INHALTSVERZEICHNIS

ASSESSING THE COMMERCIAL VIABILITY OF NEW FIBRES

by David Rigby, David Rigby Associates
Talk held at 34th IFC, Dornbirn 1995

The development and commercialization of new textile fibres is a difficult, expensive and risky process. This paper describes some of the market-based, bottom-up assessment methods that David Rigby Associates have developed for assesssing new fibres in garment end-uses.

Die Entwicklung und Kommerzialisierung neuer Textilfasern ist ein schwieriges, teures und riskantes Verfahren. Dieser Artikel beschreibt einige der von David Rigby Associates entwickelten marktorientierten, von der Wurzel aufwärts beginnenden Bewertungsverfahren, die zur Bewertung neuer Fasern für Konfektionsendverbraucher entwickelt wurden.

Introduction

The development and commercialisation of new textile fibres is a difficult, expensive and risky process. Many millions of dollars have been spent in the past on developing new fibres for which, ultimately, there was found to be little or no market demand. In the case of other, more obviously commercial fibres it has sometimes taken many years to find their most effective end-uses. The problems are particularly complex in garment end-uses, in which the often intangible considerations of aesthetics, fashion and fibre versatility must be taken into account in addition to the more measurable performance-in-use characteristics of the fibre.

Fibre companies have particular difficulties in making judgements in these areas since their development staff often have very little direct experience in downstream products and markets. There are many points in the process of development and commercialisation when important decisions have to be made about how big or how fast the next phase of investment should be or, indeed, whether to stop the project altogether (which is the most difficult decision of all). These decision-making needs give rise to the question as to whether there are any methods for arriving at robust assessments of a new fibre's market potential before committing to further major investment. David Rigby Associates (DRA) are specialist consultants in the fibre, textile and clothing industries with experience in many downstream product/market segments. We have recently carried out five projects to assess the commercial viability of new or modified textile fibres in world markets, including both fashion and technical end-uses. This paper describes some of the market-based, bottom-up assessment methods that we have developed for assessing new fibres in garment end-uses. They are based on our experience with both natural and chemical fibres and are applicable both to entirely new fibres and to modifications of existing fibres.

The fundamental principles

There are some fundamental principles relating to the likely commercial viability of new fibres which should be stated immediately. Some of these principles seem to be self-evident in retrospect but we have repeated experiences of fibre companies spending large amounts of time and money while acting contrary to them. The fundamental principles are as follows.

1. Identify, and try to engineer, as many applications as possible in which the new fibre produces a unique effect. Useful uniqueness gives the best chance of developing a market and/or commanding a premium price in the market.

2. If no unique end-product can be engineered, commercial viability will depend on:
   - substituting the new fibre for other existing fibres in 100% form
   - the new fibre's qualities as a component in a fibre mix.

3. Avoid end-use which merely reproduce the aesthetics of a cheaper fibre or fibre blend. (It is quite remarkable how many new fibre innovations we have been shown that could be easily reproduced by some form of polyester/viscose blend).

4. To achieve commercial success in today's consumer markets, a fibre/fabric innovation must offer a tangible and explainable benefit to the consumer at the point of sale of the garment (eg value, drape, handle, colour) or soon afterwards (eg easycare, crease resistance). Benefits which occur within the processing chain (eg ease of processing) will only be fully exploited if they ultimately translate into consumer benefits (eg lower prices).

Fibre and fabric types

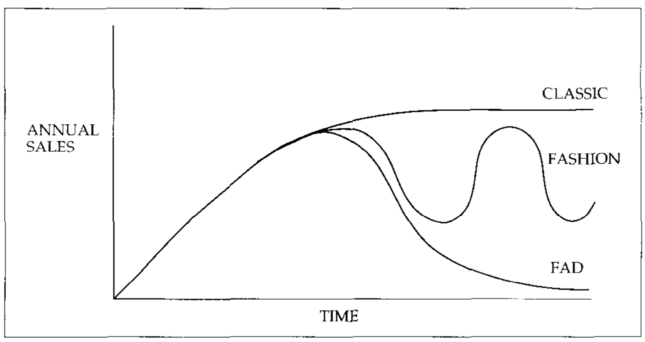


Exhibit 1

The classic and fashion components of fashion

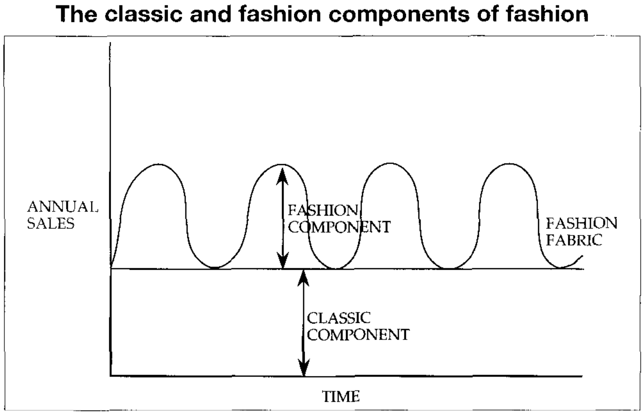


Exhibit 2

5. New fibre end-uses in garments can be classified as
   - Classic
   - Fashion
   - Fad

   as shown in Exhibit 1. "Classic" demand will grow to a level at which it will persist without being influenced by fashion. "Fashion" demand has a basic Classic element (which may in fact be zero) overlaid by a fluctuating Fashion element, as shown in Exhibit 2. "Fad" demand grows and then declines to zero when the fad is over. It is important to determine as soon as possible whether an initial demand for a new fibre in a particular end-use is Classic, Fashion or Fad. The three growth curves are indistinguishable in the early phases and the market itself does not always know how demand will develop. One of the aims of the assessment methods we have developed is to make this classification into Classic, Fashion, Fad for a particular new fibre in a particular end-use.

Summary of DRA research techniques

The ideal result of an assessment of the commercial viability of a new fibre is a statement of the volumes of fibre which could be sold in the future and at what price. We have taken this result as our target in developing our assessment methods, which contain the following elements.

1. A summary of the physical and aesthetic properties of the new fibre compared with other fibres and the consequent likely interesting end-use areas.
2. In-depth technical and market research by interviews at all levels of the garment supply chain.
3. Quantitative summary comparisons of fibre characteristics in garment end-uses.
4. Assessments of the advantages and disadvantages of using the new fibre in blends.
5. Definition of the „fabric stories" in which the fibre should have significant future use and the estimation of fibre volume sales for each fabric story at different price levels.

These elements are described in more detail below.

Physical and aesthetic properties

These will typically include: wet and dry tenacity, loop tenacity, elongation, wet and dry modulus, light fastness, fibre diameter, smoothness, reflectance, softness, propensity to fibrillate etc. A table is constructed showing how the new fibre compares with existing fibres in all these respects. Extrapolations are then made of the likely properties of the fibre in yarn and fabric form or the properties are measured/inspected from yarn and fabric samples. From this it is usually possible to identify the fibres with which the new fibre will have to compete and some end-use areas in which the new fibre is likely to have some competitive edge.

In-depth research in the supply chain

This research consists largely of interviews with decision-makers, at all levels of the garment supply chain, including spinners, weavers, knitters, dyers & finishers, garment designers and manufacturers, trading companies and retailers.

- The interviews are focused around fabric and garment samples wherever possible. These samples should be as simple as possible to avoid confusing the discussion by irrelevant issues of the current season's trends in colour, garment design etc.
- The emphasis in the research is ultimately on fabrics, since, of all the intermediate and final products in the supply chain, fabrics provide the best balance between low degree of product variety and the ability to assess the fibre's impact in garment form. By comparison, yarns have a low degree of variety but their effect in the final garment is often difficult to estimate, and garments often display a high degree of fashion-influenced variety which makes it difficult to assess the aesthetic fundamentals.
- The interviews are very open-ended to allow subjects to explain their own attitudes to the fundamental and long-term roles of different fibres in garment and their own approach to innovation and novelty in this area.
- Interview subjects are, of course, usually pre-occupied with the next one or two garment seasons. Great care is therefore taken during the interviews to avoid their responses being over-weighted by their current concerns. Subjects often have 20-30 years' experience in the industry and have seen many garment seasons come and go. Every effort is made to tap into the widely applicable knowledge and wisdom that this has created.
- Both single fibre fabrics and fibre-blend fabrics are discussed.

These interviews are carried out by consultants who have a good knowledge of downstream fabric and garment markets. This is particularly essential if a coherent set of "fabric stories" is to be identified.

Fibre characteristics in use

Based on the results of the interviews, summary comparisons are made of the new fibre's characteristics in likely target end-uses. The five assessment criteria and some illustrative comparative assessments are shown in Exhibit 3. In practice, each assessment criterion is composed of a number of sub-criteria. "Fundamental Aesthetic" for example, is composed of the sub-criteria: Handle, Lustre, Drape and Body. The number of sub-criteria associated with each major criterion is as follows.

Fundamental Aesthetic	4
Performance in End-Use	5
Processability	4
Versatility	4
Image	2

It is possible to weight the importance of the different criteria to reflect the needs of a particular end-use. Exhibit 3 shows the ratings of different fibres, including a new one, in an end-use that requires a strong fundamental aesthetic and a fibre with a high consumer image. This is not a real example. It has been constructed purely for the purpose of illustrating the methodology.

Fibre characteristics - summary (Example only)

Fibre/fabric assessment criteria	Viscose	Cotton	Wool	Silk	Linen	Polyester-Regular	Polyester-Shin Gosen	New Fibre	Weights (%)
Fundamental aesthetic	5	5	7	10	9	5	7	8	30
Performance	3	4	5	3	4	7	8	5	10
Processability	5	6	4	4	3	5	3	6	20
Versatility	4	6	4	3	3	6	6	3	5
Image	4	7	7	8	8	4	6	8	30
Weighted Average	**4.2**	**5.5**	**5.7**	**6.6**	**6.2**	**4.7**	**5.6**	**6.6**	**100**

Scores: on a scale 1 = poor to 10 = excellent

Exhibit 3

Impact in fibre blends

In assessing the impact of the new fibre in blends the following distinct major reasons for blending fibres are considered and the new fibre's impact in each area is assessed.

- Diluting a more expensive fibre
- Engineering a fabric to a price point
- Improving processability
- Improving performance in use
- Widening finishing options
- Engineering the aesthetics of the fabric.

Exhibit 4 shows assessments of some of the more common fibre blends using these criteria.

Impact of new fibre in fibre blends

		Impact of Fibre Addition/Blending					
Base Fabric/ Fibre	Fibre Added	Dilute Expensive Fibre	Engineer Price in Middle Market	Improve Performance in Use	Improve Processability	Widen Finishing Options	Engineer Aesthetics/ Fibre Synergy
Cotton	Modal		✗	✓			✓
Polyester	Viscose		✗		✗	✓	✓
Wool	Viscose		✓		✗		✓
Linen	Viscose	✓✓		✓			✗
Cotton	Polyester		✓	✓	✗		
Viscose	Polyester		✓	✓✓	✓		✗
Polynosic	Polyester		✓		✓		
Polyester	Polynosic		✗			✓	✓
Modal	Nylon		✓	✓✓	✗		✗
Cashmere	Wool	✓✓					✗

Key: ✓ = Benefit, ✓✓ = Major Benefit
✗ = Disadvantage, ✗✗ = Major Disadvantage

Exhibit 4

Fabric stories

In one of our projects we found in one retail store, side by side on a rack, six pairs of ladies' "linen-look" trousers made from fabrics of quite different fibre contents. Linen-look was in fashion that year and the producers and processors of different fibres (eg flax, cotton, polyester, wool, viscose, acrylic) had all focused on how to sell their fibre into the end-use. In this sense „linen-look" is a „fabric story" which can include a wide range of different fibres and fabrics aimed at meeting the same market need. „Soft denim", „washed silk look" and „peachskin" are other examples of fabric stories. It is necessary to define in each new fibre assessment project that set of fabric stories in which the new fibre could have a significant role to play.

Estimation of likely future demand

Estimates are made of likely future fibre demand in each of the target fabric stories based both on the findings of the research described above and on other research at the macro level of world consumption and production of various garment and fabric types. Each demand estimate for a fabric story is made on an assumption about the relative prices of the different competing fibres in the fabric story. For each such price relativity assumption, the quantitative estimates are made by estimating answers to the following questions:

1. What is the size of the current world market for this fabric story and what is the split between its classic and fashion elements?
2. What is the current market share of existing fibres in this fabric story in both 100% and mixture form?
3. What, if any, are the other new fibres which might compete in this fabric story?
4. Based on the results of the interviews, what is the likely market share achieveable by the new fibre in both 100% and mixture form?

Estimation of future demand

Fabric Story	Estimated World Market Size (kg)	Estimated Classic: Fashion Split (%)	Estimated Current % Market Shares of Existing Fibre Types A – M					Estimated Potential Future % Market Shares of Fibre Types A – N						Potential Volume for New/Modified Fibre N (kg)	
			A	B	•••	L	M	A	B	•••	L	M	N	Classic	Classic & Fashion
1															
2															
3															
4															
•															
•															
•															
P															
Total															

Exhibit 5

Exhibit 5 shows in outline, how, for a particular set of price relativities, the future total demand for a new fibre N is computed in a situation in which there are several important fabric stories (1 to P) and a number of other competing fibres (1 to M). The final estimate is in two parts:

(i) the total classic element, which can be expected as a minimum every year

(ii) the total of the classic and fashion elements, which is the maximum demand likely in any year.

Estimates of demand patterns over future years can be built up by making different assumptions about: total world fibre consumption, both overall and by fabric story; and price relativities among the different fibres.

Impact on decision making

We have found from experience that the methods described here can give credible answers to the following types of question relating to the potential for new and modified textile fibres in apparel end-uses.

- How does the market rate our fibre against competing fibres in different fabric end-uses?
- How does the market rate our fibre in different fibre blends compared with the competition?
- What are the trends in fibre substitution and what are the factors driving them? How will they evolve in the future? What will the impact be on our fibre?
- To what extent does our fibre have unique qualities? What are the most promising target end-uses for the fibre? Is future demand likely to be constant, to oscillate with the fashion cycle or to be a one-time fad?
- What volumes of fibre can we expect to sell in future years? How will these volumes vary with changing price relativities among the competing fibres?

Our clients have used the results of our assessment in many areas of decision-making, including the following:

- Whether to invest in a plant to manufacture a new fibre, how big the plant should be and where it should be located.
- The retailers, garment types, fabric types and price points to be targeted by the fibre.
- Fibre pricing policy and production cost targets.
- The desirable fibre properties to be targeted by further technical research and development work and the level of research and development budgets.
- The areas of focus and product targets for development programmes for yarns, fabrics and finishes related to the new fibre.
- The most promising countries in which to carry out collaborative product developments and the best spinners, weavers and finishers with which to work.
- Fibre branding policy.
- Targets, activities and budgets for fibre marketing, selling and promotion programmes.

Conclusion

We believe that these micro, bottom-up fibre assessment techniques that we have developed represent a revolutionary new research tool which enables fibre companies to focus on the fundamentals concerning fibre demand into the longer term. By combining with traditional macro, top-down methods (which consider trends in production capacities, demographics, lifestyles, world trade, GDP per head, etc), our experience has shown that robust and credible forecasts can be produced to support fibre companies' decision making across a wide range of critical policy areas.

CELLULOSIC FIBRE INDUSTRY – ECONOMIC AND ECOLOGICAL ASPECTS OF FURTHER DEVELOPMENTS

Bernd Wolschner, Hans Weber, Florian von Linde, Manfred Pentsch, Lenzing AG,
Talk held at Kyoto Conference on Cellulosics Oct 1994

The main driving forces in traditional viscose technology in the near future will be envimnmental protection, operating costs and quality. This article deals with developments and future prospects within these three important features of viscose fibre production.

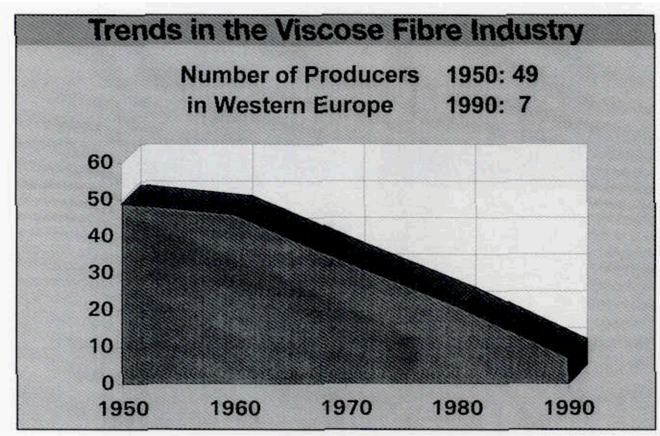
Umweltschutz, Betriebskosten und Qualität werden die wesentlichen Triebkräfte der klassischen Viskosetechnologie innerhalb der nahen Zukunft sein. Dieser Artikel beschäftigt sich mit Entwicklungen und Zukunftsaussichten dieser drei wesentlichen Merkmale der Viskosefaserproduktion.

In this lecture we will examine the future possibilities of viscose technology which is now over 100 years old. The viscose fibre, a real niche market product in the field of textiles with a market share of about 5 % of total fibre amount, is the most important cellulosic man-made fibre.

The viscose fibre was used as a replacement for cotton in particular, as the „poor man's fibre". Production capacities were persistently expanded in the 1950's and 1960's throughout the world and the peak production values were reached in the early 70's with approx. 2 mill. Va.

Then, development work on synthetic fibres was completed and they were able to set off on their triumphal march. This fact coupled with the difficulties regarding both costs and the environment, caused many viscose fibre manufacturers to close down their production facilities,

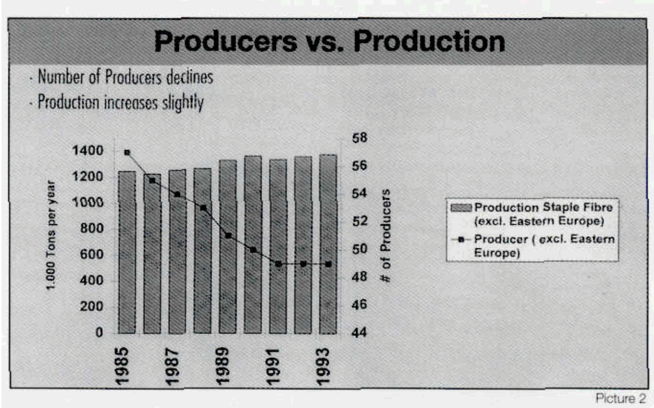
In the course of the last two decades the viscose fibre has been described as a dying fibre. A look at the production capacities in Western Europe clearly reflects this negative statement.



Picture 1

In this context should be pointed out that viscose fibre technology is based on a chemical plant technology and not on textile technology as is the case with synthetic fibre production. With its many circuits, the process is extremely complex and very difficult to control because of the natural raw material cellulose.

In the 1980's consumers suddenly began to express renewed interest in the positive propetties of cellulosic fibres. This led to a turnaround in the negative development and ultimately to the stabilisation of the viscose fibre market.



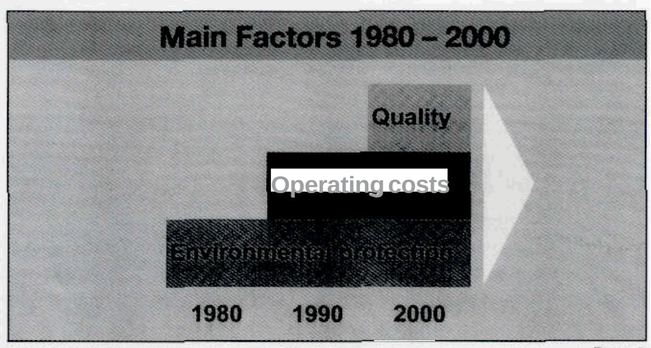
Picture 2

To make sure the manufacturing of cellulosic "man-made" fibres conforms with market requirements in the future two different processes are currently available. The prevailing viscose technology and Lyocell technology which is currently at the development stage.

The Lyocell fibre offers new physical properties. It still requires intensive development work both in fibre production and with respect to textile applications. The viscose fibre has recognised properties, however, to withstand 'interfibre competition' in the long term, here too further development work on the processes, product applications end an efficient rationalisation policy v·ill have to be carried out.

The main driving forces in traditional viscose technology in the near future will be the following:

- environmental protection
- operating costs
- quality



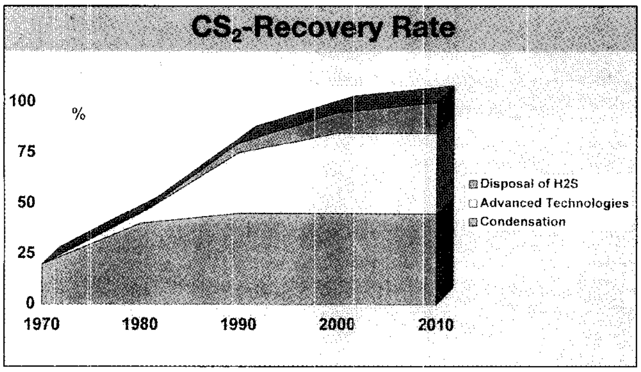
Picture 3

This lecture will concentrate on these three issues whereby the next pari of the presentation will deal with the effects of en ronmental protection.

Environmental protection

In the 1970's and 1980's environmental protection represented the potential danger to the producers of viscose fibres. Initially the investment costs required to clear up the truly serious situation regarding emissions seemed unfeasible from a commercial point of view. Intensive examination of this problem led to technological developments offering a viable solution to the environmental problem.

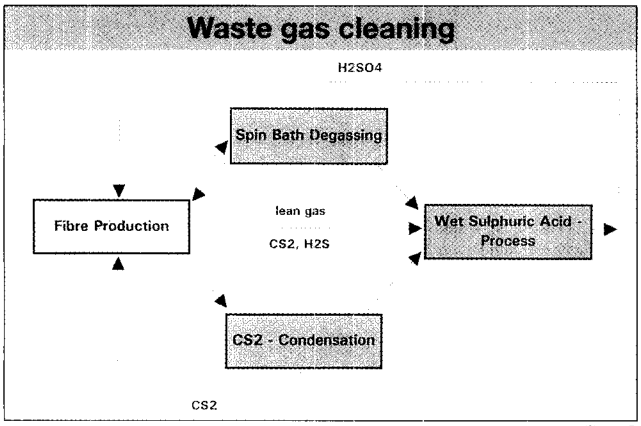
To illustrate this point the worst environmental nuisance in viscose fibre production, i.e. CS2 is taken as an example. In the 1970's condensation plants were introduced to the spinning machine area and adsorption plants for CS2 strong gases were used for the first time. The actual recovery rates were between 20 and 30 %.



Picture 4

In the 1980's improvements in the collection of flue gases produced a rise to 40 %. This was also the time of intensive discussion with the authorities on the one hand, concerning guidelines on emissions/immissions and plant suppliers on the other hand, concerning improvements in the existing and used technologies. The result was a real technological leap forward in the processing of resultant flue gases containing sulphur. This made it possible to find a solution to this very difficult environmental situation.

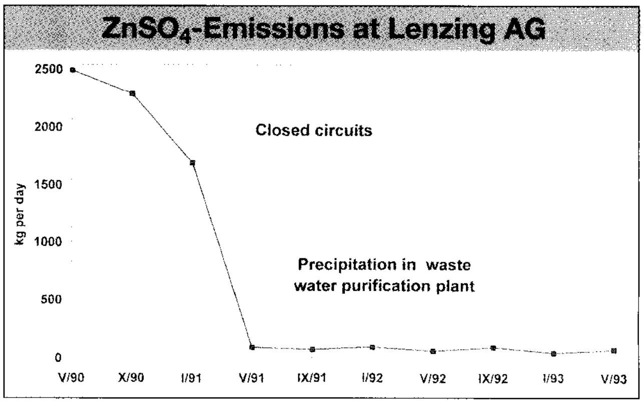
At the beginning of the 1990's Lenzing was able to reach a recovery rate of about 90% - with respect to sulphur - using a combined system of processes. The processes used were selected on the basis of the price of raw materials, the situation regarding the existing plants available and the extreme regulations issued by the authorities regarding the company's location in a well-known tourist area.



Picture 5

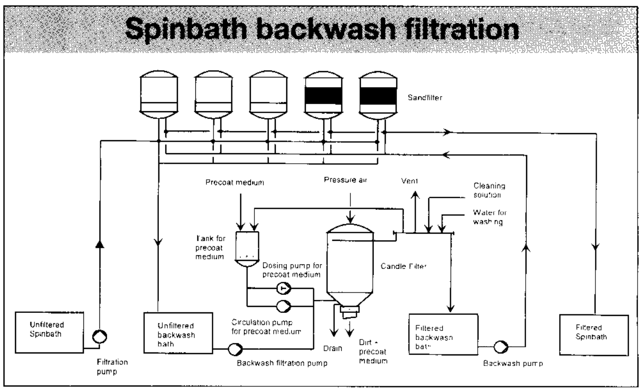
The present standard concept for the recovery of sulphurous flue gases is the combination of CS_2 condensation and the catalytic conversion of CS_2/H_2S flue gases to H_2SO_4. CS_2 recovery equals about 60 % - with relation to sulphur - and the investment costs lie within reasonable economic bounds (approx. $ 8 mill. for a plant of 70,000 to per annum).

Emissions in the spinning bath area represent a further critical item, whereby Na_2SO_4 and $ZnSO_4$ are the really problematic components. The solution here are closed circuits. However, the purification steps to remove organic sulphur impurities in particular, are absolutely essential. The second and third baths can, to a large extent, be fed back to the spinning bath if corresponding purification devices are installed. The remaining Zn load can be removed via precipitation through neutralisation in the waste water purification plant.



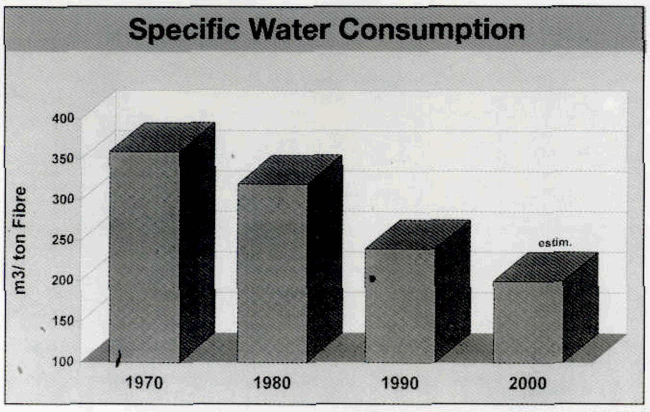
Picture 6

One example of how to reduce the loss of spinning bath is the spin bath filtration. Here the backwashing of the sand filter in the spinning bath circuit is carried out with purified spinning bath and not with fresh water. The advantage lies in avoiding the loss of the spinning bath and diluting the spinning bath with rinsing water. At the same time, the impurities are discharged in a dewatered/dried condition - and are therefore ready for disposal.



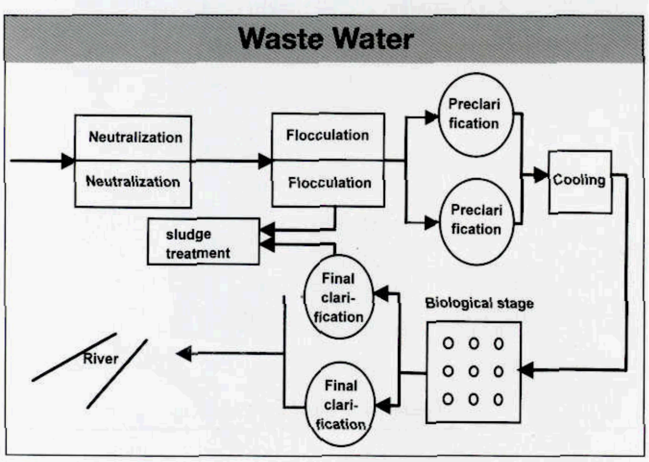
Picture 7

One indicator of the degree of circuit closure is specific water consumption whereby picture 8 shows the total amount of water consumption, i.e. it includes the consumption of process waters and cooling water. This issue will become increasingly important in the future since on the one hand, the quality of the product is directly influenced and, on the other hand, the availablity of fresh water is becoming problematic.



Picture 8

The COD loads in waste waters can be controlled in the viscose industry using standard biological waste water purification plants. These represent a considerable improvement on the neutralisation and sedimentation tanks formerly used and produce environmentally sound waste waters to be discharged from the treatment plant. The organic load is determined by the amount of pulp used i.e via its alpha content. This means that apart from the quality factor, higher pulp qualities will also be demanded by the environmental component in the future. The desired alpha content of 90-92 % at present, will have to be raised to 92-94 % even for staple fibre production.



Picture 9

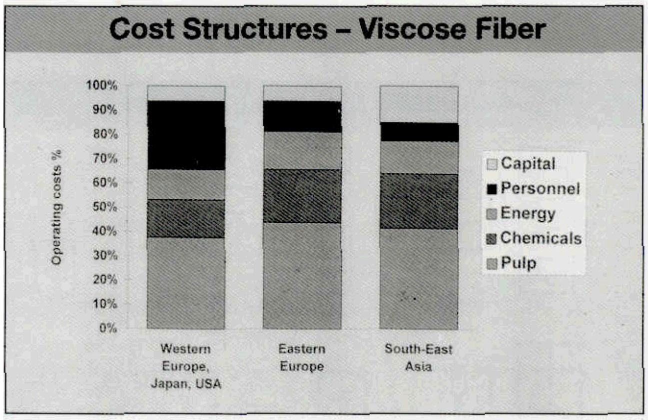
There are also a number of corresponding technical solutions available to improve MAK-values ((maximum working place concentration; (target values of 4 - 5 ppm are being discussed)). These represent new and constructive solutions for the collection of flue gases and sealing off in the spinning machinery area coupled with electronically monitored process control.

To sum up one can confirm that the viscose fibre industry has already accomplished its environmental tasks and the technological solutions available allow the economic and environmentally sound production of viscose fibres.

Operating costs

Operating costs have to be reduced both with respect to competition within the viscose industry and interfibre competition.

The points of emphasis to improve cost structure must be given different priority in different economic areas. The following diagram shows the average operating costs for the production of viscose fibres in the industrialized countries of Japan, Western Europe and the US, and in Me up-king nations of South-East Asia and Eastern Europe.



Picture 10

As a raw material, pulp makes up the largest part of the cost structure at 40 % in all economic areas, quite apart from its well-known influence on product quality and the BOD load of waste waters. The cyclical price development of pulp agrees with the paper industry and not with the textile industry. This has a marked disruptive influence on the fibre price structure as a whole. The small group of integrated pulp-viscose fibre manufacturers are not affected by this cycle and can, therefore, calculate their prices with a better contribution margin.

The shift of pulp productions from Europe and Northern America to the countries with plantations and correspondingly low wood prices and pulp prices has a very positive effect on the competitive strength of viscose fibres compared to other fibre types.

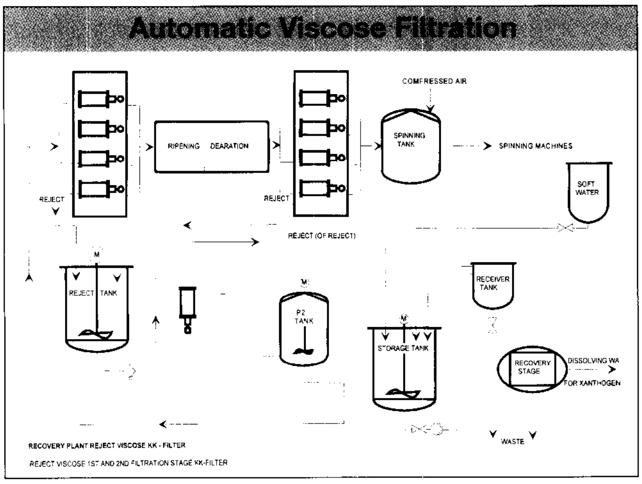
A comparison of specific employment levels (total number of employees in relation to annual production figures in 1000 t.) in the different economic areas is also of interest.

Eastern Europe has seen the development of dramatically exaggerated employment figures as a result of insufficient investment activity in the course of the last decade on the one hand, and the problematic social structure on the other. In this context it should be stressed that the personnel costs for each employee in Eastern Europe are similar to the costs in South East Asia.

In the industrialized countries personnel expenditure - 30 % of total expenditure - is the most important cost-saving factor. The present specific value of employees /1000t per annum will have to be further lowered in the near future in order to be able to compete with the countries with low wage costs. In the short-term this means that specifc values of below 5 employees/1000 t. per annum are to be expected; this means a figure of below 300 employees for an average 60,000 t. per annum.

The complete introduction of process control technology is already state of the art in most sections of viscose fibre production. Thanks to corresponding organisational changes - here the catchwords are re-engineering and lean production - considerable savings can also be achieved in the administrative sections.

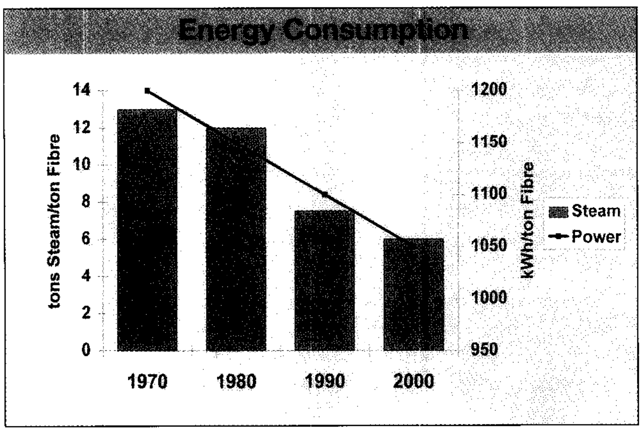
The basis for full automation is corresponding equipment which allows long-term operation without manual activity. One example is automatic viscose filtration in which both the filtration process and reject processing are operated fully automatically in a closed system.



Picture 11

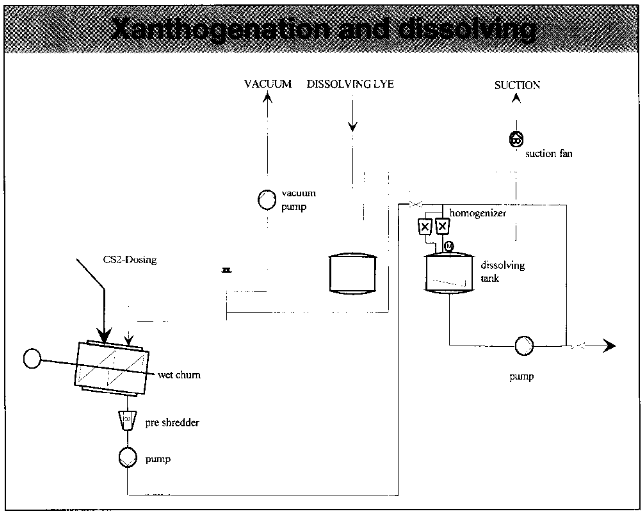
In the spinning machinery area, automation has not yet been successfully completed with respect to startup and stopping operations and spinnerette exchange; development work will be required in this area in the future.

Energy consumption was drastically reduced in the 1980's, triggered off by the energy crisis in 1978. No great changes are, therefore, to be expected in the area of steam consumption.



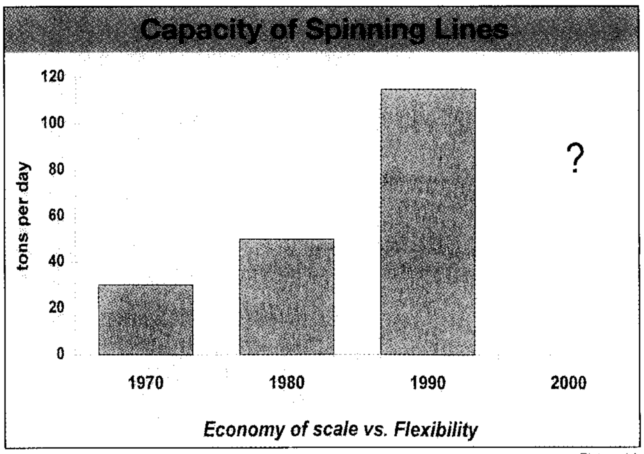
Picture 12

The consumption of electricity, which is more difficult to reduce as a result of the large number of individual consumers, can normally only be controlled within the framework of modernising complete process sections. Here attention must be paid to determine the battery limit for the correct evaluation of economic efficiency. One example is xanthogenating, where xanthogenating and dissolving are to be considered together as one system. Naturally, the capacity of the individual aggregates is an important factor since specific consumption decreases along with the size.



Picture 13

The capital costs required to construct a new line are one further important factor - particularly in new plants such as in South East Asia. A development recently introduced in this area led to the rapid expansion of the maximum capacity of one spinning line. The present standard size of a new line can be named as over 100 t. per day. This leads to a drastic reduction in specific capital costs and in the remaining fixed overheads.



Picture 14

However, reducing the number of spinning lines also clearly reduces the flexibility of product variety. At the same time so-called "just in time" supplies from customers even of smaller lots will become increasingly important. To resolve this conflict, it will be necessary to develop larger spinning lines which can also produce small production quantities in short spaces of time, one after the other. This means that our entire concept in the post-treatment and drier area must be totally reconsidered.

In this respect, the economic size of a staple fibre plant is also of interest. Industrial countries, with their high personnel expenditure and environmental costs, will require 60,000 t./a. plants as a minimum size on the long-term whereby the ideal plant size will most likely equal 100,000 t./a. This very rough estimation will depend primarily on the market price scenario for the individual plant in question.

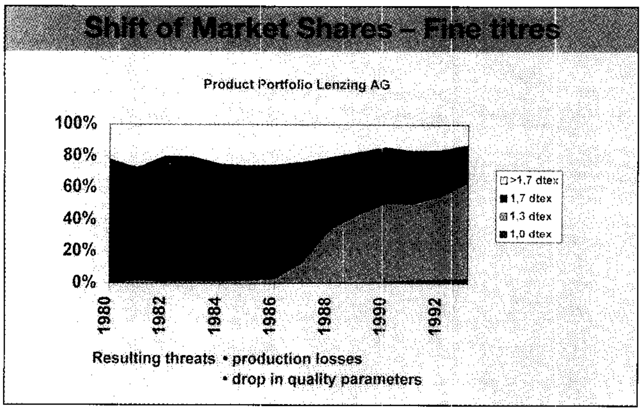
Quality

Quality will become an increasingly important distinguishing feature with respect to this product as well. It is almost impossible for poor qualities to penetrate top markets. The continuity of all different fibre features plays a major role in this regard.

No individual value, such as for example values for tenacity, is of prime importance to quality assessment. A low rate of variance with respect to all of the quality parameters will ultimately decide the category in which the product is classified i.e low/medium/top quality.

One further criterion in this context will be conformity to ISO 9000 guidelines. As we know, certification will not produce per se an improvement in quality. The retracability of organisational procedures and responsibilities will, however, guarantee constant product quality. One essential prerequisite for the documentation of individual process parameters will, however, also be the introduction of a complete electronic process control system.

The changes in market behaviour in the fine titre area exert a direct influence on process control in viscose manufacture. Parallel to the development in the synthetic fibre area, the shift of market shares in favour of finer titres in the recent past took place at an extreme speed.



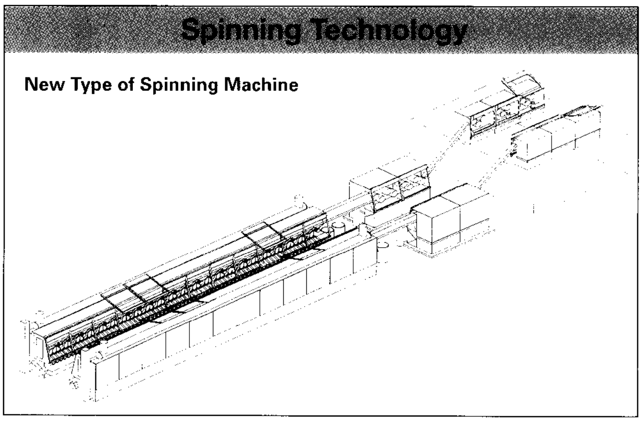
Picture 15

The threat this represents is explained by the almost linear decrease of production on the one hand, and on the other hand, the sensitivity of fine titre fibres in the production process which leads to a drop in quality parameters.

To compensate for these problems narrower process parameters are necessary in viscose production which can only be achieved using an efficient process control system.

The necessary further development work to the spinning machine was started and successfully completed with the goal of compensating for production losses, fulfilling regulations regarding environmental protection and MAK-values and achieving the highest possible level of automation.

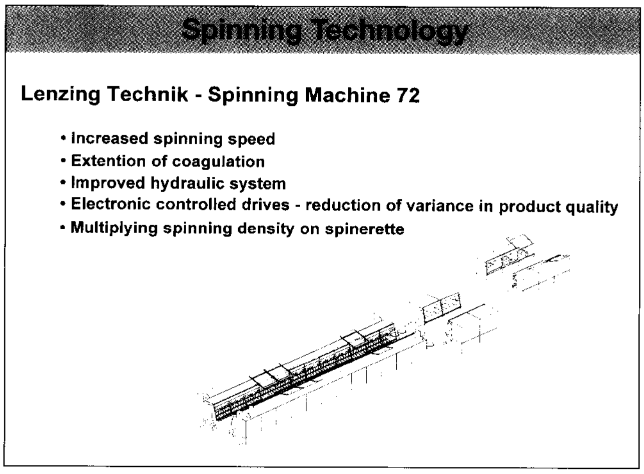
To compensate for production losses the spinning speed was increased and the spinning density on the spinnerette head was multiplied. To stabilise quality, the spinning bath hydraulic system in the spinning trough was evened out and the coagulation line was considerably extended. At the same time operability with regard to starting and shutting down operations was adapted to modern ergonomic methods.



Picture 16

Fully electronic controlled drives were introduced which also greatly reduce the variance in product quality. The seal-tight closure of the spinning machine to improve flue gas interception, is one further result of this development.

This example demonstrates the interconnection between quality improvement, rationalisation steps and environmental protection which characterizes the viscose industry.



Picture 17

Summary

The intensive discussions about the necessary measures to be taken regarding environmental protection have led to the development of economically viable solutions which have allowed the long-term survival of the viscose industry.

In the cost area, depending on the differences in different economic areas, rationalisations in staff numbers and questions about maximum capacity limits are uppermost in people's minds.

The quality will be coloured by the introduction of ISO 9000, the production of fine titres and the reduction in the variance of important parameters.

In the future, market demand for cellulosic fibres will continue to be buoyant due to the positive physical properties of the fibre. Constant increases in viscose production, even in the last twenty years, and the parallel reduction in the average titre, act as a guarantee that the viscose industry will continue to play an important role in the next century.

MATERIAL AND ENERGY BALANCE FOR VISCOSE STAPLE FIBRES AND FILAMENTS

Talk on the occasion of the 33rd International Man-Made Fibres Congress in Dornbirn
by J. Schmidtbauer/Lenzing AG and B. Böhringer/Akzo Nobel

Today, ecological aspects are also beginning to be a matter of significance to the textile industry. This talk has the task of compiling a material and energy balance for the manufacture of viscose staple fibres and filaments. This includes the depiction and quantification of the consumption of raw materials and energy as well as emissions into the air, water and soil and, therefore, aspires to describe a Central European industrial standard for viscose using modern environmentally sound technologies.

Ökologische Aspekte beginnen heute auch für die Textilindustrie eine signifikante Bedeutung zu erlangen. Dieser Vortrag setzt sich zum Ziel, eine Material- und Energiebilanz für die Herstellung von Viskosestapelfasern und -filamenten aufzustellen. Dies beinhaltet die Darstellung und Quantifizierung des Verbrauches an Rohmaterialien und Energie ebenso wie von Emissionen in Luft, Wasser und Boden und zielt daher auch darauf ab, einen zentraleuropäischen Industriestandard für Viskose unter Verwendung moderner umweltfreundlicher Techniken zu beschreiben.

1. Introduction

Today, ecological aspects are also beginning to be a matter of significance to the textile industry. Fibre manufacturers and processers face growing interest on the behalf of consumers in both the ecotoxicological properties of fibres and textiles as well as in the environmental impact of production processes, the consumption of energy and limited resources and the disposability of products.

A comprehensive assessment of this kind, of the environmental impact associated with a product's life demands the drawing up of an **eco-balance** or life cycle analysis. Unfortunately we currently lack any systematic binding international approach and a suitable data basis to enable us to draw up eco-balances for textile products. Lenzing and Akzo have, therefore, set themselves the task of compiling **a material and energy balance** for the manufacture of viscose staple fibres and filaments. This includes the depiction and quantification of the consumption of raw materials and energy as well as emissions into the air, water and soil and, therefore, aspires to describe a Central European **industrial standard for viscose** using modern **environmentally sound technologies**. We are, therefore, preparing a data base with which it will be possible to compile eco-balances for textiles and nonwovens made of viscose.

Eco-balances, which permit a comprehensive assessment of all the ecological damages associated with the life of a product, comprise an inventory analysis, an impact assessment and an evaluation of these results (Fig. 1). Since it is currently only possible to make a brief approach at assessing global ecological effects using an impact assessment and since the ecological evaluation is influenced by subjective evaluations apart from geographical, national economical and political considerations, we wish here to deal solely with **a material and energy balance**.

It is not our intention to make an **ecological comparison** between viscose staple fibres and filaments or between viscose, natural and synthetic fibres. On the other hand, the mere listing of consumption or emission figures often does not even permit the expert to judge whether this is either to be considered high or low for the relevant product. We will, therefore, try to interprete the most important parameters by demonstrating the **influence of environmentally sound production technologies** on the one hand, or making comparisons with generally **known processes** and **products**. This should not, however, be seen in the context of an evaluation because we are aware that in the final analysis, only complete systems and not individual aspects may be evaluated.

2. System boundaries

The material and energy balance presented does **not** describe **a closed life cycle** as depicted in this diagram for viscose fibres (Fig. 2). Our balance begins with the supply of wood, includes the production of pulp and viscose fibres, and ends with the storage of staple fibres and filaments ready for delivery.

Structure of an ECO-Balance

1. Goal definition and scope
- **objectives, boundaries, procedures**

2. Inventory analysis
- **raw material and energy consumption**
- **emission into air, water and soil**
- **transportation**

3. Impact assessment
- **global warming potential (greenhouse gases)**
- **acidification**
- **ecotoxity**
- **human toxicity, etc.**

4. Valuation
- **different methods**

Fig. 1

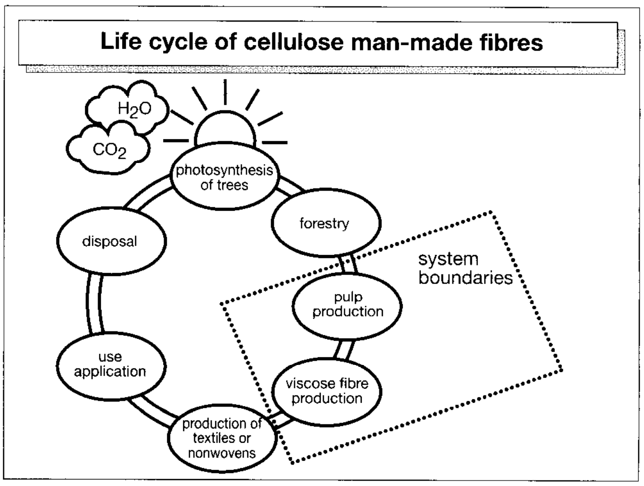


Fig. 2

The manufacture of pulp and viscose fibres is illustrated in two separate **modules** (Fig. 3). These cover the provision of process energy, required in the form of steam and electricity, the operation of connected recovery and environmental plants and the recovery of secondary products.

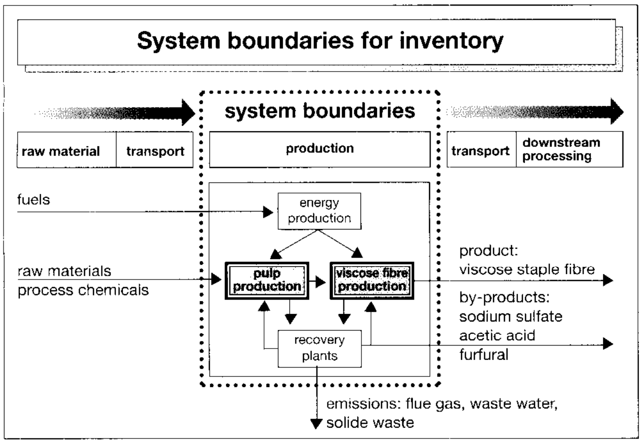


Fig. 3

The environmental impacts which result from the manufacture and transport of **raw materials** are depicted separately. Extraction and transport of fuels for energy production as well as the packaging and transport of our products and secondary products have not been considered. All of the data stems from 1992. One ton of a.d. pulp resp. one ton of conditioned fibre of prime quality were defined as reference values. Auxiliary materials, the specific consumption of which is less than **3 %** of the product mass, were only considered in the material balance. Environmental impacts during the manufacture of the former were not considered.

From a systematic point of view, the treatment of the raw material **wood** is problematic. About 40 % of its material mass is found in the target product, pulp, another 4 % in the secondary products acetic acid and furfural, and approx. 55 % of the wood mass is incinerated to produce energy.

We have now only considered the energy input into the system for that part of the wooden mass which is used for energy production and did not assign any energy content to the products. We believe this means of procedure is justified since we are dealing here with energy from replenishable raw materials and, in contrast to synthetic products on the basis of crude oil, the use of these substances does not lead to a depletion of limited resources.

In the same way, it is just as difficult to properly evaluate the **secondary products** acetic acid, furfural, sodium sulphate, sulphur and sulphuric acid which occur in the pulp and viscose process. A plausible model, for example, is to assign the consumption and emission values to products and secondary products alike in the same proportions. This would assign more than 40 % of the environmental load of the viscose process to Glauber salt.

In another model one could ascertain the ecological damages which occur during the conventional manufacture of our secondary products and allocate these to the main product, viscose fibre, in the form of a credit.

Both models are, however, speculative and obviously offer ground for controversy. We decided, therefore, to consider the "worst case" and assign all consumption and emission values to the main product.

3. Production Process

Since the majority of you are probably not all that familiar with the technology of pulp and viscose fibre manufacture, I would like to give you a short description of the environmentally-relevant process steps given the example of **integrated viscose staple fibre production** at Lenzing.

Our raw material is debarked and chopped **beechwood** which is digested using the acid magnesium bisulphite process (Fig. 4). In this cooking process the lignin is sulphonated and separated from the cellulose. In what is almost a completely closed chemical circuit the spent liquor is evaporated, burnt to produce energy and then fed into a recovery plant in which fresh cooking liquor is made from the combustion products. With the help of this costly closed loop operation and recovery process, the SO_2 emission can be reduced to a minimum.

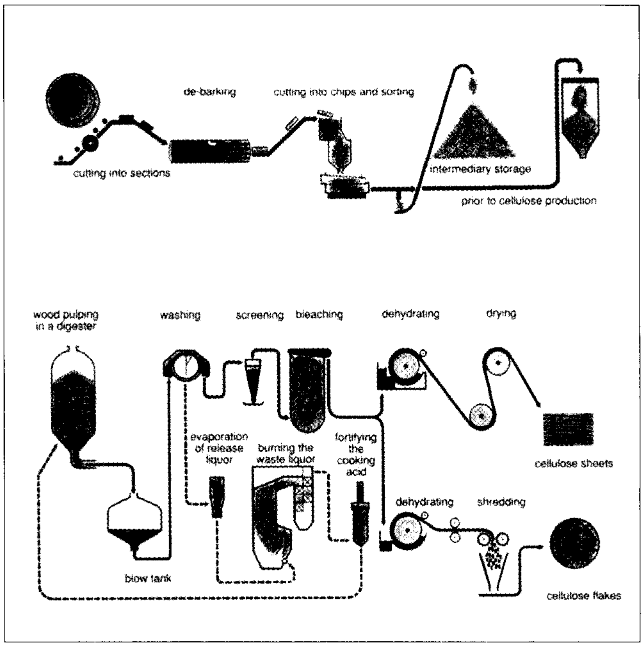


Fig. 4

The raw material wood is hereby used in its entirety: about 40 % is extracted in the form of cellulose, another 4 % in the form of the secondary products acetic acid and furfural, and the remaining materials contained in wood including the bark, are put to use via incineration in the form of steam and electricity. The raw pulp is then washed and screened, bleached in several stages, dewatered and if necessary dried. In order to exclude the formation of toxic organo-chlorine compounds (AOX) the bleaching process is performed without chlorine chemicals using oxygen, hydrogen peroxide and ozone. The bleaching waste waters with a high organic load, are evaporated and burnt. This chlorine-free bleached pulp is the raw material for viscose fibre production.

The **viscose process** begins with the steeping of the pulp to make alkali cellulose (Fig. 5). With the help of carbon bisulphide this is converted to xanthate which is dissolved in diluted soda lye. This solution is called "viscose". The finished spinning

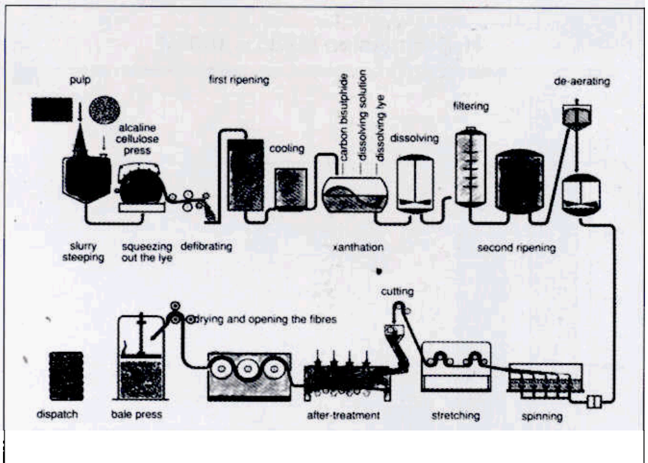


Fig. 5

Baths and off-gases from the spinning process are regenerated in recovery plants and sodium sulphate is recovered as a secondary product. The viscose staple fibre is subsequently washed in several stages, opened, dried and pressed to bales.
The charged waste waters from the viscose factory are cleaned together with those from the pulp mill in a two-step biological purication plant.

4. Energy Balance

The energy balance for a process is of particular significance to environmental friendliness. Both the energy consumption itself and the type, origin and renewability of the combustion materials and the technologies employed for flue gas purification have a significant influence on the environment.

With respect to the provision of the energy required for processes, Lenzing is completely self-sufficient.

Since pulp is only mechanically dewatered in our integrated manufacturing process but does not have to be dried, our pulp factory in fact produces more energy than it requires itself. The fact that **energy is linked** between the pulp and viscose factory and that residual substances from the same process are utilized via incineration (thick liquor, bark, biological sludge) means that it is largely possible to do without the use of fossil fuels. Three quarter; of the energy requirements are covered by renewable fuels; the CO_2 emitted is of plant origin and, therefore, does not contribute to the greenhouse effect (Fig. 6).
The energy content of the different fuels was calculated at the lower calorific value.

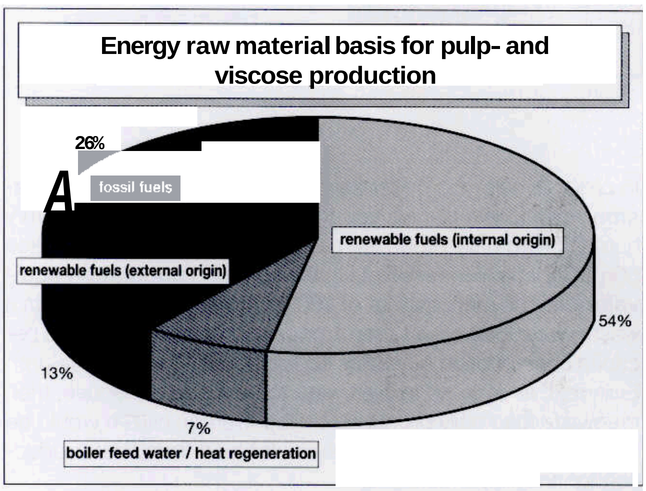


Fig. 6

5. Pulp Balance

Now we will present the material balance sheet for the production of TCF pulp at Lenzing. The **critical waste water parameters** of a pulp mill are undoubtedly the organic substances expressed in COD, BOD5 or TOC and the organochlorine compounds (AOX). in our case the **AOX problem** was resolved in optimum manner using a bleaching sequence completely free of chlorine and chlorine compounds.
As far as the **organic substances** are concerned, the next diagram (Fig. 7) shows developments since 1982. Here we can see the average **BOD_5 emission** of the Lenzing pulp, paper and viscose fibre factory expressed in terms of population equivalences. The largely closed loop operation and the development of new technologies connected with the application of environmentally-friendly processes have allowed a reduction in wastt water loads from 1 million population equivalences to 3000 popu lation equivalences within the course of one decade.

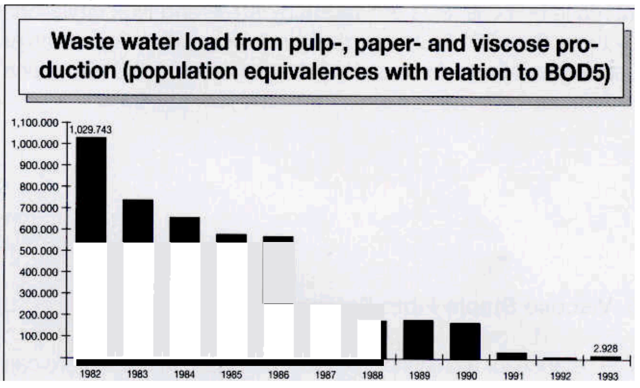


Fig. 7

With respect to **atmospheric emissions, SO_2** is typical for a sulfite pulp factory and NOx is a toxic substance component from power plants.

The complete interception of all flue gases containing SO_2 in the pulp area and their inclusion as combustion air for the recovery boiler made it possible to almost completely close the SO_2 circuit on the flue gas side. The investment in new recovery boilers with even more efficient flue gas desulphurization, the use of low-sulphur combustion materials for the production of energy and the reaiisation of different projects to save energy, led to a **reduction in SO_2 emission** by approx. **80 %** within a six year period (Fig. 8).

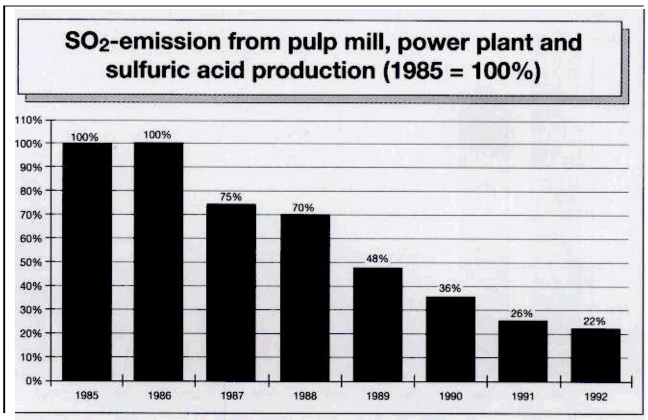


Fig. 8

Energy consumption is of course closely connected to atmospheric emissions. The **integrated** further processing of the dewatered wet pulp to viscose fibres has both economic and ecological advantages (Fig. 9).

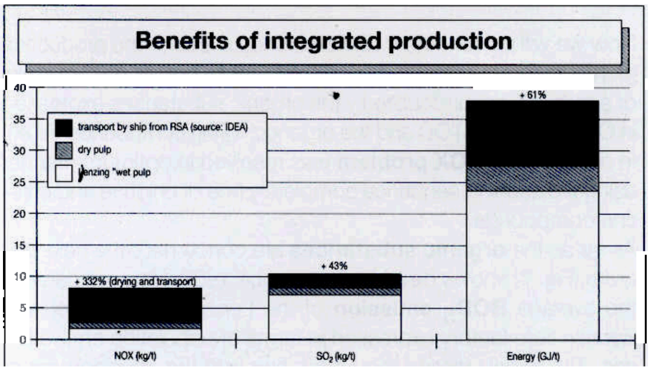


Fig. 9

The diagram will try to illustrate that energy consumption would increase by 60%, SO_2 emissions by 40 % and NOx emissions by more than 300 % if pulp made in the conditions common at Lenzing had to be dried and e.g. transported from South Africa to Austria.

6. Viscose Staple Fibre Balance

The balance for a chlorine-free bleached viscose staple fibre can be illustrated in a similar way to pulp.

Since sulphuric acid production is a part of the recovery and flue gas purification system, this process is included in the fibre balance.

CS_2 and H_2S are **characteristic** of atmospheric emissions which give a viscose factory that characteristic "Smell". The investment in costly flue gas purification plants in 1986, however, drastically reduced the emission of those intensively smelling components at Lenzing (Figs. 10, 11).

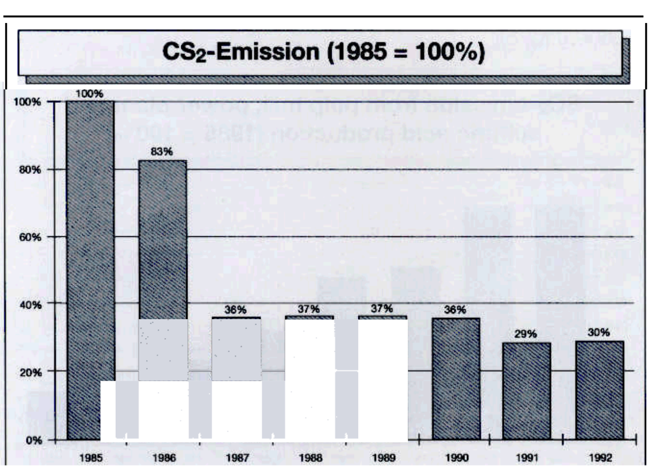


Fig. 10

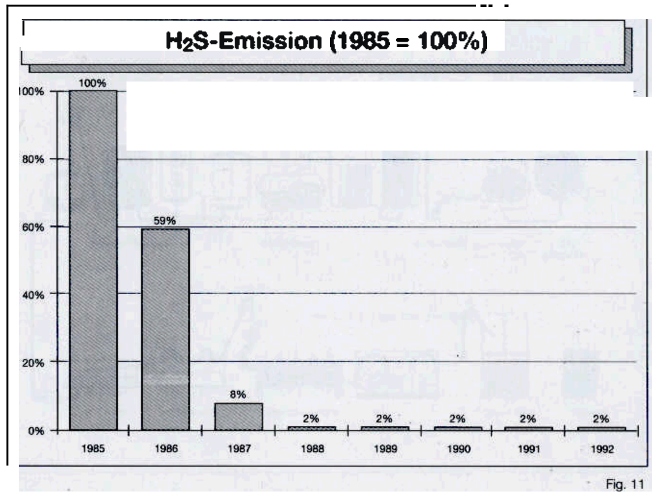


Fig. 11

So as not to impede the function of the biological purification plant, zinc is removed from the waste waters via precipitation; the remaining emission is at a minimum due to the solubility limits. The **sulphate load** is still relatively high despite the largely closed nature of the circuit involved but does not represent an acute ecological problem at the moment. There is, however, potential to further improve the viscose process in the future from an ecological point of view.

The bringing together of the two modules "pulp balance" and "viscose staple fibre balance" produces the **total balance** for the process from the beech trunk stage through to the staple fibre whereby the manufacture and transport of raw materials and process chemicals have still not been considered. These elements will be dealt with in the second part of this talk by Dr. Bohringer.

Since the individual balances have already been explained, I would now like to take a look at one characteristic parameter - **BOD_5** emissions (Fig. 12).

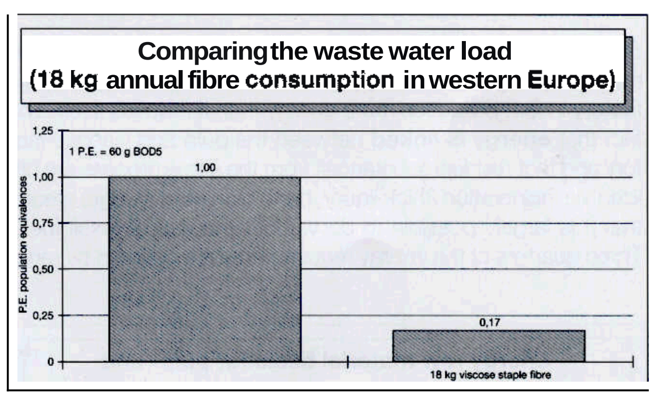


Fig. 12

In order to help you understand the extent of the **BOD emission** I would like to give you the following comparison: every human being daily produces a waste water load of on average 60g BOD which corresponds to the so-called **population equivalence.** The manufacture of 100 kg of viscose fibres effects a waste water load of less than 1 population equivalence. The per capita consumption of textiles equals about 18 kg/a in Western Europe. If all of these textiles were to be made of viscose, then the waste load daily produced by the average citizen would be five times higher than the waste water load from fiber production for his annual demand.

Due to the development and application of new environmentally-friendly processes, the investment of ATS 4 billion and consequent implementation of all possible methods to avoid or reduce toxic substance emissions, Lenzing has managed to make the viscose process environmentally sound. We are convinced that the environmental standard of Lenzing, which most viscose staple fibre manufacturers have not yet achieved, has to become standard procedure in industrialised countries if the viscose fibre wants to uphold or even to improve its position in the interfiber competition also from an ecological point of view.

7. Production of Textile Filament Yarns

Unlike staple fibers, which are sold as bales, filament yarns are wound "continuously" on bobbins. This difference has major effects in terms of process technology and also influences the material balance.

Significant differences between the two products are already found just after spinning. Instead of a few production lines with a very high number of capillaries, filament production involves a high number of single spinning points with a few fine capillaries (Fig. 13). All bobbins obtained at these spinning points must then be processed separately. As you will see, this results in certain differences in consumption levels and emissions.

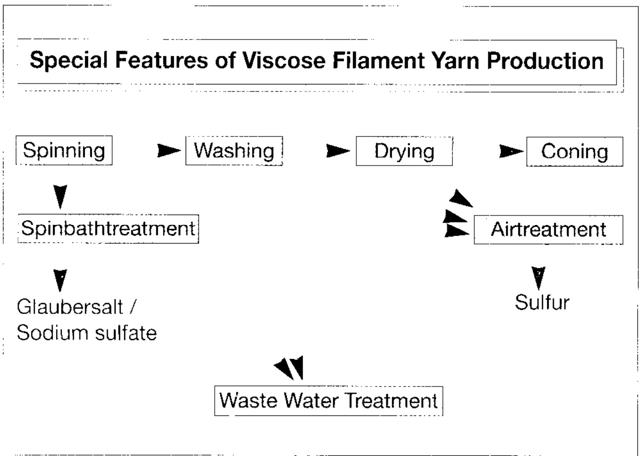


Fig. 13

Filament yarn production comprises the following operations: spinning, washing, drying, and coning. The alkaline Viscose solution is coagulated directly after the spinneret in a coagulation bath with sulphuric acid. As a by-product of the neutralisation Glauber salt or sodium sulphate is formed. Sodium sulphate is isolated during the treatment of the coagulation bath, this process is also included in the material balance. All waste water streams are treated in our own water purification plant, whose operation is included in the balance as well.

The waste air from the spinning and washing machines, which contains higher amounts of sulphur compounds due to the decomposition of the viscose solution, is fed to a purification plant. This purification plant, too, is included in the material and energy balances. A by-product generated due to the technology during air purification is sulphur.

8. Raw Material

Any material balance must include raw material consumption and consequently also indirect raw material consumption levels and emissions.

The raw materials used for producing ENKA VISCOSE filament yarns are listed in Fig. 14, with similar materials being used for staple fibers. As expected, the major raw materials for preparing the viscose solutions are cellulose, sodium hydroxide and carbon disulphide, while the most important material needed for the spinning bath is sulphuric acid. The other chemicals are substances that are used at various stages of the process: zinc and magnesium are added to the spinning bath. Sodium sulphite is an additive used during washing and a spin finish. Burnt lime is required for operating the purification plant.

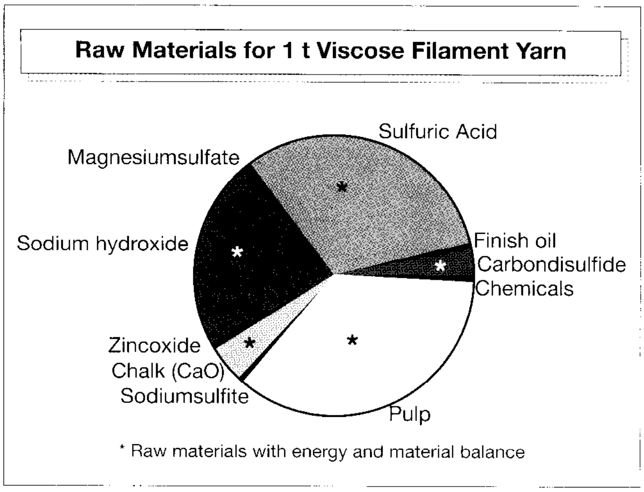


Fig. 14

In principle, a material balance like the one of viscose filaments should include the material balance of each of the raw materials involved. We have, however, tried to simplify things a little by taking into consideration only the balances for raw material accounting for more than 3 % by wt. related to one ton of yarn or fiber produced, i.e. for cellulose, carbon disulphide, sulphuric acid, caustic soda solution and burnt lime. Cellulose has been dealt with already in section 5.

For preparing the raw material balances it was necessary to have certain information and to define the balance limits. All data are based on the information received from our suppliers and may therefore not be typical of the material in general, but in any case of the material used by ourselves. Fig. 15 shows the balance limits for establishing the raw material balances. As you can see, they cover the raw material production and transport to our plant. This includes raw material consumption as well as process and transport emissions.

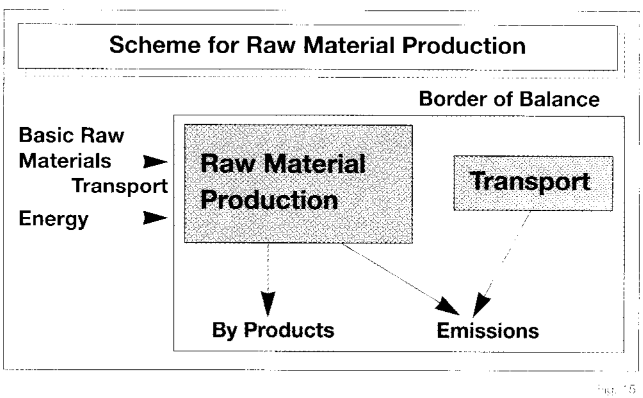


Fig. 15

The production of the basic raw materials and their transport to the plants of our suppliers could not be described for lack of information. Here the difference between viscose and synthetic fibers is evident. The preparation of material balances for petrochemical products like the ones used for synthetic fibers is far advanced. The raw materials used for viscose, however, are mainly non-petrochemical products, such as sodium hydroxide from sodium chloride, sulphuric acid and carbon disulphide from sulphur and burnt lime from limestone. When one day balance data are available for such raw materials, too, they can also be included into the material balance for viscose. For the time being, the error resulting from this neglect will have to be accepted.

Unfortunately, it is not possible to deal with all raw materials in detail in this paper. Fig. 16 shows the major raw materials used for preparing sulphuric acid, caustic soda solution, carbon dioxide and burnt lime.

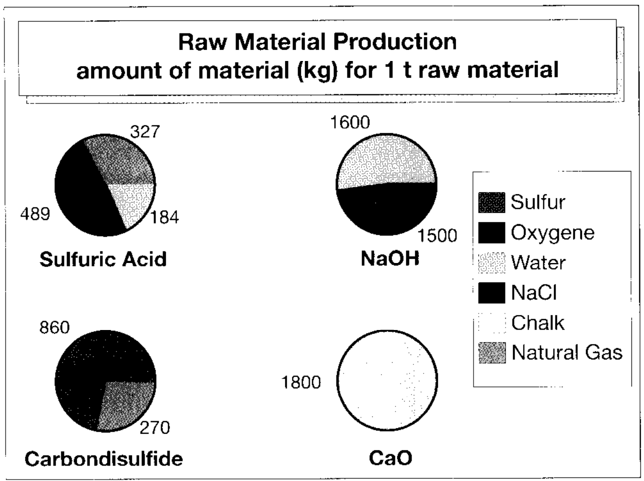


Fig. 16

In addition to raw material usage, energy consumption must be taken into account as well. These energy requirements for producing and transporting the raw materials are shown in Fig. 17. As was to be expected in view of the chemical processes involved, carbon dioxide and caustic soda solution account for most of the energy consumed, while the production of sulphuric acid even generates energy. Transport, too, requires energy, although these figures must be taken with a pinch of salt, since the existing studies and energy consumption and emission figures vary considerably. They may differ by as much as 50 % between individual studies. We have chosen the "worst case" for this paper [1].

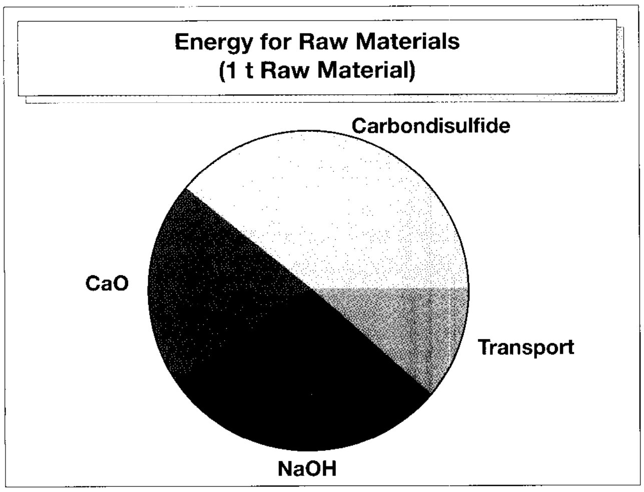


Fig. 17

Like raw material and energy consumption, the individual emissions generated during raw material production have to be considered, too.

Finally, all figures thus obtained for the production of 1 ton of raw material must be converted on the basis of the quantity of the respective raw material required for producing 1 ton of viscose filament yarn, in order to obtain a uniform standard for comparison.

9. Material Balance for Viscose Filament Yarn Production

After discussing raw material production, let us now turn to the production of filament yarn. Raw material consumption can be seen from Fig. 14. A large number of chemicals is required, the most important materials being cellulose, sulphuric acid and caustic soda solution.

The production of viscose filament yarns also involves the formation of by-products (Fig. 13), which should not be regarded as waste or remnants since they may in fact be profitably sold as raw materials. They include sodium sulphate from the spinning bath and sulphur from waste air purification. All figures that are relevant for the generation of these two by-products are included in the data for viscose filament production. Since these materials are raw materials for our customers rather than waste products, there arises the question how these by-products should be treated in the material balance (Fig. 18). This question is by no means unjustified because whenever sodium sulphate or sulphur are obtained from different sources, their consumption and the emissions associated with their production must be taken into account.

Charging of By-Products

- Raw Materials and Emissions by wt. %
- By-Products according to their Material and Energy balance
- No charge
  All Materials and Emissions only for Viscose

Fig. 18

There are several possible approaches: The viscose filament yarn and the by-products are charged with raw material consumption and emissions in relation to their proportional weight. The by-products are treated as if they had been produced by the methods commonly used. Or the by-products are not charged at all. The second approach is more convincing for it is not reasonable either to allocate consumption levels/ emissions that are typical of viscose to the by-products or to neglect the fact that any material requires raw materials for its production and causes emissions. Since no material balances for sodium sulphate and sulphur are available to us, anyway, we have decided not to charge the by-products. If, however, material balances for these by-products should come to our knowledge, we will include these into our material balance.

A material and energy balance is first of all a very comprehensive data collection. In Fig. 19 it has been attempted to present the figures for viscose filament yarns in a clearly arranged manner, the data for energy and emissions also including the raw material figures.

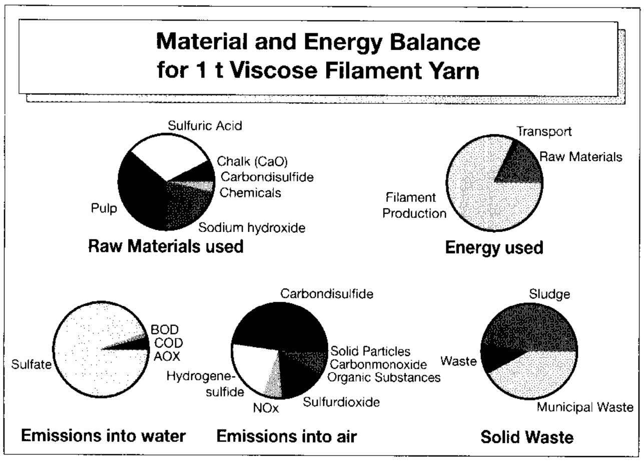


Fig. 19

As expected, about three quarters of energy consumption are accounted for by filament yarn production with its sophisticated process technology, the large number of spinning and twisting points and finally the complicated waste air purification system. The energy used for filament yarn production comprises steam and electricity. It should, however, be noted that the predominant part of the energy required is produced on the site by our own power plant, which is operated as a cogeneration plant. That is the way to efficiency of the power plant is much higher than that of public utilities.

This has also an effect on air emissions. About 30 % of the energy required is purchased in the form of electricity. This emissions directly related to energy consumption, i.e. nitrogen oxides, sulphur dioxide, organic substances, particles, carbon monoxide and carbon dioxide are largely determined by the electricity obtained from external sources. Carbon dioxide is not included here, since the respective emission is, of course, much higher than that of the other materials. The emission figures for external electricity generation (mix for Germany) was taken from the pertinent literature [2].

Apart from the energy-related emissions, there are major emissions, specifically related to the viscose process, of carbon disulphide and hydrogen sulphide, which have been substantially reduced during the last few years.

Of importance are not only the emissions into the air, but also those into the water. All of our factories, like those of most European chemicals companies, have their own purification plants. COD and BOD values can thus be kept on a low level, the efficiency of the purification plant being about 94 %. The dominant emissions into the waste water are the sulphate ions from the spinning bath, although sulphate ions are also discharged into the waste water during cellulose production. Another important waste water parameter is the AOX content, although this is relatively low in the case of viscose.

In addition to these emissions into air and water, there exist emissions in the form of solids, i.e. waste material. This waste material consists of sewage sludge, waste material similar to household waste, and only a small percentage of waste materials specifically related to the production process.

10. Overall Balance

Fig. 19 shows the material balance for viscose filament yarn at a glance.

However, it must be emphasized at this point that these figures will not be valid forever. They rather reflect the situation at a given moment and will change in the course of time.

This will be illustrated by the example of water consumption. During the past years, water consumption in the production of ENKA VISCOSE could be reduced by about 50 % (Fig. 20). This water consumption looks very high, but if it is compared with the water consumed for washing 1 ton of textiles made of viscose, for instance, in households (50 washings, half-loaded machine consuming only 60 liters of water), when it will be found that the amount of water used for the care of textiles is 5 times higher even when using the most advanced type of washing machine with the lowest possible water consumption. Of course, this consumption basically applies to any kind of textiles whatever the type of fiber of which they are made. In this connection it is also interesting to consider the amount of water required for irrigation purposes when growing 1 ton of cotton [3], which is between 7.000 and 29.000 m³/t since this is a natural raw material which takes quite some time to grow.

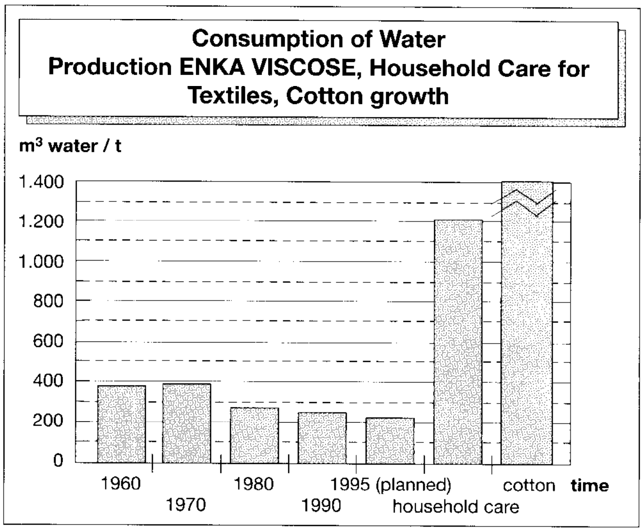


Fig. 20

This figure leads us to the following conclusions: A material balance is not a static matter, but something that may be influenced by a variety of factors.

To obtain valid results, it is necessary to analyse and compare real life cycles rather than material balances of individual steps. Picking out just single aspects of different products to be compared is something that must in any case be avoided since it implies that one of the products will always be discriminated. Furthermore, a material balance will, of course, change as a result of customers demanding products with new properties, which in turn necessitate process modifications. On the other hand, customers may accept different properties allowing us to reduce raw material consumption and/or emissions.

In the future, this will certainly be a subject to frequent discussions between customers and suppliers.

11. Summary

Lenzing and Akzo Nobel have presented here a material balance for viscose staple fibers and filament yarns which is intended to help our customers in the future to establish material balances for their own products.

In this connection, it must be remembered, however, that the figures presented apply in the first place to Lenzing and Akzo Nobel which have succeeded in making the viscose process compatible with the environment. In view of this fact we are confident that viscose staple fibers and filament yarns will offer good opportunities in the future also from an ecological point of view.

Apart from our companies, this standard ought to apply also to our Central European competitors, depending on the technology used. With high capital investment it has been possible to achieve this standard, especially in Central Europe.

Viscose is made from a natural raw material and can be disposed of by natural means. Besides that, it can be produced by environmentally friendly routes as shown here. Unfortunatelly these environmentally friendly processes are not yet realised world wide, but we think, this has to be done soon.

References:

(1) IDEA Study, Technical Annex, pages 27 to 39
(2) H. Blümel, Report by Umweltbundesamt (Federal Environmental Agency), 9/1992
(3) Commission of Inquiry "Protection of Man and the Environment" of the German Bundestag (publisher) "Verantwortung für die Zukunft – Wege zum nachhaltigen Umgang mit Stoff- und Materialströmen", Economica Verlag, 1993

NONWOVEN WIPES
A WIDE FIELD OF APPLICATION FOR VISCOSE STAPLE FIBRES

Heinrich Jakob, Lenzing AG

The production of nonwovens is nowadays the most direct way from a fibre to a textile product This article is intended to show the diversity in the use of viscose staple fibres in the different applications and possiblities in the production of wipes made out of nonwovens.

Die Herstellung von Nonwovens ist heute der direkteste Weg von einer Faser zu einem textilen Produkt. Dieser Artikel versucht, die Vielfalt des Einsatzes von Viskosestapelfasern in verschiedenen Anwendungen sowie Möglichkeiten der Herstellung von Wischtüchern aus Nonwovens aufzuzeigen.

The production of nonwovens is nowadays the most direct way from a fibre to a textile product. This quick but also in the most cases not too easy way of production is confirmed by constantly increasing volumes througout the last years. Having started with the manufacturing of cheap products out of waste and recycled materials the nonwoven industry has developed into high quality producers offering tailor-made solutions. According to EDANA the volume of nonwovens sold in Western Europe in 1993 was 570.300 tons. Looking at the development of this figure (fig. 1) it relates to a doubling within a seven years period since 1986. The average rate of increase per year ranges between nine and ten percent.

Development in Sales of Nonwovens in Western Eumpe

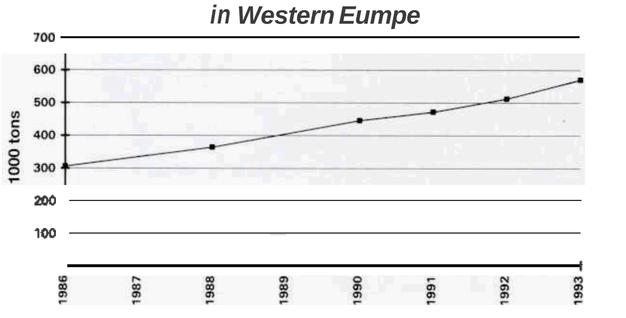
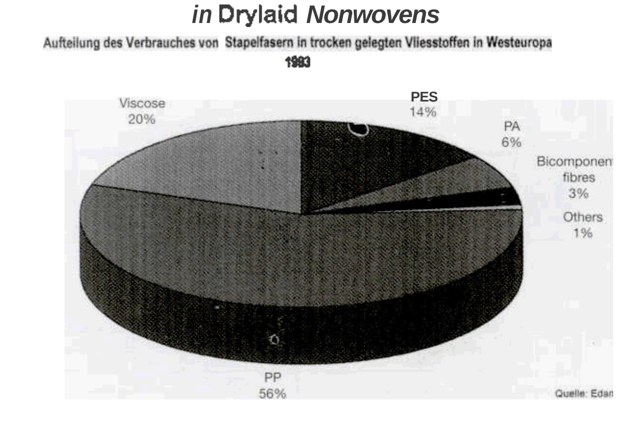


Fig. 1

As already mentioned above a most important point within the development of the nonwoven industry is the fibre material used. Was the beginning dominated by recycled materials, nowadays high quality fibres are used, adapted to the endproducts and their applications with defined and controlled qualities. Looking at the fibres used in drylaid nonwovens the dominating position of polypropylene can immediately be seen. A main influence to this situation is coming from such big applications as coverstock and geotextiles. From figure 2 it can clearly be seen that following polypropylen viscose is with a share of 20 % the most used man-made staplefibre in drylaid nonwovens ahead of polyester with a share of 14 %. Speaking about enduse viscose is a dominating fibre in the field of wipes and medical nonwovens.

Use of Man-Made Staple Fibres in Drylaid Nonwovens



Fig

This article is intended to show the diversity in the use of viscose staple fibres in the different applications and possibilities in the production of wipes made out of nonwovens. This very general term is used by EDANA as an own enduse in their statistics, what underlines the importance of these products for the nonwoven industry.

Looking at the development of the last years the same trend is shown for wipes as for nonwovens in total (fig. 3). This is also a growing market, which possessed a volume of 49.100 tons in Western Europe in 1993 and looked back at an annual growth of 9 % in average. In the total volume of the market for nonwovens wipes have a share of 9 % and are by this in fourth place by enduse (fig. 4).

Development in Sales of Nonwoven Wipes in Western Europe

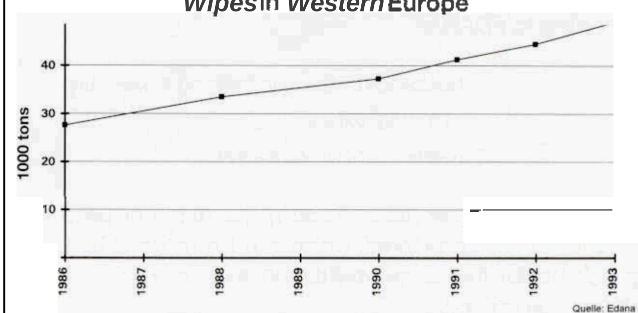
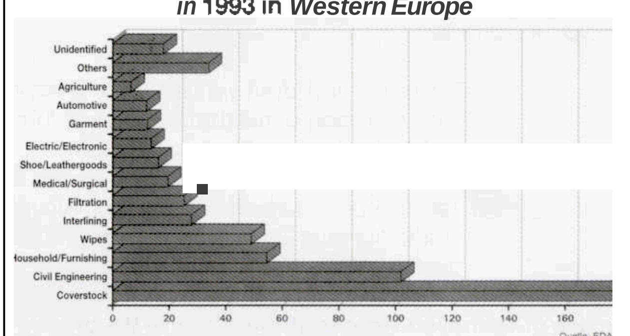


Fig. 3

Deliveries of Nonwovens by Enduse in 1993 in Western Europe



The main property of wipes is the ability to absorb fluids, respectively the absorbency and the fluid holding capacity. Exactly these properties are also the main features of viscose staple fibres. This results in the optimum preconditions in combination with the different nonwoven production technologies for the use in wipes.

As already mentioned before the term „wipes" is a very general one and a more detailed differentiation has to be found . In order to classify wipes made out of nonwovens two ways can be used:

- ○ the nonwoven production process
- ○ the enduse of the wipe

The differentiation according to the production process can be divided into webforming, bonding and finishing. The different possibilities within these production steps can be seen in figure 5.

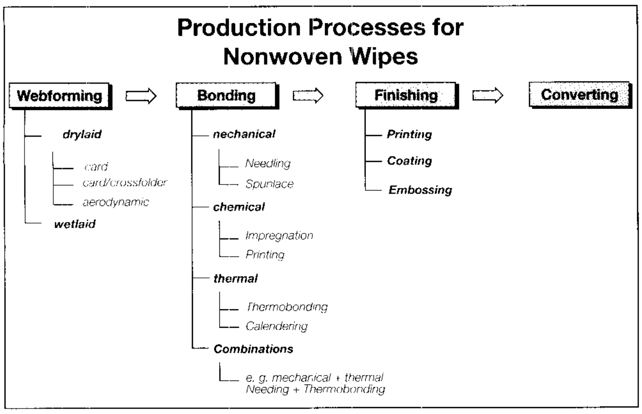


Fig. 5

According to the enduse wipes can be divided into three groups according to EDANA:

- ○ household wipes, refreshing wipes, etc.
- ○ industrial wipes
- ○ medical and hospital wipes

In addition to these differentiations the range of used web weights can be considered, which is in the range of 30 to 300 g/m², whereas the actual weight ranges are very much depending on the enduse.

Out of the wide range of resulting production- and application possibilities the use of viscose staple fibres shall be shown by two typical products:

- ○ The use of spundyed viscose staple fibres in the production of needlepunched and thermobonded household wipes
- ○ The use of chlorine free bleached viscose staple fibres in spunlaced nonwovens for medical wipes

The use of spundyed viscose staple fibres in the production of needlepunched and thermobonded household wipes

The market for household wipes has a big volume in Europe and is served by several producers. The requirements for these products are besides the functional properties also certain demands for optical appearance. The use of spundyed viscose (fig. 6) staple fibres covers these requirements in an optimum way. By the spundyed production process the colour pigments are incorporated in the fibre matrix and by this are absolutely colour-fast. Mainly used colours are pastel shades in orange, yellow, blue or green. The spundyed viscose fibres are processed in blends with thermobonding fibres, the share of these fibres being in the range of 10 to 15 percent.

The webforming is done on a card followed by a crossfolder, where the required webweight is produced. Usually the finished weight at such kind of wipes is in the range of 100 to 300 g/m². After webforming the web is usually bonded by needlepunching from both sides, by which the batt is condensed and

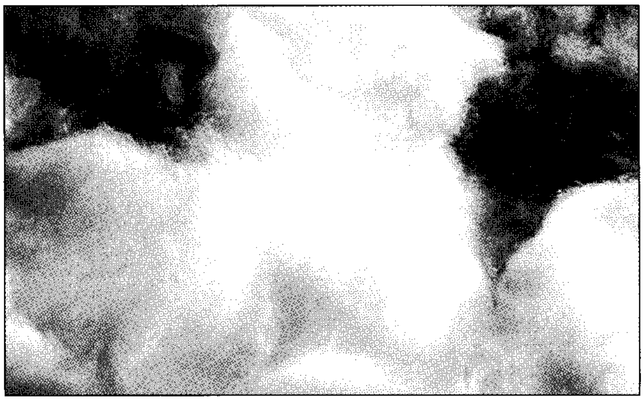
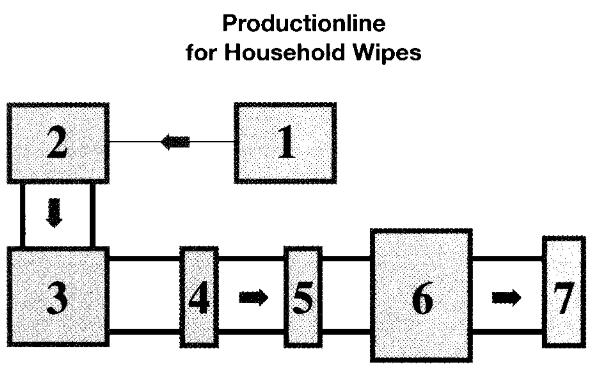


Fig. 6

consolitated. After needling the nonwoven web is thermobonded. By this the thermobonding fibres in the web are melted, which results in the required stability and the enhanced bonding of the viscose fibres in the web. This process can also be combined with a calibrating of the web in order to reach a certain thickness or density. A further step in the processing of such products can be the printing or embossing before the final converting. The design of such aline is shown in figure 7.



1	Fibre opening & blending	5	Upstroke needling
2	Card	6	Thermobonding
3	Crossfolder	7	Winding
4	Downstroke needling		

Fig. 7

In case of this application the viscose fibre determines the optical appearance and the functional properties of the produced nonwoven wipe (fig. 8).

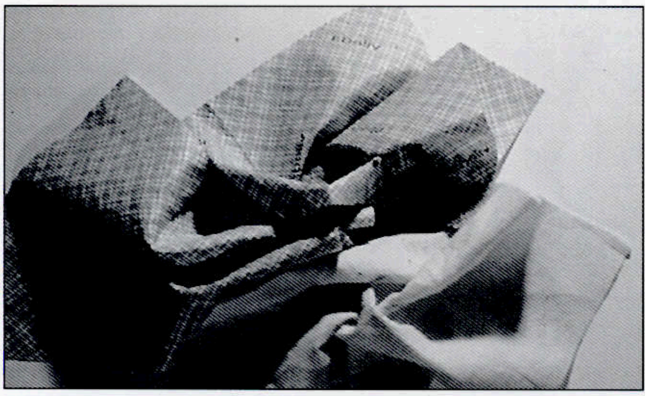


Fig. 8

Looking at this process from the environmental point of view it can be stated that no chemicals are necessary in the bonding process. Furthermore the share of viscose in the product is 100 % biodegradable and thus forms with the environmental sound production process of a chlorine free fibre and the use of the renewable rawmaterial wood a closed ecologic cycle.

The use of chlorine free bleached viscose staple fibres in spunlaced nonwovens for medical wipes

Mid of the 80's the spunlace technology has begun to be used in a wider range of industrial applications. Viscose staple fibres have established themselves due to their properties as an optimum material for this bonding technology. As a core field of application for the use of this technology the production of nonwovens for medical products did appear, where again viscose is a predominant fibre material.

The combination of the demands within this field of application with the technology characterized by its high efficiency results in high demands for the viscose fibre used

The webforming is done on one or more high capacity cards in line feeding the spunlace equipment. In most cases primary webs are used. If there is a need for higher web weights production lines using crossfolders can be used. In this case also aerodynamic webforming machines can be used, which besides the weight flexibility result also in endproducts with isotropic strength. The requirement for the viscose staple fibre is here the optimum processing on high capacity cards at high throughput rates. The schematic design of such a production line is shown in figure 9.

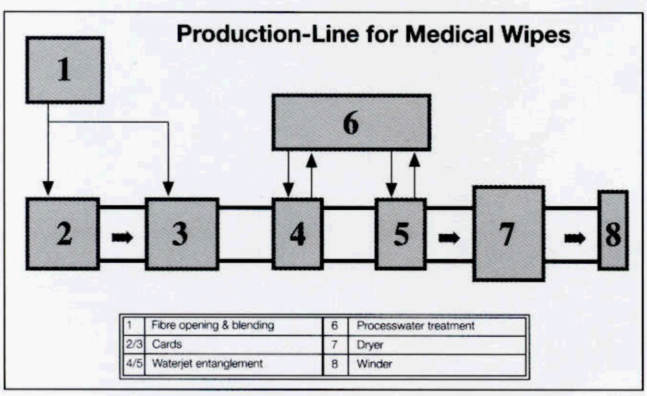


Fig. 9

Bonding of the web is usually done, as with conventional needling, from both sides with high pressure waterjets. The advantage with this kind of bonding is that there is no need for binding agents, which is just in the medical field essential. In this respect the use of a totally chlorine free produced viscose fibre is the ideal precondition.

After bonding the web is dried and converted afterwards. The use of such nonwoven wipes ranges from simple swabs for desinfection up to sterile application in operation theatres (fig. 10).

Fig. 10

Using chlorine free viscose staple fibres combined with a bonding technology free of chemical binders gives the optimum basis for the production of medical nonwovens. Here as well is by the fact that the products can contain up to 100 % viscose a full biodegradability possible. The viscose fibres not only deliver their optimum properties witin the application of the product but also give the best preconditions for the necessary disposal with a minimum impact on the environment.

VOLLAUTOMATISCHE VERSION EINER APPARATUR ZUR BESTIMMUNG DER LINEAREN MASSENDICHTE NACH DER SCHWINGUNGSMETHODE

Christoph Unterberger, Lenzing AG

Eine vollautomatische Methode zur Bestimmung des Titers textiler Stapelfasern und Filamente wurde entwickelt. Die zu prüfende Faser wird in Eigenschwingung versetzt, ohne daß die Erregerfrequenz oder die Einspannlänge der Faser verändert werden muß.

A fully automatic method for determining the titre of textile staple fibres and filaments has been developed. The fibre to be measured is set into its eigenfrequency without the need to adjust the frequency of excitation or the vibration length.

Einleitung:

Das Prinzip der Schwingungsmethode wird zum Bestimmen des Titers textiler Stapelfasern und Filamente schon lange Zeit angewendet. Für diesen Zweck entwickelte Prüfgeräte sind unter der Bezeichnung „Vibroskop" bekannt.
Der Begriff „Schwingungsmethode" besagt, daß eine zu prüfende Faser durch eine geeignete Methode in Eigenschwingung versetzt und daraus ihre lineare Massendichte ermittelt wird. Die Auswahl einer geeigneten Methode zur Anregung hat wesentlichen Einfluß auf die Leistungsfähgkeit einer Prüfapparatur.

Prinzipielle Beschreibung der Schwingungsmethode

Die Methode macht sich die Beziehung:

$$v_0 = 1/2\,l \cdot \sqrt{F/A\delta}) \qquad \text{(I)}$$

für die schwingende Saite zunutze.
Ersetzt man bei bekanntem V_0, l und F den Term $A\delta$ für lineare Gebilde sinngemäß durch den Titer T so ergibt sich dafür:

$$T = \frac{F}{(2l\,v_0)^2} \qquad \text{(II)}$$

Stand der Technik:

Bisher werden zwei Methoden angewandt, um die Faser in den Zustand der Eigenschwingung zu versetzen:

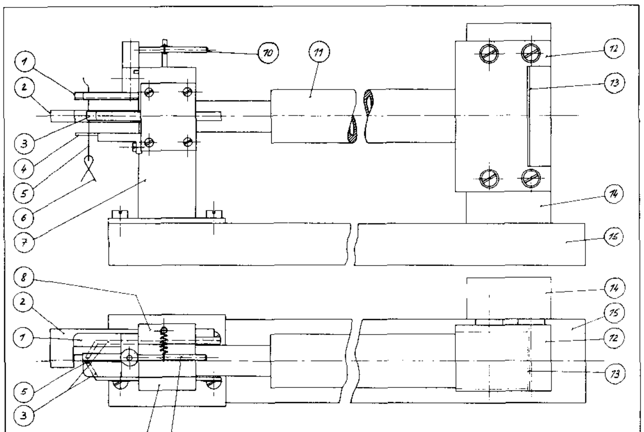
1. Variation der Einspannlänge
2. Variation der Erregerfrequenz

Bisherige Ausführungsformen von Vibroskopen arbeiten in der Art und Weise, daß entweder durch Verändern der Erregerfrequenz oder der Einspannlänge die Resonanzbedingung aufgesucht wird. Nach Einstellen derselben kann der Titer als einzige verbleibende Unbekannte aus Gleichung II ermittelt werden.

Deltaimpulsmethode:

Das hier vorgestellte Verfahren umgeht die Probleme der bisherigen Methoden. Im Gegensatz zu diesen wird die zu prüfende Faser nämlich durch einen elektrischen Deltaimpuls in eine gedämpfte Eigenschwingung versetzt, deren Frequenz genau der Grundschwingung der Faser entspricht. Harmonische kommen nicht vor.

Es wird mit einer konstanten Einspannlänge gearbeitet, Fig. 1 zeigt den prinzipiellen Aufbau der Aparatur.
Durch ein in Fig. 2 dargestelltes magisches Auge wird die mechanische Schwingung der Faser in ein elektrisches Wechselsignal umgewandelt. Das reelle Bild der zu prüfenden Faser wird wie in der Abbildung gezeigt auf eine Photodiode abgebildet. Wenn sich die Faser in Schwingung befindet, erzeugt



Autom. Vibroskop M 1 : 1,4
Ansicht vom Versuchsaufbau

Fig. 1

ihr Schatten ein dem Gleichlichtanteil aufmoduliertes elektrisches Wechselsignal exakt gleicher Frequenz. Die Phasenlage spielt für die nachfolgende Signalbearbeitung keine Rolle.

Das elektrische Signal wird mit einem schnellen AD-Wandler (mindestens 300 Stützpunkte pro Periode) digitalisiert sowie einem digitalen Bandpaßfilter unterworfen. Aus dem auf diese Weise aufbereiteten Digitalsignal kann durch verschiedene numerische sowie approximative Verfahren die Frequenz der Eigenschwingung ermittelt werden.

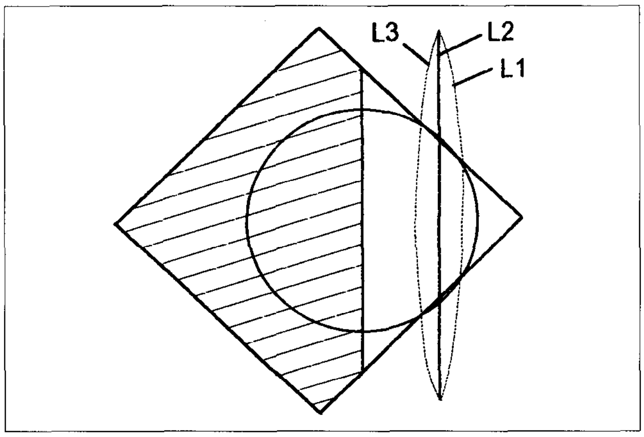


Fig. 2

Vorteile der Deltaimpulsmethode:

Die Stärke der Einkopplung des Deltaimpulses kann in einem weiten Bereich durch ein elektrisches Gleichfeld in Richtung der Faser geregelt werden. Dadurch lassen sich gut und schlecht leitende Fasern prüfen.
Durch Arbeiten mit feststehender Einspannlänge sind auch kurzschnittige Stapelfasern prüfbar.
Subjektive Einflüsse werden weitgehend eliminiert.

LENZING PROFILEN® YARNS AND FIBRES

Adalbert Wimmer, Lenzing AG

Lenzing PROFILEN® is the registered trademark of high tenacity PTFE yarns and new crimped PTFE fibres from Lenzing for the manufacture of needlefelts.
Lenzing PROFILEN® yarns are used amongst other things (e.g. dental floss) in high temperature filtration as scrims and sewing thread.

Lenzing PROFILEN® ist das eingetragene Warenzeichen für PTFE-Garne mit hoher Festigkeit und neu gekräuselte PTFE-Fasern aus Lenzing für die Herstellung von Nadelfilzen. Lenzing PROFILEN®-Garne werden neben anderen Anwendungen (z.B. Zahnseide) in der Hochtemperaturfiltration als Gitterstoffe und Nähgarn verwendet.

Our programme includes the weaving yarn type 204/300S for the manufacture of scrims for the fabrication of needlefelts. We supply this yarn on conical cross wound-cones of approx. 1 kg each in cartons of 24 cones each.

Typical data:

titre:	440 dtex
twist:	300 T/m S
tenacity:	25 cN/tex min.
(typical stress-elongation diagram in fig.1)	
elongation:	approx. 5 %
shrinkage:	3 % at 200 °C

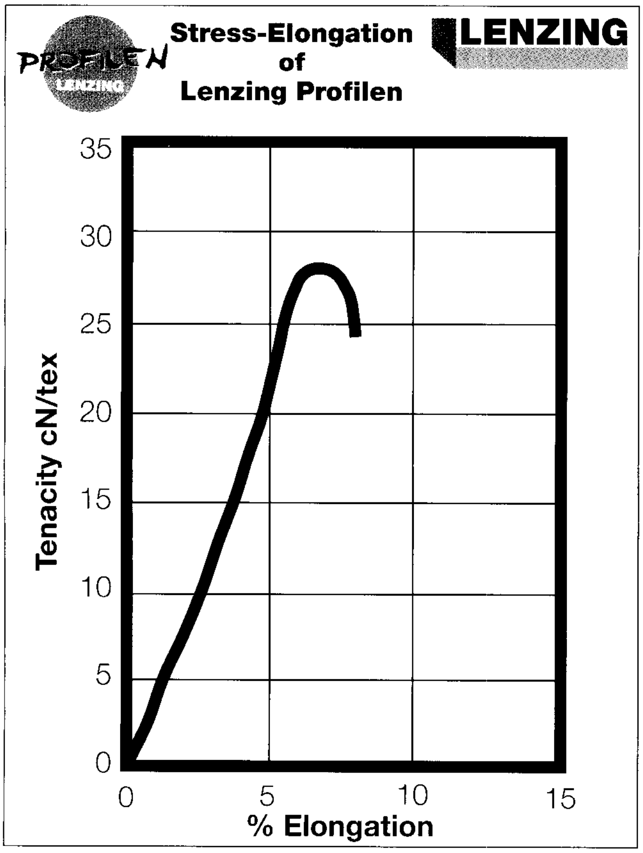


Fig. 1

Apart from weaving yarns, we also manufacture sewing thread for the fabrication of filter bags. Both types of yarns can also be manufactured in different colours upon customers' request (spun dyed). The sewing thread is a treble twisted yarn with the following typical data:

titre:	1350 dtex
twist:	400 T/m Z 3-ply
breaking force:	30 N min.
elongation:	approx. 5%
shrinkage:	3 % at 200°C

These yarns are wound on king cones with a height of 155 mm and a base diameter of 85 mm. Six cones of this kind are packed in one carton; one carton weighs approx. 3 kg.

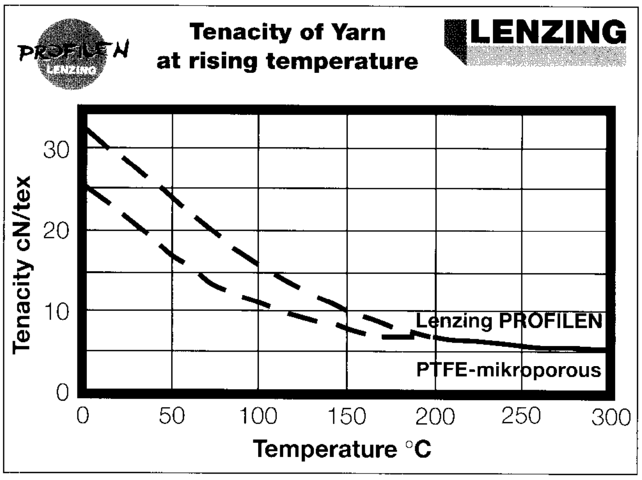


Fig. 2

Since these yarns are used almost exclusively in high temperature filtration, tenacity and elongation values at higher temperatures are of particular significance as opposed to tenacity at ambient temperature.

As with every thermoplastic, the tenacity drops the higher the temperature becomes.
One surprising fact with regard to PTFE is, however, that the falling curve levels out at a temperature of approx. 200°C and ceases to fall further as from 250°C. The value to which the tenacity falls is thereby largely independent of the starting tenacity at room temperature (35, 30 or 25 cN/tex). At 200°C, the tenacity equals approx. 7 cN/tex (fig. 2). If the temperature rises further, the tenacity remains almost constant. We

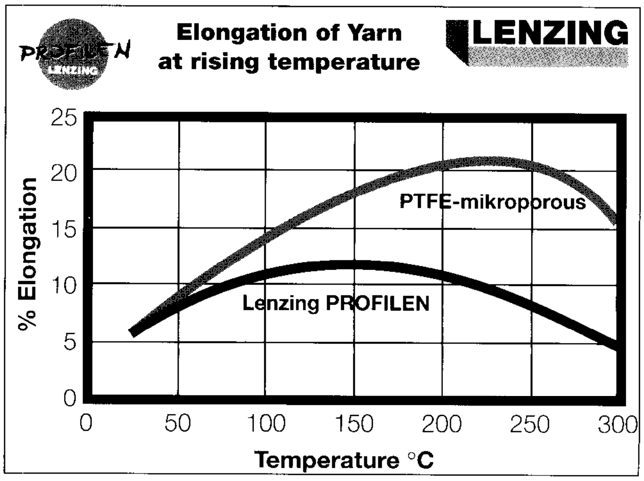


Fig. 3

conducted our measurements up to a temperature of 325°C and even at this temperature, which we all know is only 2°C below the crystallite melting point, this level remains intact.

Surprisingly, the elongation of the yarns also behaves very favourably: elongation increases, commencing at about 6 % up to approx. 12 %, and then it falls again to approx. 5 % (fig. 3). This means that our compact sintered Lenzing PROFILEN® has only a very slight tendency to flow and this is very unusual for thermoplastics.

We attribute the stress-elongation properties of our Lenzing PROFILEN® yarns, which are very favourable for use in high temperature filtration, to the special process we use to manufacture these yarns. The reason would seem to reside in the complete sintering of our PTFE yarns - they have no microporous structure.

Microporous products require different conditions for their manufacture and they differ slightly in their behaviour compared to our compact yarns. At 200 °C, the tenacity value is approx. the same as for Lenzing PROFILEN® yarns. If the temperature is raised further however, tenacity of the microporous yarns drops slightly more than is the case with Lenzing PROFILEN® yarns (fig. 2). With respect to elongation, the difference is greater. Even if the material displays, in principle, similar characteristics in the curve, the maximum value for elongation for microporous yarns at over 20 %, is clearly above the 12 % for Lenzing PROFILEN® yarns (fig. 3).

And finally we were also able to demonstrate the properties of the Lenzing PROFILEN® yarns described above in the felt. The curve of the tenacity is demonstrated in figure 4. The scrim hereby has a weight of 130 g/m². The theoretical tenacity at room temperature, on the basis of yarn tenacity would, therefore, equal approx. 830 N/5cm.

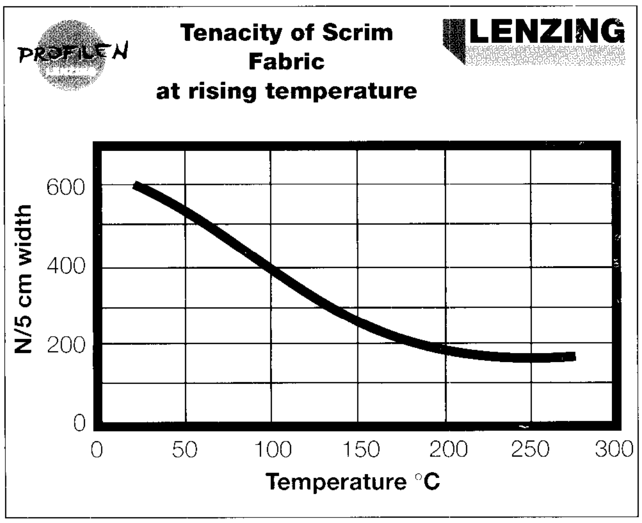


Fig. 4

Lenzing PROFILEN® Fibres:

State of the art of technology:

A reputable PTFE polymer manufacturer developed the "matrix spinning process" in the 1950's which permits the manufacture of fibres with the help of cellulose as a matrix. These fibres are dark-brown as a result of the 3 - 5 % residual cellulose. As a result of these cellulose residues and the raw surface of the fibres, needlefelts can be processed. However, in the application itself, these properties which are positive for processing prove to be a disadavantage - cleaning is hindered by the cellulose residues since they hold back the dust. This can, in the final stage, lead to the clogging up of the felts making it necessary to replace them. Moreover, it has proved necessary to keep the felt weights relatively high in order to achieve the collection rates demanded with respect to PTFE.

Several years ago Lenzing AG attempted to use the pure PTFE fibres they had manufactured using their "split peel process" to fabricate needlefelts. Unfortunately, they were unsuccessful. The "anti-adhesion" properties, which are an advantage in filtration, and the relatively high titre of 10 dtex made it extremly difficult to produce a felt at an industrial level.

New revolutionary PTFE fibres:
Following long and difficult development work, Lenzing AG has succeeded using a new kind of process, in manufacturing pure, and crimped PTFE-fibres without any kind of impurity. This is a peculiarity for PTFE and was thought to be impossible. However, the fibre is not only crimped but also has a finer titre than previous PTFE fibres - measurements revealed an average fineness of 2.4 den.

Since the titre data do not take the specific weight of the fibres into consideration we would like to briefly take a comparison with acrylic fibres. Acrylic fibres have a specific weight of 1.14 g/cm³, PTFE has a specific weight of 2.17 g/cm³. From this we deduce that a PTFE fibre of 2.4 den is comparable in cross-section with a polyacrylic fibre of 1.26 den. One can, therefore, describe this as a fine fibre.
The titre spread generally represents a curve as can be seen in figure 5. It displays a spread of 0.69 - 5.4 den at a mean value of approx. 1.7 den.

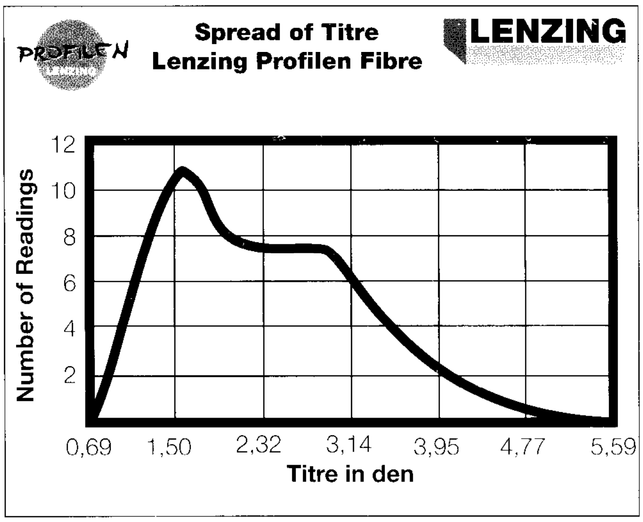


Fig. 5

With this Lenzing PROFILEN® fibre, felt manufacturers now have a PTFE fibre which emphasises all the positive properties of PTFE, can be processed to felts with excellent results and, as a result of the finer and blended titre, also produces better filtration properties.

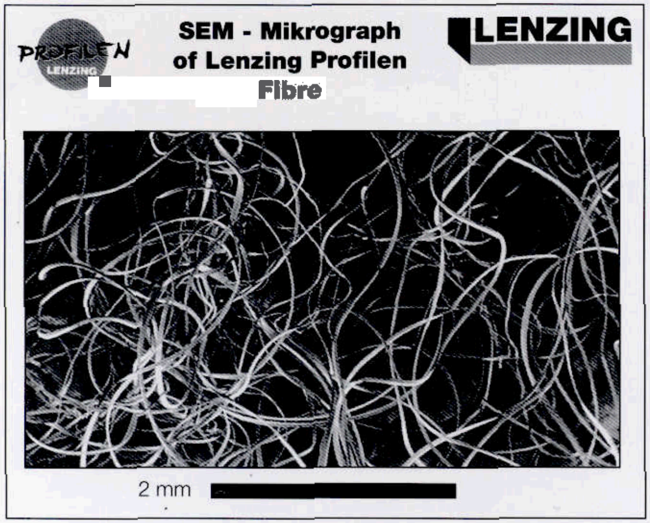


Fig. 6

From the initial processing trials to make felt we would now like to provide you with some processing recommendations:

- Main cylinder and carding equipment with metallic clothings.
- Application of an antistatic agent to the fibre before processing: 1% Catolin A 32 made from a 70% solution applied as a 20% solution; time of effect 24 hours. Albon Chemie supplies the Catolin A 32, Carl Zeiss Str. 41, D-72555 Metzingen: Tel: 07123 1231, Fax 07123 61690.
- Needles: 15 x 16 x 36 x 3 RB 26, A 06/08 PP (Messrs. Singer)
- Needling: 4 x 16 mm and 2 x 13 mm with 100 stitches/cm² for each passage.

In this way, a 600 g/m² felt was manufactured on a scrim of 130 g/m² and the filtration behaviour was examined. The following data was obtained:

- thickness: 1.5 mm at 2.0 cN/cm²
- apparent density: 0.40 g/cm³ at 2.0 cN/cm²
- air permeability:
  65 l/dm² min at 200 Pa
  160 l/dm² min at 500 Pa
- separation rate:
  0.999 and larger rising after 45 min rising to 1.0 after 60 min with a crude gas concentration of 5 g/m³ and the use of the following test dust:
  flue gas ash made of a medium load coal-fired power station with flue gas desulphurisation, spray absorption, extremely pourable, 2.5 - 3.0 µm average particle size. This is a particularly critical type of dust and produces an unstationary filtration condition particularly in the starting up stage of a plant and following purification.
- Flue gas speed: 5 mm/s

We are now in a position to state that, as a result of shrinkage, this pure PTFE fibre can be processed without any difficulty to a fleece and, therefore, to a needlefelt. From the initial tests which have been conducted so far it can even be concluded that machine performances can be increased compared to other PTFE fibres. More-over, lighter felts can be produced which offer the same filter efficiency as the heavier conventional PTFE-felts. In addition, it should also be possible to extend the filter service life as a result of release characteristics

Conclusion:

- **Scrims made of Lenzing PROFILEN® guarantee good dimensional stability of the filter bags as a result of the low elongation.**
- **Lenzing PROFILEN® sewing thread guarantees high seam durability.**
- **Lenzing PROFILEN® fibres have a tine titre, they are made of pure PTFE, they have a high crimp level, they produce a good filter efficiency, they are easy to process.**

MODIFIZIERTE CELLULOSEFASERN, DEREN EIGENSCHAFTEN UND ANWENDUNGSMÖGLICHKEITEN

Johann Knoglinger, Christoph Lotz, Dieter Eichinger, Jörg Schlangen
Lenzing AG, bei Hofer Vliesstoffseminar 1995

Die Eigenschaften der Viskosefasern wurden in den letzten Jahren immer mehr den Anforderungen der NW- und Vliesstoffproduzenten angepaßt. Es wurden neue Viskosefaservarianten mit den unterschiedlichsten Eigenschaftsprofilen entwickelt.
Dieser Vortrag gibt einen Überblick über verschiedene Viskosefasertypen, deren Eigenschaften, Verarbeitungsmöglichkeiten und Einsatzgebiete.

During the last years the properties of viscose fibres have more and more been adapted to the needs of producers of nonwoven fabrics and fleeces. New viscose fibre types with quite different properties have been developed.
In this paper a survey about different viscose fibre types, their properties, processing possibilities and end-uses is given.

1. Einleitung

Nonwovens-Produkte weisen in den letzten 10 Jahren dynamische Wachstumsraten auf. Die europäische Vliesstoff-Produktion verdreifachte sich in den letzten 10 Jahren auf ca. 570.000 t/a im Jahr 93. Die wichtigsten Einsatzmaterialien sind Polypropylen, Polyester, Viskosefasern und Zellstoff.

Viskosefasern wurden in den letzten Jahren vermehrt eingesetzt. So stiegen die Mengen von 1990 bis 94 um ca. 10 %.

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Dieser Vortrag gibt einen Überblick über verschiedene Viskosefasertypen, deren Eigenschaften, Verarbeitungsmöglichkeiten und Einsatzgebiete.

2. Modifizierte Viskosefasern

2.1 Chlorine Free Viscose

Fasereigenschaften

Die NW-Faser matt, chlorfrei ist die am häufigsten eingesetzte Faser für den Nonwoven- und Vliesstoffbereich. Die Matteigenschaft ist speziell für das optische Erscheinungsbild (Opazität) von Vliesstoffen von Vorteil. Diese sehr vielfältig einsetzbare Faser dient als Standard bei der Charakterisierung von Eigenschaften anderer in dieser Schrift vorgestellten Fasertypen und besitzt folgende physikalisch mechanischen Eigenschaften:

Titer	1,3-5,6 dtex	WRHV	80-100 %
FFK	20-26 cN/tex	WHV	20 g/g
FDK	17- 21%		

Die absolute Chlorfreiheit der Faser (Einsatz von chlorfreiem Zellstoff) ist für besonders sensible Bereiche des Einsatzes (z. B. Hygiene und Medizin) oder in ökologischen Produkten von großem Vorteil.

Anwendungen

Diese Viskosefaser läßt sich mit allen bekannten Vliesbildungstechnologien verarbeiten. Diese Fasern sind in einer sehr breiten Produktpalette verarbeitet. Die wichtigsten Bereiche sind: Tampons, Watte, Babywipes, Wischtücher, medizinische Produkte usw.

2.2 Spun-Dyed Viscose

Fasereigenschaften

Diese Viskosefasern kombinieren die positiven Eigenschaften einer Viskosefaser mit einer permanent vorhandenen Farbe. Farbpartikel sind dabei in die Viskosefaser eingesponnen worden. Die Farbtöne sind absolut farbecht und bleiben unverändert, auch wenn die Fasern trocken oder naß stark beansprucht werden. Die Farbpartikel beeinflussen die physikalischen und mechanischen Parameter der Faser nicht.

Anwendungen

Die spinngefärbten Viskosefasern werden bevorzugt in Wischtüchern nach dem Thermobondverfahren (Thermobondfaseranteil 10-15%) und in der Automobilindustrie eingesetzt. Bevorzugte Farben im Wischtucheinsatz sind Pastelltöne von gelb, blau und grün.

2.3 Flame Retardant

Fasereigenschaften

FR-Fasern zeichnen sich durch ihre permanente Schwerentflammbarkeit aus. Diese wird erreicht durch Inkorporation eines halogenfreien Flammschutzmittels. Das entstehende Produkt kombiniert im Gegensatz zu High Performance Fasern die angenehmen Trageeigenschaften der Viskose mit der flammhemmenden Wirkung. Die FR-Faser wird mit Titern zwischen 1,7 und 3,3 dtex auf Modalbasis hergestellt und besitzt dann die gleichen mechanischen Festigkeiten und Dehnungen, wie es für eine normale Viskosefaser üblich ist. FR-Fasern mit höheren Titern (5,5 und 8,9 dtex) werden auf Basis von Normalviskose hergestellt.

Anwendungen

Viskose FR-Fasern werden als Nonwovens Interliner und andere technische Produkte eingesetzt. Sie können mit allen bekannten Techniken verarbeitet werden.

2.4 Viscoray

Fasereigenschaften

Röntgenkontrastfasern sind ein typisches Beispiel für die Entwicklung eines hochspezialisierten Produktes für einen ganz bestimmten Einsatzzweck. Sie sind in Röntgenaufnahmen eindeutig zu erkennen, da ein Röntgenkontrastmittel (Bariumsulfat) sehr fein verteilt in die Viskosefaser eingesponnen wird. Die typischen Eigenschaften der Viskose gehen dabei nicht verloren.

Anwendungen

Die Röntgenkontrastfaser wird in medizinischen Produkten (Watte-Pads, Tupfer) eingesetzt und kann mit den verschiedensten Techniken verarbeitet werden.

2.5 Hydrophil A

Fasereigenschaften:

Bei dieser neu entwickelten Faser handelt es sich um eine Viskosefaser, die zusammen mit einem anderen Biopolymer, aus natürlichen Ressourcen, nach einem besonderen Verfahren ausgesponnen wird und somit besondere Eigenschaften besitzt.

Titer	1,3-3,5 dtex	WRHV	120-170%
FFK	13-25 cN/tex	WHV	20-25 g/g
FDK	10-16 %		

Die Fasereigenschaften können in den angegebenen Bereichen variiert und nach Wunsch zusammengestellt werden. Die Faser besitzt eine hohe Saugfähigkeit. Die Feuchtigkeit wird durch Druck nicht wieder abgegeben. Die Feuchtigkeit wird von der Faser aufgenommen und kann durch Trocknung wieder abgegeben werden. Auch diese Faser kann völlig chlorfrei hergestellt werden.

Mögliche Anwendungen:

Die Verarbeitung sollte sich nicht wesentlich von „normalen" Viskosefasern unterscheiden. Vernadelungstechnik, Nähwirkverfahren, Thermobondverfahren und Spunlacetechnik sind möglich.

Der Einsatz dieser neuen Faser sollte in Produkten wie Tampons, Windeln, Watte, Verbandsstoffen oder Babywipes die Produkteigenschaften oder den Mengeneinsatz wesentlich günstiger erscheinen lassen.

2.6 Hydrophil C

Diese neu entwickelte Faser wird durch das Einspinnen einer kleinen Menge eines anderen Cellulosederivates hergestellt. Durch dieses Cellulosederivat ändern sich die physikalischen Eigenschaften der Faser. Nach dem Spinnen der Faser kann das Cellulosederivat durch eine spezielle Nachbehandlung in Cellulose überführt werden. Die speziellen physikalischen Eigenschaften der Faser bleiben jedoch erhalten.

Fasereigenschaften:

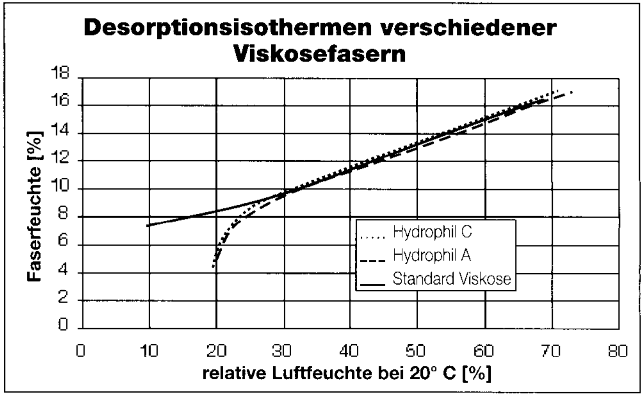
Titer	1,7-3,5 dtex	WRHV	95 %
FFK	20-23 cN/tex	WHV	27-29 g/g
FDK	16 %		

Die Faser ist extrem hoch gekräuselt und besitzt „Volumen" und eine hohe Saugfähigkeit. Die Feuchtigkeit kann durch Druck wieder schnell abgegeben werden. Die Feuchtigkeit wird durch Kapillarkräfte zwischen den Fasern gehalten. Diese Faser kann ebenfalls völlig chlorfrei hergestellt werden.

Mögliche Anwendungen:

Für die Verarbeitung dieser Fasern sind die Vernadelungstechnik, das Nähwirkverfahren und das Thermobondverfahren besonders geeignet. In Produkten wie Tampons, Windeln, Watte, Wischtüchern, Filtern, Dämmstoffen und Filzen sollte durch den Einsatz dieser Faser Vorteile erzielbar sein.

Trockenverhalten von Hydrophil A und Hydrophil C



Bei der mehrfachen Verwendung von saugfähigen Fasern ist nicht nur die Menge Wasser, die aufgenommen werden kann wichtig, sondern auch die Trocknungseigenschaften der Faser. Von den neuen modifizierten Viskosefasern Hydrophil A und Hydrophil C wurden Desorptionsisotherme aufgenommen und mit denen der herkömmlichen Viskosefasern verglichen (siehe Diagramm). Dabei stellt sich heraus, daß es keinen Unterschied oberhalb von 25% relativer Luftfeuchtigkeit im Trockenverhalten gibt. Die modifizierten Viskosefasern lassen sich auf die gleiche Feuchte trocknen wie nicht modifizierte Fasern. Diese Daten geben jedoch nur über die thermodynamischen Verhältnisse Auskunft. Über die Trockengeschwindigkeit kann dabei keine Aussage gemacht werden.

3. Lyocell-Fasern

Fasereigenschaften

Im Jahre 1986 begann die Lenzing AG mit der Entwicklung einer lösungsmittelgesponnenen Cellulosefaser - Lyocell. Seit 1990 wird eine Pilotanlage mit einer momentanen Kapazität von etwa 400 to pro Jahr betrieben. Ab 1997 werden dann durch den Bau einer Großanlage in Heiligenkreuz die Kapazitäten auf 20.000 to pro Jahr erhöht werden.

Bei dem Herstellungsprozeß werden das verwendete Lösungsmittel (NMMO) sowie das verwendete Wasser im Kreis geführt, wodurch das gesamte Verfahren den Aspekten Ressourcenschonung und ökologischer Verträglichkeit Rechnung trägt. Durch diesen Verfahrensprozeß erhält man eine besonders für den technischen Bereich interessante Faser. Die sehr feinen Fibrillen an der Faseroberfläche sowie eine permanente Kräuselung führen zu größeren Oberflächen- und Wasseraufnahmeeffekten. Lenzing Lyocell zeigt z.B. ein gutes Wasserhaltevermögen. Ebenso liegt der Naßmodul höher als der vergleichbarer Cellulosefasern.

Zudem weist die Faser ein ausgewogenes hohes Festigkeitsprofil sowohl im trockenen als auch im nassen

Zustand auf, welches mit dem von synthetischen Fasern, wie z.B. Polyester, sehr wohl vergleichbar ist. Die Naßfestigkeit beträgt z.B. 85% der Trockenfestigkeit.

Anwendungen

Durch die hohen Festigkeiten lassen sich leichtgewichtige Nonwovens mit den Vorteilen einer Cellulosefaser wie z.b. biologischer Abbaubarkeit herstellen.

Im Wasserstrahlverfestigungsprozess läßt sich die Quellung in Wasser und die mechanische Querbelastung zur Fibrillierung der Faser sehr gut ausnutzen. Hierdurch lassen sich Vliese mit sehr weichem Griff herstellen. Auch in Mischungen mit anderen cellulosischen Fasern liefert Lenzing Lyocell einen wesentlichen Beitrag zur Verbesserung des Eigenschaftsprofils des Endproduktes.

Die physiologische Unbedenklichkeit von Lenzing Lyocell wurde u.a. nach dem Erlanger Ciliatentest, einem Verfahren zur Prüfung auf Mutagenität mittels Einsatz von Bakterien wie z.B. Terahymena pyriformis bestätigt.

4. Ausblick

Cellulosische Fasern sind sehr vielfältig und besitzen neben den natürlich vorhandenen bekannten angenehmen Trageeigenschaften eine Fülle von gezielt einstellbaren Eigenschaften, die es erlauben, cellulosische Fasern in sehr großen Bereichen des privaten Lebens und der Industrie einzusetzen. Dieser Sachverhalt wird auch durch den konstanten Anstieg der Vliesstoffproduktion in den letzten Jahren bestätigt. Cellulosefasern sind in der Vliesstoffindustrie einer der wichtigsten Rohstoffe und die verstärkten ökologischen Anforderungen an die Vliesstoffindustrie schaffen optimale Voraussetzungen für den verstärkten Einsatz von Viskose in der Zukunft. Cellulosefasern werden aus einem erneuerbaren Rohstoff (Holz) hergestellt und sind biologisch abbaubar. Seitens Lenzing wurden neben den Fasereigenschaften auch die produktionstechnischen Voraussetzungen der Viskoseherstellung optimiert. Dadurch wurde auch aus ökologischer Sicht die Basis für eine umweltfreundliche Produktion geschaffen. Speziell in dieser Hinsicht bietet auch das neue Verfahren zur Herstellung von Lyocell eine ideale Ergänzung zur Palette der Viskosefasern.

SORPTIONSISOTHERMEN VON LYOCELL- UND VISKOSEFASERN

Johann Knoglinger, Lenzing AG

Es wurden die Absorptions- und Desorptionsisothermen von zwei lösungsgesponnenen Cellulosefasertypen (LENZING LYOCELL und COURTAULDS TENCEL) aus dem NMMO-Prozeß und von zwei klassischen Cellulosefasertypen aus dem Viskosefaserprozeß (LENZING VISCOSE und LENZING MODAL) bei 20, 50 und 80°C unter Verwendung einer neuartigen Meßapparatur gemessen.

The absorption and desorption isotherms of two solvent spun cellulosic fibre types (LENZING LYOCELL and COURTAULDS TENCEL) made according to the NMMO-process and of two traditional cellulosic fibre types made by the viscose process (LENZING VISCOSE and LENZING MODAL) were investigated at 20, 50 and 80°C using a new measurement apparatus.

Es wurden die Absorptions- und Desorptionsisothermen von zwei lösungsgesponnenen Cellulosefasertypen (LENZING LYOCELL und COURTAULDS TENCEL) aus dem NMMO-Prozeß und von zwei klassischen Cellulosefasertypen aus dem Viskoseprozeß (LENZING VISCOSE und LENZING MODAL) bei 20, 50 und 80° C gemessen. Dazu wurde eine neuartige Meßapparatur verwendet, bei der sich die Probe in einer klimatisierten Edelstahlkammer befindet. Durch ein Ventilationssystem wird die kontrolliert befeucht- bzw. trockenbare Kammerluft in intensiven Kontakt mit der Probe gebracht, wodurch die Einstellung des Sorptionsgleichgewichts beschleunigt wird. Unter den Bedingungen des europäischen Norm-Faserprüfklimas (65% relative Luftfeuchte bei 20° C) zeigt die Normal-Viskosefasertype LENZING VISCOSE von den vier untersuchten Fasertypen den höchsten Feuchtigkeitsgehalt (14.4 Gew.-%, absorptiv), während die lösungsgesponnene TENCEL-Faser am relativ wenigsten Feuchte aus der Luft aufgenommen hat (11.9 Gew.-%). Interessanterweise besitzt die lösungsgesponnene Type LENZING LYOCELL unter diesen Klimabedingungen einen deutlich höheren Feuchtigkeitsgehalt (13.6 Gew.-%) als die TENCEL-Faser und ist in ihrer Sorptionscharakteristik recht ähnlich zur LENZING MODAL-Faser, die auf 13.2 Gew.% Feuchtegehalt kommt.

EINLEITUNG:

Um der zunehmenden Bedeutung der lösungsgesponnenen Fasern (abgek. CLY-Fasern lt. ISO-Norm 2076) im Markt der cellulosischen Fasern auch in Hinsicht auf deren physikalische Charakterisierung Rechnung zu tragen, haben wir eine für die technische Praxis wichtige Facette aus deren Eigenschaftsprofil herausgegriffen und näher untersucht. Daher möchten wir hier die Ergebnisse von Untersuchungen zur Wasserdampfaufnahme und -abgabe aus der Luft für zwei lösungsgesponnene Cellulosefasertypen und für zwei bedeutsame Cellulosefasertypen aus dem altbekannten Viskoseprozeß präsentieren. Die Sorptionscharakteristiken der verschiedenen Fasern sind beispielsweise für die Weiterverarbeitung im textilen Sektor wichtig (Kardierung, Garnspinnen,...), da die Faserfeuchte, welche sich aus dem Feuchtigkeitsaustausch mit der (klimatisierten) Raumluft ergibt, einen bestimmten Sollwert haben muß, damit sich eine optimale Qualität der Produkte bei gleichzeitig hohen Verarbeitungsgeschwindigkeiten erzielen läßt.

Bei den untersuchten lösungsgesponnenen Zellulosefasertypen handelt es sich um Stapelfasern der Type LENZING LYOCELL[1] von der Firma LENZING AG, Österreich, und um Stapelfasern der Type TENCEL von COURTAULDS plc, England. Bei den Fasertypen die nach dem Viskoseverfahren produziert wurden, handelt es sich um die Typen LENZING VISCOSE und LENZING MODAL[2], welche einen sehr bedeutsamen Marktanteil in Europa bei textilen Anwendungen von Viskose- bzw. Modalfasern innehaben.

Messungen:

Zur Durchführung der Messungen wurde eine neuartige Meßkammer gebaut (siehe Bild 1), die im besonderen bei höheren Temperaturen Vorteile gegenüber der Standardmethode des Stehenlassens von Proben in Exsikkatoren über verschie-

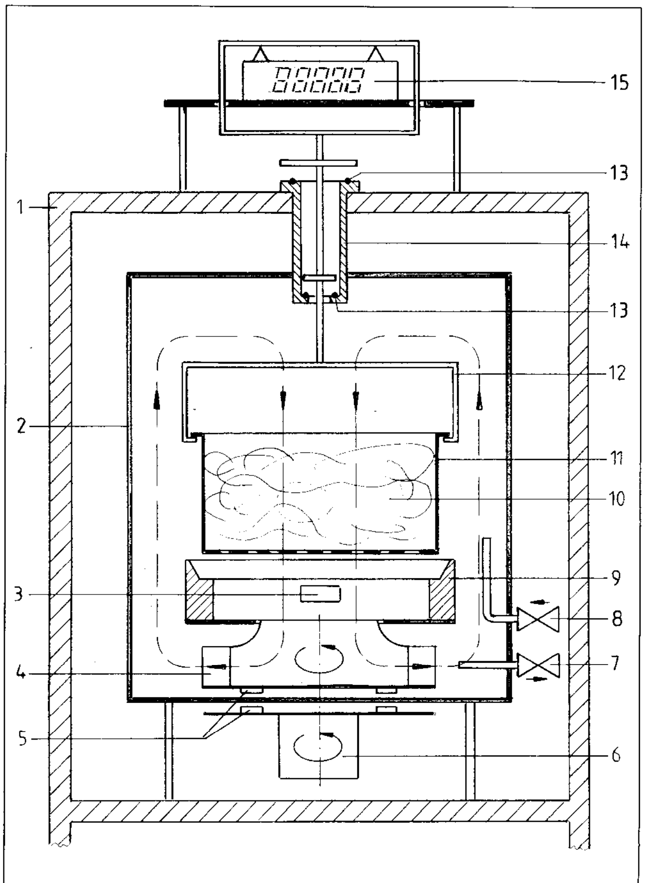


Bild 1

denen Salzlösungen bietet. Die gesamte Meßkammer (2) aus rostfreiem Edelstahl steht zur Temperierung in einem ventilierten Klimaschrank (1). Die Meßkammer ist so konzipiert, daß die im Inneren befindliche und mit einem Ventilator in Zirkulation versetzte Luft nirgends kältere Stellen vorfindet, an denen bei hoher Luftfeuchtigkeit ungewollt Kondensation eintreten könnte. Das heißt, daß alle Aufhängungs- und Verbindungsteile der Meßkammer nach außen aus einem Kunststoff mit geringer Wärmeleitfähigkeit (Polypropylen) gefertigt wurden. Um eine Feuchtigkeitskondensation im Durchführungsteil (14) zu der über dem Klimaschrank stehenden elektronischen Waage (15) zu verhindern, wurden Gummidichtungsringe (13) am Doppelverschluß eingebaut. Mittels zweier elektrisch betätigter Ventile (7, 8) werden die für den Luftwechsel notwendigen Leitungen unmittelbar an der Kammerwand abgeschlossen, sobald der Luftaustausch beendet ist und die Feuchte-Angleichungsphase beginnt. Es wurden im Inneren der Meßkammer keinerlei Materialien verwendet, die im Verdacht stehen, ihrerseits Wasser aus der Luft aufzunehmen oder an die Luft abzugeben (kein PVC, keine Kunststoffe mit Weichmachern oder mit Sauerstoff in deren chemischen Struktur, keine Lacke oder Dichtungsmassen, ...).

Die als lockeres Kardenband vorliegende Probe (10; ca. 40g) befindet sich in einem Aluminiumkorb mit Siebboden (11), der seinerseits auf einem Gestell (9) steht, unter dem ein Ventilator (4) befestigt ist. Der Ventilator wird von außerhalb der Meßkammer mit einem Elektromotor (6) angetrieben, wobei die Drehmomentübertragung durch die Wand der Meßkammer hindurch mit einer Magnetkupplung (5) geschieht. Der Aluminiumkorb mit der Probe kann mit einer Aufhängung (12) angehoben werden, sodaß er während der Messung - so wie in Bild 1 dargestellt - frei hängt. Der Wechsel der Probe geschieht durch Abnehmen eines großen, abgedichteten Glassichtfensters an der Vorderfront der Meßkammer. Bei jedem Probenwechsel wurde von uns auch der Feuchtigkeitsfühler (3) ausgewechselt, da dieser Meßfühler einer regelmäßigen Nachkalibration bedarf (Fabrikat: NOVASINA, Zürich, 10-100% relative Feuchte, -20 - +80° C, Reproduzierbarkeit +/- 0.5%rF, max. Fehler +/- 2.5%). Neben dem Feuchtigkeitsfühler befindet sich ein Pt-100-Temperaturfühler. Die Feuchte- und Temperatursignale werden mit einem Schreiber laufend aufgezeichnet.

Ein Meßzyklus geht so vor sich, daß die frische Faserprobe zuerst einmal sehr schonend bei 35° C auf etwa 2.5 Gew.-% Restfeuchte getrocknet wird. Eine stärkere Vortrocknung wurde deshalb nicht gemacht, da wir bei Versuchen mit zuvor ganz ausgetrocknetem Fasermaterial einen anderen, niedrigeren Verlauf im Anfangsstück der Absorptionsisotherme beobachten konnten. Weil für die praktische Verwendung von zellulosischen Fasern der Gebrauch von zuvor niemals ganz ausgetrocknetem Fasermaterial die Regel ist, glauben wir, daß es richtig ist, die Untersuchungsmethodik daran anzupassen, was bedeutet, daß unsere Proben ganz bewußt niemals unter 2.5 Gew.-% Restfeuchte vorgetrocknet wurden.

Zum Trocknen wird ein Teilstrom der in der Meßkammer befindlichen Luft über eine kleine, im Klimaschrank befindliche Membranpumpe abgezogen und durch eine mit konzentrierter Schwefelsäure gefüllte Waschflasche außerhalb des Klimaschranks geleitet*. Nach diesem Vortrocknen wird am Klimaschrank die gewünschte Meßtemperatur eingestellt und danach mit der Messung der Absorptionsisotherme begonnen, indem die Meßkammerluft befeuchtet wird. Dies geschieht dadurch, daß der aus der Meßkammer abgezogene Teilluftstrom nunmehr durch eine mit Wasser gefüllte Waschflasche geleitet wird. Diese Waschflasche steht im Klimaschrank und das darin befindliche Wasser besitzt dieselbe Temperatur wie die Luft in der Meßkammer, wodurch nötigenfalls bis zu 100% relativer Luftfeuchte einstellbar sind. Beim Wechsel von Trocknen auf Befeuchten (und umgekehrt) müssen ausreichend große Feuchteänderungen an der Probe herbeigeführt werden, um den durch die Hysterese zwischen Absorptions- und Desorptionsisotherme bedingten Sprung in den Feuchte-Gleichgewichtswerten sicher zu überbrücken und das physikalische Verhalten der Faser komplett von der Desorptions- auf die Absorptionscharakteristik umzustellen.
Nach dem Ändern der Luftfeuchte in der Meßkammer schließen sich die elektrischen Ventile für die Luftleitungen an der Kammerwand automatisch. Die in der Kammer befindliche, über den internen Ventilator umgewälzte Luft nimmt durch Kontakt mit dem Probenmaterial solange Feuchtigkeit auf bzw. gibt solange Feuchtigkeit an die Probe ab, bis sich ein Feuchtigkeits-Gleichgewicht zwischen dem Probenmaterial und der Luft eingestellt hat. Das Erreichen dieses Zustands kann man daran erkennen, daß sich die am Schreiberstreifen aufgezeichnete Luftfeuchte nicht mehr ändert. Dies kann bei niedrigen Meßtemperaturen und trockenen Proben mehrere Tage dauern, kann aber bei hohen Meßtemperaturen und hohen Feuchtewerten auch innerhalb von Minuten vor sich gehen. Zum Bestimmen des Gewichts der Probe nach Erreichen des Gleichgewichtszustands wird die interne Ventilation kurz abgestellt und nach dem Öffnen des Verschlusses an der Gehängedurchführung die Probe im angehobenen, freihängenden Zustand gewogen.

Nach der schrittweisen Aufnahme der gewünschten Absorptions- und Desorptionskurven wird die Probe aus der Meßkammer gegeben und nach der von BISFA anerkannten Methode für Viskosefasern bei 105° C bis zur Erreichung von Gewichtskonstanz getrocknet[3]. Die bei den Resultaten angeführten Faserfeuchtewerte beziehen sich auf die unter diesen Bedingungen ermittelten Trockengewichte der Proben.

Die besonderen Vorteile der eben beschriebenen Anlage und der Meßmethode kommen vor allem bei den Messungen bei erhöhten Temperaturen zum Tragen. Es entfällt das umständliche Hantieren mit den heißen Exsikkatoren, wie es beim Stehenlassen von Proben über Salzlösungen in geschlossenen, temperierten Exsikkatoren der Fall ist[4]. Gleichzeitig wird durch die interne Luftzirkulation mit dem eingebauten Ventilator und der dadurch gewährleisteten ständigen Durchströmung des Fasermaterials die Einstellung des Sorptionsgleichgewichts deutlich beschleunigt, weshalb bei höheren Temperaturen ein Meßzyklus sehr zügig abgewickelt werden kann. Durch die ständige Beobachtung des Luftfeuchteverlaufs brauchen im Gegensatz zur Exsikkatormethode keine Zwischenauswägungen zur Erkennung der Gewichtskonstanz gemacht werden. Es können die Feuchteverlaufskurven als Funktion der Zeit ausgewertet werden, sodaß man gleichzeitig mit den Sorptionsisothermen auch die Kinetik der Feuchtigkeitsaufnahme bzw. -abgabe untersuchen kann.

Bei tieferen Temperaturen und trockenem Probenmaterial kann die Gleichgewichtseinstellung wegen der unter diesen Bedingungen gegebenen Langsamkeit der Wasserdiffusionsprozesse im Probenmaterial mehrere Tage dauern. Wir haben mehrere solcher Luftfeuchte-Gleichgewichtseinstellungen über längere Zeiträume beobachtet und aufbauend auf diese Messungen in der Folge bei solch langsamen Gleichgewichtseinstellungsprozessen generell Extrapolationen aus bisher vorliegenden Meßkurvenabschnitten (Registrierungszeit ein bis zwei Tage) auf den Endwert durchgeführt. Der maximale absolute Extrapolationsfehler in der Bestimmung des Luftfeuchte-Gleichgewichtsendwerts wird von uns auf +/- 2 Prozent relative Luftfeuchte geschätzt. Bei Anwendung der Werteextrapolation in diesem langsamen Meßbereich kommt man auch unter diesen Bedingungen auf eine Gesamtmeßzeit pro Probe, die deutlich kürzer ist als es mit der Exsikkatormethode möglich wäre.

RESULTATE:

In den Bildern 2 - 9 sind die Absorptions- und Desorptionsisothermen bei 20, 50 und 80° C von LENZING LYOCELL (1.3 dtex, glänzend), TENCEL-Faser (1.7 dtex, glz.), LENZING VISCOSE (1.3 dtex, glz.) und von LENZING MODAL (1.3 dtex, glz.) dargestellt. Die Hysterese zwischen der Absorptions- und der Desorptionsisotherme wird generell mit höherer Meßtemperatur kleiner, sie verschwindet jedoch selbst bei 80° C nicht vollständig.

Absorptionsisothermen LENZING LYOCELL 1,3/40 gl., bei 20° C, 50° C und 80° C

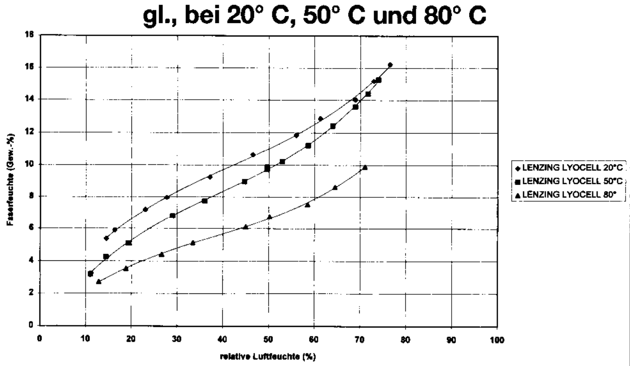


Bild 2

Desorptionsisothermen LENZING LYOCELL 1,3/40 gl., bei 20° C, 50° C und 80° C

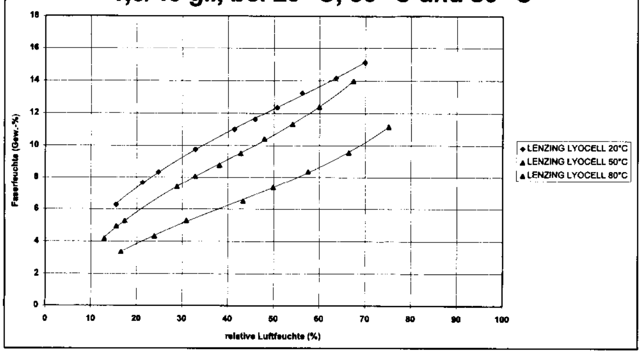


Bild 3

Absorptionsisothermen COURTAULDS TENCEL 1,7/40 gl., bei 20° C, 50° C und 80° C

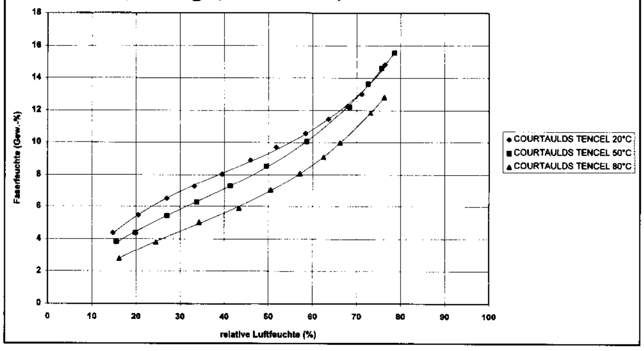


Bild 4

Desorptionsisothermen COURTAULDS TENCEL 1,7/40 gl., bei 20° C, 50° C und 80° C

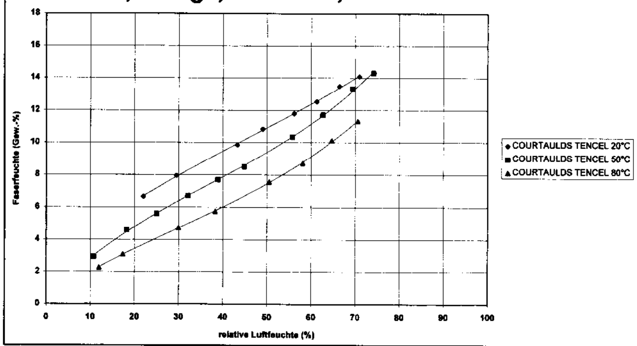


Bild 5

Absorptionsisothermen LENZING VISCOSE 1,3/39 gl., bei 20° C, 50° C und 80° C

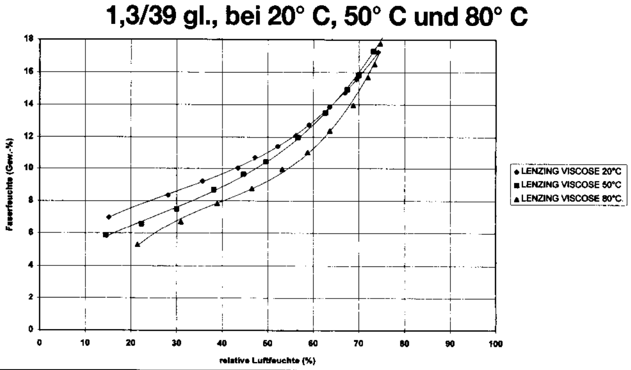


Bild 6

Desorptionsisothermen LENZING VISCOSE 1,3/39 gl., bei 20° C, 50° C und 80° C

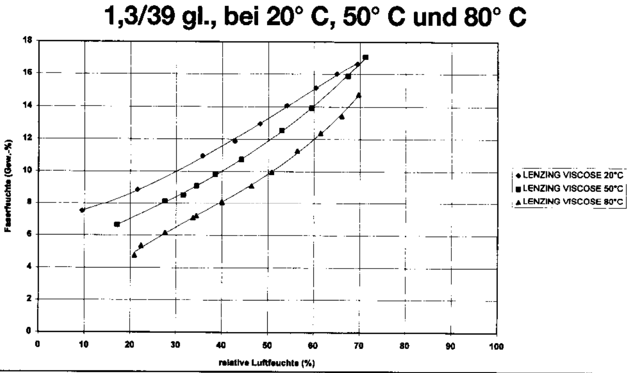


Bild 7

Absorptionsisothermen LENZING MODAL 1,3/39 gl., bei 20° C, 50° C und 80° C

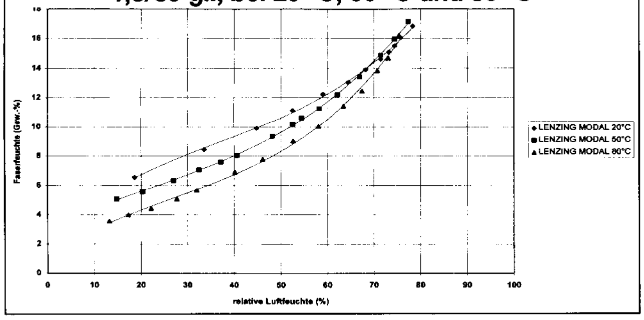


Bild 8

Desorptionsisothermen LENZING MODAL 1,3/39 gl., bei 20° C, 50° C und 80° C

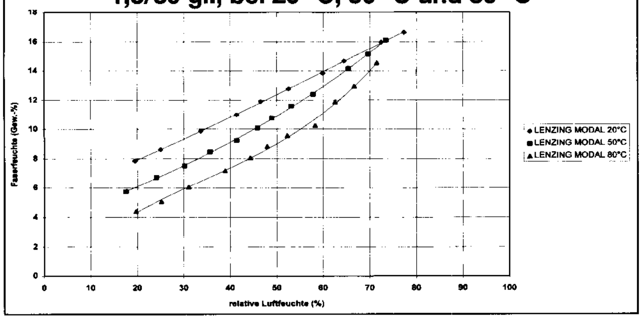


Bild 9

In Bild 10 sind die Absorptionsisothermen der vier angeführten Typen zugleich zu sehen. Was bei diesem Bild besonders auffällt, das sind die deutlichen quantitativen Unterschiede in der Wasseraufnahme aus der Luft für die beiden CLY-Typen LENZING LYOCELL und TENCEL-Faser. Dieser Unterschied konnte bei insgesamt 3 Meßreihen mit Proben aus verschiedenen Produktionsperioden beobachtet werden, sodaß ein Meßfehler zur Erklärung der beobachteten Differenz mit hoher Wahrscheinlichkeit ausgeschlossen werden kann. So ergeben sich beim europäischen Norm-Faserprüfklima (65% relative Luftfeuchte bei 20° C) für LENZING LYOCELL im Mittel aus drei Absorptions-Meßreihen 13.6 Gew.-% Feuchtigkeitsgehalt (Einzelwerte: 13.6, 13.8 und 13.4 Gew.-%), während der entsprechende Mittelwert aus drei Meßreihen für TENCEL-Faser 11.9 Gew.-% beträgt (Einzelwerte: 12.3, 11.6 und 11.7 Gew.-%). Dieser Unterschied im Sorptionsverhalten der beiden CLY-Fasertypen besteht auch noch bei 50° C, ist jedoch bei 80° C nicht mehr eindeutig, da sich dann die Absorptions- und Desorptionsisothermen der beiden Typen überschneiden. Der verschiedene Titer dieser zwei Typen (1.3 und 1.7 dtex) ist jedoch nicht für diese Differenzen verantwortlich, da wir aus einer Reihe von Messungen wissen, daß der Titer eine viel geringere Rolle bei den Sorptionsgleichgewichtswerten von Fasern spielt, als es der gegebenen Differenz entspricht.

Absorptionsisothermen der 4 untersuchten Fasertypen bei 20° C

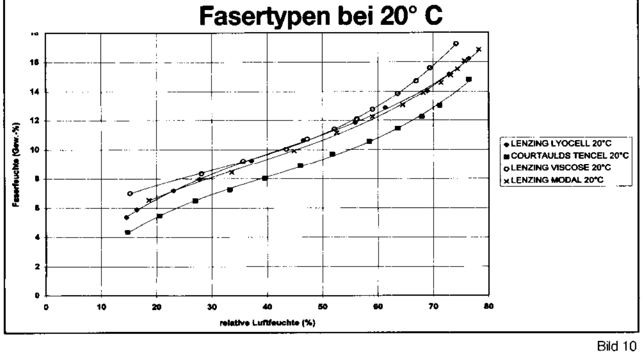


Bild 10

Während sich also LENZING LYOCELL und TENCEL-Faser in ihren Sorptionsgleichgewichtswerten deutlich unterscheiden, gibt es bei 20 und 50° C eine verblüffende Ähnlichkeit über einen großen Luftfeuchtebereich hinweg für die Absorptions- und Desorptionsisothermen von LENZING LYOCELL und LENZING MODAL. Bei 65% relativer Luftfeuchte und 20° C weist LENZING MODAL einen Absorptionsisothermen-Gleichgewichtswert von 13.2 Gew.-% Feuchte auf. Diese Ähnlichkeit im Sorptionsverhalten der beiden LENZING-Typen war von uns eigentlich nicht erwartet worden, da die Herstellungsprozeße jeweils ganz unterschiedlich sind und als Folge davon auch ganz verschiedene physikalische Strukturparameter beobachtet werden (z. B. Kristallinitätsgrad 61% für LENZING LYOCELL vs. 38% für LENZING MODAL). Daß eine Normal-Viskosefasertype unter den Normklimabedingungen einen höheren Feuchtegehalt (14.4 Gew.-% Feuchtigkeitsabsorption bei LENZING VISCOSE) aufweist als eine Modal-Fasertype (13.2 Gew.-% bei LENZING MODAL), ist schon lange bekannt[5].

Die angeführten Resultate sind derzeit von rein beschreibender Natur. Zu einer Interpretation der angeführten Unterschiede und Ähnlichkeiten - etwa mit Hilfe der Porenstruktur der verschiedenen Fasertypen - fehlen uns derzeit noch gewisse Daten. Durch ausschlußchromatographische Messungen[6] sind zwar Porenstrukturdaten für LENZING VISCOSE und LENZING MODAL vorhanden, jedoch nicht für die CLY-Typen. Aus unseren Messungen läßt sich ein deutlicher Unterschied in der Porenstruktur zwischen LENZING LYOCELL und TENCEL-Faser postulieren.

** Fußnote: Es sind überproportional große Sicherheitsflaschen vorzusehen, da aus ungeklärten Gründen die konzentrierte Schwefelsäure nach einer gewissen Verwendungszeit zu schäumen beginnen kann und der Schwefelsäureschaum gewöhnliche Sicherheitsflaschen überwindet.*

Literatur:

1) Lenzinger Berichte, Bd. 74 (1994)

2) Datenblätter, Typenprogramme und Prospekte über diverse Anwendungsgebiete dieser Fasertypen sind erhältlich bei LENZING AG, Geschäftsbereich Fasern, Abteilung FM (A-4860 LENZING)

3) BISFA: „International anerkannte Methoden für die Prüfung von Spinnfasern und Kabel aus Viskose, Modal, Acetat, Triacetat und Cupro"; Basel 1983

4) Fuzek, J.F.; „Adsorption and Desorption of Water by Some Common Fibers", Ind. Eng. Chem. Prod. Res. Dev., Vol. 24, No.1, 140-144 (1985)

5) Faserstoff-Tabellen nach P.-A.Koch, Celluloseregeneratfasern, 1. Ausgabe 1990, Institut für Textiltechnik der RWTH Aachen

6) Bredereck, K., Meister, W., Blüher, A.; „Die Hydrogelstruktur von Viskosefasern im Vergleich zu Baumwolle - Strukturcharakterisierung durch Größenausschluß-Chromatographie", Melliand Textilberichte, Jg. 74, Bd. 12, 1271-1276 (1993)

LENZING LYOCELL - AN INTERESTING CELLULOSE FIBRE FOR THE TEXTILE INDUSTRY

D. Eichinger, M. Eibl, Lenzing AG, 1995
Talk held at 34th IFC Dornbirn 1995

Die Lyocell-Faser stellt eine der größten Innovationen der Lenzing AG und vermutlich der gesamten Faserindustrie seit der Entwicklung von synthetischen Fasern dar. Das Ziel dieses Vortrages ist zu prüfen, ob die Lenzing Lyocell Faser tatsächlich den von Gesellschaft, Endverbraucher und Textilindustrie aufgestellten Erfordernissen genügt.

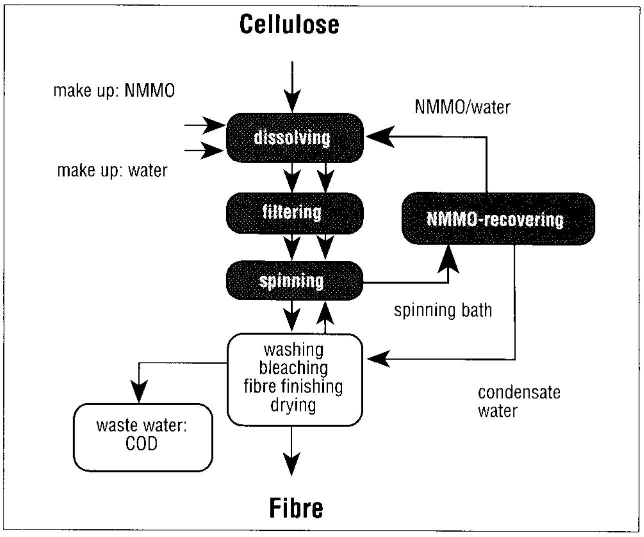
The Lyocell fibre represents one of the greatest innovations of Lenzing AG and possbly of the fibre industry as a whole since the development of synthetic fibres. The goal of this talk is to examine whether the Lenzing Lyocell fibre does indeed satisfy the requirements made by society, the end-user and the textile industry.

The Lyocell fibre represents one of the greatest innovations of Lenzing AG and possibly of the fibre industry as a whole since the development of synthetic fibres. Following intensive technological, product and market evaluation, in May 1995 Lenzing AG decided to install a 20,000 t. per annum production line which will go into operation step-by-step in 1997.
In the course of development work to date, numerous technological hurdles have already been overcome. The successful introduction of the fibre to the market is connected to the question of whether this new fibre will satisfy the requirements made by society, the end-user and the textile industry in the industrialised countries.

These can be summarised as follows:

- ecology
- innovation
- performance

The goal of this talk will now be to examine whether the Lenzing Lyocell fibre does indeed satisfy these requirements.



Picture 1

Ecology:

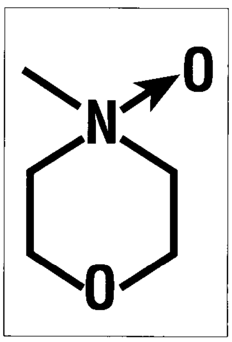
The fulfilment of this criterion is one basic prerequisite of any new technology and new fibre, otherwise the fibre's chances of survival are non-existent.

What are, therefore, the elements which enable the environmentally kind production of a cellulose fibre?

- Closed circuit production using the direct solvent process
- A toxicologically harmless solvent
- Replenishable raw materials

Closed circuit production using the direct solvent process:

60 years ago the active group of amine oxides[1], which dissolve cellulose, was discovered. Since substances of this kind decompose easily, particularly at raised temperatures, in contact with reducing groups - i.e. with end groups of cellulose for example - or under the influence of metal ions, the former were only able to assert themselves roughly 30 years later when N-Methyl-morpholine-N-oxide[2], which is considerably more stable, was discovered. Now known as NMMO, the product haunts scientific journals.



Picture 2

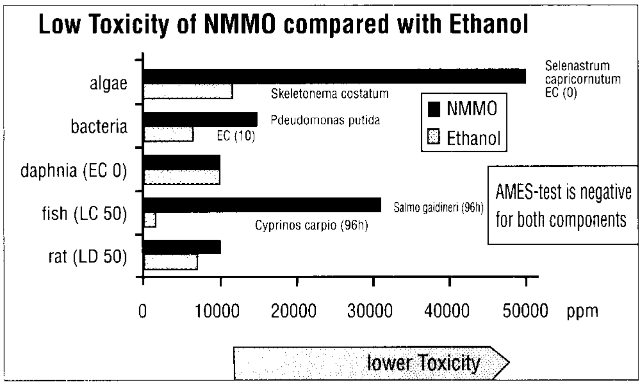
Up until a few years ago, it was not possible to obtain NMMO in the quantities required for industry since no alternative industrial application was known until then. The high costs of the solvent, for the reason named above, demanded the development of an almost closed circuit process. This can, however, only be accomplished when the manufacture of the solution in particular is designed so as to prevent thermal decomposition of the NMMO[3] apart from stabilising and recovery technologies.

Toxicology of the solvent:

Amine oxides are not new substances. They are practically ubiquitous which means that they for example make up a considerable washing-active part of personal hygiene products which normally undergo intensive dermatological and toxicological examinations. From this, it should, therefore, be possible to deduce toxicological safeness for industrial applications.

Toxicological examinations were of course also carried out on NMMO itself.

To help visualise and compare the toxicological data, Lyocell is compared in the picture which follows with the most tested and world's best known solvent and nutriation alcohol ethanol .



Picture 3

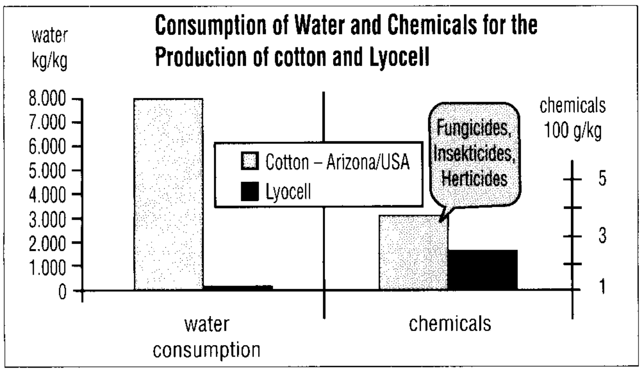
In the five toxicity examinations on hand carried out on various living organisms in the food chain, i.e. on rats - representing mammals - fish, small crayfish (Daphnia), algae and bacteria, it is clear that NMMO is less toxic than ethanol.

The discovery that the mutagenesis test according to AMES was negative was also of great significance since NMMO is to be considered as toxicological and clinical harmless.

Replenishable Raw Material:

Aside from natural fibres, all man-made cellulosics can lay claim to this attribute. However, in this context we were interested in production methods in practice i.e. the use of water and chemicals.

A comparison with cotton suggests itself. To be able to argue on the basis of comparable production standpoints, pulp production was immediately taken into consideration in the Lyocell manufacturing process .



Picture 4

The extremely high amount of water required for cotton immediately takes our eye. Compared to cotton, Lyocell reveals lower consumption factors in both cases. Lyocell requires only half the amount of chemicals which are not as environmentally harmful by far since cotton for example requires a share of these chemicals to protect it from pests - environmentally harmful and health-hazardous chemicals such as pesticides, insecticides and fertilisers are still necessary - which makes it necessary to test the cotton prior to its use. Lenzing Lyocell easily complies with the Ökotex 100 Standard.

Conclusion: After examining the toxicological data for the solvent and comparing the former with the data for natural fibres, the customer in the textile industry can be sure that he is processing an ecologically perfect fibre.

Innovation:

The fashion industry is a shining example of permanent innovations and the search for new discoveries. Apart from designing clothing, the coloration of the fabrics and, above all, the handle of a fabric play a decisive role.
When it comes to fashion, the fibre producer's immediate partner is the fabric manufacturer, since using finishing techniques, he is in a position to confer the handle / drape / optical appeal desired on the fabrics.
What role can a new fibre such as Lyocell play in this respect?

Creating handle:

It is exceedingly difficult to make an objective measurement of the handle of a fabric. In addition, different cultures perceive touch in different ways. Kawabata introduced an objective evaluation of touch in 1968 developed on the basis of how the Japanese experience touch. In the meantime the method he developed is increasingly gaining in recognition and popularity.

With the help of special measuring devices this system ascertains 20 different important fabric properties (Examples: stretching work, recovery capacity, maximum breaking elongation, shearing resistance, bending rigidity, bending hysteresis height, compressibility, thickness, coefficient of friction,...) including mass per unit area as the 21^{st} parameter.
Factors emerge from these measurements which clearly mirror the way the Japanese feel about touch but also provide excellent figures for reasons of comparison almost making it possible to quantify the subjective way handle is perceived.
At this juncture, four important handle properties will be more clearly defined:

○ **Koshi - rigidity and elasticity**
Handle parameters in which bending rigidity dominates. Springiness promotes this feeling of handle. Fabrics with a higher density and those containing elastic yarns promote this feeling of handle.

○ **Numeri - pliable smoothness**
A feeling of handle which contains several components including pliability and smoothness as well as softness.

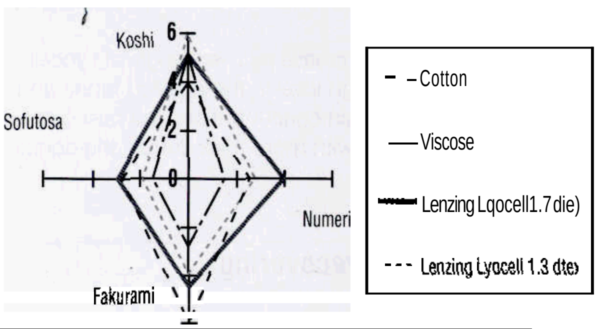
○ **Fukurami - fullness and softness**
Reflects the bulkiness and fullness of a fabric, elastic properties with respect to compressibility and thickness. This parameter is closely connected to sensations such as the flow of heat.

O Sofutasa - a soft handle

This term comprises Koshi, Numeri and Fukurami. It is an important overall impression for fabrics intended for ladies outerwear. It is primarily the smoothness which is expressed.

Experiments were now conducted with comparable fabrics made of cotton and Lenzing Lyocell with a mass per unit area of 150 g/m2, i.e. the same mass per unit area, yarn count and structure.

Kawabata: Woven Textiles desized

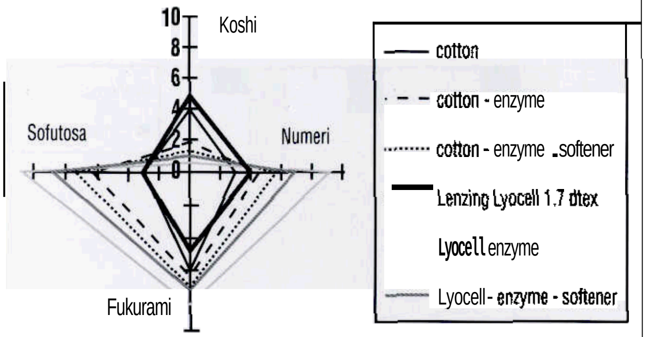


Picture 5

We examined the desized fabrics first. A comparison was again made with viscose of 1.3 dtex the reason being that the difference in handle/drape between viscose and cotton, as the most important representatives of the cellulose fibre industry in the truest sense of the word, means something to most consumers. There is also a differencein handle between the yarns made of fibres of different counts, which becomes clear when comparing Lenzing Lyocell 1.7 dtex with I.3 dtex.
Therefore, we amve at the conclusion that with respect to handie properties. Lyocell is closer to cotton than viscose when desized.

In the step which followed, the cotton and Lyocell fabrics previously mentioned both underwent a Garment-Finishing-Process, i.e. an enzyme treatment when washing. Normally this process is performed on the made-up part producing the "washed out" - look so much appreciated in Denim fabrics.

Changing the Handle via Enzymatic Treatment

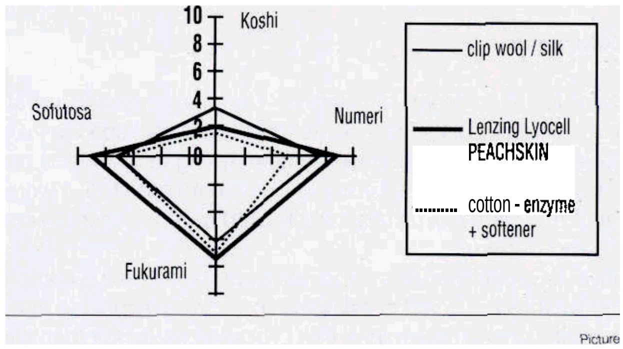


Picture 6

Both fabrics become softer whereby the Lyoceil fabric softens to a greater extent than the cotton. This can be seen in the spread with respect to Sofutasa, Numeri and Fukurami. Koshi diminished in both cases.
Even if cotton and Lyoceil were relatively close in the desized condition, they develop quite differently as a result of enzyme treatment, i.e. both become softer and this effect can be further enhanced by adding softeners. Lyocell can, therefore, be modified and influenced to a much greater extent than cotton.

If not cotton, which natural fibres does an enzyme-treated Lyocell-fabric resemble?

Lyocell compared with a Wool/Silk-blend



Picture

In one further comparison, a so-called PEACH-SKIN effect was achieved on Lyocell using enzymes and posttreatment in the so-called AIRO 1000 - which is a posttreatment jet operating with an air/water mixture - which was compared with a wool-silktwill with a comparable mass per unit area. A wool-silktwill was selected because no data was available on pure silk fabrics of this weight. It is clear that Lyocell exceeds this fabric in terms of softness and is not equalled by cotton treated with enzymes and softeners.

What can be made responsible for the softness in this case?
The SEM shots compare Lyocell-fabric on the left-hand side in desized form with the afore-mentioned PEACH SKIN effect achieved using the method described above on the right.

Desized **Peach Skin**

Picture 8

The fibre structure in the left-hand picture clearly resembles a cotton yarn and for this reason, the closeness to cotton is not surprising. In the right-hand picture very fine fibre hairs - so-called fibrils- can be clearly perceived protruding from the outermost fibres. These fibrils are - as in silk - responsible for the pleasant soft touch of the fabrics.
For a long time the Japanese have been attempting to make copies of different natural fibres with microfibres, however, this is only successful when the fibres and their surfaces are tailor-made to achieve a specific effect. The Lyocell-fibre is so very ver-

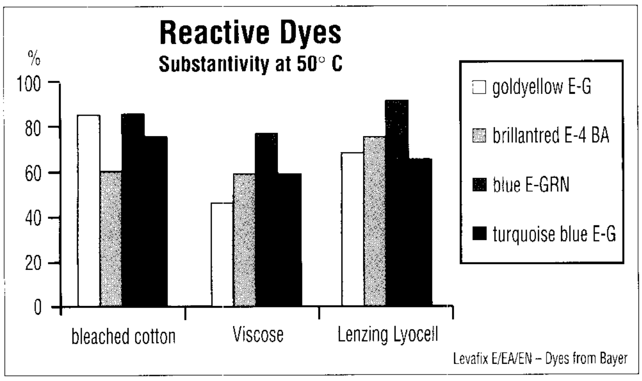
satile that handle variations ranging from cotton to wool and silk or perhaps even in new directions can be achieved or are possible using finishing methods. However, these developments are possible only because Lyocell offers a corresponding basis. The finishing technologies behind these developments challenge the creative spirit and development capabilities of fabric manufacturers. Lyocell as a measure of the innovative strength of the textile industry?

Coloration

Some textile engineers and fibre development engineers will still have memories of the development of the last fibre species - e.g. Polyester - for which completely new dyeing technologies had to be developed. Since Lyocell is also a cellulose fibre, it would seem that similar dyestuffs can be used to those used on cotton and viscose .

Bayer AG examined this hypothesis and performed a comparison across the board of cellulosic fibres. With respect to direct dyestuffs, it was determined that Lyocell looks darker than bleached cotton respectively viscose and is only outdone by mercerised cotton.

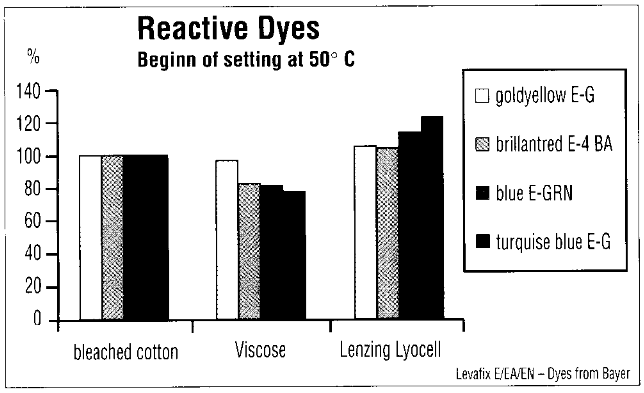
As for reactive dyestuffs - Bayer AG selected golden yellow E-G, brilliant red E-4BA, Blue E-GRF and turquoise blue E-G - it is true that considerable differences exist with respect to substantivity and dye yield rate alone (always relative).



Picture 9

The substantivity (affinity) profile of these four dyestuffs compared to bleached, mercerised cotton and Lenzing Viscose is, with respect to Lyocell, balanced and resembles viscose more than cotton.

The relative fixing yield, which can be seen as a measurement of colour depth, is in any case higher in Lyocell than cotton.



Picture 10

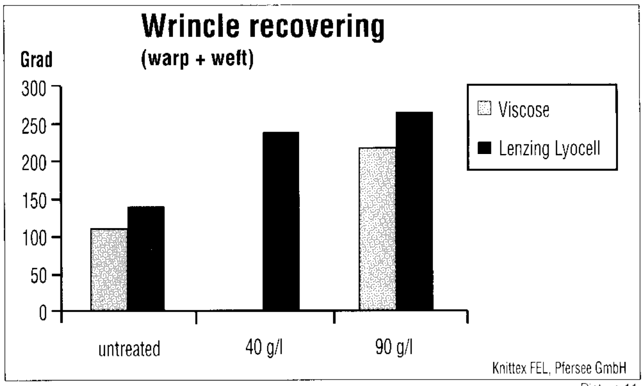
I.e. by way of conclusion one can state that with respect to direct dyestuffs and reactive dyestuffs, the dyeing behaviour is comparable to other cellulose fibres, however, the dyeing specialist is offered economic and ecological advantages since the colour depth is deeper.

Performance

Easy Care Behaviour

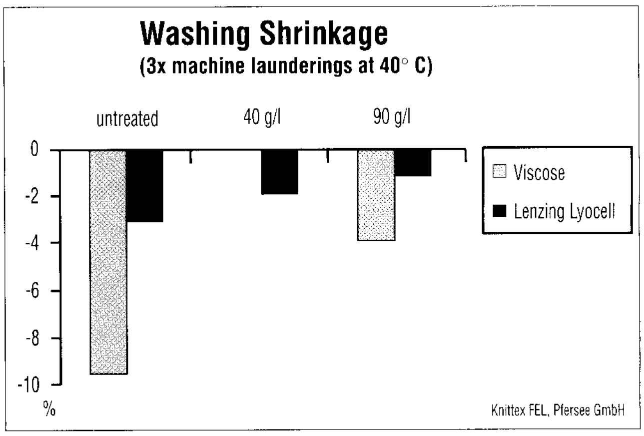
In all cellulosic fibres the utility values required are reached using cross-linking chemicals[6].

One essential point is the crease recovery angle of Lyocell which commences at a very high level in the desized fabric and can, using low amounts of resin concentrations, be raised to a level unparalleled by viscose with more than double the concentration of resin.



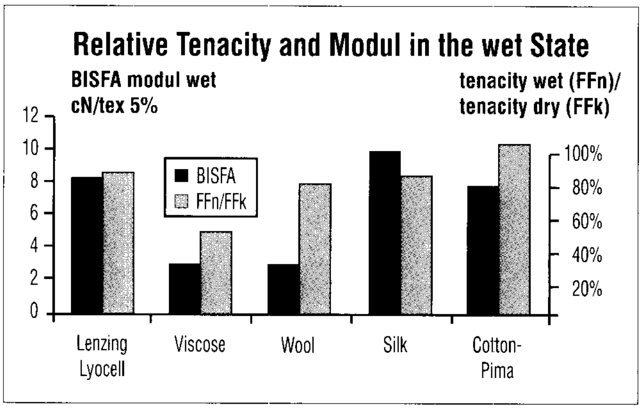
Picture 11

The wash shrinkage level of a plain weave fabric is much lower with respect to Lyocell than viscose so that in this respect no finishing would be required on most Lyocell fabrics. Here the picture is even more drastic since even when 90 g/l of resin are applied, viscose cannot reach the wash shrinkage level already present in Lyocell in an untreated state.



Picture 12

This property can most probably be explained by the high wet modulus of this fibre, which can compete with top cotton qualities. In wool, the relatively high shrinkage in various textiles processes - such as the milling process - is put to use.

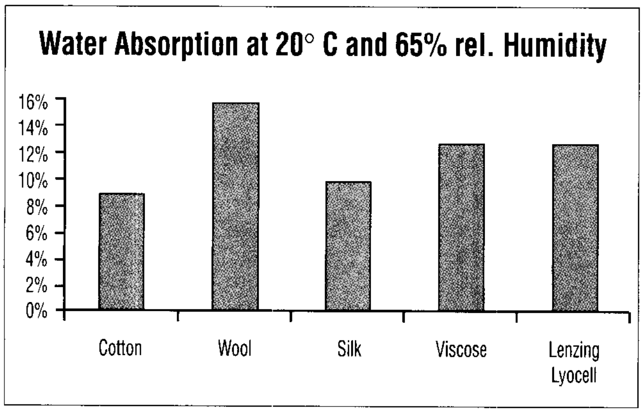


Picture 13

As was shown in the Kawabata measurements, products which resemble wool can be produced with Lyocell with a low level of shrinkage.
These findings, however, mean for the cellulose fibre world, that Lyocell can build on a high level with respect to Easy Care properties due to its inherent strength properties. In this way, the finisher can save on man-made resin finishing. Moreover, ecology - by adhering to different ecological standards (e.g. Öko-tex 100, reduction of waste water) - and economy were taken into account.

Moisture absorption

In order to obtain information about the physiological wear properties of Lyocell, moisture absorption was examined in a normal climate (20°C, 65% air moisture) i.e. due to the hydrophilicity of the cellulose, a certain amount of moisture transport can be assumed from the skin. Until now, practical tests have shown that Lyocell is particularly pleasant to wear.



Picture 14

As can be ascertained from the diagram, the moisture absorption of Lenzing Lyocell lies at the same level as viscose which of course puts Lenzing Lyocell in the same physiological wear category as most natural and cellulose fibres. However, the difference between the man-made-cellulose fibres, viscose/Lyocell, and cotton is significant.

Summary

- Lenzing Lyocell would appear to be a kind of fibre chameleon brought to life by an ecological fibre process.
- The basic high strength of this fibre makes it possible to treat the fibre at different stages in the textile chain in a dry and wet state.
- Thanks to the reduced application of resin and dyestuffs, the costs are lower for the fabric manufacturer and the ecological risk is lower.
- The dyeing behaviour and wear comfort of Lyocell correspond to cellulosic fibres. A range of handle and look variations can be produced, the most popular currently being those which resemble wool or silk.
- This variability can, however, only be developed given the corresponding know-how and the latest textile technologies. We see Lyocell, therefore, as an opportunity for the innovative textile entrepreneur in the industrialised world since development work will produce a large number of opportunities to differentiate.

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LYOCELL – EINE ÖKOLOGISCHE ALTERNATIVE

H. Firgo, M. Eibl, D. Eichinger, Lenzing AG

Lyocell ist aufgrund der einzigartigen Kombination von Vorteilen ein attraktiver Rohstoff für die gesamte textile Kette. Doch auch in bezug auf die Herstellung stellt die Lyocellfaser eine echte ökologische Alternative zu anderen wichtigen Fasertypen dar. In diesem Artikel werden ökologisch/technologiscbe Aspekte der Herstellung von Lyocell-Fasern insbesondere mit der Baumwollproduktion verglichen.

Due to its unique combination of advantages, Lyocell is an attractive raw material for the whole textile pipeline. But also in respect of the production Lyocell is a true ecological alternative to other important fibre types. In this article, ecological and technological aspects of the production of Lyocell fibres are compared especially with the production of cotton.

Parallel zur stark wachsenden Weltbevölkerung stieg in den letzten 50 Jahren auch der weltweite Faserverbrauch stark an. Insgesamt wurden im Jahre 1950 ca. 9,4 Mio Tonnen Fasern verbraucht, mittlerweile liegt die Jahresverbrauchsmenge bereits bei ca. 43 Mio Tonnen. Während dieser Periode vergrößerte sich aber auch der durchschnittliche Faserverbrauch pro Kopf und Jahr von 3,7 kg auf heute bereits 7,6 kg (Abb.1).

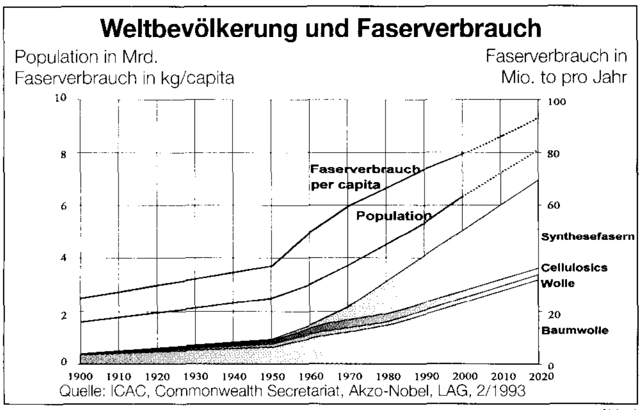

Abb. 1

Diese eklatanten Mengensteigerungen wurden größtenteils durch eine Ausweitung und Intensivierung der Baumwollproduktion einerseits, aber vor allem durch ein überproportional starkes Wachstum der synthetischen Fasern auf petrochemischer Basis (vor allem Polyester) andererseits getragen. Der Prokopfverbrauch hängt eindeutig mit den Einkommensverhältnissen in den jeweiligen Ländern zusammen und ist deshalb geographisch gesehen stark variierend (Abb.2).

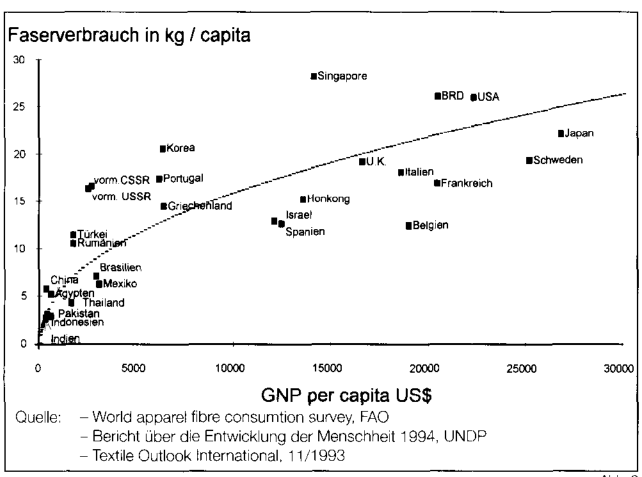

Abb. 2

In vielen Entwicklungs- und Schwellenländern verbrauchen die Menschen weniger als 5 kg Fasern pro Kopf und Jahr, während die Konsumenten in den Industriestaaten sich vielfach mehr als 20 kg leisten können. Trotz des überproportional starken Anstieges der Synthesefaserproduktion haben die Baumwolle, aber auch die industriell hergestellten Cellulosefasern heute ihren festen Platz am globalen Fasermarkt. Besonders in den reichen Industrieländern zeigt sich, daß die Cellulosefasern insgesamt einen Anteil von ca. 50 % am Gesamtfaserverbrauch haben. Offensichtlich können mit diesem Verhältnis von hydrophilen, physiologisch attraktiven Cellulosefasern zu hydrophoben, aber sehr pflegeleichten und funktionellen Synthesefasern die anspruchsvollen Bedürfnisse der Kunden in den reichen Ländern am besten abgedeckt werden.

Nimmt man die Prognosen zur Entwicklung der Weltbevölkerung in den nächsten Jahrzehnten ernst und extrapoliert die Mengenentwicklung der verschiedenen Faserarten oder den Faserverbrauch pro Kopf, so resultiert im Jahr 2020 für 8,1 Mrd. Menschen eine Gesamtfasermenge von 70 bis 75 Mio. Tonnen, wobei unter Beibehaltung des Verhältnisses hydrophiler zu hydrophober Fasern ein Cellulosefaserbedarf von 30 bis 40 Mio. Tonnen entstehen wird. Dieses Scenario ist wegen des doch sehr langen Betrachtungszeitraumes zugegebenerweise etwas spekulativ, aber man kann doch daraus ableiten, daß dazu eine Steigerung der Cellulosefaserproduktion von mindestens 50% notwendig ist, wenn der in den Industriestaaten übliche Komfort bei Textilien gehalten werden soll.

Eine Ausweitung bzw. Intensivierung der Baumwollproduktion in diesem Ausmaß erscheint trotz existierender, ehrgeiziger Ziele zur Erhöhung der Hektarerträge kaum möglich, da gerade in einigen großen „Baumwolländern" die Bevölkerung besonders schnell wächst und die Baumwollproduktion dort wegen ihres hohen Wasser- und Agrarflächenbedarfes in Konkurrenz mit der Nahrungsmittelproduktion steht.

Eine sinnvolle Alternative zur Baumwollproduktion ist die industrielle Fertigung von Cellulosefasern auf Basis Zellstoff, der aus Holz oder in Zukunft möglicherweise auch aus einjährigen Pflanzen gewonnen wird. In vielen europäischen Ländern, darunter Österreich, ist die Holzentnahme aus den Wäldern kleiner als die zuwachsende Menge. Auch die Holzproduktion in Plantagen in den USA oder in den regenreichen tropischen Regionen kann heute bereits sehr umweltverträglich und mit hohen Flächenerträgen erfolgen. Die vormaligen Probleme bei der Zellstoffproduktion sind heute gelöst, die Aufschlußchemikalien werden im Kreis geführt, die Zellstoffbleiche kann völlig ohne chlorhaltige Chemikalien nur mit Sauerstoffverbindungen durchgeführt werden. Einer der zukünftig wesentlichsten Vorteile dieses Rohstoffes wird sein, daß zumindest beim Sulfitverfahren kaum fossile Energie verbraucht wird, sondern daß bei moderner Prozeßführung durch die Verbrennung des Ligninanteiles des Holzes sogar Überschußenergie anfällt.

Bislang wurden auf dieser Rohstoffbasis vor allem Cellulosefasern nach dem Viskoseverfahren hergestellt. Viskose- und

Modalfasern haben heute in der Textilindustrie neben Baumwolle und den Synthesefasern vor allem im modischen Bereich ihren festen Platz. Daneben hat die Lenzing AG nunmehr ein neues Verfahren zur Herstellung von Cellulosefasern entwickelt, das derzeit im Burgenland in eine erste kommerzielle Großanlage umgesetzt wird.

Die neue Faser trägt den Gattungsnamen „Lyocell" und wird nach einem Direktlösungsmittelverfahren (N-Methylmorpholin-N-oxid, „NMMO") hergestellt (Abb. 3).

Cellulosefaser

- hergestellt nach einem Direktlösungsmittelverfahren
- Lyocell: Gattungsname durch BISFA (International Bureau for Standardisation for Man-made-fibers)
- Lösungsmittel: NMMO (N-Methyl-morpholin-N-oxid)

Eigenschaftsprofil einzigartig

- hohe Trockenfestigkeit
- sehr hohe Schlingenfestigkeit
- sehr hohe Naßfestigkeit
- gute Anfärbbarkeit
- kontrollierte Fibrillierung

Abb. 3

Die Fasern haben außerordentlich interessante textilmechanische Eigenschaften, besonders im nassen Zustand.

Das Verfahren besticht vor allem durch seine Kreislaufführung (Abb. 4).

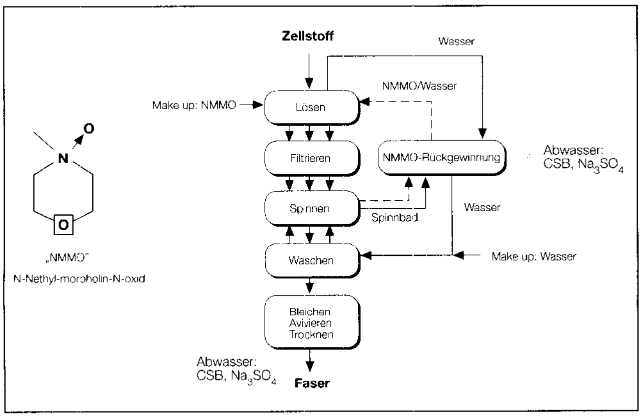

Abb. 4

Der Zellstoff wird in konzentriertem wässrigem NMMO dispergiert und unter intensiver Scherwirkung bei gleichzeitigem Verdampfen von Wasser gelöst. Die hochviskose Lösung wird filtriert und anschließend durch Spinndüsen in ein wässriges Spinnbad extrudiert, wo die Cellulose in Faserform wieder regeneriert wird. Das Spinnbad, das durch den NMMO-Eintrag aus verdünntem, wässrigem NMMO besteht, wird gereinigt, durch Verdampfen des überschüssigen Wassers aufkonzentriert und anschließend wieder zur Lösungsherstellung verwendet. Das bei der Verdampfung anfallende Kondensat wird dazu benutzt, das mit den Fasern aus dem Spinnbad mitgeschleppte NMMO aus den Fasern auszuwaschen. Die Rückgewinnungsrate bezogen auf das eingesetzte Lösungsmittel ist größer als 99,5%. Die ohnehin sehr geringen Emissionen an Lösungsmittel werden in adaptierten biologischen Kläranlagen bis unter die Nachweisgrenze abgebaut.

Das Lösungsmittel NMMO zeichnet sich durch äußerst günstige toxikologische Eigenschaften aus. Der besseren Anschaulichkeit halber sind in Abb. 5 verschiedene Toxizitätskennzahlen von NMMO im Vergleich zum allseits bekannten Ethanol dargestellt. NMMO erweist sich bei fast allen Tests als wesentlich untoxischer als Alkohol. Darüberhinaus konnte in diversen Untersuchungen gezeigt werden, daß NMMO nicht mutagen ist.

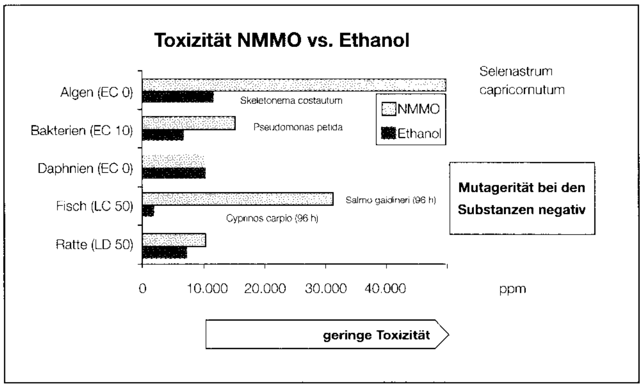

Abb. 5

Die folgenden Vergleiche einiger spezifischer Verbrauchsdaten von Baumwolle und Lyocell sollen zeigen, warum wir der Meinung sind, daß die industrielle Fertigung von Cellulosefasern in der Zukunft eine große Chance besitzt. Die Angaben sollen keineswegs als Versuch einer Ökobilanz gewertet werden, eine solche würde einen sehr hohen Aufwand bedeuten, sie zeigen aber doch plakativ, daß das „Naturprodukt Baumwolle" nicht zwangsläufig die ökologisch günstigere Variante gegenüber der industriellen Herstellung von cellulosischen Textilfasern darstellt.

Auf Abb. 6 ist der Flächenbedarf für die Produktion von Baumwolle beispielhaft dargestellt.

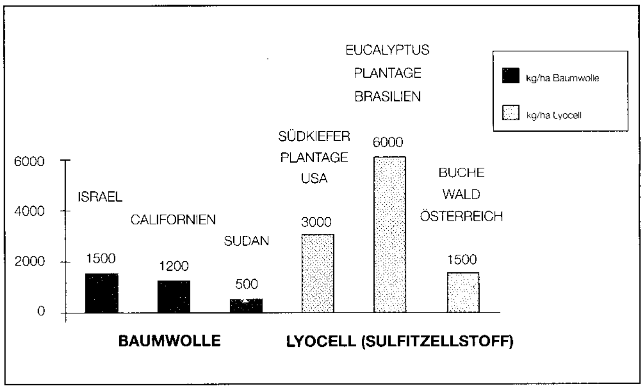

Abb. 6

Die Flächenerträge sind weltweit sehr unterschiedlich, hohe Erträge sind normalerweise nur bei künstlicher Bewässerung zu erzielen. Israel gehört mit 1500 kg Baumwolle pro Hektar und Jahr zu den absoluten Spitzenreitern beim Flächenertrag, auch die 1200 kg/ha für Californien sind international gesehen nicht die Regel, der Sudan liegt mit 500 kg/ha im vorderen afrikanischen Mittelfeld.

Wesentlich bessere Flächenausbeuten können erzielt werden, wenn man Holz als Rohstoffbasis für Cellulose verwendet. Die Erträge liegen z.B. bei Plantagenproduktion bei Südkiefer in den USA bei 3000 kg Zellstoff pro Hektar und Jahr, in Brasilien bei 6000 kg Zellstoff/ha.

Aber auch unsere heimische Buche, die nicht in Plantagen produziert wird, muß sich im Vergleich zu Baumwolle nicht verstecken, mit ca. 1500 kg/ha werden noch immer Erträge erhalten, die bei Baumwolle zu den absoluten Spitzenwerten gehören. Hier sei auch angemerkt, daß die Holzproduktion in der Regel auf künstliche Bewässerung und Pflanzenschutz verzichten kann und im Gegensatz zur Baumwolle auch mit wesentlich ärmeren Böden zurechtkommt. Bei den angegebenen Ausbeuten von Lyocell ist bereits berücksichtigt, daß bei der Zellstoffherstellung nur ca. 40% des eingesetzten Holzes als Zellstoff gewonnen werden. Die Ausbeute an Lyocellfasern in der nachgeschalteten Faserproduktion beträgt nahezu 100%.

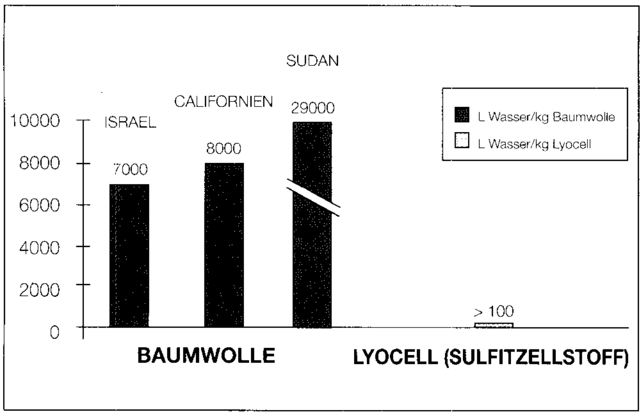

Abb. 7

In Abb. 7 wird der Wasserbedarf bei der Baumwollproduktion mit dem der Lyocellproduktion verglichen. Für die Baumwollherstellung werden unglaublich hohe Mengen an Wasser benötigt. Die Bewässerungsmengen variieren regional sehr stark. Die Skala reicht von Produktion ohne künstliche Bewässerung über Teilbewässerung bis zu 100% Bewässerung. Fest steht jedenfalls, daß nur bei intensiver Bewässerung auch hohe Hektarerträge erhalten werden. In Israel werden beispielsweise 7 m^3 Wasser/kg Baumwolle auf die Felder gepumpt, in Californien 8 m^3/kg. Im Sudan werden unglaubliche 29 m^3 Wasser/kg Baumwolle aus dem Nil abgezweigt, die Austrocknung des Aralsees wird hauptsächlich der Baumwollproduktion in den umliegenden Staaten zugeschrieben. Diese Zahlen sollten bedenklich stimmen, da viele der baumwollproduzierenden Länder mit Wasser ohnehin nicht reich gesegnet sind. Die für die Produktion von Lyocell (inclusive der Rohstoffbasis Zellstoff) verwendete Menge an Wasser ist dagegen sehr gering und liegt bei weniger als 100 l/kg Lyocell (ohne Kühlwasser).

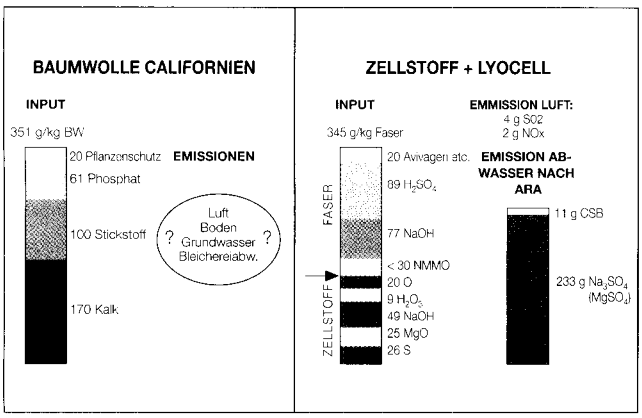

Abb. 8

Abb. 8 vergleicht den Chemikalieneinsatz der Baumwollproduktion mit dem der Lyocellproduktion. Als Beispiel für die Baumwolle wurde Californien ausgewählt, da einerseits quantitative Angaben über diesen Aspekt nur für wenige Länder gefunden wurden und andererseits in diesem Fall von einem ökonomisch optimierten Einsatz im Verhältnis zum Ergebnis ausgegangen werden kann. Neben den doch beträchtlichen Mengen an Düngemitteln stechen vor allem die 20 g Pflanzenschutzmittel pro kg Baumwolle ins Auge. Die hier zum Einsatz kommenden Insektizide und Herbizide sind vielfach hoch toxisch und schlecht abbaubar. Über die Auswirkungen dieser Verbindungen auf Boden und Grundwasser liegen kaum quantitative Untersuchungen vor. Die Mittel werden größtenteils mit dem Flugzeug auf die Felder aufgebracht, daher ist auch eine Beeinträchtigung der Luft anzunehmen. Mittlerweile unternimmt die Baumwollindustrie allerdings große Anstrengungen, um den Pflanzenschutz auf eine ökologisch verträglichere Basis zu stellen. Integrierte Pflanzenschutzmethoden und selektivere Schädlingsbekämpfung, sowie neue resistentere Arten, die durch Züchtung oder Genengeneering erhalten werden, werden auf breiter Basis erprobt. Ob die neuen Methoden unter Beibehaltung der gewohnten Flächenerträge und Herstellungskosten nachhaltig erfolgreich werden, bleibt abzuwarten.

Für die Herstellung von Lyocell inklusive Zellstoff werden nicht mehr Chemikalien verwendet als für die Baumwolle. Der Graphik ist zu entnehmen, daß für die Zellstoffherstellung in Lenzing nur relativ kleine Mengen an Schwefel und Magnesiumoxyd als Aufschlußchemikalien verwendet werden, da diese in einem weitestgehend geschlossenen Kreislauf geführt werden. Für die Zellstoffbleiche werden nur mehr Sauerstoff, Wasserstoffperoxyd, Ozon, sowie Natronlauge verwendet. Nicht alle Chemiezellstoffhersteller weltweit benutzen eine ökologisch derart optimierte Technologie, aber die meisten befinden sich am Weg dorthin. Für die Lyocellfaserherstellung wird neben weniger als 30 g NMMO/ kg Faser noch Natronlauge und Schwefelsäure in relativ kleinem Ausmaß benötigt. Die zusätzlich eingesetzten Hilfschemikalien wie Avivagen sind toxikologisch kein Problem und biologisch gut abbaubar. Nach der biologischen Abwasserreinigung werden ca. 230 g Neutralsalz (vorwiegend Natriumsulfat, in untergeordnetem Maße auch Magnesiumsulfat) sowie ca. 11g CSB pro kg Faser in den Vorfluter emittiert. Auch die Emissionen in die Atmosphäre bewegen sich in vertretbar kleinem Rahmen.

An dieser Stelle sei angemerkt, daß die Angaben für die Lyocellproduktion auf den Erfahrungen mit dem Betrieb einer kontinuierlichen Pilotanlage beruhen, und daß das Optimierungspotential im langjährigen kommerziellen Betrieb enorm groß ist. Zusammenfassend kann festgestellt werden, daß man zur Herstellung von Lyocell nicht mehr Chemikalien benötigt als zur Herstellung von Baumwolle, daß aber bei der Baumwollproduktion die problematischeren Produkte eingesetzt werden.

Neben dem Vergleich des Flächen- und Wasserbedarfes, der eindeutig zugunsten von Lyocell bewertet werden kann, und dem Vergleich des Chemikalieneinsatzes, der für Lyocell zumindest nicht negativ ausfällt, ist natürlich auch ein Vergleich des Einsatzes an Energie bzw. nicht erneuerbarer fossiler Rohstoffe interessant (Abb.9).

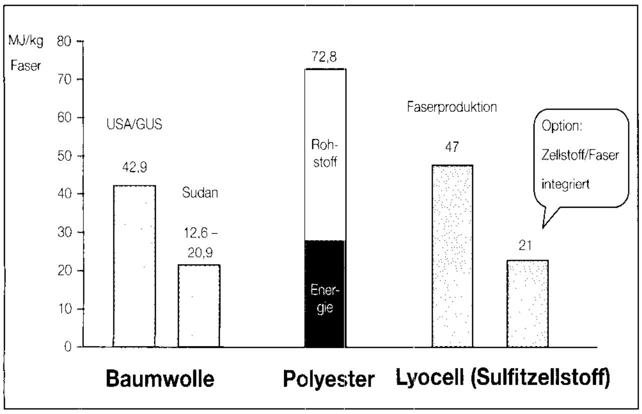

Abb. 9

Es ist dem unbedarften Konsumenten sicherlich nicht bewußt, daß die Baumwollproduktion „vor Ort" (ohne eingesetzte Chemikalien und Transportwege zu den Weiterverarbeitern) doch eine beträchtliche Menge an Primärenergie benötigt. Immerhin braucht man für die weitgehend maschinelle Produktionsweise in den USA oder GUS 42,9 MJ Primärenergie pro kg Baumwolle. Für den Sudan werden 12,6 bis 20,9 MJ/kg angegeben, wobei hier die Differenz zu den Industriestaaten durch die Arbeitskraft der Menschen aufgebracht werden muß (Quelle: Schlußbericht der Enquete-Kommission „Schutz des Menschen und der Umwelt - Bewertungskriterien und Perspektiven für umweltverträgliche Stoffkreisläufe in der Industriegesellschaft", BRD, 1994).

Bei der Herstellung von Polyesterfasern, der zweiten „großen" Fasertype ist der Energieaufwand für die Polymerisation und Faserherstellung mit 25,8 MJ/kg Faser vergleichsweise gering, allerdings muß hier berücksichtigt werden, daß die Faserrohstoffbasis aus Naphta (aus Erdöl) und Erdgas besteht, und diese mit ca. 47 MJ/ kg Polyesterfaser bewertet werden. Damit ist der Einsatz von nicht erneuerbaren Ressourcen bei Polyester mit insgesamt 72,8 MJ/kg wesentlich höher als bei Baumwolle. Der Einsatz von nicht erneuerbaren Ressourcen für die Lyocellproduktion muß differenziert betrachtet werden.

Für die Faserproduktion ausgehend von zugekauftem Sulfitzellstoff veranschlagen wir auf Basis unserer Pilotanlagenerfahrung ca. 47 MJ/kg Faser. Dieser Energieverbrauch ist auf jeden Fall noch optimierbar. In dieser Betrachtung ist der Einsatz von fossiler Energie für die Herstellung des Zellstoffes beim Zellstofflieferanten mit Null angesetzt, da die Herstellung von Sulfitzellstoff energieautark durchgeführt werden kann, obwohl - vermutlich wegen vielfach günstiger Energiepreise - nicht alle Zellstoffproduzenten diese Option nützen.

Bereits bei dieser Betrachtungsweise werden also für die Produktion von Lyocell vergleichbare Mengen nicht erneuerbarer Ressourcen wie für die von Baumwolle benötigt. Eine außerordentlich interessante Option stellt die Lyocellherstellung in einer integrierten Zellstoff/Faserproduktion dar, wie sie von der Lenzing AG derzeit bei der Viskosefaser durchgeführt wird. Bei dieser energieoptimierten Variante, bei der der Energieüberschuß der Zellstoffproduktion einen Teil der für die Faserproduktion benötigten Energie abdecken kann, ist ein Primärenergiebedarf von nur mehr 21 MJ/kg Lyocellfaser zu erwarten. Dieser Wert liegt deutlich unter dem Bedarf für die Baumwollproduktion in den Industriestaaten und erreicht sogar das Niveau der Baumwollproduktion in den Entwicklungsländern.

Zusammenfassend können wir also feststellen, daß Lyocell weniger Flächen- und Wasserbedarf als die „Naturfaser Baumwolle" benötigt, daß der Chemikalieneinsatz bei beiden Fasern in etwa gleich hoch ist, wobei bei der Lyocellproduktion die weniger problematische Chemie verwendet wird, und daß der Einsatz nicht erneuerbarer Ressourcen für Lyocell derzeit auf vergleichbarem Niveau wie bei der Baumwolle liegt, wobei für die Zukunft durchaus eine Option auf sogar wesentlich niedrigeren Primärenergieverbrauch für Lyocell gegeben ist.

Lyocell hat auf Grund dieser ökologisch/technologischen Überlegungen in der Zukunft das Potential, eine „große" Faser zu werden, der schwierige Einstieg in den umkämpften Textilfasermarkt wird jedoch nur gelingen, wenn die Faser selbst gegenüber den derzeit am Markt befindlichen Typen zusätzliche Vorteile bieten kann. Auch hier hat Lyocell einiges zu bieten (Abb. 10).

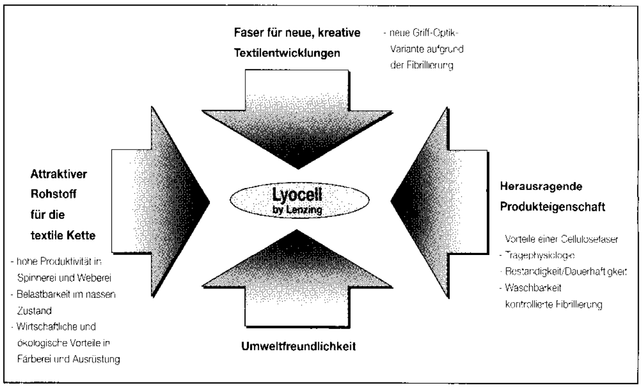

Abb. 10

Lyocell ist auf Grund der einzigartigen Kombination von Vorteilen ein attraktiver Rohstoff für die gesamte textile Kette. Die besonderen morphologischen Eigenschaften, allen voran der fibrilläre Charakter von Lyocellfasern gestattet die Entwicklung neuer, kreativer Griff/Optik - Varianten für hochmodische Textilien. Für den Endverbraucher bieten Artikel aus Lyocell neben diesen modischen Aspekten noch den Vorteil der ausgezeichneten Tragephysiologie der Cellulosefaser, Beständigkeit und Dauerhaftigkeit sowie gute Waschbarkeit. Auch die vergleichsweise gute Umweltverträglichkeit des Produktionsprozesses, die Verwendung eines nachwachsenden Rohstoffes und die biologische Abbaubarkeit der Faser werden für ein ständig wachsendes Segment von Konsumenten ein Argument sein, Textilien aus Lyocell zu kaufen.

In der textilen Veredelung ermöglicht die hohe Naßfestigkeit die Herstellung von Artikeln auf Cellulosefaserbasis, die bislang der Baumwolle vorbehalten waren, wie zum Beispiel Indigo gefärbte Jeansstoffe. Die gute Anfärbbarkeit von Lyocell und der geringe Schrumpf bei Naßbehandlungsschritten bedeuten für die textilen Veredelungsbetriebe ökonomische und ökologische Vorteile. Die hohe Faserfestigkeit führt zu hoher Produktivität in Spinnerei und Weberei.

Die Summe dieser Vorteile, die für alle Teilnehmer der „textilen Pipeline" vom Spinner bis zum Endverbraucher positive Aspekte beinhaltet, stimmen uns optimistisch, daß Lyocell als cellulosische Faser eine große Zukunft vor sich hat.

THE FORMATION AND STRUCTURE OF A NEW CELLULOSIC FIBRE

Hilda A. Coulsey and Steve B. Smith
Courtaulds Corporate Technology Coventry UK
Talk held at 34th IFC, Dornbirn 1995

In this paper some of the key features of the formation and structure of direct solvent spun cellulosic fibers will be discussed and compared to other related lyotropic rigid rod systems and polymer melts. A mechanism for the development of mechanical properties will be described. The resultant structural features that arise will be contrasted to other cellulosic fibres produced from traditional routes.

In dieser Arbeit werden einige der wesentlichen Merkmale der Bildung und Struktur von lösungsmittelgesponnen cellulosischen Fasern besprochen und mit verwandten lyotropischen starren-Stäbchen-Systemen und Polymerschmelzen verglichen. Ein Mechanismus für das Entstehen der mechanischen Eigenschaften wird beschrieben. Die entstehenden strukturellen Merkmale werden mit anderen nach traditionellen Verfahren hergestellten cellulosischen Fasern verglichen.

1. Introduction

The ability of amine oxides to directly solvate cellulose has been known for a number of decades, but the systematic development of a fibre spinning technology has only come about since the late 1970's[1].

Amine oxides allow the direct dissolution of cellulose. In comparison to the traditional viscose rayon route, the polymer remains underivatised, and it can be incorporated in solution at much higher concentration. Courtaulds' fibres spun from these solutions are known as Tencel®. Direct solvent-spun cellulose fibres are generically known as lyocell.

The process is unique in its ability to produce highly-oriented cellulose fibres in an environmentally benign manner. This arises from the use of a simple and clean solvent which can be almost

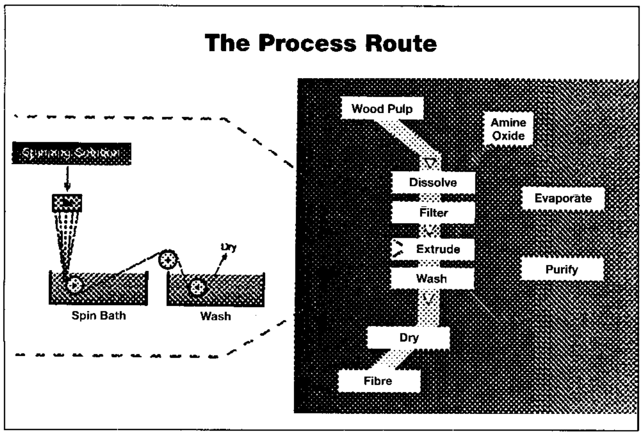

Fig. 1

quantitatively recycled, n-methyl morpholine oxide. Figure 1 schematically illustrates the process, highlighting this aspect.

Fibre structure is dominated by the pronounced microfibrillar character which exists over all length scales.

The fibre properties that are achievable lie at the upper end of cellulose-based textile products. In particular the retention of wet tenacity and modulus is exceptional, wet strength exceeding that of cotton. This gives opportunities for demanding processing routes, the generation of peach skin-like fabric handles and exploitation in industrial areas.

As a result of the "dry-jet/wet spinning" method, the Tencel spinning process shares a number of features with the extrusion of lyotropic rigid rod systems and polymer melts. In this paper some of the key features of formation will be discussed, and compared to these other related systems. A mechanism for the development of mechanical properties will be described. The resultant structural features that arise will be contrasted to other cellulosic fibres produced from traditional routes.

2. Fibre structure

2.1 Mechanical and structural features

At the whole-filament level, the most obvious difference between Tencel and viscose rayon is that Tencel has a regular circular cross section, with no surface crenulations.

Radial variations in the degree of crystallinity and orientation are seen in a number of fibres. Tencel, has not given any evidence for transverse variation in the values of principal refractive indices, or birefringence; see Figure 2 (to about 1μ resolution).

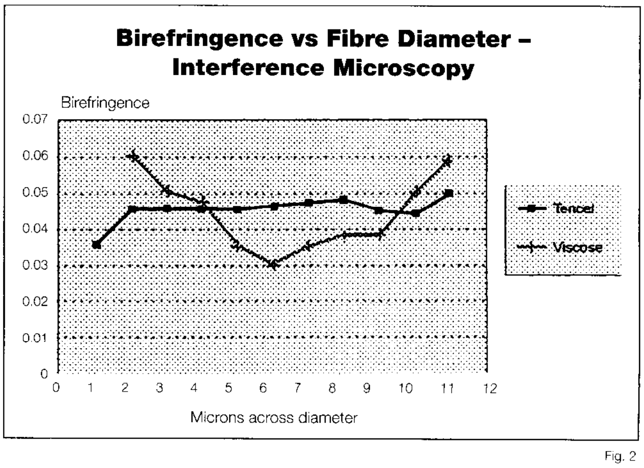

Fig. 2

By contrast, viscose rayon shows a well defined boundary, at a significant fraction of the diameter. Figures 3 and 4, are optical micrographs of dyed cross sections of both fibres. There is a good physical basis for a transition from a more crystalline and oriented exterior to a poorly-crystalline, disoriented, interior for viscose rayon[2].

Dyed Cross Section – Viscose Rayon

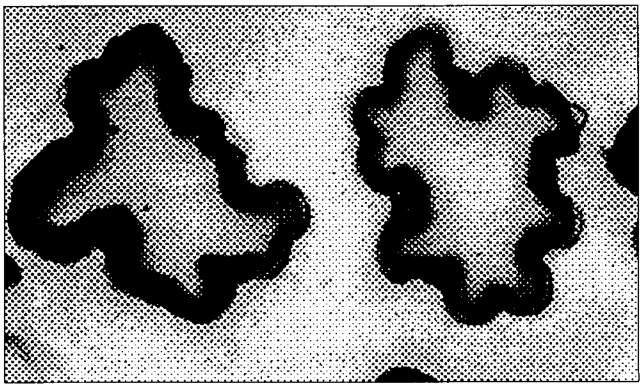

Fig. 3

Dyed Cross Section – Tencel

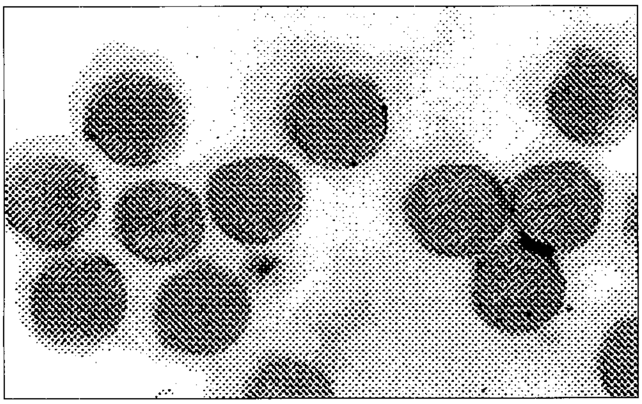

Fig. 4

The degree of crystallinity in Tencel is greater than staple rayon. Making a simple comparison, based on the ratio of sharp to diffuse intensity in the WAXD pattern from a disoriented fibre mat, gives the result that Tencel is ~60% crystalline, whilst high tenacity rayon is nearer 40%. Figures 5 and 6 show the diffractograms.

A Scherrer analysis of the WAXD pattern provides a value of 40Å, for the lateral dimension of the crystals. This is little different to that found in viscose rayon. By contrast, the meridional peaks tend to be very sharp in Tencel, showing that the crystals have higher aspect ratio than in viscose Rayon.

WAXD ... Tencel Mat

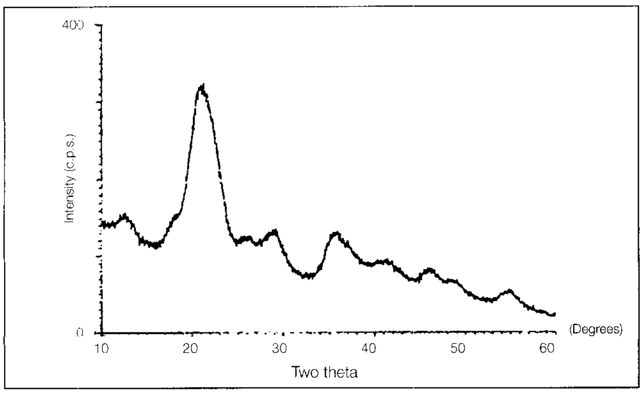

Fig. 5

WAXD ... Rayon Mat

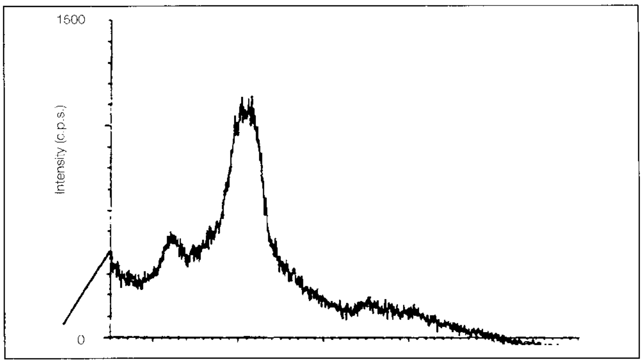

Fig. 6

2.2 Comparative cellulosics

Over the last 50 years the viscose rayon process has been skilfully developed to produce families of products which display a range of mechanical properties[3].

Some key points are worth reiterating:

- High levels of orientation are associated with high tensile strength.
- Modulus, especially in the wet state, is highly responsive to the retention of high molecular weight, and the development of high crystallinity.
- The coupling of BOTH of the above factors is key to the achievement of high property retention in the wet state. High orientation in its own right does not necessarily confer high wet stability.

The above points can be illustrated by reference to the mechanical properties and crystallinity/orientation of Tencel as compared to a tyre-cord and a polynosic textile fibre with similar levels of dry tenacity (see Table 1).

Comparative Properties of Cellulosic Fibres

Fibre	Tenacity (cN/tex)		Initial Modulus (cN/tex)		Extension (%)		f (x)	$f_{(tot)}$
	Dry	Wet	Dry	Wet	Dry	Wet		
Tencel	42	38	1300	270	11	13	0.96	0.88
Tenasco	42	30	880	80	16	20	0.94	0.70
Tufcel Polynosic	40	32	1000	200	14	18	0.94	0.81

(Courtaulds' measurements)

Table 1

In the last four decades, a number of approaches have achieved very high dry-state properties from viscose routes, and a common feature is the achievement of high levels of crystalline orientation. However, despite similar crystalline orientation factors, it is clear that contributions from less ordered components must exercise major control, in particular over wet-state properties.

A number of cellulosics have approached the dry state properties of Tencel, but the industry has found it difficult to translate these gains into very high wet tenacity and modulus. When this has been most successful, it has required the use of environmentally unfriendly processing aids, that are characteristic of all viscose-based processes. The combination of wet-state property retention and fibrillability is key to the unique fabric aesthetics that Tencel® makes possible.

2.3 Natural long fibres and secondary structure

Cotton dominates the world usage of cellulosic fibres, but is not an appropriate comparative model in view of its relatively low overall orientation, although in gross mechanical respects it resembles Tencel. The bast fibres, eg. jute, flax and ramie, display a number of characteristics which are distinctly different to anything which has been achieved in manmade Cellulosics. In particular they have discrete layer structures, but their orientation is not very much higher than Tencel.

In some cases with a degree of independence from their orientation distribution, man-made fibres can acquire secondary structure, by a number of mechanisms, eg. Dobb's elucidation of the pleated sheet morphology of Kevlar[4], Hermans[5] description of lateral order variations in rayons with the same degree of crystallinity and Turek and Simon's[6] demonstration of flow patterns in extrusion, and their effects on LCP systems. In general this ordering will not approach the scale and complexity of natural fibres.

Nevertheless the ability of the NMMO system to dissolve cellulose which is little different in chain length to that found in nature, allows us to spin highly-oriented fibres with potential to produce properties which have traditionally been associated only with natural fibres. Table 2 shows the consequences of doing this.

Comparative Properties of Cellulosic Fibres

Fibre	Tenacity (cN/tex)		Initial Modulus (cN/tex)		Extension (%)		f (x)	$f_{(tot)}$
	Dry	Wet	Dry	Wet	Dry	Wet		
Ramie	82	74	2000	1300	4.5	5	0.98	
Cordenka	64	52	1900	850	5.5	6	0.97	0.92
Experimental Lyocell	61	58	1950	490	8.0	9	0.94	0.90

(Courtaulds' measurements) Table 2

2.4 Larger scale solid/void structure in cellulosics

In the bone-dry state there is often very little evidence for the presence of discrete porosity in cellulosic materials. Comparative crystal vs bulk densities suggest only ~ 2% voidage[7]. However all Cellulose fibres show a pronounced degree of swelling in aqueous media, and Tencel is no exception. The largest swell occurs laterally.

The simplest model is that the fibres have a degree of porosity which can open and close smoothly as it accepts and rejects water. There is no conclusive evidence from WAXD or NMR for water to penetrate the crystals in cellulose[7]. Tencel conforms to this view.

In the dry state the SAXS scatter is a very weak streak pattern. The high degree of anisotropy is clear, but there is little evidence for significant porosity. When the fibre is wetted the pattern changes completely, to produce a strong intensity maximum on a Bragg spacing of ~ 75 Å, see Figures 7, 8, 9 and 10.

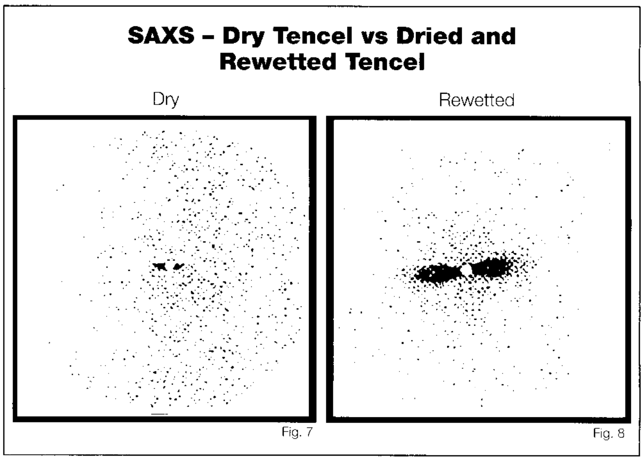

Fig. 7 Fig. 8

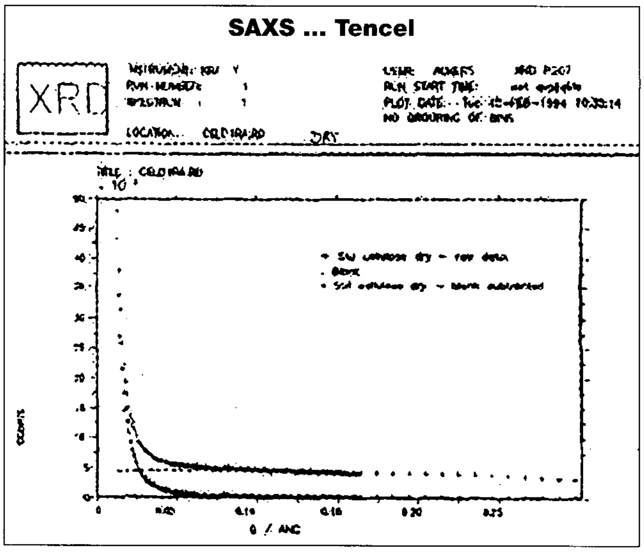

Fig. 9

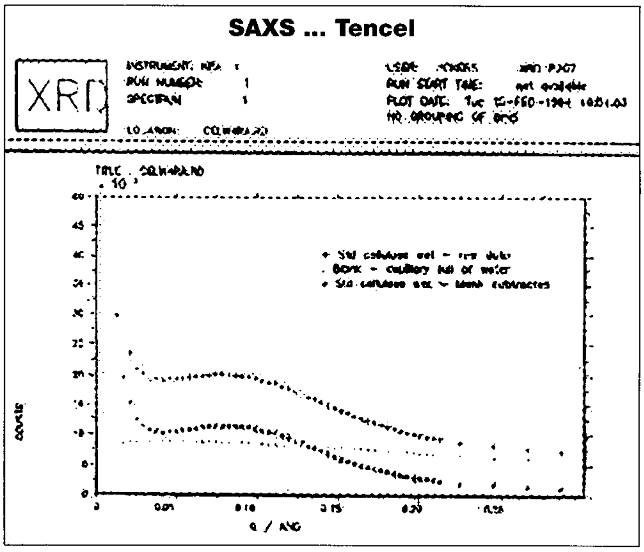

Fig. 10

A lateral interference peak is not unique to Tencel; it was noted first in the 1950's when a very wide variety of rayon-based routes were under investigation[8]. The degree to which cellulosic fibres show this distinct wet-state behaviour is widely variable, although the more highly-oriented fibres were found to be more likely to do so, Figure 11.

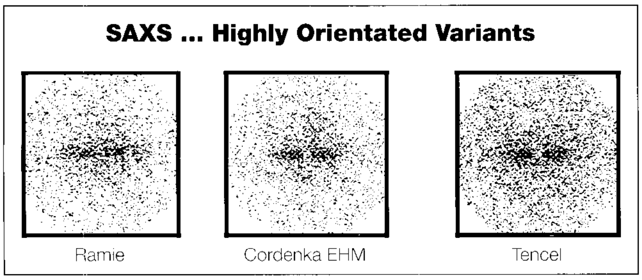

Fig. 11

The existence of weak meridional scattering maxima, or "long periods" in cellulosic fibres has been reported by a number of workers. They have often been used to support a series crystallite/amorphous descripbon of behaviour[9], for example. Tencel gives no evidence for such behaviour, and is probably best considered as paracrystalline[10].

Split Kevlar Filament

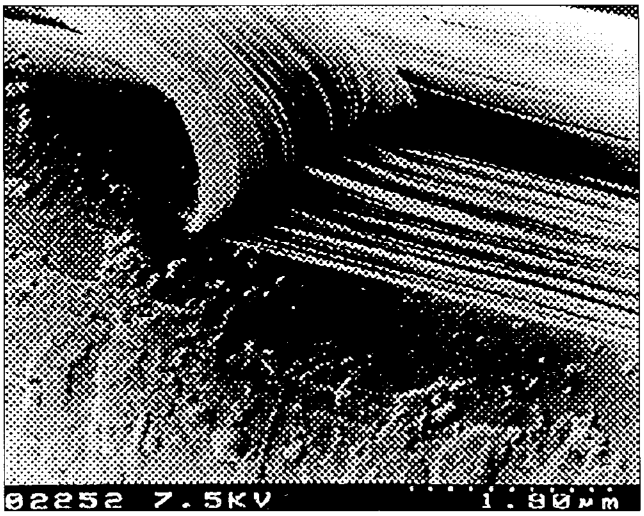

Fig. 14

Split Tencel Filament

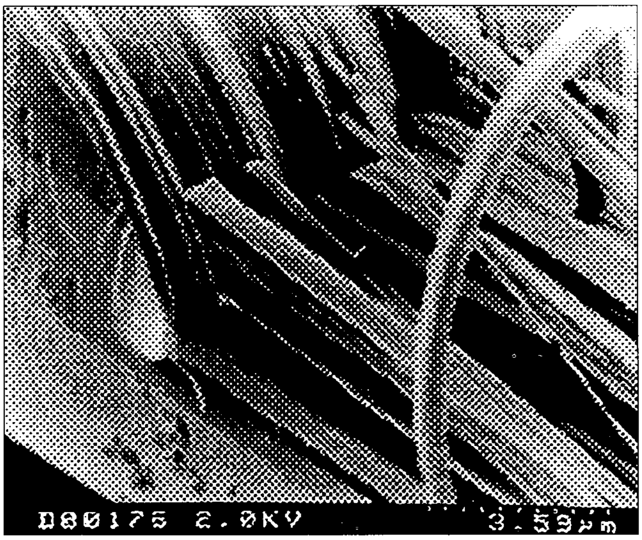

Fig. 12

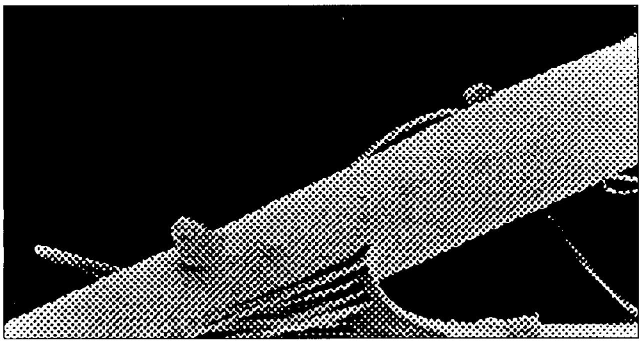

Fig. 13

What is not in doubt is the high axial continuity in Tencel, as evidenced by the WAXD and SAXS patterns. The ability to propagate effectively infinite splits in torn fibres also argues for extreme continuity. These tearing fronts pass smoothly along many 1000's of crystallites, with no lateral deviation. Figures 12 and 13 are split Tencel fibres and a comparison with Kevlar, Figure 14.

2.5 Observations on conditioned and wet modulus values

The magnitude of wet modulus reduction may be expected to depend on how the initial crystallite orientation distribution, and aspect ratio behave as the material wet swells in water.

Wet-modulus trends are seen, in moving from ultra-highly oriented Cordenka EHM, with larger crystals than Tencel, through Tencel itself, to Tenasco tyre cord.

Ultra highly-oriented crystallites will show only a small rotational component upon tensile loading; most of the load is taken in axial extension. Hence in the swollen state, any additional lateral compliance does not have a large effect. Large crystals, and low lateral swelling, will also reduce the change in lateral compliance on swelling. The modulus of Cordenka EHM falls by a 2:1 ratio.

At the other extreme, low orientation involves a dominant effect of rotation. In systems which also have high wet swelling, we expect that this combination will lead to major stiffness changes, dry to wet. Such a picture applies to rayon staple. Additionally, with poor crystallinity, ie. a high proportion of defect domains, we expect severe axial disturbances as water interrupts continuity along the axis. The modulus falls by as much as 15:1, dry- wet.

Similarly, whilst Tenasco has highly-oriented crystallites, and good dry properties, they must exist in series with a proportion of defect domains, which may be similar to viscose staple. We can infer this from its similarly high degree of axial swelling, and wet modulus therefore falls almost as much, at ~ 11:1.

Well-oriented Tencel nearly achieves the orientation found in Cordenka, but has apparently a significantly-higher porosity. Swelling is ~70% by volume, as compared to ~45% in Cordenka EHM. With very little length increase, wet-state behaviour may be expected to be dominated by the change in lateral compliance. Practically a 4:1 reduction in modulus occurs. However, strength retention is excellent, indicating that little disturbance occurs along the axis, and any chains which are in defect domains are well oriented.

2.6 Discussion on structure

The major structural features of Tencel that bear on performance and applications are:

- High crystallinity and orientation.
- Laterally periodic crystallite/void structure in the wet state.
- Exceptional retention of tenacity in the wet state.
- Good retention of modulus in the wet state.
- Large degree of lateral swelling in the wet state, despite the high crystallinity.
- Little length increase in the wet state.
- Highly fibrillar filament-tearing surfaces and wet state fibrillability.

3. Fibre formation

To understand the origins of fibre microstructure it is helpful to consider the ways that fibres can be formed from polymer solutions.

The formation of oriented fibres, by wet spinning, from polymer solutions, involves two major processes:

(i) The alignment of the molecules in the direction of the fibre axis, (note at this stage we do not discuss the degree of chain extension).

(ii) A solvent/non-solvent exchange, leading to desolvation of the polymer, and recovery of the solid-state material in fibrous form.

The two processes are not always employed in the sequence described. Examples where orientation comes first are aramids and Tencel. An example where desolvation precedes orientation is in wet-spun acrylics.

Some processes in fact have a degree of concerted orientation and desolvation, and all of the viscose rayon-based processes are in this category. Here the solvation is modified in the coagulation bath, to give an intermediate gel state at the same time as extensional strain is applied to orient it, eg. the Viscose process. Figure 15 illustrates the (conceptual!) differences in the processes.

Tencel has developed with a true solution-state draw, based on the highly viscous characteristics of the solutions. Relaxation times are manipulated by reducing the solution temperature as practised in melt-spinning.

4. Formation processes in tencel

4.1 General features of solutions of cellulose in NMMO hydrates

Ternary solutions of cellulose and n-methylmorpholine oxide, and water can be formed at elevated temperature. Typical extrudable compositions at 90 to 120°C would be 10-20% cellulose, 5 - 12% water and 75 - 80% NMMO. Molecular weight of the cellulose has a major effect in determining the precise composition selected.

Dry-jet/wet spinning is a preferred spinning route, since the elevated temperature of the polymer solution is incompatible with lower-temperature aqueous spin baths. Moreover, the temperature/viscosity characteristics of the dopes are ideally suited to sustaining elongational strains in a cooling regime.

It has been shown that the thermal behaviour of ternary compositions is mainly determined by the NMMO/water ratio[11]. The ternary phase diagram for moderate- d.p solutions first formed at about 100°, shows that there is a narrow solution region, bounded on one side by a crystalline NMMO phase, and on the other by the binodal for liquid/liquid phase separation[12], Figure 16.

The lower temperature equilibrium behaviour of these solutions is as expected dominated by the presence of the crystallisable major component - NMMO. Given that this is so, it may be

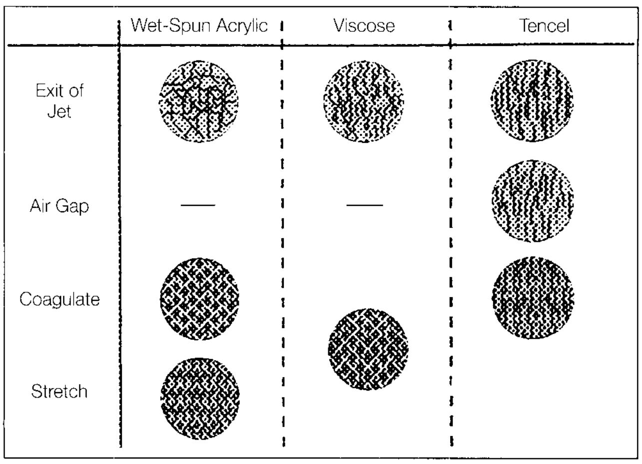

Fig. 15

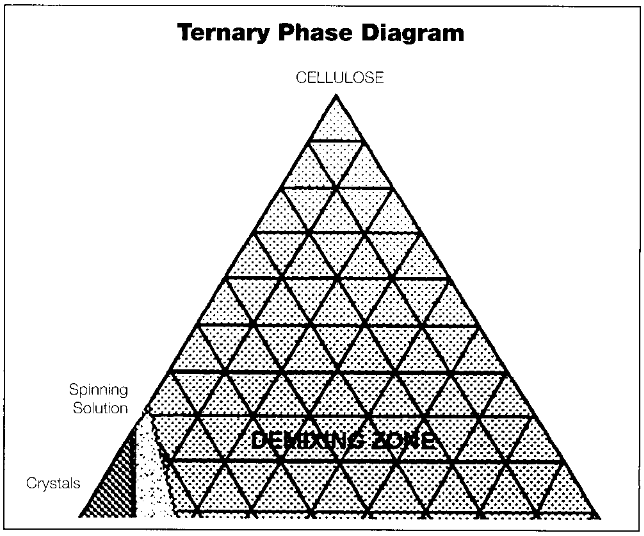

Fig. 16

expected that in a cooling regime NMMO would crystallise and drive cellulose out of solution. In this case we may expect that the bulk morphology would be controlled by primary NMMO crystals. It is perhaps fortunate that this is a long-timescale event, otherwise the formation of homogeneous oriented fibres would probably be impossible.

In fact no NMMO crystallisation has been observed in the lifetime of a spinline.

The character of the dope in the spinline is as a supercooled solution with respect to the crystallisation of NMMO.

4.2 The development of mechanical properties in the spinline

In common with melt systems, the key features that determine spinning behaviour and property development are:

- The degree to which the spinning solution can initially develop orientation, and maintain it as a function of applied strains and cooling regimes.
- Any ordering process that can occur in the solution state.

In this system, as for aramids, there is also an important additional process to consider:

- Recovery of solid structure by nonsolvent-induced phase separation.

4.2.1 Flow-induced Orientation

If undrawn material is coagulated it displays low orientation, hence the anisotropy in the final fibres is mostly induced in the airgap. Contrast this with liquid crystalline systems which can in principle leave the die with persistent high levels of order and orientation built in.

The airgap environment is characterised by elongational flow, in a cooling regime. Flow birefringence studies demonstrate that very low strain rates are adequate to achieve high orientation, as temperature falls from > 100° to < 50°. Figure 17 shows the results.

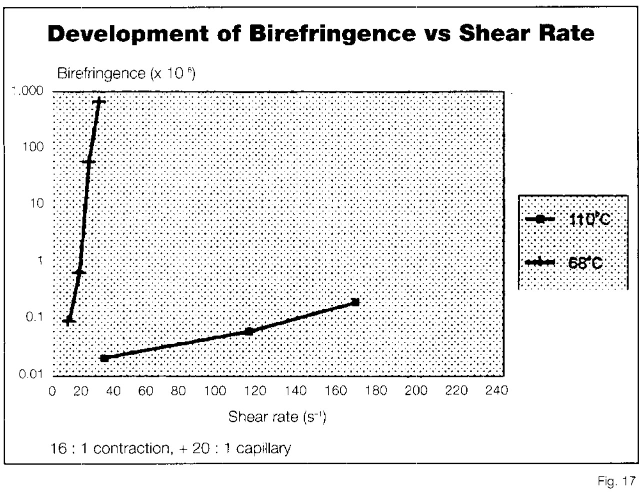

Fig. 17

From flow studies we can also say something about the magnitude of the operative relaxation times, by the simple expedient of assessing whether orientation can be either induced or can decay in particular timescales.

4.2.2 Flow-induced Ordering

Compelling evidence for some form of transition to liquid crystalline behaviour has been discussed by Navard[13] and Chanzy[14]. Navard has found discontinuities in curves of capillary viscosity vs temperature; at temperatures of about 90° C, for a range of shear rates. Navard also sees a change in die swell vs shearrate behaviour, at a similar temperature. Kogan[15] also noted rheological changes at a similar temperature. Navard operated at 25%, and found that the critical concentration for mesophase formation was between 20% and 24%. The formation of an ordered phase in these solutions does not seem to involve the magnitude of viscosity reduction, seen in many lyotropic liquid crystals, from more obviously rigid molecules. At 25% concentration, handling and preparing the solutions commercially tends to be impractical. In general therefore commercial processes will operate at sub-critical concentrations for mesophase formation. Birefringence behaviour which is subjectively similar to Tencel has been seen in solutions of rigid rod polymers. Picken[16] shows that in an, initially, isotropic PpPTA/sulphuric acid system, an ordering process sets in steeply at ~40, which can be deduced from a step-up in the birefringence/temperature curves at low shear rates. The Tencel flow birefringence measurements certainly show a major behavioral difference over the same range of temperature as Navard suggests. However, we can qualitatively predict such behaviour from theories of chain dynamics, without invoking ordered-phase formation[17].

At this time it is concluded that the solution increases its relaxation time by a large amount over a small temperature interval, during which it acquires high levels of orientation. It then retains this orientation persistently. Effectively the solution has high induced anisotropy. However, it is not clear whether the chains are fully extended or whether a model of hinged oriented segments is most appropriate.

5. Spinning studies

5.1 The development of mechanical properties as a function of spinning variables

The relationship between applied strain and mechanical properties achieved has been explored, under conditions of forced convective cooling. Fibres were spun at a range of draw down ratios (DDR's).

(Note that the DDR is expressed as the ratio of velocities of the take-up roller to that in the extrusion die; Vt/Vo. This is common in the literature. However, given that even under draw, some "residual" die swell remains, the effective strain in the airgap is somewhat higher than Vt/Vo as-calculated. The major effect is seen at low-draw strain values, since it is here that residual die swell is largest. It causes little discrepancy at higher strains, since the die swell is largely „pulled out". This point is often neglected in discussions of spinline dynamics.)

Figures **18,** 19 and 20 show tenacity, initial modulus and extension-at-break respectively, as a function of DDR

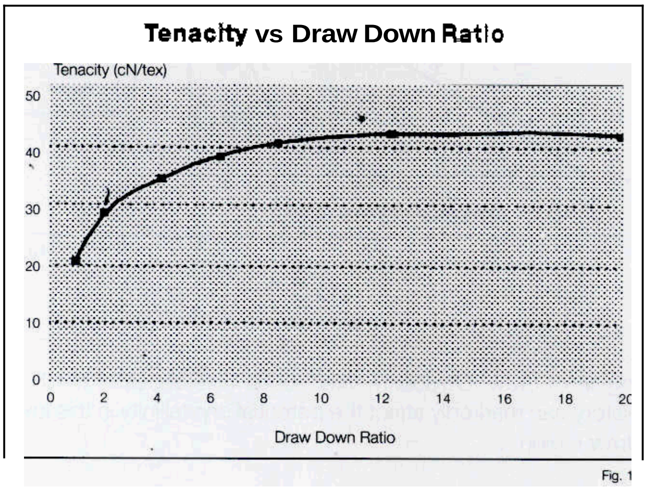

Fig. 1

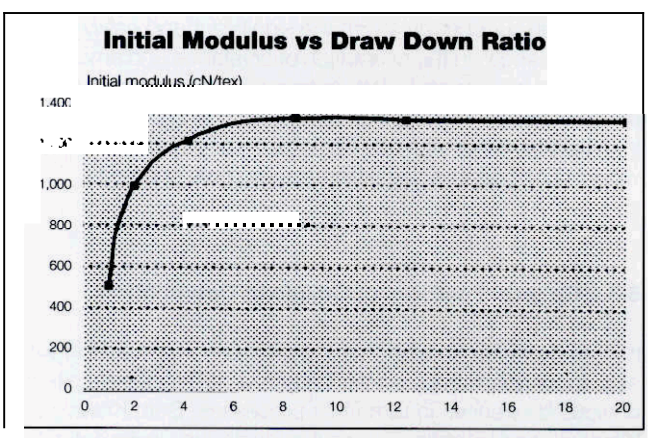

Fig. 19

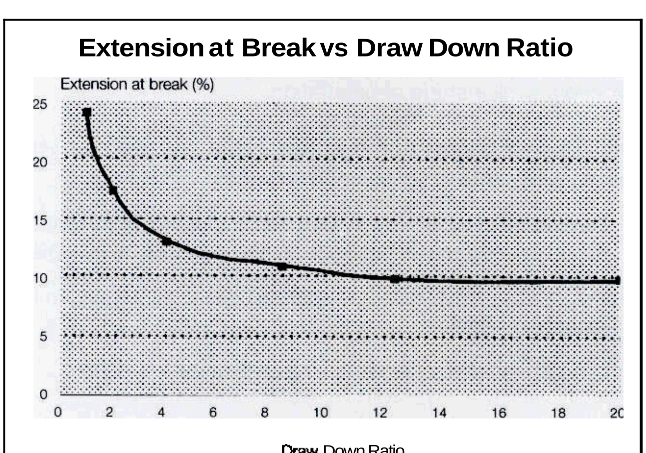

Fig. 2

5.2 The dependence of the observed mechanical properties on orientation and crystallinity

Crystalline orientation has been calculated from azimuthal *scans* on the major 002/101 bar reflection at -21". Figure 21 shows calculated crystalline Orientation functions, f(x), for the range of DDR's. Full width at half-maximum, FWHM, values have also been plotted against DDR in Figure 22, since f(x) values tend to be very close together for much of the range .

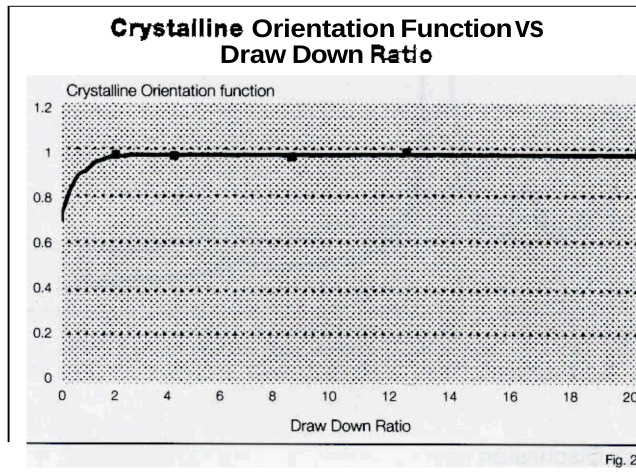

Fig. 21

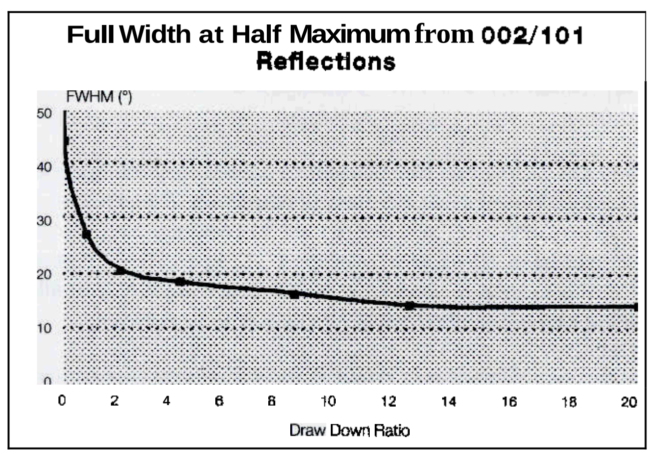

Fig. 22

To estimate total orientation we have employed the sonic modulus approach[18]. The plot of total orientation vs DDR is shown in Figure 23.

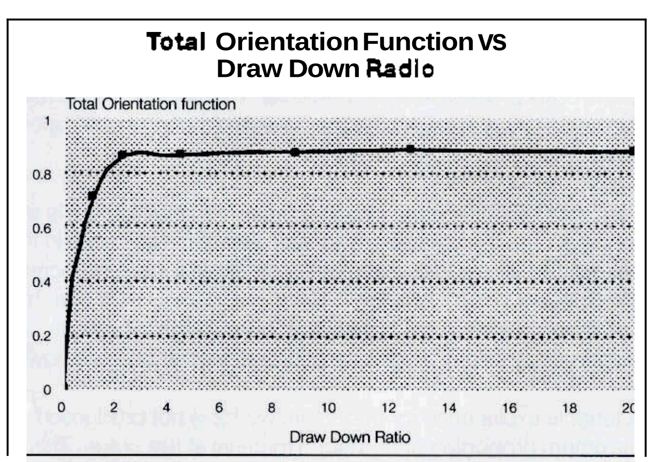

Fig. 2

WAXD equatorial scans were compared according to the ratios of sharp to diffuse intensity. Crystallinity comparisons are shown for four cases in Figure 24. These are undrawn, DDR = 1, and DDR = 2, DDR = 12 respectively.

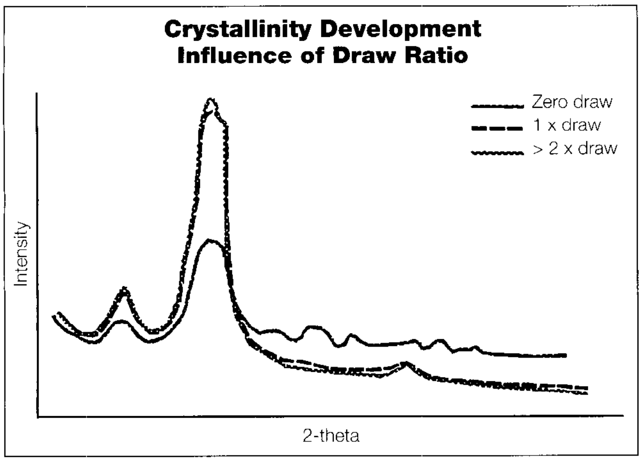

Fig. 24

5.3 Discussion

There is a rapid approach to the maximum degree of crystallinity, and within the limits of measurement, it has effectively saturated at DDR's of only ~1. This insensitivity of crystallinity to DDR over much of the working range is a feature of Tencel spinning.

Very low DDR's can be sufficient to achieve a close approach to saturation values in mechanical properties. These figures, ie. DDR's of only 4-6, are in contrast to melt spinning, but are close to reported values in lyotropic LC's, eg. PpPTA[19]. It seems that this system is showing a much closer approach to affine deformation than the melt spinning of flexible polymers.

At the very beginning of drawing, there is a positive increase in crystallinity, only up to DDR ~1. Beyond this there is, as we have seen, little detectable association of DDR and crystallinity. In Region 2, crystallinity is apparently little changed, but orientation increases.

5.3.1 A Mechanism for Deformation

By plotting the two orientation functions, ie 'crystalline' and 'total' against each other, it is possible to examine some features of the draw process itself. In particular, we can assess the relative importance of improving the so-called "amorphous" orientation. Figure 25 shows f(x) vs f(tot).

Perhaps one of the more important features of behaviour is the way that both the crystalline and total orientation functions in the coagulated fibres, track each other, as draw down ratio increases above a value of about 1. By strong contrast we see that before this we have the potential to build a high crystalline orientation, say at a DDR of 1, whilst total orientation is still low.

A tenable explanation for this is that we have not produced the maximum proportion of crystalline material at this stage. This is supported by the rapid rate of change of crystallinity in this

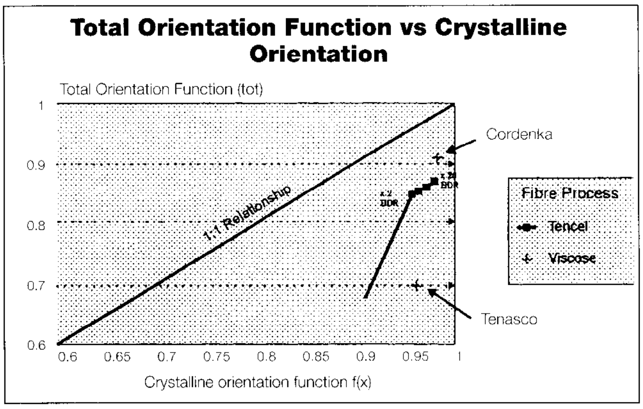

Fig. 25

region of draw. Obviously, very subtle differences in the flow history can markedly affect the potential crystallinity in this low-draw region.

As Figure 24 shows, WAXD from a zero-draw fibre reveals ~20% crystallinity. Applying DDR's of > 1 we apparently go straight to the maximum crystallinity state of (~60% after coagulation), and further orientation operates on the material as a single entity.

This behaviour contrasts with the significant and easily discernible differences in the orientation of crystalline and amorphous regions in high speed melt spinning[20]. Here distinct second phase behaviour has been deconvoluted during draw. Behaviour in melts may reflect the addition of amorphous chains into growing crystals as they are progressively more oriented.

5.3.2 General Features of Cellulose Coagulation

It is perhaps remarkable that the viscose rayon-based routes also show qualitatively similar behaviour to Tencel, despite the obvious differences in formation processes. Both Krassig and Kitchen[21] and Hermans[22] have demonstrated similar saturation of crystallinity once a certain level of orientation has been exceeded, in tyre-cord routes. Generally it appears that once we make a significant departure from the isotropic state, orientation becomes largely independent of crystallinity in cellulose fibres. This may be considered as somewhat indicative of rigid-chain behaviour. The actual level of crystallinity is widely different between processes however. For each kind of process, a characteristic % crystallinity is being developed, as the chains exceed a similar stage of orientation.

The different degrees of crystallinity that are built are listed below, with some indication of the process differences.

- Traditional viscose rayon process including high-tenacity products (concerted desolvation and orientation) - ~40%.
- Polynosic, HWM, (strongly retarded desolvation prior to orientation) - 55%.
- Lyocell - no desolvation prior to orientation - > 60%.

It is tempting to assume that the degree of crystallinity simply follows the amount of chain orientation that is achieved prior to complete desolvation. This can be shown to be only partly true.

Tencel offers a unique opportunity to coagulate highly-oriented molecules in radically different media. This is unavailable in the traditional routes, where there is more interdependency of potential orientation and spinbath chemistry. If we do this we see that the 60% crystallinity figure is not specific to the order of orientation - desolvation.

Coagulation in methanol produces largely amorphous material from disoriented solution, and only ~40% crystallinity from fully-oriented solution[23]. Apparently the drive to crystallisation in the water/NMMO exchange, is strong enough to override some degree of mutual disorientation, so that ~20% crystallinity is built. Since random orientation exists in both cases, water must facilitate a specific interaction, allowing some 3d Cellulose II crystallinity to develop.

We speculate that the degree of crystallinity, at any given level of chain orientation may be primarily controlled by the solvent/non-solvent interaction parameter, g_{12}. For highly polar interacting species this is very favourable[24], indicating that there is a strong drive to remove solvent/polymer interactions and replace them with solvent/nonsolvent ones. Under these circumstances the highest crystallinity is developed. As g_{12} becomes less favourable, then the desolvation is less well-defined. Whether this equates to increased chain mobility during crystallisation, or whether the more polar species actively facilitate the polymer/polymer association, is unknown. In any event, a sharp phase transition, from chain-extended polymer is qualitatively what would be expected for high crystallinity. Section 7 enlarges on these points.

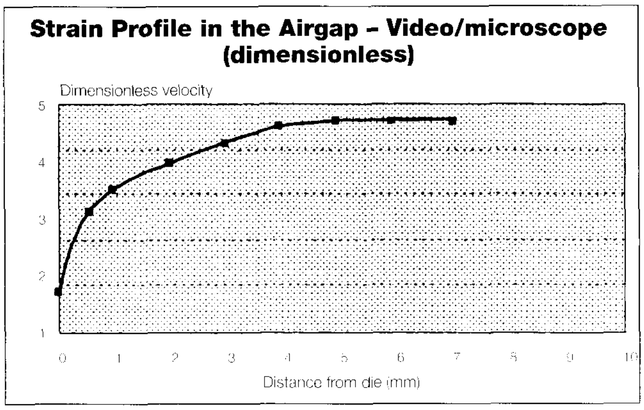

Fig. 27

Temperature and strain profiles are shown in Figures 26 and 27. It is clear that the filament cools rapidly to ambient temperature. In melt spinning terms, the stream deformation is concentrated within a very short distance of the die.

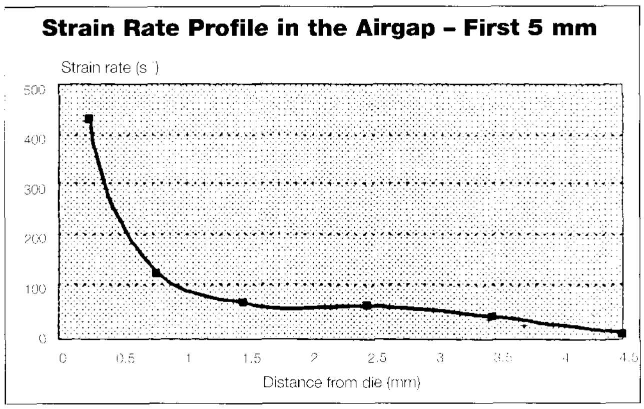

Fig. 28

6. Integration of flow orientation studies and observed spinning behavoir

6.1 Examination of the airgap dynamics

The analysis of the dynamics of a single filament in the airgap follows melt-spinning practice. The measurable variables are temperature, diameter, and spinline tension, for a range of DDR's.

From these we can calculate strain, strain rate, and elongational viscosity, as a function of distance from the die, or time in the airgap.

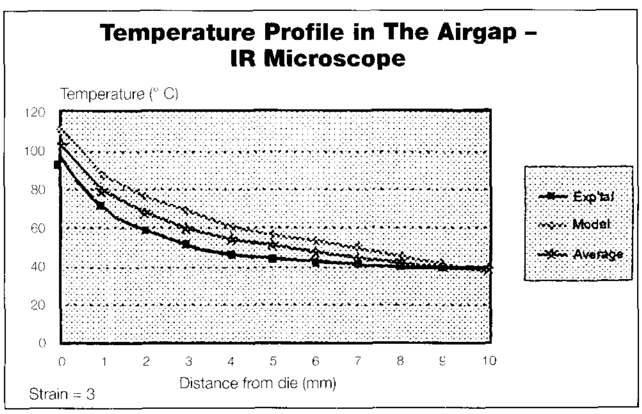

Fig. 26

Figure 28 shows the operative strainrate as a function of distance from the jet. Using filament tensions, and diameter profiles, we can calculate a stress profile along the filament. The elongational viscosity, profile can then be calculated from the relationships cited by Kiang and Cuculo[25].

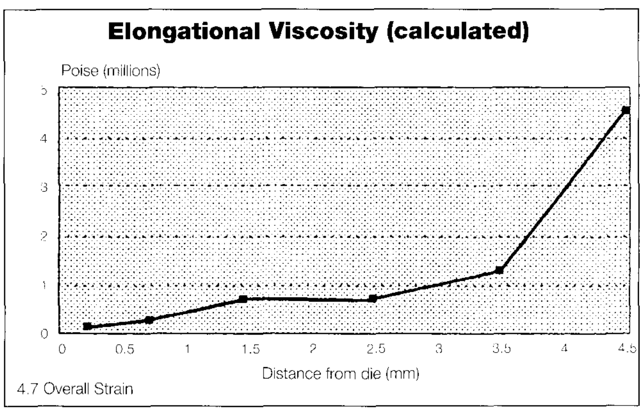

Fig. 29

Elongational viscosity shows the expected rapid rise, as temperature falls along the spinline, Figure 29.

As temperature reduces in the presence of a strong elongational flow, a point is reached when solvent viscosity rises, chain/solvent friction increases, thermal motion reduces, and the chains begin to respond to the flow.

7. Phase separation in the spin bath – recovery of solid structure

We now discuss the consequences of taking the oriented supercooled pre-coagulated filament, and recovering cellulose by nonsolvent-induced phase separation. We propose that the solution at the end of the airgap is effectively a persistent, oriented, monodomain.

It is believed that Tencel desolvates in a simple manner, following well-established principles of solution phase behaviour, illustrated in Figure 30[26]. The oriented supercooled solution enters the coagulation bath from the airgap with its initial composition, a. The filament swells by a small amount within 100's of msecs, indicating that the exchange process is modestly biased towards non-solvent entry. The solvent/polymer associations are broken, and the oriented cellulose molecules interact with themselves, to form solid domains.

Phase Separation in the Spinbath

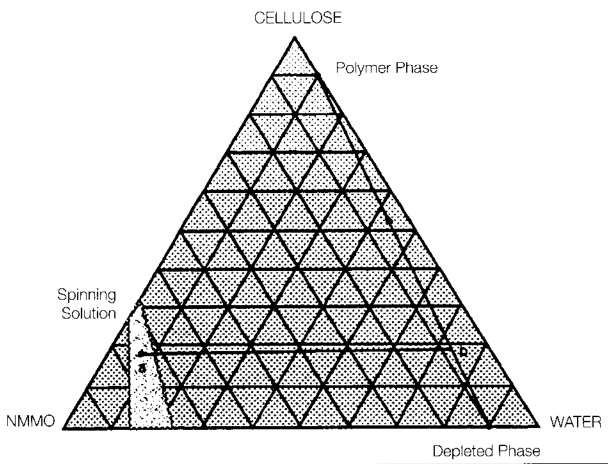

Fig. 30

Experimental data for Tencel shows that the composition moves from a to b in 50 msecs.

Dube and Blackwell[23] also reported compositions in this region of the phase diagram in 150 msecs. Point b is deep inside the demixing region, and is achieved in a very short time, (orders of magnitude faster than the polymer relaxation time to lose orientation). Hence all of the induced airgap orientation remains in place. The consequence of arriving at this bulk composition is that the solution separates into polymer-rich and polymer-depleted regions.

The compositions of these regions are determined by the relevant tie line. We show the polymer rich region as pure cellulose, which is qualitatively likely at this depth in the composition space. The depleted region will inevitably contain no polymer at this depth in the demixing zone[24].

The polymer-rich regions are created in the form of laterally interconnected lamellae, whilst the depleted regions form needle-like liquid filled voids, Figure 31. Both solid and void phases are bicontinuous. The structure is transversally isotropic. Whether crystallisation is consecutive to l/l phase separation, or concerted with it, may never be known, in any event it does not affect the operation of the process in terms of regenerating crystalline Cellulose II. The practical result is almost immediate crystallisation of the polymer-rich regions, as the concentration of water in the solvent/non-solvent mixture increases. We have noted the lack of the 101 reflection in WAXD, until drying - but the material has reached an equilibrium condition in terms of its ability to crystallise.

Coagulation of Tencel Solutions

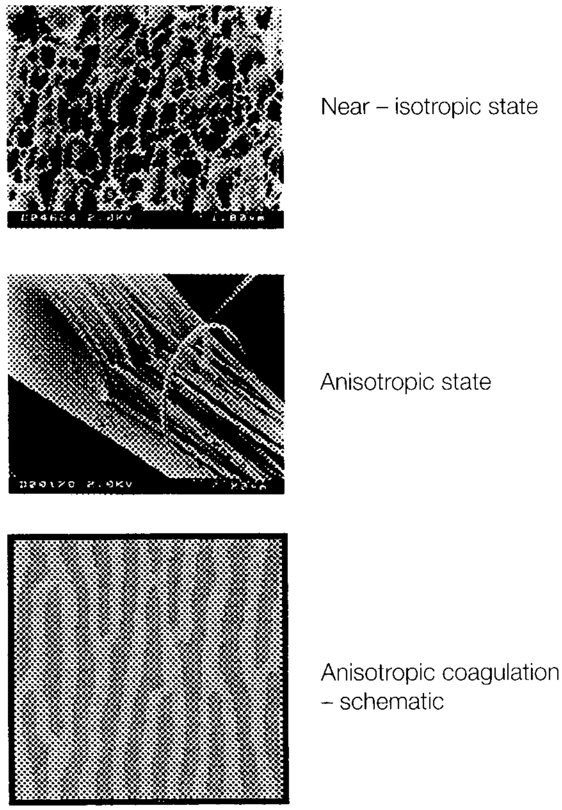

Fig. 31

The SAXS evidence for lateral periodicity is a strong pointer to a spinodal decomposition mechanism. Cohen and Thomas[27] have described such a separation for the lyotropic rigid rod PBZT system.

Due to the extremely high chain orientation, and the strongly interactive solvent/nonsolvent exchange, the morphology of the polymer-rich regions is created without a discernable amorphous component (See Section 5.3.1). The amorphous components of ~40%, is entirely explicable in terms of the surface area of the long, thin crystallites.

Figure 32 illustrates a proposed scheme.

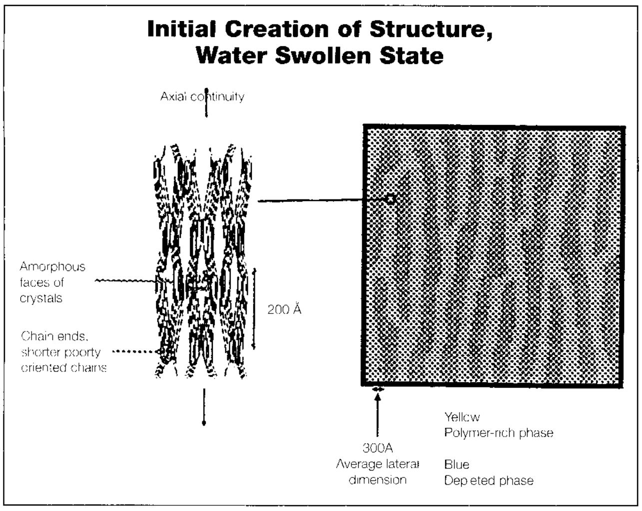

Fig. 32

7.1 Contrast with other wet spinning systems

This coincident development of an oriented, and crystalline, solid phase is in marked contrast to other wet-spinning systems, eg. acrylics and viscose rayon. Here the short relaxation time of the spinning solutions leaves little or no imposed orientation as the filament exits the die and begins to coagulate. As a result, the first-formed structure is isotropic, and crystallinity and orientation must be developed by subsequent drawing of the solid/void network.

In rayon the processes are more complex. The formation processes involve a number of chemical and physical transformations, which occur both consecutively and concertedly.

Of major importance is the chemical transformation of the monovalent sodium cellulose xanthate to divalent zinc cellulose xanthate. This proceeds from the surface of the filament, at the same time as the solvent quality is being modified by the reduction of pH, and elongation is applied.

McGarry and Priest[2] discuss the potential explanations for skin/core development.

8. Conclusions

The structure of Tencel has been contrasted to some other cellulose fibres, both natural and man-made. The key features of formation have been examined, and a semi-quantitative model for deformation, property development, and structure has been deduced.

There are outstanding problems, in gaining a precise understanding of the nature of the ordering in fibres spun from this direct solvent system. Many features are similar to lyotropic liquid crystalline systems. Although the modulus is far below theoretical values in the standard textile product, it can be made to approach values seen in ramie when fibres are spun from high m.wt cellulose. The degree of chain extension remains the most problematic issue. It is recognised that far more quantitative work is required.

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MARKETING OF NEWCELL® FILAMENT YARNS

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Talk held at 34th IFC, Dornbirn 1995

By starting the NewCell® project in 1992 and giving the approval to build a pilot plant in Obernburg/D., AKZO NOBEL expressed its strong desire to maintain its leading position as the world's largest producer of cellulosic filament yarns and its strong belief in the potential of the environmentally friendly production technology of the NMMO-process. This article deals with the marketing approaches to translate the advantages NewCell® offers into the language of the consumer.

Mit dem Beginn des NewCell®-Projektes 1992 und der Zustimmung zum Bau einer Pilotanlage in Obernburg/D. hat AKZO NOBEL den Willen zur Beibehaltung der Marktführerschaft als der größte Produzent von cellulosischen Filamentgarnen sowie den Glauben an das Potential der umweltfreundlichen Produktionstechnologie des NMMO-Verfahrens ausgedrückt. Dieser Beitrag behandelt die Marketing-Ansätze zur Übertragung der Vorteile von NewCell® in die Sprache der Konsumenten.

1. History and Background

For almost 20 years now AKZO NOBEL has been dealing with basic research on solvent spinning technology based on the NMMO-process. 20 years? This sounds like half an eternity in the fast moving textile world. One might think: Why didn't AKZO NOBEL speed up the development and go to market earlier? The answer to this is „timing". We believe that every time has its fibre (liked most) and every fibre has its own timing. Time is now mature for NewCell®.

After developing the staple fibre product using this new process, Central Research switched over to the filament version after the divestment of our viscose staple activities in 1983. Since then the development work within AKZO NOBEL has concentrated on filament yarn for textile and semi-technical enduses under the name of NewCell®.

By starting the NewCell® project in 1992 and giving the approval to build a pilot plant in Obernburg/D, AKZO NOBEL expressed its strong desire to maintain its leading position as the world's largest producer of cellulosic filament yarns, wellknown under the brand name of ENKA® VISCOSE, and its strong belief in the potential of this environmentally friendly production technology. After having suffered from a certain decline in the seventies, cellulosic yarns and fibres have experienced an increasing demand since the middle of the 1980s as consumers associate them with other textile raw materials of natural origin such as wool, cotton or silk. If the seventies were the decade of synthetics and the eighties saw a revival of the yarns of natural origin, we are witnessing in the nineties a peaceful coexistence of natural and man-made fibres. Anything in blends and combinations is allowed as long as it serves the market demand for novelties and meets certain environmental standards. Nevertheless as the last cotton shortage proved, in the long run there will not be enough supply to satisfy the world's growing demand for natural fibres and yarns. We cannot convert all the soil to raise sheep and silkworms or to grow cotton. We will need the available land to grow enough food for the world's increasing population.

So we have every reason to assume that the next decade will become the period of „man-made fibres of natural origin", very well represented by cellulosics produced by the NMMO process using dissolving wood pulp as raw material.

Consequently, a cellulosic filament yarn with improved properties compared to existing ones such as viscose rayon, cuprammonium or even acetate, produced by an environmentally friendly process like the NMMO technology should have a great market potential, especially in times when worldwide production capacities in cellulosics have continuously been declining for decades (one of the reasons being stricter environmental legislation) and market demand is growing. Moreover, NewCell®, the first lyocell filament yarn, should be the logical complement to the spun yarns produced from Tencel staple fibre or shortly Lenzing Lyocell.

The problem is to translate the advantages NewCell® offers and which the experts in the textile pipeline easily recognize, into the language of the consumer. This is the task of Marketing.

2. Internal Research and Development

Launching a new generation of cellulosic filament yarns like NewCell®, which is so much different from existing yarns, demands certain preparations in development and marketing. At AKZO NOBEL we distinguish internal development, market (external) development and marketing activities which occur successively and simultaneously at the same time.

First of all the internal research & development had to be done by AKZO NOBEL themselves, which means we had to refine internally the basic yarn properties. Therefore a NewCell® pilot plant was erected close to Central Research at Obernburg/D to do the process engineering (in preparation for upscaling to a production plant) and to produce limited quantities for internal development and market sampling.

Even if the basic yarn properties have been defined, the internal research and development activities will continue with a high level of manpower being involved as the NMMO technology for filament is not yet fully exploited with the textile applications. During the introduction phase our customers will certainly still need the support of Cellulosic Research.

What are now the advantages of NewCell® compared to other cellulosic filament yarns?

To summarize the multiplicity of data shown in Fig. 1, we may point out that NewCell® is able to offer the same advantages which the existing cellulosics already have like wear comfort, moisture absorption, versatility in applications etc ...

Technical Yarn Properties of Cellulosic Filament Yarns

	NewCell (pilot plant)	ENKA Viscose (spool-spun)	Cupro	Acetate
yarn titre (dtex)	40 – 170	67 – 600	22 – 167	50 – 167
filament titre (dpf)	0,8 – 3,0	1,4 – 7,5	1,0 – 1,8	1,7 – 6,0
dry tenacity (cN/tex	30 – 42	16 – 20	16 – 25	10 – 14
wet tenacity (cN/tex)	20 – 27	6 – 10	10 – 16	7 – 10
dry elongation (%)	6 – 10	16 – 22	9 – 15	20 – 28
wet elongation (%)	8 – 13	20 – 27	17 – 30	25 – 35
knot strength (cN/tex)	23 – 34	13 – 16	12 – 19	9 – 13
loop strength (cN/tex)	18 – 29	13 – 16	15 – 22	9 – 13
boiling water shrinkage (%)	0,5 – 2,0	0,5 – 2,0	1 – 6	1 – 1,7
absorption of moisture (%)*	11 – 13	11 – 14	11 – 14	6 – 7
water retention (%)	60 – 70	90 – 100	80 – 90	20 – 30

* standard atmosphere: 20° C; 65% rel. humidity

Figure 1

Additionally

- NewCell® can be spun in very fine total deniers and, what is perhaps even more important, in single filament counts below 1 dtex. In this way it is suited for a wide range of new end-uses as it is a cellulosic microfilament yarn;
- NewCell® has a tenacity in the dry state which is twice as high as that of other existing cellulosic filament yarns and in the wet state even three times as high. This has proved to be important for enduses like intimate apparel, as well as for care, processing and finishing properties;
- NewCell® has an excellent dimensional stability in the fabric and the garment due to the low, non-continuing shrinkage of the yarn and reduced water retention level. Once the yarn and fabric shrinkage is released, the article does not shrink any more, which is an important precondition for machine washability;
- NewCell® can be texturized and this effect remains stable even after washing. This offers the option of bulky but light-weight fabrics;
- NewCell® has the ability to fibrillate. As it is possible by appropriate finishing methods either to release controlled fibrillation of NewCell®, to freeze the state of fibrillation desired or to prevent the article from fibrillation if it is to be avoided, NewCell® is more versatile than nonfibrillating yarns like viscose rayon or fibrillating yarns like cuprammonium. Unlike the formerly often practised resin finishing method, this new process preserves the very much esteemed properties and hand of cellulosics. Consequently the ability to fibrillate is no longer a disadvantage but an advantage as it is an additional option and allows more variations in articles made from the same grey fabric.

What do these technical advantages mean to the consumer? We tried to translate them into his language (Fig. 2):

- NewCell® leads to new lighter (total denier), different (cellulosic micro) and, if desired, bulkier articles allowing cellulosics to serve end-uses which so far have been the domaine of synthetics.
- the appreciated wear comfort of cellulosics is maintained;
- garments made of NewCell® are machine washable (40°C, household detergent);
- unfortunately, garments of NewCell® still have to be ironed. At least the creasing of NewCell® is not worse than in viscose rayon or cuprammonium;
- the environmental soundness of the production process and the biodegradability of the yarn go beyond all existing ecological standards provided that appropriate environmentally friendly finishing methods are used.

Value Related Properties of Fabrics made from Cellulosic Filament Yarns

	NewCell	ENKA Viscose	Cupro	Acetate
variety of articles				
- light weight fabrics (< 80 g/m²)	++	(+)	+	o
- cellulosic micro (< 1 dpf)	yes	no	no	no
- peach skin type fabrics	yes/no	no	yes/no	no
- lustre	dull/bright	dull/bright	dull/bright	bright
- light fastness	+(+)	+	+	o
- light stability	++	+	?	?
wearing comfort				
- absence of electrostatic charge	+	+	+	–
- absorption of perspiration	+	+	+	–
- breathability	+	+	+	o
- creasing (dry state)	o	o	o	–
- fastness to perspiration	+	+	+	o
washability				
- dimensional stability	+	o	o	+
- shape retention	o	(-)	?	?
- resistance to mechanical treatment	++	o	o	o
- washing fastness 104°F	++	++	+	o
140°F	+	+	(+)	–
- creasing after washing (Monsanto scale)	+	o	o	–
- permanence of air texturization	++	–	n/a	n/a
care properties				
- ironing	+	+	+	o
- dry cleaning	+	+	+	+
environmental soundness				
- production process	++	(+)	–	–
- bio-degradability	+	+	+	–

++ = excellent; + = good; o = fair; – = poor

Figure 2

3. External Development

As AKZO NOBEL intends to serve the market with a customer-designed product the logical consequence is to cooperate with people who are far closer to the market than the man-made fibre producer. The idea is to get a feedback from the market about its needs through the whole textile pipeline from the consumer via trade, fashion house, fabric maker back to AKZO NOBEL in order to improve NewCell® accordingly. The development work should in this way be driven by the market and not by the people in the ivory tower of the man-made fibre producer who is rather far away from the consumer front. This approach will hopefully contribute to risk reduction concerning the investment into this new generation of textile yarns.

Therefore AKZO NOBEL formed a partnership with competent fabric makers (weavers, warp knitters, circular knitters with integrated finishing facilities) in conjunction with leading fashion houses in the respective market segments. Thus AKZO NOBEL is incorporated in many triangles between the fibre producer, the fabric maker and the garment manufacturer, in which a constant exchange of ideas, market response and know-how takes place.

The market segments currently being studied are:
- Ladies/Men's Outerwear
- Sports-/Leisurewear
- Intimate Apparel, i.e. Lingerie
- Hosiery
- Linings
- Semi-technical End-uses

One result of market-driven development is that the partner is free to determine the count and number of filaments of the yarn he wishes to receive and the NewCell® pilot plant management will try to meet his request by production on demand (of course within the existing physical boundaries). In this way we have been able to get a feed-back from the market within a very short time.

After three months of sampling in the market the first impression is that

- the response to NewCell® is very positive overall;
- after having tasted Tencel and Lenzing Lyocell spun yarns, the market is longing for the Lyocell filament version called NewCell®;
- especially the very fine counts (< 50 dtex) of NewCell® are assessed to have a big market potential;
- the versatility of NewCell® concerning end-uses is very much appreciated;
- a sound knowledge and proper application of finishing methods are crucial;
- the non-polluting production process matches the consumer's growing awareness of environmental issues.

It is our intention to do several sampling cycles with each development partner, trying to translate the comments and feed-back we are getting into an improved product.
As soon as any trends can be identified from the feedback from the textile pipeline, this information will facilitate our decision on whether and how we should invest.

The feedback we expect to obtain from the market will be about the following subjects:

- unique selling properties (USP) of NewCell®
- yarn counts and number of filaments demanded
- clear definition of textile properties required
- suitability for different processing technologies
- make-up and packing required
- experience in finishing methods (fibrillation vs. non-fibrillation)
- promising market segments
- consumption indication/forecast

Of course, the sampling and thus the development work will have to be continued even after the termination of the project phase of NewCell®. Certainly some difficulties will arise during the transition period from pilot plant to large-scale production when the capacity will not be sufficient to meet the market's growing demand for NewCell® we are expecting.

4. Marketing of NewCell®

4.1 Marketing Philosophy

The marketing concepts to be developed will be influenced by the results of the internal and external development activities. Nevertheless, some basic conditions are clear to AKZO NOBEL already now. The marketing philosophy represents the framework within which the positioning concepts will have to be developed.

The basic elements of the NewCell® marketing philosophy are:

- NewCell® will be complementary to ENKA® VISCOSE, not a substitute. Even if NewCell® has some significant advantages, there will be market segments still using ENKA® VISCOSE, whilst others will prefer NewCell®. There will be and have to be two different, completely independent product lines ENKA® VISCOSE and NewCell® serving our customers needs at their best.
- NewCell® will be a rather rare, not a mass product. Of course, we intend to grow with the market, but those partners who will invest in and for NewCell® can be sure that they will find NewCell® only in high-value products and not in every retail store. We strongly believe that NewCell® has a big potential and consequently a long lasting future and therefore we should prevent this topic being worn out in one or two fashion seasons by getting into the wrong people's hands.
- NewCell® is still the working name of our lyocell filament yarn. Of course, we plan to create a brand or perhaps different brands for fashion and semi-technical articles. Whether it will be a business-to-business brand or a real consumers brand will depend on the positioning concepts to develop. In any case we intend to support any brand that will emerge by appropriate promotion and advertising campaigns worldwide.
- The customer intimacy approach is the only strategy we feel will be appropriate to introduce this new product into the market. Practised customer intimacy in combination with an active brand policy will also be less vulnerable to competition.
- If one takes customer intimacy seriously, the vehicle to communicate this approach is to provide service. A service concept includes recommendations for processing and finishing, a high level of product quality and excellent logistics. Generally speaking, we will try to have the answers ready even before they arise with the partner.
- In order to ensure a constant improvement in product and service quality, we are introducing Total Quality Management already in the project phase. This will facilitate especially the scale-up when it comes to commercial production and this attitude towards the customer will be adopted also by the staff members joining later on. ISO 9001 and other standards are static and only tell the consumer that the producer is producing constantly at a certain quality level, wherever this level may be. ISO 9001 and related standards already are or will soon become a must. The only way to keep the ball rolling is to practise Total Quality Management.
- Markets and national borders are breaking up. Traditional customer-supplier relationships are dissolving. The textile industry is increasingly practising global sourcing. It's one world and one textile market today. It is no longer possible to create a 'Made in Europe' concept and impose it on the rest of the world. Asia and the Americas have their own culture and their own styles and want to be taken seriously. Global marketing with regional accents will be the only possible answer.

4.2 Market Research

The man-made fibre producer is positioned at the very end of the textile pipeline beginning with the consumer and including the trade, the garment manufacturer, the fabric maker and the yarn producer. The consumer is at the other end, which means rather far away from us. In order to learn more about the elements of the textile pipeline, especially about those stages with which we normally don't deal directly, we have conducted some basic market research.

This will help us in three respects:

- We will learn more about the consumer, how he or she thinks, how they make their buying decisions and what they are interested in.
- We will learn more about retailers and makers-up and thus be in a better position to make NewCell® a beneficial product for all stages of the textile pipeline.
- It will help us to minimize the risks of market introduction by positioning NewCell® properly.

The qualitative market research consisted of

- a desktop trend analysis
- group discussions with female consumers in several countries
- interviews with experts in production, making-up and retailing

Despite the fact that most people believe that fashion (and thus serving fashion) cannot be categorized, measured and predicted, there were some longer lasting trends to be recognized. Longer lasting in this case means valid for the next 3 to 5 years.

- The buying decision is taken under the ambivalence of emotional and rational influences. Both elements want and need to be served. Functional but not fashionable garments will fail and so will very fancy articles which don't have a minimum of quality which is recognizable to the consumer.
- Despite the observation that no one likes to admit openly that he or she goes for labels, consumer brands are gaining increasing influence in certain consumer groups especially teenagers, who lack sufficient knowledge of materials and their properties to make up their own minds. The brand in this case has the function of a kind of reinsurance against wrong buying decisions as it is an indicator of a certain constant level of quality, a certain standard in size and form which fits the consumer's body and it is an "entry card" to certain groups the consumer wants to belong to.
- There is a clear trend to individualization. Trends are no longer followed by the mass of people automatically. Instead of one or two trends there are hundreds of trends and generally more short-term trends. This makes it difficult to recognize trends in due time and to serve them. For us it means that NewCell® needs a certain versatility, without exaggerating as this would happen at the expense of the credibility of any concept. This means we need to be able to serve almost any fashion, but we need to be distinctive and recognizable.
- There is a growing consciousness of nature and environmental issues. Eco as a trend is out, but compatibility with the environment will sooner or later become a must, a standard. Consumers are not ready to pay more for a less harmful product, they simply demand ecological correctness. Companies, products and brands which do not meet the consumer's expectations in this respect will be stigmatized, outed and be the losers. In this respect the market is now ripe for lyocell products. 10 years ago NewCell® perhaps wouldn't have had a chance.
- On the one hand, the consumer is generally getting more price-conscious and is no longer ready to pay any price retailers are asking. On the other hand, there is an ongoing trend to luxury which people are allowing themselves in order to reward themselves. The key to both is value. Value driven brand marketing will be the access to the consumer even more than in the past.
- Nature as the absolute reference on the one hand and thus the preference for natural products like wool, cotton or silk exists beside a growing appreciation of the functionality of synthetics (especially among the younger consumers). NewCell® as a yarn of natural origin with superior properties compared to the naturals could be a product combining the best of both worlds. Marketing will have to build a bridge between the emotional inclination towards naturals and the rational preference for the functionality of synthetics.
- Quality is a must. There is no way other than to provide quality in every respect - quality of the product, the service and the concept. Brands which once fail to meet the consumer's expectations with regard to quality can overnight become a label for non-quality, from which they will never recover.
- The chances for NewCell® and other lyocell products are generally assessed as very positive. However, lyocell is an unknown product. There is still a lot of work to be done to convince all stages of the textile pipeline of the benefits of NewCell® when going to market. Appropriate promotion and advertising will be mandatory and more crucial than for any other brand based on already existing and known materials.

4.3 Positioning of NewCell®

Due to its properties and its versatility there are different possibilities how to market NewCell®, which all can be covered by NewCell®. Even if we should wait for the final results of the market Development and the market research, already now three corner stones can be recognized, marking the position of NewCell® in the market:

a) The Value Concept
NewCell® stands for value. Only high value articles will be made of NewCell®. When buying garments made of NewCell®, the consumer will always get the best value for his money. Quality and aesthetics of the products made of NewCell® will have to be outstanding. This demands perfect control of the whole textile pipeline in order to ensure this high level of value. Marketing within a club or the like will be a must. NewCell® will be rare and precious.

b) The Natural Concept
NewCell® is a natural yarn or at least a yarn of natural origin. Its environmental friendliness at all stages is beyond any doubt.This means we have to prove the ecological correctness from the cradle to the grave. With regard to practising such a concept there are still two question marks: the production step of dissolving wood pulp and the finishing of fabrics and garments. In other words: Will it be possible to produce a „clean" woodpulp and will it be possible to develop finishing methods which will serve market expectations concerning the fashion to come and which are not harmful to the environment?

c) The Ideal Fibre

NewCell® is the perfect synthesis between natural yarns and fibres, such as cotton, wool or silk, and synthetics. Its functionality is far superior to all other cellulosics and our natural resources are protected as its raw material is gained from renewable tree farms. NewCell® simultaneously meets the consumer's emotional and rational expectations. NewCell® is versatile enough to be used in easy-care garments as well as articles which are free from chemical agents. NewCell® is the ideal yarn/fibre.

5. Outlook

AKZO NOBEL will conclude the market development as well as the technical and commercial feasability study in 1996. Latest by then we will have our answers ready to the still open market questions. Consequently NewCell® will grow into the textile market and enrich the possibilities of variation in fabrics and garments with the Lyocell filament yarn.

We of AKZO NOBEL will be proud of serving the consumer also in the 21st century.

LENZING LYOCELL - POTENTIAL FOR TECHNICAL TEXTILES

D. Eichinger, C. Lotz, Lenzing AG, 1995

The Lenzing Lyocell fibre is a ***very interesting material to*** work with for technical applications Therefore ***first*** basic ***trials were initiated to inform about the property profile of*** this ***fibre itself*** and ***in use*** in ***spunlace processes.***

Die ***Lenzing-Lyocell-Faser ist ein sehr interessantes Material für technische Anwendungen. Deshalb wurden erste*** **Versuche** ***initiiert, um Kenntnisse über*** das ***Eigenschaftsprofil der Faser an sich und über ihre Anwendung*** in ***Spunlace-Verfahren zu gewinnen.***

The Lenzing Lyocell fibre is a very interesting material to work with for technical applications.

Therefore first basic trials were initiated to inform about the property profile of this fibre itself and in use in spunlace processes.

Properties:

A well-balanced high tenacity **profile**

Lenzing Lyocell is a high tenacity cellulosic fiber if compared to Viscose on the one hand and Polyester on the other hand. Remarkable is the ratio between wet and dry tenacity of approx 85%.

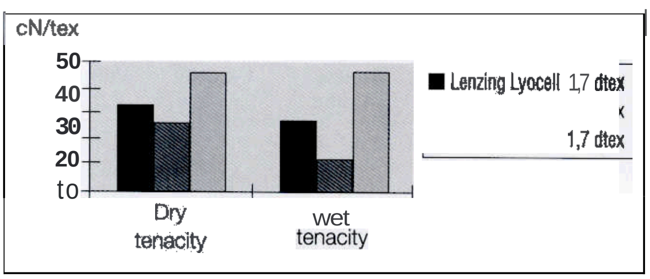

Fig. 1

Elongation

The elongation profile of Lenzing Lyocell, even in the wet state reaches the values of Viscose.

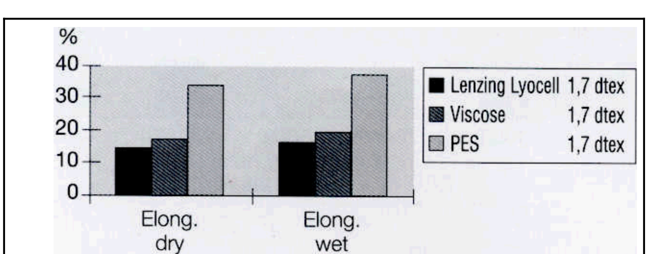

Fig. 2

Water absorption

The wettability of Lenzing Lyocell is between Cotton and Viscose[4] (Fig. 4)

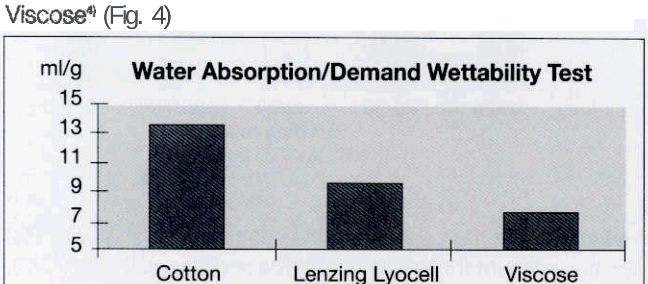

Fig. 3

According to water retention (DIN 53814) Lyocell ranks also between Cotton and Viscose. Here Viscose is able to hold the highest amount of water.

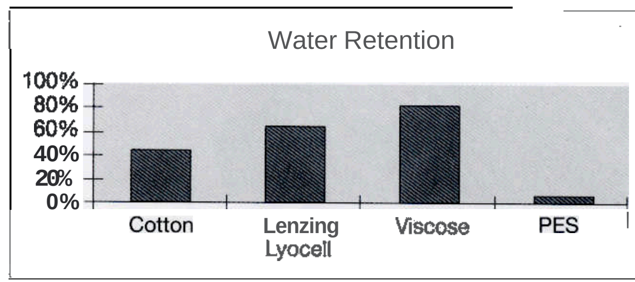

Fig. 4

The wet modulus of Lyocell is found above Viscose and Cotton (Pima I).

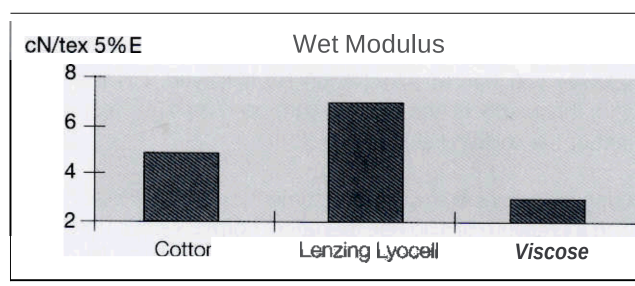

Fig. 5

The water holding capacity of Lenzing Lyocell is comparable to a Viscose used in nonwovens.

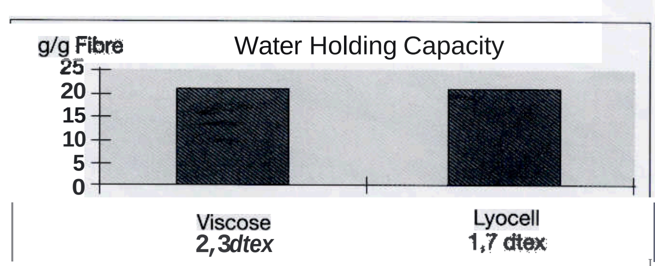

Fig. 6

The sinking time meets the requirements of the pharmacopea europea unless it is higher than the one of Viscose.

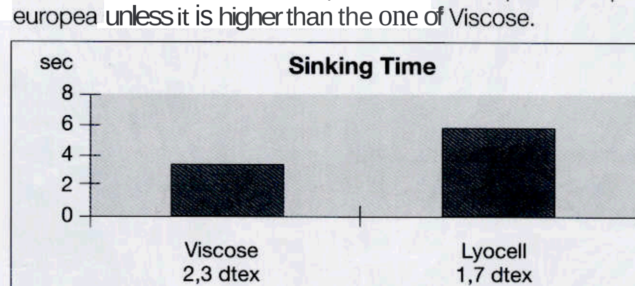

Fig. 7

Fibrillation

Fig. 8 demonstrates that Lenzing Lyocell fibre is made of a complex structure of micro and macro fibrils.

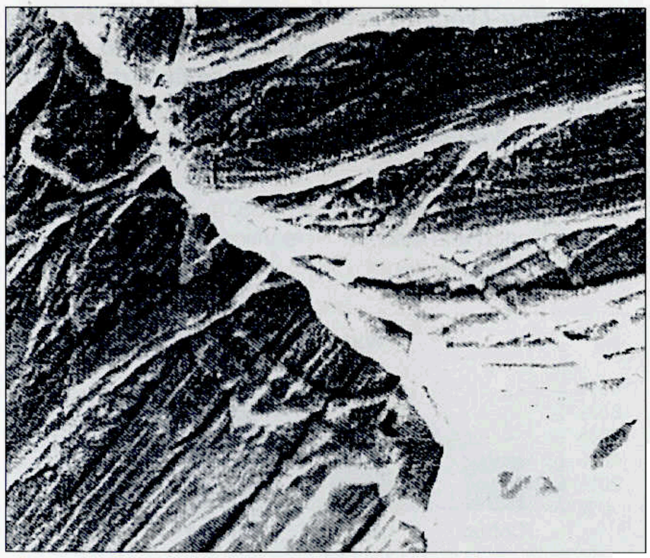

Fig. 8

The fibrils break and protrude from the surface as a result of swelling in water and subsequent mechanical transverse.

Cellulose fibres generally have a tendency to fibrillate[3]), but Lyocell-fibres have the greatest propensity. Fibrillation means that very soft handle effects can be achievea. 0n rhe other hand, these effects can only be controlled by high-tech equipment at the finishing stage.

During processes like hydroentaglement, i.e on a Perfojet-Sytem using a pressure of **150** bar, this effect normally does not appear (Fig. **9**) But of course it is possible to fibrillate the fibre after a number of passages (Fig. 10).

Fig. 9

Fig 10

Lyocell in Technical **textiles**

Using Lyocell for nonwovens (spunlaces) the tensile strength is outstanding for cellulosic fibres and is comparable rather to Polyester than to Cotton and viscose - parallel-layed webs - (Fig. 11[5]).

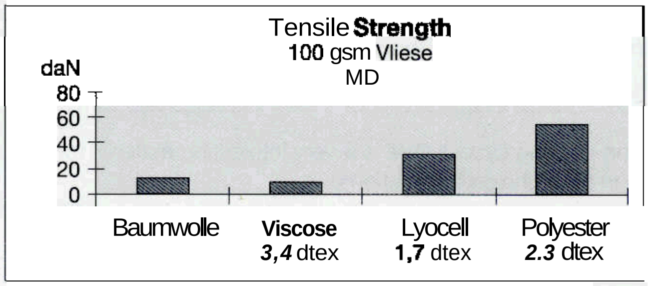

Fig. 11

The elongation of Lenzing Lyocell meets the level of cotton.

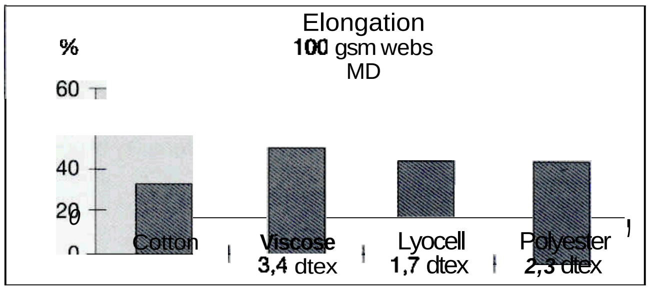

Fig. 12

Blended with cotton the tensile strength grows with increasing portion of Lenzing Lyocell.
The elongation seems to be independent from this fact.

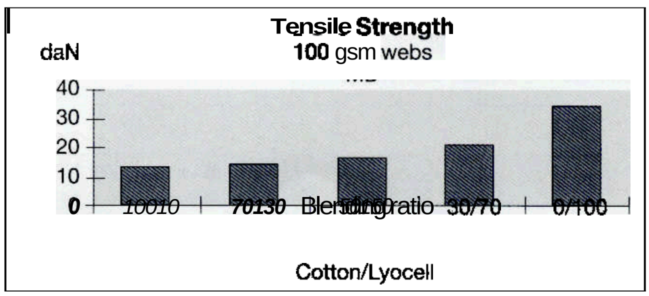

Fig 13

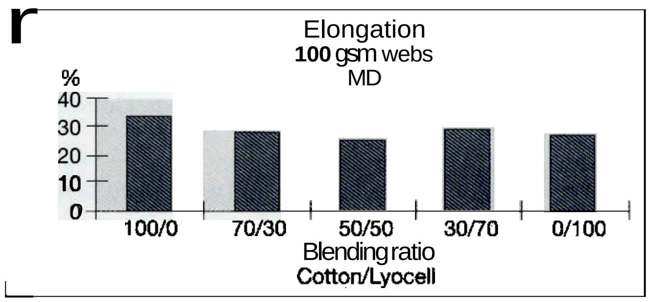

Fig 14

Hydroentangling Lyocell using different pressures shows at 150 bar an optimum for tensile strength/elongation (DIN **29073/3**), water absorption (DIN **53924**) and air permeation (DIN **53887**) - cross-layed webs - (Fig. **15-18**)

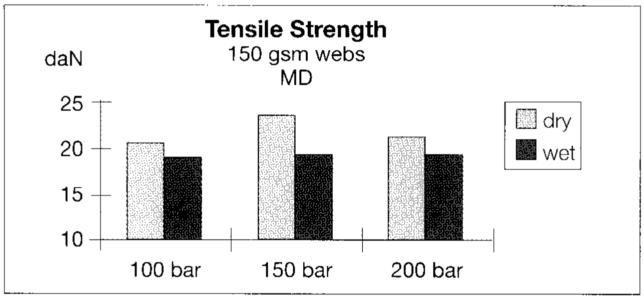

Fig. 15

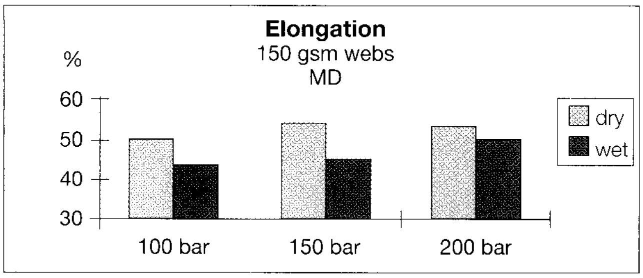

Fig. 16

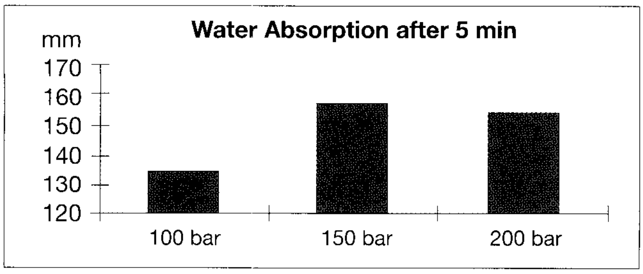

Fig. 17

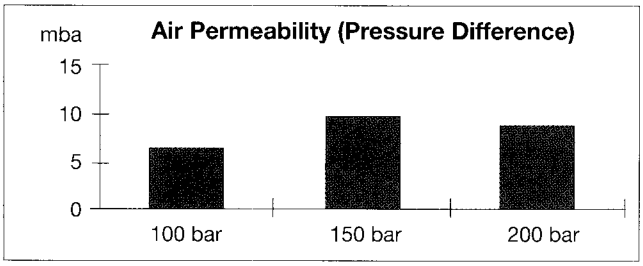

Fig. 18

Ecology/Toxicity

Future technologies must satisfy ecological considerations with respect to a low use of resources and ecological compatibility in particular in comparison to cotton (see Tab. 1).

1. Wood is a replenishable raw material and pulp can be made out of this with much higher yield per hectare than cotton.
2. No pestizides and fertilizers are needed.
3. Huge water demand for the production. In comparison to that huge amount of water is needed for irrigation of cotton. Therefore the Lyocell technology represents a very environmentally-friendly and resource-saving alternative to produce cellulose fibres.

Comparison of some specific production data for Cotton and Lyocell

	Cotton Arizona/California	Southern Pine (USA) / Lyocell	Eucalyptus (Brasil) / Lyocell	Eucalyptus (top values / Lyocell
Field kg / ha . a	~1200	3000	6000	9100 – 11000
water consumption / kg fibre	up to ~8000 irrigation	< 100 Pulp and Lyocell production (without cooling water)		
Chemicals kg / kg fibre	~0,10 N ~0,06 P ~0,002 K_2CO_3 ~0,17 chalk ~0,020 fungicides, insecticides, herbicides	~0,026 S ~0,025 MgO ~0,049 NaOH ~0,009 H_2O_2 ~0,020 O_2 ~0,002 O_2		Pulp production (Lenzing AG 1993) Lyocell production
		< 0,03 NMMO < 0,01 auxiliary chemicals		Lyocell prod.
Emissions kg / kg fibre	Soil damage Ground water pollution	~0,025 (als SO_4^{2}) ~0,014 Mg_{2+} ~0,028 Na+ ~0,007 CSB	waste water pulp prod. after WWTP	< 0,0025 SO_2 gaseous emission pulp prod.
	Bleaching waste water CSB = COD	< 0,002 NMMO < 0,001 NMM+M < 0,004 CSB	waste water Lyocell prod. after WWTP	< 0,0008 NMM/M gaseous emission Lyocell prod.

Tab. 1

Tab. 2 demonstrates some important values regarding the toxicological and eco-toxicological properties of NMMO[3].

Some information on the Toxicity of NMMO

- **acute oral toxicity (rat):**
  LD_{50} > 10.000 mg / kg; Ratte
- **acute toxicity (fish):**
  LC_0 28,8 g / l; LC_{50} 31,2 g / l (96 h);
  Salmo gaidneri R.
- **bacterial toxicity:**
  EC_{10} 14.900 mg / l (16 h) an
  Pseudomonas putida
- **crustacean toxicity(daphnia):**
  EC_0 10.000 mg / l; EC_{50} 14.000 mg / l
- **algae toxicity:**
  no growth inhibition fo selenastrum capricornutum due to waste waters with 5g/l NMMO
- **mutagenicity:**
  non mutagenic in DNA Repair-Test und Ames-Test
- **partition coefficient n-Octanol/water:**
  log P_{OW} -1,8

Tab. 2

The chemical structure of NMMO is shown below (Fig. 19)

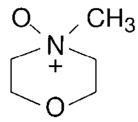

Fig. 19

Physiology

According to the Erlanger Ciliatentest (a method using bacterias like Terahymena pyriformis) NMMO fibres are physiologically harmless[6].

Potential Applications of Lenzing Lyocell in Technical Textiles

- Papers
- Filters
- Geo-Textiles
- Medical textiles
- Hygienic textiles
- Abrasive bearer
- Bearer for coatings

Conclusion:

Fig. 20 summarizes why Lenzing Lyocell is an interesting raw material for the textile industry.

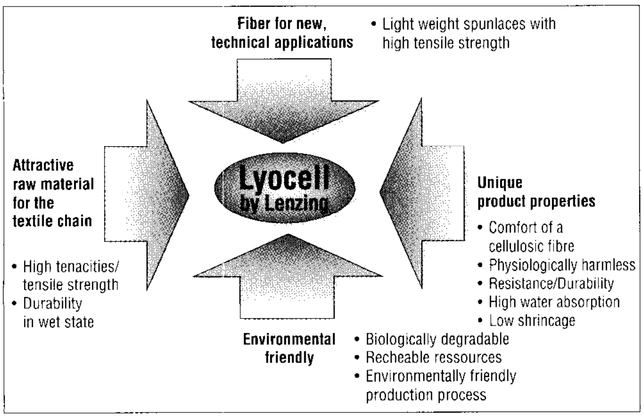

Fig. 20

Literature:

1) Gränacher, Sallmann 1936, DRP 713 486
2) Johnson, 1969, USP 3 447 939
3) Firgo et al, Lenzinger Berichte 74, S. 81
4) Lichtstein, Demand Wettability, 1974
5) Unitika, Nonwovens report 1994
6) Gräf, Erlanger Ciliatentest,1973

ERSTE ERFAHRUNGEN MIT LENZING-LYOCELLFASERN IN VLIESSTOFFEN

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Forschungsinstitut für Leder- und Kunstlederlechnologie GmbH Freiberg

Erste Ergebnisse über den Einsatz der Lyocellfasern in Vliesstoffen lassen erkennen, daß diese Fasertype sehr interessant für Vliesstoffe ist. Aus Lyocellfasern wurden aerodynamisch gebildete Wirrvliese und kreuzgelegte Vliese hergestellt. Die Vliese wurden auf einer Labornadelmaschine und einer Wasserstrahlanlage mit unterschiedlichen Flächengewichten verfestigt.

First results of the use of Lyocell fibres in nonwovens show, that this fibre type is very interesting for nonwovens. Lyocell fibres were processed into aerodynamically laid random webs and into cross laid webs. The webs were bonded with different area weights on a laboratory needling machine and a hydroentanglement apparatus.

Einleitung

Über die Entwicklung und die textile Verarbeitung von Lyocell-Fasern zu Garnen und daraus hergestellten Flachengebilden wurde schon mehrfach berichtet[1]. Ihre guten Festigkeits- und Formänderungseigenschaften im trockenen und nassen Zustand im Vergleich zu anderen Viskosefaserqualitäten und auch gegenüber Polyesterfasern rechtfertigen die Fragen zu beantworten: „Wie verhalten sich die Fasern bei der Verarbeitung zu Vliesstoffen? Welche Eigenschaften werden im Vliesstoff erreicht und welche Einsatzrichtungen zeichnen sich ab?" Hinzu kommt ihre spezifische Fibrillierneigung wie sie nur bei speziellen Chemiefasern bekannt ist. In den letzten 10 – 15 Jahren hat sich im Faserstoffeinsatz für Vliesstoffe in Westeuropa ein starker Wandel vollzogen. Wahrend der mengenmäßige Einsatz von Viskosefasern konstant geblieben ist, sind bei Polypropylen und Polyester starke Steigerungen zu verzeichnen[2]. Auf Grund ihrer spezifischen Eigenschaften ist die Lyocellfaser auch eine interessante Fasertype für den Einsatz in Vliesstoffen. Die Lyocellfasern wurden dankenswerter Weise von der Lenzing AG zur Verfügung gestellt. Die Untersuchungen konnten im Rahmen eines institutsinternen Projektes durchgeführt werden[3].

Verarbeitungsverhalten bei der Vliesbildung und -verfestigung

Für die Versuche kamen Lyocellfasern 1,7 dtex, 40 mm zum Einsatz. Die im Labormaßstab hergestellten wasserstrahlverfestigten und genadelten Vliesstoffe und die erhaltenen Ergebnisse wurden mit denen aus normalen Viskose- und Polyesterfasern verglichen.

Aus den Fasern wurden aerodynamisch gebildete Wirrvliese und kreuzgelegte Vliese hergestellt. Auf beiden Vliesbildungssystemen ließen sich die Fasern ohne Schwierigkeiten zu gleichmäßigen Vliesen verarbeiten. Eine Faserschädigung in Form der Faserkürzung oder Fibrillierung trat nicht ein. In den Bildern 1 und 2 ist die Faserlängenverteilung in Form eines B-Bartes nach dem Almeter-Verfahren dargestellt.

Faserlängenverteilung vor dem Kardieren

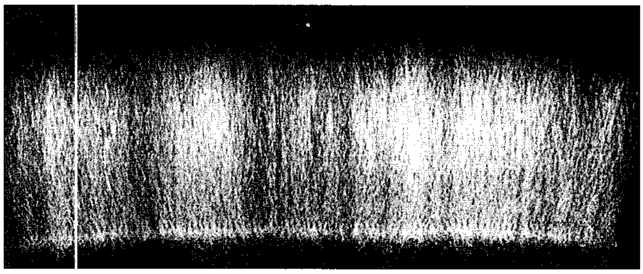

Bild 1

Faserlängenverteilung nach dem Kardieren

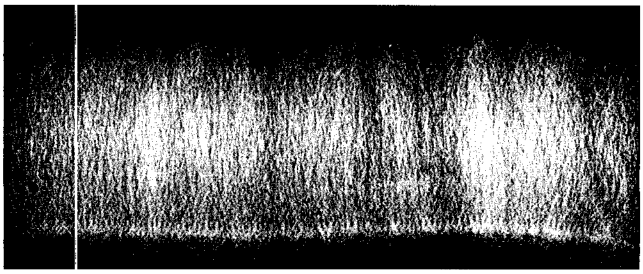

Bild 2

Auf der im STFI vorhandenen Labornadelmaschine Typ OD-II/6 mit Vlieszufuhrsystem CBF 6 der Fa. Dilo und der Wasserstrahlanlage nach dem NORAFIN-Prinzip wurden die Vliese mit unterschiedlichen Flächengewichten verfestigt.

In der nachfolgenden Übersicht sind die durchgeführten Versuche zusammengestellt.

Versuchs-Nr.	Vliesbildung	Verfestigung	Soll-Flächengewicht
Lyo 1	Wirrvlies	Wasserstrahl	60 g/m²
Lyo 2	Kreuzlagenvlies	Wasserstrahl	60 g/m²
Lyo 3	Kreuzlagenvlies	Nadeln	100 g/m²
Lyo 4	Kreuzlagenvlies	Nadeln	150 g/m²
Lyo 5	Kreuzlagenvlies	Nadeln	200 g/m²

Die Herstellung der Nadelvliesstoffe erfolgte unter folgenden Bedingungen:

Nadelart: 15 x 18 x 38 x 3M 222 G 20 17 geprägt
Stichdichte: 150 E/cm²
Stichtiefe: 10 mm

Die Verfestigung mittels Hochdruckwasserstrahlen erfolgte mit Drücken von 0,5 bis 12 MPa.

Eigenschaften der Lyocell-Vliesstoffe

Die textilphysikalischen Kennwerte der wasserstrahlverfestigten Vliesstoffe aus Lyocellfasern sind in der folgenden Tabelle denen aus Polyester- und Viskose Normalfasertypen gegenuber-gestellt.

In der Tabelle 1 sind sowohl fur den trockenen als auch fur den nassen Zustand die mittlere Hochstzugkrafi als die halbe Summe von Hochstzugkraft langs und quer wiedergegeben. Zum Ausgleich der Flachengewichtsabweichungen wurde diese mittlere Höchstzugkraft fur 100 g/m² Vliesstoff berechnet

Eigenschaften der wasserstrahlverfestigten Vliesstoffe

Versuch-Nr.		Lyo 1 Wirrvlies	Lyo 2 Kreuzlagen-dies	PES-F Wirnlies	CV-F Wirniies
Flachengewicht	g/m²	60.7	62,95	71,55	55
Dicke	mm	0,513	0,479	0,639	0,447
Dichte	g/cm³	0,118	0,132	0,112	0,123
Höchstzugkraft längs	N	109,4	67.5	212,6	68,5
Höchstzugkraft quer	N	86,6	126,9	133,1	45,4
Dehnung längs	%	34	44,9	43,9	32,4
Dehnung quer	%	52,7	32,5	104,8	57,7
Naßzugkraft längs	N	105,55	64,7	220,7	58,9
Naßzugkraft quer	N	88,15	114,3	125	38,8
Naß-Dehnung längs	%	38,9	48,6	48,3	37,1
Naß-Dehnung quer	%	52	35,1	102	57
mittlere Höchstzugkraft	N	98	97,2	172,85	47,4
mittlere Höchstzugkraft naß	N	96,85	89,5	172,8	48,85
mittlere Höchstzugkraft 100 g/m²	N	161,45	154.41	241,58	86.18
mittlere Hochstzugkraft naß/100 g/m²	N	159,5	142,2	241.51	88.8

Tabelle 1

Bild 3 enthalt den Kraft/ Dehnungsverlauf der NORAFIN-Vliesstoffe mit Wirrviiesstruktur. In Bild **4** ist die mittlere Hochstzugkraft der NORAFIN-Vliesstoffe aus Lyocellfasern im Vergleich zu denen aus Polyester- und Viskosefasern wieder-gegeben

Kraft/Dehnungsverlauf von NORAFIN-Vliesstoffen

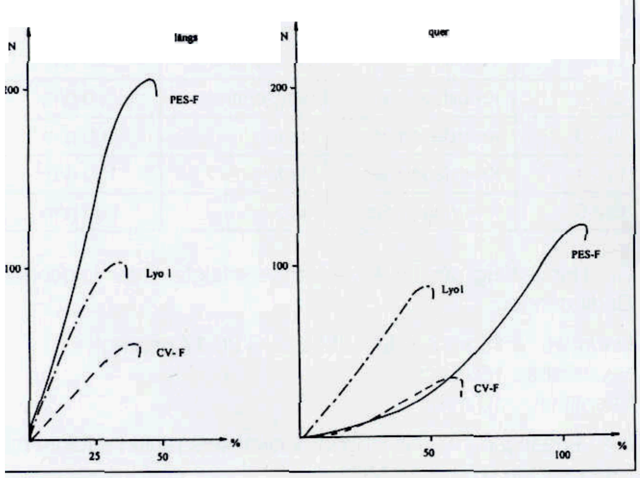

Bild 3

Mittlere Höchstzugkraft wasserstrahl-verfestigter Vliesstoffe

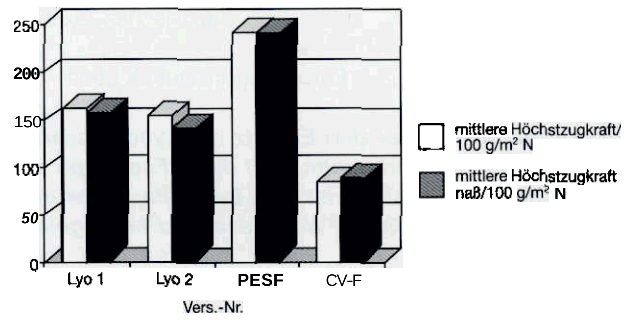

Bild 4

Die Festigkeiten der Lyocell-Vliesstoffe liegen gegenuber denen von vergleichbaren aus Viskosefasern ca. 40 bis 60 % hoher.

Die angegebene hohe Naßfestigkeit der Fasern zeigt sich auch bei den Vliesstoffen. Im Vergleich zu den Zugkräften im trocke-nen Zustand sind kaum Anderungen zu verzeichnen. Dies kann mit der Naßverfestigung der Vliese erklärt werden. Sehr deut-lich wird der Unterschied im Kraft/Dehnungsverlauf der Vliesstoffe aus den verschiedenen Faserstoffen. Es werden bei der Wirrvliesstruktur die bekannten Unterschiede bei Beanspruchung in Langs- und Querrichtung sichtbar. Im Vergleich zu Vliesstoffen aus Polyester- und Viskosefasern be-sitzen die aus Lyocellfasern ein ausgeglichenes Kraft-Dehnungsverhalten in Längs- und Quemchtung. Dies führt auch bei der Verfestigung des Lyocellvlieses mit Wasserstrahlen zu einer geringeren Langenanderung bei den auftretenden Verarbeitungsspannungen. Der Vliesstoff aus Wirrvlies hat eine geringere Dicke und eine hohere Dichte zum flächengewichts-gleichen kreuzgelegten Vliesstoff.

Aus der REM-Aufnahme Bild 5 des wasserstrahlverfestigten Lyocell-Vliesstoffes ist zu erkennen, daß Wasserstrahldrücke von 12 - 15 MPa zu keinem Aufspleißen der Fasern führen.

Aufnahme mit dem Rasterelektronenmikroskop von wasserstrahlverfestigten Lyocell-Vliesstoff

Bild 5

Die ermittelten textilphysikalischen Werte der Nadelvliesstoffe sind in der folgenden Tabelle zusarnmengefabt.

Eigenschaften der Nadelvliesstoffeaus Lenzing-Lyocellfasern

Vers.-Nr.				
Flächengewicht				
Dicke		2,127	2,118	2,785
Dichte	g/cm³	0,051	0,073	0.076
Höchstzugkraft längs			128,9	130.8
Höchstzugkraft quer	N	165,3	89,8	101,9
Dehnung längs	%	87,8	70,8	73,7
Dehnung quer	%	66.3	59,7	61,2
Naß-Höchstzugkraft langs	N	110,8	161,7	212
Naß-Höchstzugkraft quer	N	199,8	166	241,9
Naß-Dehnung langs	%	57,5	38,7	45,8
Naß-Dehnung quer	%	40,1	30,5	34,4
mittl. Höchstzugkraft	N	126,2	109,35	116,35
mittl. Höchstzugkraft naß	N	155,3	163,85	226,95

Tabelle 2

Mittlere Höchstzugkraft von Nadelvliesstoffen aus Lenzing-Lyocell

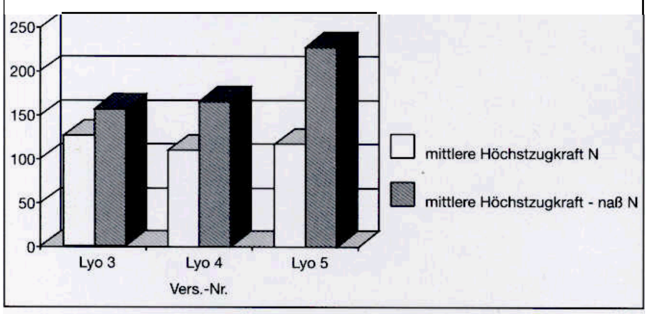

Bild 6

Lenzing-Lyocellfasernließen sich gut zu Nadelvliesstoffen verarbeiten. Ein Vergleich zwischen den Mustern Lyo 3 mit Lyo 4 und Lyo 5 in Bezug auf die Hochstzugkrafte irn trockenen Zustand zeigt ein sich anderndes Verhältnis zwischen Längs- und Querrichtung. Die Muster Lyo 4 und Lyo 5 besitzen hohere Langsfestigkeiten als in Querrichtung. Bei den Naßhöchstzugkräften liegen die Nabfestigkeitswerte in Querrichtung für alle drei Muster uber denen der Längsrichtung.

Besonders deutlich wird in Bild 6 sichtbar, daß die mittleren Höchstzugkräfte der drei Muster etwa im gleichen Festigkeitsbereich liegen, wahrend die Naßhöchstzugkräfte mit steigenden Flachengewicht ansteigen, Die Naßreißdehnungen sind bis zu 30% geringer gegenuber denen im trockenen Zustand.

Möglichkeiten des Einsatzes von Vliesstoffen aus Lyocellfasern

Vliesstoffe sind im Hinblick auf die Herstellung von Ledersubstituten wichtige Trägermaterialien, da sie einerseits den hohen Qualitäts- und andererseits den asthetischen Anforderungen auf Grund der vorhandenen Faserstruktur am besten gerecht werden. Bei imprägnierten Vliesen ist die Schnittkantenfestigkeit sowie die lederähnliche Rückseite, insbesondere bei feinen Fasern, unübertroffen. Aus tragehygienischen Gesichtspunkten eignen sich vor allem porose Materialien, die nach dem Koagulationsverfahren hergestellt werden, fur lederähnliche Produkte in speziellen Einsatzgebieten mit hohem Eigenschaftsniveau, wie z.B. im Schuh-, Bekleidungs- und Polstersektor. Beim Koagulationsverfahren wird der Trager im Direktverfahren mit in Dimethylformamid (DMF) gelostem Polyurethan impragniert und / oder beschichtet. Die aufgebrachte Polymerschicht wird durch Fällung unter Ausbildung einer Kapillarstruktur verfestigt, wie in Bild 7 zu erkennen ist.

REM-Querschnittaufnahme eines Koagulates auf Vliesbasis

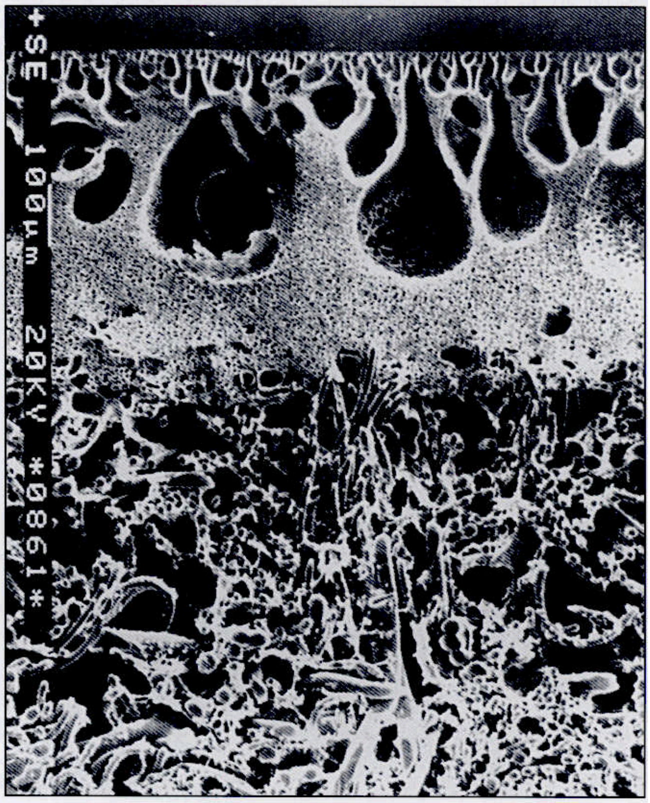

Bild 7

Das Rohkoagulat erhalt durch entsprechende Zurichtsysteme eine lederahnliche Optik. Fur derartige Produkte kornmen bisher vorwiegend Vliesstoffeaus svnthetischen Fasern bzw. mit geringem Cellulosefaseranteilzum Einsatz Cellulosefaservliese im unteren Flächenmassebereich genugen den Anforderungen fur das Koagulationsverfahren nicht. Auf Grund der hervorragenden Naßfestigkeiten eignen sich Vliesstoffe aus Lyocellfasern auch fur Impragnier- und Direktbeschichtungsverfahren in und mit wässrigen Medien. Dabei verspricht der Einsatz einer nabfesten Cellulosefaser einen besonderen Eigenschaftsvorteil in Bezug auf die Erzieiung verbesserter tragehygienischer Eigenschaften. Erste Impragnier- und Beschichtungsversuche an der Koagulations- Technikumsanlage des FILK bestatigen den Eigenschaftsvorteilder neuen Cellulosefaser. Dabei brillieren sowohl wasserstrahlverfestigte als auch Nadelviiesstoffe durch ihre ausgezeichnete Formbestandigkeit während des Naßprozesses. Besonders vorteilhaft wirkt sich auch die hohe Affinitat der Polyurethanbeschichtung zur Faser sowie die angenehme Haptik des Verbundes auf das Eigenschaftsniveau aus. Die im Vergleich zu beschichteten Polyesterfasewliesen verbessetten tragehygienischen Eigenschaften lassen sich durch geeignete Prüfmethoden belegen. Z.B. weisen Lederaustauschstoffe unter Verwendung von 125 g/m² Lyocellfasern eine Wasserdampfaufnahme nach DIN 4843 von 8,2 mg/cm².8h, vergleichbare Produkte unter Verwendung von 190 g/m² Polyesterfasern 4,8 mg/cm².8h auf.

Zusammenfassung

Bereits diese ersten Ergebnisse über den Einsatz der Lyocellfasern in Vliesstoffen lassen erkennen, daß diese Fasertype sehr interessant für Vliesstoffe ist. Sie ist eine echte Erweiterung der Viskosefaser-Sortimentspalette. Ihre guten faserspezifischen Eigenschaften, besonders ihr Verhalten im nassen Zustand, bringen nicht nur Vorteile im Verarbeitungsprozeß, sondern finden sich auch in den Vliesstoffeigenschaften wieder. Die guten Naßfestigkeitseigenschaften zeigen Vorteile bei der Weiterverarbeitung der Vliesstoffe in wässrigen Medien und bei ihrem Einsatz in technischen Anwendungsbereichen im nassen Zustand.
Die ermutigenden Ergebnisse berechtigen zu der Annahme, daß Vliesstoffe auch mit niedrigeren Flächengewichten herstellbar sind.

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STFI- Bericht 4/1995

BLEICHE VON GEWEBEN EIN VERGLEICH ZWISCHEN BAUMWOLLE, MODAL- UND LYOCELL-FASERN

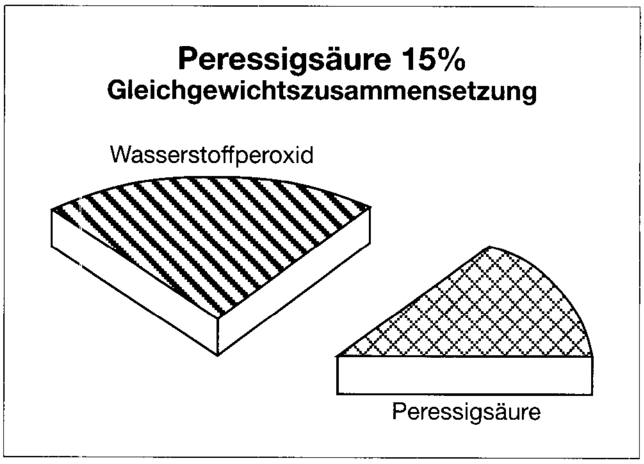
Dipl.-Ing. Vinzenz Olip, ÖCW Zweigniederlassung der Degussa Austria, Weißenstein

Ausgehend von Geweben aus Baumwolle, Modal- und Lyocellfasern wurden systematische vergleichende Laborversuche unter Verwendung der von Degussa Austria hergestellten chlorfreien Bleichchemikalien Wasserstoffperoxid und Gleichgewichtsperessigsäure durchgeführt.

By using the chlorine free bleaching chemicals hydrogen peroxide and equilibrum per-acetic acid manufactured by Degussa Austria systematic comparison tests were carried out on fabrics made from cotton, Modal and Lyocell fibres.

Seit 1908 wird in Weißenstein im technischen Maßstab Wasserstoffperoxid hergestellt. Damals gelang die erste technische Synthese nach dem in allen Lehrbüchern beschriebenen „Weißensteiner Verfahren". Mit der Verbesserung der Herstellungsmethode und Vergrößerung der Produktion ging die anwendungstechnische Entwicklung zur Bleiche von Textilien Hand in Hand. Seit dieser Zeit gibt es eine enge Zusammenarbeit zwischen Lenzing AG als Hersteller von Textilfasern und Degussa Austria als Hersteller von Bleichmitteln. Seit Beginn der Technikumsproduktion von Lyocellfasern wurden uns immer wieder Proben für Bleichversuche zur Verfügung gestellt.

In einem Vergleich wurden Gewebe aus Baumwolle, Modalfaser und der Lyocellfaser im Labor gebleicht.



ÖCW Weißenstein Abb. 1

Seit der Entwicklung der Synthese von Wasserstoffperoxid und Einführung dieser Chemikalie in die Vorbehandlung von Textilien muß ein Bleichverfahren folgende Anforderungen erfüllen:

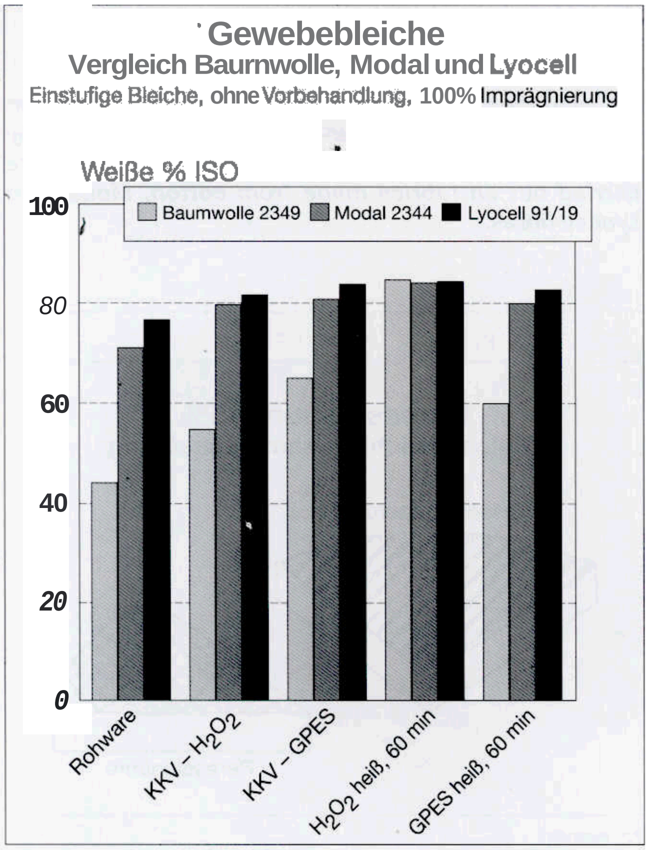
- hoher Weißgrad
- gute Weißestabilität
- gute Saugfähigkeit der Ware
- geringstmögliche Faserschädigung
- Wirtschaftlichkeit

Je nach Faserart sind die optimalen Bleichmittel auszuwählen. Aus Umweltschutzgründen wurden nur die chlorfreien Produkte Wasserstoffperoxid und Gleichgewichtsperessigsäure eingesetzt.

Peressigsäure ist eine farblose, charakteristisch stechend riechende Flüssigkeit. Sie ist ein sehr starkes Oxidationsmittel und bevorzugt eingesetzt wird sie heute im Bereich der Krankenhauswäsche zur chemothermischen Desinfektion im Waschprozeß. Bei Degussa Austria GmbH werden durch Einstellung eines chemischen Gleichgewichtes in einer Mischung aus Wasserstoffperoxid, Essigsäure und Wasser unter Mitwirkung von Katalysatoren und Stabilisatoren Gleichgewichtsperessigsäuren (GPES) mit Gehalten von 4 bis 40 Gewichtsprozent hergestellt. Für die Durchführung nachstehender Untersuchungen wurde 15%-ige Gleichgewichtsperessigsäure verwendet. Diese enthält in der Gleichgewichtszusammensetzung ca. 15% Peressigsäure und ca. 20% Wasserstoffperoxid (Abbildung1). Man bezeichnet dieses Verfahren auch als „saure Peroxidbleiche": Der Griff der gebleichten Ware ist besonders weich und die Faserschädigung gering. Eine Peressigsäurebleiche erlaubt das Erreichen einer besseren Weiße in einer nachfolgenden Bleichstufe und sollte als aktivierende Stufe vor einer Peroxidbleiche eingeführt werden.

In unzähligen Versuchen wurden Bleichsequenzen ohne Einsatz von Hypochlorit oder Chlordioxid (Natriumchlorit) d. h. nur mit H_2O_2 und/oder Peressigsäure durchgeführt. Eingesetzt wurde ein Baumwollgewebe 2349 mit einem Weißgrad von 44% ISO und einem DP-Wert von 2090. Von Lenzing AG zur Verfügung gestellt wurde ein Gewebe aus Lenzing Modal 2344 mit einem Weißgrad von 71% ISO und einem DP-Wert von 430 sowie ein Lyocell-Gewebe mit einem Weißgrad von 77 und einem DP-Wert von 520. Der Titer betrug 1,7 dtex. Die Gewebe bestanden aus Ringgarn Nm 50/1 und wurden gesengt und entschlichtet zur Verfügung gestellt. Die Weißgrade wurden ohne optischen Aufheller als % ISO bei 457 nm mit dem Zeiß Elrepho gemessen.

Abbildung 2 zeigt die Ergebnisse einstufiger Bleichen, die ohne Vorbehandlung als Klotz - Kaltverweilbleichen (KKV) mit 100% Imprägnierung bei Raumtemperatur und einer Verweilzeit von 20

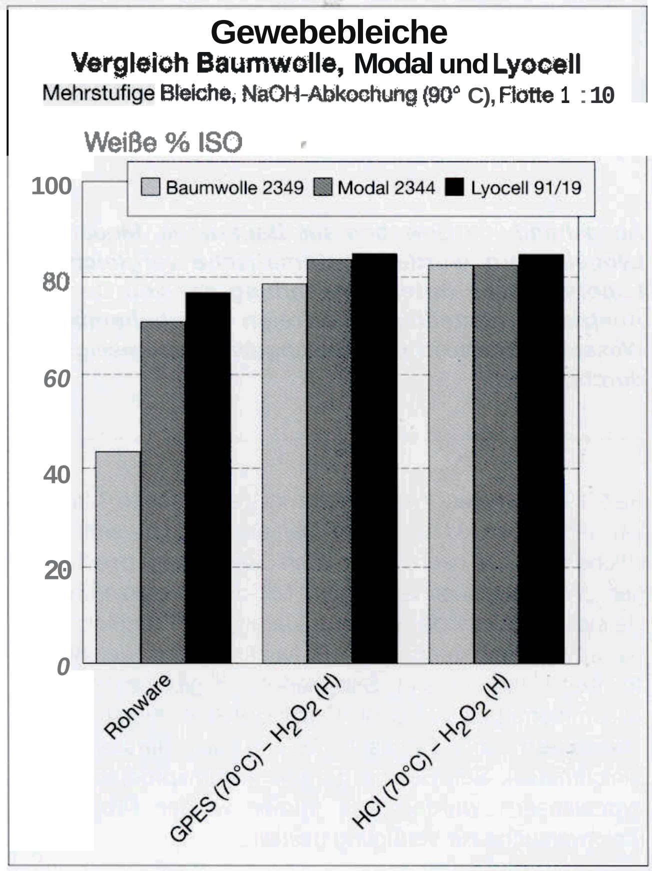


ÖCW Weißenstein Abb. 2

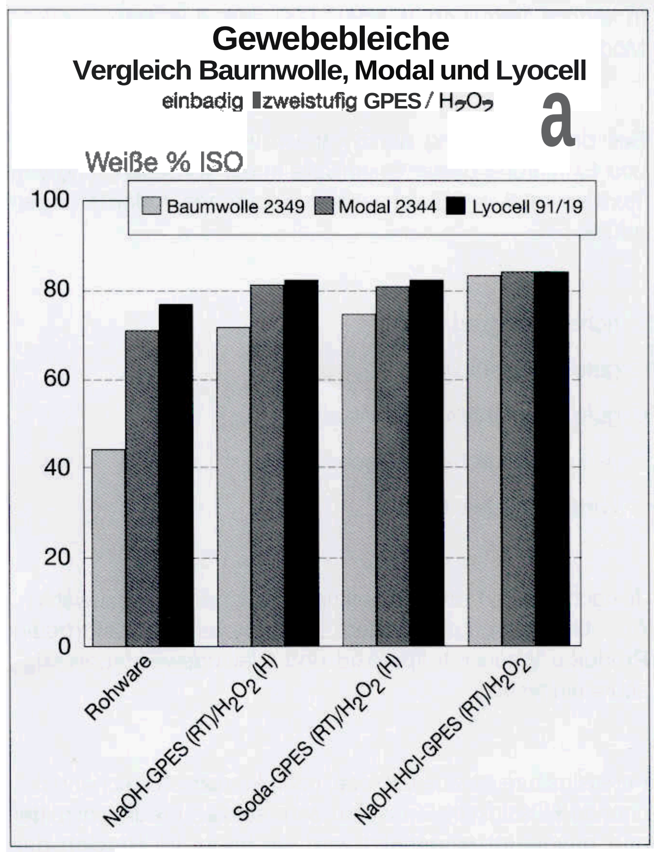
Stunden durchgefuhrt wurden. Mit dieser einfachen Technik kann bei den von Lenzing hergestellten Geweben aus Modal/Lyocellfasern ein WeiBgrad von 80/82% ISO mit H_2O_2 und 81/84% ISO mit GPES eneicht werden. Hinsichtlich des DP-Wertes wurden die besten Ergebnisse bei den Kalt-Verweiibleichen emeit und diese Techniken sind sowohl fur Gewebe aus Modal- als auch Lyocellfasern zu empfehlen.

Die Heißbleichen wurden bei 90°C *mit* H_2O_2 und 70°C mit GPES durchgefuhrt. Die Flottenlänge betrug 1:10 und die Verweilzeit 60 Minuten. Mii der H_2O_2 - Heißbleiche konnten bei alien Gewebendie höchsten Weißgrade von 84 + % ISO erreicht werden. Auffallend ist aber der bei dieser Behandlung auftretende starke DP-Wert-Abfall auf **1660** bei Baumwolle und 310/350 bei Modal/Lyocell. Mil einer GPES Heißbleiche wird diese Faserschädigung nicht festgestellt, bei Baumwolle und Modalgeweben werden aber auch nur Weißgrade von 60 bzw 80% ISO erzielt.

Der Weißgrad kann verbessert und der Verlust an Festigkeiten reduziert werden, wenn vor der Bleiche ein aikaiisohes Abkochen und eventuell eine Stufe mit Säure zur Neutralisation und Entfernung der Metalle durchgeführt wird. Bei den nachstehend angeführten mehrstufigen Bleichen wurde als erster Schritt eine Abkochung mit 1 5 ml/l NaOH *50%* bei 90°C und **30** Min Verweilzeit (Abbildung 3) und nachfolgend eine Säurestufe bei 70% und **30** Minuten Verweilzeit appliziert. Als Saure wurde in einer Versuchsreihe 1 ml/l GPES 15%, in der anderen Reihe Salzsäure verwendet, um einen pH - Wert zwi-



ÖCW Weißenstein Abb. 3



ÖCW Weißenstein Abb. 4

schen 5 und **6** einzustellen. Die folgende Bleiche mit 5 ml/l H_2O_2 bei 90°C ergibt Weißgrade, die vergleichbar denen sind, die bei den Heißbleichen erreicht werden. Durch die alkalisch / saure Vorbehandiung wird aber ein wesentiich höherer

DP-Wert bei den mehrstufigen Bleichen als bei den Heißbleichen festgestellt. Peressigsäure wiederum gibt höhere DP-Werte als Salzsäure. Mit mehrstufigen Bleichen, die nach der Sequenz - Alkali - Säure - Peroxid - durchgeführt werden, können Gewebe aus Modal- und Lyocellfasern auf Weißgrade von 83 - 85% ISO gebleicht werden. Bei Baumwolle erreicht man 79 / 83% ISO, wenn man HCl / GPES einsetzt.

Gleichgewichtsperessigsäure (GPES) enthält, wie in Abbildung 1 erkennbar, neben Peressigsäure auch noch Wasserstoffperoxid. In den folgenden Anwendungsbeispielen soll gezeigt werden, daß in einbadig / zweistufigen Bleichverfahren (Abbildung 4) beide in der GPES vorhandenen Oxidationsmittel, die ja auch verschiedene Wirkungen haben, in der Bleiche ausgenutzt werden können. Die Vorbehandlung mit Natronlauge, Soda oder Natronlauge / Salzsäure erfolgte wie bei den mehrstufigen Bleichen bereits beschrieben wurde. Die Bleiche mit GPES (3 ml/l) startete bei Raumtemperatur und dauerte 60 Minuten. Mit Natronlauge wurde ein pH-Wert von 5 - 6 eingestellt. Anschließend wurde die Bleichflotte erwärmt, mit NaOH auf einen pH- Wert von 10 eingestellt und mit 5 ml/l H_2O_2 aufgestärkt. Nach weiteren 60 Minuten Verweilzeit wurde die Bleiche im selben Bleichbad beendet. Mit dieser Technik wurde das Optimum an Weiße bei geringster Faserschädigung und DP-Wert Reduktion erreicht. Obwohl die zur Verfügung gestellten Gewebe sehr unterschiedliche Weißgrade hatten, konnte eine Endweiße von 84 bis 85% ISO erreicht werden.

Zusammenfassung:

Ausgehend von Geweben aus Baumwolle, Modal- und Lyocellfasern wurden systematische Laborversuche unter Verwendung der von Degussa Austria hergestellten chlorfreien Bleichchemikalien Wasserstoffperoxid und Gleichgewichtsperessigsäure durchgeführt. Es wurde beobachtet, daß Baumwolle, die eine deutlich geringere Ausgangsweiße hatte, mit H_2O_2 oder GPES auf das hohe Weißeniveau der Gewebe bestehend aus Modal- oder Locellfasern gebleicht werden kann. Mit den verwendeten Bleichmitteln können auch die von Lenzing zur Verfügung gestellten Gewebe ohne Schädigung auf höchste Weißgrade gebleicht werden.

PROPERTIES OF LENZING VISCOSE AND LENZING MODAL APPLIED TO FINISHING

Ing. Walter Schaumann, Lenzing AG

Lenzing AG is the largest fibre producer of Modal and viscose staple fibres in the world. The processer of Lenzing viscose and Lenzing Modal fibres has a wide selection of different spun fibre types to choose from which can cater for all types of textile designs and structures.

Lenzing AG ist der weltgrößte Hersteller von Modal und Viscose-Stapelfasern. Dem Verarbeiter von Lenzing Viscose und Lenzing Modal steht ein breites Spektrum an verschiedenen Spinnfasertypen zur Auswahl, die alle Möglichkeiten der textilen Gestaltung berücksichtigen.

I. Introduction

The history of fibres

Of the different possibilities to dissolve and spin cellulose the method developed by the Englishmen Cross and Bevan became most popular and was the method adopted by Lenzing. During the first World War with its shortage of raw materials viscose manufacturers discovered it was possible not only to produce filament fibres but also, by cutting the fibres into short staples, to create a substitution product for cotton.

The viscose staple fibre continued to be the recognised substitute for cotton up until the Second World War. Considerable improvements to the fibre, which Lenzing helped to make, boosted fibre prestige leading to its classification as a distinct species.

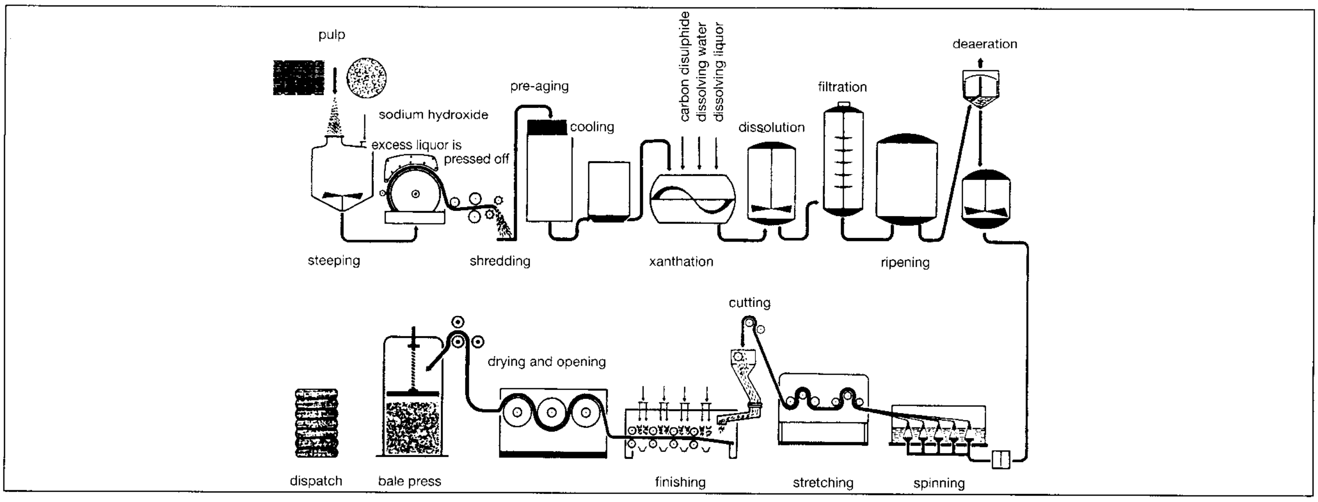
The generic term „man-made fibres" which today in the German language comprises both synthetic and cellulosic man-made fibres unfortunately creates a classification which distinguishes between viscose and Modal fibres with their natural properties and natural fibres in an insufficient manner.

Like cotton, viscose and Modal fibres are made of pure cellulose. To obtain these fibres natural wood pulp, which is not suitable for direct use on textiles, is converted in a controlled process to form longer fibres which compared to the pure natural product have the advantage of high homogeneity and programmable properties.

About 16 % of the global production of approx. 1,8 million to. of viscose staple fibres is covered by Lenzing AG including plants in Austria, USA, and Indonesia.

Lenzing is therefore the largest fibre producer of Modal and viscose staple fibres in the world.

The processer of Lenzing viscose and Lenzing Modal fibres has a wide selection of different spun fibre types to choose from which can cater for all types of textile designs and structures.



II. Except from the Fibre Programme

(for ring and rotor spinning

Normal crimp, super crimp, bright, dull, natural white and spun-dyed.

Fibre types – Lenzing Viscose

dtex \ mm	32	38/40	50	60
1,3		o		
1,7	o	o		
2,2			o	
2,8		o	o	
3,3				o

Other types are available on request

Available in different titres 1.3 - 5.5 dtex, both bright and dull, Lenzing Modal matches BISFA standards in its entire titre range.

Now 1.0 dtex Modal is also available in a bright form.

Today, both Modal and viscose fibres can be produced in spun-dyed form in a technologically mature process.

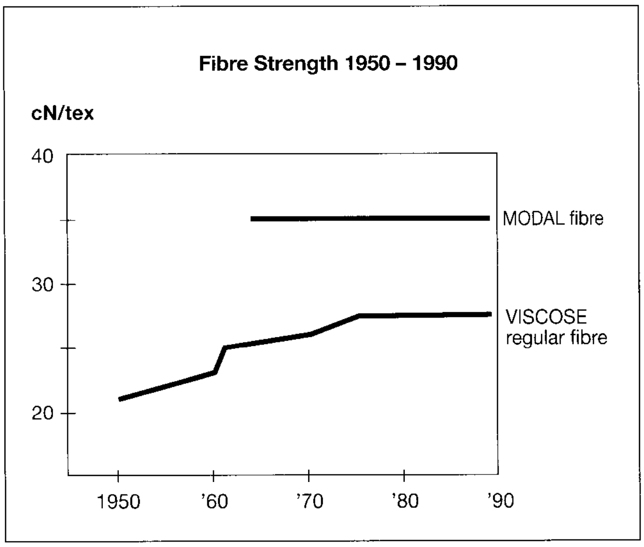
Fibre types – Lenzing Modal

dtex \ mm	32	38/40
1,0		o
1,3	o	o
1,7	o	o

Other types are available on request

III. Fibre Properties

Due to the improvements in the quality of normal viscose fibres over the last 25 years, the development of Modal fibres along with new machine concepts and finishing technologies, viscose and Modal fibres now boast a wide range of applications.



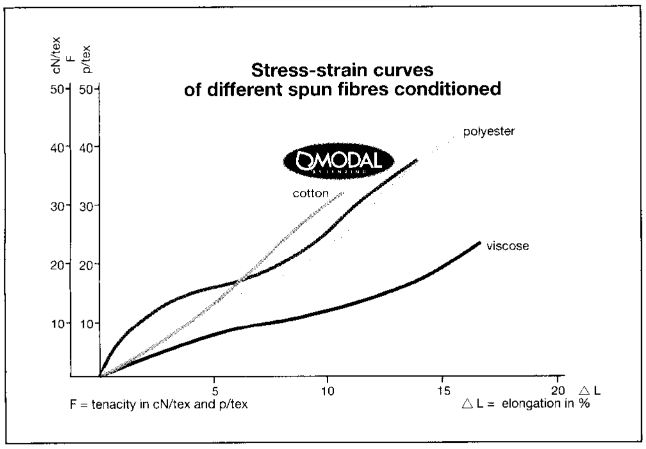
Certain limits should also be observed when processing today's generation of normal viscose fibres.

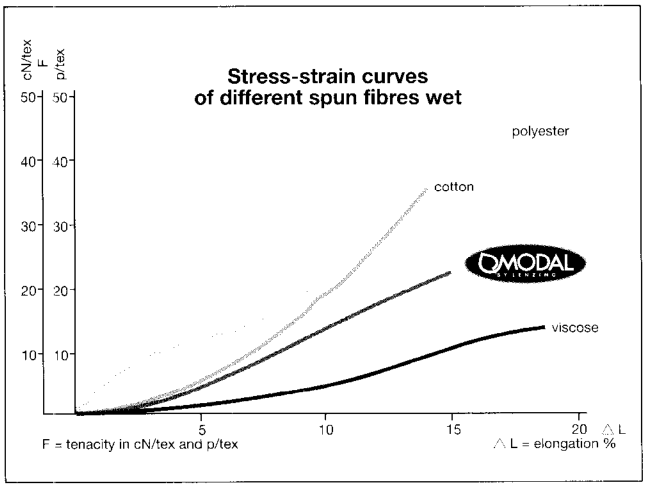
These limits are discussed below as are the different areas in which Modal fibres are superior to normal viscose fibres with respect to processing properties and utility values.

The difference between normal viscose fibres and Modal fibres is the result of the different raw material used and the different production process.

A spinning solution with double the amount of DP is used for Modal fibres; along with other spinning parameters, such as the composition of the spin bath, draw-off speed and the stretching ratio this leads to the production of higher quality fibres.

Compared to viscose fibres Modal fibres have a higher tenacity in both a wet and conditioned state, a higher wet modulus, lower water retention capacity, a low level of swelling and greater resistance to alkaline.

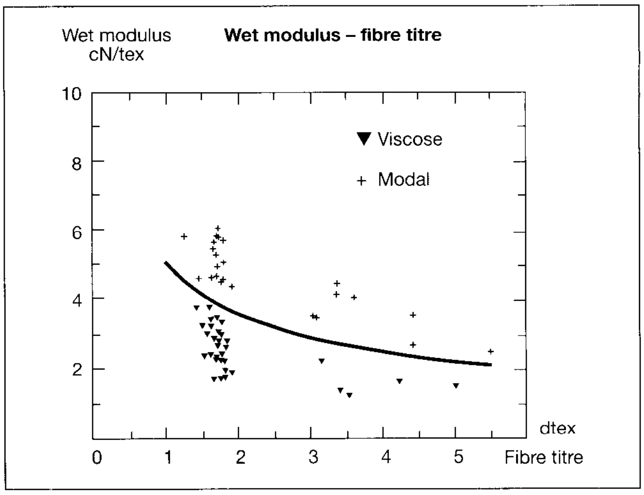




The tensile strength/elongation behaviour of Modal fibres is preprogrammed to suit the blending partners used i.e. polyester and cotton.

Wet Modulus

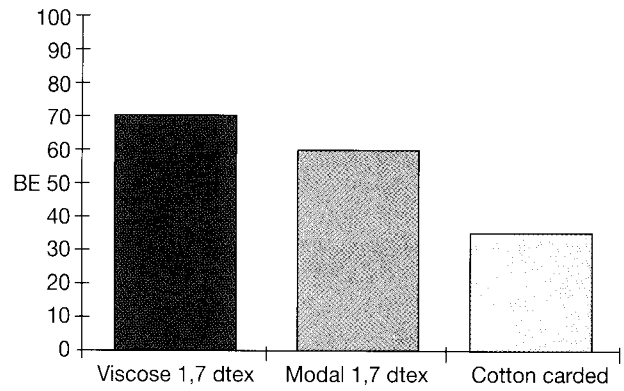
The following diagram shows wet modulus BM for regenerated cellulose fibres of different qualities and origins for titres 1.3 - 5.5 dtex, as a function of $B_M = 0,5\ \sqrt{T}$, as a separating line between normal viscose fibres ($B_M < 0,5\ \sqrt{T}$) and Modal fibres ($B_M > 0,5\ \sqrt{T}$).



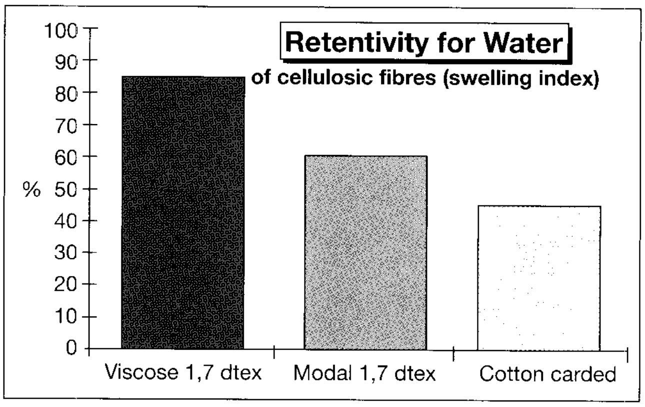
Thanks to their excellent properties these fibres have now been classified as a separate genetic fibre group according to BISFA regulations and must be labelled as such according to existing regulations.

Degree of whiteness - Purity

Viscose and Modal fibres are supplied in a pure state and with a higher degree of whiteness than cotton. Bleaching procedures are only required for completely pure white goods or pastel shades. Blends of Modal fibres and cotton require bleaching baths with a reduced chemical content.



Degree of whiteness
of different cellulosic fibres



Specific gravity

The specific gravity of cellulose fibres equals approx. 1.5. This and a relatively low yarn volume are the reason why yarn/plys do not float up as easily as acrylic. This must be taken into consideration when dyeing hanks, e. g. winding as short as possible and circulation of the dyebath.

Degree of polymerisation

To be able to produce spinnable solutions, the lengths of the cellulose molecules, which display a DP of x-thousand on the starting material i.e. cellulose, must be correspondingly reduced.

In the finished fibres the following DP values can then be determined.

Fibre Type	DP Value
Viscose	approx. 300
Modal	approx. 400
bleached cotton	1.600 - 2.500

Water retention value (Swelling index)

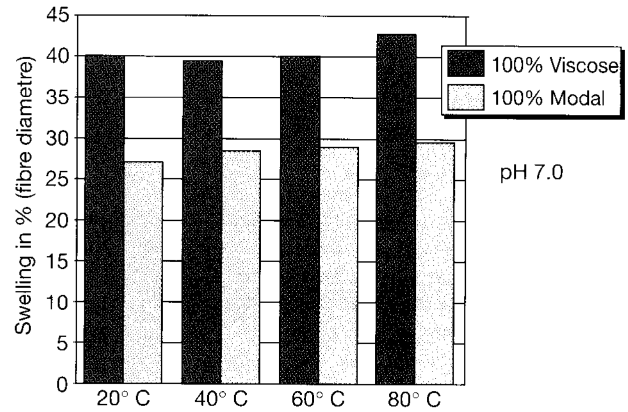
The water retention value of Modal fibres is closer to that of cotton (approx. 60 %) and thus clearly below that of viscose fibres (approx. 85 %).

This low water retention capacity represents a number of advantages when processing and utilising this type of item. One of these advantages is for example the low energy con- sumption during drying processes.

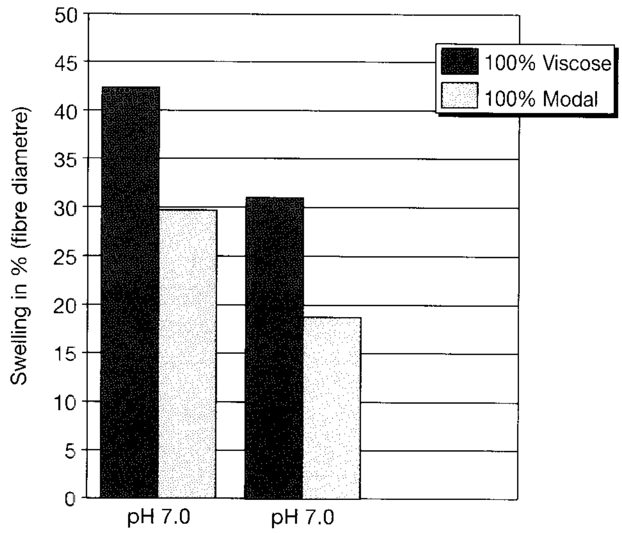
Fibre Swelling

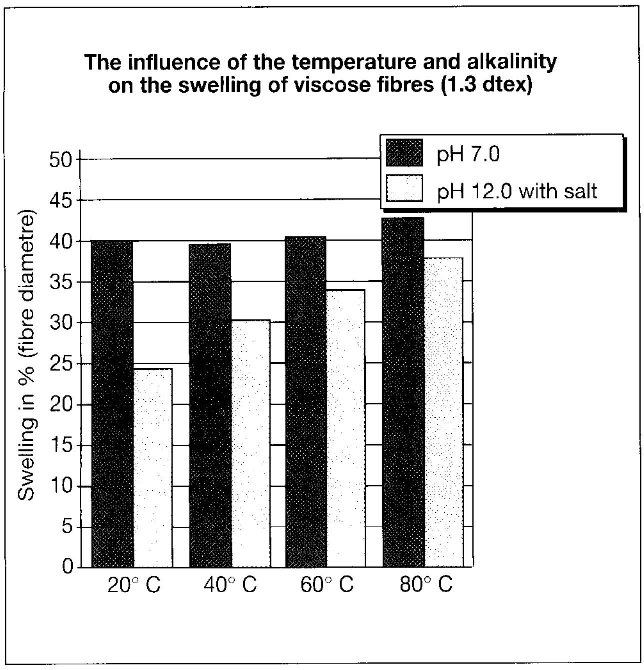
In watery substances viscose fibres tend to swell more strongly than Modal fibres or cotton. This swelling process happens very quickly and is almost totally finished after ten seconds in the lower temperature range.
The higher the temperature the more the fibres swell. The addition of salt leads to a reduction in the extent of swelling, the higher the rate of alkalinity in the dyebath, and at high temperatures in particular, the more this increases.

The influence of temperature on the swelling of viscose and Modal fibres (1.3 dtex, pH 7)



The influence of 50 g/l sodium sulphate on the swelling of viscose and Modal fibres (1.3 dtex, 80° C)





In their swollen state regenerated cellulose fibres can be formed to a certain extent. The term given to this is hydroplasticity.

Chemical resistance

Viscose and Modal fibres react both quickly and intensively on coming into contact with alkali and remain largely uninfluenced by normal chemical concentrations. Both fibre types can be strongly activated by a lye concentration of 4.5 % NaOH (7 °Bé) to such an extent that distinctly higher dye absorption results. While a concentration of 4.5 % NaOH (7° Bé) represents the upper limit as far as viscose fibres are concerned Modal fibres can in certain circumstances be treated with mercerising lyes of 17 - 22 % (24 - 28 °Bé).

Thermal stability

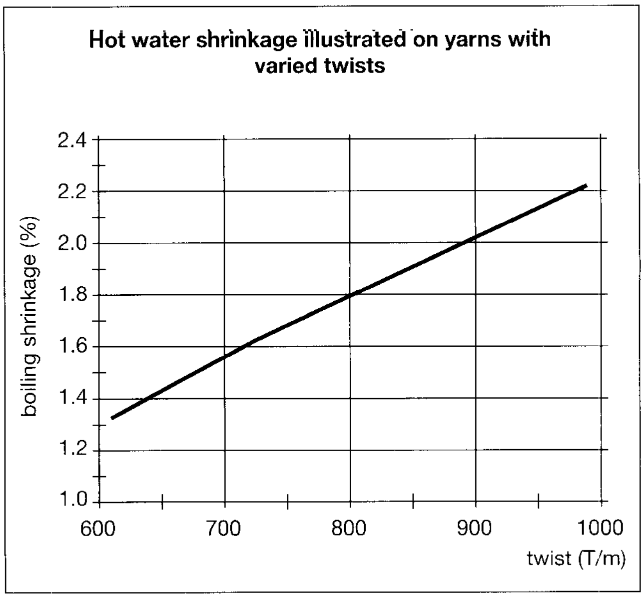
Viscose and Modal fibres are made of cellulose as is cotton and thus have no thermoplastic properties. Both fibre types can resist the temperatures and treatment periods used during finishing. The primary softener used on the fibres is not resistant to temperatures and turns yellow at temperatures over 100 °C. With bleached goods of polyester blends the thermal setting temperature should not surpass 180 °C. Above this temperature the degree of whiteness begins to drop. For the same reason higher condensation temperatures should also be avoided during finishing. Magnesium chloride is a good catalyst agent here.

Long reaction times at high temperatures dry out the fibres (hard crust). The normal moisture content of the fibres is thus impaired and the rate of moisture absorption is reduced which becomes visible in foulard processes in the form of wetting problems and in the form of tailing in dye processes in particular.

Shrinkage

Hot water shrinkage

Viscose and Modal fibres are delivered on the market in their final shrunk form. The changes in length in the semifinished and finished products are primarily the result of mechanical deformation occuring in the course of textile processing.



IV. General Instructions for Pre-Treatment

As with all textiles made of cellulosic fibres the best results - lustre/drape/handle - are achieved when all wet processes are conducted with low levels of pressure and stretching.
This is also true of Modal fibres which compared to normal viscose fibres, however, are a lot less sensitive.

Hot Water Shrinkage of yarns and fabrics

Processing Condition	Fibre Origin		
	Viscose	Modal	carded-cotton
Yarn/twisted yarn shrinkage (Hot water 96°C)			
Fibre fineness			
Ring yarn Nm 50	-2,0/-2,5	-1,5/-2,0	-1,5/-2,0
Ring yarn Nm 70	-3,0	-2,0	-2,0
Rotor yarn Nm 50	-2,5	-2,5	
Rotor yarn Nm 40	-2,5/-3,0	-1,5/-2,0	
Plyed yarn (ring) Nm 40/2	-3,5/-4,0	-2,5/-3,0	
Fabrics (warp shrinkage wash 60° C)			
Fabrics made of Nm 50 (Ring) Fibre titre **1,7 dtex**			
desized	-3,0	-1,5	
finished + sanforized (continuously)	-1,0	-0,5	
Fabrics made of Nm 50 (Ring) Fibre titre **1,3 dtex**			
desized	-5,5	-3,0	
finished + sanforized) (continuously)	-1,5	-0,5	
Fabrics made of Nm 70 (Ring) Fibre titre **1,7 dtex**			
desized	-12,0	-8,0	-6,0
finished + sanforized (discontinuously)	- 1,5	-1,0	+/-0

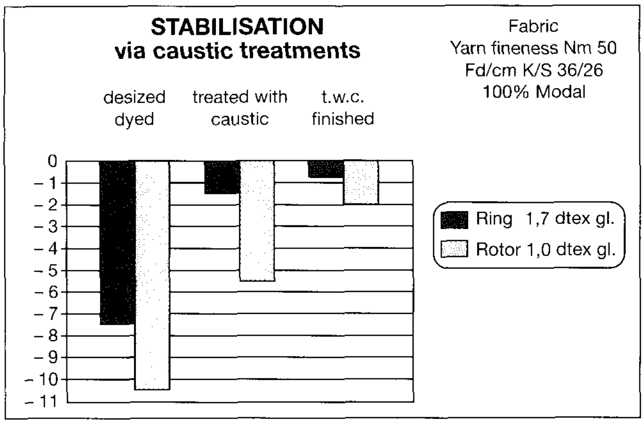
At the pretreatment stage the tension from the preliminary textile stages should be reduced i.e. the aggregates for washing or desizing should be constructed in such a manner that the fabric can relax when in contact with the treatment bath.

Due to the auxiliary agents applied to the various preliminary phases both knitted and woven goods made of 100 % Modal or viscose fibres must be cleaned and must be prepared for dyeing and/or printing.

For the pretreatment phase it is extremely important to know and check whether the warp ends have been waxed. If these have not been properly cleaned stripiness effects would appear in the warp. Taking these dangers into consideration it is normally better not to wax the warp after sizing.

Compared to normal viscose fibres the alkaline treatment of Modal can be more intense. With corresponding concentrations (6 - 7 °Bé) the dye yield can also be positively influenced.

At the same time caustisizing leads to an improvement in dimensional stability.



Recently various auxiliary agent manufacturers presented combined pretreatment processes for the preparation of printed goods in particular. These combine a number of previous goals including bleaching in one phase. The typical handle of Modal and viscose fibres plus their silky lustre are not effected by these substances.

Recipe

Pad cold with

5 ml/l	washing and dispersing agent (e. g. Ultravon GPN)
2 ml/l	solubilizing agent (e. g. Invatex CR)
8 ml/l	org. stabilizer (e. g. Tinoclarit CBB)
40 g/l	NaOH 100 %
10 - 30 ml/l	H_2O_2 35 %
10 - 16 h	batching time then hot rinse (tension?)

There is already enough experience to show that this rational method is just as well suited to the pretreatment of dye-goods.

Polyester Blends

Textiles made of polyester blends can be pre-treated as is the case with pure regenerated fibre fabrics i.e. treated with alkali. To stabilise polyester blends the polyester part in knitted goods is frequently set in a post-treatment phase, with blends made of fine-titre fibres pre-setting treatment is partly used to retain the handle.

Woven goods are normally pre-set or the setting takes place during the thermosol dyeing-process.

DIMENSION STABILISATION via addition of polyester

Batist Nm 70	% Warp shrinkage after 1 wash 60° C		
Blend ratio	Modal 100%	Modal/PES 67/33%	Modal/PES 50/50%
Treatment phase: desized, PES thermal set	8.0	3.0	3.0
finished	2.0	2.5	2.0
	sanforised	without sanforisation treatment	

In case subsequent finishing of the knitted goods is not intended, pre-setting leads to a slight improvement in pilling behaviour. Fabrics which are finished do not require this type of pre-treatment.

Cotton Blends

When pretreating normal viscose/cotton blends the low rate of wet tenacity and the greater sensitivity of the normal viscose fibres to alkali must be taken into consideration.

In addition, due to the dye properties of Lenzing Modal in blends with cotton it is possible to achieve better tone-in-tone dyeing effects than with blends made of cotton/viscose.

Thus Modal is used more often in this area.

Blends of Modal fibres and cotton are generally pre-treated like pure cotton i.e. boiled off, bleached and - if necessary - also mercerised. The chemicals added to the boiling and bleaching phases are reduced correspondingly depending on the share of Modal fibre.

Due to the high swelling propensity of Modal fibres in lyes of a higher concentration special guide-lines have been drawn up for mercerising cotton/Modal blends particularly with respect to blend, fabric construction and machine construction.

Optical Brightener

Whilst optical brighteners display a normal substantive effect on viscose, a selection must be made when dealing with Modal to obtain good yields comparable to that of cotton.

V. DYEING

1. The influence of fibre titre

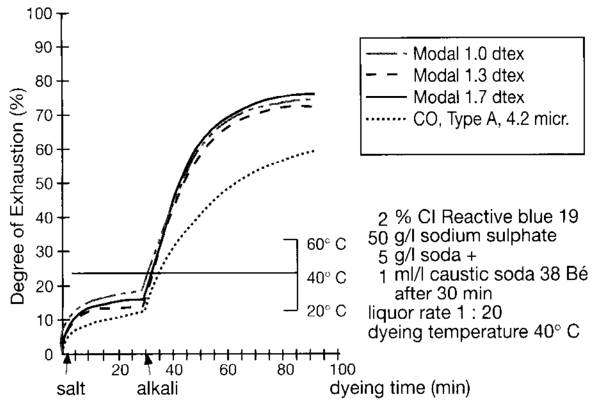
The clear influence of fibre titre on dye impression is ascertainable in exhaust method dyeing in particular. Here, Modal 1.0 dtex displays much lighter dye yields than Modal 1.7 dtex for example. Fibres with titres between 1.3 and 1.7 dtex also displayed differences in colour intensity for viscose or Modal.

Thus it is clear that viscose or Modal fibres of a different origin should not be mixed nor should different titres if the processer desires a homogeneous dyed fabric.

In pad batch dyeing the differences in colour between qualities of different viscose or Modal fine-titre fibres are slight.

The lighter colour impression is physical and is present in both natural and synthetic fibres the finer the fibres become.

Dye take up

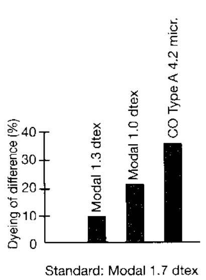


The influence of the Titre to the Remission-Behaviour

Quantity of Dyestuff 2%
Dyeing Temperature 40° C
Kind of Light D 65; 10

Dyeing difference – CIELAB Units

	ΔE	ΔL	ΔA	ΔB	ΔC	ΔH
Modal 1.3 dtex	1.82	1.14	–0.85	1.14	–1.14	–0.85
Modal 1.0 dtex	3.90	3.08	–1.78	1.60	–1.59	–1.79
CO Type A 4.2 micr.	6.45	4.84	–0.96	4.15	–4.15	–0.95



Standard: Modal 1.7 dtex

62 rem

2. Influence of delustering agents

Since only very small amounts of delustering agent are incorporated into the fibre these have no direct influence on the dye affinity of the viscose or Modal fibres.
The lighter dye impression of dull fibres compared to bright fibres is caused by increased reflection of the light rays from the surface area of the fibres, these light rays do not contain as much colour. So the low colour intensity is physical.

The different reflection behaviour of dull fibres results in different visual effects perceived by the human eye. To avoid different colour impressions these items must have a high rate of homogeneity. This is particularly true of yarn titre, yarn twist and number of threads in the fabric.

3. Tips on selecting dyestuffs

The dye behaviour of regenerated cellulose fibres will depend upon the dyestuff group, the dyestuffs, dyeing method, the type of fibre - i.e. normal viscose or Modal - and the fibre titre. Viscose and Modal fibres can basically be dyed using all dyestuffs suitable for cellulose fibres.

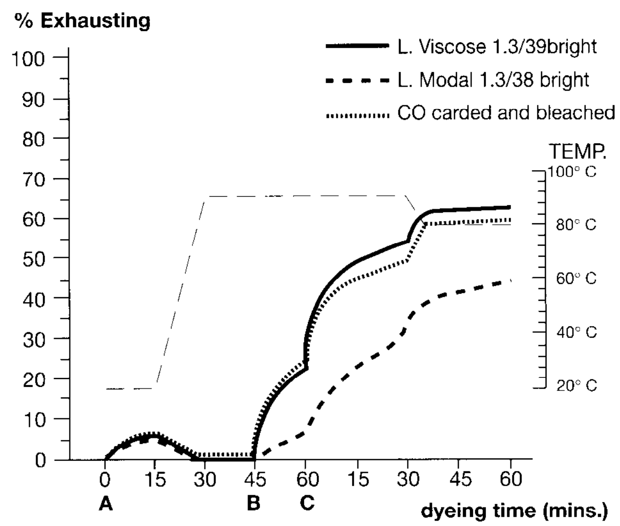
The following are often used:

direct dye-stuffs
reactive dye-stuffs
sulphuric dye-stuffs
vat dyes

and occasionally

leuco vat ester
indigo and
naphtol dye-stuffs

Direct dyestuffs reveal a comparatively higher affinity to viscose fibres and cotton than to Modal fibres. Only a few dyestuffs are thus available for blends of cotton/Modal which produce sufficient colour yields in the exhaust process and thus good tone-in-tone dyeing results on both fibre types.



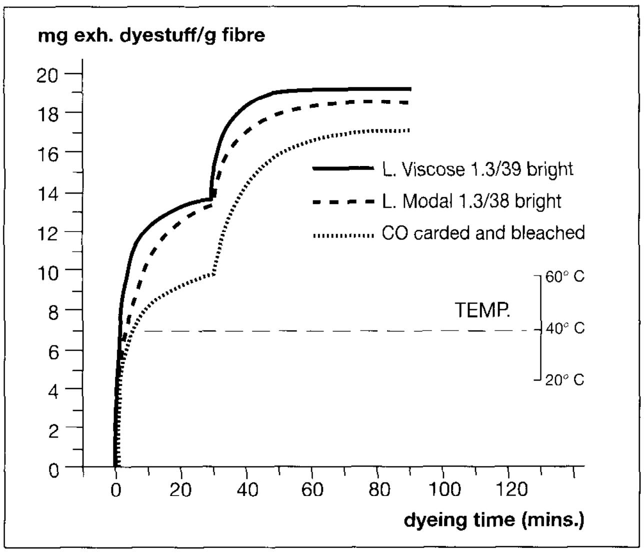
Rate of Exhausting: (Praxitext 100, without filter)

Dyestuff:	2 % Cl. Direct blue 244
Liquor ratio:	1 : 20
Salt:	15 g/l Sodium sulphate

A Dyestuff
B 1/2 Salt
C 1/2 Salt

Reactive dyestuffs mostly reveal higher absorption and fixation rates as applied to Modal and viscose fibres than in the case of cotton (exceptions occur in connection with phthalocyanine dyes). For dyestuffs with a higher fixation speed, alkali metering is recommended.

Rate of Exhausting: (Praxitext 100)
Dyestuff: 2 % CI. Reactive blue 209
Salt: 50 g/l Sodium sulphate calz. (from the beginning)
Alcaline: 15 g/l Sodium calz. (after 30 mins.)
Liquor ratio: 1 : 60
Dyeing temperature: 40°C continuos



The reactive dyestuffs are still well suited to dyeing blends with cotton since with the right dyestuff selection and in view of the processes available good tone-in-tone dye effects can be achieved in the exhaust and cold pad batch process.

Sulphuric dyestuffs

These dyestuffs which are still used frequently on ladies outerwear fabrics must be applied very precisely and handled carefully in the aftertreatment to avoid damage to the cellulose fibres. In the exhaust process the sulphuric dyestuffs tend to have a stronger affinity to the regenerated cellulose fibres than to cotton.

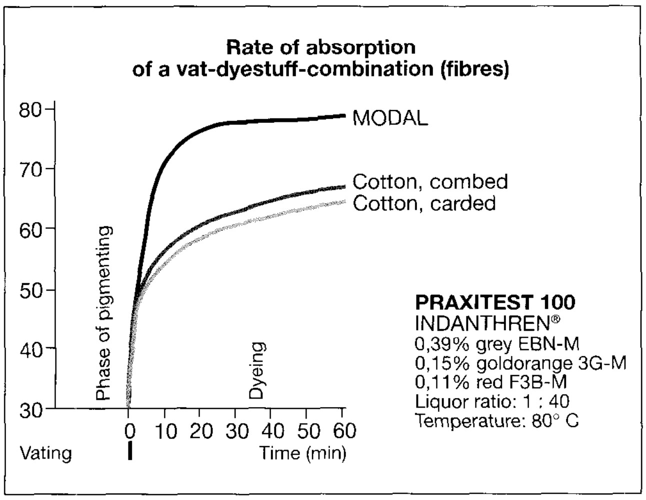
Vat dyestuffs tend to have a higher affinity with Modal and viscose fibres in the exhaust process than with cotton. Light shades in particular should thus only be dyed with the help of semipigment or pigment processes.

Leuko vat dyestuffs

These dyestuffs reveal a higher substantive effect on viscose and Modal fibres in the exhaust procedure than on cotton. In a continuous process the influence of the substantive effect of the dyestuffs is reduced so much that good tone-in-tone dyeing effects can be achieved with blends with cotton.

Indigo

Indigo too has a higher affinity to viscose and Modal than to cotton. Effects such as a "denim" effect can thus be strengthened in blends with cotton. The intensity of the wash-out effect is similar.



Naphtol dyestuffs

Clearer and partly lighter shades result on viscose and Modal compared to cotton. It is however possible to dye bright shades with good tone-in-tone effects and good fastness values using corresponding Naphtanilid combinations on blends of cotton/Modal as well.

4. The discontinuous dyeing process

4.1 Dyeing using dyeing apparatus:

Due to the high speed of dye take-up (and fixation speeds) it is recommended to work on full flooded dyeing apparatus with alternative dye bath circulation.

a) Yarn hanks:
Yarn hanks made from or with Viscose or Modal fibres - in the finer titre area in particular - tend to "stick together" when the dyebath is drained (i.e. after the pretreatment phase). This "sticking together" of the hank is partly irreversible and often produces unevenness in the colouring in the centre of the hank.

We recommend producing the hanks with the smallest diameter possible and operating with a higher pump capacity (which also helps lift the hanks away from the distance rods). Overflow rinsing prevents the hanks sticking together and helps to avoid unevenness and insufficient wash-off.

b) Yarn bobbins:
Conical cones:
The cones must be homogeneously wound to ensure an even dye result and in the same way, the bobbin edges should be carefully rounded off.

The winding hardness is maintained at approx. 25 Shore taking the relatively high swell of the material into account; this equals a volume of approx. 360 - 380 g/l.

Thus, the winding diameter (particulary with finer yarns) should be limited to 160 mm due to both the swelling of the material and the resultant dyeing problems whereby with yarn tubes of 170 mm a weight of approx. 850 g per cone is reached.

Cylindrical Cones:
It has become apparent that lighter dyeing results on the edges can be avoided with winding hardnesses of approx. 25 Shore and a pressure rate of 20 %.

Leakages which result from the shrinkage of the yarn tubes with cross-wound bobbins or from the sink of the bobbin columns with cylindrical laps can lead to uncontrolled dyebath leakages and can be reduced by the use of drop locking device.

The high water absorption and fibre swelling of viscose fibres - and to a lesser extent Modal fibres - mean these can be formed to a certain extent (hydroplastic). This means in practise that with dyebath circulation from the inside to the outside, the yarn layers are carried by the dyebath i.e. float and can thus be more easily dyed than is the case with circulation from the outside to the inside. In this case the yarn layers are pressed together by the dyebath flow and the dyebath throughput is reduced.

In order to compensate for this, the intervals are determined as 4/5 minutes for example capacity is tuned to the dyebath throughput and the affinity of dye stuffs the pump capacity is regulated so that the material would not be compressed.

Twisted Material is difficult to dye on cross-wound bobbins (deformations at the yarn cross points and insufficient dye penetration of the yarn cross points). Preliminary trials are to be recommended.

Attention:

These flow problems concern both dyeing itself and the distribution of the post treatment products to improve wet fastness. If these products are unevenly distributed this can lead to shade shifts between the inside and outside yarn layers.

4.2 Dyeing on Rope Dyeing Machinery:

The marked swelling of the material and the creasing tendency associated with this generally indicates a necessity to adapt a dyebath ratio of 1:20 on jet dye machinery. Heating and cooling the dyebath slowly also has a positive effect with respect to avoiding creases during operation. The addition of fold inhibitors is recommended for all processing bathes.

Medium-thick, thick (with the exception of towelling goods) and closely woven fabrics can scarcely be dyed on this type of machinery since the material tends to have crease marks. No restrictions of this nature are necessary for knitted goods.

The fabric rotational speed depends upon the fabric construction and on the affinity and reactivity speed of the dyestuffs. Constructions which are both open and sensitive to traction as is for example the case with knitted goods should have the lowest possible rotational speed to avoid hairiness of the fabric (and longitudinal stretching) caused by the dynamics of the dyebath and the conveyance of the fabric.

5. The Semi-continous dyeing process
The primary process here is the pad-batch process with reactive dyestuffs. This produces good colour yields on both viscose and Modal fibres whereby there are some limitations with respect to the application of phtalocyanin dyestuffs.

Prior to the dyeing process the material must be evenly cooled and display a residual moisture content of 10 %.

The machine assembly should be arranged so that an air passage is available after the foulard process to further swell the material. The winding device must operate without any tension and be equipped with a central drive. Friction winders can produce fabric shifts around the edges which could produce uneveness in the material.

The fabric speed must be kept constant whereby the contact time between the fabric/dyebath should equal more than 1 - 5 seconds (see VII/1c).

6. The Continuous Dyeing process

a) Pad dry:
Using this method it is not possible to achieve good dye yields for the quantities used with reactive dyestuffs on viscose and Modal. The use of air/vapour mixtures does not lead to a great improvement either. The colour yields remain in any case below the level reached on cotton.

b) Wet-steam
Up to medium shades selected reactive dyestuffs produce good and better colour yields on viscose and Modal compared to cotton for example.

In this range the colour yields are comparable with the yields obtained in the pad-batch-process.

The wet-steam process for example has proved suitable for terry fabrics made of cotton/Modal on machines with a Küster flexnip.

c) Pad-steam
The pad-steam process may be applied with either vat dyestuffs or reactive dyestuffs whereby the use of reactive dyestuffs should be limited to the blend cotton/Modal since there is a danger of frosting effects if this is used on fabrics made of 100 % regenerated cellulose fibres.

7. Spun-dyed fibre types:

Lenzing AG offers a number of colour shades in the viscose fibre types in particular. These spun dyed fibres reveal high - maximum fastness values.

Spun-dyed fibre types can generally not be qualified as fast against overdyeing procedures. Depending on the type of spin dye used their behaviour tends to differ. Thus not all dyestuffs are resistant to the reduction agent used when cross-dyeing with vat dyestuffs. In these cases preliminary tests are recommendable.

Lenzing AG is able to supply its spun-dyed fibres with the highest cross-dye fastness levels. These type of special conditions must however be indicated on the order. Spun black fibre types are in any case cross-dye resistant.

VI. END FINISHING

1. General Information

Cellulose fibres and regenerated fibre types in particular absorb relatively high amounts of water and swell to a lesser or greater extent.
Fabrics made of cellulose fibres reveal a low level of dimensional stability in their swollen state and a higher propensity to folds than in their dry state.

In order to stabilise woven and knitted goods made of cellulose fibres and increase the utility values of the fibres it is necessary to reduce the water absorption capacity of the fibres. This is achieved with the help of cellulose cross-linkers.

The type of cross-linker and additive to be used, with minimal formaldehyde or without formaldehyde, will depend upon the desired construction, effects and fashion requirements.

One important factor for ensuring the efficiency of the cross-linker is that the fabric should contain no alkaline and there should be sufficient time for the products to diffuse into the fibres and change with the swelling water already present there.

In the same way it is important not to dry the padded fabric at too high a temperature to prevent migration of the cross-linkers to the fibre or fabric surface. The latter would lead to surface concentrations of the cross-linkers which would be contrary to the effects desired i.e. the improvement of crease behaviour and have a negative effect on utility values e.g. abrasion behaviour.

2. Cross-link processes

With easy-care finishing methods higher cross-linker amounts are needed with viscose and Modal than with cotton to achieve comparable effects. Modal fibres tend to have more favourable behaviour than viscose fibres due to their specific properties. The higher cross-linker amounts lead to a corresponding reduction in abrasion resistance.

Compared to cotton, articles made of viscose and Modal fibres display much lower losses in tenacity due to this cross-linkage. No losses in tenacity result when the goods are given low-tension treatment in the proceeding stages.

The selection of the cross-linking process should be done taking shrinkage values for the ready finished fabric into account as well as the special requirements made of the finished article

Dry cross-linking is the process normally employed either in the form of shock condensation or with intermediate depository after the drying process. Articles which are stretched too intensively in the initial stages and thus have high shrinkage values can be sanforised at this intermediate stage followed by subsequent cross-linking.

To achieve good dimensional stability (shrinkage/lengths) remember that a final sanforisation process can only be effective up to a certain extent since the relatively flat surface and already cross-linked regenerated cellulose fibres cannot be compacted to the same extent as cotton.

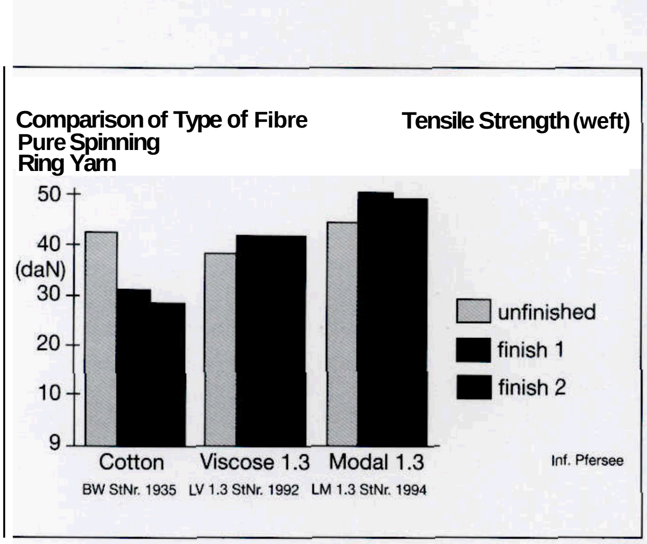
Example: With a shrinkage of 8 % after cross-linking and prior to the sanforisation process, compact to a residual shrinkage rate of *4* % to avoid elongation at the making-up stage or in usage.

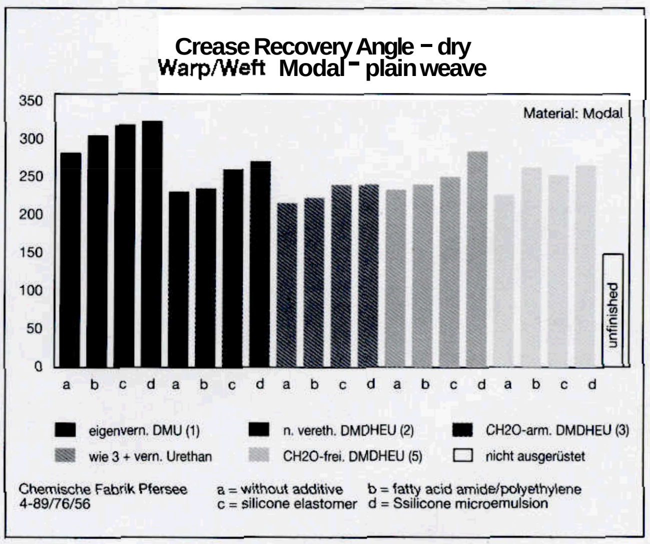
With shrinkage rates of 12 % and more after cross-linking the process should be switched to intermediate sanforisation. These type of shrinkage values - as already mentioned - cannot be limited permanently via a final sanforisation process and the fabric will extend when being turned at the making-up stage.

For items for which good abrasion resistance is demanded damp cross-linking can be recommended. This type of cross-linking is discontinuous and demands a high level of measuring precision with respect to residual humidity prior to intermediate storage. This is still one of the best ways of keeping the abrasion values at a good level.

3. The effect of different cross-linkers and additives

As shown in the following graph with the example of the crease recovery angle of a Modal fibre fabric (L1/1) it is possible to reach the level of a conventional reactant cross-linker using modified cross-linkers for finishes without a high level of formaldehyde or with none. The effects can be positively influenced by the addition of film formers and additives which provide handle.





VII. PROCESSING INSTRUCTIONS

1. General Comments:

a) Tension:

Starting with the winding process up to knitting, warping and sizing and all wet areas in the finishing process should be done by low tension.

In the pre-treatment of the woven goods remember that loom-state products may have a relaxation shrinkage of over 20 %. Thus it would be helpful to give the product a chance to relax the first time it comes into contact with water.

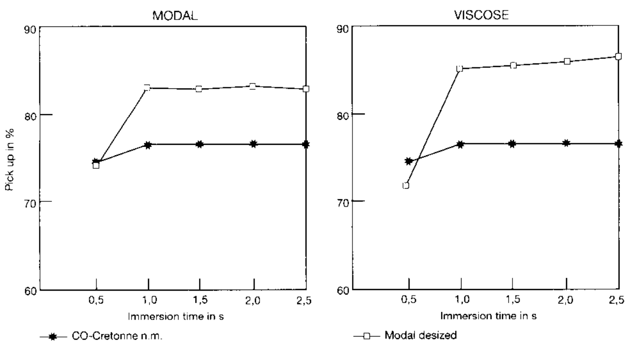
With knitted goods sensitive to tensile strength it is advisable to place the goods in a scray after the foulard passage and from there onto the tenter frame.

b) Drying:

To reduce tension still present or which has resulted at the individual finishing stages, articles made of regenerated cellulose fibres must in general be dried on pin stenters.

For good wetting properties the product should be dried to a residual moisture content in the area of 8 - 10 %. We recommend drying temperatures of 100 - 130°C. Excessive drying produces a danger of a hard fibre crust which could lead to a change in water retention capacity and the wetting properties of the products.

Influence of immersion time on dyebath pick-up



Source: Ciba Geigy

In foulard processes this has an effect on both dyeing and finishing results.
With intensive drying the substances to be found in the fibre tend to migrate.

Drum driers are not to be recommended for the reasons already provided. The goods are flattened by the cans and thereby lose their flowing handle.

c) Slop-pad:

First the water is drawn off of the regenerated cellulose fibres from dye and chemical baths, followed by large-molecular substances which usually take longer to diffuse into the fibres.

The contact time (dip to nip) for the goods in the bath should remain constant in the area of 1.5 seconds.

An air passage after the pad process promotes diffusion of the dyestuffs and chemicals on the one hand and gives the fibre time to continue the swelling process.
This is particularly important for the pad batch processes with a precisely regulated pick-up.

In combination with corresponding lap devices preferably those with adjustable direct drive, this avoids deformation, moirés and uneven dye results.

THE FINISHING BEHAVIOUR OF CELLULOSIC MAN-MADE FIBERS OF THE SECOND AND THIRD GENERATION

Talk held at AATCC Symposium, March, 20th – 21st, 1995
Reinhard Kampl, Walter Schaumann, Lenzing AG

The cellulosic regenerate fibers have come a long way. Cupro, acetate and Viscose fibers were developed more than 100 years ago. In this paper properties and finishing behaviour of cellulosic man-made fibers of the second and third generation are compared.

Die Celluloseregeneratfasern haben eine lange Geschichte. Die Entwicklung von Cupro-, Acetat- und Viskosefasern ist mehr als 100 Jahre alt. Dieser Aufsatz vergleicht Eigenschaften und Veredelungsverhalten von cellulosischen Man-Made-Fasern der zweiten und dritten Generation.

Introduction

The cellulosic regenerate fibers have come a long way. Cupro, acetate and Viscose fibers were developed more than 100 years ago. The use of high tenacity Viscose and Modal fibers shows that these cellulosic regenerate fibers have not only come a long way but are well-established nowadays.
By developing the solvent-spun cellulosic fiber „LYOCELL" the future has been transferred to the present.
This type of fiber - belonging to the third generation of cellulosic man-made fibers - enables the textile industry to expand its already wide range of applications in function and fashion even further.

Historic overview

Lyocell is the latest product amond the cellulosic regenerated fibers; its historical development is presented below (Viscose and Lyocell types)

1st Generation

1894	Large scale production of the first cellulosic filaments according to the Viscose process (Viscose Synd. Ltd./London)
1916	First production of Viscose staple fibers (Glanzstoff AG)
1950	Considerable tenacity improvements of Viscose staple fibers particularly in the years between 1950 and 1970 resulted in an extended application range

2nd Generation

ca. 1960	Development and production of Modal staple fiber types according to the Viscose process. Two different types: * High wet modulus - HWM * Polynosic Around 1970 the HWM type was prevailed on the European market - the US only produced HWM. The Far East produces Polynosic and Viscose.
ca. 1975/ 1980	Development of fine-denier Viscose fibers with higher tenacity
1986	Development of Micro-Modal (HWM)

3rd Generation

ca. 1980	Pilot plant development of the „Newcell"-process (AM. ENKA)
1987	License agreement Lenzing/Akzo Pilot production since 1990
1990	License agreement Courtaulds/Akzo Bulk production since 1992

Fig. 1

What are the differences in producing Viscose, HWM, or Lyocell staple fibers?

Process flow

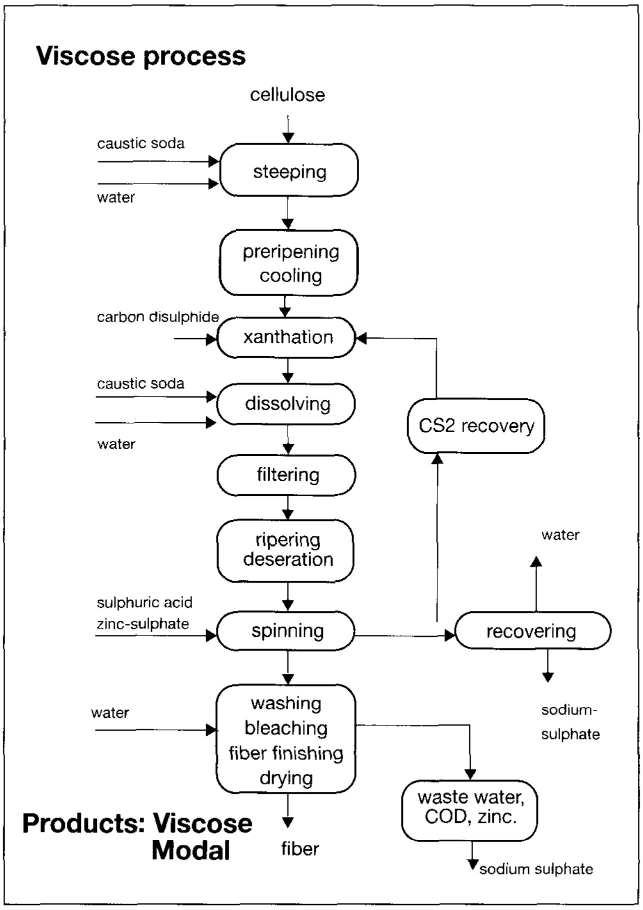


Fig. 2 a

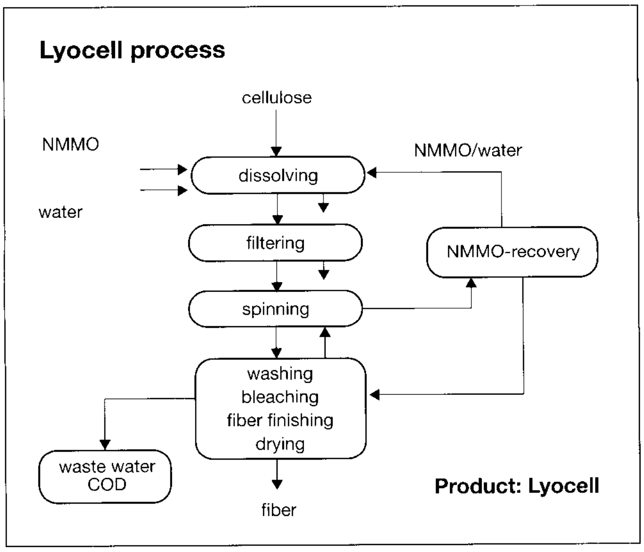


Fig. 2 b

The above chart shows that the Lyocell process includes considerably less production steps and that the tidious production of viscose spinning mass is avoided.

Due to the circulatory process, the Lyocell process is an essential relief for the environment (waste air and waste water). Based on its high recovery rates of over 99%, the Lyocell process is the most environment friendly process for producing cellulosic fibers.

What are the characteristic features for the various cellulosic fibers ?

Fiber Data

Titre 1,7 dtex	Viscose*	Modal (HWM)*	Poly-nosic	Lyo-cell**	Cotton 1,8 dtex
Tenacity cond. cN/tex	26	35	38	33	28
Elongation cond. %	18,5	13	11	14	10
Tenacity wet cN/tex	13	19	26	27	30
Elongation wet %	21	14	12	17	11
Loop strength cN/tex	7	8	5	16	20
Wet mod. cN/tex / 5 %	3	6	10	7	5

Table 1

*** Lenzing Fiber types**
**** Lenzing Lyocell is presently produced in a pilot plant. Above data is the goal for the 1997 large scale production.**

The fiber data - as well as the fiber properties in general - depend on the raw material used and on the production process.

Which fiber properties are important for processing cellulosic fibers ?

Important fiber characteristics for finishing

* Wet tenacity
* Wet elongation
* Wet modulus
* Dyeability
* Water retention capacity
* Fiber swelling
* Fibrillation

Fig. 3

Wet Tenacity

The wet tenacity is extremely important for processing cellulosic regenerate fibers. As presented on table 1 Viscose shows the lowest wet tenacity level. This means that for pretreatment and dying Viscose fabrics cannot be processed on machines which exert strong tensile stress on the material. Modal is considerably more stable, but the residual shrinkage values would also be too high.

Lyocell with a wet tenacity of 86% - 90% shows the highest wet tenacity level among the cellulosic regenerate fibers, and could be processed without any problems on such machines. However, due to fiber/fabric flattening of all cellulosic regenerate fibers caused by swelling, such processes should generally be avoided.

Wet Elongation / Wet Modulus

Viscose shows the highest wet elongation and, therefore, reacts very sensitively to tensile stress (slashing, weaving, finishing).

HWM Modal shows considerably better stability and lower work losses based on the higher wet modulus.

The wet elongation of Lyocell is approximately the same as for HWM Modal. Due to the much higher wet modulus of Lyocell these fabrics show an even better dimensional stability with about the level of Polynosic and cotton fabrics.

Dyeability

The following factors influence the dyeability of cellulosic fibers:

Influencing factors on dyeability of cellulosic fibers

* Fiber structure (skin / core)
* Orientation
* Cristallinity
* Fiber pore strucutre
* Inner fiber pore volume

Fig. 4

Influencing factors on dyeability of cellulosic fibers

In addition. dyeability depends on the dyestuff type (direct, reactive or other dyes) and its specific affinity to the various cellulosic fibers.

For example, direct dyes mostly show low affinity to the HWM fiber and therefore, this fiber clearty dyes lighter than for instance Viscose, Polynosic, Lyocell, and cotton.

With reactive dyes, however, the HWM type dyes darker than cotton, byt lighter than Viscose, Polynosic and Lyocell (blends will be briefly discussed later).

The latter fiber types show a high dye absorption speed and good dye yieid in ascending order of cotton, HWM, Viscose, Polynosic and Lyocell.

Better yields are certainly welcome, as such processes are more economic and less residual dyes are found in the waste water, which in return helps the environment. The high dye absorption speed will not be a problem with fabrics made of 100% Lyoceil.

Choose the dyestuff

Substantivity of different reactive dyes

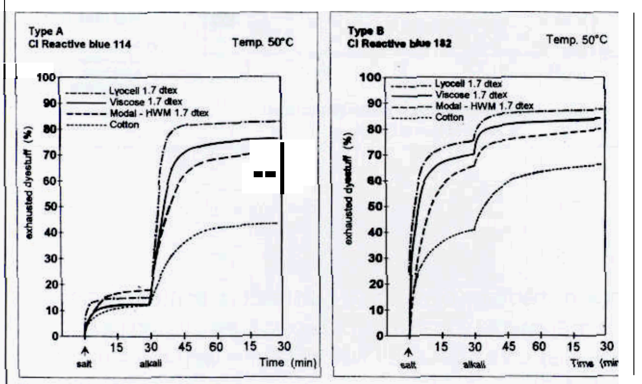


Fig. 5: SUBSTANTIVITY OF DIFFERENT REACTIVE DYES

That means with reactive dyes, those dyes can be selected which reach a good dye distribution in the substrate during the first phase of substantivity (see type „B").

In line with the state of the art, it is also possible to control the substantive application behaviour of reactive dyes by dosing salt and alkali in the dyebath.

With blends of various cellulosic fibers the high dye absorptiin speeds have to be considered somewhat differently.

When using the exhaustion process, it is only possible to dye fiber blends with similar affinity in order to obtain a satisfactory color tone and equal depth e.g. Lyocell/Viscose/Polynosic or blends of cotton/HWM Modal which are already traditional and show good solidity with selected reactive dyes.

In the pad batch process, which is less sensitive to differences in affinity, cellulosic fiber blends are more likely to show satisfactory results. (Color fastness with cellulosic regenerate fibers is very good and sometimes better than with cotton. With a very dark shade there may be problems with rubber fastness of such fiber types which show a lower affinity.)

Water Retention Capacity

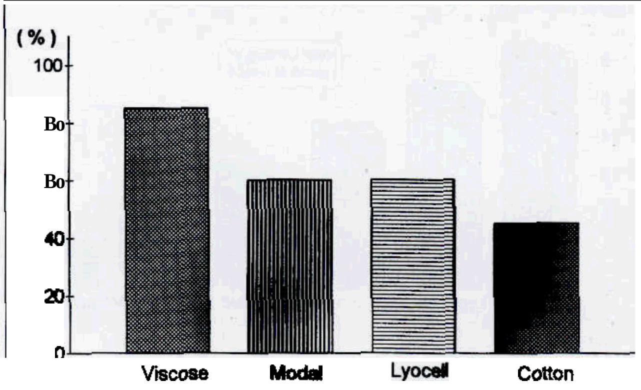


Fig. 6 WATER RETENTION CAPACITY OF CELLULOSIC FIBERS

Fig. 6

In general, the water retention capacity of cellulosic regenerate fibers is higher than that of cotton. For practical use this means that with ail Foulard processes. where dyes and/or chemicals are applied to the fabric, pick up has to be high enough in order to guarantee good diffusion and distribution of the products applied.

Fiber Swelling

Corresponding to the relatively high water retention capacity, the swelling of cellulose regenerate fibers is also considerably higher than with cotton.

In a swollen condition, these fibers show a less stability (reduced tenacity, increased elongation) and are thus to a certain degree hydroplastic, i.e. deformable. HWM, Polynosic, and Lyocell are clearly more stable than for example Viscose. Fiber swelling is, however, also very high. This fact should be considered in case of open width or rope treatments.

Proceeding on the assumption that Lyocell fabrics are often (at least) pre-treated in open width form due to their tendency for fibrillation, these treatments may cause the fabrics to feel flat.

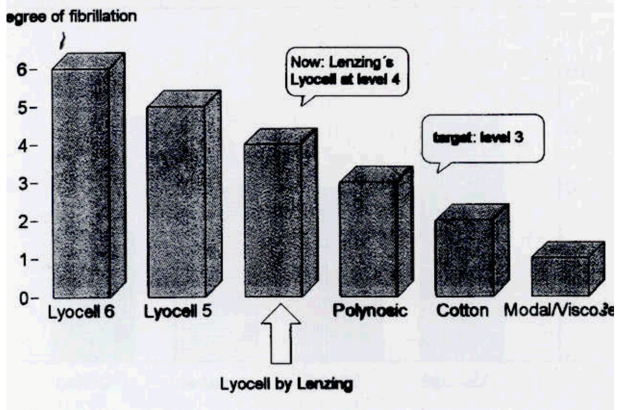
This means that in order to obtain a soft flowing hand, the wet treatment should also be carried out under low tension and with little pressure just as with Viscose or Modal fabrics.

Eased on the high swelling of cellulosic regenerated fibers and the resulting high wet stiffness, the dye bath ratio should be higher for these fibers than with cotton fabrics in rope treatments. The use of auxiliary chemicals for avoiding crease *marks* is necessary with these fiber types.

Fibrillation

The partly breaking open/coming off of the fiber surface along the fiber axis of cellulosic fibers is called fibrillation. The phenomena occurs when exerting strong mechanical influence on the fabric surface e.g. during bending, squeezing or rubbing while in a swollen condition.

Fibrillation



Flg 7 FIBRILLATION

Fig. 7

Whereas Viscose and Modal fibers only show a little tendency for fibrillation, this tendency is higher with Lyocell and Polynosic fibers.

As for Lyocell, the reason therefore is the high orientation degree of crystalline and amorphous fiber sections and a comparatively low bundling of crystalline parts. This leads to a decreased cross-sectional stability of fibers in the swollen condition.

Among others, the degree or the wet modulus, which can be put into the following order: Viscose, HWM/cotton, Lyocell/ Polynosic - is another indicator for the fibrillation tendency of cellulosic fibers.

For eliminating the fibrillation tendency and for largely stabilizing this effect - e.g. for home laundries - it is necessary to reduce the water retention capacity or the fiber swelling by applying cross linking agents.

Finishing

Contrary to Viscose, with HWM and Polynosic fabrics or, in particular with Lyocell fiber fabrics, only low quantities of low formaldehyde finishing agents ere necessary for obtaining the required fabric care properties.

Also, low quantities of resin are sufficient for eliminating the undesired fibrillation of Polynosic or Lyocell fabrics.

Since several cellulosic fibers are weakened by the chemical bonding of the resins with the cellulose, it is normally better to use the lowest amounts of resin possible to get the fabric properties desired.

Crease angle recovery

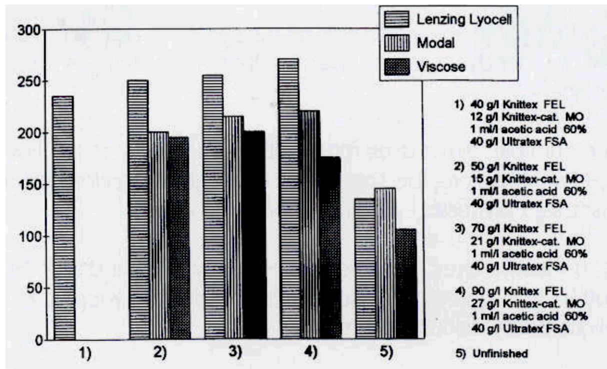


Fig. 8 CREASE ANGLE RECOVERY - DRY
(warp and weft 30 min.)

Fig.

Wash shrinkage - warp direction

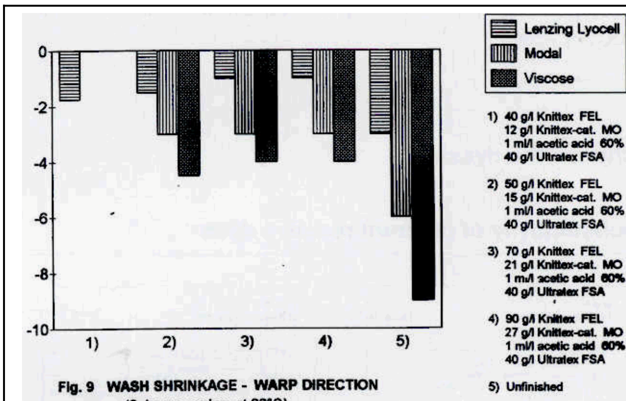


Fig. 9 WASH SHRINKAGE - WARP DIRECTION
(3 home washes at 30°C)

Fig

Modem chemistry provides us with reactive bonding systems for chemical agents suitable for cellulosic fibers, which help to produce easy care fabrics, as well as fabrics with low formaldehyde content.

Formaldehyde content (according to AATCC 122-1982)

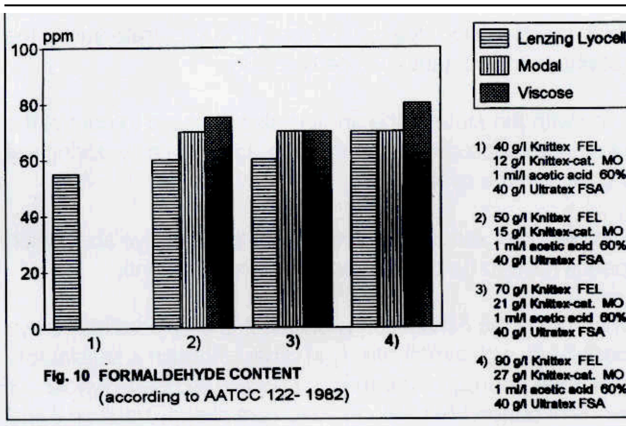


Fig. 10 FORMALDEHYDE CONTENT
(according to AATCC 122-1982)

Fig.

Machines / Processes

Fiber Characteristics

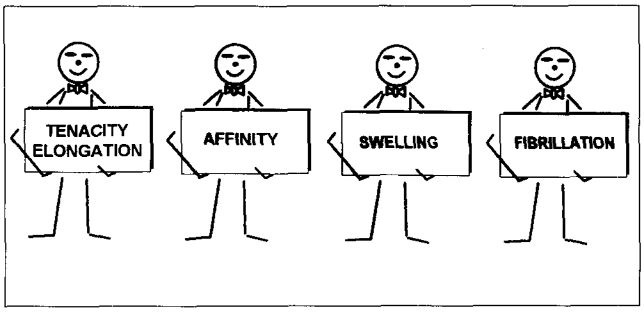


Fig. 11

Indications on possible processes for fabrics and knits of cellulosic regenerate fibers can be gathered from the characteristic fiber features. For woven Viscose fabrics we should select machines and processes which do not exert tension on the fiber. This is also recommended for the HWM type. With fabrics which are treated in rope form, we should try to use machines which transport the fabric with low mechanics and bath turbulence in order to avoid roughness of the fabric surface. (lint/hairyness).

The tenacity and dimensional stability of Polynosic or Lyocell allow the use of all processes. The fiber swelling and the tendency for fibrillation, however, are indicators for individual treatments.

The open width treatment of fabrics on conventional machines, where the fabric runs over rolls, would almost avoid fibrillation, but the fabric hand would be flat and unattractive.

Fabric treatments in rope form lead to the desired fabric fullness, however, result in irregular fibrillation effects if machines are used which do not ensure precise layering (opening) of the fabric. As can be seen in practice, this is only possible on airjet dyeing machines (e.g.: THEN Airflow). On this machine type, both regular fibrillation effects of medium degree or smooth fabric surfaces in case of subsequent treatment with enzymes can be obtained.

The fibrillation tendency of Polynosic or Lyocell currently presents an enormous advantage where fashion fabrics with vivid surface are in demand. Such fabrics can be produced by different ways.

For open width treatment, machines, which are normally used for subsequent washing of print fabrics or knits are well suited. This will result in good voulme fabrics with low fibrillation.

Lyocell finishing flow wovens - rope form

Grey Fabric
⇩
Desizing
(Open Width)
⇩
Rope Washing
(Primary Fibrillation)
⇩
Rope Dyeing
(Air-Jet)

Bio Polish **(Drying)**

Resin Finish **Second Fibrillation**
(Airo 1000)

Softening
Resin Finish

Fig. 13

Lyocell finishing flow wovens - open width form

Grey Fabric
⇩
(Singeing)
Desizing
⇩
Wash Off
(Sieve Drum)
⇩
Stenter Dry
⇩
Pad batch Dye
⇩
Wash Off / Softening
(Sieve Drum)
⇩
Jet Dryer
⇩
(Emery Grind)

Resin Finish **Tumbler**

Fig. 12

If intensive peach-skin effects and a very soft hand are desired, it will be useful to combine open width and rope treatments. Dyeing can still be done in open width form for such cases. In addition, also special after treatment machines are used such as AIRO 1000, THIES ROTO-TUMBLER, or THEN-AIR FLOW with HT-TUMBLE-MODULE for varying the fabric surface and the hand. Fabrics of HWM fibers require more intense and longer treatments for obtaining similar effects due to their low fibrillation tendency.

As largely known, knits have sensitive surface structures and often there is also the problem of the dimensional stability. Frequently knits without resin finish are further processed. Modal is especially suited for cases where such fabrics are purely used as washing fabrics - either in 100% Modal or in the classic blend with 50% cotton.

These fabrics, mainly dyed with reactive dyes, maintain their soft hand and color brightness after many washings.

Micro-Modal is used more and more for knits. This is true of ladies wear as well as for lingerie, where blends with fine cotton or combinations with spandex yarns lead to very soft and comfortable fabrics.

Conclusions:

- Viscose is a very good fiber and proved to be successful especially for fashion fabrics. Nowadays, it would be unthinkable to develop fashion fabrics without it.
- Modal - mainly the HWM type - conquered technical, as well as highly sophisticated fashion areas based on its special fiber properties and is considered to be the ideal blend partner for cotton.
- Lyocell is one step further in the development of cellulosic regenerate fibers with regard to increased tenacity and stability and opens up new applications for fashion fabrics due to its special hand and surface effects.

The extremely environmental friendly production for Lyocell fibers is the direction for the future and opens up prospects into a time where industry and environment coexist harmonically.

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PROCESSING BEHAVIOR AND APPLICATIONS OF LYOCELL

R. Kampl, H. Leitner, Lenzing AG

Experience with Lyocell has shown that this new fiber type offers various interesting ways for textile processing from spinning to finishing and on to the final product. The Lyocell fiber has a potential which is almost ideal for high performance processing throughout the textile industry.

Erfahrungen mit Lyocell zeigen, daß diese neue Fasertype vielfältige interessante Wege der textilen Verarbeitung vom Spinnen zum Veredeln und bis zum Endprodukt bietet. Die Lyocell-Faser besitzt ein Potential, welches praktisch ideal für Hochleistungs-Verarbeitungen in der gesamten Textilindustrie ist.

Since 1982 Lenzing AG has been working on various alternative methods for producing cellulosic fibers. After promising test results in the technical laboratories, a pilot plant with a capacity of 500 kg/day was established in 1989. Operation began in August 1990.

In the meantime, the initial capacity has been increased to 1200 kg/day.

At the end of October of last year, the Supervisory Board approved investment costs for a fully equipped Lyocell plant. In 1997, the Lyocell fiber, presently managed as individual business unit, will be available on the market with an initial capacity of 10,000 tons/year.

The capacity will gradually be increased to 20,000 tons/year.

What's new about this cellulosic fiber?

Lyocell, the name of the fiber type, is the generic name for this new cellulosic fiber type produced by dissolving wood pulp in an organic solvent. Unlike in other well known cellulosic fibers, the fiber is not formed by means of a derivative, but by directly dissolving wood pulp in organic solvents.

The formation of the fiber greatly differs from the production of conventional cellulosic fibers. Also, the fiber structure is very different. Comparative trials on regenerated fibers of the regular Viscose type and the Lyocell type were carried out in order to determine the characteristic properties of the new fiber.

This new fiber showed longer crystallites, less clustering of crystalline areas as well as shorter and better oriented amorphous sections. It could also be seen that the hollow area system and the inner surface were of importance.

The unique structure of this new fiber is probably caused by the new spinning mechanism.

Lyocell

- LYOCELL IS THE NAME OF THE FIBER TYPE ACCORDING TO BISFA FOR A NEW CELLULOSIC FIBER;
- IT IS PRODUCED BY AN ORGANIC SOLVENT SPUN PROCESS;
- ORGANIC SOLVENTS ARE TO BE CONSIDERED A MIXTURE OF ORGANIC CHEMICALS WITH WATER
- THE SOLVENT SPUN PROCESS IS TO BE UNDERSTOOD AS THE DISSOLVING AND SPINNING WITHOUT THE FORMATION OF A CELLULOSIC DERIVATIVE

Fig. 1

Apart from the fact that this new technology is very consistent with the environment, we would like to discuss in detail the excellent fiber properties, which gain more and more importance for the textile industry especially when applying high performance techniques.

The fiber tenacity is salient, exceeding the tenacity of high quality cotton fibers both in dry and wet conditions. Especially, the wet tenacity lying between 80% to 90% of the dry tenacity stands out from other cellulosic regenerated fibers available on the market.

The good dimensional stability and the excellent dyestuff absorption of textiles made of the new Lyocell fiber are further advantages.

Both, the absorption rate and the dye bath utilization are higher than with cotton or other conventional cellulosic regenerated fibers.

Comparing Stress Behavior
Lenzing Viscose/Modal/Lyocell

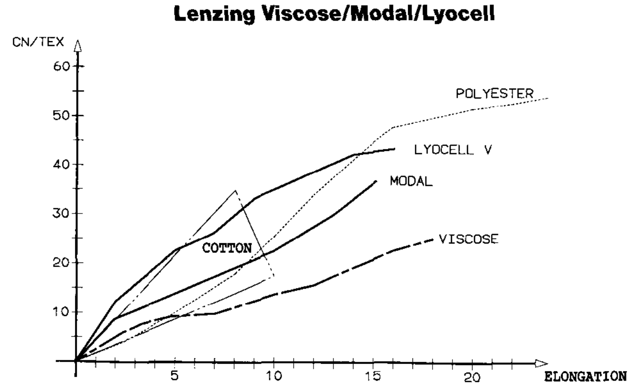


Fig. 2

It is evident that in some cases this advantage may cause problems with regard to regularity and when dyeing fiber blends. These problems can of course be solved – depending on the dyes and special methods used.

Based on the high orientation of the molecules in the longitudinal direction (crystallinity) this fiber type shows a tendency towards fibrillation.

Dye Bath Absorption
(Field Test 100, without filter)

DYE STUFF:	2X C/REACTIVE BLUE 204	
DYE BATH RATIO:	1 : 20	
SALT QUANTITY:	50 G/L SODIUM SULFATE AFTER 15 MIN.	
ALKALI:	6 G/L SODIUM CARBONATE AFTER 30 MIN.	
THEN FURTHER 60 MIN		
TEMPERATURE:	CONTINUOUSLY 60 DEGREE C	
FIBER TYPE:	LENZING LYOCELL	1.7 DTEX (1.3 DEN.)
	LENZING MODAL	1.7 DTEX
	LENZING VISCOSE	1.7 DTEX

Fig. 3

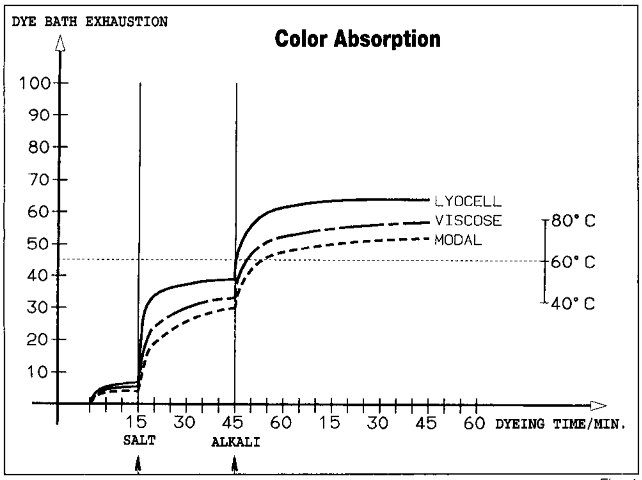


Fig 4

Fibrillation is the peeling off of fibrils along the fiber surface of individual fibers which have been swollen in water and which were exposed to mechanical stress.
Fibrillation is caused during the wet treatment when the rope form is used. For this reason the open width treatment is recommended for pretreatment as well as for the dyeing process of such textiles.

After special finishing with cross linking agents the fabric swelling is reduced to such an extent that fibrillation will no longer be caused when washed.

Comparing Fiber Data
Lenzing Lyocell/Modal/Tencel

		V LYOCELL	K LYOCELL	MODAL	TENCEL
FIBRE STRENGTH	dtex	1.7	1.7	1.7	1.7
TENACITY COND.	cN/t%	44	33	33	41
ELONGATION COND.		17	14	14	13
FIBRILLATION		5	3.5-4.5	1	5

Fig. 5

As the fiber properties strongly depend on the wood pulp used, we engaged in two fiber types, V-Lyocell and K-Lyocell.

The difference between the two Lyocell types mainly lies in the fiber tenacity and in the fibrillation. The K-Lyocell type shows lower fiber tenacity, which lies in the range of Modal, and less tendency for fibrillation.

It is very important to stay focused on the buyer's application and therefore, the product which is best suitable for the individual application should be offered to the customer.

Not every end-use will require the highest fiber tenacities which show the highest fibrillation, but it will be useful to select the fiber in accordance with the final product.

Lenzing is the world's largest Viscose fiber manufacturer and known for both, its good quality and for being a fair business partner where „value to the customer" is not a phrase, but an intend.

Spinning

Having discussed the fiber properties, I would now like to switch to the core theme of my paper: the processing behavior of these fibers.

Raw Materials and Trial Planning

We compared the 1.3 dtex/40mm (1.1 den/1 9/16") K-type Lyocell – i. e. the fiber type with less tendency for fibrillation and a comparable fiber tenacity to Modal – with our Modal and Viscose fibers of the same fiber tenacity and cut length.

The aim of the trial was to show the different yarn qualities obtained under similar conditions on high performance machines, which – as known – decisively influence productivity and quality when further processed.
The three different fiber types were processed under exactly the same conditions in prespinning and in ring spinning. In rotor and air jet spinning, the spinning alpha and the spinning agent had to be modified for rotor an air jet spinning due to the different fiber properties.

Comparing Fiber Data
Lenzing Viscose/Modal/Lyocell

		VISCOSE	MODAL	LYOCELL
FIBRE STRENGTH	dtex	1.3	1.3	1.3
TENACITY, COND.	cN/tex	25.0	32.6	32.3
ELONGATION COND.	%	18.1	12.1	12.3
TENACITY, WET	CN/tex	12.7	18.9	26.1
WET ELONGATION	%	52.5	58	80.8

Fig. 6

Spinning Preparation

In prespinning, all fiber types were processed into one sliver count Nm 0.20 (metric count) or 5.0 g/m with a carding performance of 30 kg per hour. "Good and comparable" processing behavior was observed in each case.

Then, drafter slivers with the same count, i.e. Nm 0.20, were prepared for ring spinning on high performance sections SB 851 and RSB 85.
Nm 0.33 sliver count was selected for the rotor and air jet yarns. Excellent processing behavior could be observed in each case.

On the flyer the preyarn fineness Nm 1.7 was spun in order to produce ring yarns with Nm 60/l later on.

Ring Spinning

In ring spinning, pre-yarns of the same fineness were spun to yarn of Nm 60/l with 19,000 rpm on a Zinser 319 with IMDS and PK 225 drawing system.
The output was 24.5 m/min., the ring runner velocity was 38 m/sec respectively. The processing properties of all three fiber types were good, however, the Lyocell fiber gradually showed higher break factors.

As the Lyocell fiber was a provenance produced on a pilot plant, it showed some coarse fibers and could not be compared with the Viscose and Modal fibers with regard to fiber purity.

Based on these coarse fibers all yarn regularity and purity values of Lyocell are slightly impaired regardless of the spinning process.

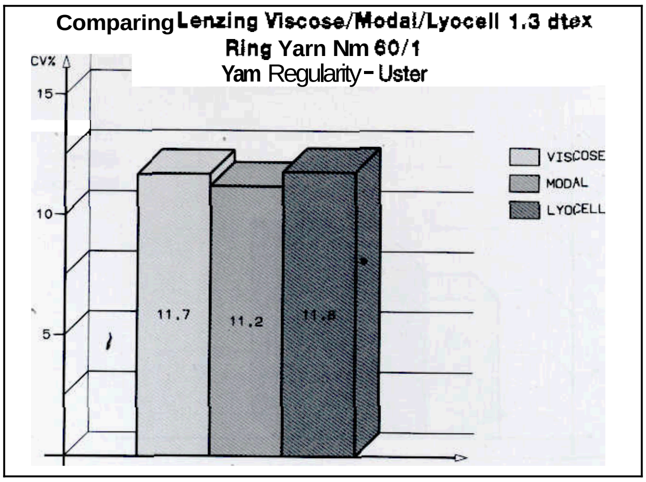
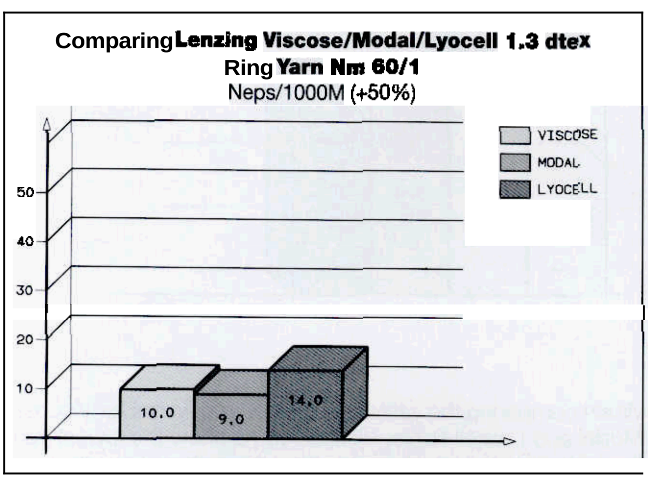
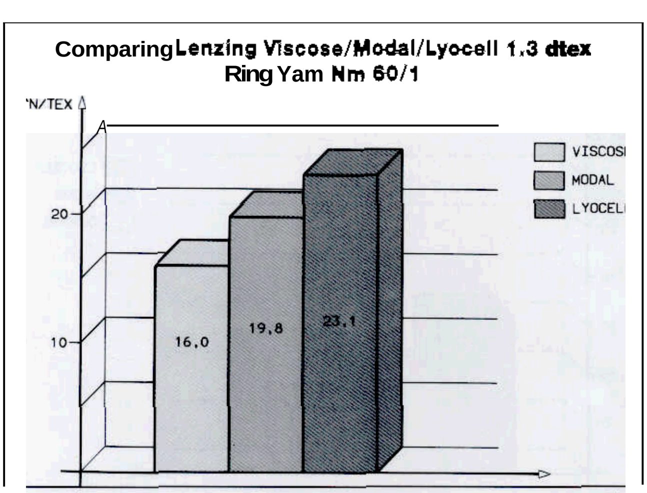


Fig. 7

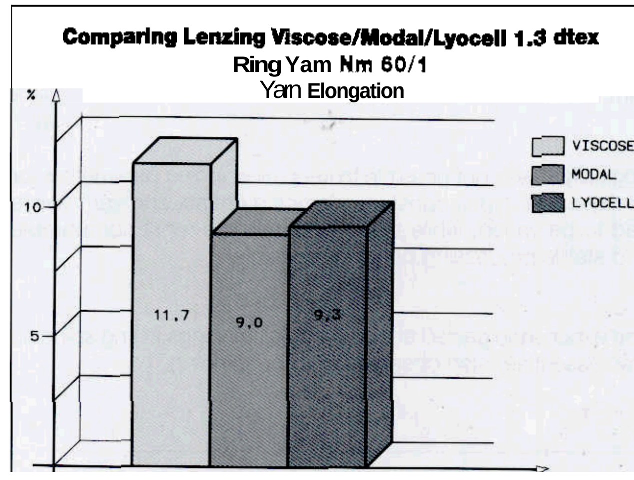
As to the uster yarn regularity, the Modal fiber showed the best value, however, bearing in mind that all fibers lay below the 5% line according to the uster statistics what in return presents an excellent standard.



With regard *to* the imperfections, we would only like to show the neps per 1000 m as a representative sample for all sizes. Regardless of the provenance none of the yarns showed thin areas The neps were in their tendency comparable to the thick areas shown above, where again Modal showed the best values.



Fig



The most decisive advantage of this new cellulosic Lyocell fiber, however, lies in its outstanding property of providing a considerable better material utilization than conventional cellulosic regenerated fibers. Therefore, much higher yarn strengths can be obtained with comparable fiber tenacities.

With regard to ring yarn, the material utilization percentage for all regenerated fibers lies at approx. 60% – 65%. while it is approx. 70 – 75% for Lyocell.
This clearly shows the difference between Modal and Lvocell. their fiber ienacities being comparable in this case.

As expected, the yarn elongations of Modal and Lyoceli are clearly lower than with the regular Viscose.

Rotor Spinning

As largely known, Viscose is a fiber tailored to rotor spinning. Almost 50% ***of*** the capacity processed in Europe goes into rotor spinning, where from the fine to the coarse yarns, from 100% Viscose to various fiber blends, anything is offered.
Modal has the advantage of being very similar to cotton and therefore, it is often spun to rotor yarns in cotton blends but also in 100%.

Great yarn qualities of any blends and types are offered and sold to a variety of end-uses.

The reason for this breakthrough of Viscose and Modal was that the tendency to fine fibers had fully started – what met very well with the high performance technologies – and that we had been able to offer fine denier fibers. Today, Viscose and Modal are spun to yarn deniers up to Nm 80/1 with performances up to 130 000 rotor rotations.

A fiber with the properties of Lyocell is ideal for continuing this tendency. **A** fiber with this potential is best suited for high performances. In the near future it will be possible to offer cellulosic rotor yarns with tenacities now found in synthetic yarns.

The results shown here were prepared together with the Institut fur Textil- und Verfahrenstechnik in Denkendorf (Institute for Textiles and Processing Techniques), as all three spinning technologies were available at the institute for the trials.

Based on practical experience from processing Lyocell in Europe and overseas, we may say that these fibers will reach comparable performances to Viscose and Modal in processing. Lyocell can be processed with very good results, both on an Autocoro by Schlafhorst or on a R1 by Rieter.

As already mentioned sliver of the count Nm 0.33 was prepared for all provenances. It was spun to yarn on a rotor spinning machine of the R1 type by Rieter with a performance of 120,000 rpm.

Logically, it was not possible to keep all spinning parameters for all three fiber types constant. Spinning agents and yarn twists had to be varied, while trying to obtain the most comparable and stable processing behavior possible.

The experience gained at comparable spinnings in ring spinning was essentially also observed in rotor spinning.

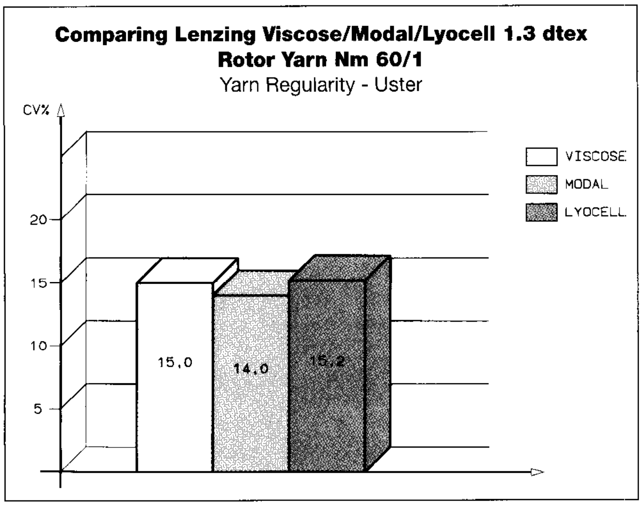


Fig. 11

With regard to uster regularity again Modal showed the best result. Both Viscose and Lyocell showed less favorable results on the same level.

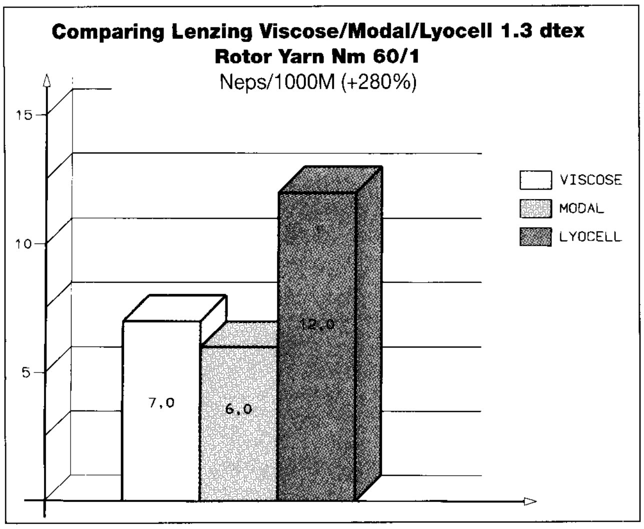


Fig. 12

As far as imperfections were concerned, the same tendency could be seen. Again, Modal came out best. As a representative example for all sizes, we would like to present the neps tested by (+280%) over 1000 m.

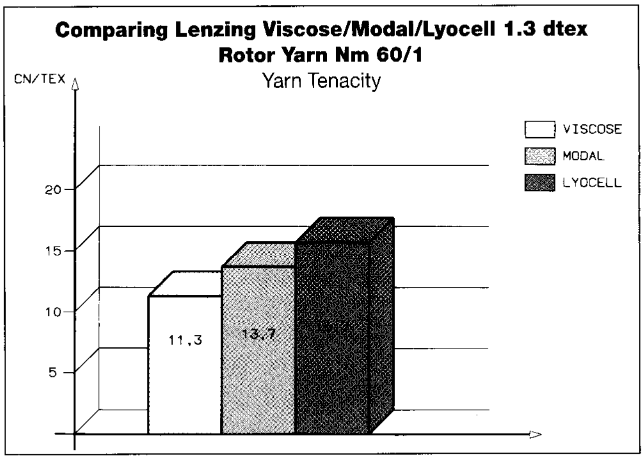


Fig. 13

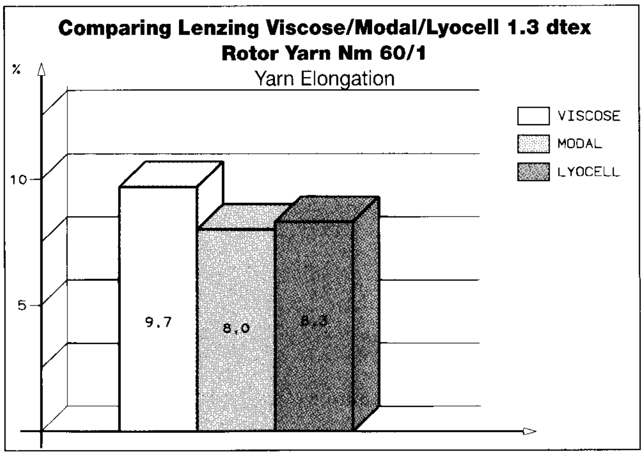


Fig. 14

When comparing the yarn tenacities of rotor yarns for Viscose, Modal and Lyocell fibers, Viscose yarns show the lowest yarn tenacities, while Lyocell yarns show the highest tenacities.

Like in ring spinning, it holds true that the material utilization of Lyocell is also higher in rotor yarns than in regenerated fibers and cotton.

The yarn elongations of rotor yarns confirm the results obtained in ring spinning. The viscose rotor yarns have the highest yarn elongations, while Modal and Lyocell yarns show considerably lower elongations.

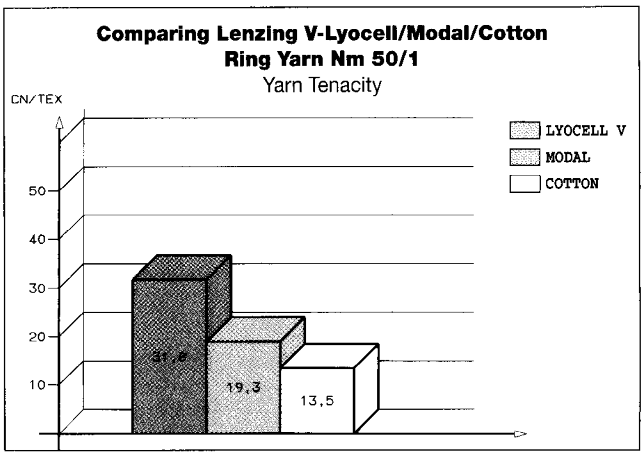


Fig. 15

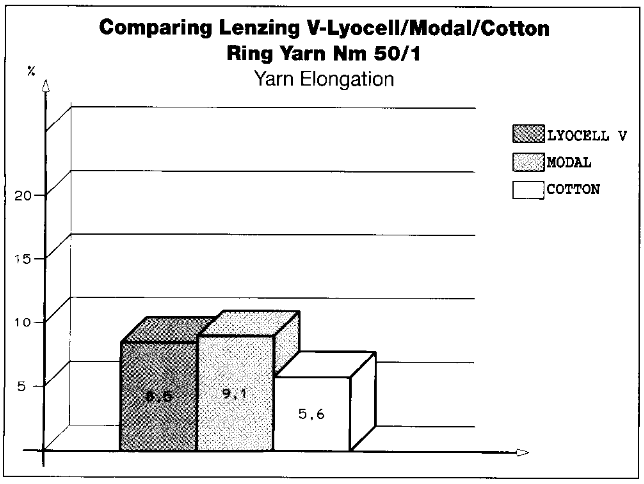


Fig. 16

Before discussing the air jet spinning technology, we would like to show you the ring and rotor yarn values obtainable with V-Lyocell.

These yarns were not spun during the trials at the Institut für Textil und Verfahrenstechnik in Denkendorf but are from our technical laboratories in Lenzing. The ring yarns were produced on a Zinser 330 and the rotor yarns were spun on the Schlafhorst Autocoro 240 SE9.

I would also like to mention that all yarns tests – also those of the actual trials discussed in this paper – were examined on the Uster Tester III and Uster Tensorapid in the laboratory. That means that all yarn values shown are absolutely comparable.

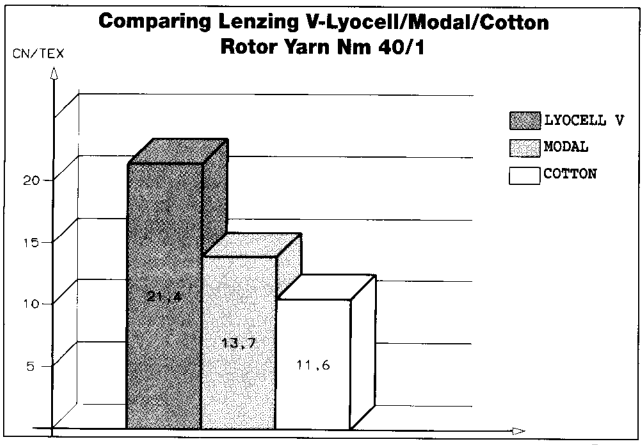


Fig. 17

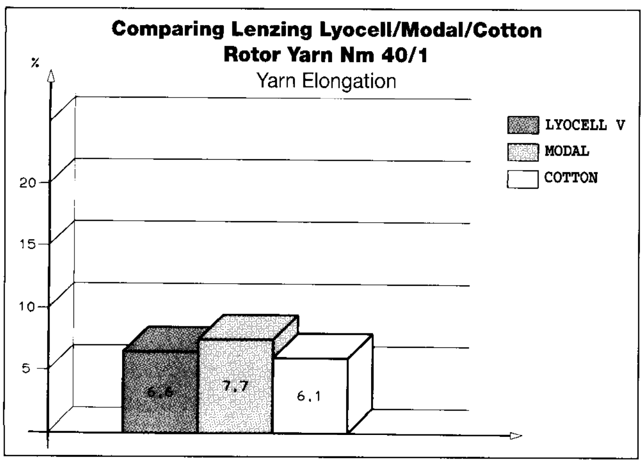


Fig. 18

The yarn strengths are conclusive not only for ring yarns but also for rotor yarns. The yarn elongations are also slightly higher than with the K-type Lyocell.

Air-Jet-Spinning

Apart from rotor spinning, the new air jet spinning technology has already been successful on the market. Especially in the United States, this technology is successfully used for synthetic fibers and its blends.
In air jet spinning, greatest attention has to be paid to the working ability of the fibers, fiber friction, and fiber purity.
Due to the bad fiber orientation and thus the bad material utilization of all the new spinning technologies compared to ring spinning, fiber tenacity plays a decisive role.

These requirements are perfectly tailored to the new cellulosic Lyocell fiber. We see a promising market potential as, apart from a few exceptions where Modal is used, practically no pure cellulosic fibers have been used for air jet yarns.
As mentioned in the beginning, here too, slivers with a count of Nm 0.33 were used for all comparable provenances.

The processing behavior of Viscose and Modal was very good. Lyocell showed excessive break factors based on coarse fibers.

Besides the processing properties these results clearly show the high performance potential of Lyocell.
The results obtained at comparable spinnings by using the ring and rotor technologies hold also true with spinnings on the air jet.

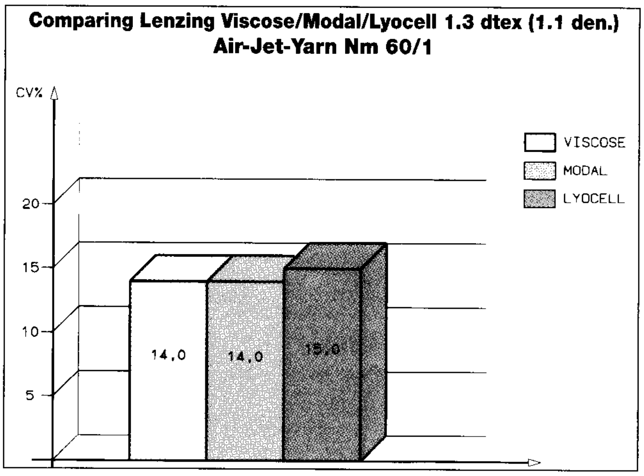


Fig. 19

Compared to the rotor yarns – the yarn regularities were better in all fiber provenances. This fact had been noted several times before and was presented in a paper on the occasion of an OE colloquium here in Eningen.
As we now see, it is also true for Lyocell.

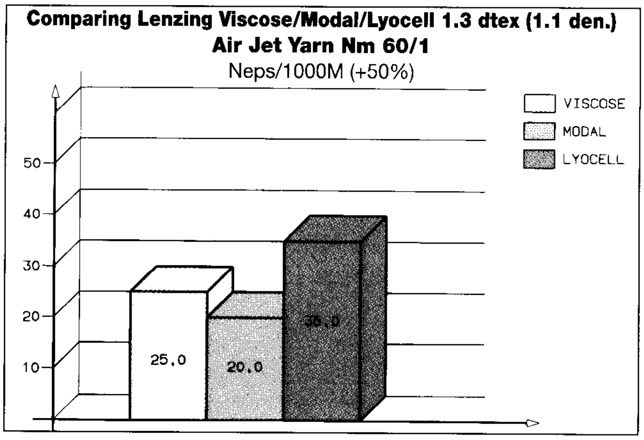


Fig. 20

The yarn purity of yarns spun on an air jet is higher than in rotor yarns. Again, the nep values are shown as a representative example for all imperfections.

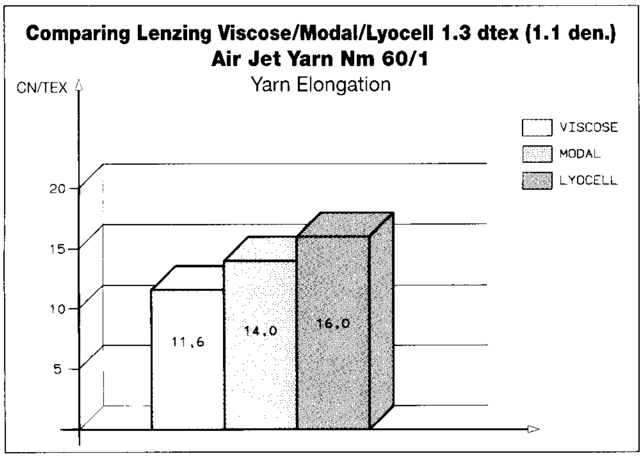


Fig. 21

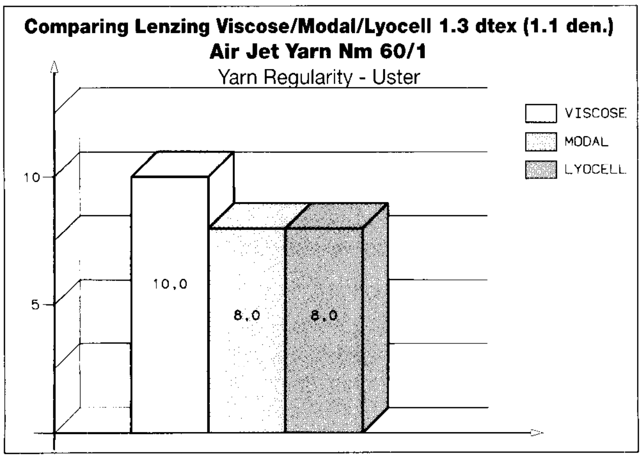


Fig. 22

Like in the ring and rotor spinnings, Lyocell shows the highest material utilization compared to Viscose and Modal.

Basically, the yarn elongations depend on the selected spinning parameters, they will, however, be found on the level of rotor yarns.

Fabric Manufacturing

Practical experience in processing Lenzing Lyocell showed that Lyocell can be spun with identical machine settings needed for Viscose and Modal fibers.
In individual cases it may be necessary to slightly change the settings according to the specific conditions of a plant.

This is also valid for processing Lyocell yarns in the weaving preparation such as warping, slashing, and weaving. Fabrics of Lenzing Lyocell are manufactured on air jets, projectile and grip weaving machines under high performance conditions and are offered and developed in a great variety of applications.

During our work we came across great interest on the part of our coustomers in developments of Lyocell fibers and yarns. Partly, this interest derives from the novelty of Lyocell.
We are, however, also convinced that the specific properties of these fibers, which recently have been documented in various publications, cause that interest.

- ○ High dry and wet tenacity
- ○ High dimensional stability in the textile area
- ○ High material utilization in the yarn
- ○ High loop tenacity
- ○ High wet module
- ○ Fibrillation

These are some of the parameters which drew the attention of the market to this new fiber type.

Besides applications in the technical, semi-technical, or non-wovens fields, Lyocell is mainly used in the apparel industry.

Due to the fibrillation, a specific fiber property of Lyocell, Lyocell fabrics are somehow predetermined for producing textiles with

- ○ a peach skin look
- ○ or a worn look.

This, of course, does not mean that textiles of Lyocell yarns automatically always fibrillate. For several final applications this would result in very negative effects for the fabric quality and in particular for the customer.

Fibrillation can be promoted or reduced by several parameters in spinning, weaving, and most of all in the equipment.

Low yarn twist, open fabric structures, high temperatures, as well as strong mechanical stress during dyeing and finishing are parameters which tend to promote fibrillation. High twist, more compact constructions, low mechanical stress together with low temperatures and specific finishing processes minimize fibrillation considerably.

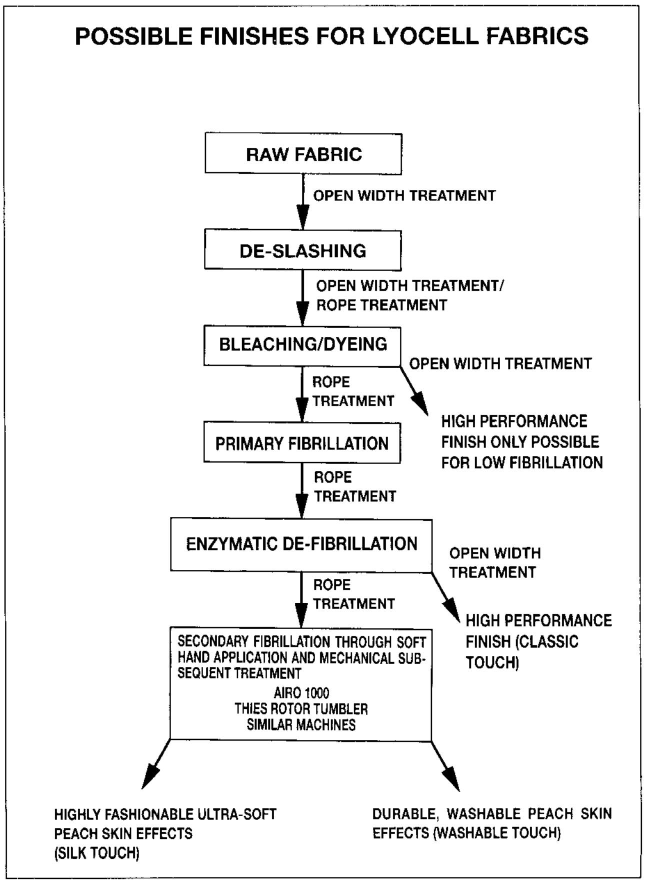


Fig. 23

Above figure presents a good survey on how to manufacture fabrics with a totally different hand or optics by modifying the finishing processes.

By combining different finishing processes and methods, it is possible to manufacture fabrics of Lyocell with a totally different hand and totally different optics.

The combination of open width and rope treatments with primary fibrillation and subsequent defibrillation with final finishing give textiles the clear fabric structure and the characteristic hand and flow of the Lyocell fabrics.

The secondary fibrillation in rope treatment with mechanical influence of the fabric surface on special machines e.g. Airo 1000 or in the Rotor Tumbler from Thies, however, results in textiles with specific surface effects such as silk touch etc.

An outstanding advantage of Lyocell textiles is the excellent dimensional stability even in critical applications.

Future washable fabrics are often treated with cross linking agents in order to eliminate the undesired surface changes during the use and care.

Based on the specific properties of Lyocell fabrics we see, among others, the following market potential:

Classical Apparel – Ladies Wear, Men's Wear, Children's Wear

Light weight up to medium weight, piece dyed, printed

Summer Dresses
Blouses – elegant
Shirts – elegant
Skirts – Suits
Pants / Coats

Fashion Apparel – Ladies Wear, Men's Wear, Children's Wear
Light weight up to medium weight fabric, yarn dyed, piece dyed, peach skin, garment washed

Blouses – Leisure
Shirts – Leisure

Denims

Knit Fabrics

Lingerie, Sleep Wear
Sweat Shirts

Home Furnishings

Damask Linens

Summary

- So far, our experience with Lyocell has shown that this new fiber type offers various interesting ways for textile processing from spinning to finishing and on to the final product.
- The Lyocell fiber has a potential which is almost ideal for high performance processing throughout the textile industry. We may speak of the fiber which guarantees synthetic properties in processing, while showing a wear comfort better than cotton.
- Lenzing Lyocell offers the level of dimensional stability which so far has only been obtained in blends of cellulosic fibers with synthetics.
- Lenzing Lyocell is the fiber best suited for creating emery effects, sand wash optics or the used look.
- Apart from the mere technological properties of Lyocell, also the ecological aspect of the fiber production should be positively emphasized. The recovery of the solvents used presents an advantage which makes this fiber type clearly superior to conventional cellulosic regenerated fibers.
- When the technological properties of this fiber are considered and are properly applied to the relevant end uses, Lyocell presents an enrichment for the textile industry.
- We are convinced that the current development level of the Lyocell fibers and products is only the beginning and that with increased availability of the Lyocell fiber the coming years will see many new textiles and product varieties on the market.

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MÖGLICHKEITEN DER LENZING-LYOCELL-FASER FÜR DEN KREATIVEN TEXTILVEREDLER

Vortrag gehalten auf der VTCC-Tagung in Baden-Baden, Juni 1995

Friedrich Brauneis, Lenzing AG

Die neue Lyocell-Faser bietet neue Fasereigenschaften, die von einer cellulosischen Man-Made Faser bisher noch nicht oder nur zum Teil geboten werden konnten. Dieser Vortrag behandelt die allgemeinen und spezifischen Eigenschaften der Lyocell-Faser sowie die daraus resultierenden Veredelungsmöglichkeiten.

The new Lyocell fibre offers new fibre properties, which have not or only in lesser amounts been found in other cellulosic man-made fibres. This talk deals with the general and specific properties of the Lyocell fibre and finishing possibilites resulting therefrom.

1) Lenzing-Lyocell Story[4)]

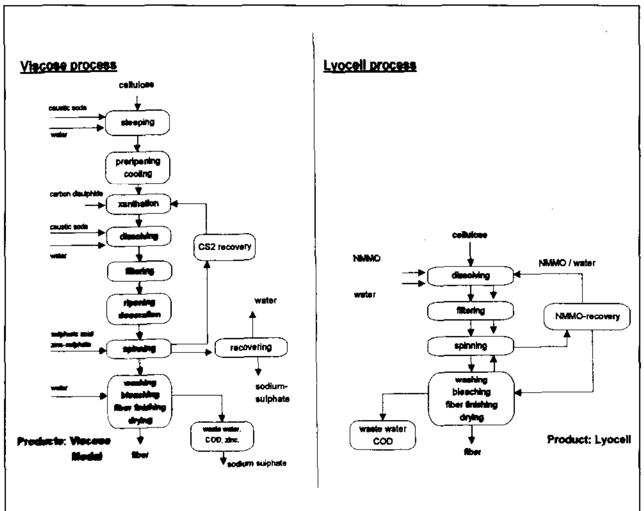
Ein neuer Prozeß zur Herstellung von Cellulosefasern

Motiviert durch die Suche nach neueren Verfahren, die einen Quantensprung hinsichtlich Ökologie und Produkteigenschaften darstellen, begann im Jahre 1986 der weltgrößte Faserhersteller - die Lenzing AG - mit der Entwicklung einer neuen Cellulosefasergeneration.

Diese Entwicklung basiert auf den grundsätzlichen Entdeckungen[1, 2, 3)], daß Aminoxide in der Lage sind Cellulose aufzulösen und somit einem speziellen Spinnverfahren zugänglich sind.

Nach Lizenznahme der weiterführenden Basispatente von Akzo entwickelte die Lenzing AG das Verfahren weiter und betreibt seit 1990 eine Pilotanlage deren momentane Kapazität etwa 400 to pro Jahr beträgt. Mit dem Bau einer Großanlage, Kapazität 20.000 JaTo, wird im August 1995 begonnen. Die geplante Inbetriebnahme der Großanlage ist für Beginn 1997 vorgesehen. Der Vergleich zwischen dem Viscoseprozeß und dem Lyocell-Prozeß zeigt, daß beim Lyocell-Verfahren wesentlich weniger Schritte und Chemikalien beherrscht werden müssen und das Lösungsmittel sowie das verwendete Wasser nahezu vollständig im Kreis geführt werden können.

Lyocell- Viscose Prozeß



Grafik 1

Was ist Lenzing Lyocell?

Die BISFA hat für Lyocell einen Gattungsbegriff eingeführt: Eine Cellulosefaser, die durch ein Lösungsmittelspinnen mittels eines organischen Lösungsmittels erhalten wird:

1.) ein „organisches Lösungsmittel" ist im wesentlichen eine Mischung von organischen Chemikalien (im Falle des Lenzinger Lyocell-Verfahrens handelt es sich dabei um N-Methylmorpholin-N-Oxid und Wasser).

2.) „Lösungsmittelspinnen" ist die Lösung und das Spinnen ohne die Bildung eines Derivates.

Nach der Entwicklung von Viscose-, dann von Modal-Fasern könnte man die Lyocell-Faser als dritte Generation der cellulosischen Man-made Fasern bezeichnen.

BISFA cell. Man-made Faserdefinitionen

Definitions of Viscose, Modal, Cupro, Lyocell, Acetate and Triacetate Staple Fibres and Tows

Generic Name	Constitution of Polymer	Typical chemical formulae of characteristics
Viscose	Cellulose II	Cellulose fibre obtained by the viscose process
Modal	Cellulose II	Cellulose fibre having a high breaking force and a high wet modulus. The breaking force (B_c) in the conditioned state and the force (B_m) required to produce an elongation of 5% in the wet state are: B_c (cN) ≥ 1.3 $\sqrt{T}$ +2T; B_m (cN) ≥ 0.5 $\sqrt{T}$; where T is the mean linear density in decitex*
Cupro	Cellulose II	Cellulose fibre obtained by the cupro-ammoniacal process
Lyocell	Cellulose II	Cellulose fibre obtained by an organic solvent spinning process**
Acetate	Secondary cellulose acetate	Cellulose acetate wherein less than 92% but at least 74% of the hydroxyl groups are acetylated
Triacetate	Cellulose triacetate	Cellulose acetate wherein at least 92% of the hydroxal groups are acetylated

* These equations relate to the numerical values in the units stated

** It is understood that:
1) An "organic solvent" means essentially a mixture of organic chemicals and water
2) "solvent spinning" means dissolving and spinning without the formation of a derivative

This footnote is part of the definition and is to be used with it.

Grafik 2

2) Die spezifischen Eigenschaften von Lenzing-Lyocell

Allgemeines:

Dadurch daß hier eine cellulosische Faser vorliegt, sind schon viele Eigenschaften vorgegeben. Ebenso sind dadurch die anwendbaren Chemikalien, Hilfsmittel und Maschinen in einer Art Vorauswahl gegeben.

Wie Ihnen bekannt ist, besitzen die cellulosischen Man made-Fasern eine Reihe von hervorstechenden Eigenschaften. Um nur einige exemplarisch hier anzuführen:

- O die gute Farbbarkeit, mit der Moglichkeit sehr echte Farbungen herzustellen,
- O durch den hohen naturiichen Gianz und die Reinheit der Faser die Moglichkeit. praktisch alle Farbnuancen zu produzieren
- O der weiche Griffsowie der eiegante Fall der Textilien
- O die Mischbarkeit mit praktisch allen Faserarten
- O durch die Faserfeinheit in der Garn- und Flachenherstellung eine hohe Variabilitat
- O hoher Tragekomfort
- O hohes Saugvermogen
- O Verrottbarkeit
- O nachwachsender Rohstoff

usw.

Eigenschaften allgemein von Lenzing-Lyocell

Faseraufbau

Hoher kristalliner Anteil und hoher Orientierungsgrad in Richtung der Faserlangsachse.

Faserquerschnitt/Faseroberfläche

Die Faser besitzt einen runden bis ovalen Faserquerschnitt mit einer giatten Faseroberflache.

Die Faser weist eine permanente Krauselung auf, welche aber nicht so ausgeprägt ist wie z.B. bei der Wolle.

Permanente Kräuselung

Grafik 3

Alkalibeständigkeit

Ein Laugierprozeß z.B. mit 8°Bé NaOH, bringt eine Erhohung der Farbausbeute, was speziell fur den Druck von Interesse sein durfte.

Die Laugenbeständigkeit ist ausreichend, um einen Merzerisierprozeß sowie eine Ammoniakbehandlung durchführen zu konnen.

Wie von der Lenzing-Modal-Faser her bekannt ist mit dem Merzerisieren eine merkliche Verhartung des Warengriffs verbunden, wobei hier bedingt durch das hohe Quellvermogen der Faser, von entscheidender Bedeutung ist, wie stark und wie oft Quetschwerke eingesetzt werden müssen.

Faserquellung

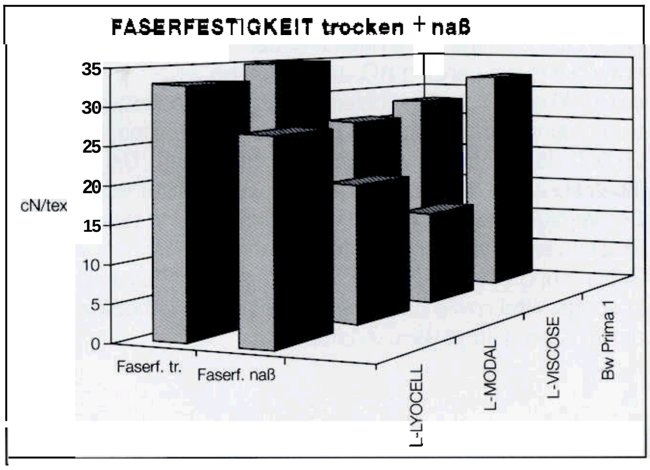
Diese liegt noch etwas hoher als bei Viscose, was eine hohe Naßstarre bedeutet.

Ein Vorhandensein von 50g/l Giaubersalz kalziniert bewirkt eine Verminderung des Queilvennogens. was fur den Verfahrensablauf in der Reaktivausziehfarberei in Betracht gezogen werden sollte.

Nun zu den spezifischen Eigenschaften von Lenzing-Lyocell

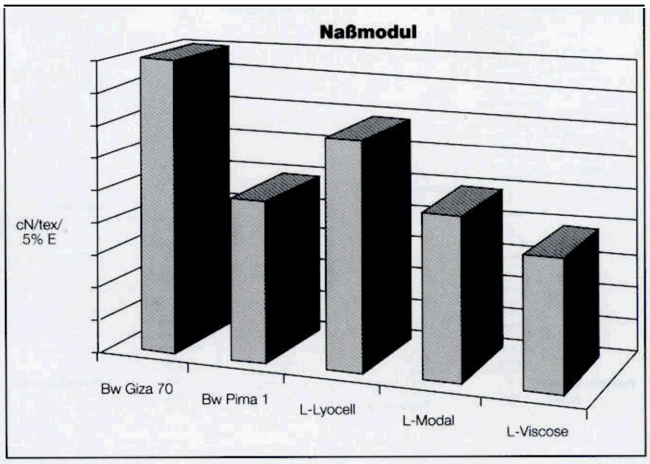
Faserfestigkeiten trocken und naß, im Vergleich zu anderen cellulosischen Fasern

Faserfestigkeiten



Grafik 4

Naßmodul



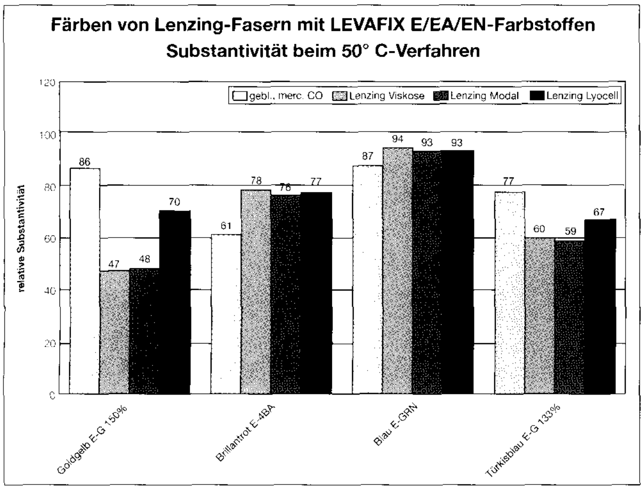
Grafik 5

Die hohen Faserfestigkeiten, speziell die hohe Naßfestigkeit und der hohe Naßmodul, bewirken während der Verarbeitung eine üblicherweise nur geringe Dehnung der Textilien. Dadurch sind ausgezeichnete Restschrumpfwerte leicht zu erreichen.

Gute Farbausbeute

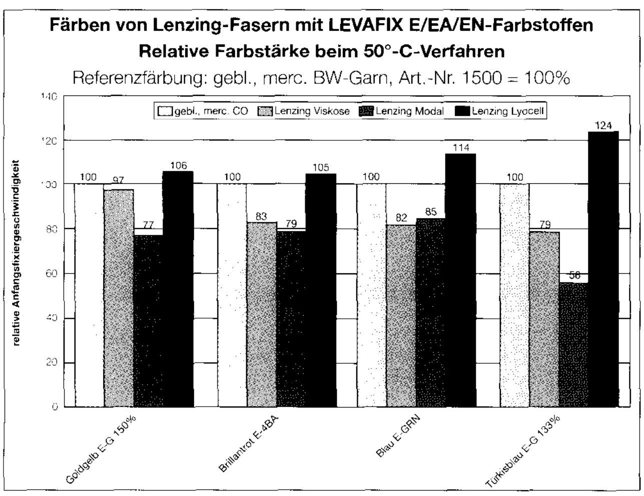
Die Farbausbeute ist im Vergleich zu Viscose etwas höher, im Vergleich zu Baumwolle oder zu Lenzing-Modal (= Typ-HWM-

Substantivität - Levafix E/EA/EN-Farbstoffe



Grafik 6

Relative Farbstärke - Levafix E/EA/EN-Farbstoffe



Grafik 7

Modal) deutlich tiefer, wobei die Substantivität der Farbstoffe in etwa gleich wie bei Viscose ist .

Dies ist speziell bei Fasermischungen mit Baumwolle und Lenzing-Modal zu beachten, um eine gute Ton-in-Ton-Färbung auf beiden Faserteilen zu erreichen. Vorversuche im Labor sind daher in diesem Fall sehr zu empfehlen.

Fibrillierung

Grafik/Bild 8 zeigt, daß die Lyocell-Faser eine komplexen Struktur aus Mikro- und Makrofibrillen aufweist.

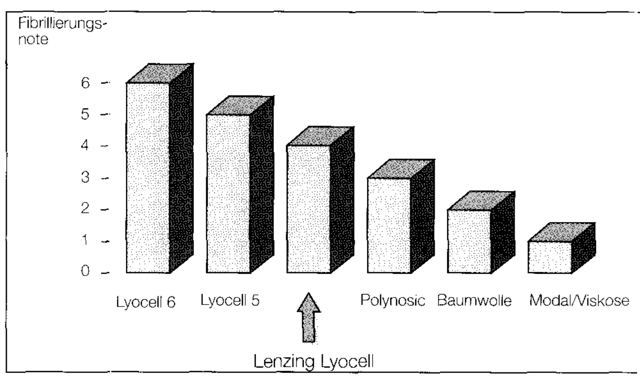
Durch Quellung in Wasser und mechanischer Querbelastung, wie sie bei der Veredlung im Strang bzw. bei der Haushaltswäsche auftritt, werden die Fibrillen gebrochen und treten aus der Faseroberfläche heraus.

Grafik 8

Cellulosefasern neigen generell zum Fibrillieren[3], Lyocell-Fasern jedoch besonders.

Dadurch ist es möglich einerseits neue Effekte zu erzielen, andererseits muß diese Eigenschaft, speziell in der Veredlung, beherrscht werden.

Grafik/Bild 9 zeigt den Fibrillierungsgrad verschiedener Cellulosefasern im Vergleich.



Grafik 9

Hohe Fibrillierungsgrade bedeuten rasche Erzielung von interessanten Griff- Optik- Effekten, jedoch eine schwere Beherrschung der Veredlungsvorgänge.

Das bedeutet auch, daß Vergrauung bzw. Scheuerkantenmarkierung an der Oberfläche leicht auftritt.

Lenzing-Lyocell setzt sich dabei das Ziel einer kontrollierten Fibrillierung (= Note 3), um einerseits griffliche Aspekte nach wie vor zustande zu bringen, und andererseits die Veredlung zu vereinfachen.

Vielfältige Artikelgestaltung durch die Fibrillierung

Grafik/Bild 10
- Foto von einem Gewebe entschlichetet (Jigger), ohne Fibrillierung und am Jet gefarbt, fibrilliert.

Grafik 10

Ebenso ist es natürlich auch bei entsprechender Verarbeitung moglich Artikel ohne Oberflächenstruktur herzustellen, also Textiien mit glatter Oberfläche.

Nun zu einem sehr wichtigen Punkt, namlich das

Behandeln in Strangform bei der Naßveredlung

Bedingt durch das relativ hohe Quellvermogen der Lyocell-Faser (liegt noch etwas hoher ab bei Viscose) und durch die Tendenz zum Fibrillieren, tritt bei Naßbehandlungen in Strangform leicht eine partielle Fibrillierungauf. Zusätzlich erscheint der geschützte Bereich in der Warenfalte dann als dunklere Stelle. z.B. bei Jet-Farbung, oder allgemein bei Naßbehandlungen in Strangform.

Durch die Naßversteifung in Kombinationmit der Fibrillierneigung der Faser ist eine gute Warenverlegung bei der Strangbehandlung sehr wichtig. Andernfalls treten Lauffalten, sowie die bereits erwähnten grauen Streifen auf dem Textil sehr schnell auf.

Wichtig ist auch zu erwahnen daß diese Vergrauung der Warenoberfläche auch dann zum Vorschein kommt, wenn entweder vor dem Färben/Drucken, z.B. beim Entschlichten, oder nach dem Färben/Drucken, z.B. Drucknachwasche, die Ware ungleichmäßig fibrilliert wird.

Was ist hier maschinenseitigzu beachten?

Färbemaschinen mit guter Warenverlegung sind Jets vom Typ Airflow, sowie Jets bei denen eine Fahrweise mit Luft moglich ist. Zu der erstgenannten Jet-Type gehort der Airflow von Fa. Then. Bei der zweitgenannten Jet-Type gibt es eine Reihe von Maschinenherstellern,wie z.B. die Alizée von Firma ICBT, oder die Luft-Roto von Firma Thies, welche hier die geeigneten Jets anbieten konnen.

Durch die Luft im System der Farbemaschine wird der Warenstrang bei jedem Warenumlauf geoffnet und dadurch ist eine ausreichende Warenverlegung gewährleistet. Dies haben Versuche auf 30 Kg. Kleinmaschinengezeigt. Inzwischen wurde dies auch bereits von der Praxis bestatigt.

Was konnen hier Faltenverhindererbewirken?

Die Zugabe von sogenannten Faltenverhinderern oder Gleitmittel bringt zwar eine Verbesserung im Laufverhalten. Dies alleine ist allerdings zur Verhinderung der oben genannten Fehlermöglichkeiten nicht ausreichend. Wichtig dabei ist, daß in allen Behandlungsbadern eine genugende Menge an Faltenverhinderer vorhanden ist.

Ein markanter Einfluß vom chem. Aufbau der Faltenverhinderer konnte bei unseren bisher durchgefuhrten Versuchen nicht festgestellt werden. Es laufen allerdings zur Zeit noch Versuche bei diversen Hilfsmittelherstellern, und daher ist es uns noch nicht moglich, hierzu eine endgultige Aussage zu treffen.

Welches sind noch weitere Einflußfaktoren ?

- O Erwahnt muß hier der starke Einfluß der Gewebe- oder Maschenwarenkonstrulionauf das Leufverhalternwerden. Sehr dichte Wareneinstellungen bewirken eine noch zusätzliche Erhohung der Naßstarre. Die Maschenware reagiert durch die offene Konstruktion noch empfindlicher auf die oberflächliche Vergrauung als Gewebe.
- O Der Farbton und die Farbstarke des Textils sind maßgebend, wie deutlich die Vergrauung sichtbar wird.
- O Realivfarbstoffe mit bi- oder mehrfunktionalen Molekülen bewirken bei den Nassbehandlungen nach der Färbung eine mehr oder wenigar deutliche Reduzierung der Fibrillierneigung.
- O Beimischungen von nicht fibrillierenden Fasern vermindern die Gefahr der Entstehung von grauen Streifen, ein Mindestprozentsatz von 25 % ist allerdings notwendig. um eine sichtbare Verbesserung zu bekommen.

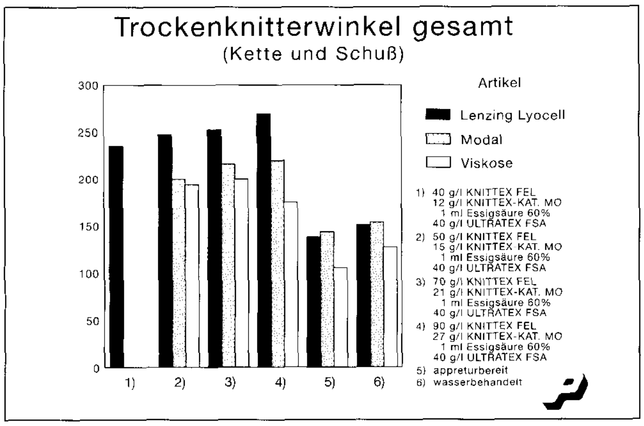
Was kann getan werden, wenn die grauen Streifen bereits entstanden sind?

Eine nachtragliche Korrektur der Streifen ist meist nur zum Teil mit Cellulaseprodukte moglich. Das heißt also, wenn bereits eine starke partiell unterschiedliche Fibrillierung der Oberfläche entstanden ist, welche meist auch mit einer Oberflächenscheuerung einhergeht, dann kann mittels Cellulasebehandlung die Ware meist nicht mehr fehlerfrei gemacht werden.

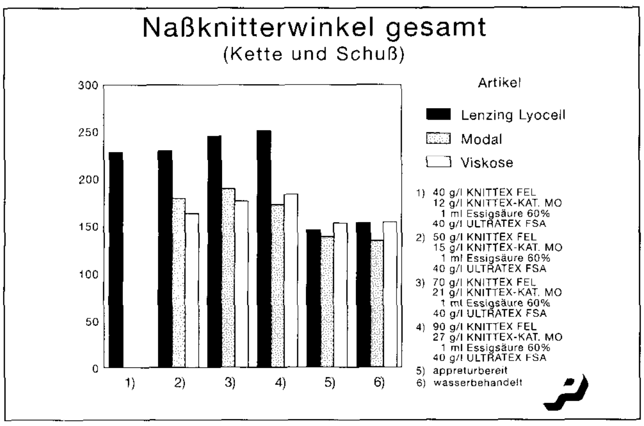
Hilfreich ist eine Cellulesebehandlung, um eine flusige Oberflache zu korrigieren. sowie leichte Streifen zu entfernen.

Eigenschaften bei der Hochveredlung

1.) Nur geringe Mengen an Cellulosevernetzer notwendig[5]

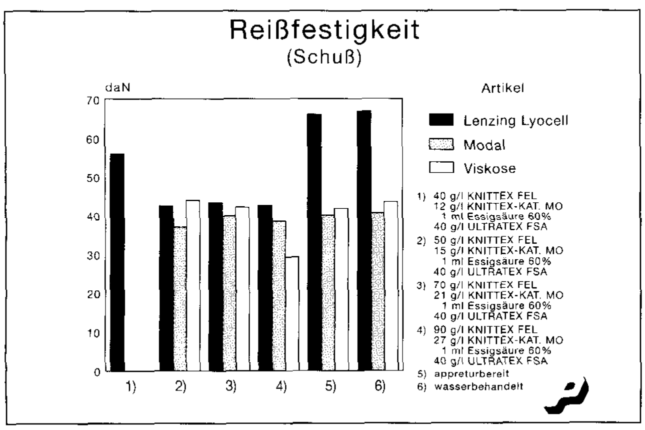


Grafik 11



Grafik 12

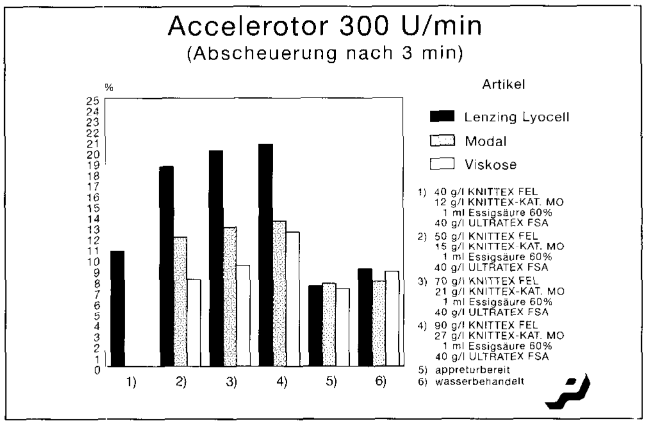
2.) Hohe Werte bei der Reißfestigkeit[5]



Grafik 13

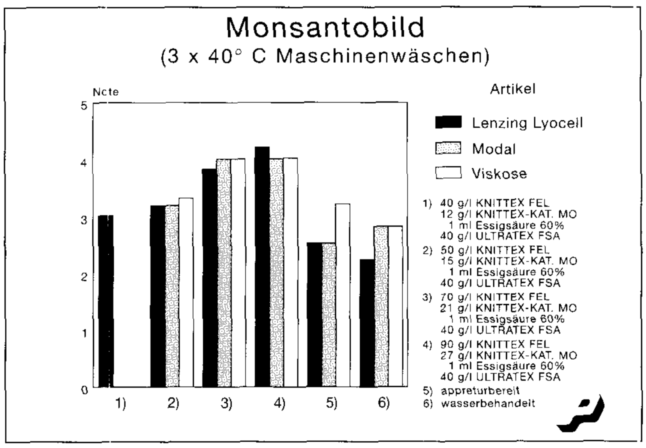
3.) Scheuerwerte[5]

Da nur geringe Menge an Cellulosevernetzer notwendig sind können gute Scheuerwerte erreicht werden, die sehr nahe jener Werte sind die Baumwollartikel erzielen.



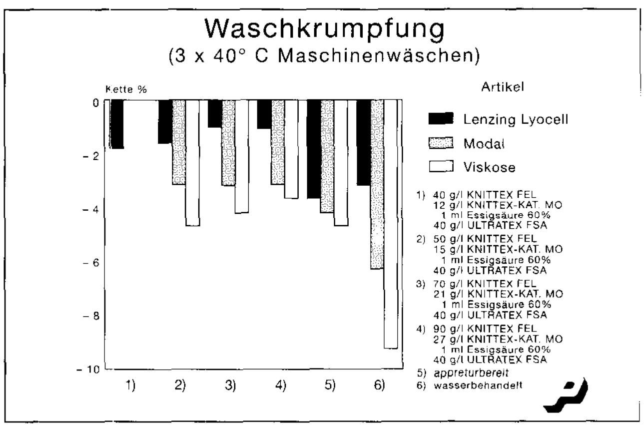
Grafik 14

4.) Wash and wear Verhalten[5]



Grafik 15

5.) Waschschrumpf[5]



Grafik 16

Bereits ohne Ausrüstung mit Cellulosevernetzer sind ausgezeichnete Schrumpfwerte erzielbar auf Grund der hohen Trocken- aber vor allem der hohen Naßfestigkeit und dem Naßmodul der Lenzing-Lyocellfaser.

Wie kann die Vergrauung im Gebrauch verhindert werden?

Hier ist die Ausrüstung mit Cellulosevernetzer anzuführen, wo schon mit geringen Harzeinsatzmengen waschstabile Textilien hergestellt werden können und somit das Fibrillieren gestoppt wird.

Waschpermanente Textilien ohne Hochveredlung?

Ohne Hochveredlung, also z.B. nur mittels Cellulasebehandlung bei einem 100% Lyocell-Artikel waschpermanente Textilien herzustellen, ist zwar für einige wenige Artikel möglich. Die Voraussetzungen dazu sind:

- daß die Primärfibrillation ausgelöst, und anschließend mit Cellulase behandelt wurde (Bio-polish).
- Ein Trocknen auf einem Tumbler - Typ Airo 1000 - wo mit hohen Warenumlaufgeschwindigkeiten gefahren wird, um einen Teil der Fibrillen noch zusätzlich zu entfernen.
- Weiters eine helle Farbe oder ein melé Optik. In diesem Fall ist dann die Fibrillierung der Faser nicht, oder nur sehr gering sichtbar.
- Meist wird in diesem Fall nur eine leichte Wäsche empfohlen.

Dieser Veredlungsgang kann aber unserer Meinung nach noch nicht als unproblematisch bezeichnet werden, da noch zu wenig Erfahrungswerte vorliegen.

Zusammengefaßt zu diesem Punkt ist daher zu sagen, daß eine wirklich ausreichend permanente Reduzierung der Fibrillierneigung zur Zeit nur mittels einer Vernetzung der Faser, durch eine Hochveredlung, erreichbar ist.

3) Was bedeuten diese speziellen Eigenschaften für den Veredler?

Dem Textilveredler steht eine sehr versatile Faser zur Verfügung, da einerseits durch die hohen Faserfestigkeiten, speziell die hohe Naßfestigkeit, sowie die gute Farbausbeute der vorhandene Maschinenpark meist gut eingesetzt werden kann. Auch sind Maschinen mit einer höheren Zugbeanspruchung möglich zu verwenden, welche z.B. bei Viscoseartikel nicht mehr eingesetzt werden können.

Natürlich mit der erwähnten Einschränkung bezüglich Naßbehandlung in Strangform.

Weiters bei der Hochveredlung, wo durch die geringe notwendige Harzmenge auch die Griffbeeinflussung durch Cellulosevernetzer gering ist. Die geringe Menge an Cellulosevernetzer ist auch im Hinblick auf die Restformaldehydwerte von Vorteil.

Die Fibrillierungstendenz der Lyocell-Faser ermöglicht, verschiedenste Oberflächenstrukturen zu erzielen. Dies ist zwar prinzipiell mit einer wenig fibrillierenden Faser auch möglich, aber mit einem ungleich höheren Aufwand an Zeit, Chemikalien und Mechanik. Dadurch hohe Kosten, und das Risiko von Fehlpartien z.B. durch Lochbildung etc.

Die hohe Faserfestigkeit sowie der weiche Griff (trotz eines weichen Griffes besitzen auch leichte Textilien noch genügend „Körper"), zusätzlich der natürliche Glanz der Faser, ermöglichen noch zusätzlich eine Erweiterung bei der Vielfalt der Artikelgestaltung.

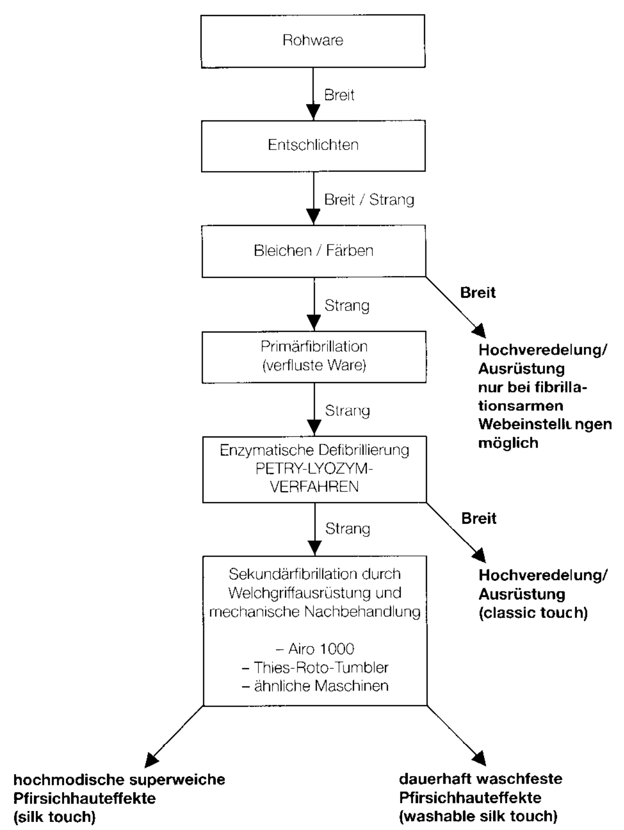
Als Beispiel für die neuartigen Möglichkeiten, welche Lenzing-Lyocell bietet, möchte ich hier die Griff-Optik Dissonanz erwähnen. Gemeint ist, daß ein Lyocell-Gewebe im ersten Eindruck wie ein Baumwolldemin aussieht aber im Griff wesentlich weicher, fließender ist (= Überraschungseffekt, da unerwartete Kombination)

Die neuen Technologien wie Cellulosebehandlung und Tumbler von Typ Airo 1000, sind für den Veredler immer mehr angewandte Verfahrensschritte um neuartige Effekte zu erreichen, oft mit dem Ziel möglichst viele verschiedene Artikel herzustellen ausgehend von nur einer oder wenigen Gewebe- bzw. Strickkonstruktion.

Im Garment-Wash-Bereich hilft einerseits die Fibrillierneigung der Lyocell-Faser die Wash-out-Effekte leichter zu erreichen (Grossteils kann auf den Einsatz von Bimssteinen verzichtet werden).

Andererseits sind diese Prozesse so zu steuern, daß helle Streifen nicht zu markant auftreten, d. h. eine möglichst gleichmäßige Mechanik über die Oberfläche der Ware ist wichtig.

Mögliche Wege der Lyocellfaser in der Stückveredelung



Grafik 17

4) Zusammenfassung

Die Lenzing-Lyocell Faser bietet neue Fasereigenschaften, die von einer cellulosischen Man-made Faser bisher noch nicht oder nur zum Teil geboten werden konnten.

Neben den allgemeinen Vorteilen einer cellulosischen Man-made Faser bietet diese neue Fasergeneration noch zusätzlich die Vorteile wie

- ○ noch verbesserte Farbausbeute,
- ○ hohe Festigkeiten,
- ○ sowie bedingt durch die hohe Festigkeit und den hohen Naßmodul,
- ○ leicht erzielbare niedrige Restschrumpfwerte der Textillien
- ○ einen geringen Bedarf an Cellulosevernetzer.

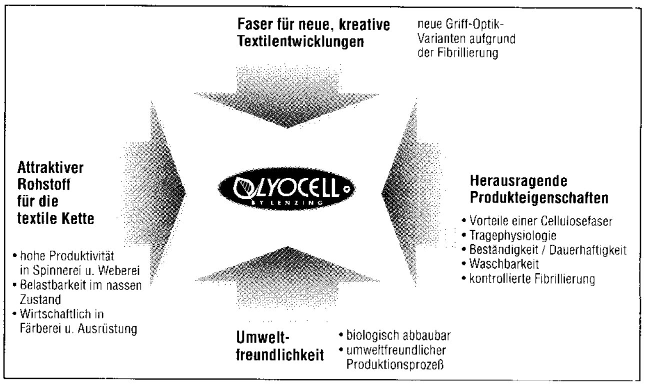
Als Vorteil sehen wir weiters die kontrollierte Fibrillierung der Faser, welche die Möglichkeit bietet, die Endprodukte sehr vielfältig zu gestalten.

Eine neue Faser mit neuen Eigenschaften erfordert speziell in der Beginnphase eine entsprechende Qualifikation, speziell in der Veredlung, bietet aber dadurch andererseits die Möglichkeit sich aus dem Preisdruck, welcher bei den Standardprodukten herrscht, abzuheben.

Nicht unerwähnt soll hier auch werden daß die Lenzing-Lyocellfaser neben den ökologischen Vorteile einer cellulosischen Faser, wie z.B.

- ○ Verrottbarkeit,
- ○ nachwachsender Rohstoff,

noch zusätzlich verfahrensseitig den Vorteil bietet, daß beim Lyocell-Prozeß das Lösungsmittel sowie das verwendete Wasser, nahezu vollständig im Kreislauf geführt werden kann (Rückgewinnungsrate über 99%).



Grafik 18

Literatur:

1) Gränacher, Sallmann 1936, Drp 713 486
2) Johnson, 1969, USP 3 447 939
3) Firgo,et al, Lenzinger Berichte 74, S81
4) Eichinger, et al „Lenzing-Lyocell- das Potential einer neuen Cellulosefaser"
5) Pfersee Chemie GmbH, et al, Techn. Rundbrief Nr. 30

DAS FÄRBERISCHE VERHALTEN VON LENZING LYOCELL – BEI EINSATZ VON REAKTIV- UND DIREKTFARBSTOFFEN – IM AUSZIEHVERFAHREN

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Friedrich Brauneis, Lenzing AG

Das färberische Verhalten von Lenzing-Lyocell-Fasern - wie Substantivität, Fixierverhalten, Farbausbeute - wurde mit Levafix- sowie Sirius-Farbstoffen im Vergleich zu Baumwolle, Lenzing-Viscose und Lenzing-Modal untersucht.
Es erweist sich, daß trotz der sehr hohen Farbstärke die Aufziehgeschwindigkeit der Farbstoffe bei der Lenzing-Lyocell Faser ähnlich wie bei Viscose ist. Farbstoff- und Salzbedarf sind geringer als bei Baumwolle, Viscose oder Modal.

The dyeing behaviour of Lenzing-Lyocell-fibers - as substantivity, fixation behaviour and color yield - was investigated with Levafix and Sirius dyes in comparison with cotton, Lenzing-Viscose and Lenzing-Modal. It is shown that in spite of a very high dye yield the take up speed of the dyes with the Lenzing-Lyocell fiber is similar to Viscose. Demand of Dye and salt is lower than with cotton, Viscose or Modal.

Einleitung

Lenzing-Lyocell ist eine neue – nach einem vollkommen neuen Herstellverfahren produzierte – cellulosische Man-Made-Faser. Sie weist dadurch im Aufbau Unterschiede zur Baumwolle, aber auch zur Viscose- und Modalfaser auf.

Prinzipiell können alle für cellulosische Faserstoffe geeigneten Farbstoffe für die Lenzing-Lyocellfaser eingesetzt werden.

Färberisch relevante Eigenschaften von Lenzing-Lyocell

Die hervorstechensten, für das Verhalten beim Färben maßgeblichen Eigenschaften sind:

- rundovaler Faserquerschnitt
- Glanz
- gute Zugänglichkeit für Farbstoffmoleküle
- keine Mantel-Kernstruktur
- hohes Quellvermögen

Dazu ist noch anzumerken, daß die hohe Naßfestigkeit und der hohe Naßmodul erlauben, Artikel aus dieser Faser auf Maschinen einzusetzen, welche hohe Zugbeanspruchungen erfordern.

Das Heißluftfixierverfahren mit Reaktivfarbstoffen ist auf Grund der geringen Farbausbeute von Lenzing-Lyocell nicht zu empfehlen.

Quellung der Lenzing-Lyocell Faser

Wie schon oben erwähnt, besitzt die Faser ein hohes Quellvermögen. Beim Behandeln im Warenstrang, wie auf Jets, Strangwaschmaschinen u.s.w., ist dies zu beachten. Das Gleiche gilt bei der Garmentbehandlung. Die Naßversteifung der Ware kann zu einer unzureichenden Waren/Strangverlegung führen und dadurch die Bildung von Aufscheuerungen, Warenknitter und hellen Streifen begünstigen. Die Bildung der hellen Streifen wird durch die Fibrillierungstendenz der Faser noch zusätzlich beschleunigt.
Durch den Einsatz von Jets vom Typ „Airflow“, oder allgemein Jets, bei welchen durch Beblasen der Ware mit Luft eine ausreichende Strangverlegung erfolgt, können meist die vorher erwähnten Fehler vermieden werden.

Weiters ist beim Arbeiten mit Wickelkörpern zu beachten, daß die Wickeldichte möglichst gering ist. Bei der Pad-Batch-Färbung soll der Faser genügend Zeit gegeben werden, sodaß der Quellungsprozeß zum Großteil abgeschlossen ist, bevor das Textil zum Verweilen aufgerollt wird (mindestens 2,5 Sekunden). Hier ist es ebenfalls wichtig, die Wickelhärte möglichst gering zu wählen.

Verhalten beim Färben mit Sirius-Farbstoffen

Es wurden Direktfarbstoffe eingesetzt, die sich bezüglich des Anfärbens von Baumwolle und Viscose unterschiedlich verhalten und unterschiedlichen Salzbedarf aufweisen.

Damit sollte die Lenzing-Lyocellfaser gut charakterisierbar sein.

V-Wert

Der V-Wert ist ein Relativwert für die Farbstoffaufnahmegeschwindigkeit bei einbadigem Färben der zu prüfenden- und einer Standardfaser. Er liegt bei Lenzing-Lyocell etwas unter dem Wert der merc. Baumwolle, aber über denen der übrigen geprüften Substrate (Tabelle 1).

V-Werte

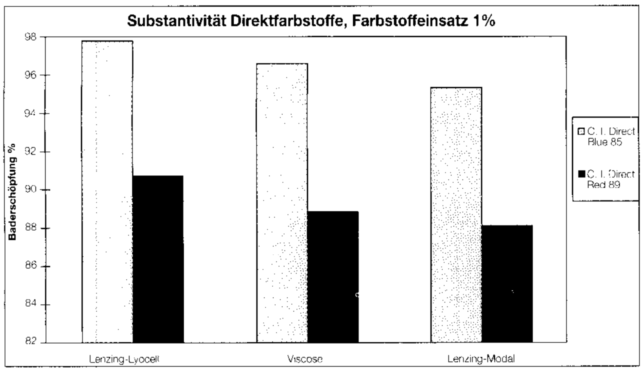
Geschwindigkeit der Farbstoffaufnahme von Fasern im Vergleich zu gebleichter Baumwolle. Einbadige Färbung der zu prüfenden und einer Standardfaser mit Sirius® lichtblau GR-LL 167%.

V-Werte:	CO gebleicht	V = 1,0
	CO merz.	V = 1,4
	Lenzing.Lyocell	V = 1,3
	Viscose	V = 1,1
	Lenzing-Modal	V = 0,9

Tabelle

Kurzzeitfärbung

Kurzzeitfärbungen, 5 Minuten bei 40°C, zeigen den Beginn der Farbstoffaufnahme (first strike).
Im Mittel verhält sich Lenzing-Lyocell wie Viscose. Der „first strike“ ist deutlich geringer als bei mercerisierter Baumwolle.



Grafik 1a

Substantivität

- Sie liegt für Viscose und Modal immer etwas unterhalb von Lenzing-Lyocell (Grafik 1a).
- Wenn Salz knapp bemessen wird, oder bei Farbstoffen mit hohem Salzbedarf (Türkis), liegt Lenzing-Lyocell unter mercerisierter Baumwolle.
- Bei ausreichend hoher Salzmenge ist die Endbaderschöpfung für Lenzing-Lyocell und mercerisierte Baumwolle in etwa gleich.

Salzmengen

Entsprechend werden für Lenzing-Lyocell die für mercerisierte Baumwolle üblichen Salzmengen empfohlen (Tabelle 2).

Sirius-Farbstoffe

Empfohlene Salzmenge bei Flottenverhältnis 1 : 20

merc. Baumwolle / Lenzing-Lyocell

% Farbstoff	Farbstoffgruppe 1 g/l Salz	Farbstoffgruppe 2 g/l Salz
bis 0,25	1,5	2,5
0,25 - 0,50	2,5	5,0
0,50 - 1,00	5,0	10,0
1,00 - 2,00	7,5	15,0
über 1,00	12,5	25,0

gebleichte Baumwolle

% Farbstoff	Farbstoffgruppe 1 g/l Salz	Farbstoffgruppe 2 g/l Salz
bis 0,25	3,0	5,0
0,25 - 0,50	5,0	10,0
0,50 - 1,00	10,0	20,0
1,00 - 2,00	15,0	30,0
über 2,00	25,0	40,0

Viscose

% Farbstoff	Farbstoffgruppe 1 g/l Salz	Farbstoffgruppe 2 g/l Salz
bis 0,25	5,0	10,0
0,25 - 0,50	8,0	15,0
0,50 - 1,00	10,0	20,0
1,00 - 2,00	15,0	30,0
über 2,00	25,0	40,0

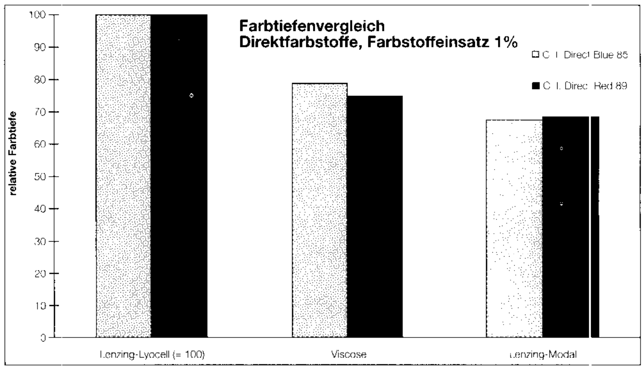
Bei Flottenverhältnis 1 : 10 sind die Konzentrationen zu halbieren. Bei Türkis kann die Ausbeute durch höhere Salzmengen als für Farbstoffgruppe 2 noch erhöht werden.

Tabelle 2

Farbtiefenvergleich

Bei gleicher aufgezogener Farbstoffmenge wirkt Lenzing-Lyocell heller als mercerisierte Baumwolle, aber deutlich dunkler als Viscose oder Modal gleichen Fasertiters.

Die Farbmessungen ergaben gegenüber Lenzing-Lyocell:
für Viscose 20-30 % geringere Farbtiefe
für Modal ca. 30 % geringere Farbtiefe
(Grafik 1 b)



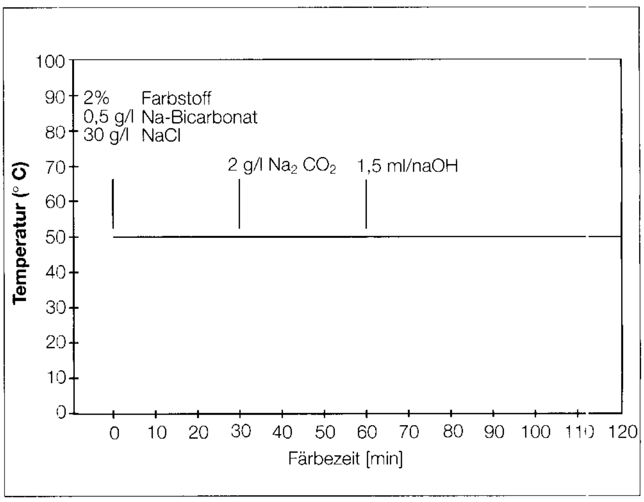
Grafik 1b

Bei einbadiger Färbung mit Baumwolle wirkt Lenzing-Lyocell visuell heller als mercerisierte Baumwolle. Gebleichte Baumwolle war deutlich heller als Lenzing-Lyocell.

Verhalten beim Färben mit LEVAFIX E / EA / EN - Farbstoffen

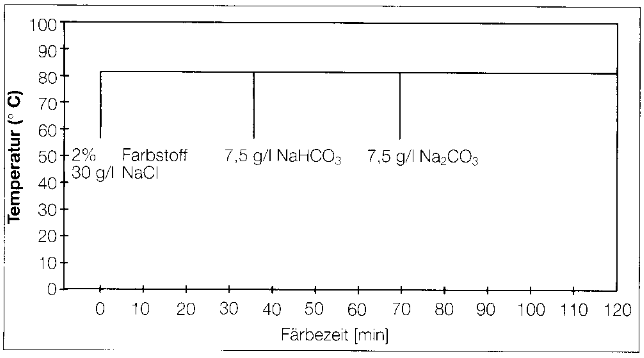
Geprüft wurden 4 Levafixfarbstoffe, ausgewählt in ihrem Eigenschaftsprofil extrem auseinanderliegend, bei einer Färbetemperatur von 50° C und 80° C.

Färbeprofil, 50° C Färbetemperatur



Grafik 2

Färbeprofil, 80° C Färbetemperatur



Grafik 3

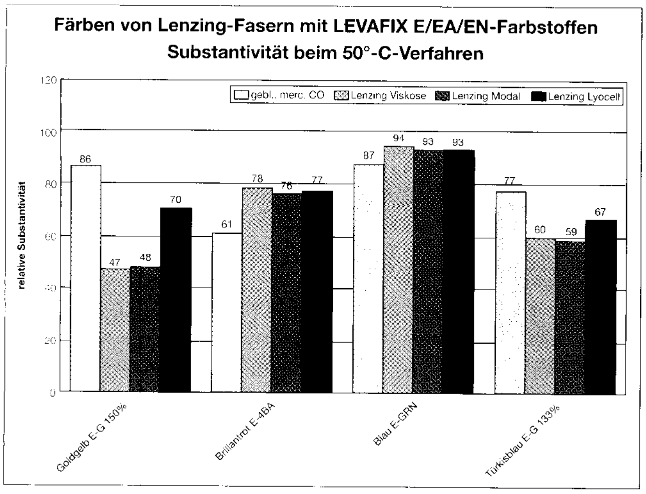
Substantivität

Darunter wird der mit Salz, vor dem Alkalizusatz, aufgezogene Anteil des Farbstoffs verstanden.

Lenzing-Lyocell liegt sowohl bei einer Färbetemperatur von 50° C wie bei 80° C zwischen Viscose und mercerisierter Baumwolle.

Wie zu erwarten liegt bei einer Färbetemperatur von 50° C die Substantivität über der bei 80° C, da mit der gleichen Salzkonzentration gefärbt wurde.

Substantivität Levafixfarbstoffe , 50° C Färbetemperatur



Grafik 4

Anfangsfixiergeschwindigkeit

Geprüft wird die Fixierausbeute 5 Minuten nach der Alkalizugabe. Die Anfangsfixiergeschwindigkeit ist die Ausbeute nach 5 Minuten, relativ zur End-Fixierausbeute (in %).

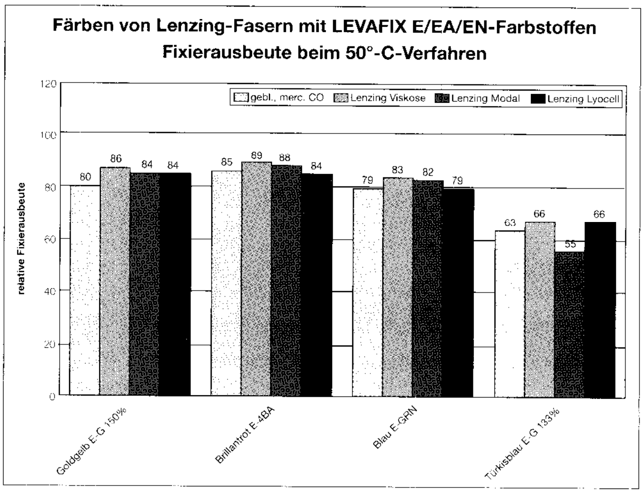
Die Anfangsfixiergeschwindigkeit von Lenzing-Lyocell liegt bei oder etwas unter Viscose, aber höher als die von mercerisierter Baumwolle.

Fixierausbeute

Gemeint ist der Anteil an fixiertem Farbstoff auf der Faser.

Lenzing-Lyocell liegt sehr ähnlich wie Viscose und Modal (Modal hat bei Türkis eine geringere Fixierausbeute). Die mercerisierte Baumwolle liegt bei 50° C teilweise, bei 80° C stets etwas darunter.

Fixierausbeute Levafixfarbstoffe, bei 50°C Färbetemperatur.

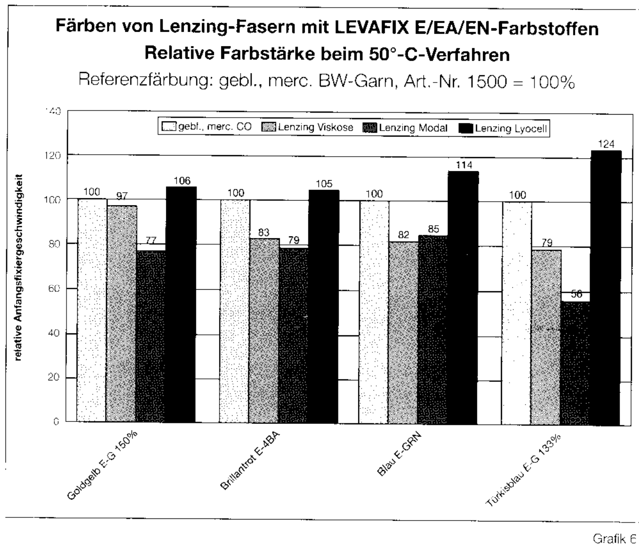


Grafik 5

Relative Farbstärke

Die Fixierausbeute zeigt deutlich geringere Unterschiede zwischen Lenzing-Lyocell und den Vergleichsfasertypen, als dies der optische Farbeindruck zeigt, also die messbare Farbstärke. Sowohl bei einer Färbetemperatur von 50°C als auch bei 80°C liegt die Farbstärke bei Lenzing-Lyocell deutlich über der von Viscose und Modal, merklich über der von mercerisierter Baumwolle. Besonders groß ist der Unterschied bei Türkis.

Relative Farbstärke, bei 50° C Färbetemperatur



Grafik 6

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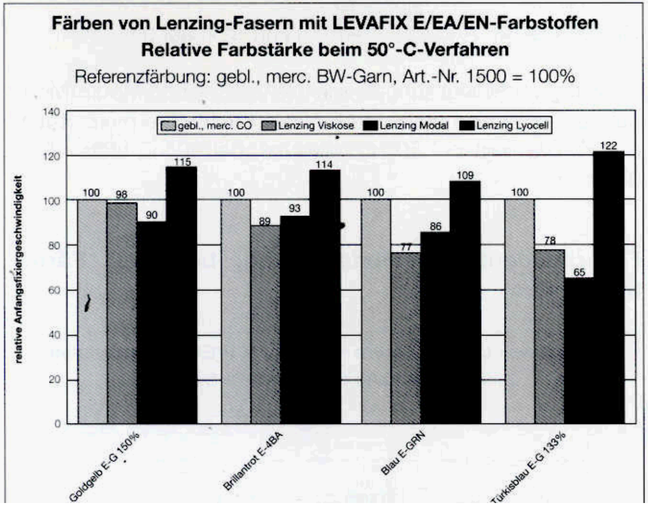
Relative Farbstärke, bei 80°C Färbetemperatur



Grafik 7

Schlußfolgerung

Obwohl die Farbstarkevon Lenzing-Lyocellmeist deutlich uber der von den anderen geprijften cellulosischen Fasern liegt, im Besonaeren deutlich uber aer von geolechter Baumwol e, sind d e Daten für aie Aufziengescnw ndgkeit und Substantivität bei Drea- m a Reakt vfarostoffen auf einem uberrascnena g.nst - gen Niveau. Aus a esem Grund sna keine besonaeren Schwier gkeiten be aer Farbegallat zu erwarten.

Durcn aie nohe Farbstarke be Lenzing-Lyoce ı sina o e not- wenaigen Mengen an Farostoff und/oder Salz, vergl chen m.t Baumwo. e una V scose. tei s aeutl ch geringer.

Die bisher geprijften Farbechtheiten zeigen Werte, welche keine großen Unterschiedezu denen von Viscose und Baumwolle auf- weisen

Textilien mit dem sogenannten Peach-skin-Effekt, bei denen die Lyocellfaserfibrilliert wurde. zeigen bei der Reibechtheit, und hier vor allem bei Reibechtheit naß, bedingt durch den Anteil an feinen Faserteilen. rneist eine Verschlechterung der Werte.

Wenn Fasermischungen vorliegen, insbesonders bei Mischungen Lenzing-Lyocell rnit Baumwolle, sollten farberische Vorversuche durchgefuhrt werden um abzuklaren, ob der gewunschte Farbausfell erreicht werden kann.

LYOCELL – EINE VIELSEITIGE CELLULOSISCHE FASER

Dieter Eichinger, Michael Longin, Sigrid Seidl, Georg Sagerer,
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Das vielseitige Eigenschaftsprofil der Lyocell-Fasern ermöglicht den Einsatz in verschiedensten technischen und nichttechnischen Gebieten. Nachstehend sind die wichtigsten Anwendungsmöglichkeiten von Lyocell-Fasern aufgeführt.

The versatile property-profile of Lyocell fibres renders the use in very different technical and non-technical fields possible. In the following the most important fields of use of Lyocell fibres are listed.

Bekleidung:
- Als Stoffe für Kleider, Mäntel, Socken, Damen- u. Herrenunterwäsche, Pyjamas, Pullover, Schal, Halstücher, Krawatten, Talare, Textilgürtel, Fingerhandschuhe, Gamaschen, Schuheinlagen
- Sportbekleidung , z.B. für Wandern, Tennis, Schi, Langlauf, in Reithosen z.B. in Mischung mit Baumwolle, schweißsaugende Arm und Stirnbänder, Badehosen, Bikini, Badeanzüge, Bademäntel, Kampfanzüge für Kampfsportarten (hohe Reißfestigkeit)
- Hüte, Kappen, Hauben
- Einlagestoffe und -vliese für Hosenbünde, Hemdkrägen und Knopfleisten
- Filze für Mäntel, Hüte, Teppiche, Pantoffel
- Bondings für: Mantelstoffe, Freizeitkleidung, Hüte und Mützen, Sporttaschen, Koffer und Rucksäcke

Gebrauchsgegenstände:
- Bettwäsche, z. B. Polster und Decken, Wollsachen, Vorhänge, Verpackungsmaterial, Hygienebereich, z.B. in Tampons, Damenbinden und Wattepads
- Stoffe in der Möbelindustrie, Autoindustrie, z.B. in Schonbezügen fürs Auto, Vorhänge, Tapeten
- (Einweg-) Überzüge für das Kopfteil von Eisenbahn, Bus und Flugzeugsitzen, Einwegschutzanzüge und Arbeitsbekleidung
- Sonnenschirme, Regenschirme
- Zeltplanen, Campingliegenüberzüge
- Uhrbänder
- Brieftaschen
- Schustergarne, Schuhbänder, Anorakbänder z. B. für Kapuzen
- Textileinsätze bei Schuhen (z.B. Turnschuhe)
- Teppiche, Teppichrücken
- Füllmaterial für Briefe (gepolsterte Briefumschläge)
- Füllmaterial für Futons oder andere Matratzen
- Einwegtischdecken
- Stoff- und Papiertaschentücher
- Küchentücher, Spültücher
- Leinwände
- Fahnen
- Hängematten
- Netze (z.B. für Semmeln), Tragtaschen
- Seidenblumen, Friedhofschmuck (Blumen, Kränze, Gestecke - Ersatz für PVC-Produkte)
- Totenhemd etc., Futterstoff für Särge

Technische Anwendungsgebiete:
- Autohimmel
- Papiere aller Art
- Staubsaugerfilter, Kaffeefilter, Teebeutel
- Technische Filter: als Filtertücher oder als Filtermaterial in der Tiefenfiltration
- Transportbänder
- Einsatz in Faserzementmischungen (Vorteil der Fibrillierung ergibt bessere Einbindung in die Zementmatrix)
- Nadelfilze für Filter (Rauchgasreinigung, Papiermaschinen, Klimaanlagen)
- Ölfilter
- faserverstärkte Anstriche
- Beschichtungsgrundgewebe für Kunstleder, Luftmatratzen, Regenmäntel etc.
- faserverstärkte Compounds (Formteile für Automobilindustrie)
- Verstärkung von Spanplatten in Richtung Biegebeanspruchung
- Putzpapiere für die Industrie
- Papiersäcke (Zement etc.)
- Schleif- und Poliermittelgrund (Fußbodenpolieren, Autopolieren usw.)
- Einlage bei Kabelisolierungen (Feuchtigkeit)
- Ersatz für Glas- u. Steinwolle
- Garne für Sackgewebe z. B. in der Landwirtschaft
- Segel für Segelboote, Segeltaue
- Naturtaue und Seile
- Schläuche (z. B. für die Feuerwehr)
- Kabelmäntel
- Dämmwolle für Isolierungen in Bauwerken und Autoindustrie
- Tragefreundliche medizinische Strumpfmaterialien und Verbandmaterial
- Ohrenstöpsel
- Reifencord
- Kunststoffverstärker
- Fasermaterial für Farben
- Sanierung von Altbauten zum Entsalzen (Mahlen von Abfallmaterial)
- Kompostier- bzw. verrottbare Produkte aus mehr oder weniger verdichteten Faservliesen, z.B. Kaffee-, Teefilter, Planen, Säcke, Eierkartons, Dämmaterial, Verpackungsmaterial, Joghurt-, Sahnebecher etc.,Trinkbecher, Teller (Einweggeschirr), Blumentöpfe und Pflanzkübel für Jungpflanzen.
- Vliese für Gartenbau, Landwirtschaft, Straßenbau, Bachbett- und Deponiegewebe
- Fischernetze
- Bucheinbände
- Pollierwatte
- Trägermaterial für Enzyme
- Antikörper z.B. für biotechnologische, medizinische und analytische Einsatzgebiete
- Trennmedien in der Chromatographie
- Ausgangsmaterial für Cellulosederivate (CMC, Azetat, Nitrozellulose)

und vieles mehr !!