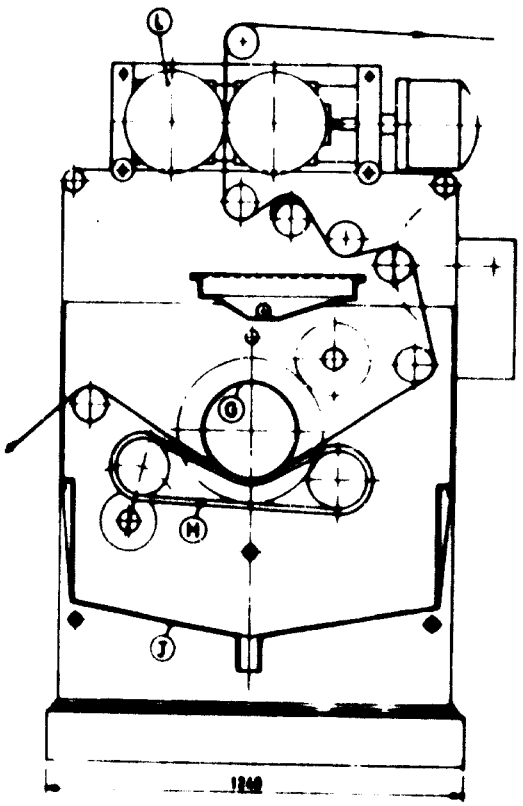
It can be seen that with a few exceptions, all the machinery manufacturers offer a dispositif for measuring the lengthwise tension and / or the extension based on some principle or other. Several machinery manufacturers use the information obtained for the control of the mercerising range. I think that this step should be today a matter of course. A few remarks on this point will follow at the appropriate place.

Concentration control of strong and weak lye belongs in general to the normal equipment, as well as the temperature control for the caustic soda in the impregnator and the washing water. Separators for the strong lye clarification, and evaporators for the waste liquor of the stabilizing zone are delivered by almost all the machinery manufacturers upon request. Several machinery manufacturers complete their installations by strong pre-expander systems prior to the impregnation zone, a valuable attachment for chainless machines, and two manufacturers of this type deliver upon request MYCOCK-expansion roller stabilizing compartments.

Demonstrating now a few typical features of both systems as well as of certain specific makes by the help of some slides I do not want to be suspected to make hidden publicity.

This picture shows you the basis lay-out of a chain type mercerizing range, in this case a FARMER-NORTON installation. 3-roller impregnation padders - in this case two units - with free running cloth are typical for this type machine. A loss of fabric width due to swelling contraction is here not a disadvantage. To replace the lacking swelling time on the padders, so-called timing drums are provided. However, these may limit the free shrinkage somehow. The lengthwise tension, and as a result, the adhesion of the cloth to the drums is maintained by the two compensator controlled padding units. This double impregnation and squeezing of the free running cloth provides favourable conditions for an improved penetration of the fabrics. Some doubts exist, however, about the effectiveness of the second impregnating unit as post-impregnation, because the fabric enters immediatly after the stretch zone, not to mention the already existing strong swelling of the outer yarn zones, which makes the further introduction of caustic soda to the center more difficult. For to further improv. impregnating efficiency it might be recommended here to take advantage of the sponge effect, in feeding caustic soda into the nip-roller outlet. An other advanta of this impregnator type is, that only a relatively small quantity of caustic soda is present in the system an therefore soiled, especially in the case of raw-mercerisation.

This company informed me, that they have improved the impregnation, replacing the first impregnation padder by a vacuum impregantion unit.



The next important point of our model installation is the 2 bowl-feed nip.

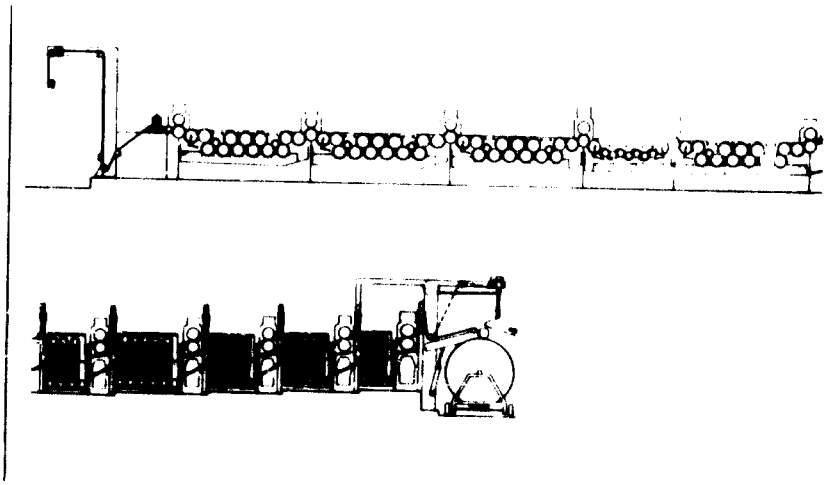
The lengthwise stretch is controlled over the pneumatic warp tension regulator and the relative speed of the two corresponding nip-roll sets. But the tension to be applied depends on the quality of the fabric and the question arises wether a control based on the elongation would not be better suited.

A very slight overfeed should be arranged between feed-nip and stenter, which eases the load on the frame and assists in addition, much in the sense of our earlier demand, the weave-in of the chain, respectively the straightening of the weft of the fabric at the stenter entry. Immediately following the cross-extension for the desired width, begins the extraction of the caustic soda. Their concentration must be already below the critical level before leaving the chain in order to avoid another deformation. Somewhat problematic with this machine type in the extraction of the caustic soda from the selvedges and their immediate vicinity; according to the machinery manufacturer,

this requires an acidification at the end of the washing-range which follows the stenter. 1 - 2 closed caustic soda recuperators with a counter-current flow of boiling water as well as 1 - 2 conventional washing compartments serve to the additional de-causti-fication. For a complete neutralization this installation can be followed by a V-trough with squeeze-unit for the application of acetic acid, followed by an air retention zone and a spray tower. This is, however, unnecessary if the treatment which follows is an alcali based process, such as caustic boil-off, peroxide or hypochlorite bleaching. For economical reasons it is appropriate to adjust in such cases the final alcalinity to the desired level by the flow of the fresh water.

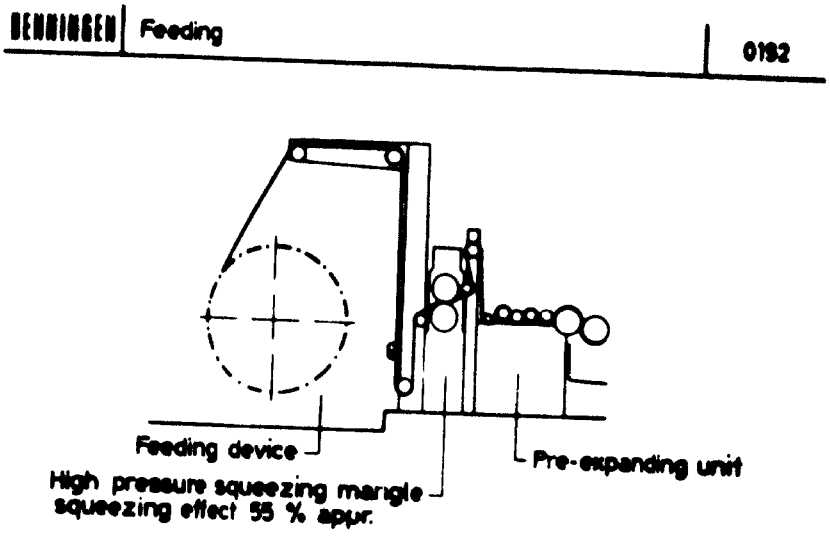
In its basic conception such an installation comes fairly close to our ideal, anyway closer than the chainless type range which will be discussed later. With the vacuum padder another step toward the inprovement of impregnation has been made. An additional improvement could further be obtained by a viscositiy reduction and an increase of the diffusion speed of NaOH through an increase of the caustic soda temperature, and last but not least, the securing of a sufficient diffusion time. A weak point may be the caustic extraction in the stenter area because the transport of caustic soda out of the fibre is also subject to the earlier discussed laws. The working speeds reached today give the possibility to insert such a range into a pre-treatment installation.

BENNINGER | Schematic Cloth Run Mercerising Machine MGA | 0089



This picture shows, as counterpart, the principle of a chainless mercerising range from the BENNINGER COMPANY. Installations of this type are based on the building bloc system and can be adapted to all kind of conditions. All these machines work in their critical stages, that is, in the impregnation and stabilizing zones, on the principle of controlled cloth guidance, avoiding the loss of width, because a later recuperation normally is not any more possible. Only two machinery manufacturers, BENNINGER and COLLER, deliver facultatively so-called MYCOCK-expander units, which will be discussed later, and which make a limited cross-extension possible. The prevention of cross-shrinkage asks for an intimate contact with the roller surfaces, which, in turn, requires a certain length-tension. For this reason the roller systems are, in general, not driven, but are pulled by the fabric. Only in special cases friction couplings are provided for part of the system. This means in practice, that in the impregnation zone an elongation takes already place due to the length tension, a condition which does not correspond at all to our demands for the obtention of a good impregnation and of an optimum structural improvement. The mercerising lye is sprayed with pumps and spray pipes between the upper rollers and runs over the collector pans back to the reservoir. Compared to the chain type machine, a much greater volume of caustic soda solution is required and exposed to soiling. The stabilizing units are in their construction completely identical with the impregnation units, with the exception, that instead of caustic soda, a hot washing liquor is sprayed between the rollers. This washing liquor circulates through the washing and

stabilizing units counter-current to the cloth. Open width washing compartments are added at the end, the number of which depends on working speed and the heaviest type of cloth.



The struggle for the width, typical for this system, is at the origin of tricks. All builders of chainless ranges place robust expander roller sections in front of their impregnation zones, that is, they try to feed the fabric at the greatest possible width to mercerisation, avoiding therefore the costly way over a stenter-frame pre-drying.

The already mentioned expander roller sections, placed in the stabilizing zone, make a limited width recuperation possible. The working principle is easy to understand. The expanding capacity depends on the sliding friction of the cloth on the surface of the expander roller. A relatively high length-tension is therefore necessary to insure a close contact. The balancing of the forces has to be tried out for each fabric quality. A definite weakness of the principle concerns the edge-zones of the fabric. A more or less pronounced higher density of the warp-threads connot be avoided in these zones, a fact which is especially annoying with coloured woven fabrics with stripes and squares. The reason for this is a drop of length- and cross-wise tension in these regions which leads to reduced adhesion and on the roller surface and sliding. The limited transmission of force obliges to reduced force-requirements, therefore to a partial lye extraction. But one has to bear in mind that the margin between permanent and non-permanent extension is rapidly crossed, different from quality to quality, and that a satisfactory control is not possible in practice. From the management of this machine-maker I have been informed that a new stretching-system has been developed and will be demonstrated at the next ITMA in Milan. This is good news and gives reason to expect this first demonstration with great interest.

The process control of these installations, apart from lye concentration, temperature and time of contact - that is in practice the machine speed - is done depending on the machinery manufacturer over the fabric tension with the help of compensator rollers, or by so-called quotient measuring devices consisting of tacho-generators mounted on the squeeze-roller drive motors, comparing the revolutions of the squeezing units. Both systems are regulating the drive of the squeezing units. One machinery manufacturer only offers a control system for shrinkage and extension, measuring directly on the fabric the percentage of length loss or gain, which seems to me to be the most preferable one.

Summarizing we can state, that this system, if high quality treatments are required, has - compared to the chain type machine - de-

finite weaknesses, beginning with the impregnation, further with the limited possibility to adjust length contraction and extension, and finally the precarious to completely lacking control of the cloth width. On the other side these machines are simple and not prone to break-downs. But their undisputed advantage is in the great production reserve with double track or multiple layer operation. If however, the mercerising range is part of a pre-treatment line, this advantage loses its importance.

Before we turn our attention to point matters, the comparison of some important economical factors will be tried. But let us say beforehand, that the information has been collected from various sources with variable difficulties, and that their credibility may also be variable. Possibly we should believe only what we measured ourselves, and certainly each finisher knows his own consumptions perfectly well.

Consumptions of modern Mercerising Machines

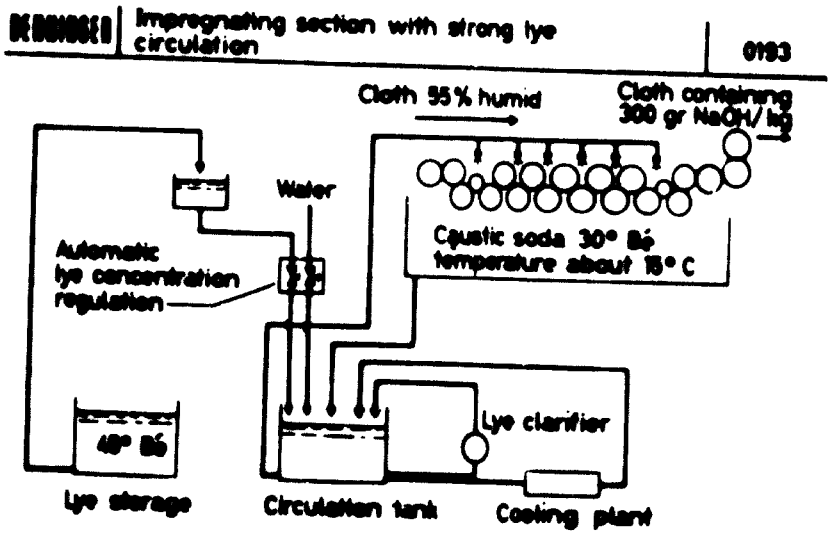
Consumption \ Machine	chain-type	chainless-type
strong caustic 38° Bé	~ 1 l/kg cloth	~ 1 l/kg cloth
water	10 l/kg "	5 l/kg "
steam	? kg/kg "	1 kg/kg "
acetic acid	? ml/kg "	1 ml/kg "
el. power	70 kW	20 kW
operator	1-2 wages	1-2 wages

After this comparison, let us turn our attention to things which are common to both systems. An adequate instrumentation for the production control is today considered as self evident for a process like the mercerisation. The transformation of the measured values into control impulses for the automatic regula-

tion of important functions is a next step which numerous machinery manufacturers took for various process-parameters, and which they deliver, at least part of them, as standard equipment. If we count the control factors which are of decisive importance to quality and economics, and which would have to be measured and adjusted with more or less reliability, it becomes evident that an automatic control of these parameters must be demanded as guarantee for the quality and also as relief for the personal. Not to have them would be a saving at the wrong place. The principles applied are in general well established and a fear of oversophistication is not justified.

At the same time let us discuss a few attachments which, seen from the qualitative, economical and also ecological point of view, can be declared as indispensable.

The automatic control of the high concentration caustic soda is indispensable; where moist cloth is mercerised.



The continuous dilution of the caustic soda by the addition of water out of the fabric must be continuously compensated by an addition of high-concentrated lye. The dilution is raising with raising water content of the cloth. The continuously produced excess lye can become an economical problem, a fact which draws the attention on the importance of a high capacity squeeze unit. Such a unit works cheaper than an evaporator, and the relief of the excess lye should not be discussed any more among responsible professionals.

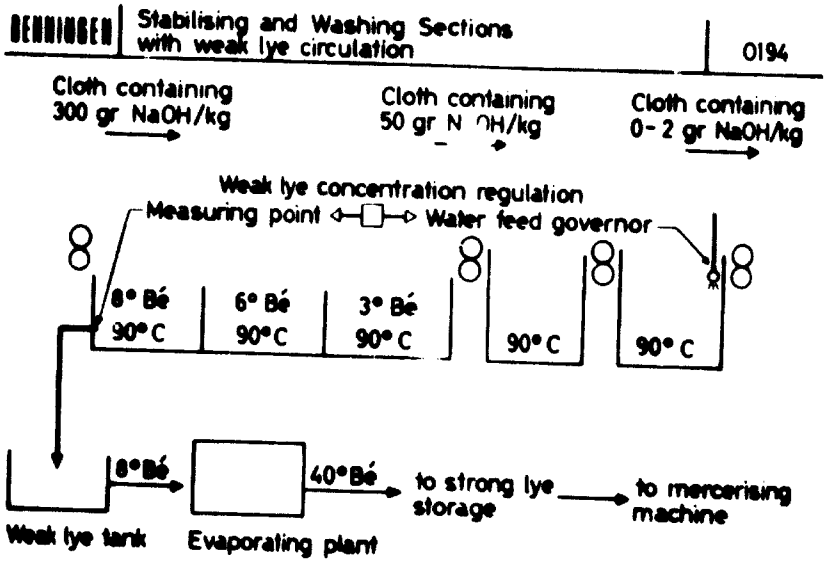
The temperature of the lye is another important control factor which influences the quality. Most common are 15-20°C. Reaction heat, dilution heat, and room temperature produce a shift to higher temperatures, which has to be compensated by refrigeration units.

Dust, linters etc, which are introduced with the cloth, are soiling increasingly the liquor and should be eliminated continuously by filters or separators.

Let us stay with the consumer product caustic soda, because it is in connection with economical questions of decisive importance. We can consider the consumption of NaOH for impregnation as a fixed quantitiy, about 300g NaOH / kg of cloth. We can also consider as certainity that these 30% NaOH per kg of cotton have later to be eliminated, for the moment up to a rest content of about 5% in case a caustic boil-off follows, or almost or even completely, depending on the next processing stage. But the use of the resulting low concentration caustic soda is limited in all plants. Market competition but also our duty to keep the waters clean world-wide and to conservation of raw-materials, do not allow any more to discharge the excess into the drain. In addition this would mean, in view of the high oil prices, the loss of expensive heat energy. Efforts to recuperate both cost factors have become today an economical necessity.

We know, that the exchange capacity of washing units depends to a high degree on the temperature. Our stabilizing and washing units

should therefore be equipped with temperature controls. The application of the counter current flow principle through the whole extraction section should be a matter of course. A corresponding modification will pay for itself where it does not exist yet. This, again, may be illustrated by a flow diagram from the BENNINGER COMPANY.



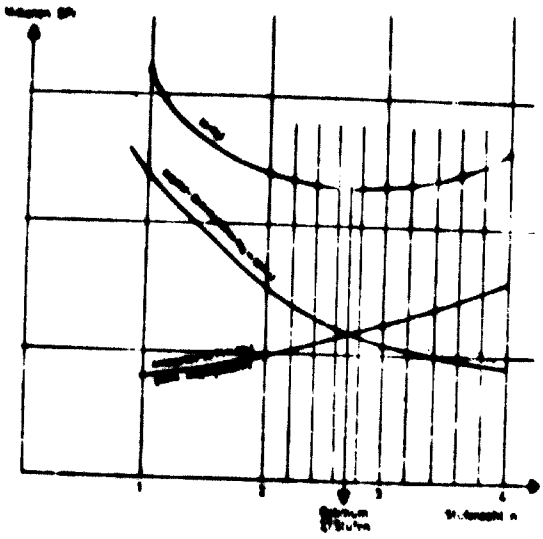
This company controls the fresh water flow through the NaOH concentration of the diluted liquor discharged by the first stabilizing unit. The determination of this control-concentration presents itself as optimation problem in view of the size and economy of the evaporator. It will be generally around 6-10°Bé.

With smaller mercerising production loads the recuperation of the weak lye could be done in batches with single stage evaporators, but with increasing production it will be necessary fo use multiple stage installations and continuous processing, with a benefit of a greater efficiency concerning steam and cooling water consumptions.

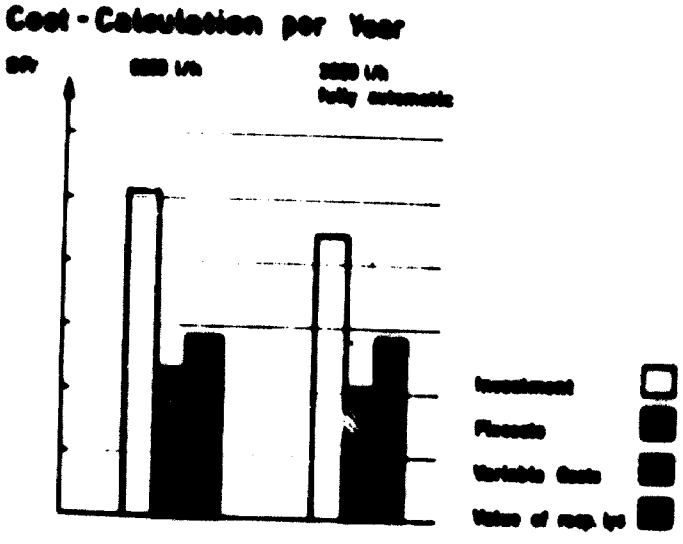
Consumption Figures for Evaporating Plants (approx)

Number of Stages			1	2	3	4
Steam Consumption as a % of	Vapour-Compression Plant Evaporating Capacity	without	110	65	45	35
		with	55	40	32	27
Water Consumption in multiples of		without	18	10	7	5
		with	10	7	5	4

This table shows the comparison of steam and cooling water consumptions of different types of evaporators, related to the evaporating capacity. It is evident, that the concentration of the diluted lye becomes an important factor for economical reasons. An increase should therefore be desirable, but one must consider that the exchange phenomenon on the fabric are - like with impregnation - subjected to rigid physico-chemical laws which, in this case, would forcibly require additional stabilizing and washing compartments. In a modern plant will be surely the heated up water be sent to the hot water production plant and all the excess heat from condensate and concentrate be recuperated by heat exchangers.



This diagramm demonstrates clearly how the efficiency of these installations depends on the number of stages.



This table gives an overall view of the efficiency calculations for 2 evaporators with 3 stages, taking as a basis an average production of 8 t / hour of diluted caustic soda at 6°Bé, or approx. 4%, and the cost of energy, water and labor for a specific case in Switzerland. The installation to the left has been layed out for concentrating the daily production of weak lye during one-day-shift and is manually controlled. The installations on the right works around the clock with a smaller hourly output and has an automatic control. The economical advantage of the later is clearly visible.

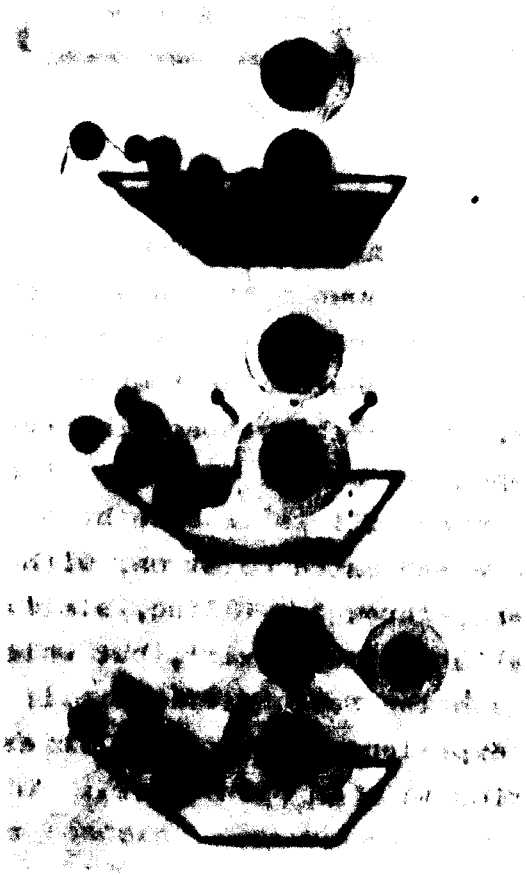
Evaporators need a minimum of supervision. Our calcul is based on ½ man-day, periodical cleaning included. On the other side it must be mentioned that they ask for certain limitations in working on the mercerising machine. I mentioned already earlier that the wetting agents may produce problems. We may expect the same from anorganic and organic precipitations as they are to be expected when working with hard water, or mercerising grey fabrics. A decantation in basins and / or the use of separators may then be necessary. The raw-mercerisation seems also with this aspect to be problematic, unfortunately.

The <u>tension, respectivly dimensional control</u> which is so important for the qualitative results, has already been mentioned earlier, and the attention was drawn at that moment on the positive and negative aspects of both machine types and of the measuring systems. The utilisation of the measurements obtained, it be tension forces or speed ratios, respresent no problem for the control of the machine, and has already been realized by several machinery manufacturers. They do not agree, apparently, about the question which of the mentioned measurements is to be prefered from the technological point of view. Personally I prefer the direct length measurements, but not without making sure that they indicate the real changes.

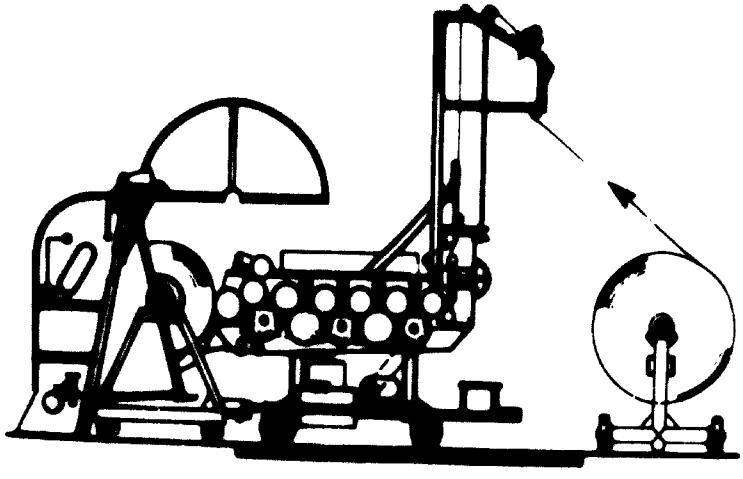
Before we leave the discussion about the equipment, I would like to present two constructions less as curiosities, but rather as solutions for small productions, respectively for special cloth qualities. It has to be mentioned that the working methods do

not satisfy our demands for a high quality mercerisation, but that they might be qualified satisfactor, for a simple caustic soda treatment.

Both machines are built for a batchwise treatment of the fabric with to a large extent, unchanged dimensions. Common to both is a sufficient swelling time and on the other side, the disadvantage that the swelling of the fibre in the package result in a heavy pressure between the layers. Whether this situation may lead with delicate fabrics to moiré effects is not known to me.



The builder, DORNIER (BRD) calls this installation a mercerising padder. The batching speed is given with 23m/min, the batching capacity with 600 - 700 m. 3800 - 4200 m per shift are mentioned as [illegible] capacity. After a first extraction in the machine itself, following in a way the principle of the yarn mercerising machine and the jigger, the post extraction takes place outside on jiggers or on open-width washing machines.



This installation, built by KLEINEWEFERS (BRD) can be considered as a combination of the known centrifugal washing-machine CENTRIFUGA with its typical perforated batching beam and in addition a mobile caustic soda impregnation unit with a conventional controlled cloth guidance. The batching speed is given with 60m/min, the batch capacity, dependi , on the quality, with 2000 - 5000 m. The de-caustification which follows is done by a combination of hydrostatic pump pressure and batch rotation, with flow radial through the batch. Also here, through swelling, similar conditions as in the previous installation must exist, but which in this case can make the flow through the batch difficult, if not impossible. Based on personal experience the possibilities of this unit will be limited to fabrics with an open weave.

. Possible improvements, requirements

Let us go back to our first question: "What do we expect from mercerization?" and let us ask further: "Could we do a better work?" and further: "Is there a real need for such improvement?"

The first answer to these questions must then be: If dye receptivity is the main reason for our treatment and only a slight gain in lustre is sufficient, but at the same time a dimensional stability below the optimum and a relatively high loss of strength during wet-finishing can be accepted then a chainless type of machine under optimum working conditions can be adopted. It offers a high production reserve and has a high flexibility in case of frequent changes in quality and width. The machinery builder should provide in the future, for qualitative and economical reasons, sufficiently long impregnation zones, the installation of control systems for the most important process parameters, and finally efficient and therefore also economical washing systems for the caustic soda-extraction. The development of a new expanding device with a better effect as the MYCOCK units, and without their specific weaknesses for the cloth edges would be a real performance and improve on the weaknesses of this type of machine as compared to the chain type. From the finisher we should expect a better understanding for the phenomena of the process and the expected and, beyond that, the to be reached results. The basic laws of nature cannot be violated! Finally, the finisher has to educate the machinery manufacturer through clear demands based on his better knowledge and his experience.
The economy of a finishing step and also the resulting ecological problems are his concern today and will be especially tomorrow. The enormously increased oil prices teach us to reduce the heat consumption to a minimum and to recuperate afterwards as much as possible through heat exchanges. A correct water circulation through the de-caustification and stabilizing compartments combined with a control of the fresh water supply could result in a decisive improvement of the heat as well as the water consumption. This is a fact which has not yet been recognized everywhere.

However, if we pretend to more than an improvement of the dye substantivity and clain a better lustre, and expect an optimum of dimensional stability as well as an optimum strength after a finishing with cross-linking agents, the chain type machine is to be prefered. But the machine in itself is not yet a guarantee for a good result, it only gives the finisher the prerequisites. The recommendations which have previously been given to the machinery manufacturer and the finisher about the impregration, are also valid here without reserve. The obtention of a faultless impregnation and the observance of a sufficient swell time remain finally preoccupations of the finisher. This type of machine gives him the possibility to balance shrinkage and subsequent extension.

This is an important prerequisite which relieves him from preoccupations especially concerning the cloth width with which the owner of a chainless type machine has to battle and which obliges him often to qualitative and economical compromises. Therefore the insertion of the mercerising step into the pretreat process seems to me less problematic with the chain-type machine.

With this last remark we arrived at a very important question. It is the question where mercerization should be placed into the pretreatment process with advantage. Unfortunately there is no absolute answer to this question, because every decision imposes compromises. The flexibility exercized in the sequence of the process from article to article in earlier times is not possible any more with the modern pretreatment ranges. In addition to this we met many conflicting problems on different occasions during my exposition.

Insertion of Mercerisation into Pretreatment

criteria \ state	sized grey	desized grey	boiled-off	bleached
wetting	0	--	+	+ +
contact time (wetting speed or machine length)		--	+	+ +
caustic soiling		--	+	+ +
caustic recuperation		--	+	+ +
dyeability		(+)	+	+
lustre		+ +	+	+
handle and appearance		+ +	+	--
structural setting		(+)	+	(+)
width - loss		+	(+)	-
ease of inserting		+	-	+

0: not recommended -: negative influence +: positive influence

The present table shows an attempt to represent with some system the consequences of this important question. Also this table is loaded with compromises and therefore the conclusions cannot be better.

The economy of the mercerising is mainly given be 3 important consumption figures:

- Lye consumption (related to the production)
- Water consumption
- Heat consumption (related to the second)

A few words about possibilities to increase the economy have already been said, and there should be not doubts about the necessity to exhaust them. There can be no objection against the recommendation, that a critical analysis in the own plant is always paying for itself.

Rewarding economical and qualitative problems are also still waiting for the mechanical engineers. The need for high efficiency

decaustification systems with a minimum of water consumption has already be mentioned. The utilisation of the existing research results, I am thinking especially of the utilization of hot caustic soda, is an urgent recommendation from the qualitative as well as economical point of view.

After suggesting improvements concerning the economies, our last question must consequently be whether improvements are realy required on the qualitative side. We gave already a certain negative answer, if we are only interested in the dyeing aspect, we could be rapidly satisfied with ourselves. This statement is also true if we have to deal with fibre blends with a proportion of 50% or more of synthetics.

We had to learn that a similar condition does no forcibly exist with respect to easy care fabrics. We could defend, however, the opinion that the high losses in strength are here not obvious and that the consumer so far has advanced no strong claim for a better quality. As finisher we are faced with a question of conscience. I am countering with another question: Why should we not try to do a better job, deliver a better quality, if it is not or perhaps only insignificantly more expensive? Are not the permanent finishing crosslinkers to be applied for producing the demanded dimensional stability sometimes perhaps more expensive? As finisher we have the knowledge which enables us to do a better work, and it is our duty to demand from the machinery manufacturer the required assistance. We have all an interest to satisfy our consumers for to conserve the reputation of the cotton fibre.

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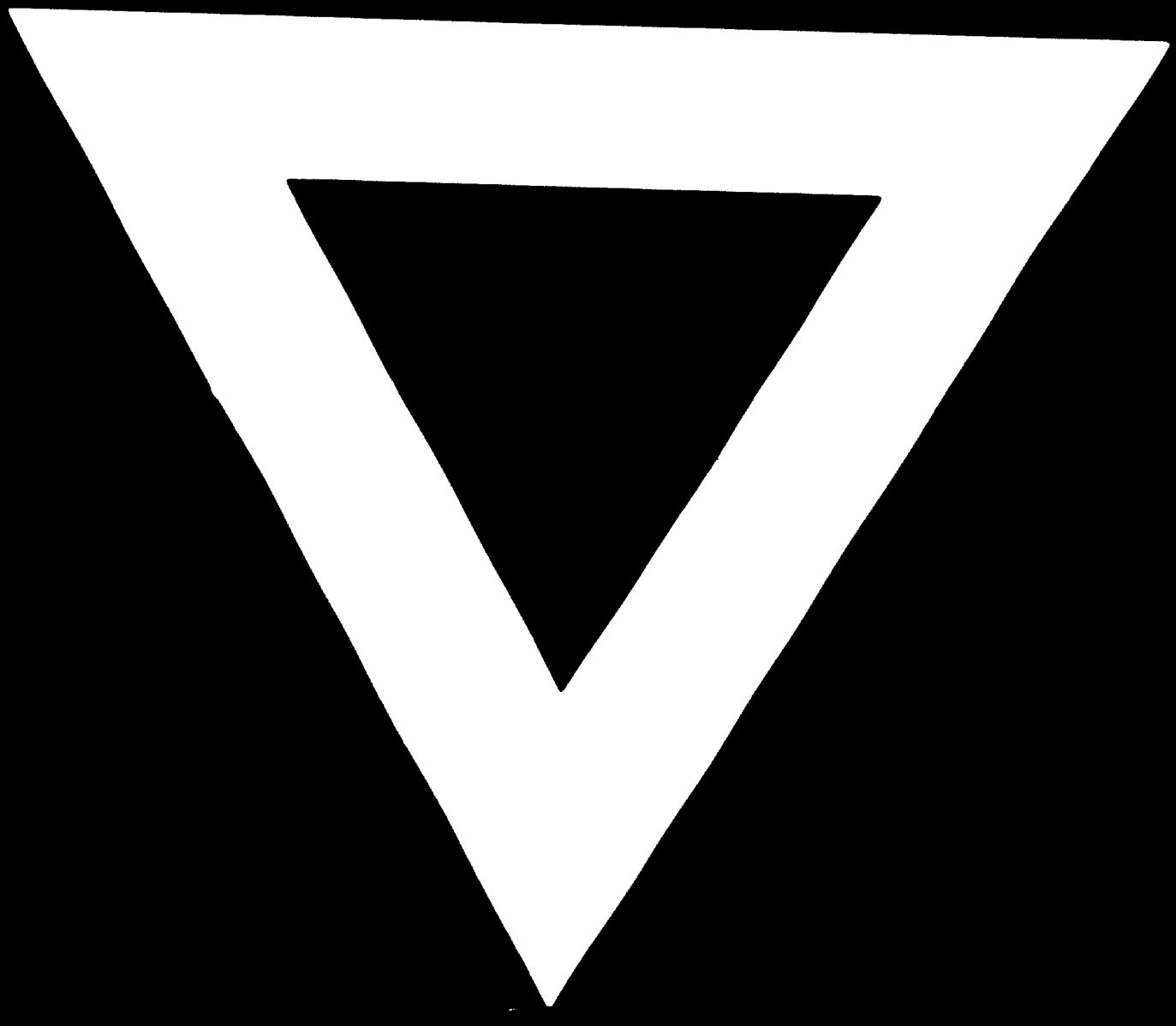

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