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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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THE ŁÓDŹ TEXTILE SEMINARS

2. Spinning

UNITED NATIONS

CONTENTS

EXPLANATORY NOTES

References are indicated in parenthesis in the text, by name of author and year of publication. The full references are listed, alphabetically by author, at the end of each article.

References to "tons" indicate metric tons and to "dollars" ($), United States dollars, unless otherwise stated.

The following abbreviations have been used:

cpi means "courses per inch".

Denier (den) is the weight in grams of 9,000 metres of yarn.

gg is "gauge".

kcal is kilocalorie.

Metric count (Nm) is the number of kilometres of yarn per kilogram.

A nanometer (nm) is 10^{-6} mm.

rev/min is revolutions per minute.

Tex is the weight in grams of 1,000 metres of yarn; millitex (mtex) is 0.001 tex.

wpi is "wales per inch".

Worsted count is the number of 560-yard lengths per pound of yarn.

SYSTEMATICS OF METHODS FOR SPINNING MAN-MADE FIBRES

by

W. Ankudowicz

The techniques of yarn production depend on the properties of the fibres from which they are spun. Among these, length, fineness, crimp, adhesiveness, freedom from impurities and hygroscopicity are generally considered as of basic importance, since they directly affect the layout of machines, the number of technical operations and the design of the working elements.

Three basic kinds of textile fibres were in use when mechanized spinning processes began to be developed during the nineteenth century and at the beginning of the twentieth century, namely, wool, cotton and bast fibres. Consequently, three basic spinning systems were created and developed in the course of a steady progress and specialization of yarn production. There were thus woollen, cotton, and bast fibre-spinning techniques, the first becoming divided into the worsted and woollen systems.

Quite a different situation arose when man-made fibres appeared. At first they were processed on the then-existing equipment, according to techniques applied at that time for natural fibres. Man-made fibres were initially produced in wool- or cotton-like varieties and spun with a corresponding system, either alone or in blends, the matching of the properties of the different fibres being strictly observed.

The steady and rapid growth of supplies of man-made fibres brought about the development of new spinning techniques designed exclusively for the processing of specific man-made fibres into yarns for specific end-uses.

All techniques for the production of yarn may be divided into the four following basic groups, according to the raw materials used: *(a)* natural fibres, *(b)* blends of natural and man-made fibres, *(c)* blends of two or more man-made fibres and *(d)* a single kind of man-made fibre.

All of these groups may be subdivided according to the properties of the fibres and the characteristics and end-uses of the yarns. Table 1 lists various techniques for processing natural and man-made fibres, with indication of the staple length of the latter.

It can be seen in this table that, of the 22 listed techniques, nine refer to natural fibres, namely: worsted, woollen, fine-count, medium-count and waste-cotton, hackled flax, tow, jute and hard fibres. The conventional worsted system is most generally used with man-made fibres. The system had to be modified, first of all because in it dyeing is mostly carried out before carding and not in sliver. Carding conditions also differ for wool and man-made fibres.

TABLE 1. METHODS OF YARN PRODUCTION

	Method	*Material and length of staple*
1	Conventional worsted system	Long and medium-length wool, man-made staple fibres (70–140 mm)
2	Worsted system, with use converters	Man-made tow 3,300–5,600 tex
3	Abbreviated converter system	Man-made tow 4,500–5,600 tex
4	Woollen system	Short wool and reclaimed fibres, man-made fibres (50–80 mm), wastes
5	Medium-count cotton system	Cotton and cotton-like man-made fibres (28–40 mm)
6	Fine-count cotton system	Long-staple cotton, cotton-like man-made fibres (36–40 mm)
7	Waste cotton system	Cotton waste, man-made fibres up to 40 mm length, spinning waste
8	Modified cotton system	Man-made fibres (50–75 mm)
9	Non-combing system	Man-made fibres (80–120 mm)
10	Hackled flax system	Hackled flax and man-made fibres (90–120 mm)
11	Flax tow system	Flax tow and hacklings, man-made fibres (90–100 mm)
12	Jute system	Jute, man-made fibres (140–200 mm)
13	Carpetings	Man-made fibres (100–200 mm)
14	Hard fibres	Sisal, hemp, man-made fibres (about 100 mm)
15	Fine tow conversion	Continuous filament tow of 110–670 tex total fineness
16	False-twist texturing	Continuous filament yarn, 2.2–17.0 tex
17	Stuffer-box texturing	Continuous filament yarn, 11–330 tex
18	Air-blown texturing	Continuous filament yarn, 5.5–22 tex
19	Undulation	Continuous filament yarn, 2.2–11 tex
20	Bi-stabilization texturing	Continuous filament yarn, 8.5–17 tex
21	Core-spinning	Continuous filament for core and any staple fibres for sheath
22	Orientation and cutting of foils	Granulated polyolefin materials

The good results achieved with dyed fibres in woollen-type spinning led the producers of man-made fibres to begin the production of spun-dyed fibres. However, this did not occur in cotton-type spinning, in which dyed fibres are seldom used.

In the cotton-spinning system, man-made fibres are processed alone as well as in blends with cotton, the spinning techniques being only slightly modified.

Blends of man-made fibres with flax have been used only on a limited scale. Recently, however, prospects for an increased use of such blends can be noted, because certain chemical processes have been developed that can alter the structure of flax in such a way that its fibres will more readily blend and be spinnable with man-made fibres. Yarns produced in this way will have the characteristics of flax textiles. Also, these blends may be spun with both the dry and wet methods.

In the jute system of spinning, man-made fibres are spun alone for the production of carpets or blended with jute to produce sacking and the like.

Special techniques for man-made fibres

Since man-made textile fibres differ from their natural counterparts as regards such characteristics as cleanness, dimensions formed at the will of the producer, and in many physical and chemical properties, special processing techniques have been developed all over the world to convert them into yarns. These techniques vary widely because they must be adapted to the form of the initial raw material (staple fibres, tow, fine tow, continuous filament or granulates for foil production).

Converter spinning

Tow-to-top converters permit shortening of the spinning process, making it less costly. Compared to the conventional combing technique, which comprises seven different operations, the converter technique requires only three, namely, converting and two gillings. The resulting top can be processed further, depending on the end-use of the yarn, in the following ways: *(a)* dyed, blended with wool tops and combed as a blend; *(b)* spun raw (undyed) to counts up to 40 tex; or *(c)* combed and spun raw (undyed) to finer counts.

Converters are of three different kinds, depending on the principle on which they operate, namely, *(a)* fibre-cutting, *(b)* plain rupturing and *(c)* controlled breaking.

The selection of the type of converter depends on the character of the yarns that can be spun from some varieties of fibres, for example, high-bulk or standard yarns from acrylic fibres.

A combing plant equipped with converters requires 55 per cent less floor space and requires 60 per cent less power and 50 per cent less labour than one that lacks them.

The modified cotton-spinning system

As applied to man-made fibres, the conventional cotton-spinning system uses fibres no longer than 40 mm and of a fineness no greater than 3 den; thicker fibres would spin only to coarse counts, for example, not below 33 tex. For finer spinning, the length of fibres is increased to 50, 60 or even 75 mm, and the fibres are made coarser than cotton (2.75 to 3 den), since finer fibres at these lengths tend strongly to form neps in the yarn. In consequence, fabrics woven or knitted from these yarns have more of a wool-like character, which is manifested by their handle, draping and appearance. The cost of production of yarn of this kind is about one-half as great as it would be with the worsted system. The usual layout of the machines is as follows:

(a) One single scutcher to form laps for feeding cards;

(b) One flat card with wire clothing on the cylinder and doffer;

(c) Roller draw-frames with drawing devices that are adjustable to actual fibre length;

(d) One roving frame with a drawing device that is adjustable to the fibre length;

(e) One ring spinning frame that differs from conventional frames in having a suitably adapted two-zone drawing device.

Yarns as fine as 19 tex can be produced with this equipment. If still finer counts are desired or a better yarn regularity must be secured, this layout must be supplemented with a cotton-type combing operation. The card would then be followed by three additional machines, namely, an initial draw-box, a draw-frame with lap delivery and a combing machine.

The other machines would remain the same. Obviously, the production cost is increased, but it does not reach the cost level of the worsted process.

The non-combing or semi-combing system

This system is intended only for man-made fibres spun into yarns for hand-knitting or industrial use, with counts between 50 and 125 tex. Typical equipment for this system is supplied by such manufacturers as J. Mackie (Northern Ireland) and Carniti (Italy). A typical layout comprises the following machines:

(a) One mixing and opening picker;

(b) One high-production card with an output of about 100 kg/hour;

(c) Three intersecting gill boxes, the second of which has an autoleveller; and

(d) One ring frame adjusted to sliver feeding, spinning onto packages weighing 1.6 kg each. Frames of this kind usually deliver at one side and are fed from cans at the other side.

Carpet system

This system is rather similar to the non-combing system and produces yarns of 2,000 to 3,000 tex for carpet manufacture. The layout of the machines is as follows:

(a) Mixing pickers;

(b) One single swift card;

(c) Two intersecting gill boxes, and

(d) Single-side can-feeding ring frames, as above.

The specific weight of the sliver fed into the spinning frame is approximately 7 g/m.

Careful blending of the fibres is of great importance, particularly because several colour components are commonly used in these blends, and also because of the wide variation in fibre fineness, which can range between 20 and 100 tex.

Fine tow-to-yarn conversion

As far as spinning of staple fibres is concerned, this is the shortest process of yarn production. The fibres are obtained by rupturing continuous filaments to form a fine tow, which is fed into the spinning machines, breaking the filament into fibres of a specified staple length and then spinning them with use of the ring frame arrangement.

These techniques have not yet found wide use because of the high cost of producing fine tow. Also, yarns made from fine tow have properties different from those of conventional yarns; for example, they have higher tensile strength and lower elongation at the breaking point. Consequently, their final destination is for industrial uses, such as for conveyor belts, nets and sacking.

The most suitable materials for this purpose are polyvinyl alcohol fibres, the conventional spinning of which is very much hampered by the accumulation of static electricity charges on the fibres.

Although none of these techniques is yet in widespread use, several prominent machine builders have designed devices for this conversion system. At least nine such designs are known to exist. They may be divided into two groups: those that operate on the principle of a plain rupturing and those in which rupturing is controlled.

Texturing

The thermoplasticity and great strength of synthetic fibres permits the use of new methods of processing continuous filaments into high-bulk yarns. Developments in this area have proceeded rapidly everywhere. In 1966 the production of such yarns amounted to 250,000 tons, and it has probably doubled by this time.

There are several methods of texturing, and the resulting yarns are classed accordingly as follows:

(a) Textured by true or false twist (Helanca, Elastil, Fluflon, Superloft, Elastic are just a few of about 25 trade marks now in use);

(b) Crimped by the stuffer-box method (Anilon, Ban-Lon, Newlon, Spunized, Gofron);

(c) Undulated by being drawn over a blade-edge (Agilon, Evalon);

(d) Bi-stabilized by re-setting (Astralon, Crimplene, Saaba, Melan, Meron);

(e) Bulked by air-blowing (Taslan, Skyloft, Mirlan, Suflete).

Core-spun yarns

The widely differing properties and specific merits of particular types of man-made fibres create various opportunities to produce yarns of various compositions. For example, continuous-filament and staple fibres may be combined. Thus, yarns for specific end-uses can be produced. Some examples are a yarn that is very strong because of its synthetic filament core but that feels soft because cotton fibres form its sheath, non-flammable yarn with a glass filament core and synthetic fibres for the sheath, combination yarns and super-elastic yarns with cores of polyurethane filaments.

Oriented foil yarns

The thermoplastic properties of synthetic materials permit their use for the production of yarns directly from synthetic foils. In this system a polyolefin material is first made into a continuous foil, which is then cut lengthwise into narrow strips, later being drawn across a heating zone. The resulting tapes can successfully replace, for example, jute yarns in the production of sacking or sisal in the manufacture of cordage. Although sacks made from such yarns weigh only about one third as much as the usual jute sacks, they are equally strong and more durable.

Techniques such as these decrease the usefulness of jute and sisal and permit the production of yarns from other fibres in a single operation.

INTENSIFICATION OF TECHNICAL PROCESSES IN COTTON-SPINNING

by

W. Kłopotowski

All elements of contemporary development of spinning techniques are included within the concept of intensification of spinning processes, appearing in the form of constructional solutions and the building of new types of machines that permit shortening of technological processes and increasing machine operating speeds.

This is important for industrial practice, since the complex development of spinning techniques has evolved only in the 1960s. It was not until quite recently that radical changes in the systems of mechanical treatment of fibre occurred. Scientific research and construction works were concentrated in three main directions of development: *(a)* in the automated system of raw material treatment, *(b)* in considerable increase of operative machine speed and *(c)* in the automation of certain sections of processing. An eloquent example is a comparison between the operating speeds of machines built around 1950 and those offered for sale in 1966 (table 1).

The introduction of new technical equipment into spinning mills does not change the essence of the technical processes, but it does revolutionize the ways of conversion of fibres into yarn and simplify production processes.

TABLE 1. OPERATING SPEEDS OF SPINNING MACHINES

Technical operations	*1950*	*1966*
Lap forming[a] (kg/hour)	150—180	180—220
Carding (kg/hour)	4—8	15—32
Drawing (m/min)	28—36	250—450
Combing (kg/hour)	6—8	25—55[b]
Roving (rev/min)	500—850	1,200—1,800
Spinning (rev/min)	8,000—12,000	12,000—18,000

[a] Does not take place in the new types of automated processing systems.
[b] Latest models of combers of Saco-Lowell, United States.

Modernized or newly built mills equipped with new machines and auxiliary devices may, in every respect, be superior to mills built three to five years earlier; for example, in respect to production per machine unit, in precision of the performed operations and in automatic process control, as well as in economic respects such as a lower index of expenditures on buildings, higher efficiency of human labour and lower production costs. The effects of machine processes are, of course, conditioned upon higher costs of machines and technical devices, as well as upon proper selection of machines for particular raw materials and the produced yarn.

Automated spinning systems

Today, the worldwide tendencies in the development of spinning techniques are the combination of a considerable number of technical operations with the automated system and automation of the combined lines of production.

It has been possible to realize this in the cotton-type spinning system in a relatively short period and to combine into a single line of production the following technological and mechanical operations: feeding the material from the bales, opening, blending, cleaning of materials, conveying opened and cleaned material to the carding machines, feeding as many as a dozen or so carding machines with regular layers of material, formation of card slivers and doubling and conveying the card slivers to the first drawing frame.

As built by different firms in many countries, two types of production lines appear most frequently: from bale to card sliver or from bale to the first drawing-frame sliver. Either system may be economically justified under appropriate conditions.

TABLE 2. SOME AUTOMATED FIBRE-PROCESSING SYSTEMS

Producer and country	*Order of operations*	*Technical characteristics*
Platt Bros. United Kingdom	**From bale to sliver after the first drawing-frame**	**Consists of four parts connected with the pneumatic feed conveyor: (1) a group of openers, a group of connected opening and cleaning machines, and a two-way separator; (2) a group of vacuum cleaners and 2 two-way separators; (3) an automatic feeding system and 16 cards; (4) conveyors for 4 slivers and a drawing-frame with levelling devices. Maximum production is about 320 kg/hour.**
Platt Bros. United Kingdom	**From bale to card sliver**	**Consists of three parts connected with the pneumatic feed conveyor: parts (1) and (2) are as above, and part (3) has 24 cards that deliver coiled sliver into cans. Maximum production is 480 kg/hour.**

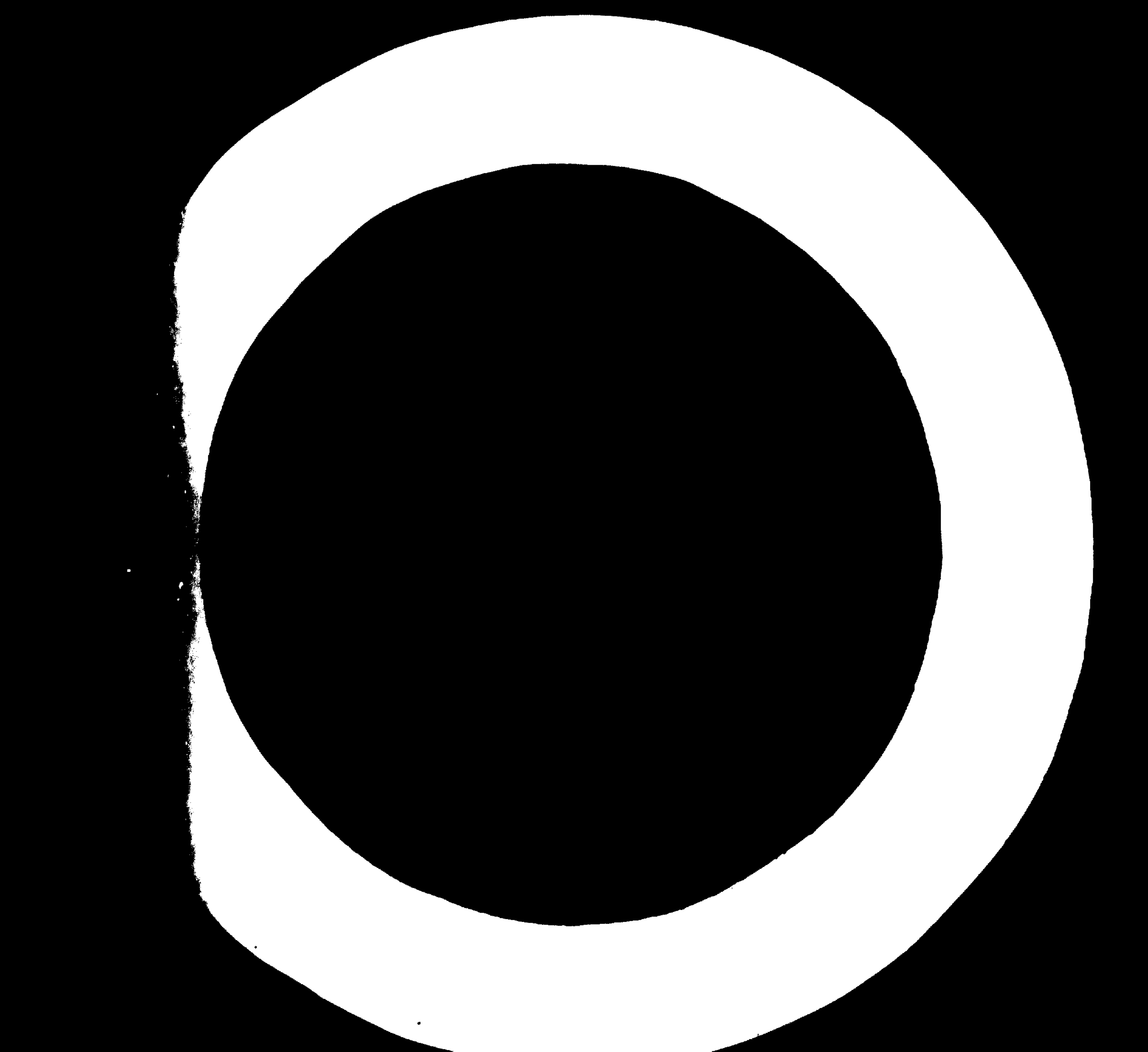


TABLE 2 *(continued)*

Producer and country	*Order of operations*	*Technical characteristics*
Rieter ("Aero-feed" type) Switzerland	From bale to sliver after the first drawing-frame	Consists of four parts connected with the pneumatic feed conveyor: (1) a group of pluckers with an electronic feed-control system and feeders; (2) a group of opening, cleaning and blending machines; (3) a group of feeders each feeding ten cards pneumatically; (4) a conveyor and a drawing-frame equipped with electronic auto-levelling and automatic can-changing devices. Maximum production is from 600 to 800 kg/hour.
SACM ("Flocomat" type) France	From bale to sliver	Consists of two parts: (1) a cyclical plucker with 8 to 10 cleaning points; (2) 8 to 10 hopper feeders and 8 to 10 cards. (The hopper feeders ensure regularity of the layer.) Production is about 200 kg/hour.
NASS ("Automated Spinning System" type) Japan	From bale to sliver of the second drawing-frame	Consists of four parts: (1) a cyclical plucker with 8 to 10 cleaning points; (2) 8 to 10 weighing feeders and 8 to 10 cards; (3) a conveyor of card slivers, and breakers equipped with automatic levellers; (4) a wheel transfer system to move cans from the breakers to the second drawing-frame, with automatic sliver-doubling devices. Later stages, as far as winding and transfer of the yarn, are connected with special elevators and automated devices for conveying the intermediate products to further processing stages.
Whitin (Systemated sliver spinning) United States	From bale to card sliver	Consists of three parts: (1) a group of openers of the Trützschler type; (2) a group of opening, cleaning and blending machines with pneumatic card-feeding systems; (3) 16 high-production cards of the Maxi-Cleen type. Production is about 400 kg/hour.

It should, however, be taken into consideration that there appear to be wide differences between the automated systems built by different firms; for example, in the arrangement and number of machine units, in the effectiveness of operations of the working elements, in the manner of connecting the machines, in the construction of the feeding arrangements and in the measuring and control system, as well as in other technical details, which may influence the selection of machines for the intended production in a decisive way.

Table 2 lists some firms that build automated systems for fibre processing.

These examples indicate the real technical differences between the groups of machines offered for elementary mechanical processing and simultaneously lead to the three following conclusions:

(a) Aggregation of machines in the cotton-spinning system is an accomplished fact, as a result of which there is progress from intermittent-type spinning into the automated processing system at the earlier stages of the processes;

(b) The aggregated groups of machines generally assure an adequate degree of mixing of the blended fibres, but with blends of natural with man-made fibres, and particularly with synthetic fibres, strict maintenance of the proportions of the components is difficult;

(c) Selection of suitable types of devices for determined types of materials and for a programmed production of yarns requires keener technical and economic analysis than does the selection of machines for the conventional type of material processing.

Increase of machine operating speeds

Carding machines

Technical progress in the sphere of building of cotton-type carding machines has lead to a fivefold to sixfold increase in the output of these machines. Carding output, which until recently was limited to 4 to 6 kg/hour, has been greatly speeded in newly built or modernized mills. At present almost all spinning-machine producers offer carding machines with production capacities of 20 to 30 kg/hour and assure achievement of such production rates under definite operating conditions. Many factors influence the production rate of newly built cards. Among these are the following: *(a)* accelerating the operating speeds of the licker-in up to about 1,000 rev/min and the cylinder speed to 300 to 400 rev/min, as well as (most frequently) the application of web-doffing devices from the doffer with aid of a suitable arrangement of rollers; *(b)* installation of metallic coverings on the main cylinder and doffer; *(c)* very accurate regulation of distance between the working elements; *(d)* installation of casings in the doffing and pneumatic devices zone which remove dust and debris from the machines; and *(e)* equipping the carding machines with grouped or individual devices to remove the wastes from beneath them.

This fivefold or sixfold increase in card production has permitted solution of the problem of connecting the carding machines with the opening and cleaning machines.

Almost all types of carding machines are adaptable to feeding by laps formed on conventional scutchers as well as by loose layers of fibres delivered from chutes in the automated system.

It should, however, be stressed here that there are differences of technical features between the types of machines built by different firms. The vast progress in technical sciences and independent individual solution of constructional problems has contributed to this, which is made clear by the technical characteristics of cards produced by a few machine makers, as shown in table 3. No less interesting are the technical features that are typical of the machines of other producers. For example, there is the Ace-Card type of convertible carding machine built by Gunter and Cooke in the United States, a peculiarity of which is control of air-flow and a sectional way of machine cleaning. Of particular interest is the small diameter of the doffer barely 305 mm.

Drawing frames

The effectiveness and output of drawing frames for cotton and for man-made fibres of the cotton type have been greatly increased. The operating speed of drawing frames has had a tenfold increase during the last ten or twelve years. With the increasing working speed of these machines, the number of delivery units has also changed. At a speed of up to 40 m/min these machines were usually built as 6-delivery machines; at a speed of about 150 m/min as 4-delivery machines; at speeds of 200 to 250 m/min as 2-delivery machines; and finally, at speeds above 400 m/min as 1-delivery machines. Roller drawing frames built currently by numerous machine producers work at speeds of 200 to 250 m/min. The Mercury drawing frame of Platt Bros. of the United Kingdom and the DD type drawframe of Saco-Lowell of the United States are characterized by speeds above 400 m/min. Table 4 presents some data regarding drawing frames.

Technical progress in drawing frames was not, of course, confined exclusively to increasing their operating speeds. All high-speed drawing frames are equipped with pneumatic flies and dust-cleaning systems. Drawing frames combined into automated lines are equipped with auto-levelling devices, based on the principles of mechanical performance or an electronic system.

New types of drawing frames, which prepare sliver for spinning, except for the process of roving formation, constitute an altogether different group. They deliver slivers to normal or special short cans or, instead of a can system, they are equipped with coilers that wind slivers into bobbin packages by which ring-spinning frames and spindleless spinning frames are directly fed.

The former system is used in the Japanese and American machines and the latter in British (Tweedales and Smalley) and Czechoslovak machines (Kovo). Drawing frames forming cylindrical sliver bobbin packages work at a speed of about 50 m/min, so their production rate is considerably lower than those of drawing frames that deliver slivers to the cans.

Roving frames

The old technology of the use of roving frames, which depended upon strict control of the quality of the semi-products during several stages, lost its primary significance when drafting appliances for ring spinning frames that permit direct stretching of the yarn to the desired count, directly from the sliver, were developed. However, roving, as a separate stage of spinning, has been maintained, thanks to the two following developments: *(a)* the forming of yarn packages into shapes that are convenient for feeding the spinning as well as for controlling the fibre density of the semi-products by pre-twisting the rovings and *(b)* a considerable increase in roving

TABLE 1. CHARACTERISTICS OF SOME TYPES OF COTTON CARDING MACHINES

Producer and country	Type	Working width of machine (mm)	Licker-in: Diameter (mm) / Speed (rev/min)	Cylinder: Diameter (mm) / Speed (rev/min)	Doffer: Diameter (mm) / Speed (rev/min)	Can sizes diameter X height (mm)	Production (kg/hour)	Technical features
Platt Bros., United Kingdom	680	1,016	249 / 440—910	1,290 / 310	710 / 7—35	914×1,070	16—22	Web take-up by roller system with spiked take-up rollers, doffer speed control by servo-motor, dust-extracting devices in groups of 4 to 6 machines.
Marzoli, Italy	C 20	1,016	220 / 720—1,330	1,283 / 260—400	698 / 7.5—23	510×1,070	15—24	Web take-up by a pair of metal rollers; drafting apparatus 2/3 draft (2 propellers and 2 bottom rollers) 1.5—2 times; dust-extracting waste-removing and devices, automatic can changing.
Rieter, Switzerland	C 1/1	900—1,000	253 / 920	1,290 / 360	680 / 10—48	600×[illegible]	15—30	Web take-up by roller system individual dust-extracting system, collective waste-removing system differential gear drive of doffer.

SACM, France	HP	950		240/800	1,300/320	600/45	500×1,070	15—25	Web take-up by pair of assisting rollers; pneumatic system for transfer of fibres to cylinder-doffer, doffer take-up rollers, collective waste-extracting and waste-removing devices.
Ingolstadt, Federal Republic of Germany	KD 03	1,016		240/800	1,283/400	600/40	1,000×1,070	15—30	Web take-up by comb and pair of rollers, two-can system with automatic transfer, collective waste-extracting and waste-removing devices.
Toyoda, Japan	CK 7	1,016		197/1,125	1,016/400	500/25—30	450×1,070	13.5—22.6	For cotton: Web take-up by comb and pair of rollers. Mechanical transport of separated wastes. Two-can sliver coiling system. For man-made fibres: Web take-up by roller system.
Vulkan, Union of Soviet Socialist Republics	CZMFW-450	1,000	I	182/3,600	670/650	670/14—30	400×1,000	16—22	Web take-up by comb (2,000 vibrations/min). Individual dust extraction, mechanico-pneumatic waste-removal system.
			II	230/1,400					
Polmatex, Poland	CZ 66/10	1,020		237/1,200	1,250/310	660/20	450×920	7—10	Web take-up by comb with 1,000 vibrations/min.

TABLE 4. CHARACTERISTICS OF SOME TYPES OF MODERN DRAWING FRAMES

Characteristics	*Ingolstadt (Federal Republic of Germany)*	*Ingolstadt (Federal Republic of Germany)*	*Rieter (Switzerland)*	*Platt Bros. (United Kingdom)*	*Whitin (United States)*	*Marzoli (Italy)*
Type	RSB 1	SB-62	DO-4	741 Mercury	Model 7	M4R
Drafting system	3 on 3 or 4 on 4	3 on 4	3 on 5	3 on 3	4 on 5	3 on 4
Total draft	4—8	up to 10	—	3—10	—	—
Way of roller loading	Spring	Spring	Pneumatic	Spring	Spring	—
Way of cleaning the appliances	Pneumatic	Pneumatic	Pneumatic	Pneumatic	Pneumatic	—
Number of deliveries	1	2	4	1	2	4
Spacing (mm)	—	450	500	—	—	—
Speed of delivery (m/min)	300	250	180	457	224	180
Diameter and height of cans (mm)	800/1,060	500/1,067	457/—	914–457/1,070	508/1,070	406/1,087
Sliver capacity (kg)	50	24	20	24	24	16
Other features	Autoleveller range of regulation ± 50 %	Automatic can changing and transport of cans from breaker to second drawing frame	1-delivery type, speed 250 m/min and draft changing 40% + 20%	Automatic can changing first draft frame cans — 914 mm second draft frame cans — 457 mm	After roller changing it is possible to process fibres up to 76 mm	Drafting apparatus is inclined less than 30°

frame production as a result of the increase in the rotational speed of the spindles, together with a considerable increase in the thickness of the roving.

When producing rovings of 0.8 to 2 Nm, roving frames built at this time operate at speeds of 1,200 rev/min or more. For example, the Rovematic FC roving frame, built by Saco-Lowell in the United States, operates at a speed of 1,800 rev/min.

Yarn package loads on modern roving frames usually fall within the range of 1.5 to 2.5 kg.

The characteristics of some types of roving frames are shown in table 5.

Spinning frames

Modern spinning frames are characterized by the precise performance of all the working elements and minor parts of the machine. Thanks to this accuracy of performance, contemporary ring spinning frames built by well-known machine makers may attain working speeds of about 18,000 rev/min at a traveller speed of 45 m/sec (Model FC of Nuovo San Giorgio, Italy). In industrial practice, attainment of this speed of spindle rotation is exceptional, because the strength of the spun product is usually insufficient to withstand the variable tensions that occur.

Table 6 shows the general technical features of some types of spinning frames.

Spindleless spinning frames

The conventional way of spinning on ring spinning frames does not suit the modern tendencies toward increased operating speeds of machines and automation of processes.

New ways of forming yarns that will be several times more productive than the conventional ring spinning frames are being sought. For example, the so-called "open-end spinning" is a new process that is under investigation in Europe, North America and Japan. This process permits the separation of the spinning, twisting and winding mechanisms from each other. The possibilities of technical solutions in this case are numerous, and the number of patents, about 70 of which have been filed, indicates this. Devices used in this process may be divided into four groups: *(a)* devices that operate on the basis of pneumo-mechanical ways of yarn forming, *(b)* devices that operate on a pneumatic basis (whirling movement of air), *(c)* hydraulic devices (whirling fluid movement) and *(d)* electrostatic devices that exploit the electrostatic field for straightening and parallelizing the fibres.

At present, the only practical industrial result of these widespread investigations has been the recent development of the BD-200 spindleless spinning frame by Kovostav in Czechoslovakia. This system of yarn formation permits a considerable increase of production per spinning point, for the following reasons:

(a) Spinning takes place without the traditional spindle-ring-traveller link, which limits working speed of the spindles and production of the ring spinning frames;

(b) The twisting element runs at a speed of 30,000 rev/min, as a result of which the production rate at the spinning point may be from 2 to 2.5 times higher than with spindles of high-production ring frames;

(c) The yarn produced is wound directly into cylindrical packages of a capacity of 1,000 g;

(d) The machine is fed by slivers from the second drawing frame, which wind slivers into cylindrical discs.

TABLE 5. CHARACTERISTICS OF SOME TYPES OF ROVING FRAMES

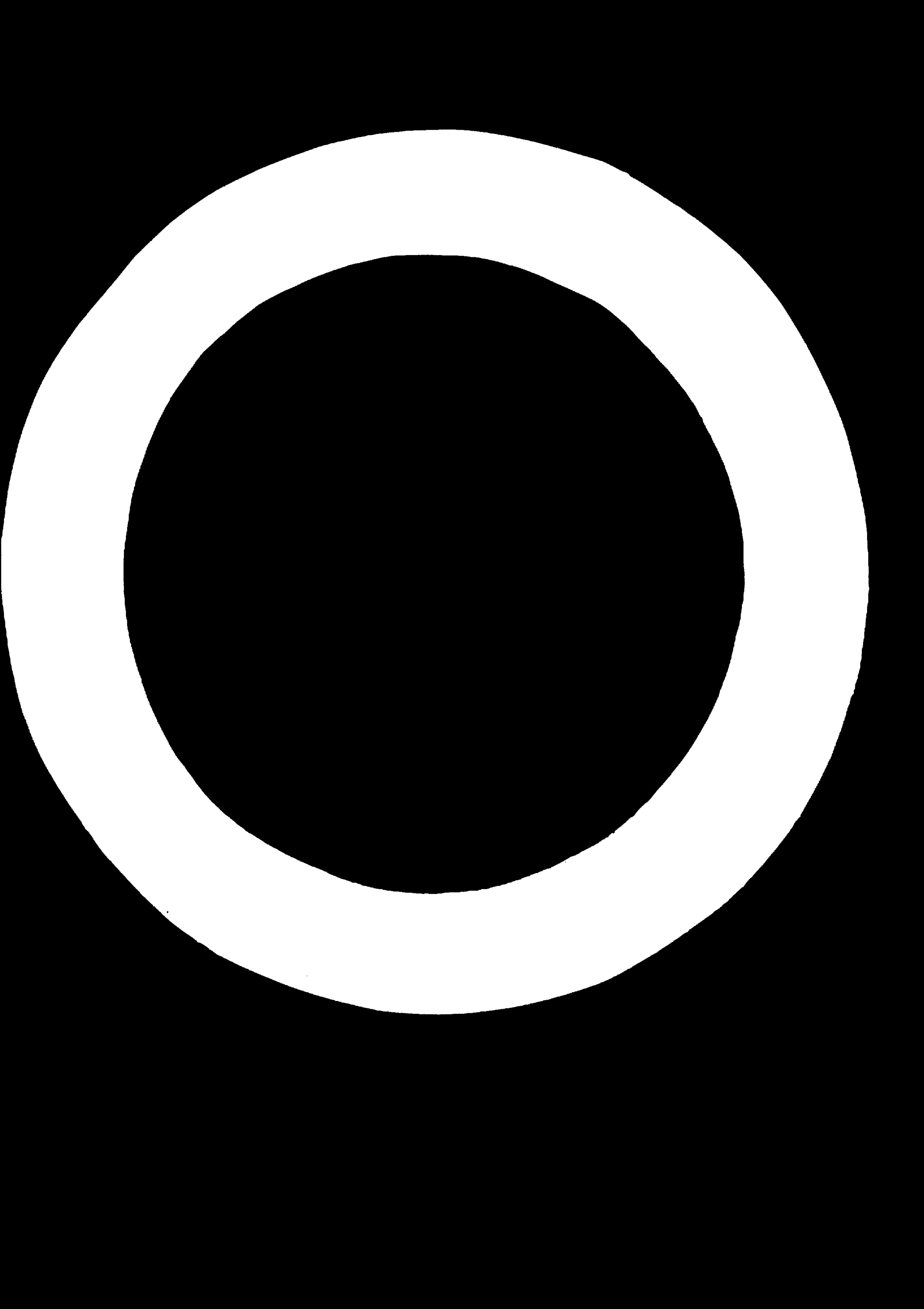
Characteristics	*Platt Bros. (United Kingdom)*	*Ingolstadt (Federal Republic of Germany)*	*Saco-Lowell (United States)*	*Whitin (United States)*	*WiFaMa (Poland)*
Type	M 32 MK III	KG 6	Rovematic FC	—	PA 9
Drafting system	3 on 3 single zone	—	1 B	—	3 on 3 single zone 4 on 4 double zone
Range of draft	6—12	10—28	—	—	3—6 6—12
Range of metric count (Nm) of rovings	0.8—2	—	—	—	1.7—4.5
Sizes of yarn packages					
height (mm)	356	300	400	355	250
diameter (mm)	178	175	140	163	130
Number of spindles	48—96	48—80	96	96	48—132
Load of yarn packages (kg)	—	1.5—2.5	Up to 4.0	—	—
Spindle rotation (rev/min)	1,200	—	1,800	1,200	750—850

TABLE 6. CHARACTERISTICS OF SOME TYPES OF RING SPINNING FRAMES

Characteristics	*Platt Bros. (United Kingdom)*		*Whitin (United States)*	*Saco-Lowell (United States)*	*Roberts (United States)*	*Elitex (Czecho-slovakia)*	*WiFaMa (Poland)*
Type	MR3 MK II	Super	Vanguard NW	Spinomatic	—	DP 75	PJ 31
Number of spindles	380	396	—	384	—	312—360	384
Type of drafting apparatus	Duo-Roth	Duo-Roth	STA-S	—	—	double zone double apron	Duo-Roth
Ring diameter (mm)	57	44.5	51	—	44.5	50	50—56
Winding height (mm)	254	254	254	—	254	240	250
Rev/min	13,000	up to 16,000	14,500	up to 16,500	up to 15,000	11,000	12,000
Feeding	Roving 1.0 Nm	Roving	Roving	Roving 1.5 Nm	Roving	Sliver on discs	Roving 24—54 Nm
Comments	Technical data concern production of yarn up to 40 Nm		Drafting apparatus permits treatment of fibres up to 50 mm or 80 mm (depending on the required equipment)	Magnetic pressure of upper rollers		Range of count 20—50 Nm	

Yarn produced on spindleless Czechoslovakian spinning frames is characterized by a rather non-conventional structure, a lesser degree of evenness and a somewhat lower tensile strength than normal yarn.

At present, the open-end spinning system has not yet acquired significance on an industrial scale, but it is undoubtedly a future course of progress in spinning techniques. Along with this, it may be expected that technical solutions that would, in effect, increase production by more than 2.5 times might be applied in the processing of fibres with different spinning properties.



AUTOMATIC BLENDING IN WOOLLEN AND WASTE-SPINNING SYSTEMS

by

B. Sikora

Present developments in woollen and waste-spinning systems primarily concern the increased efficiency of carding sets and spinning frames, with a consequent decrease in the labour required for various operations. This in turn has called for increased efficiency of the preparatory equipment in spinning mills, and the requirements regarding the fibre blends to be processed in them have also become more important. A need to mechanize and automate some of these technical processes has arisen.

Both of these spinning systems comply fully with the requirements for complete automation, from the very beginning of the process, when the fibres are prepared and blended, until the yarn is finished. For this reason, the entire technical process has been divided into three principal stages: *(a)* initial preparation of fibres, *(b)* collection of blend components, their blending and the feeding of carding sets and *(c)* condensing and spinning.

At this time the use of an automatic flow line for blends is the most highly developed system. This is because, in both woollen and waste spinning, blending is of paramount importance since the production cycle is quite short and carding and spinning are very much affected by the way in which a blend is formed. To increase the uniformity of the blend, to ensure the proper opening and uniform dressing of the fibres with lubricants or other chemical agents, which may influence significantly the yield in further operation (for example, intensified or shortened carding), many machine builders have begun to produce special equipment that can be adapted to the mechanization and automation of blending processes.

A partly mechanized fibre-blending system consists of stationary or rotating blending and lubricating chambers provided with a pneumatic arrangement that feeds them with blend components and delivers the blend to mixing devices or fibre bins. However, in this system the weighing and proportioning of blend components must be done manually.

Equipment of this kind is supplied by machine builders such as Temafa and Spinnereimaschinenbau in the Federal Republic of Germany, by Rieter in Switzerland and by Davis and Furber Machine Co. and Proctor and Schwartz in the United States. Some of this blending machinery is described below.

The Rieter fibre-blending system is highly mechanized. As shown in figure 1, the blend components (*M*) are manually spread on a feeding table (2), which moves them to an opener (1), from which, through an air duct (3) they reach a perforated-cylinder condenser (4), from which it falls onto a lattice transporter (5). This transporter has both a rotary and a reciprocal back-and-forth motion that causes the blended material to be delivered in uniform layers, overlapping each other, into a container (6) with a vertical endless belt armed with pins (7).

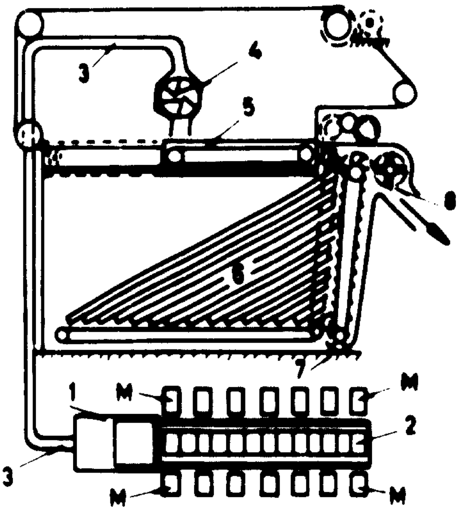


Figure 1. Rieter fibre-blending equipment (see text)

The blended material is pressed against this vertical belt by a moving lattice that forms the bottom of the container. The belt (7) removes vertical layers of the material, which sticks to the pins, from which the fibres are removed by a stripping roller (8) and fall into an air duct. From there they are blown to next opening and blending operations; for example, to a mixing picker.

This equipment is fully mechanized except for the operations of weighing the blend components and spreading them on the feed table, which are done manually.

The Proctor and Schwartz fibre-blending equipment shown in figure 2 consists of a large chamber, the bottom of which is formed by a transporter (1). The top of the chamber is provided with a row of rollers (2). The previously weighed-up blend components, in quantities proportional to their percentage in the blend, are pneumatically delivered onto a small transporter (3), which passes them to the rollers (2), all of which rotate in the same direction. As soon as the layer of fibres reaches the end of the roller system, every second roller reverses its former rotation, and the fibres fall into the chamber. This process is repeated continuously, and successive uniform layers of blended fibres thus cover the transporter at the bottom. When the chamber has been filled, feeding is stopped, and the rollers at the side (4) begin to carry away fibres pressed against them by the transporter (1) at the bottom, which is simultaneously set in motion *(c)*. The fibres thus removed are carried pneumatically to a picker. Two such chambers, mounted side by side, can be operated alternately so that one of them can be filled while the other is being emptied, thus permitting continuous operation. Although this system is highly mechanized, the weighing of blend components is still done manually.

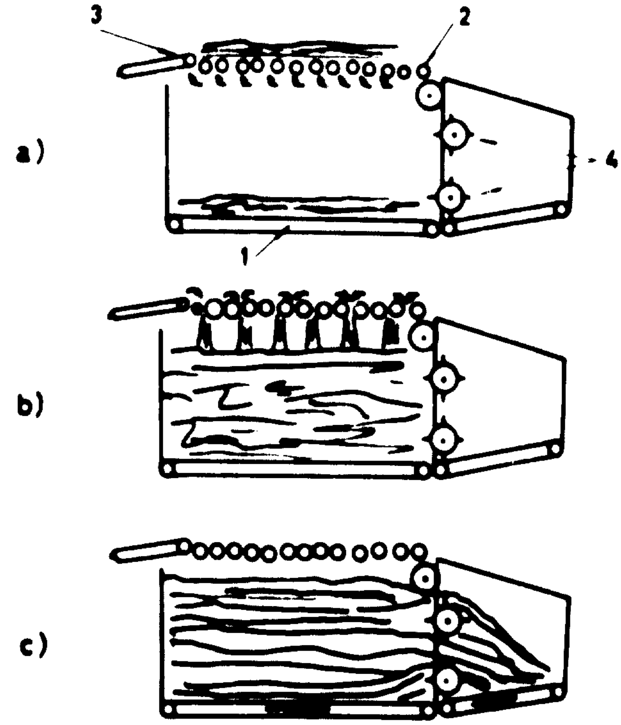


Figure 2. Proctor and Schwartz mixing chamber (see text)

Mechanized fibre-blending systems for continuous operation are built by American manufacturers such as Proctor and Schwartz, Fiber Controls Corporation and Hunter Machine Co., by Spinnbau in the Federal Republic of Germany and by Platt Bros. in the United Kingdom. Fibre-blending equipment of these kinds include automatic weighing hopper feeders that weigh the component fibres in the proportions desired in the blend. They are delivered onto a common conveyor so that, after it has passed by the last hopper feeder, the conveyor carries fibres that have been deposited in layers, according to the desired composition of the blend. The blend components carried by the conveyor then enter an air duct and are blown into blending machines or chambers in which they are also lubricated.

The hopper feeders mentioned above can be arranged perpendicularly or obliquely to the conveyor (as is the case with the Spinnbau equipment). As shown in figure 3, the Platt Bros. fibre blender, instead of hopper feeders, has chutes (2) placed directly above the collecting conveyor (4). The feeding of the blend components into the chutes is done pneumatically through a perforated-cylinder dispenser (1). The desired proportions of blend components can be controlled by adjusting the rotational speed of the feed rollers situated at the output end of the chutes (3). The material is removed from the conveyor by a stripping roller (5), which at the same time drives the fibres into an air duct.

The steady and regular filling of the chutes, which is required for the proper proportioning of the blend components, is assured by the action of photo-electric cells.

Fully automated fibre-blending machines are manufactured in the Federal Republic of Germany by the Spinnbau and Schirp companies. Their primary purpose

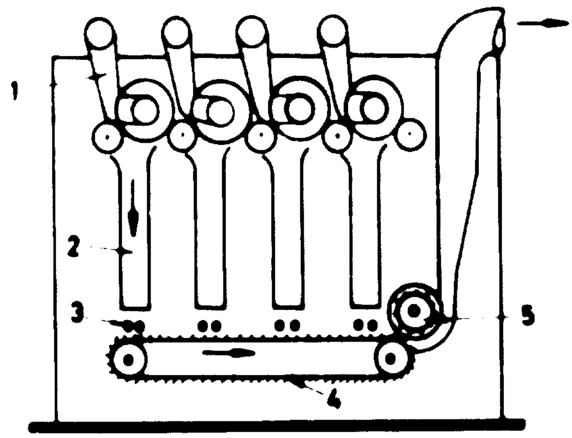


Figure 3. Feeding chutes of the Platt Bros. fibre-blending system (see text)

is to eliminate manual operations, the operatives being employed only to supervise the process. The Spinnbau automatic fibre blender operates as follows. The various blend components are deposited in separate bins. A special device, controlled from a panel feeds the components, pneumatically and mechanically, in the required proportions, into circular mixing chambers (figure 4) through a vertical tubular duct (1) and a rotating dispenser (2), which drops the fibres onto a rotating floor (3). The chamber rests on a large platform scale that indicates, because of special calibration with the empty chamber, the absolute weight of the material that it contains. After the correct amount of component A has been placed in the chamber, other bins, containing components B, C etc. are discharged into it in a set sequence. Once the chamber has been filled, its inner parts namely, the tube (1), floor (3) and mobile partition wall (4) are set in motion. At the same time the material is drawn away through suction slots (6) by an air current caused by an exhaust fan (5). The rotary motion of the wall and floor causes the material to approach the suction slots and a stationary wall (7). The rapidity with which the chamber is discharged depends upon the number of suction slots. The fibres are sucked away vertically, down from the top, and good blending is thus achieved. The blend is blown further on to a blending machine, from which it is blown again to the next (rectangular) blending chamber, around which it is spread by a cyclone device that moves slowly along it. From this second chamber the material may be blown again, either to the blending machine or to bins in the card room.

With equipment of this kind, a great uniformity of blending can be obtained, since the material is well separated and manual operations are completely eliminated. On the other hand, this equipment is unsuitable for small lots or for multicomponent blends.

Figure 5 shows the layout of an automatic blending arrangement that is adapted to blends of any type and that also provides a direct coupling of the blending and carding sections into a single continuous production line. The line comprises hopper feeders (1) that supply specified blend components, according to their required proportions, on a common conveyor (2), which passes the material deposited on it to an opening picker (3). Two such pickers can be used if required.

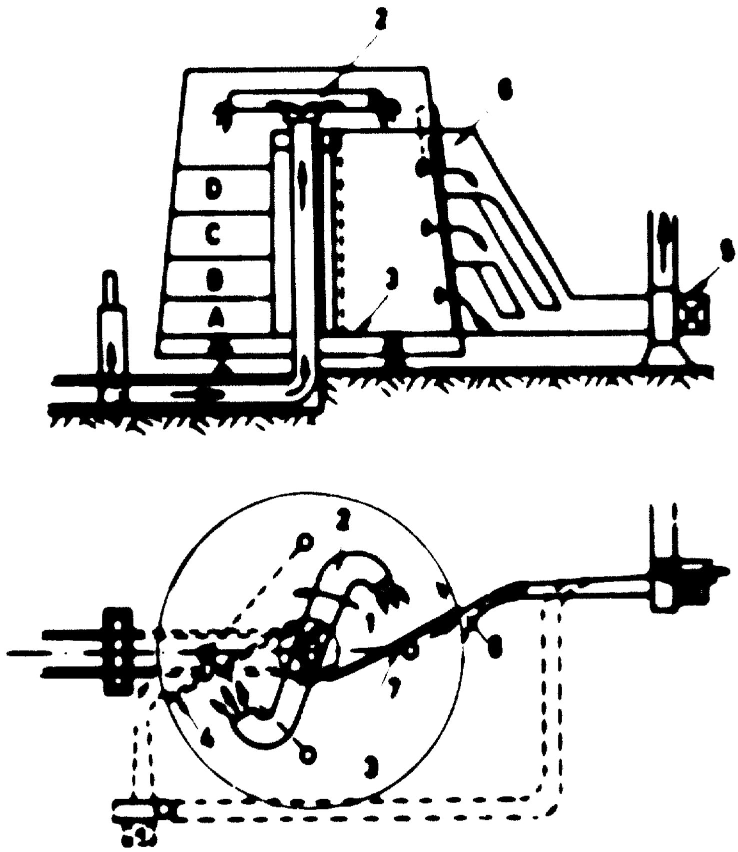


Figure 4. The Spinnbau automatic fibre-mixing chamber (see text)

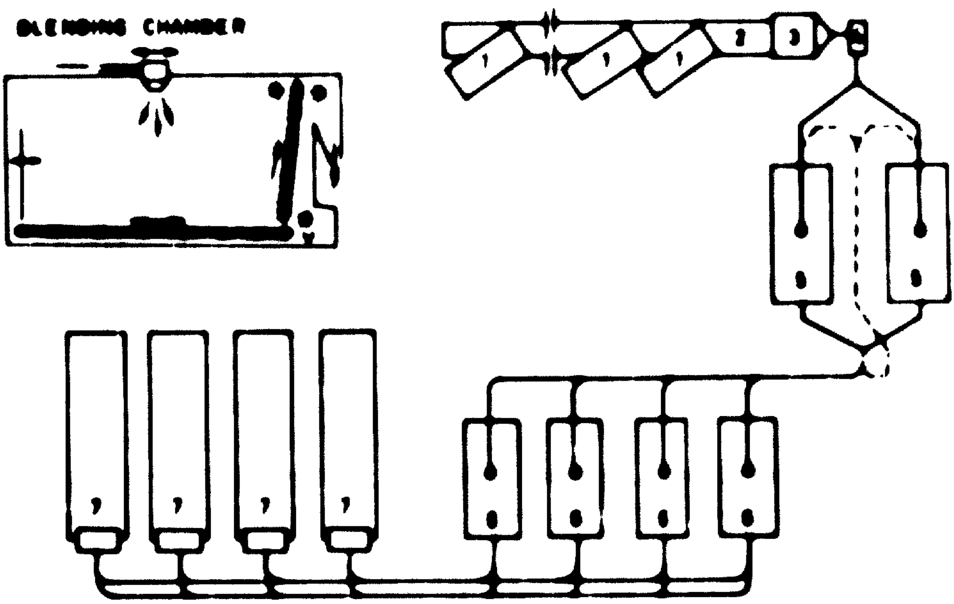


Figure 5. Layout of an automatic fibre-blending arrangement

The material delivered by the picker enters an air duct in which it is lubricated (4) and blown to a blending chamber (5). This rectangular chamber (a cross-section of which is shown in the upper left portion of figure 5) has a capacity that is adjustable from 500 to 2,000 kg, depending on the total weight of the blend. The fibres, which have been mixed and lubricated, are spread by a mobile cyclone dispenser in thin horizontal layers until the chamber is full. No matter how many fibre components the blend includes, the number of the layers is constant. The chamber is discharged mechanically by means of a vertical endless pinned lattice sheet which secures a good mixing of fibres. To avoid damage to the individual layers of the blended material while the chamber is being discharged, the bottom of the chamber is formed by a conveyor belt that moves together with the back wall of the chamber, towards the vertical endless pinned lattice sheet pressing the fibres against it, thus ensuring their uniform removal by the pins. If a very accurate and even mixing of components is required, and particularly when the number of components is large and their shades different, the blend from one chamber can be blown to another that operates in the identical way. The blend formed in the mixing chamber (5) is moved from it to mechanized bins (6) into which it is deposited in a manner similar to the loading of the mixing chamber. In this way another blending and opening stage is effected.

The bins are discharged pneumatically, the material being blown into special containers (7) that feed the carding sets. The numbers and kinds of machines and devices that form the automatic blending line may differ, depending on the required output and the composition and weight of the blend, as well as on the number of carding sets that must be fed.

In general, trends in the development of fibre-blending machinery follow the lines given below:

(a) The displacement of manual operations by mechanised continuous arrangements or by completely automated production lines;

(b) Mechanical proportioning of blend components;

(c) Continuous proportioning of blend components by hopper feeders for long and repeated runs of materials with very similar components;

(d) Mechanical weighing of fibres and blending them in machines of large capacity and complicated design;

(e) A decrease in the number of mixing stages for blends with few components;

(f) Intensification of opening processes by the use of more effective pickers;

(g) Construction of blending chambers with vertical discharging arrangements for fibre blends with many components;

(h) Pneumatic transport of fibres to secure a better opening and blending;

(i) Automatic lubrication and conditioning of the component fibres;

(j) Automatic control of the flow of material, its composition and its moisture content;

(k) Linkage of blending machinery and carding sets into continuous production lines.

CONVERTER SYSTEMS

by

R. Jóźwicki

The new methods of manufacturing staple yarns from man-made fibres tend to take advantage of the original parallelization of fibres, eliminate superfluous operations and make the production of yarn simpler and cheaper. In the last few years, converters, that is, the machines for the production of tops directly from filamentous tow, have been developed.

All converters that have been developed and built thus far can be classified according to their manner of stapling fibres into one of three groups: *(a)* those operating on the principle of simple rupturing of the fibres, *(b)* those operating on the principle of controlled rupturing of the fibres, and *(c)* those operating on the principle of cutting the fibres. Each of these three methods of stapling fibres has its own merits and drawbacks, which influence the quality of the tops produced.

Simple breaking of the fibres

The main advantage of this system is its simplicity, because the stapling is brought about by the stretch-breaking forces occurring between two pairs of rollers turning at different speeds.

If the roller speed difference $V_2 - V_1$ is greater than the stretch capacity of the fibres, it results in the breaking of single filaments. This system has drawbacks that lower the quality of the produced sliver, yarn and fabric. Four of these are the following:

(a) Randomly broken fibres have high length irregularity, which hampers their further processing and lowers the quality of yarns made from them;

(b) As a result of structural changes that occur in the fibres, their stretching capacity is diminished. This produces increased shrinkage of yarn and fabric made of broken fibres;

(c) Breaking of fibres demands great forces, which to some extent limits the thickness of the processed tow;

(d) The machine must be very sturdy, because of the necessity of employing these great forces.

Among the machines operating on the principle of simple rupturing of fibres, only the Seydel one (Federal Republic of Germany) is employed in industry to a wide extent.

Controlled breaking system

The principle of controlled rupturing lies in the introduction of a new element breaker (bar blades) into the breaking zone, which deflects filaments at a certain angle, thus facilitating and controlling the breaking of individual fibres.

As a result of the introduction of control elements to the rupturing system, four advantages have been achieved: *(a)* a considerable improvement of length regularity of the broken fibres, *(b)* decrease of the force exerted on fibres, as compared to the system of simple rupturing, *(c)* the possibility of processing thicker tow and *(d)* lighter machine construction. The system of controlled rupturing is applied in industry for producing top from polyacrylonitrile tow, which is then processed into a bulky yarn.

Fibre-cutting system

Cutting, as accepted generally in the technology of converting tow into tops, is based on the principle of bias-cutting of a properly tensioned filamentous layer, consisting of several tows, with the aid of a cutting apparatus comprised of two steel rollers. On the surface of the upper (cutting) roller there are spiral knives wound at a certain angle to its axis. Cutting roller blades are pressed with great force against the lower (anvil) roller, which has a hardened surface.

Cutting, or rather, crushing, of filaments takes place between the cutting roller and the anvil roller as a result of the pressure of blunt blades (the thickness of the spiral cutting edge of the blade is 0.25 to 0.4 mm) against the smooth surface of the anvil roller.

This method completely eliminates the drawbacks of breaking methods, because it secures the desired length of fibres and their regularity, involves no structural changes in the fibres processed and permits processing of tow of any thickness, even up to about 2 million den.

The cutting system, on the other hand, has two disadvantages: crushing and press-joining of fibre ends at the points where they had been cut, as a result of which tufts of fibres enter the yarn and weaken it locally, and the presence of fibres that are not completely cut.

Among these types of converters only cutting converters are of any wide consequence to the textile industry; rupturing converters are only of secondary importance.

A typical cutting converter is comprised of a feeding creel, a system of tensioning-feeding bars and a traversing mechanism for changing the angle at which the tow layer is fed to the cutting rollers, thus producing a varied linear distribution of stapled fibres. The cutting roller has spiral knives wound on its forming surface at an angle of 83° to the axis of the roller. The spacing of the spirals depends on the cutting length. The knives are blunt, and their cutting edges are 0.25 to 0.4 mm thick. The roller diameter (knives included) is 127 mm. The knife roller rests on a smooth steel roller of the same diameter, and the former is pressed against the latter with the force of about 2.5 tons.

The bias-cut layer is then passed to an opening apparatus comprised of two pairs of rollers (75 mm in diameter) with broad and deep grooves. The upper rollers are pressed against the lower ones by means of springs. The pre-opened layer is transferred to an intersecting drafting field, the purpose of which is to open and separate tufts of joined fibres. After leaving the drafting arrangement, the fibres are formed into tops, embossed and coiled into a can.

All cutting converters (for example, the Greenfield (United Kingdom), the Tematex-Roberts (Italy), the Rieter (Switzerland) and the K-2 (Poland)), are of approximately the same construction. The Pacific, a converter made in the United States, is an exception; in place of an intersecting drafting field it has a two-zone roller field.

The characteristics of the better known and more widely utilized converters, as well as those employed in the Polish textile industry, are presented in table 1.

In the converter method, the required standards for the tow of man-made fibres must be very much higher than those for the staple fibre system. This results primarily from the character of the converter process, which, although shorter and simpler, requires a much higher degree of precision than the conventional process employed for staple fibres. Furthermore, the raw material must satisfy the following requirements:

(a) The tow of man-made filaments should be very loose and have high separability of fibres;

(b) The filaments in the tow must be precisely parallelized, and the tow itself cannot be twisted. In addition, the tow cannot have crimps or other deformations that can hinder its smooth cutting;

(c) The tow cannot contain broken fibres, knots, too great a number of doublings, places in which the filaments cohere and the like;

(d) The individual filaments in the tow must be of the same thickness throughout their entire length, and they must have the same break resistance, stretch factor, colour and other characteristics;

(e) The tow must be given an effective anti-electrostatic treatment that will assure the correct processing of fibres at later stages of production.

The quality indices for Polish converter tow are shown in table 2. Quality indices of converter tops passing through the converter and two passages intersecting should be similar to those given in table 3.

The use of converters on a commercial scale has shown that even the finest fibres of all kinds may be processed by this method. Good quality of tow is the only condition for the correct running of the process of top production and achieving high standards.

The extent to which the tow-to-top technique may be employed should be determined by technological and economic considerations.

Experience to date in the use of converters in worsted spinning has shown that they are quite successful in industry and should be employed widely, whenever possible.

Figure 1 presents schematically the possibility of employing the tow-to-top technique for the production of worsted yarn containing man-made fibres, as far as the composition of yarn, combination of colours and dyeing process are concerned.

TABLE 1. TECHNICAL CHARACTERISTICS OF SEVERAL TYPES OF CONVERTERS

Properties	Converters			
	K-2 (Poland)	*Greenfield (United Kingdom)*	*Tematex-Roberts (Italy)*	*Pacific (United States)*
Number of tows fed to the converter:				
polyester fibres (thickness of a single tow, 300,000 den)	6	6—7	6—7	6—7
polyacrylonitrile fibres (thickness of a single tow, 480,000 den)	4	3—4	3—4	3—4
Total weight of feeding (million den)				
polyester fibres	1.8	1.8—2.1	1.8—2.1	1.8—2.1
polyacrylonitrile fibres	1.92	1.44—1.92	1.44—1.92	1.44—1.92
Feeding speed range (m/min)	4.3—7.3	5.55 and 7.93	5.75 and 11	5.5
Total draft range	6—12	6—12	6—12	16.5 and 19.2
Delivery speed range (m/min)	48—95	33.4—95.1	34.5—106.5	90.7 and 106
Delivery weight range (g/m)	16—24	16.7—33.4	16.7—33.4	10.4 and 12.2
Can dimensions (mm)	600×900	600×900	600×900	405×870
Theoretical output rate range (kg/hour)	52.4—68.6	50—71.5	51.7—79	58.1

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TABLE 2. QUALITY INDICES FOR POLISH CONVERTER TOW

Properties	Polyester fibre I	Polyester fibre II	Polyacrylonitrile fibre I	Polyacrylonitrile fibre II
Deviation of mean thickness of tow from nominal thickness, max. (per cent)	± 10.0	± 15.0	± 10.0	± 15.0
Thickness irregularity of tow in 1-m segments, max. (per cent)	± 2.0	± 4.0	± 2.0	± 4.0
Deviation of mean thickness of fibre from nominal thickness, max. (per cent)	± 10.0	± 15.0	± 10.0	± 15.0
Stretch resistance of fibre in dry condition, min. (g/tex)	40.0	32.0	22.5	18.0
Stretch resistance variation coefficient in dry condition, max. (per cent)	15.0	20.0	18.0	25.0
Relative resistance in loop, min. (per cent)	—	—	35.0	30.0
Breaking elongation in dry condition, max. (per cent)	52.0	70.0	35.0	35.0
Number of crimps in 10 mm, min. 2.5 to 6 den	4.0	4.0	4.0	4.0
above 6 den	—	—	2.0	2.0
Crimping degree, min. (per cent) 2.5 to 6 den	15.0	15.0	16.0	16.0
above 6 den	—	—	12.0	12.0
Crimp durability, min. (per cent)	60.0	60.0	60.0	60.0
Shrinkage of fibres, max. (per cent)	—	—	4.0	4.0
Number of cracked fibres on tow surface in one metre of tow, max.	15.0	30.0	15.0	30.0

TABLE 3. QUALITY INDICES OF CONVERTER TOPS

Properties	*Polyester fibre*		*Polyacrylonitrile fibre*	
	I	*II*	*I*	*II*
Thickness of top (weight of 1 running metre)	17.0 ± 2.0	17.0 ± 2.0	18.0 ± 2.0	18.0 ± 2.0
Thickness variation coefficient, 1-m top segments, max. (per cent)	4.0	5.5	4.0	5.5
Top fibre length deviation coefficient	According to the demand of the client			
Deviation from nominal mean thickness, max. (per cent)	10	10	10	10
Impurities				
contents of tufts of press-joined fibres, max. (per cent)	0.07	0.15	0.10	0.30
number of fibres stuck together, max. (per cent)	0.01	0.05	0.05	0.10
number of tufts of short fibres in 1 running metre top, max.	2.0	4.0	3.0	5.0
Breaking strength of 1-m top	35.0	25.0	30.0	20.0
Content of under-cut fibres in top, max. (per cent)	0.35	0.50	0.50	0.80

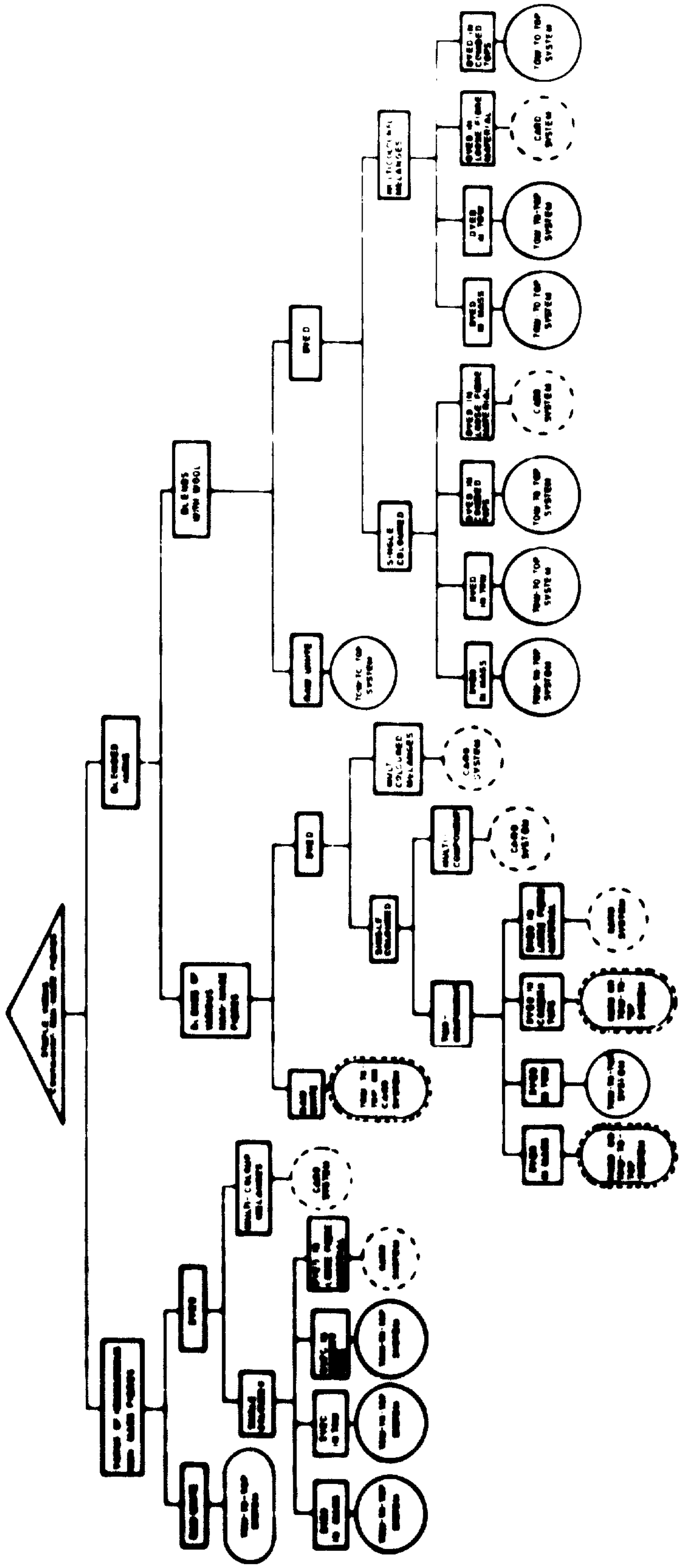


Figure 1. The use of converters in the manufacture of yarns containing man-made fibres

THE SPINNING OF MAN-MADE FIBRES

by

R. Jóźwicki

The man-made fibres, each of which is characterized by its own physico-mechanical and usability properties, are usually processed in spinning mills as blends of two or more. The employment of multi-component blends is determined by technical, utilitarian and economic factors. The products of blends of man-made fibres are distinguished by remarkably better useful properties, pleasant appearance and handle. This results from the different advantageous properties introduced by the individual components of the blend. For instance, one can blend polyester fibres, which have high tensile strength, abrasion and crease resistance and which are not hygroscopic, with viscose fibres that are characterized by high hygroscopicity and thus obtain a product that is resistant to wear and creasing, as well as being hygroscopic. Even greater improvement of the useful properties of the products may be obtained if blends of three or more components are employed, for example polyester-polyacrylonitrile-viscose fibres.

The properties of the blend products are determined, in the first place, by the proportion of particular yarn components, but the appropriate selection of length and thickness of the component fibres is also of great importance. The length, thickness, and bending strength of the fibres determine their location in the yarn. While the longer and finer fibres tend to work toward the centre of the yarn, the shorter and thicker fibres tend to form the outer layers. To obtain the uniform intermixing of fibres, the parameters of the component fibres should be chosen in such a way as to eliminate the possibility of such autosegregation of particular components during yarn formation.

The same is true of blends of wool and man-made fibres. The proper choice of length and thickness of staple fibres determines the character and the properties of the yarn produced. If it is desired that the wool fibres form the outer layers of the yarn and the chemical fibres locate themselves in its centre, the length of man-made fibres should be much greater than that of the wool fibres. In blends, however, if a uniform mixing is desired, the length and length distribution of wool and man-made fibres should be equal or nearly so.

The thickness of man-made fibres added to wool should always be less than that of wool fibres, in order to improve the spinning properties of the blend.

Typical technical process for polyester-wool and polyester-viscose fibre blends

The polyester-wool blends are usually processed according to the technical process shown in figure 1. The process of converting the polyester fibres from raw material into finished yarn consists of eight production stages:

First stage: Production of polyester tops by means of converting or carding and preparation of the tops for dyeing by using two passages of drawing frames.

Second stage: Dyeing of the polyester tops in high-temperature equipment. This is followed by applying the anti-electrostatic preparation and drying the tops on cylindrical drums.

Third stage: Blending polyester sliver tops with wool tops prepared and dyed by conventional wool-processing methods. In this stage these two types of tops are joined on the blending machine and subsequently drawn on the intersectings, then combed on the rectilinear or circular combers and finally, in order to straighten them after combing, the tops are again drawn on the intersectings. (The process of blending may differ in its course and number of machines employed, depending on single- or multi-coloured blend.)

Fourth stage: Preparatory spinning of blends on preparation machine sets of the continental system (French or New Bradford system).

Fifth stage: Fine spinning on ring spinning frames.

Sixth stage: Doubling of yarns, together with yarn clearing on capacitative (for example, Qualitex) or comb slub-catchers.

Seventh stage: Twisting of the yarn.

Eighth stage: Winding of final yarn on cross-wound cone packages.

The spinning process of polyester-wool blends is long and comprises many expensive operations, such as combing of the blended tops. The blending process for polyester (Elana in Poland) and wool slivers prior to delivering them to the preparatory machine set must be particularly extensive, because the blending of the polyester and wool fibres is very difficult. In the case of production of yarn from polyester and viscose fibre blends, the technical process is much simplified, for the polyester fibres are used extensively as staple-cut fibres, dyed in the loose state and blended with viscose fibres prior to carding. The course of the technical process for the polyester-viscose blends is shown in figure 2.

The production of yarn from pure polyester fibres can be simplified still further by the use of converters for the production of tops.

Spinning technology of blends of polyamide fibres with wool and with some other man-made fibres

Polyamide fibres are processed in worsted spinning mills of the French or English systems in blends with wool and viscose fibres. In the French system, polyamide fibres of 3 to 4.5 den thickness and 80 to 120 mm staple length are used. In the English system, fibres of 5 to 12 den and staple length above 120 mm are used.

The polyamide fibres can be dyed in loose material, in tops, in yarn, or as woven cloth. The application of fibre preparation after dyeing can be carried out during the

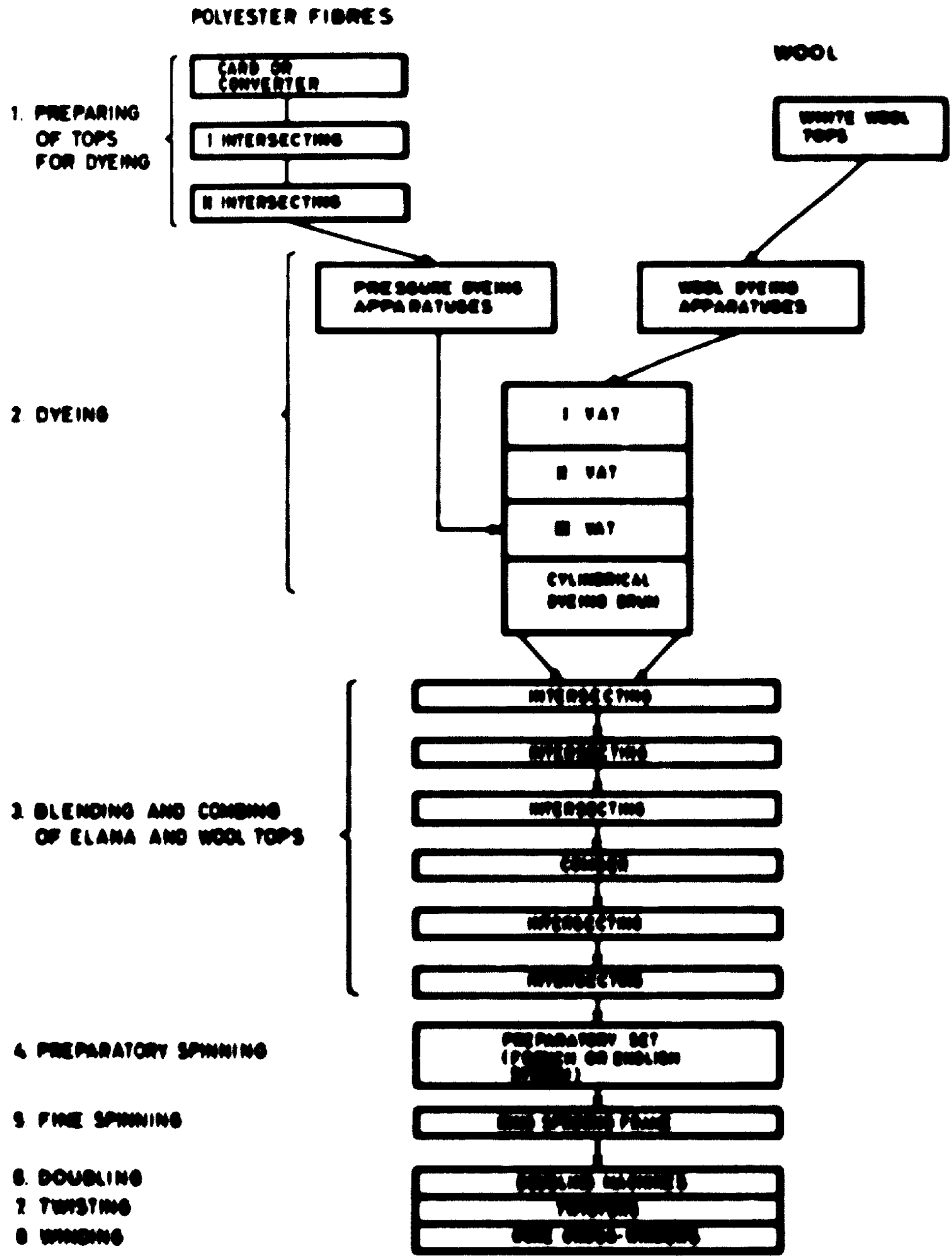


Figure 1. Technical process of spinning blends of polyester and wool fibres

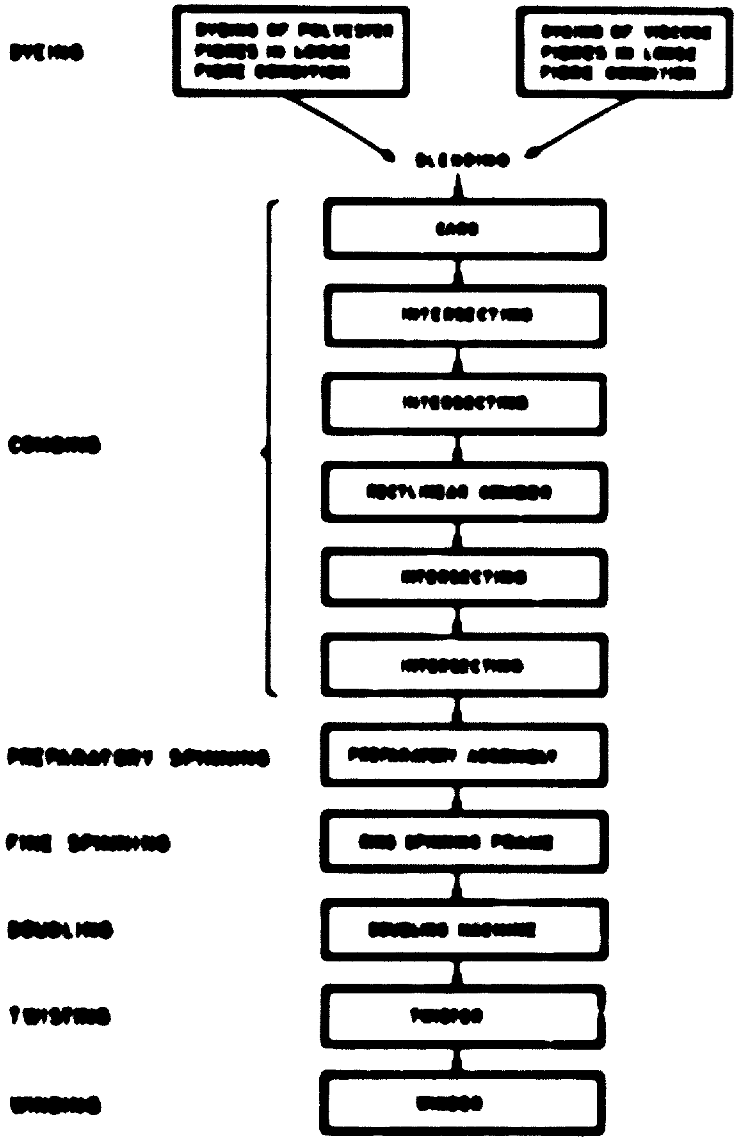


Figure 2. Diagram of the technical process of spinning blends of polyester and viscose fibres

final after-dyeing bath or can be applied to the already dried fibre, with the aid of sprayers. To reduce static electricity in the fibres during processing, the following atmospheric conditions should be maintained: for 100 per cent polyamide fibres, 65 to 75 per cent humidity and a temperature of 23° or 24°C; for wool-polyamide blends, 75 to 80 per cent humidity and a temperature of 23° or 24°C. The blending of polyamide fibres with other fibres may take place in loose material prior to carding, in tops prior to combing or in tops in the preparatory section.

For the processing of polyamide fibres in the French system, preparatory sets with intersectings should be chosen. The use of the smallest number possible of intersectings is recommended. Drafts should be smaller than those for wool. The course of spinning process is presented in table 1.

TABLE 1. SPINNING PLAN FOR POLYAMIDE FIBRES

Machine	*Feeding top weight (g/m)*	*Doubling*	*Draft*	*Delivery top weight (g/m)*
I Intersecting	18	6	9	12
II Intersecting	12	3	6.4	5.63
III Intersecting	5.63	2	5.4	2.08
IV Intersecting	2.08	2	4.4	0.771
Roving frame	0.77	1	10.4	0.294

Spinning technology for processing polyacrylonitrile fibres into bulk and standard yarns

Polyacrylonitrile fibres can be processed in worsted spinning mills in a homogeneous state, in blends with wool and in blends with other man-made fibres.

Yarns from 100 per cent polyacrylonitrile fibres should be produced from tow by the tow-to-top system. Dyeing of fibres for homogeneous non-bulky yarns should be carried out in mass or in tow. Dyeing in top extends the technological process and raises the costs. After dyeing in top, an additional operation of combing is necessary for yarns of 40 metric count or higher.

Yarn consisting of polyacrylonitrile-viscose fibre blends should be produced from staple fibres with the aid of the card system. Dyeing should be carried out with the aid of the pigment method or in the loose state prior to carding.

Bulky yarns composed of 100 per cent polyacrylonitrile fibres or from polyacrylonitrile-viscose fibre blends should be produced from fibres dyed in mass or in tow or from non-dyed fibres. Dyeing should take place only in yarn or in finished products after the yarn or product had been shrunk.

Normal and bulky yarns from homogeneous polyacrylonitrile fibres should be made from tow by a shortened tow-to-top system.

The full set of machinery for the production of bulky yarn from tow comprises, first, for the preparation of fibrous top from tow, 2 Turbo-Stapler converters, 2 Turbo-Setter drying shrinkage chambers and 1 Hood drawing frame for aligning fibre length in tops and for blending of shrunk and unshrunk fibres. (All of these machines are American.) Afterwards, a 7-passage set of machinery for the production of roving and yarn is required (table 2).

TABLE 2. SEVEN-PASSAGE SET OF MACHINERY FOR THE PRODUCTION OF ROVING AND YARN

Machine	*Number of heads in a machine*	*Number of delivered tops (cans)*	*Number of doublings*	*Range of drafts*	*Range of delivery top weight (g/m)*	*Delivery speed range (m/min)*
Pindrafter intersecting	1	1	6—10	6—12	20—25	up to 110
Pindrafter intersecting	2	2	4	6—12	15—20	up to 110
Pindrafter intersecting	2	4	4	6—12	10—18	up to 110
Potndrafter intersecting	4	4	5	6—10	5—10	up to 70
Potndrafter intersecting	4	4	5	6—10	3—5	up to 70
Roving frame	82	—	1	10—18	300—1,000 tex	up to 32
Ring spinning frame	264	—	1	10—32	15—32 tex	up to 22

TEXTURED YARNS

by

A. Khiko

The thermoplastic properties and high strength of synthetic fibres have made it possible to evolve new methods of manufacturing textured yarns from filaments. The result of texturing is first of all a change in yarn structure. In the course of thermo-mechanical treatment, changes are made in the arrangement of fibres and in the structure of yarns made from them, which acquire new features that make possible their immediate use, eliminating the spinning process completely in the production of knitted articles and fabrics. Furthermore, the use of textured yarns permits a considerable increase of variety by giving the finished articles new physical and mechanical properties that cannot be acquired when conventional yarns are used.

This technology has been developing rapidly in all countries. In 1966, the world production of these yarns reached 250,000 tons, and it is expected that within the next two or three years this figure will be doubled.

Methods of manufacturing textured yarns

There are several methods of texturing filaments, each resulting in yarns of differing properties.

According to the method of texturing, one can distinguish the five following kinds of yarns.

(a) Stretch by methods of real or false twist (Helanca, Elastil, Fluflon, Superloff and about 25 other trade names);

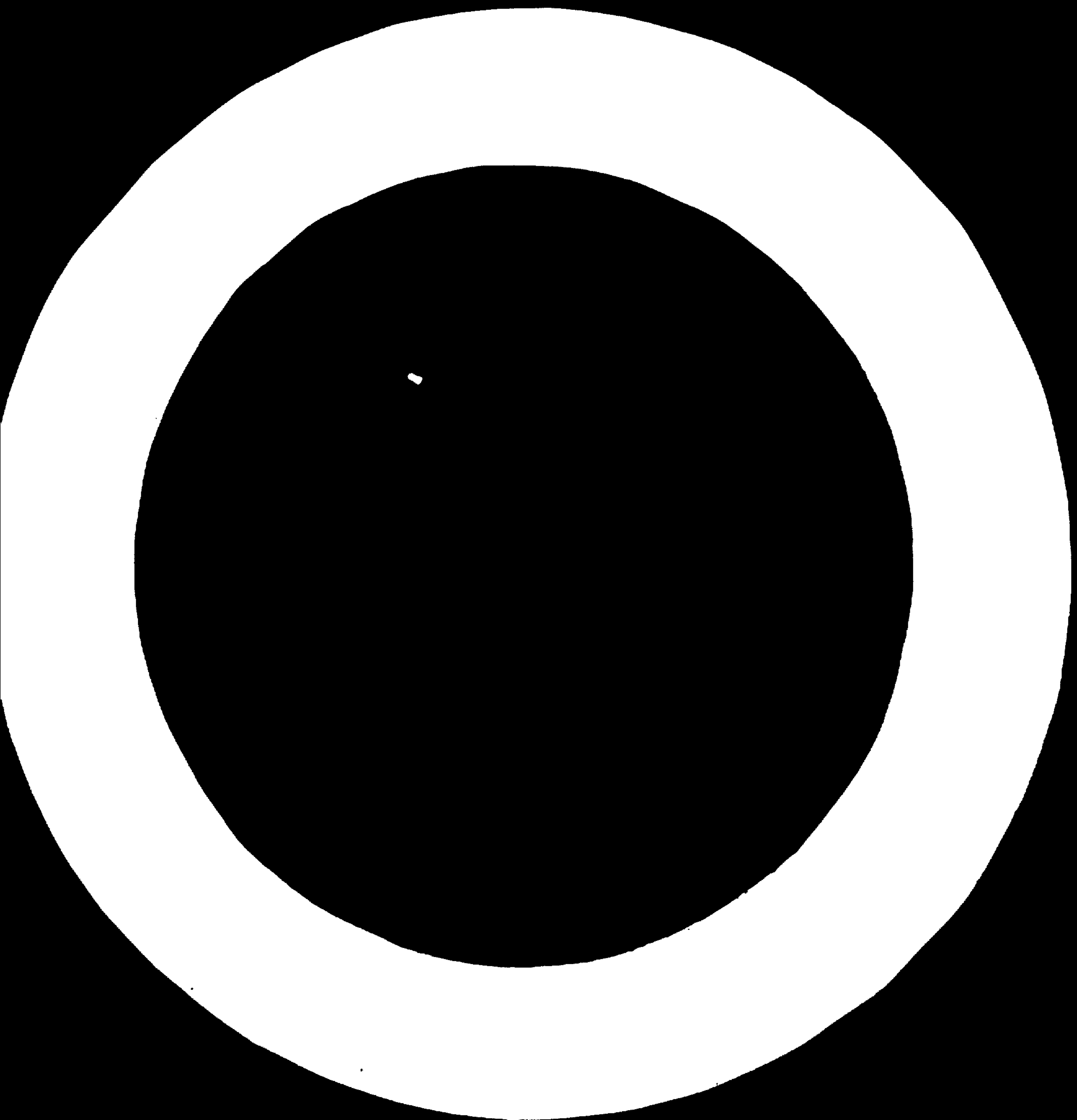
(b) Crimped by stuffer-box method (Agilon, Ban-Lon, Newlon, Spunized);

(c) Curled by edge crimping method (Agilon, Evalon);

(d) Bi-stabilized by the method of repeated stabilization (Astralon, Crimplene, Saaba);

(e) Looped by the air-texturing method (Taslan, Skyloft, Mirlan, Sufleta etc.).

Taking the properties of various types of textured yarns into consideration, they may be divided into the two basic groups of stretch (elastic) and bulked yarns (figure 1). The essential features of stretch yarns are their great elasticity and elongation, reaching in some cases to 500 per cent. The feature that gives the stretch characteristics is the permanent twisting tendency caused by the operation of twisting moment in the elementary fibres of the yarn.



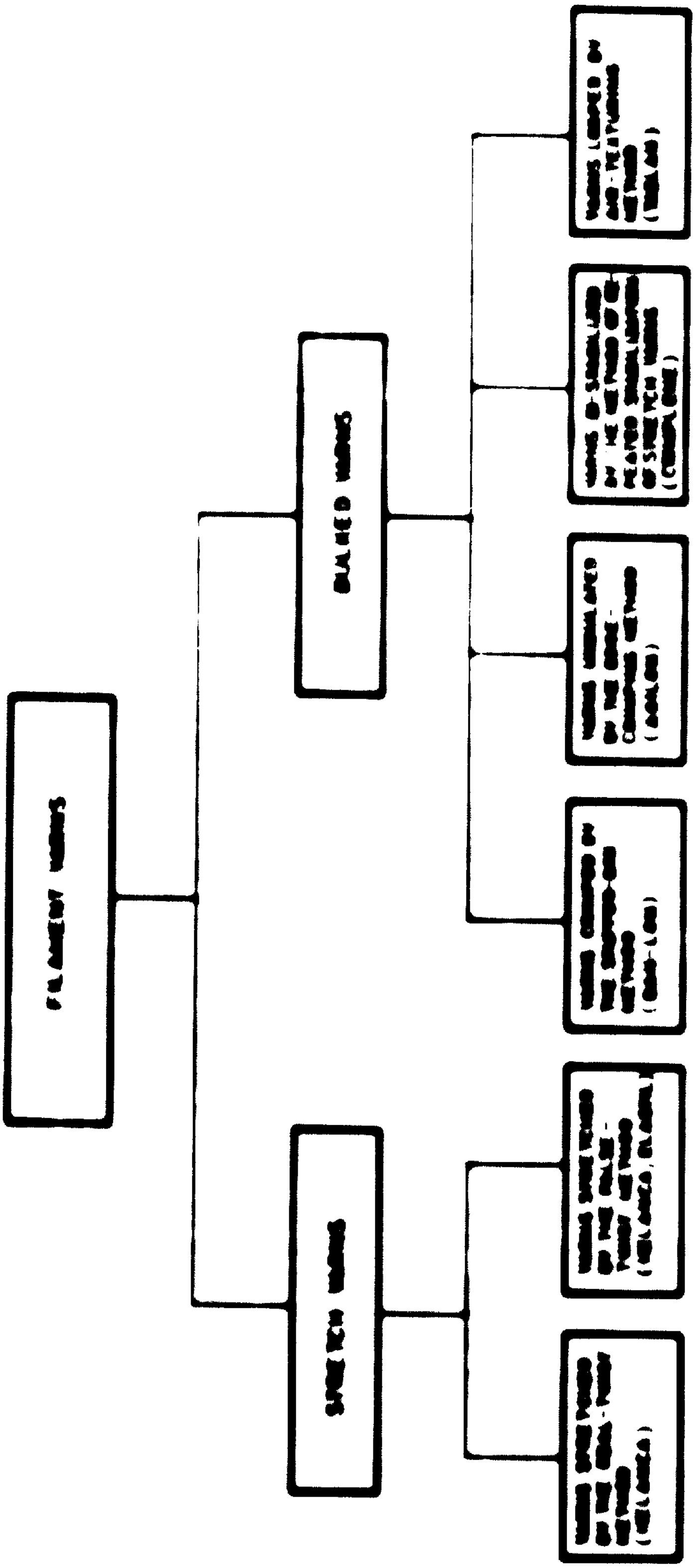


Figure 1. Systematics of textured filament yarns

Bulked yarns, however, show no twisting tendencies and are characterized by a considerably lower elongation, which ensures a greater dimensional stability of the finished product. The oldest way of texturing yarns is the production of elastic yarn by the real-twist method and comprises five operations: twisting, stabilizing on bobbins, untwisting back to the zero point, plying two yarns with Z and S twists, and re-twisting. Because of its very low efficiency, this method is falling out of use. Texturing by the false-twist method has found the widest application in hosiery and elastic products.

About 80 per cent of the textured yarns presently produced are obtained by this method, which consists in giving the twist, stabilizing it in a heater, simultaneously untwisting it in the reverse direction by a false-twist element and cross-winding on bobbins.

The false twist acting on a plasticized fibre leaves the effect of alternate real twist. This technique of texturing is also developing very rapidly in respect to machine development. In the first machines of this type, the false-twist spindles ran at 60,000 rev/min, but now machines are being built that run at 300,000, 400,000 and 500,000 rev/min, with the prospect that speeds of 1 million rev/min may be attained in the near future.

Table 1 presents a survey of the most up-to-date machines for the production of textured yarns by the false-twist method as well as the names of the leading world producers.

The most recent friction methods of giving false twist, introduced in Japan and Finland, make it possible to attain the speed of 3 million rev/min.

The second group comprises the bulked yarns which, as has been noted, have a considerably smaller elongation than stretch yarns. The distinctive feature of bulked

TABLE 1. MACHINES FOR THE PRODUCTION OF TEXTURED YARNS BY THE FALSE-TWIST METHOD

Model	*Builder*	*Rev/min (maximum)*
Cs 12	E. Scragg, United Kingdom	400,000
KRZ - 250	Friedrich Unde, Federal Republic of Germany	300,000
No - 553	Leesona Corp., United States	345,000
TES - 702	Nazionale Cogne, Italy	400,000
ARCT - Ft - 400	ARCT, France	400,000
ARCT - FT_4	ARCT, France	300,000
FZ - 25	Heberlein, Switzerland	350,000
Barmag	Barmer, Federal Republic of Germany	350,000
Sotexa FT_{12}	S.M. et T., France	400,000
AM - 1	Klinger Manufacturing, United Kingdom	700,000

yarns is their marked increase of volume with only a negligible increase in weight. The most usual methods of producing bulked yarns are the stuffer-box method and bi-stabilization.

Stuffer-box crimped yarns can be used either for knitted articles (100 to 300 den) or for tufted carpets (1,000 to 3,000 den).

Yarns looped by the air-texturing method are different from the others. They are characterized by less bulkiness and are mostly used in fabrics.

One can also obtain bulky yarns by using the so-called "knit-unknit" technique, which consists in stabilizing and unsewing knitted articles made of smooth polyamide yarns. Articles made of this reknit yarn are bulky.

The linear speeds of texturing by various methods are as follows: with false-twist, 100 to 600 m/min; air-texturing, 400 m/min; crimping, 150 m/min; and curling, 100 m/min.

Properties of textured yarns and their uses

The properties of yarns textured from filaments are different from those of traditional yarns. Changes of manufacturing parameters always result in a change of yarn nature, whereas in the production of conventional yarns the influence of a technical process is much smaller. In the production of textured yarns from a raw material of defined physical properties, one can obtain several types of yarn that differ in their construction and consequently in their properties. Simultaneous thermal and mechanical treatments, while changing both of these factors (for example, an elevation of temperature attended by a decrease of pressure, or *vice versa*) increase the number of properties the yarn can acquire in the process of texturing.

Figure 2 shows the interdependence of elongation and load obtained for textured yarns produced by different methods. The tests were made on an apparatus of the Instron (United States), with the distance of jaws being set at 50 mm and the initial load at 200 mg. Before the test the yarn, wound on skeins, was subjected to the action of steam at the temperature of 100°C for 15 minutes.

The characteristic feature of textured yarns is the complexity of their elongation, which may be divided into the straightening elongation and elongation of the yarn substance. The straightening elongation is the extent of yarn stretch or crimping, the stability of which is determined by means of the so-called elastic elongation. In the action of loads causing straightening elongation, the yarn substance remains intact. However, one cannot establish the line between the straightening elongation and the elongation of the yarn substance on tensile testing machines because the inertia of this type of apparatus is too great.

As can be seen from the curves in figure 2, stretch yarns are characterized by an exceptionally large straightening elongation (represented by the curve section near the abscissa). It exceeds 100 per cent, for both the yarn stretched by the real-twist method (Helanca) and that stretched by the false-twist method (Elastil). It can also be seen that there is greater elongation of these yarns than can be noted in bulked yarns. The measure of elongation increases of stretch yarns is the value reach at the breaking load, which ranges, according to the way of curling, from 300 up to 500 per cent. Bulked yarns generally show much lower elongations, and there are differences among the various types. In this group the crimped yarns have the largest elongation and the looped yarns the smallest.

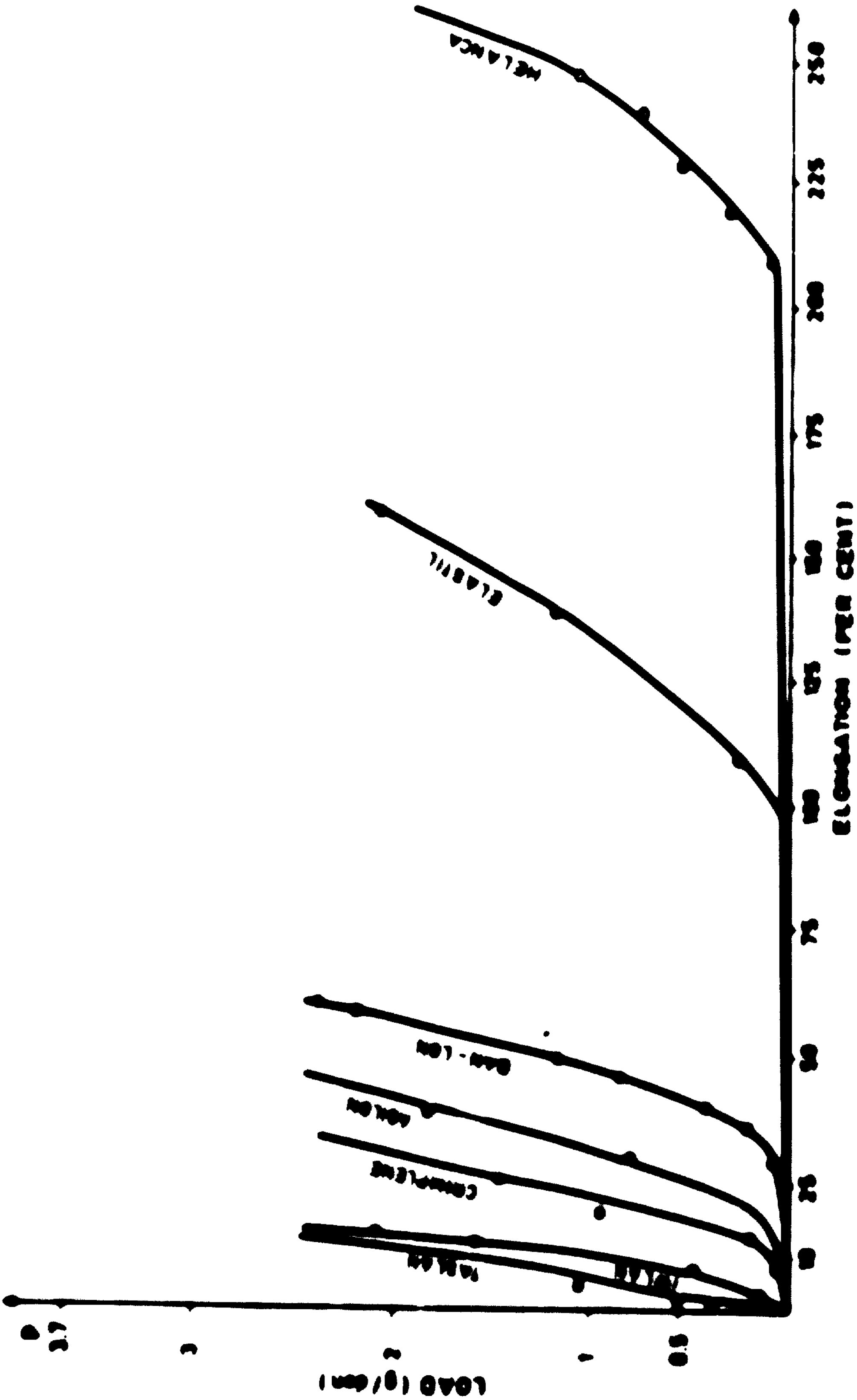


Figure 2 Load elongation of some textured yarns

TABLE 2. INFLUENCE OF TEXTURING METHODS ON THE ELONGATION OF YARNS

Kind of yarn	*Kind of raw material*[a]	*Elongation at the load of 6.5 g (per cent)*	*Breaking elongation, approximate values (per cent)*
Stretch	PAS or PES	104—72	380—300
Crimped	PAS or PES	32—34	89
Curled	PAS	20	79
Bi-stabilized	PES	10	59
Loop	PAS or PES	21.2	25—20
Wool	Wool	1.5	18
Cotton	Cotton	0.8	6

[a] PAS—polyamide "silk"; PES—polyester "silk".

In table 2 are presented elongation values at the load of 6.5 g, which approximately equals the straightening elongation of stretch yarn, as well as the values of breaking elongation. For the sake of comparison, the values for wool and cotton yarns have also been given.

The raw material from which the yarn is made is of some importance although, as can be seen from table 2, it is the method of texturing that has the greatest influence on elongation.

As noted above, the difference of elongation between the stretch and bulked yarns has been accepted as the basis for dividing all textured yarns into two basic groups. The other essential feature, which permits clear distinction between the two groups, is the existence of twisting moment in single fibres of stretch yarns.

This moment appears because the yarn is twisted in two directions, of which only one becomes stabilized. In this situation untwisting does not lead to the

TABLE 3. YARN SHRINKAGE IN STEAM OF 100° C

Kind of yarn	*Shrinkage (per cent)*
Stretch	50
Crimped	37
Curled	6.5
Bi-stabilized	8
Loop	0.15
Wool	5
Cotton	2.6

TABLE 4. USES AND ADVANTAGES OF YARNS TEXTURED IN VARIOUS WAYS

Texturing method	*Chemical group*[a]	*Count range and thickness (den)*	*Use*	*Effects obtained in the finished product*
Yarns stretched by the real-twist method (Helanca type)	PA 6 and 66 PE, PAN	12—400 800—1,200 3—3.74	All kinds of hosiery, bathing costumes, gloves, elastic bandages, warps for furnishing fabrics	Great elasticity, crêpe-line feel
Yarns stretched by the false-twist method	PA, PE and PAN	15—300 2—4.2	All kinds of hosiery, orthopaedic stockings, bathing costumes	Great elasticity, soft feel
Yarns crimped by the stuffer-box method (Ban-Lon type)	PA, PE	15—5,000 2—13.5	Outer clothing; knitted upholstery, fabrics, carpets	Keeping the shape, warmth, soft feel
Yarns produced by edge-crimping method (Agilon type)	PA, PE	9—210 3—3.72	Stockings, socks and knitted articles of interlock type	Great fluffiness, soft feel, elasticity
Yarns bi-stabilized by the method of repeated stabilization of stretch yarns (Crimplene type)	PA, PE	15—300 2	Outer clothing, underwear, tricots, pleated skirts, furnishing fabrics	Keeping of shape, limitation of fluffiness and elasticity, agreeable feel
Yarns looped by the air-texturing method	PA PE PCV V AC 3AC	40—200 65—150 120—200 100—300 230—345 300—600 1.2—6.2	Weaving products: outer clothing, furnishing fabrics, carpets. Knitted articles: knitted underwear, outer garments, lace, socks, curtains	Characteristics of yarns made of staple fibre, the possibility of making the product thinner

[a] PA = polyamide; PE = polyester; PAN = polyacrylonitrile; PVC = polychlorovinyl; V = viscose; AC = acetate; 3AC = triacetate.

equilibrium in the fibre arrangement but gives rise to lasting tendencies towards twisting in the direction that has already been stabilized. This feature gives the articles made from curled yarns a special and distinctive crêpelike appearance.

Yarn shrinkage is an indication of the nature of the finished product. Shrinkage in steam at the temperature of 100°C for textured yarns is shown in table 3.

The uses of these various yarns are conditioned by properties given to them by different methods. Table 4 surveys the uses of textured yarns. Nearly all of the assortment groups produced from natural fibres and chemical staple fibres have been included.

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FOREWORD

This publication is the second of a series devoted to textile engineering and closely related fields. It is part of the Training for Industry Series published by the United Nations Industrial Development Organization (UNIDO).

Rapid world-wide increases in population and industrialization are reflected in the textile and allied industries. In any ranking of human needs, fibres and textiles for clothing and industrial purposes are second only to food-stuffs. The continuing quantitative and qualitative changes in textile production require the broadest and most complete dissemination of information in this important area.

The purpose of the present series is to make available to the developing countries the most recent scientific and technical information in order to help them to establish textile industries or to improve the effectiveness and economic viability of existing textile industries that are still in the earlier stages of economic development.

At the suggestion of UNIDO, with the support of the authorities of the Polish People's Republic, a post-graduate in-plant training course in textile industries was held in Łódź from May through September 1967. The course was repeated from May through October 1968, and its content was modified and up-dated on the basis of experience and new information. It was repeated again in 1969 and it is planned to continue this programme, up-dating its subject matter and improving its usefulness to the textile industries of the developing countries. It is on these courses that the present series is based.

The courses were organized by the Textile Research Institute in Łódź with the object of training a group of already highly qualified specialists in all branches of industry relating to textiles. Under normal conditions, such training would require work in mills and in research and development over a period of several years.

The courses give the participants an opportunity to become acquainted and to do actual work in conjunction with some of Poland's leading research centres and industrial enterprises, and to discuss with experts problems connected with techniques, technology, economics, organization and research in the field of textiles. In organizing the courses, the Textile Research Institute endeavours to co-ordinate the content of theoretical lectures, technical discussions and practical studies in laboratories and mills, covering all the fundamental problems of textile industries.

The main object of the seminars is to adapt the broad range of problems presented by Polish specialists to the direct needs of the developing countries. Lectures by the research workers of the Institute formed the core of the programme. The lectures do not review or repeat the basic problems usually studied at technical colleges and high schools in the course of normal vocational training; rather, they deal with subjects most often of concern to the management and technical staff of a textile enterprise.

The lectures, as presented in this series, have been grouped in eight parts: textile fibres; spinning; knitting; weaving and associated processes; non-conventional methods of fabric production; textile finishing; testing and quality control; and plant and power engineering.

It is hoped that the experience gained from these courses, as presented in this series, will contribute to the improvement of textile industries everywhere, and particularly in the developing countries.

The views and opinions expressed in this publication are those of the individual authors and do not necessarily reflect the views of the secretariat of UNIDO.

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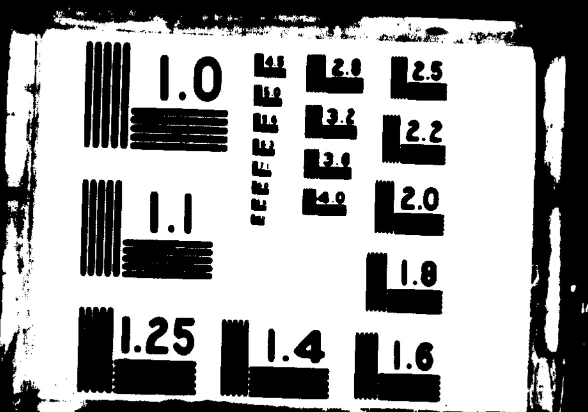


THE PROCESSING OF WASTE CONTAINING SYNTHETIC FIBRES

by

B. Sikora

All over the world, there is a constant rise in the production of synthetic fibres and a concomitant rise in the production of products made from them. In consequence, there has been a simultaneous and constant rise in the amount of waste that contains synthetic fibre and a development of the production of articles made from it. This is especially true of waste containing more than 40 per cent synthetic fibre.

The sorting of waste that contains synthetic fibres

The first and fundamental condition for the rational exploitation of waste with a synthetic fibre content and its correct processing is proper sorting. This should be guided by technological usability (spinning and non-spinning), the synthetic fibre content (up to 40 per cent synthetic fibres and more than 40 per cent synthetic fibres), 100 per cent synthetic fibres, blends, the kind of product (knitted fabric cuttings, woven cuttings, tangled yarn threads, hosiery waste), the kinds of synthetic fibres contained in them (polyamides, polyesters, polyacrylonitriles etc.), the form of the synthetic fibres (continuous, continuous curled, cut) and their colour.

By carrying out the correct sorting of waste according to its properties, it is possible to apply suitable treatment processes and machines for given kinds of waste, to obtain from them high quality pluckered fibres with great technical value, and to exploit them correctly and rationally for the production of yarn on suitable machines.

The characteristics of machines for cutting, pluckering, defibring and spinning synthetic-fibre waste

The basic groups of machines used for the processing of waste are those designed for treatment (cutters, tearing machines, defibrators), blending (mixing equipment) and the formation of rovings and yarns (carding sets and spinning frames).

Because of the specific properties of synthetic fibres (high breaking strength, thermoplasticity and the like, waste with a synthetic fibre content requires treatment

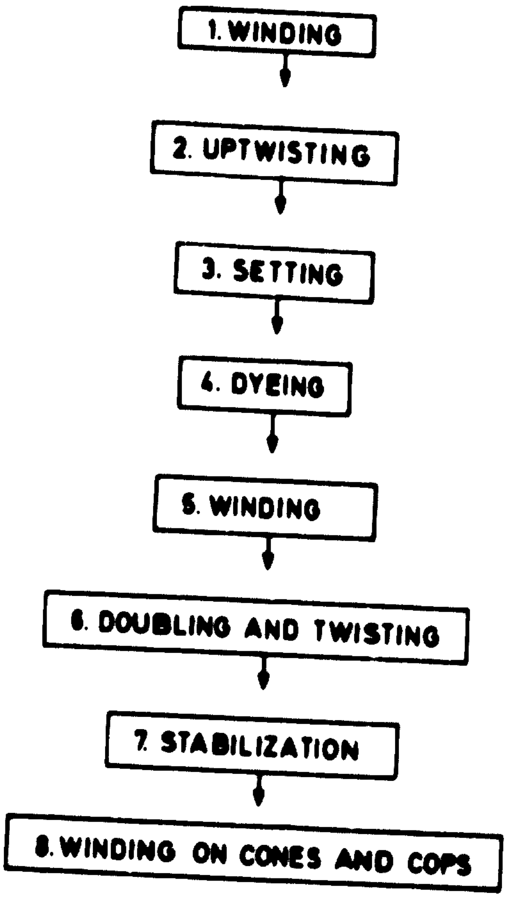


Figure 1. Diagram of the process of smooth-thread manufacture

stainless sheet steel and is cut lengthwise. Before winding the yarn, a protective bag made from a knitted material is put on the bobbin. It is wound across the cylinder.

The stabilization process takes place in an autoclave. The stabilizing medium is steam introduced into the autoclave, from which the air has been exhausted. The temperature for stabilizing white threads is 80° to 120°C, whereas the figure for threads destined for dyeing is at least 130°C. The stabilization process is automatic. During this process the yarn is on bobbins taken from twisters after removal of the side heads (flanges). The bobbins are on pins fixed to trucks introduced into the autoclave. The stabilization cycle (loading, producing, vacuum, cooling) lasts about three hours.

The dyeing process is carried out in pressure equipment, the bobbins being removed and the packages wrapped in knitted bags. The yarn is arranged in dyeing boxes, which are then introduced into the pressure equipment.

Dyeing is followed by winding. This stage is required because the yarn has been dyed on loose bobbins wrapped in knitted material. Winding is done on machines fitted with stationary spindles for fixing the bags of yarn as well as with a rotating cap that unwinds the threads from the package. Doubling single yarns and throwing them in a two-ply yarn is done in a machine called the doubling-twisting machine. Yarn is wound on bottle-shaped metal bobbins.

Repeated stabilization is done in an autoclave. The ply-yarn is on bobbins from the doubling-twisting machine.

The winding of short thread lengths is done on paper tubes as well as on small plastic bobbins that have a side head. Long thread lengths are wound only on bobbins of this type.

The range of thread lengths is as follows:

30 den × 2–from 3,500 to 75,000 metres
40 den × 2– from 2,800 to 55,000 metres
70 den × 2–from 1,600 to 32,000 metres

Synthetic threads made from core-spun yarn

Threads made from core-spun yarns are produced in many countries. The Polish production process is described below.

In order to reduce the melting of synthetic threads in the sewing process, the filament yarn (core) is covered with cotton fibres.

The percentage of cover and the thickness of the filament yarns that make up the core, as well as doubling, must all be adjusted as to obtain threads that correspond to most commonly used cotton threads (commercial count 40/3, which is equivalent to 68/3 Nm).

As the core, yarn from polyester continuous filaments tex 125/24/12 with a tensile strength of 5.5 to 6 g/den and with an elongation of 8 to 10 per cent is used.

Egyptian "Menoufi" cotton (38/40 in FG class + 1/4) is used for cover. The share of raw materials in the yarn is core, 72 per cent, and cover, 28 per cent.

Wrapping the polyester core in cotton with simultaneous S-twisting is done on a ring spinning frame. The number of twists per metre is 670.

The method and equipment necessary for wrapping are shown in figure 2. Winding, doubling and throwing are done in the same way as with cotton threads, while the parameters differ only slightly. (This refers particularly to the number of twists.) As a rule, there appear to be no difficulties in the doubling process; it is the same as with cotton threads.

Dyeing is done in two stages: first, dyeing the polyester core with suspension dyes, and second, dyeing the cotton cover with direct or sulphur dyestuffs in pressure dyeing machines. Dyeing is done on cross-wound bobbins. During the process, the product shrinks up to 10 per cent or even more (depending upon the colour).

In order to prevent the thread wrapping from slipping and causing breaks, the thread is steeped in starch solutions, synthetic waxes or the like.

The further finishing process consists in winding the threads onto spools or bobbins suitable for the final use. The winding is cross-cylindrical, and thread length is about 400 metres.

The most important customer of threads with synthetic cores and cotton covers is the clothing industry, which uses them for garments made from pure polyester fabrics or from fabrics made of polyester blends with some other fibres.

In Poland the trade name of polyester threads with cotton cover is Elanka. Their physical and mechanical properties are shown in table 1.

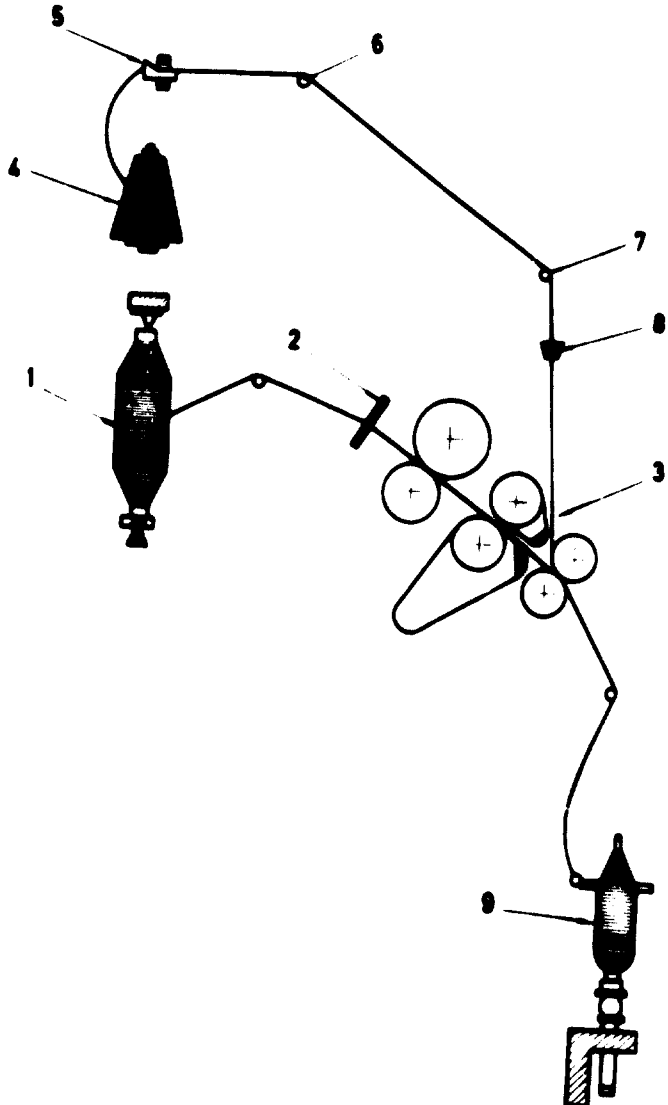


Figure 2. Diagram of the production of core-spun yarn: (1) roving for wrapping, (2) roving guide, (3) drawing frame (Duo-Roth), (4) package with continuous yarn core, (5) counter faller, (6, 7) guiding rods, (8) guide, (9) package with core yarn

TABLE 1. MECHANICAL PROPERTIES OF ELANKA THREADS

Metric count	22—23
Tensile strength of single thread (grams)	1,500
Breaking length (1,000 metres)	33
Variation coefficient of tensile strength (per cent)	6
Elongation (per cent)	15—18
Number of breaks per metre of seam	0.05

Synthetic threads from textured yarns

Threads of this kind are usually made from yarns produced by the air-texturing method. Owing to the presence of air in their structure, such yarns and the threads made from them have the capacity of conducting away the heat generated during sewing, thus reducing the possibility of thread breakage during the sewing process caused by the melting of the synthetic material. The advisability of using threads made from textured yarns results also from the fact that good adjustment of threads to the finished garment, which in this particular case is usually a knitted article made from textured yarn, makes for a neat appearance of the seam and makes for uniform wearing qualities. The technological process is diagrammed in figure 3.

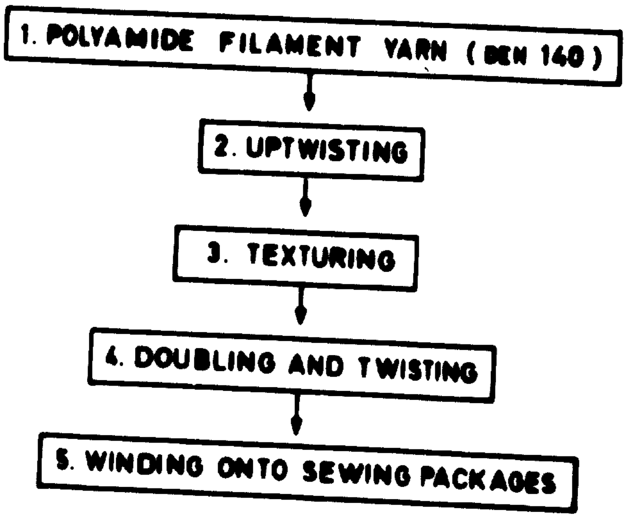


Figure 3. Diagram of the process of manufacturing threads from textured yarns

TABLE 2. MECHANICAL PROPERTIES OF THREADS MADE FROM TEXTURED YARNS

Characteristics	*140×2*	*140×3*
Metric count	28	18.5
Number of twists per metre	540	510
Breaking length (1,000 metres)	24	22
Minimum tensile strength (grams)	850	1,200
Variation coefficient of tensile strength	12	12
Strength at the loop (grams)	600	600
Variation coefficient of twist number	8	8

Supplementary twisting of the textured yarn can be done on ring twisting machines with the lowest number of spindle rotations that are possible without damage to the texturing effect. Twofold or threefold doubling is done on thread-doubling winders or on twisting machines, also with a slightly reduced number of spindle rotations. It is also possible to use doubling-twisting machines that perform both the operations at the same time. The required thread properties are shown in table 2.

Slow-burning threads

Until recently, work clothing designed for protection against high temperatures was sewn with linen threads which, because of their poor resistance to high temperatures, quickly wore out. Consequently, such protective clothing was inadequate.

Sewing threads can be made from glass fibre and other fibres by manufacturing core-spun yarn (wrapping non-inflammable staple fibre around glass fibre), which then is doubled and twisted into a sewing thread. Blending both raw materials in the core-spun yarn gives good results because the glass-fibre core gives the yarn, and the thread made from it, high breaking strength in the direct conditon, while the wrapping guards the core against mechanical damage. The resulting core-spun thread is characterized by sufficient elasticity and slow burning.

In Poland, glass fibre of 100 Nm is used as the core and polychlorovinyl fibre, 3.75 den, length 60 mm, as the wrapping. Two varieties of slow-burning core-spun threads are produced: 16/3 Nm and 22/3 Nm.

The process of thread manufacture is shown in figure 4. The wrapping of the core (operation No. 5) is done as shown in figure 2. The mechanical properties of these threads are shown in table 3.

The raw slow-burning threads produced on the twisting machines are then soaked and wound (cross-cylindrical winding).

TABLE 3. MECHANICAL PROPERTIES OF SLOW-BURNING CORE-SPUN THREADS

Characteristics	*Parameters*	
Metric count	5	7
Number of twists per metre	390	450
Breaking length (1,000 metres)	20	20
Minimum tensile strength (grams)	4,000	2,900
Minimum elongation (per cent)	2.5	2.5
Maximum variation coefficient of tensile strength	8	8
Strength at the loop (grams)	1,900	1,500
Variation coefficient of the twist number	5	5
Maximum number of hidden faults per 10,000 metres	5	5

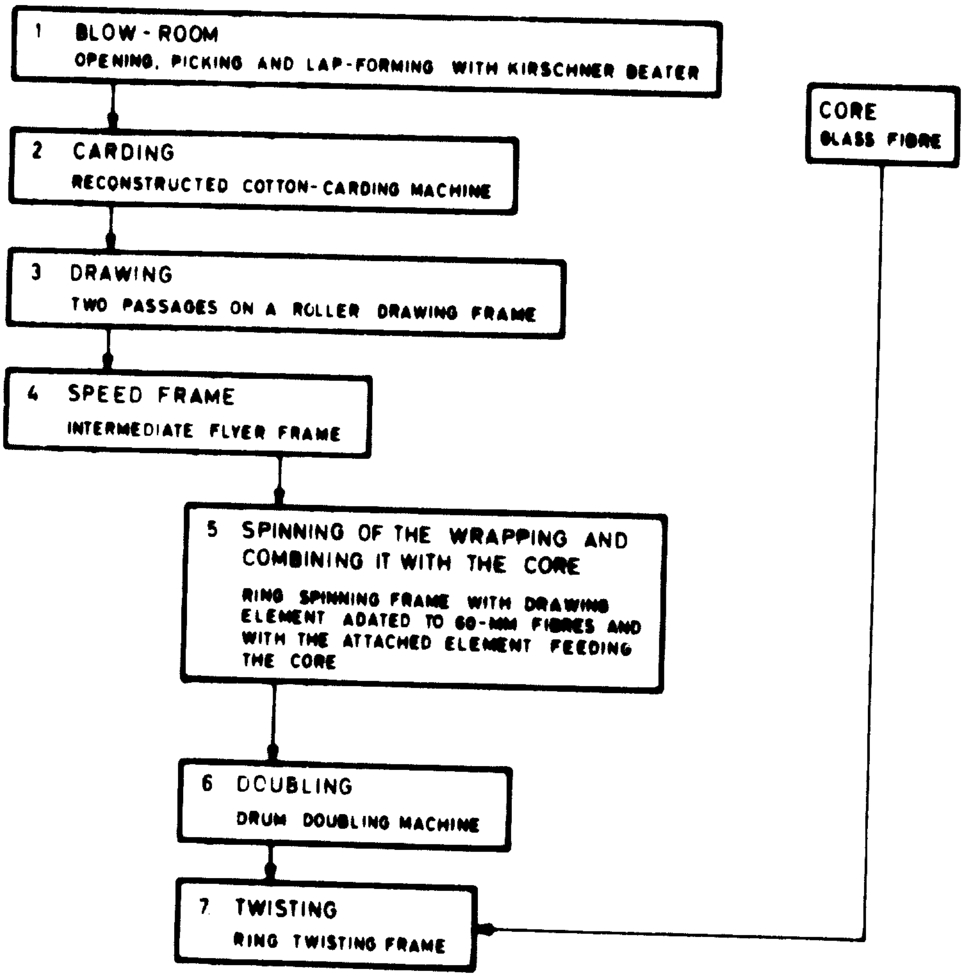


Figure 4. The process of manufacture of slow-burning core-spun thread

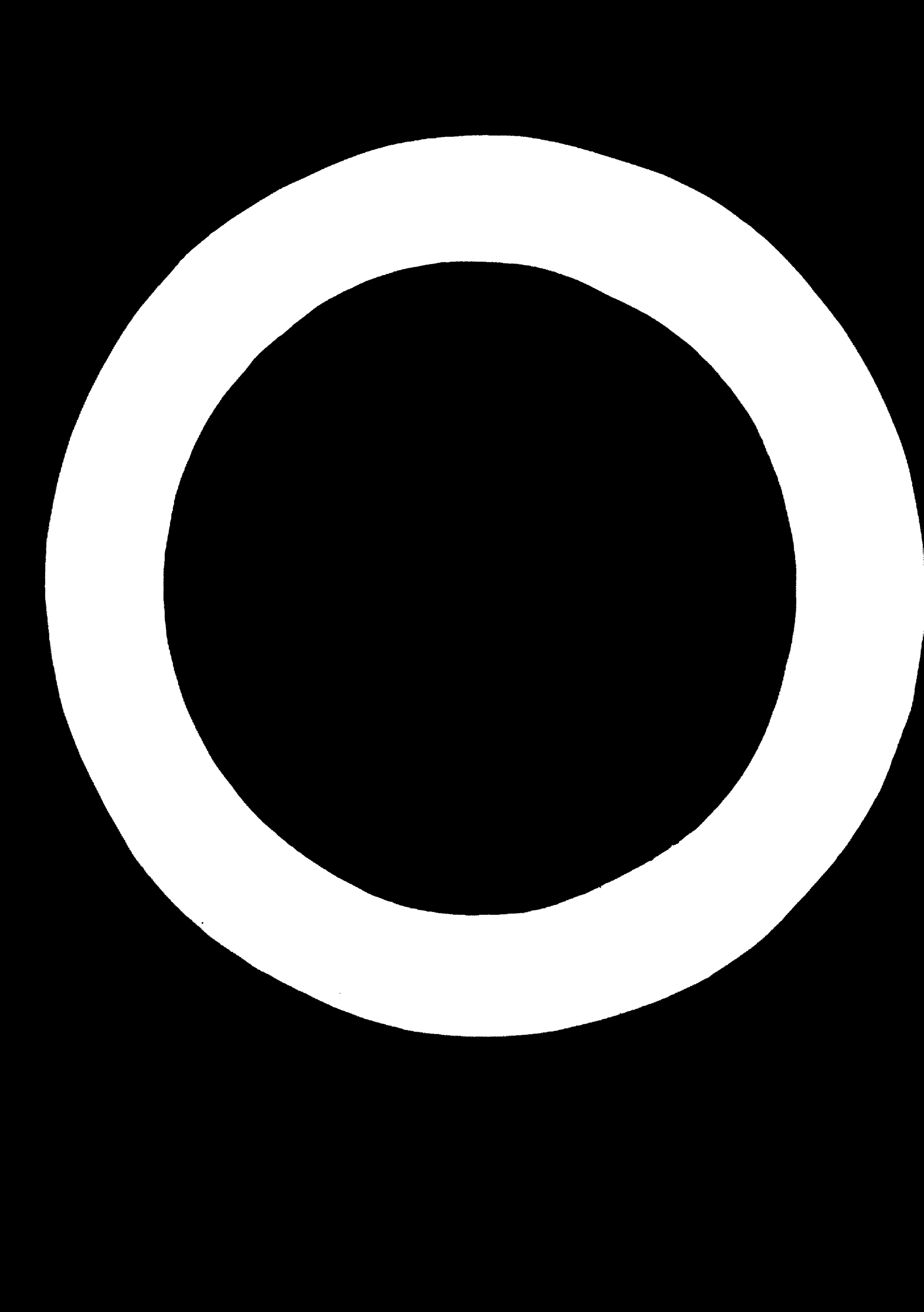
The customers for these slow-burning threads are the factories that make fire-proof clothing. The following fabrics are sewn with these threads:

Asbestos protective fabric

Thickness (at the test pressure of 50 g/m^2)	1.5 mm
Weight per square metre	950 g
Number of threads per 10 cm	
warp	80
weft	47
Weave	plain

Asbestos thermo-insulating fabric

Thickness (at the test pressure of 50 g/m^2)	2.3 mm
Weight per square metre	1,100 g
Number of threads per 10 cm	
warp	57
weft	24
Weave	plain



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slightly different from that for conventional waste. In the treatment of the former, three basic kinds of operations are performed: cutting, pluckering and defibrating, which are carried out on the machines discussed below.

Cutters

Waste materials are cut to make further treatment easier. All waste materials with the exception of combed fabric cuttings and very small knitted fabric cuttings (width less than 10 mm) are subjected to cutting.

Waste materials are cut according to their properties, and this is done on single or double-direction cutters. Single-direction cutters, such as the Italian Sacfem machine, have one transverse knife, and the length of the cut can be regulated within the range from 2 to 12 cm. These cutters are of two kinds, mobile and stationery. The output of these cutters, depending upon the kind of waste materials being cut, is 60 to 200 kg/hour. It is also possible to carry out cutting in two directions on this kind of cutter, passing the waste materials through the cutter twice, with a simultaneous change in the setting of the feeding conveyor. However, it is much better to use special double-direction cutters for cutting in two directions. Cutters of this kind have two kinds of knives, longitudinal and transverse, but there is only one transverse knife, while there can be from 2 to 5 longitudinal ones. The length of the transverse cut can be regulated in the range of 8 to 80 mm, while the length of the longitudinal cut is constant for a given type of cutter and depends on the spacing of the longitudinal knives. The output of cutters of this kind, such as the Polish Fampa GK-14, ranges from 200 to 500 kg/hour.

Tearing machines

Only certain kinds of waste materials that contain synthetic fibres are subjected to pluckering. One of the most modern machines for this purpose is the Polish Befama Ac-11 tearing machine, which is characterized by compact construction, functional casings and easy adjustment of the operating elements. The feeding equipment, which consists of a conveyor belt and introducing rollers, is driven by a separate motor equipped with a speed changer. This facilitates the work by permitting the processing of the material two or more times in the same section, thus achieving better opening and blending of the fibres. The tearing drum, driven by a multi-geared motor, has three rotating speeds, which are used according to the waste materials being processed. The drum is automatically braked by switching off the machine. In the space where the non-defibrated rags are separated from the tearing machine there is an appliance for eliminating the formation of so-called "boards" of fibres and rags. The non-defibrated rags are fed onto the feeding table by a pneumatic feeder. The de-dusting screen drums have a stepless speed regulation. The operating width of this tearing machine is 600 mm, the diameter of the tearing drum with sheath is 640 mm and the output ranges from 60 to 160 kg/hour.

Defibrators

The final treatment process on the defibrators is undergone by all kinds of waste materials that contain synthetic fibres. Defibrators with Garnett-type wire clothing are constructed by various firms as two-, three, four- and even five-drum defibrators.

The best machines for defibrating these waste materials are the defibrators made in Italy by Sacfem. These machines are equipped with a well-developed apparatus for

preliminary defibrating. On a three-drum defibrator the following saw-sheath numerations are used: drum I – 20/1.3, drum II – 24/1.1 and drum III – 30/1. This guarantees the correct, progressive and complete defibrating of all kinds of waste materials. These defibrators can be fed manually or by weight feeders that are equipped with electromagnetic trappers of metal and are adapted for feeding the defibrators both with loose fibres as well as with waste materials. The defibrated waste materials can be collected from the defibrators in the form of a loose fleece, for carding, or in the form of a tape rolled into a ball or collected in a sliver can, for combing.

Machines and equipment for blending

In the woollen spinning industry and in the condenser waste-spinning industry, two kinds of machines can be used: permanent mixers with an operating width of 600 mm and an output of 100 to 150 kg/hour, and rotary mixers with an operating width of 1,200 mm and an output of 500 to 800 kg/hour. The advantage of these mixers, set rotationally or on a circular track, is the possibility of setting the machines at any angle, which facilitates the work and makes it easy for the operatives to put the raw material anywhere on the feeding lattice. In order to decrease the number of operatives, to increase the output of the machines and to improve the mixing of the raw materials, these mixers can be equipped with automatic feeders. The lubrication of the raw materials can be carried out by layering them, either above the feeding lattice or at the exit of the mixers by spraying arrangement. Mixers of this kind are constructed by the Polish firm Befama in two sizes: type AB-3 (small) and AN-5 (large).

Automatic mixing sections

The primary advantage of automatic mixing sections is the elimination of hand operations, operatives being needed only for supervision. This is possible because of the automatic proportioning of the ingredients of the blend, their pneumatic transport to the defibrating equipment, their lubrication in the pneumatic transport channel, their automatic layering in the mixing chambers by cyclone equipment, the automatic unloading of the chambers and the passing of the blend by the pneumatic transport to the mechanized container, which makes possible the automatic feeding of the carding machines. The automatic mixing section makes possible the joining of the mixing section with the carding section in a continuous line.

Carding sets

Depending upon the count of the yarn and its intended use, the carding process and the production of rovings can be carried out on double or triple carding sets. The sets constructed by the Polish firm Befama are among the most modern in this field. This firm constructs carding sets in two basic versions: *(a)* Large-sized sets with increased dimensions (series CR 30 to CR 35) and *(b)* sets with normal dimensions (series CR 40 to CR 45), which are automatic and semi-automatic, with operating widths of 1,800, 2,000 and 2,200 mm, outputs of 20 to 60 kg/hour (depending on the yarn count) and speeds of roving winding from 10 to 40 m/min. They are equipped with automatic hopper feeders of high weight and with equipment for sucking away the side threads of the roving.

TABLE 1. TECHNICAL CHARACTERISTICS OF BEFAMA RING SPINNING FRAMES PG 5, PG 6 AND PG 7

Type of machine	*Pitch (mm)*	*Diameter of ring (mm)*	*Height of coil (mm)*	*Speed of spindle (rev/min)*	*Yarn twist (twists/m)*	*Drawing*	*Recom-mended yarn count (Nm)*	*Number of spindles*
PG 5	200	160	520	900—5,500	50—325	1:2	1—3	180
	160	120	520	1,240—6,200	60—390	1:2	2—6	220
PG 6	140	110	420	1,340—6,700	80—520	1:2	4—8	260
	125	95	420	1,540—7,700	90—585	1:2	6—12	300
PG 7	110	85	320	1,700—8,500	100—650	1:2	8—16	340
	100	75	320	1,900—9,500	110—715	1:2	10—20	380
	90	65	320	2,200—11,000	123—800	1:2	12—24	420

TABLE 2. SUMMARY OF PROCESSES AND TREATMENT CONDITIONS OF WASTE MATERIALS CONTAINING MORE THAN 40 PER CENT SYNTHETIC FIBRE

Waste material group	*Kind of waste materials*	*Form of synthetic fibres*[a]	*Processes and treatment conditions*			
			Length of cut on cutters (cm)			*Number of drums*
			Single direction	*Double direction*	*Tearing machine*	*Defibrator*
Knitted fabric cuttings	100 % polyamide	cgk	4—6	—	1	4
	100 % polyacrylonitrile	ct	10—12	—	—	3
	50 % polyamide + wool	cg	10—12	—	—	3
	50 % polyamide + cotton	cg	10—12	—	1	4
	40 % polyamide + cotton + viscose	cg	10—12	—	1	4
	40 % polyamide + wool + viscose	cg	10—12	—	—	3
Woven cutting	40 % polyamide + wool	cg	—	—	1	4
	55 % polyester + wool (or viscose)	ct	—	—	1	4
	70 % polyester + viscose fibres	ct	—	—	1	4
	100 % polyester or polyacrylonitrile	ct	—	—	1	4

Tangled thread yarn	100% polyamide	cgk	2—4	2×5[b]	1	4
	100% polyamide	cg	6—8	4×5[b]	—	3
	100% polyacrylonitrile	ct	8—10	—	—	3
	100% polyester	ct	8—10	—	—	3
	50% polyamide + wool	cg	10—12	—	—	3
	55% polyester + wool (or viscose)	ct	10—12	—	—	3
	70% polyester + viscose	ct	10—12	—	—	3
	40% polyamide + cotton + viscose	cg	8—10	—	—	4
	40% polyamide + wool + viscose	cg	10—12	—	—	3
	40% polyamide + wool	cg/ct	10—12	—	—	3
Cuttings from hosiery	100% polyamide	cgk	—	2×5	1	4
	100% polyamide	cg	—	4×5	1	3
	50% polyamide + wool	cg	—	6×5	1	3
	40% polyamide + viscose	cgk	—	2×5	1	3
	40% polyamide + cotton + viscose	cg	—	4×5	1	4
	40% polyamide + wool + viscose	cg	—	6×5	1	3

[a] The following designations have been introduced: cgk — curled continuous fibres,
cg — continuous fibres,
ct — cut fibres.

[b] The double-direction cut in the case of the tangled thread yarn, in the form of drawn cops.

Spinning frames

In the carded spinning industry, ring spinning frames are used rather than mule spinning frames. Befama produces three types of ring spinning frames, PG 5, PG 6 and PG 7, that are adapted to the carded spinning industry. These spinning frames have a double-sided construction with an individual drive at each side (commutator motors that permit a continuous change in the direction of the spindle). The spinning frames have a one-zone drawing apparatus constructed as an apparently twisted spiral and provided with a device for removing the broken threads by suction. Regulation of the drawing is achieved by a P.I.V. stepless gear. The spindle bench is stationary and the ring is mobile. These spinning frames are equipped with spindles for a suppressed balloon-spinning system. The technical data for these spinning frames are given in table 1.

Typical processes applied in the production of yarns containing synthetic fibres

The kinds of processes and conditions for the treatment of each group of waste materials, according to the previous division, are given in table 2.

Before the pluckering or defibrating processes, the waste materials with less than 100 per cent of synthetic fibres should be lubricated (2 to 4 per cent lubricating agents), and waste materials of 100 per cent synthetic fibre content should be treated with anti-electrostatic preparations (1 to 2 per cent anti-electrostatic agent in relation to the weight of the moistened waste materials).

The pluckerings from the synthetic fibre waste materials constitute a spinning material of full value, and they can replace several other raw materials that are presently used in woollen and carded-waste blends such as noils, wool-type and cotton-type viscose fibres and woollen pluckerings.

In the woollen spinning industry, blends with contents of the above-mentioned waste materials (from 10 to 30 per cent) can be used in the production of warp and weft yarns for the following purposes: men's coat and suit fabrics, ladies' coat and costume fabrics, dress fabrics, plaids and blankets (here the yarns of 100 per cent synthetic fibre content mentioned above can be used) and for knitted fabrics intended for sports wear, men's underclothing, socks and jerseys.

In the cotton condenser spinning industry, blends with some of these waste materials (from 10 to 40 per cent synthetic fibre) can be used in the production of warp and weft yarns for the backing of linoleum, warp yarns for the backing of carpets, and weft yarns for the following kinds of fabrics: bandages, cables, linings, plaids, quilts, coverlets, flannels, pyjama fabrics, winter shirtings, mattress coverings, working clothes and yarns for knitted fabrics intended for sports wear and underwear linings and for socks.

It should be mentioned here that, because of the great difficulties and costs connected with the dyeing of synthetic fibre waste materials, and especially of waste fibres with polyester and polyacrylonitrile fibre content, such fibres should be used in blends intended for melange fabrics or coloured woven fabrics.

The conditions for the processing of blends containing synthetic fibre waste in mixing, carding and spinning departments are the same as for the processing of traditional blends and depend on the length and thickness of the fibres in a blend and on the count of the yarn produced.

Waste materials containing synthetic fibres can also be used in worsted spinning departments. This mainly concerns loosely combed waste materials such as the ends of tapes and rovings, reels and other light-weight waste materials that require only preliminary defibration and mixing on a carding mixer before being processed in the traditional worsted way. Yarn counts from 12 to 30 Nm can be produced from this kind of waste material.

In worsted spinning departments, tangled thread yarns with 100 per cent polyacrylonitrile and polyamide fibre content can also be used after defibration. From these waste materials, in blends with 40 per cent new fibres, yarn with counts from 12 to 24 Nm can be produced that can be used like worsted yarn. In this case, the defibrated waste materials collected from the defibrator in the form of tapes are subjected to drawing on intersecting drawing frames, combed and then mixed in tapes with new fibres.

As can be seen from this short discussion, solutions have been found for some of the problems connected with the treatment and exploitation of synthetic fibre waste materials However, some other problems remain unsolved, but the situation is constantly improving.

TECHNOLOGY AND USE OF SPECIAL THREADS

by

W. Rozmarynowski

Synthetic threads

Most common among the synthetic threads are the plain ones used as the basic raw material for either polyester or polyamide silk without modifying its surface; the proportion of thread made from textured yarns is much smaller. These yarns are obtained in the course of modifying the "silk" structure by means of the Taslan method, which is known in Poland as the Iwlan method. The same is true of threads made from core-spun yarns.

Synthetic plain threads

There are many possibilities for adjusting the process of manufacturing smooth threads. They may be produced from polyamide and polyester filaments. A typical production programme can be presented as follows:

Thread symbol	*Kind of doubling*	*Use*
60 den	30 den × 2	Sewing threads
80 den	40 den × 2	Sewing threads
140 den	70 den × 2	Sewing threads
180 den	90 den × 2	Sewing threads
270 den	90 den × 3	Technical threads
250 den	125 den × 2	Sewing threads
840 den	210 den × 4	Technical threads
1,260 den	420 den × 3	Technical threads
1,260 den	210 den × 2 × 3	Technical threads

Threads are produced according to the diagram shown in figure 1. The raw material is delivered as no-twist yarn (about 20 twists per metre) on cylindrical bobbins. The weight of the package is about 1.2 kg. The first production stage is the winding of this yarn for the next stage.

Packages on two flange bobbins are fed to a double deck twister. The yarn is wound onto special bobbins that consist of two side heads (flanges) that support a cylindrical part by means of spring washers. The cylindrical part is made from