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PROGRESS IN COTTON PROCESSING MACHINERY [1]

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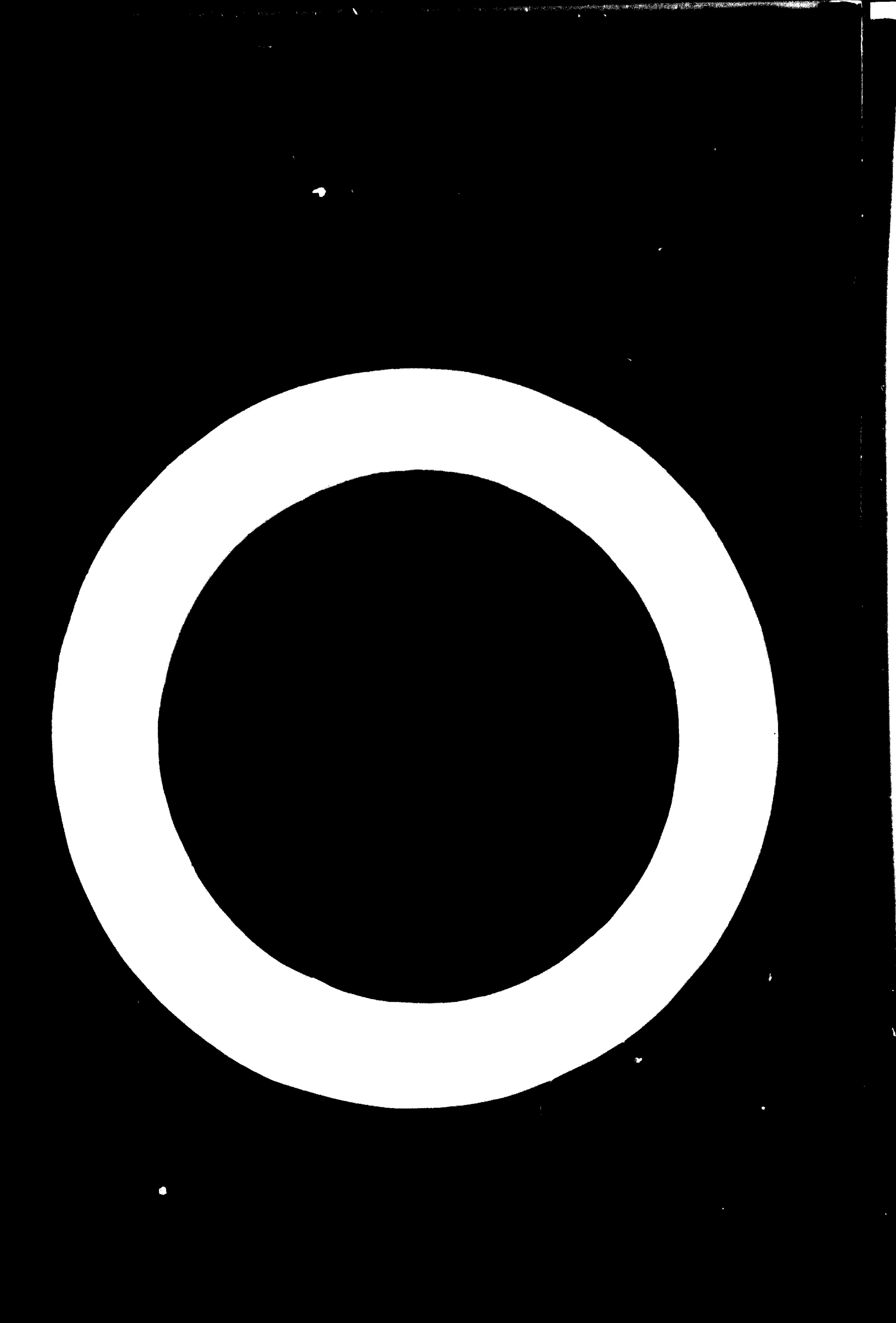

PROGRESS IN COTTON PROCESSING MACHINERY

Introduction

Industries are not unlike growing plants. They need pruning to remove dead wood, feeding to stimulate continuous progress and, above all, a suitable climate for the fruits of their labour to reach maturity, when market demand is at its peak.

It is essential for vigorous growth in any industry that all its component parts are tuned into recognise changing conditions and for management to implement the results of progressive development. It is the purpose of this paper to review some of the most important trends which are now changing the cotton spinning and fabric-making industry; to assess the programme and opportunities for cotton arising from these trends.

Major trends

I will refer briefly to a few of the important textile industry trends before describing the progress in individual processing machinery. These trends are concentrated in the fibre competition, including influence of fibre properties on fabrics and end-products, the use of fibre blending, the need for uniformity of fibre properties with increased machine speeds, the shift from weaving to knitting for apparel fabrics and the movement towards light-weight clothing.

Perhaps the most severe influence comes from the keen inter-fibre competition for the existing yarn market, namely between the natural fibres, of which of course here we are concerned with cotton only, the man-made cellulosic fibres and the truly synthetic fibres. There was a time when particular articles of clothing and the fabric from which they are made were associated almost exclusively with one fibre type. The penetration of the market, first by the man-made cellulosics in the late '30's, and by the synthetics in the '50's, changed the picture considerably. So, new associations were also created, such as nylon for the ladies' stocking market, which replaced silk yarn, etc. Encroachment on the cotton region of application by man-made fibres has proceeded and is still continuing. However, market acceptance of the man-made fibres merely through the sheer weight of promotion and availability of yarns in suitable counts and deniers is now settling down to what has become known not so much as one fibre, one product, but more appropriately as fibre and yarn engineering, with fitness for purpose being a principal virtue.

Traditionally, cotton fibre properties have been considered solely for their adaptability for the spinning process. The spinner has set his requirements for fibre length, fibre length uniformity, maturity, cleanliness, tendency to nep and other characteristics. No doubt the marketing system for all cotton is based largely on the spinner's needs. The influence of fibre properties on fabrics and the final product, however, cannot be ignored, particularly with the trend to process integration as larger textile groupings are formed and rationalised.

Man-made fibres are recognised primarily for certain superior functional properties, such as strength, while cotton is still regarded by the consuming public as the standard with respect to aethetics and comfort.

Today's situation has been characterised by one speaker at a recent conference as the choice between 'easy-car' and 'easy-wear'. To some people, fibre blending in all its forms is the answer.

Spun polyester is a major synthetic fibre competing with cotton and is often used in blends with cotton for shirts, sheets, etc. No doubt it is a growing competitor with the all-cotton wovens, as well as the all-synthetic warp-knits. This applies also for the workwear and overall field. Cotton no doubt can hit back here by improving its easy-care virtures without loss in strength or abrasion resistance. In the field of the cellulosic man-made fibres, polynosics are replacing cotton content in some applications, particularly in blends with synthetic fibres. In this case cotton needs to increase cleanliness and the consistency of fibre properties, which then will simplify processing and will also improve the lustre of the final product. No doubt in all cases there is work to be done on assessing fibre properties in blends which will most nearly satisfy all end-use requirements.

Against this fibre background comes the increased speed of production machinery employed and the greater degree of automation being used. Cotton-type processing machinery is not lagging in this respect at all; certain new developments such as open-end or break spinning and twistless spinning are particularly advantageous for the cotton fibre. It must be emphasised, however, that with increased speeds on any machine there is more urgent need still for improving the over-all consistency of raw materials in process through greater uniformity of fibre properites.

In fabric manufacture, another trend is the continuing shift from weaving to knitting, particularly in the apparel field. While this is especially pronounced in the United Kingdom, it is also prominent in other Western European countries as well as in the United States.Some forecasts go so far as to predict that by 1980 as much as two-thirds of the apparel market in Great Britain will be supplied in knit goods and only one-third left to the woven sector. I shall deal with this aspect later in this paper [illegible] it has been only the man-made fibre market that has benefited from this switch to knitting because until recently the dominant growth area has been in fine gauge warp knitting which is particularly suited for the smooth filament yarns and not suitable for spun yarns whether of cotton or any other fibre. This is some justified hope, however, that by the introduction of new-type machinery spun yarns will also benefit greatly from this shift to the knitting process.

No doubt it needs some new, imaginative development work, but there are strong indications that the knitted fabric field is potentially fruitful also for the cotton fibre.

The movement towards lighter weight apparel fabrics is another continuous trend which is applicable to both woven and knitted fabrics. Whether this particular development will be to cotton's advantage, is again a question of easy-care or easy-wear, and in off-duty clothing no doubt comfort in wear (a plus for cotton) may be regarded as the more important factor.

Developments in mechanical processing of cotton

Textile processing techniques are, today, going through a phase of significant changes and modifications. Up to the 1950's the spinning and weaving equipments looked much like it did during the previous 30 years. The new textile age started around 1960 through the availability of very precise measuring techniques, better construction materials and the application of electronics throughout the textile processing stages. It was in the cotton industry of the last century where the principles of mechanisation (of a factory) were first introduced. The cotton industry played the role of pacemaker for mass production methods, and the concentration of manufacturing facilities into one location (into the mill) was practised for the first time by spinners and weavers. The words 'mass production' were already being applied to textile mill operations at the beginning of the last century. Today, again, the cotton industry is at the forefront of fully automated processing. Wherever the economics can justify it, manual labour is being replaced by capital-intensive equipment. A single operative can be put in charge of machinery worth anywhere between £20,000 and £80,000. In this respect the textile industries compare well with other manufacturing industries.

To show how technical progress is advancing, let us see how the requirements for human labour in textile mills have changed over the centuries. Of course, there have been a number of certain important technical innovations which at the time of their conception usually represented a significant step forward. However, if we look over long periods of time, evolution seems to proceed at a fairly steady rate and all these significant events seem to fit perfectly into a uniform pattern. The man-hours required to produce one kilogram of cotton yarn or 100 meters of woven cotton cloth have been calculated since the beginning of the mechanisation age up to the present day. The result is a surprisingly constant rate of labour reduction, in spinning as well as in weaving. The slope of the curve indicates that during a 75-years span labour requirements are reduced by a factor of ten. A mill producing 200 kilograms of cotton yarn per hour needs 20 operatives today. If this trend continues (and there is no reason why it should not), 75 years from today a fully automated plant of the same capacity will be controlled by two operatives. Therefore, the significant changes of the area of full automation.

Let us now examine the latest developments from fibre to yarn, and from yarn to fabric.

Harvesting

Over the past several years, machine-picking has become widely used. In the USA it is done universally, in other countries it is at various stages of introduction, depending on the relative cost of labour and machinery. The many comments which have been made in the past regarding machine-picking are hardly worth repeating. Machine-picked cotton contains a larger amount of non-fibrous matter than hand-picked cotton, so that an extra cleaning effort is needed [illegible] ginning station and in the spinning mill.

From the point of view of subsequent processes less fibre breakage and less foreign matter is desirable. Here most progress and improvements have to come from developments in ginning machinery. But thought should also be given towards making the fibre itself easier to gin.

Spinning mill process

The early spinning mill consisted of a series of individual processing steps. There were usually ten operations for carded yarns and perhaps 13 for the production of combed yarns. The modern mill looks quite different. A few major operations have remained, some of which are interconnected. Today we must distinguish essentially between two main sections in a cotton spinning mill. The first encompasses fully automatic opening, cleaning and blending; interconnected directly and automatically to the carding and drafting process. The second section then consists of the roving and spinning operation, processes which to date have been rather difficult to incorporate into an automatic line. The entire interconnection of all manufacturing steps from bale to yarn is technically possible, but only seems justified if the production of the spinning unit can be increased by a factor of about five to ten, i.e. if the number of spinning spindles can be reduced drastically. The introduction of the so-called open-end spinning technique may be a solution in this direction.

Blow-room machinery

As just indicated, full automation today is possible from bale to drawn sliver. At the opening stage it appears logical to eliminate human labour which is involved in loading the transport-lattices with layers of materials which are taken by hand from the bales to be blended. It is not only heavy and dirty work, but much depends upon how carefully and how reliably this blending is being carried out. So-called automatic bale-digesters have been known now for several years and they have reached a high level of perfection today. In such machinery, fibre tufts are removed from the bottom of the bales which are placed on the plucker. Tuft removal is done by an actual plucking motion or by the action of saw-toothed beater drum . In the Trutschler machinery, the bales move back and forth across the plucker system. The tufts drop on to a conveyor belt and are blended in sandwich-form with the material of other plucker units which work in parallel. Another novel method of automatic opening is employed in the bale digester by Rieter, whereby six bales are rotated slowly over a platform which incorporates five beater sections to remove and collect the fibre tufts at a predetermined rate.

With the application of such automatic bale-digesters two factors are of utmost importance to the cotton breeder: 1. There is a definite tendency to reduce the number of bales which are blended together in the opening process of the cotton mill, stressing the need for increased uniformity and possibly for careful pre-blending at the ginning station. 2. The bales must reach the spinning mills in such a shape as to conform with the requirements of the bale digester, otherwise the bales cannot be worked up properly. While most cotton coming from the development countries or from the Eastern Block states usually are in very good condition, bales from the USA sometimes arrive in extremely poor shape, thus making automatic bale-opening very difficult. Both spinners and machine-builders are looking for standardised raw-material bales with respect to dimension, specific volume and packaging.

Cleaning

If a cleaner fibre could be supplied to the spinning mill, then the possible damage done by blowroom machinery, which is never nil, would be minimised. The less trash there is from the outset the less opening treatment is required, which means reduced fibre damage or fibre breakage. No doubt many short fibres are created by breakage during picking, ginning, opening and carding, so that cleanliness and short fibre content are related. In particular, cleanliness will play an important role in exploiting the potential of the cotton fibre for the new open-end spinning technique. On the other hand it is well known that short fibres produce weaker and more uneven yarns, because they are more difficult to process in the drafting zones, create fuzziness in the fabric and make it more difficult to produce a permanently smooth fabric surface. During the past decade there was a tendency to perform the opening and cleaning action mostly by axial type openers or air stream cleaners which treat the fibres more gently, but one observes today a definite trend back towards equipment using Kirschener-type beaters or saw-tooth drums. This is a direct cause of the higher trash content in most cotton shipped to the mills today. With reference to the clean man-made fibre bales, the need for less trash content in cotton bales must be stressed over and over again.

Carding

Within the past few years, card production has increased from about five to between 16 and 40 kg/hour, the lowest production applying to the long, fine cotton, the highest to the short, coarse qualities. There is even talk of stepping-up the productivity to 100 kg/h. High-production cards are being accepted generally today, and cards can be connected directly to a line of blowroom equipment. The scutcher lap is eliminated by the use of a chute feed arrangement. As an example, the Rieter system has four to eight cards which are fed from a tuft feeder. Fibre conveyance is provided through a blower and the material flow is monitored and regulated using an optical absorption technique. At the delivery end of the card, the sliver passes through a storage box, which serves as a buffer during start-up or shut-down, and eliminates the need for elaborate synchronisation between the cards and the drawframe. Four to six card slivers are combined and transported on a conveyor belt to the autoleveller frame which produces a drawn sliver of controlled evenness.

A card attachment which has become widely used and is likely to become universal in the near future is the so-called crush-rolls at the delivery end of the card. This is a very heavy, polished [illegible] of rollers between which the cotton-web is crushed, thus pulverising any trash particles but without damaging the fibres themselves. The waste falls out from the web by gravity.

In judging the product of a high-speed card, every expert, be it the machine-manufacturer or spinner, must admit that by comparison with the old standard the web is not quite so clean and not so free from neps as formerly. Furthermore, unless the card clothing is selected very carefully, high-speed cards may definitely damage the cotton staple. Thus, the producer must make an optimum choice between cleanliness of the web and the productivity of the card. There have been considerable changes in the shape of the metallic wire clothing of the cylinder and doffer on the cotton card. Modern card clothing has only very short teeth and there is definitely no room to collect any dirt or short fibre in the clothing itself. Unless the card is equipped with properly positioned suction devices, some trash [illegible] will still remain in the card sliver. Should this be the case there is no doubt that cotton yarns produced from such sliver will be of inferior quality.

Spinning

For years the mill size has always been described in terms of spindle numbers. This is due to the fact that as much as 60 to 80% of the total power consumption in a mill and roughly 50% of the total labour costs are spent at this stage of production. It is quite evident that increased production speed as well as the introduction of automation would bring about significant benefits in the costs of yarn preparation. We shall be reviewing two important spinning developments, as they are of significance in the use of cotton fibre. These are the open-end spinning and the twistless spinning techniques.

Open-end spinning

The three limiting factors of the ring-spinning technique, which are the primary motivation for the new spinning technology, are power consumption, yarn tension and ring traveller friction. Open-end (OE) or break-spinning has been developed on cotton and is used mostly with cotton today. Whereas in ring-spinning the total yarn package must be rotated in order to obtain the necessary twist, only a relatively small mass must be rotated in open-end spinning. The take-up package is turned only very slowly in order to wind the spun yarn. This means much less power consumption at a given speed or, at the same power consumption as in ring spinning, much higher rotational speeds are applicable in OE spinning. Furthermore, there is no spinning balloon, therefore the yarn tension is less and, since there is no ring and traveller, the problem of friction is overcome. In principle, a break in the fibre continuity is introduced in a drawing or opening process. Then follows a transfer and depositing of the fibres on the inner surface of a rotating cup.

This so-called Rotor or turbine-type, open-end spinner has today the best chance of being introduced in certain areas of cotton spinning. Originally developed in Czechoslovakia, several major machine builders in the world are now engaged in the manufacture of rotor-type semi-commercial units. The latest version of the so-called BD 200 frame is manufactured in Czecholoslovakia and also, under licence, in Italy and Japan. The largest installations of open-end spinning are at Courtaulds in England and at Daiwa in Japan, each with about 50,000 ring equivalent spindles. It appears that Daiwa and other Japanese spinning firms have ambitious plans to increase their open-end capacity. The latest information indicates that up to spring 1970, installations in Japan had risen to 230 frames (200 spindles each at eight different concerns).

Rotor-type, open-end spinning frames are also being developed in Europe. For example, the Integrator machines by S.A.C.M. in France, and three large machine manufacturers, namely Platts in England, Ingoldstadt in Western Germany and Rieter in Switzerland, are pooling their knowledge in the development of another rotor open-end frame. Some semi-commercial units are already being tried out in the mills of various countries. These will be shown at the 1971 Textile Machinery Exhibition in Paris.

The development of open-end spinning machinery has, to date, concentrated mainly on the short staple sector; therefore, among the natural fibres it is only cotton and blends with man-made fibres up to about 40 mm cut-length, which are used to produce yarns in the cotton count range of No 6 to No 14. For the application of man-made fibres further limitations must be considered including their crimp, fibre-fineness and finish.

Most investigations about cotton yarns report good yarn quality, except for the breaking strength which is 15-25% below that of ring-spun yarn. However, since OE yarns are superior to ring spun yarns in respect of uniformity and elongation, it is claimed that OE yarns process at least as well on looms or on knitting machines. It is further reported that in general the fabrics are more uniform and give a better cover, but they may have a somewhat harsher handle. It appears as if some special finishing treatment may become a necessity if comparable end products are to be obtained. Except for the fact that the maximum staple should not be greater than the diameter of the turbine, open-end rotor spinners are not very sensitive to the shape of the staple diagram. A uniform staple works as well as the very undesirable length distribution of comber-waste, for example.

In our laboratories we have worked up cotton slivers of various staple lengths. Very short staple, which causes problems on the ring spinning system, usually can be processed into yarn on the open-end machine without much difficulty. In fact the open-end yarn from comber waste can be made as strong as a ring-spun yarn made from the same source, and the elongation to break is even higher. The longer the staple being used, the larger is the strength loss by comparison with ring-spun yarns. These findings are associated with the inability of an open-end machine to spin the fibres in a parallelised configuration into the yarn. A typical open-yarn structure has extending loops. These loops do not contribute to the strength, but they do increase the bulk of this material. If a long staple is processed, the relative portion of such loops and hooks becomes greater while the yarn becomes less flexible, rod-like and coarser. As fibres are depositied on the inner surface of the rotor, one finds indeed considerable disorder, which is responsible for the entirely different yarn structure.

No doubt plenty of development work is needed yet to produce better fibre allignment in open-end yarns. At our Institute we were able to improve this situation noticeably by using a standard roller drafting system instead of a card roller opening device. The remarkable observation was made that it is indeed possible to apply draft ratios of about 300:1 with very good drafting uniformity, whereby in ring-spinning drafts of about 50 are very difficult to exceed, unless two drafting zones are being used. Extremely high draft is made possible as the output speed of the drafting unit is above 250 ft/min, and this is exactly in the speed range of an open-end spinner.

Open-end spinning, furthermore, appears ideally suited for producing fibre blends. By dyeing techniques it could be shown that improved homogenuity over ring yarns is obtained. A surprising result from spinning trials with blended material was a 50/50 blend polyester and American 1 1/16 in. carded cotton that came very close to the properties of a 50/50 blend of polyester and Peru pima combed cotton. Furthermore, man-made fibres usually run better when blended with cotton than used in 100% form. This improvement appears to be associated with the elimination of static charges when cotton fibres are part of the fibre blend.

By far the greatest handicap of the open-end spinning technique is its sensitivity to dirt, trash and fibrous particles, which will be deposited on the turbine wall, causing the yarn to break finally. Frequent cleaning intervals are a necessity and, therefore, the most important requirement on the part of the raw material is greater cleanliness. This must be kept in mind in judging the future success of cotton as an ideal fibre for OE-spinning.

Twistless spinning

Since ancient times yarn-making has required a fibre twisting operation to obtain strength and compactness. The idea of promoting sufficient fibre-to-fibre friction by merely bonding or glueing the fibres together without the need for twist insertion, was followed up about ten years ago by the Fibre Research Institute TNO in the Netherlands. If there is no need for twisting, great possibilities are offered with respect to the rate of production. Pilot plant facilities have been built and it looks as if the process is very promising when applied to cotton or flax.

Before the cotton roving is used, in twistless spinning, it must be treated chemically, which means usually an alkaline boil-off to remove the fatty substances and to bring it into a thoroughly wetted state. The wet roving is taken off the spool by the first set of drafting rollers. This unit is a drafting system which does not employ any means for mechanical control of the fibres. Cohesion and contraction effects caused by a certain quantity of free water present permit the smooth control if fibre movement in the drafting zone. After leaving the delivery roll the thin ribbon is twisted by a pneumatic false-twist device and then the yarn is wound in a twistless state on to the yarn package.

The pick-up of inactive starch by the yarn takes place from the delivery roll which is covered with a narrow track of starch by means of a narrow supplementary roller. The starch remains inactive until the wet yarn packages are placed in a low pressure steamer to be treated for about one hour at 110°C. Here the starch is given an opportunity to swell and to migrate along the fibre surface, forming an active, adhesive film. Finally, a drying treatment of about 100°C terminates the production of these twistless yarns.

The great advantage of this spinning system is its speed which is between 125 m/min and 200 m/min, i.e. considerably above open-end spinning speeds.

The properties of twistless fabrics differ appreciably from those of conventional fabrics with the same construction and yarn number. Usually the fabric surface is smoother; due to the absence of twist a better cover factor is obtained also and the fabric is more lustrous. The fabrics are reported to have very excellent resistance to laundering and potential is seen in shirtings, sheetings, tentings and dress fabrics. While so far only laboratory type small scale equipment has been available, a pilot plant is being built in Holland and will go into production during this year. It will be interesting to follow up any new information about this process which may offer prospects for combining other wet processing, such as mercerising or dyeing, with the spinning process.

Fabric manufacture

Whether new technologies for the manufacture of textile cloth will soon replace conventional techniques is a question that has been under discussion for some time. The opinions stated may shift from one extreme to another and it is indeed rather difficult to give a reliable answer. No doubt it is just as wrong to state that weaving is doomed as it would be to ignore the non-woven sector or stake everything on knitting. Recent production statistics covering the past 15 years show that there has been a definite slow-down of the growth rate in the weaving industry, Great Britain alone actually shows an increase since about 1960. Of technical interest is the fact that in spite of the drastic reduction in the number of weaving machines the total output, nevertheless, shows an increase per year of about 3%.

In the past decade a phenomenal growth of knitting, both warp-knitting and weft-knitting, has been observed, and it is expected that this growth will continue for some time. Other areas, such as the non-woven sector, have also been gaining momentum since about 1960. As far as I know there is a market survey by IIC in progress to identify the causes of the rapid growth in knitting and the markets that have been invaded by it. There is no question that the major growth has taken place in the production of fine gauge, warp-knitted synthetic fibre fabrics. Several factors have contributed to this: the high production speeds, possibility of wide width (more than 200 inches), pressure from synthetic fibre producers, the better handle of knitted synthetics over woven synthetics, little or no yarn preparation and better easy-care properties. About 80% of these fabrics are made from nylon and the main market divides roughly into 40% lingerie, 25% shirts and 11% for dresses and blouses. In the market area mentioned above the usage of synthetic fibres will always be dominant. However, there are considerable growth opportunities for cotton in many other areas.

Cotton, which of course is well established in weft-knitting for men's underwear, should be able to defend this position due to the better wear characteristics and comfort of the fabric. With stabilisation and resin finishing treatments now available to eliminate shrinkage in laundering, cotton should also be able to penetrate the knitted terry towel, fine gauge interlock and ladies' dress markets. In spite of the appreciable higher productivity of knitting machinery which is five to ten times that of weaving, economic appraisals indicate for several end-use products only a marginal advantage for the knitting process. These findings are due to the considerably higher costs of texturised or fine denier filament yarns. Here again cotton is in good position and it would appear worthwhile to search for methods to prepare cotton yarns in such a way as to utilise fully the potential of high speeds in knitting.

In the outerwear industries of Europe and the United States, the output ratio of woven to knitted goods stands at about 4:1. Total production will approximately follow a 3% yearly increase. If weaving were given no further change to grow, the knitting output would double within the next five years, equalling woven production around 1985. It seems more reasonable, however, to assume that weaving, too will continue to grow, say between 1 and 2% per year, which in turn means for knitting a yearly growth of about 14% in 1970, slowing down to about 7% in 1980.

There is no doubt that the callenge of knitting techniques is exerting a significant influence on new engineering efforts in the design of weaving machinery. A definite trend to wide machinery giving higher productivity is observed. Sulzer shuttleless looms are being built now up to widths of 213 in., enabling simultaneous weaving of several cloths. The warp can be split-up in different ways to allow for the most economical production of various cloth widths.

The highest rates of weft insertion are achieved today on the so-called multi-phase loom. Although these machines are still in the evaluation phase, I shall give a brief description of this technique. A series of small weft carriers is propelled across the machine one after the other by means of individually activated reed bars. Each shuttle carries just enough yarn to cover one pick and winding is done from one large stationary supply package by means of a special winding apparatus. The fabric production is about 20 to 30% above any other known weaving machine. There are some serious limitations, particularly with respect to weave density, pattern design and colour choice, but the loom is suitable for special products such as light structure cotton cloths in plain weave. Several machines are now undergoing mill trials with selected cotton weaves.

Summary

In conclusions I should like to summarise the cotton situation with respect to developments in processing machinery as follows:-

Automation calls for more uniform raw materials

Bale-to-bale variations should be as small as possible

Whenever possible there should be identification of the major properies of every bale

High speed machinery has less cleaning power and fibre damage is very likely: Cleaner raw material

OE machinery may not be very sensitive to staple variation but requires extremely clean sliver. Stiffer fibres process better

From the growth in knitting (14 - 7%) cotton can benefit by improving easy-care properties and developing yarn structures that allow higher machine speeds.

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