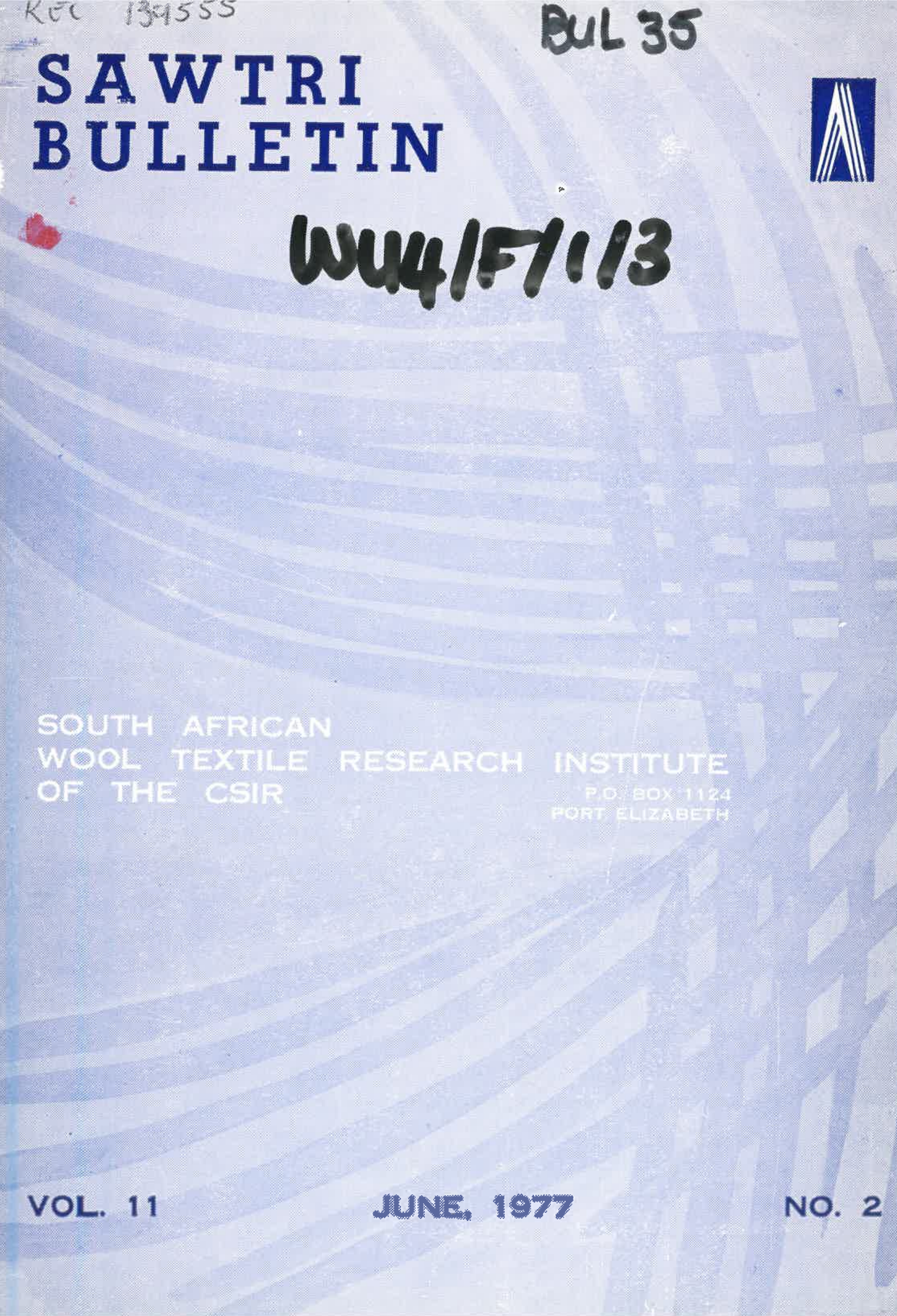
SAWTRI BULLETIN



SOUTH AFRICAN
WOOL TEXTILE RESEARCH INSTITUTE
OF THE CSIR
P.O. BOX 1124
PORT ELIZABETH

VOL. 11
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SAWTRI BULLETIN

Editor: M. A. Strydom, M.Sc.

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SOUTH AFRICAN
WOOL AND TEXTILE RESEARCH INSTITUTE
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P.O. Box 1124
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PUBLICATIONS COMMITTEE

INSTITUTE NEWS

National symposiun on "New Developments in Fabric Manufacture"

Full details of the program for the official opening of the building extensions, the celebrations of SAWTRI's 25th anniversary and the symposium are now available.

On Tuesday, 16th August, the Institute will be open from 14h00 onwards for guests interested in an informal tour of the premises. The official opening of the extensions and the symposium by the Hon. Minister of Planning, dr. S. van der Merwe, will commence at 16h30, and the cocktail party to celebrate the 25th anniversary starts at 17h30.

On Wednesday, 17th August, the symposium will commence at 09h00 in the auditorium of PECATE. Registration will take place from 08h00 to 09h00. Each speaker will have 40 minutes at his disposal, which includes a question-and-answer session. The timetable is as follows:

09h00 – 09h40:	Dr. R. Wheatley, Messrs Karl Mayer Maschinfabrik: Knitteds versus Wovens.
09h40 – 10h20:	Dr R. Howe and Dr N. Scott, Messrs S. A. Nylon Spinners: Whither Fibres to Fabrics?
10h20 – 10h40:	Tea
10h40 – 11h20:	Dr. L. Hunter, SAWTRI: New Developments in Staple Yarn Spinning and the Properties of Knitted and Woven Fabrics produced from These Yarns.
11h20 – 12h00:	Mr P. Honeyman, Messrs Romatex Floor Coverings: Needle Punching.
12h00 – 12h40:	Mr G. A. Robinson, SAWTRI: Fabrics from Repco Yarns.
12h40 – 14h00:	LUNCH
14h00 – 14h40:	Dr R. Wheatley, Messrs Karl Mayer Maschinfabrik: Warp Knitting.
14h40 – 15h20:	Dr D. P. Veldsman, SAWTRI: Textiles in AD2000
15h20 – 15h40:	TEA

Pre-symposium brochures containing the program and other relevant details will be issued by the CSIR's Conference Division in the usual manner.

Meetings and Lectures

The SAWTRI-Rhodesian Cotton Grower's Association Steering Committee met on the 11th March to co-ordinate the Institute's cotton research projects which are undertaken on behalf of the Rhodesian Cotton Industry.

Mr F. Prins of Spindlefabrik Suessen AG addressed staff members and the Eastern Cape Branch of the Textile Institute on automation in rotor spinning and the automation of ringframes using Suessen drafting systems. This lecture was delivered by Mr Prins on the 16th May in the SAWTRI lecture room.

The Institute's Liaison Officer, Mr Neville Vogt, also delivered two papers. On the 5th May he delivered a paper on the "Role of Research in Wool Marketing" to the 1977 Rhodes University Farm Economics Course held in Grahamstown. On the

Mr H. Camiou of the Uruguayan Wool Secretariat, Dr Lawrance Hunter of SAWTRI and Mr J. Grignet of Centexbel, Brussels, discussing the SAWTRI Yarn Friction Tester

Mr Neville Vogt of SAWTRI with Mr J. Otequi of Lanera Santa Maria, Montivideo in the yarn testing laboratory

9th June he addressed the Eastern Cape branch of SADFA on CSIR and SAWTRI services to industry. Dr Malcolm Roberts, Group Leader for Dyeing and Finishing, also addressed the Border branch of SADFA on 20th May on SAWTRI's latest research results in the fields of solvent dyeing, transfer printing and chrome dyeing.

Prior to departing on his overseas visit to the USA, Britain and Iran (as announced in the March issue of this Bulletin), Dr Veldsman addressed the South African Dietetics and Home Economics Association in Bloemfontein on the 5th May. The topic of his talk was "Some New Finishes on Textiles". On the 22nd March, he also addressed the Western Cape Branch of the Textile Institute on several aspects concerning new developments in wool processing as from spinning.

Dr Veldsman has been nominated by the CSIR for a further two year period on the Wool Testing Advisory Committee of the S. A. Wool Board.

Visits and Visitors

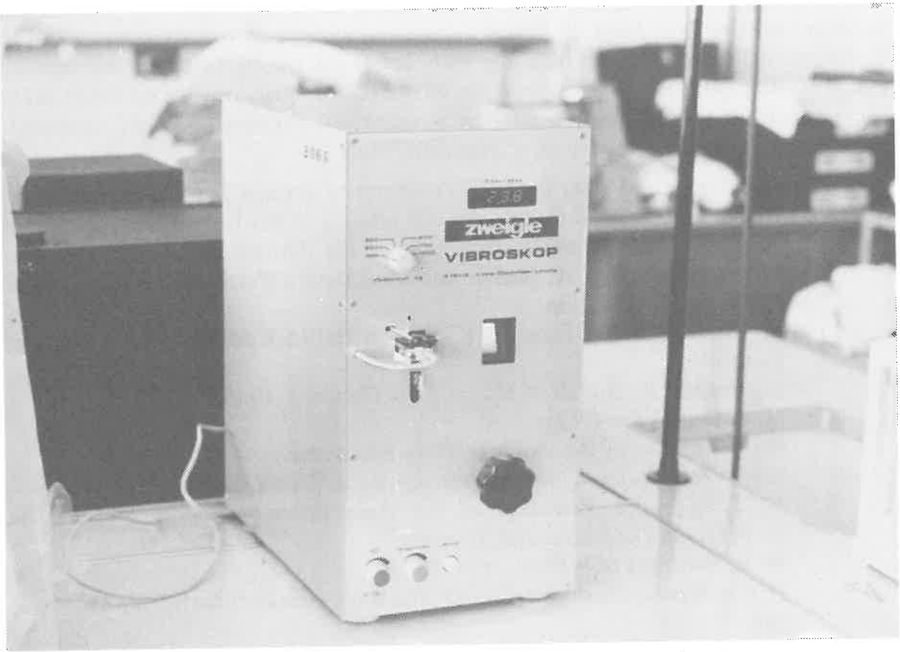
Members of the staff paid visits to various branches of the Industry during the last three months. Dr Veldsman, Mr Alan Robinson and Mr Neville Vogt visited a number of textile mills in the Western Cape from the 21st to the 25th March for technical discussions. Dr Lawrance Hunter and Mr Robinson paid a week-long visit to the Rhodesian textile industry from the 18th to the 22nd April. During their visit they were consulted by various mills and a one-day seminar was attended in Salisbury on the 21st April. Dr Hunter presented a paper on quality control and Mr Robinson delivered a paper dealing with increased productivity in the weaving industry. The purpose of their visit to Rhodesia was primarily to establish direct contacts with local mills with a view to increase and improve SAWTRI's service to the Rhodesian textile industry on a consulting basis.

Prior to, during and after the IWTO conference in Cape Town several delegates visited SAWTRI, especially to discuss matters relating to the Institute's work on the processing of wool blends. These visitors included the following:

Messrs B. Mackay, A. Becher and Miss Sandra Welsman from the Australian Wool Corporation;
Mr A. G. Stutter, Director of the Australian Wool Marketing Standard Authority;
Mr and Mrs R. Hullah of Messrs Wool-Combers, Bradford;
Mr P. Bell of the IWS;
Mr H. Camiou of the Uruguay Wool Secretariat;
Mr D. Delplanque of Messrs Peignage de la Tóssée, Turcoing;
Mr J. Pommies, President of the Association of Scourers of France;
Mr J. Grignet of Centexbel, Brussels;
Mr R. Bownass of WIRA;
Dr and Mrs K. Ziegler of the German Wool Research Institute, Aachen, and
Mr J. Otegui, President of Lanèra Santa Maria S. A., Montevideo.

A delegation of the Romatex group of companies, headed by the Chairman of

Dr Derek Turpie addressing a contingent from the Romatex group of companies during their recent visit to the Institute



The Textile Physics Department's new Zweigle Vibroscope for the accurate determination of fibre linear densities

Romatex Industrials, Mr Jack Ward, visited the Institute on the 10th May to familiarise themselves, on behalf of the Romatex group, with the Institute's work.

Sulzer training courses at SAWTRI

The first of the Sulzer loom training courses for 1977, originally scheduled for 9th May to the 3rd June, was postponed by one week. The second course, however, is still to be held from the 20th June to 15th July.

Cotton Board and SAWTRI to forge closer ties

It is a pleasure to welcome the Cotton Board to the rank of organisations sponsoring research at SAWTRI. The Board has decided to sponsor a major project on the seasonal variations in the properties of South African cotton cultivators. It is hoped that our collaboration with them will be a long and fruitful exercise. The Cotton Board has also accepted an invitation to nominate a representative on SAWTRI's Research Advisory Committee.

SAWTRI – Israel Fibre Institute exchange scheme

Under the exchange agreement between the CSIR and the Israel National Council for Research and Development, Dr A. Basch, Senior Research Chemist in the Analytical Chemistry Department of the Israel Fibre Institute in Jerusalem will be spending two months at SAWTRI as from October, 1977. We wish to welcome Dr Basch and hope that his short stay will not only be to the benefit of SAWTRI and the Fibre Institute alone, but also to the mutual benefit of science and technology in South Africa and Israel.

New Subscribers

The following firms have joined the ranks of subscribing members to the work of the Institute:

Alpha Textiles (Pty) Limited, Randfontein.
Ken Plaskett Fabrics (Pty) Limited, Cape Town.
Spencer Hey (Pty) Limited, Epping.
Bytimex (Pty) Limited, Pinetown.
Tanatex South Africa (Pty) Limited, Pinetown.
Berkfield Consolidated (Pvt.) Ltd., Bulawayo
Cotton Printers Rhodesia (Pvt.) Ltd., Bulawayo
Elfin Textiles (Pvt.) Ltd., Salisbury

It is extremely gratifying that even in these rather unsettled economic times, there are still progressive textile firms who value the services that SAWTRI has to offer to industry.

Staff Matters

Three new staff members have been appointed at the Institute. Mr Gert van der Walt, who holds a B.Sc. (Textile Science) degree from the University of Port

Elizabeth, has been appointed in the Protein Chemistry Division. Mr van der Walt obtained considerable industrial experience prior to his appointment at SAWTRI.

Mr P.W. Goliath has been appointed as Technician in the Spinning Department. Mr Goliath joins SAWTRI from Valley Textiles Limited, Port Elizabeth, where he has worked for nearly eleven years.

Mr W. P. (Trompie) Strydom has been appointed Senior Technical Officer in the Dyeing and Finishing Division. Mr Strydom holds a Diploma in Textile Technology from UPE. He was previously employed by Fine Wool Products, Uitenhage, for seven years and the last two years he gained considerable experience in textile chemicals with Messrs Rohm and Haas.

We wish to welcome these new staff members and hope that their industrial experience will be of great benefit to SAWTRI.

SAWTRI PUBLICATIONS

Technical Reports

No. 341 : Roberts, M. B., Tranfer Printing of Wool with Reactive Dyes, part III: Further Studies of Important Variables using a Commercial Polyethylene/Paper Laminate Support (March, 1977).

No. 342 : Silver, H. M. and Roberts, M. B.: The use of the Heat Shock Principle as a Means of Producing Wool Fabrics Dimentionally Stable to Fusion and Steam Pressing (March, 1977).

No. 343 : Turpie, D. W. F. and Mozes, T. E.: Treatment of Wool Scouring Liquors part V: Isolation of Major Constituents Responsible for the Destabilising Effect of Sea-Water (March, 1977).

No. 345 : Robinson, G. A. and Green, M. V.: Cockling in Fully-Fashioned Knitwear, part III: A Comparison of Two Similar Wools of Different Origins (March, 1977).

No. 346 : Horn, R. E.: A Laboratory Investigation into the Possible use of Acetylation for (i) The Elimination of the Discolouration of Phenol-Formaldehyde Resin-treated Cotton Fabric and (ii) The Prevention of Subsequent Discolouration on Exposure to Light (March, 1977).

No. 347 : Veldsman, D. P.; Van der Merwe, J. P. and Taylor, H.: Some Preliminary Observations on the Open-End Spinning of Wool (March, 1977).

No. 348 : Turpie, D. W. F. and Benecke, J. A.: The Influence of Variations in Sliver Linear Density on Rectilinear Combing Performance (April, 1977).

No. 349 : Mozes, T. E. and Turpie, D. W. F.: Treatment of Wool Scouring Liquors, part VI: Initial Studies on Hollow Fibre Pilot Scale Ultrafiltration (March, 1977).

No. 350 : Hunter, L.: The Hairiness of Wool Worsted Singles Yarns (June, 1977).

No. 351 : Roberts, M. B.: The Effect of Common Processing Conditions upon the Mohair Fibre (June, 1977).

No. 352 : Smuts, S. and Hunter, L., Studies on some Wool/Acrylic Woven Fabrics, Part II: Polyurethane and Polyacrylate Treated Plain and 2/2 Twill Lightweight Fabrics from Wool Blended with Regular Acrylic (June, 1977).

No. 353 : Hunter, L. and Smuts, S., A Preliminary Report on Certain Physical Properties of Commercial Woven Wool and Wool Blend Fabrics (June, 1977).

Papers Appearing in Other Journals

Veldsman, D. P.: Breë Riglyne vir S. A. Katoenkultivars, *Landbouweekblad* 58 (10), 34 (Maart 1977).

Van Rensburg, N. J. J. The SAWTRI Simultaneous Shrink-Resist and Flame-Retardant Treatment for All-Wool Fabrics. *S.A. Journal of Science* 73 (3), 69 (March, 1977).

Turpie D. W. F.: Recent Work in South Africa on the Effect of Raw Wool Blending on Subsequent Processing Performance — Part I: Components Differing in Style, Class Description, Length (Limited Variations) and Diameter (Limited and Large Variations) *Wool Tech. and Sheep Breeding.* **XXV** (1), 10, 33 (1977).

TEXTILE ABSTRACTS

Anon, Dimensionally Stable Woven Fabrics on the Triaxial System *Text. Manuf.* 77 (1), 31 (Jan., 1977).

This short communication deals with the relatively new Triaxial system of weaving in which fabric is formed by interlacing three ends at 60° angles. Two warp ends and one weft end are interwoven at equal angles to produce a fabric with the following distinctive properties:

(1) Higher bursting strength and the elimination of potentially catastrophic failures;
(2) High tear strength and shear resistance;
(3) Improved flex qualities.

It is stated that the Triaxial system was developed some seven years ago to produce a light-weight fabric for parachute gliders which had to bring back space capsules although its uniform stretch in all directions could make it suitable for athletic and foundation garments. It is suggested that because of its desirable characteristics, it could also find outlets in upholstery, outerwear, sail cloths, truck covers, filter fabrics, etc.

(L.H.)

N. Wilson, Close-up on Antistatic Fibres and Finishes. *Text. J. Austr.*, **10** (July, 1976).

This article discusses the generation and measurements of static electricity and describes the various antistatic fibres and finishes used in textiles, e.g. in apparel and carpets.

(L.H.)

F. Powell, New Methods of Obtaining Stable pH's in the Acid Range, *Text. J. Austr.*, **10** (August, 1976).

The use of ultra-phosphates, generally added at the beginning of a process, to accurately control the pH during processing at levels below about 5,5 is discussed and described. These chemicals also act as chelating agents, particularly for chelating iron from acid bleach liquors. Their use in the dyeing of polyester is treated in some detail and the effect of pH on the exhaustion of various disperse colours is illustrated graphically. It is stated that in the case of the dyeing of wool or nylon or both, if the fibres can be dyed successfully over a wide range of pH's acetic, formic or sulphuric and will be more economical than the ultras, but where the pH is important, such as reactive dyestuffs on wool, the use of ultra can assist greatly in maintaining the correct pH.

(L.H.)

W. O. Goodman, Texturized Polyester Processing, *Text. Asia,* **83** (Feb., 1977).

In this article the author discusses the preparation, dyeing and finishing of 100 *per cent* polyester woven or knitted fabric and offers some practical ideas and formulae which could help the dyer to cut costs and time. It is stated that more and more evidence shows that oil on the fabric (texturizing and knitting oils, for example) is the major problem in dyeing. Even certain cracks and rope marks are believe by some to be oil related. In scouring knitted fabric a low-foaming nonionic detergent together with a small amount of soda ash are recommended. It is stated that the efficient removal of oil and size prior to dyeing should reduce problems such as dye spotting, cracks and shading and uneven dyeings. Lubricants may be necessary in the dyebath to help prevent cracks, crushes and ropemarks and a defoamer is generally used to prevent foam, since tangles and pump cavitation are caused when foam is produced in large amounts.

(L.H.)

C. O. Graham, P. L. Rhodes and R. J. Harper, Processing Cotton with Chemically-altered Fiber Friction, *Text. Res. J.,* **47**, 102 (February 1977).

Chemical treatments which affect those fibre properties that influence cotton processing efficiency are discussed. It is concluded that cotton raw stock, which has been chemically treated to increase fibre-to-fibre friction, can be processed although the treatment adversely affected the carding action and the yarn strength. Such treatment improve fibre parallelization and reduce roving twist requirements but not that of the yarn. Lubricants which reduce fibre friction do not improve carding and necessitate higher yarn twists although they could reduce ends-down during

spinning, provided the fibre friction is not reduced to such an extent that the fibre parallelization is reduced.
(L.H.)

S. M. Suchecki, Vapor Phase Finishing Comes to Seventh Avenue, *Text. Ind.*, **141**, 116 (January 1977).

The commercial application of the Vapor Phase techique of imparting permanent press properties to a variety of all-cotton knitted garments (e.g. sportswear, slacks, denims, corduroys, skirts, etc.) is described.

The garments should be clean and absorbent prior to treatment.

The first step in the process, is a brief pre-steaming and soaking cycle, followed by the injection of powdered para-formaldehyde which sublimates when it falls onto the hot plates. The temperature at this stage is 49–60°C. Within a minute the catalyst (sulphur dioxide) and steam are fed into the chamber. After a brief preheating cycle, the formaldehyde-sulphur dioxide vapours are exhausted and replenished with fresh air. The temperature is increased to 116 – 121°C and crosslinking takes place. This takes about 10 minutes. An exhaust cycle removes gaseous by-products, high pressure steam is injected to remove unreacted formaldehyde from the garments and exhaustion with fresh air completes the process. The whole process lasts about 25 minutes. Various advantages are claimed compared to conventional resin treatments, e.g. low add on (0,1 *per cent*), soft handle if required, uniform application, better soil repellancy, better colour retention and resistance to pilling and abrasion. It is not recommended to treat fabrics containing less than 20 *per cent* of cotton. The process can be extended to linen and rayon fabrics and blends of these and is also thought to be particularly suitable for jeans (denims). The process was commercialised some five years ago but has been applied primarily to woven cotton blend garments for the industrial markets.
(L.H.)

H. Petersen, Andwendung der Statistischen Versuchsplanung in der Textilehochveredlung, *Textileveredlung* **12**, 58 (1977).

The application of statistical planning to the textile finishing field provides insights into relations between different factors which methods hitherto used cannot give. For example, the author studied the crosslinking reactions of cellulose under various conditions. The results depended not only on the chemical constitution of the finishing agent, but also on various other variables. From the results tables and yield graphs were prepared. The optimum of the *most economical finishing conditions* for any desired level of finishing effects may easily be derived from these graphs. Furthermore a technique using transparent films was developed to integrate individual graphs into a comprehensive one. Nomograms based on regression analysis equations were calculated and the equations were recorded on magnetic card programs for use in an electronic pocket calculator. The publication contains 22 tables and 14 figures.
(N. J. J. v. R.)

SEMI-AUTOMATIC FEEDING OF THE ELGIN DECORTICATOR FOR *PHORMIUM TENAX*

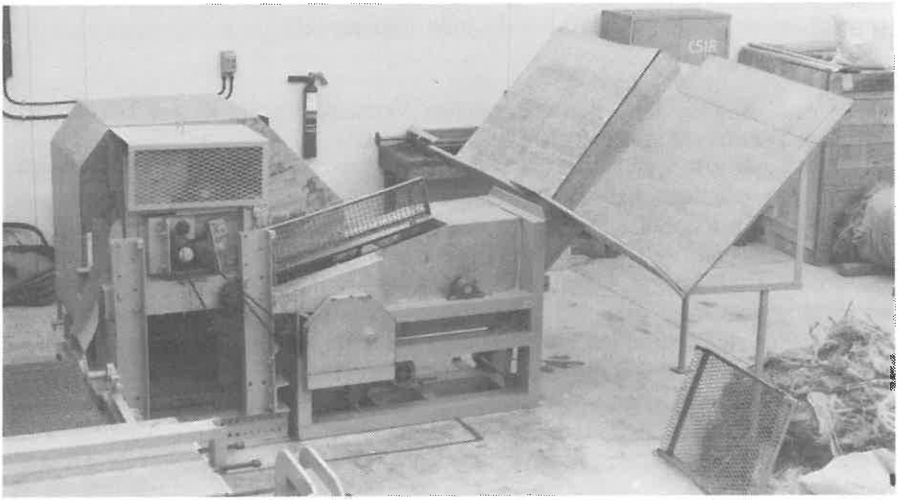
by D. W. F. TURPIE

ABSTRACT

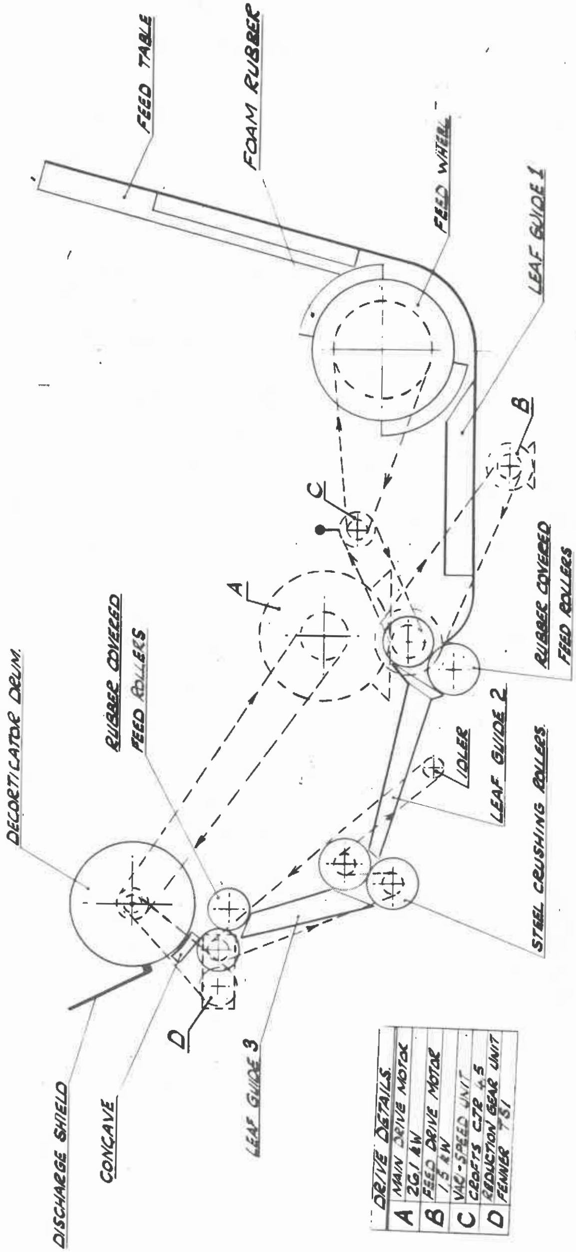
A semi-automatic feed fitted to an Elgin decorticator for Phormium tenax *is described. This resulted in a significant reduction in human fatigue which played a dominant rôle in earlier trials.*

INTRODUCTION

It was recently reported that the potential production of the Elgin "Mini" Mk II decorticator for *Phormium tenax* had been increased by fitting an improved feeding and discharge chute[1]. The divided feeding chute enabled better control to be exercised over leaves entering the decorticator, and the discharge chute resulted in a lessening of the disturbance to the fibres by air currents on the fibre discharge side. It was demonstrated, albeit using only very small quantities of leaves, that a *theoretical* production rate of about 190/250 kg of fibre per hour (i.e. 1 500 kg to 2 000 kg per 8-hour shift) was possible from leaves of good quality. This theoretical limit was far above the production rate possible in practice. In fact it was *not* possible to maintain a rate of 150 kg/hr for more than a few *minutes* using two feed



Side view of decorticator showing feed chute on the right



DRIVE DETAILS.	
A	MAIN DRIVE MOTOR 2G/1 kW
B	FEED DRIVE MOTOR 1.5 kW
C	VAC-SPEED UNIT CROFTS CJR 4.5
D	REDUCTION GEAR UNIT FENNER 751

FIGURE 1
Diagrammatic view mini-decorticator with feed unit

operators. It is doubtful if even a third or a half of this rate could have been maintained for any length of time.

It was clear from the foregoing that if a reasonable production rate was to be maintained for reasonably long periods of time, some automation of the feeding system would be highly desirable in order to reduce operator fatigue. Accordingly, a semi-automatic feed was designed and constructed at SAWTRI as described hereunder.

DESCRIPTION OF THE SEMI-AUTOMATIC FEED

A diagramatic view of the Mini-decorticator with semi-automatic feed unit is shown in Fig. 1. The semi-automatic feed unit comprises a feeding table, feed chute, feed wheel, leaf guide No. 1, feed rollers and leaf guide No. 2, the last-mentioned being positioned in front of the steel crushing rollers of the decorticator in place of the original feeding chute. (The crushing rollers, leaf guide No. 3 and feed rollers to the decorticator section were not affected by the design of the automatic feed). The semi-automatic feed is driven independently of the decorticator section by its own drive motor 'B', power being transferred to a pair of

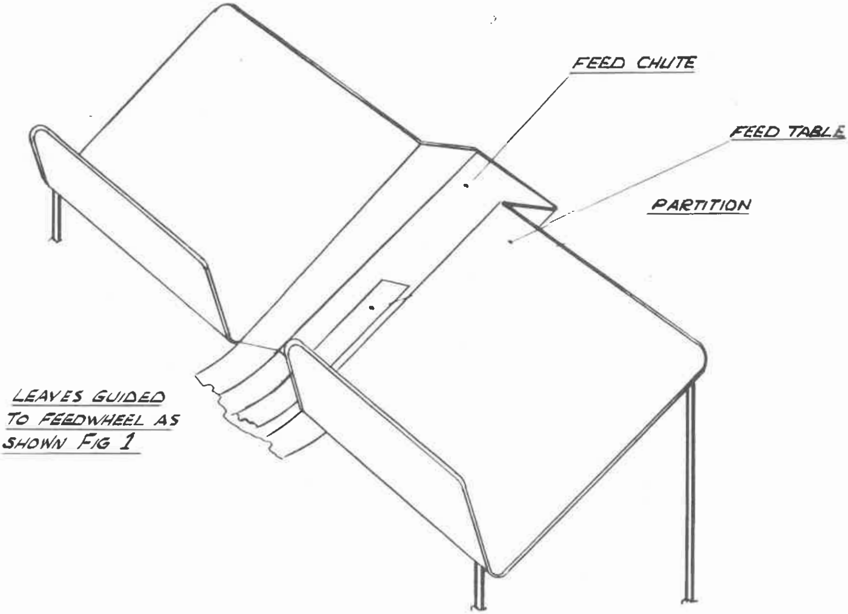


FIGURE 2
Feed table

rubber covered feed rollers by a direct V-belt drive and from these feed rollers to the feed wheel via a variable speed unit comprising an expandable pulley.

An oblique view of the feed table is shown in Fig. 2. Bundles of leaves are placed on both sides of this table, butt-ends down, and are fed by two operators, one at each side of the table, into the feed chute. The chute is divided with a partition down the centre so that the leaves fed by each operator are kept apart. Each operator feeds two or three leaves at a time into the chute with a rythmic motion, the leaves being directed downwards towards the mouth of the chute.

The feed wheel (Fig. 1) rotates at a speed which can be varied from 829 to 1 684 r/min. Two strips of foam rubber, 50 mm thick, are glued onto the periphery of the wheel, as illustrated, each being about one quarter of the circumference in length, and positioned at opposite sides of the wheel. The width of each strip of foam rubber is about half the width of the feed wheel, enabling one strip to be glued opposite the right hand section of the divided mouth of the feed chute and the other to be glued opposite the left hand section of the divided mouth of the feed chute. The bottom of the feed chute is set to just clear the foam. When leaves are presented to the mouth of the chute they are struck by the foam at from 14 to 28 times per second (depending on the rotational speed of the feed wheel) and when the frictional force is high enough they are shot along the leaf guide towards the rubber covered feed rollers at an initial speed approaching from 26 to 53 m/s. The rubber covered rollers have a diameter of 130 mm and are set to rotate at 3 367 r/min. The leaves are ejected from these rollers down a second leaf guide towards the steel crushing rollers at an initial speed approaching 23 m/s.

The semi-automatic feed was subjected to tests in which 700 kg of leaf, were put through the decorticator. The production capacity of the machine was estimated from these trials to be around 700 kg of green leaf per hour without any undue fatigue being suffered by the feed operators, provided auxiliary labour was used to keep the feed table supplied with fresh bundles of leaf and was used to relieve the feed operators from time to time. This production rate was equivalent (based on a yield of 14%) to about 100 kg of dry fibre per hour, or roughly 0,75 ton of dry fibre per 8-hour shift.

ACKNOWLEDGEMENTS

The author acknowledges the initial work carried out by Mr H. E. Schmidt on the design of the semi-automatic feed, and the modifications leading to the present design which were carried out by Mr K. Schröder and his staff. The author also wishes to thank the Xhosa Development Corporation for supplying the leaves and Mr N. J. Vogt for making all the necessary arrangements.

REFERENCES

1. Godawa, T. O., Increasing the Production Capacity of the "Mini" Mk II Decorticator for *Phormium tenax*., *SAWTRI Bulletin* 9 (4), 15 (December, 1975).

A PRELIMINARY NOTE ON THE REDUCTION IN THE CONTAMINANTS OF RAW WOOL BY DESUINTAGE SCOURING

by D. W. F. TURPIE and S.A. MUSMECI

ABSTRACTS

The passage of raw wool samples through the first bowl of a pilot scouring plant containing only mains water effected a significant reduction in all contaminants, i.e. mineral matter, suint and grease. The temperature of the water was shown to be of considerable importance.

INTRODUCTION

There appears to be little information available with regard to the efficiency with which individual *contaminants* of raw wool, i.e. mineral matter, suint and grease, can be removed by using cold or warm water in a first bowl treatment. Such information could be of importance in the present climate of pollution control and effluent treatment, and in the design of a suitable system of treatment for wool scouring liqours.

The usual method for scouring raw wool, namely conventional emulsion scouring involves an aqueous procedure in which the wool is propelled by mechanical action through a series of bowls containing water and a surface active agent, and is squeezed by squeeze rollers after emerging from each bowl. In its classical form the temperature of the liquor in the bowls cannot be less than the melting point of wool grease, namely about 40°C, and there is a backflow of liquor from the last bowl to the first resulting in the production of an effluent containing wool grease, suint and mineral matter. The suint salts present on the fibre assist in the scouring process since they contain potassium salts of higher molecular weight fatty acids, and other inorganic salts which facilitate wetting of the wool and emulsification of the wool grease[1]..

Suint can be used to partially cleanse the fibre by using lukewarm water only in the *first* bowl of a conventional scouring set. This modified form of emulsion scouring is known as desuintage scouring, and the first bowl is normally referred to as a desuinting bowl. Typical immersion time in a desuinting bowl is 3 minutes at a temperature of 32° to 43°C. At these temperatures the suint salts are readily soluble and maximum effectiveness may be derived from their colloidal suspending properties to remove as many of the heavier dirt particles as possible. It has been claimed that as much as 40 *per cent* of the total shrinkage can be removed in this manner[2]. Periodic or continuous removal of the contents of the bowl is advisable to prevent the concentration of salts and dirt from reaching saturation point. It has also been claimed that while small amounts of *grease* can be removed in a cold to luke warm rinse (30–32°C) from near-neutral *fine* wools, substantial losses of grease may occur for *crossbred* wools, and the procedure would appear to be undesirable when followed by centrifugal grease recovery[3].

A system of scouring in which concentrated suint liquors are used in the first *two* or *three* bowls of a scouring set and known as the Duhamel, or suint process, was widely discussed about 1930. These suint liquors varied in pH from about 5,5 to 8,4 and thus enabled scouring to be effected at temperatures up to 70°C without damaging the wool. The suint liquors had to be continuously clarified with respect to both grease and sand and the success of the process largely depended on the efficiency of the clarification[4]. It has been stated that this process does not normally reduce the grease content of the wool to a sufficiently low level, and recovery of the grease from the extraction liquor is difficult[5].

As a preliminary exercise it was thought to be of interest to study the efficiency with which the contaminants can be removed in a cold or warm water first bowl treatment without allowing the suint to build up, i.e. to determine the effect of the aqueous treatment itself. If the suint itself has detergent properties then greater efficiency in removal of such contaminants would ensue. This, however, could be the subject of a further study in which the concentration of suint was deliberately elevated.

EXPERIMENTAL

The equipment used comprised the hopper, first bowl and squeeze rollers of a one foot wide Petrie & McNaught pilot scale scouring plant. The hopper was filled with a well blended average style 8/11 months 64's mixture containing various fleece wools, backs and bellies. The feed rate was set at 50 kg/hr. The total loading on the squeeze rollers was set at zero to obviate any possibility of wool sticking at the nip.

Initially, the bowl was filled with mains water and the temperature raised to 25°C. The hopper was started, and scouring continued for 10 minutes. Five minutes were allowed to ensure a steady flow of material through the system, and then the wool emerging from the squeeze rollers was sampled continuously for three minutes into a small plastic bag. Sampling was discontinued as soon as the hopper was stopped. The contents of the bowl were discharged to waste, the bowl re-filled with water from the mains, the temperature raised to 30°C, and the experiment repeated. Repeat experiments were then carried out at 35°C, 45°C and 55°C.

All samples were dried in a CSIRO regain tester to the bone dry state, subsampled immediately within a few seconds of weighing to minimise errors due to moisture regain, and the subsamples tested for grease, suint and ash (to represent mineral matter).

The grease was determined by soxhlet extraction of 5 g subsamples using dicloromethane as solvent. The suint was determined by soxhlet extraction of the de-greased samples using distilled water as solvent. Ash was determined by heating 10 g subsamples in a muffle furnace for 12 hours at 700°C.

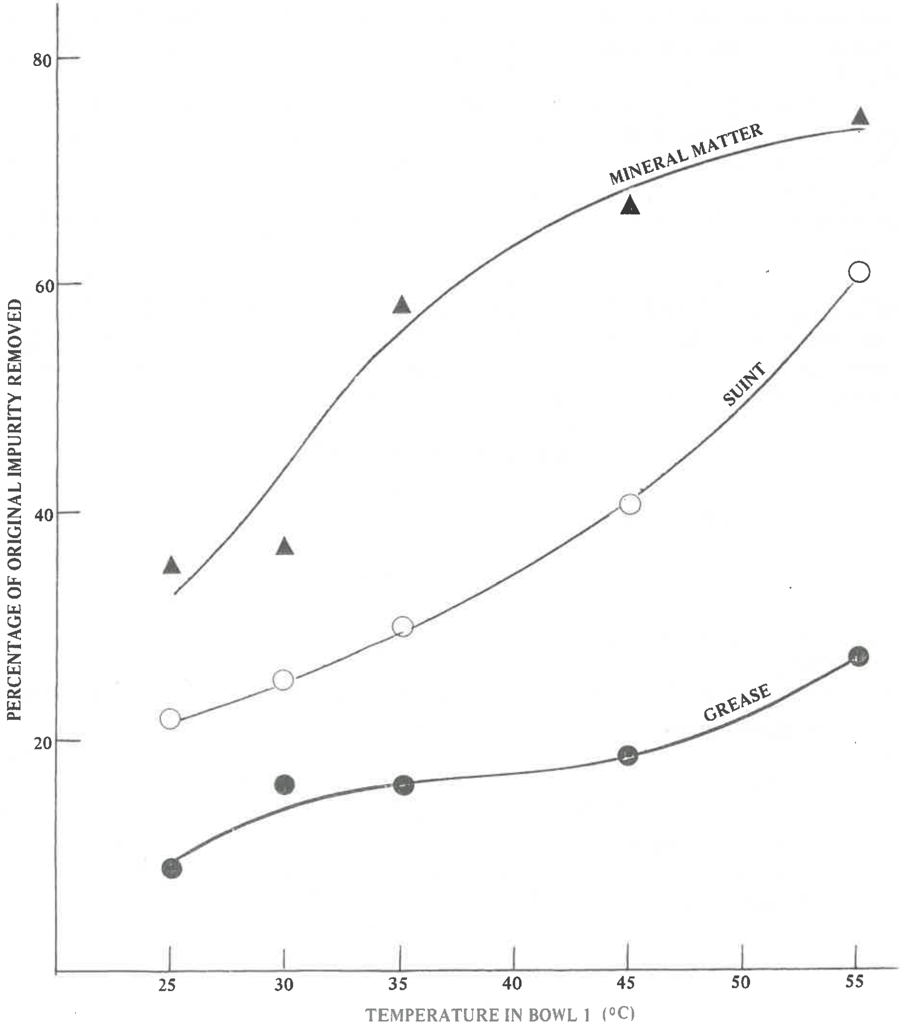


FIGURE 1

Reduction in contaminants of raw wool by one passage through the first bowl of a pilot scouring plant containing mains water only.

RESULTS AND DISCUSSION

Analysis of the raw wool showed that it contained 86,6 g of contaminants per 100 g bone dry clean fibre. These contaminants comprised 31,0 g grease, 12,3 g suint and 43,3 g ash. Similar analyses were carried out for the various scoured samples, and the results also expressed on the basis of clean bone dry fibre. The percentage reduction in each contaminant was then calculated and these results are given in Fig. 1.

From Fig. 1 it is clear that passage of the raw wool through the first bowl containing only mains water effected a reduction in the raw wool contaminants. The greatest reduction was in respect of mineral water, followed by suint and then grease. For all three contaminants temperature was shown to be of considerable importance. An increase from 25 to 55°C resulted in an almost linear increase in all cases.

At 25°C approximately 35 *per cent* of the mineral matter, 20 *per cent* of the suint and 10 *per cent* of the grease were removed. At 55°C the respective percentages were 75, 60 and 25. The removal of grease at the lower bowl temperatures, i.e. below the melting point of the grease, may possibly have been due to the fact that some of it adhered to particles of mineral matter.

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REFERENCES

1. Howitt, F. O. and Preston, R., The Composition of Suint. *J. Text. Inst.*, **51**, T841 (1960).
2. Von Bergen, W. and Mauersteyer, H. R., American Wool Handbook, *Textile Book Publishers New York,* 410 (1948).
3. Hoare. J. L. Wool-scouring Effluent, Part III. The Effect of an Initial Rinse on Grease Recovery. Letter to the Editor, *J. Text. Inst.,* **65**, 500 (1974).
4. Thompson, T. E., The Scouring of Raw Wool in Theory and Practice. *Emmott & Co., Ltd.*, Manchester, 19 (1948).
5. McNamara, E. J., Jr., The Practical Aspects of Neutral Grease Wool Scouring. *Am. Dyest. Rep.,* **46** (20), 731 (October, 1957).

THE CAUSTIC MERCERISATION OF COTTON FABRICS: PART II INVESTIGATION INTO THE MERCERISATION EFFECT OF CAUSTIC SODA SOLUTIONS AT ELEVATED TEMPERATURES

by F. A. BARKHUYSEN

ABSTRACT

Plain weave, twill and denim fabrics were treated with a caustic soda solution at the boil and at room temperature and certain properties of the fabrics were compared. In general a treatment with hot caustic soda was not superior to a treatment at room temperature. In fact, in some cases it was inferior to the conventional caustic soda treatment. The barium numbers of the fabrics treated in hot caustic soda decreased when the fabric mass increased. The barium numbers of the lightweight and twill fabrics treated in hot caustic soda were higher than those of the fabrics treated in cold caustic soda, whereas the reverse was the case for the denim fabric.

INTRODUCTION

The use of caustic soda as a swelling agent to enhance certain properties of cotton is a well-known and well-established procedure. The history of this phenomenon dates back to the 19th century when Mercer[1] and Lowe[2] discovered that caustic soda was absorbed by the cotton fibre and caused swelling of the cellulose structure of cotton. Swelling results in a separation of the molecular chains of cellulose and an accompanying re-arrangement that affords increased reactivity. This observation forms the basis of the mercerisation process as it is known today.

It is also well-known, however, that the mercerisation process, when carried out on an industrial scale on yarn or fabric, is by no means as efficient as it should be. This is due to the fact that the reaction is restricted mainly to the surface of the yarn or fabric. Under normal conditions the caustic soda swells the fibres at the surface of the yarn rapidly, thereby compacting the surface and thus hindering further penetration of the caustic soda into the interior of the structure[3].

In general a swelling agent with a lower degree of swelling but with better penetration properties is therefore needed. Liquid ammonia was found to be one such swelling agent. The vacuum impregnation technique to aid the even and thorough penetration of a solution into a fabric was also investigated[4]. It was also reported that mercerising with caustic soda at elevated temperatures, approaching the boiling point of the caustic soda solution, resulted in a more rapid, thorough and even treatment than does the conventional method[5, 6, 7, 8]. On the other hand, Bechter *et al*[3] stated that the higher the mercerising temperature, the better the uniformity of the treatment, but the lower the degree of mercerising.

The purpose of this investigation, therefore, was to compare hot caustic soda mercerisation with the conventional room temperature mercerisation process.

EXPERIMENTAL

Scoured and bleached lightweight plain weave (128 g/m^2), 2/1 twill weave (223 g/m^2) and undyed denim cotton fabrics (290 g/m^2) were used in this investigation. These fabrics were divided into two lots. One lot was treated with a 19 *per cent* (m/v) caustic soda solution at room temperature and the other lot was treated in a *boiling* 19 *per cent* caustic soda solution. 0,5 *per cent* ®Leophen BN (mass/volume) was used as wetting agent. The treatments were carried out as follows: a cotton sample was mounted on a stainless steel frame (clamped at the two ends in the warp direction) and immersed in the caustic soda solution in a slack state. The sample was then stretched back to its original warp length while still immersed in the solution. The sample was then removed from the solution, immediately cooled down by blowing cold compressed air onto the fabric, rinsed with hot water, neutralised with a 3 *per cent* acetic acid solution, rinsed again with hot water and dried. In the case of the hot as well as cold caustic soda treatments immersion times of 10, 20, and 40 seconds were used.

Shrinkage measurements were determined in the usual manner by washing the fabrics in a Cubex apparatus[6]. The degree of mercerisation (barium number) of the samples was determined according to the AATCC method 89-1971.

Two reactive dyes and one direct cotton dye were used to determine the effect of the temperature of the caustic soda solution on the dye absorption of the cotton. The dyeings were performed in a Linitest laboratory dyeing apparatus and were carried out according to the manufacturer's recipes. The amount of dye absorbed by the fibre was determined by analysis of the spent dye liqour with a Zeiss PM 2 DL Spectrophotometer. The colour difference (ΔE) between the dyed samples were calculated from X,Y, and Z measurements obtained from a Harrison-Shirley Digital Colorimeter. The Kubelka-Munk values for some of the dyed fabrics were also determined.

RESULTS AND DISCUSSION

The area shrinkage results of the lightweight and twill fabrics are given in Table I. The results were analysed statistically (Analysis of Variance). It was found that for, the lightweight fabric, a treatment in hot caustic soda resulted in a lower percentage area shrinkage after washing when compared with a treatment at room temperature. In the case of the twill fabric no significant difference in area shrinkage was found between a treatment at room temperature and at the boil.

TABLE I

AREA SHRINKAGE VALUES OF THE LIGHTWEIGHT AND TWILL COTTON FABRICS TREATED WITH CAUSTIC SODA AT ROOM TEMPERATURE AND AT THE BOIL, USING VARIOUS IMMERSION TIMES

Treatment	Area shrinkage (%) of the lightweight fabric after		Area shrinkage (%) of the twill fabric after	
	NaOH	120 min* wash	NaOH	120 min* wash
Untreated Control		8,0		11,4
Room Temperature 10 s	9,3	0	7,9	1,3
Room Temperature 20 s	8,3	3,0	6,9	3,6
Room Temperature 40s	10,1	–0,3	7,0	3,0
100°C – 10 s	7,5	–1,2	5,3	5,5
100°C – 20 s	7,6	2,7	4,3	6,3
100°C – 40 s	8,5	0,6	–	–

* Based on the dimensions of the fabrics after the NaOH treatment.

Certain chemical and physical properties of the two fabrics are given in Table II. It was found that a treatment of the cotton fabrics with caustic soda increased the dyestuff absorption of both fabrics. The *hot* caustic soda treatment, however, did not effect higher exhaustion values than the cold caustic soda treatment, irrespective of immersion time. The analysis furthermore showed that the treatment with hot caustic soda resulted in a smaller colour difference value (ΔE) between the treated and the untreated control fabric than a treatment at room temperature. A higher degree of mercerisation (barium number), however, was found in the case of the fabrics treated with hot caustic soda. This effect was larger in the case of the lightweight than the twill fabric. The statistical analysis showed that the different immersion times had no effect on this fabric property. The breaking strength results showed that no improvement was obtained by a treatment in hot caustic soda when compared with a treatment at room temperature. On the average, the breaking strength values obtained after a hot caustic soda treatment were found to be lower than those obtained after a treatment at room temperature.

In the case of the denim fabric (Table III) it was found that hot caustic soda produced *lower* barium numbers than the treatment at room temperature. It seems that the hot caustic soda process gave high barium numbers in the case of the lightweight fabric, but the values decreased as the fabric mass increased. For example, for an immersion time of 40 seconds the barium number of the lightweight, twill and denim fabrics decreased from 148 to 131 and 124, respectively. The cold caustic soda treatment, on the other hand, gave values of 135, 131 and 135, respectively. It is obvious, therefore, that the hot caustic soda process became progressive-

TABLE II

SOME CHEMICAL AND PHYSICAL PROPERTIES OF THE LIGHTWEIGHT AND TWILL COTTON FABRICS AFTER TREATMENT WITH CAUSTIC SODA, AT ROOM TEMPERATURE AND AT THE BOIL, USING VARIOUS IMMERSION TIMES

	Lightweight Fabric				Twill Fabric			
	Barium Number	**ΔE**	**Exhaustion (%) ***	**Breaking Strength (N)**	**Barium Number**	**ΔE**	**Exhaustion (%) ***	**Breaking Strength (N)**
Untreated Control			67,7	256			72,2	1 000
Room Temp. - 10 s	132	7,12	79,5	276	126	9,31	74,8	1 027
Room Temp. - 20 s	135	8,20	79,7	258	131	925	78,0	1 067
Room Temp. - 40 s	135	8,00	80,8	273	131	8,47	75,8	1 076
100°C – 10 s	135	6,85	78,8	249	136	7,80	74,8	1 020
100°C – 20 s	140	6,57	78,8	263	136	8,50	78,2	1 013
100°C – 40 s	148	7,35	78,3	257	131	8,51	78,2	1 052

* C I Reactive Red II

TABLE III

SOME CHEMICAL PROPERTIES OF THE DENIM FABRIC AFTER TREATMENT WITH CAUSTIC SODA AT ROOM TEMPERATURE AND AT THE BOIL, USING DIFFERENT IMMERSION TIMES

Treatment	Barium Number	Dyes					
		CI Direct Red 81			CI Reactive Blue 74		
		%Exhaustion	ΔE	K/S Value	%Exhaustion	ΔE	K/S Value
Untreated Control		74,9		1,977	64,3		0,664
Room Temperature – 10 s	127	74,5	8,25	4,423	63,9	9,70	0,980
Room Temperature – 40 s	135	74,9	7,20	4,170	64,7	9,66	1,316
100°C – 10 s	121	73,3	6,69	3,944	65,8	10,79	1,385
100°C – 40 s	124	78,9	7,24	3,573	65,9	11,16	1,321

ly worse as the fabric mass increased. A statistical analysis of the results furthermore showed that the dye absorption and colour difference values of the denim fabric were the same whether treated with caustic soda at room temperature or at the boil. The Kubelka-Munk values of the fabric dyed with the direct dye was lower after a treatment with caustic soda at the boil than at room temperature, i.e. the dyed fabric appeared lighter in colour after a treatment at the boil than after a treatment at room temperature. In the case of the reactive dye, however, slightly higher values were obtained when the fabric had been treated in hot caustic soda.

SUMMARY AND CONCLUSION

Lightweight plain, twill and denim cotton fabrics were treated with caustic soda at room temperature and at the boil. It was found that, in the case of the lightweight fabric, a treatment at the boil resulted in a lower area shrinkage during washing than a treatment at room temperature, but in the case of the twill fabric, however, no significant difference was observed between the two treatments. No differences were observed between the dye absorption of fabrics treated at room temperature and at the boil. A hot caustic soda treatment, however, resulted in fabrics with a lower colour difference value than a treatment at room temperature. A higher barium number (degree of mercerisation) was, however, found in the case of fabrics treated with hot caustic soda, especially for the lightweight fabric. It was also found that the breaking strength of the fabrics did not increase after a treatment in hot caustic soda when compared with those obtained after a treatment at room temperature.

In the case of the denim fabric, a hot caustic soda treatment resulted in a lower degree of mercerisation when compared with a cold caustic soda treatment. No significant difference in dye absorption and colour differences values were found between the two methods of treatment.

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THE USE OF PROPRIETARY NAMES

® Leophen BN is a trade mark of Messrs BASF. The fact that a chemical with a proprietary name has been used in this investigation in no way implies that SAWTRI recommends it and that there are not others as good or even better.

REFERENCES

1. British Patent 13296 (1850).
2. British Patent 4452 (1890).
3. Bechter, D., Fiebig, D. and Heap, S. A., Investigations into the Uniformity of Mercerising Cotton Fabrics. *Textilveredlung* **9**, (6) 6,265 (June 1974).
4. Silver, H. M., The Caustic Mercerisation of Cotton Fabrics. Part I : A Laboratory Investigation of the Vacuum Impregnation of Caustic Soda. *SAWTRI Bulletin,* **10** (3), 14 (Sept. 1976).
5. Anon, Some Consequences of Hot Mercerising. *Canadian Text. J.,* **92** (9), 149 (Sept. 1975).
6. Anon, Hot Mercerising, *Am. Dyest Rep.,* **64** (9), 24 (Sept. 1975).
7. Duckworth, C. and Rusnak, I., Some Consequences of Hot Mercerising of Cotton : An Anglo-Hungarian Study. *Text. Month* 60 (June 1976).
8. Moffatt, M. C., Developments and Trends in Fabric Preparation including Hot Mercerising. *Dyers Dyegest,* **5**, (3) 37 (May 1976).
9. Barkhuysen, F. A., Liquid Ammonia Mercerisation of Cotton, Part II : The Influence of Anhydrous Liquid Ammonia on the Dimensional Stability of Cotton Fabrics. *SAWTRI Techn. Rep.* No. 286, (March 1976).

PREDICTION OF THE PHYSICAL PROPERTIES OF SINGLES WOOL WORSTED YARNS FROM FIBRE PROPERTIES

by L. HUNTER

INTRODUCTION

It is the ideal of every textile technologist and scientist concerned with research on staple yarns to be able to establish precise relationships between the physical properties of the yarns on the one hand and the fibre properties on the other hand. This would enable the yarn properties to be predicted in advance from those of the fibres and therefore would allow the technologist to select his raw material and yarn parameters (linear density and twist for instance) in the most economical way to give a yarn the properties he particularly desires. In other words the textile technologist would be in a position to "engineer" his yarn strictly in accordance with his requirements. This review attempts a summary of progress which has been made towards achieving this goal.

Before reviewing the literature, however, let us take a look at some of the obstacles and practical difficulties inherent in attempting to establish relationships between fibre and yarn properties. Clearly two approaches are possible. The first approach is theoretical, of which the Martindale[1] model for yarn irregularity is a fine example. The second approach is empirical. Presumably the theoretical model or relationship would represent the ideal case, arrived at from a statistical treatment of the fibre assembly (taking into consideration all the inherent variations in the fibre dimensions and properties) but probably ignoring the imperfections of the processing machinery which manipulate the raw wool from the staple into yarn.

With the exception of Martindale's work to which reference will be made later, no theoretical models (relationships) appear to have reached the stage where the textile technologist can, in practice, derive the yarn properties directly by, for instance, inserting the values for the fibre properties into an equation and arriving at a value for the yarn property under consideration (e.g. breaking strength or extension at break), even if the value is only an "ideal" or average towards which he has to strive. This review will confine itself, therefore, to those empirical relationships which enable the relevant fibre and yarn characteristics to be used to predict, quantitatively, the yarn physical properties.

As mentioned earlier, however, many problems present themselves when trying to predict yarn properties from those of the fibre. For instance, how does one allow for different degrees of fibre entanglement and felting during scouring and then subsequent differences in fibre breakage during carding and perhaps gilling and combing? Furthermore, the settings and condition of the card will affect the fibre breakage and so will the degree of weathering of the wool. How does one quantify these effects so that they can be incorporated into equations relating yarn to fibre properties? The above obstacles could perhaps be overcome by considering the fibre properties only, as they occur in the top, but then one still has the effect of different levels and types of lubricant to consider and the type, condition and efficiency of the drawing and roving operations. The spinning process is the final and often the most critical. Eccentric front rollers on the spinning frame, for instance, can play havoc with the number of fibres in the yarn cross-section and, therefore, with the yarn properties. Even the spinning system itself (e.g. cap, flyer or ring) and type of drafting unit can have a noticeable effect on yarn properties. The maintenance, condition and cleaning of the spinning frame and other factors such as draft, spindle speed, etc., can all affect the properties of a yarn spun from one raw material and it is virtually impossible to quantify or allow for these effects when trying to derive relationships between fibre and yarn properties.

It is clear from the above discussion that it is virtually an impossible task to derive mathematical relationships between fibre and yarn properties which will be generally applicable. Two possibilities remain, the one is to establish relationships from which the "ideal" yarn properties for a certain raw material can be predicted and the other is to establish empirical relationships from which the properties of an "average" commercial yarn can be predicted. The latter has been favoured in practice and is the theme of this article, except in the case of the Martindale model.

IRREGULARITY

As far as the application of the theoretical approach to the irregularity of a strand composed of staple fibre is concerned, the work of Martindale[1] is probably the most often referred to. Martindale, by assuming that in an ideal yarn (strand) the fibre are distributed completely at random, derived the following relationship between irregularity (CV) and the average number of fibres in the yarn cross-section[1] – –

$$CV_1 = 100\sqrt{\frac{(1 + 0{,}0004\ V_d^2)}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where CV_1 is the ideal or limiting coefficient of variation of the yarn linear density, V_d is the percentage coefficient of variation of the fibre diameter and n is the average number of fibres in the yarn cross-section. For wool n can be calculated approximately as follows:

$$n = \frac{\text{Yarn tex}}{1{,}029 \times 10^{-3} \times d^2(1 + 0{,}0001\ V_d^2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$= \frac{972\ \text{Yarn tex}}{d^2\ (1 + 0{,}0001\ V_d^2)}$$

where d = mean fibre diameter in micrometres (μm).

Knowing the yarn linear density (i.e. count), fibre diameter and diameter variation, it is possible to calculate the irregularity of a yarn spun under so-called "ideal conditions", i.e. where the fibres are randomly distributed according to a Poisson distribution. This limiting irregularity is still used today to assess spinning performance in producing a particular yarn. In this case the irregularity of the yarn is measured and divided by the limiting irregularity (calculated by means of eq (1) to give what is termed an irregularity index I which is then used as a measure of the spinning performance. For worsted yarns a value of 1,2 for I is regarded as being good (very even yarn), a value of 1,35 is regarded as average while a value of 1,5 is claimed to be poor (uneven yarn). These values, strictly speaking, are only applicable to limiting counts, as coarser yarns than these generally exhibit higher values[2].

In practice, the observed irregularity is invariably higher than the limiting value and, furthermore, there are indications that the yarn irregularity (CV) does not vary as $n^{-0,5}$ but rather as $n^{-\alpha}$ where

$$0{,}33 \leqslant \alpha \leqslant 0{,}5$$

It has been suggested[3,4] that this may be due to the fibres moving in bundles (clusters) and not individually, thereby effectively reducing the number of fibre components, which act independently, by a factor which depends upon the average number of fibres present in a cluster or bundle. The latter is said to depend upon the average number of fibres (n) per yarn cross-section. This was also the opinion of Grignet and Godard[5]. Simpson[6] maintained, however, that the above explanation did not account for the decrease in irregularity index with an increase in draft. He suggested instead that the phenomenon could be explained in terms of the effect of "perfect drafting" on the relative contributions of the random and non-random waves present in the material. According to this theory random wave lengths are not affected by drafting but their intensity is increased while the length of non-random waves is increased by the draft. Therefore, an increase in draft will increase the effect of the random waves on the variation and the actual variation will approach that of a random yarn.

Recent work[7-12] has confirmed that CV of fibre diameter does play a rôle in determining the yarn irregularity as originally predicted by Martindale. In fact the effect of CV of fibre diameter observed experimentally was sometimes slightly larger[7-10] than that predicted theoretically. Nevertheless, in an earlier study, Bastawisy *et al*[13] found no effect of CV of fibre diameter on yarn irregularity.

It is apparent from the above discussion that Martindale's theoretical model has certain practical limitations and, furthermore, it does not allow for the effect of fibre length characteristics on yarn irregularity which has been observed in practice for both worsted[11,12,14-18] and cotton[19,20] yarns. Various empirical studies, therefore, have been undertaken to establish relationships between yarn irregularity and the fibre properties which are valid under practical conditions.

Bornet[4] investigated the relationship between yarn irregularity (short and long term) and fibre diameter and yarn count for a wide range of cotton and worsted yarns. On the basis of his results he proposed an unevenness level (L) as a measure of spinning performance. This was based on a Poisson model intermediate between Martindale[1] and Temmerman's[3]. He obtained the following relationship – –

$$L = \frac{Vn^{0,33}}{50a} \quad \ldots\ldots\ldots\ldots (3)$$

where V is the measured yarn irregularity (i.e. CV),

n is the average number of fibres in the yarn cross-section

and a is a constant, the value of which depends on the CV of the fibre diameter. He suggested a value for a of 1,12 for wool which is based on a CV of fibre diameter of 25,2 *per cent*. Bornet stated that for worsted yarns, values of L below about 1,3 were good while values above about 1,5 could be considered as being poor. He stipulated, however, that n must be greater than 64.

Recently Grignet *et al*[21] published the following relationships arrived at empirically from the data of 411 yarns:

$$\begin{aligned} \ln U(\%) &= 0{,}895 + 0{,}168\,(\ln \text{diameter})^2 \\ &\quad - 0{,}088\,(\ln \text{diameter})(\ln Nm) \\ &\quad + 0{,}090\,(\ln Nm)^2 \quad \ldots\ldots\ldots\ldots (4) \end{aligned}$$

number of readings (n) = 411

multiple correlation coefficient (r) = 0,867

where Nm is the metric count $= \frac{1\,000}{\text{tex}}$

A linear regression analysis carried out on the same data yielded:

$$U(\%) = 0{,}30\,(\text{diameter})^{0,832}\,(Nm)^{0,366} \quad \ldots\ldots\ldots\ldots (5)$$

$$\text{or} \quad CV(\%) = 4{,}7\,(\text{diameter})^{0,832}\,(\text{tex})^{-0,366} \quad \ldots\ldots\ldots\ldots (6)$$

n = 411

r = 0,843

Vroomen and Francise[22], analysing the same data, obtained:

$$\ln CV(\%) = 4{,}248 - 0{,}337 \ln \bar{n}_s \quad \ldots\ldots\ldots\ldots (7)$$

$$\text{giving } CV(\%) = 70\bar{n}_s^{-0,337} \quad \ldots\ldots\ldots\ldots (8)$$

n = 411

r = 0,767,

where $\bar{n}_s$ is the average number of fibres in the yarn cross-section:

They also obtained:

$$\ln CV(\%) = -0{,}604 + 0{,}759\,(\ln \mu d) + 0{,}328\,(\ln Nm) \quad \ldots\ldots\ldots\ldots (9)$$

$$\text{giving } CV(\%) = 0{,}547\,(\text{diameter})^{0,759}\,(Nm)^{0,328} \quad \ldots\ldots\ldots\ldots (10)$$

$$= 5{,}27\,(\text{diameter})^{0,759}\,\text{tex}^{-0,328} \quad \ldots\ldots\ldots\ldots (11)$$

What appears to be the only study relating yarn irregularity to all the most important fibre properties (i.e. fibre diameter, CV of diameter, mean fibre length and CV of fibre length) was carried out by Hunter[11] and Hunter and Gee[12] on 306 commercial and 147 yarns spun at SAWTRI. The findings of the above study will be discussed now since, to a large extent, they allow the irregularity of an average wool worsted yarn to be predicted from the fibre properties. By "average" is implied the irregularity of an average, wool worsted yarn produced under commercial conditions.

The empirical relationships derived for the combined results of the SAWTRI and commercial yarns will be discussed mainly, as they are considered to be generally applicable.

In an analysis in which the independent variables were yarn linear density in tex (X_1), mean fibre diameter in μm (X_2), mean fibre length in mm (X_3), CV of fibre diameter in *per cent* (X_4) and CV of fibre length in *per cent* (X_5), the following empirical relationships were established. The fibre properties were determined on fibres removed from the actual yarns.

Multilinear Analysis on Log Results

$$\text{Irregularity (CV in \%)} = 3{,}18\, X_1^{-0{,}423}\, X_2^{1{,}063}\, X_3^{-0{,}122}\, X_4^{0{,}127} \quad \ldots\ldots\ldots (12)$$

n = 453

r = 0,873

By means of the above equation 76 *per cent* (r^2 x 100) of the observed variation in yarn irregularity could be explained in terms of the four significant variables, only CV of fibre length having no apparent effect on the yarn irregularity. This equation therefore allows the irregularity of an "average" type of yarn to be predicted from mean fibre length and diameter and CV of diameter *as these occur in the yarn*. The actual irregularity of any particular yarn would obviously depend upon all the factors enumerated above. The equation can be simplified greatly by fixing certain of the variables (for example yarn linear density (X_1) and others as the circumstances dictate).

Other equations derived were:

$$\text{Thin places per 1 000 metres} = 4{,}6 \times 10^{-5}\, X_1^{-4{,}15}\, X_2^{9{,}99}\, X_3^{-1{,}52}\, X_4^{1{,}16}$$

$$n = 453; \quad r = 0{,}898 \quad \ldots\ldots\ldots (13)$$

$$\text{Thick places per 1 000 metres} = 5{,}09 \times 10^{-6}\, X_1^{-3{,}48}\, X_2^{8{,}26}\, X_3^{-1{,}3}\, X_4^{2{,}42}$$

$$n = 453; \quad r = 0{,}834 \quad \ldots\ldots\ldots (14)$$

$$\text{Neps per 1 000 metres} = 1{,}84 \times 10^{-12}\, X_1^{-1{,}60}\, X_2^{4{,}17}\, X_3^{1{,}31}\, X_4^{1{,}49}\, X_5^{3{,}32}$$

$$n = 453, \quad r = 0{,}506 \quad \ldots\ldots\ldots (15)$$

The critical dependence of the frequencies of thin and thick places on the mean fibre diameter (X_1) is clearly illustrated by the above equations. These equations, too can be used to predict the "average" properties of a yarn if the fibre properties are known.

If fibre breakage subsequent to combing is either neglected or a correction factor is introduced, the above equations may be used to predict the irregularity properties of an "average" yarn for the fibre properties as they are in the *top*.

The low correlation coefficient obtained for the frequency of neps indicate that this property is far more dependent upon processing variables than was the case for the other yarn irregularity properties, clearly illustrating the limitations of any empirical study attempting to relate yarn properties to fibre properties.

YARN TENSILE PROPERTIES

Compared with the yarn irregularity properties, the position with the yarn tensile properties is even more complex since, in addition to the variables which affect yarn irregularity, the fibre tensile properties, yarn twist and the interfibre friction (affected by type and level of processing additive, residual grease, top or package dyeing, etc.) will play a rôle in determining the yarn breaking strength and extension at break. Although a number of studies have been carried out on the effect of, amongst others, yarn linear density, mean fibre diameter, mean fibre length, twist, CV of fibre diameter, CV of fibre length, fibre tenacity, fibre crimp, these studies generally only covered one or two fibre properties at a time and then only for a limited number of wool lots. It is virtually impossible to generalise, and the prediction of the yarn tensile properties from the fibre properties is not possible from the results of these studies. Holdaway and Robinson[23] derived a theoretical equation relating the yarn breaking strength to certain fibre and yarn variables but it is difficult to use their relationship on a routine basis in a quality control laboratory and emphasis will, therefore, be placed on an empirical study of Hunter[24] and Hunter and Gee[12]. The relevant literature was reviewed in an earlier publication[24] and will not be referred to here. Once again, as for the yarn irregularity properties, the study covered 453 yarns with the analysis the same as those applied to the yarn irregularity.

A measure of the fibre strength and extension was obtained by measuring the tenacity and extension of parallel yarn bundles on a Stelometer at a gauge of 3,2 mm (1/8"). It is *estimated* that the bundle tenacity and extension so obtained are roughly 10 *per cent* and 40 *per cent* respectively, lower than that which would have been obtained had the fibres been tested in the conventional manner (i.e. in top form), partly due to the fibre inclination in the yarn and fibre ends within the test zone. This must be kept in mind if fibre tenacity values obtained on *tops* are used.

A multiple linear regression analysis of yarn breaking strength (Y) vs yarn tex (X_1), mean fibre diameter (X_2), mean fibre length (X_3), yarn twist (X_7) in t.p.m and bundle tenacity (X_8) in gf/tex, yielded the following best fit equation:

$$Y \quad = \quad 0{,}4519\, X_1^{1,331}\, X_2^{-1,067}\, X_3^{0,191}\, X_7^{0,218}\, X_8^{1,147} \qquad \ldots\ldots\ldots(16)$$

$$n = 453; \qquad r = 0{,}974$$

A similar analysis on the yarn extension (Y) results, with bundle tenacity (X_8) being replaced by bundle extension (X_9) yielded:

$$Y \quad = \quad 2{,}143 \times 10^{-3}\, X_1^{0,980}\, X_2^{-1,373}\, X_3^{0,135}\, X_7^{0,766}\, X_9^{1,667} \qquad \ldots\ldots(17)$$

$$n = 453; \qquad r = 0{,}799$$

The agreement with the equation obtained for the commercial yarns was good with the exponent of twist close to that (0,71) obtained by Holdaway and Robinson[23].

Example: Given the following values for the yarn and fibres, calculate the breaking strength of an average yarn:

X_1 = 20 tex
X_2 = 22 μm
X_3 = 65 mm
X_7 = 682 t.p.m (giving a worsted twist factor of 2,6)
X_8 = 10,5 gf/tex (a typical value for an undyed yarn).

Inserting the values directly into equation (16) gives a breaking strength (Y) = 123 gf (121 cN) A 40 tex yarn spun to the same twist factor (X_7 = 482 t.p.m) from the same raw material would have a breaking strength of 287 gf (281 cN).

The corresponding values for yarn extension, given a bundle extension (X_9) of 14 *per cent* would be 12,2 *per cent* for the 20 tex yarn and 18,6 *per cent* for the 40 tex yarn (using equation 17 in this instance).

Therefore, to use the above equations, all that is necessary is for values of the relevant independent variables to be known and inserted into the corresponding equations.

The above equations show that a very high percentage (about 94 *per cent* for strength and about 60 *per cent* for extension) could be explained in terms of mean fibre diameter and CV of diameter, mean fibre length, bundle tenacity (or extension as the case may be), yarn linear density and yarn twist. Clearly, the relationship derived will only really be applicable for the ranges of fibre and yarn properties covered here, in particular for twist factors below that required for maximum strength but not lower than about 20 t.p.cm x $\sqrt{\text{tex}}$. The fibre length, as measured in the yarn should be between about 40 and 75 mm, fibre diameter between 19 and 25 μm and CV of fibre length between 38 and 60 *per cent*.

The above equations clearly indicate the complexity of trying to predict the yarn tensile properties from the relevant fibre and yarn properties, even when ignoring such factors as fibre crimp, processing variables, additives, etc. Obviously, if more variables can be kept constant, such as yarn linear density and twist, for instance, then the equations become less cumbersome to use. Clearly too, none of the significant parameters can be eliminated without sacrificing information and accuracy.

Once again it must be emphasized that the relationship arrived at here empirically only hold for similar ranges to those covered here. This is particularly important for twist and fibre length.

TWO-PLY YARN

In the case of irregularity (CV in *per cent*) the relationship derived for the singles yarn can be applied to two-ply yarns by using any one of the following equations[25]:

$$CV_{\text{two-ply}} = 5{,}47 + 0{,}445\, CV_{\text{singles}} \tag{18}$$

$$CV_{\text{two-ply}} = 2{,}22\, CV_{\text{singles}}^{0{,}623} \tag{19}$$

$$CV_{\text{two-ply}} = 0{,}71\, CV_{\text{singles}} \tag{20}$$

The last equation is the theoretical relationship whereas the other two have been arrived at empirically[25].

For the yarn tensile properties, the position is not so simple since the magnitude and direction of the plying twist greatly affects these yarn properties and no simple relationship is available.

REFERENCES

1. Martindale, J. G., A New Method of Measuring the Irregularity of Yarns with some Observations on the Origin of Irregularities in Worsted Slivers and Yarns. *J. Text. Inst.* **36** T35 (1945).
2. Uster-Manual of Evenness Testing, Part 2: Basic Information and Evaluations – Issued by Messrs Zellweger "Uster" Ltd., (1961).
3. Temmerman, R. and Hermanne, L., Application of the Index of Irregularity to the Study of Spinning on the Cotton System, *J. Text. Inst.* **41** T411 (1950).
4. Bornet, G. M., The rating of Yarns for Short-Term Unevenness, *Text. Res. J.* **34**, 381 (1964).
5. Grignet, J. and Godard, P., Expected Short-term Irregularity Value of Wool Worsted Yarns. Variations of Huberty's K and the Index of Irregularity with Fibre Fineness and the Number of Fibres in the Cross-section, IWTO Technical Committee, Report No. 19 (Rome, May, 1973).

6. Simpson, J., Discussion of the Irregularity Index as a Measure of Cotton Yarn Evenness, *Text. Res. J.* **35**, 854 (1965).
7. Lang, W. R. and Rankin, R. K., The Effect of Variability of Fibre Diameter on Worsted Processing, Part I: The use of Comparison Samples from a Single Merino Flock, *J. Text. Inst.* **59**, 432 (1968).
8. Corbett, M. C., Lang, W. R. and Yu, T. M., The Effect of Variability of Fibre Diameter on Worsted Processing, Part II: The use of Comparison Samples of Commercial Tops and their Blends, *J. Text. Inst.* **59**, 439 (1968).
9. Martindale, J. G., The Effect of Variability of Fibre Diameter on Worsted Processing, *J. Text. Inst.* **60**, 81 (1969).
10. Lang, W. R., The Effects of Fibre Diameter on Worsted Processing – Reply, *J. Text. Inst.* **60**, 83 (1969).
11. Hunter, L., The Relationship between Certain Yarn and Fibre Properties for Single Wool Worsted Yarns, Part I: Short Term Yarn Irregularity, *SAWTRI Tech. Rep.* No. 211 (Feb., 1974).
12. Hunter, L. and Gee, E., The Relationship between Certain Yarn and Fibre Properties for Wool Worsted Yarns, *Proc. 5th Int. Wool Text. Res. Conf. (Aachen) IV* 277 (Sept. 1975).
13. Bastawisy, A. D., Onions, W. J. and Townend, P. P., Some Relationships Between the Properties of Fibres and their Behaviour in Spinning using the Ambler Superdraft Method, *J. Text. Inst.* **52**, T1 (1961).
14. Grosberg, P., Correlation Between Mean Fibre Length and Yarn Irregularity, *J. Text. Inst.*, **47**, T179 (1956).
15. Bratt, R. L. The Effect of Staple Strength on Worsted Processing, Part III: Fibre-Length Distribution and Spinning, *J. Text. Inst.*, **56**, T62 (1965).
16. Townend, P. P., Matto, A. R. and Clegg, P. C., How Fibre Length and Strength Influence Worsted Yarns, Part I: Fibre Length, *Text. Month*, 58 (May, 1973).
17. Townend, P. P., Matto, A. R. and Clegg, P. C., How Fibre Length and Strength Influence Worsted Spun Yarns, Part II, *Text. Month,* 44 (June, 1973).
18. Parkin, W. and Sewell, J. A., Some Effects of Mean Fibre Length on the Production of All-Wool Worsted Yarns, *Proc. 5th Inst. Wool Text. Res. Conf. (Aachen),* IV, 250, (Sept., 1975).
19. Ukidve, A. V., Sundaram, V. and Oka, P. G., Influence of Some Fibre Length Parameters on Yarn Irregularity, *Textile Digest*, No. 3, 115 (Sept., 1971).
20. Tallant, J. D., Fiori, L. A. and Legendre, D. C., The Effect of Short Fibres in a Cotton on its Processing Efficiency and Product Quality, Part I: Affecting the Short Fibre Content by the Addition of Cut Cotton Fibres, *Text. Res. J.*, **29**, 687 (1959).
21. Grignet, J., Catére, H. and Godard, P., Irrégularité a court terme Recherche De La Meilleure Regression D'Ensemble, *Ann. Sc. Text. Belg., XXIV*, No. 1, 26 (June, 1976).

ERRATUM

Page 6: **Please amend list of Technical Reports as follows:**

No. 343 : Turpie, D.W.F. & Mozes, T.E., Treatment of Wool Scouring Liquors, Part IV: Destabilisation of a Mohair Scouring Effluent by Sea-Water (March 1977).

No.344 : Mozes, T.E. : Treatment of Wool Scouring Liquors, Part V: Isolation of Major Constituents Responsible for the Destabilising Effect of Sea-Water (March 1977).

Vroomen, F. and Francise, C., La régularité a court terme des fils de laine Leignée, *Ann Sc. Text. Belg. XXIV*, No. 1, 47 (June, 1976).

Holdaway, H. W. and Robinson, M. S., Strength and Extensibility of Singles Worsted Yarns as Determined by Twist, Linear Density and Wool Fineness, *J. Text. Inst.*, **56**, T168 (1965).

Hunter, L., The Relationship between Certain Yarn and Fibre Properties for Single Wool Worsted Yarns, Part II: Yarn Tensile Properties, *SAWTRI Tech. Rep.* No. 223 (June, 1974).

Hunter, L., The Irregularity of Two-Ply Wool Worsted Yarns, *SAWTRI Tech. Rep.* No. 241 (Feb., 1975).