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TRAINING FOR INDUSTRY SERIES NO. 3

THE ŁÓDŹ TEXTILE SEMINARS

4. Weaving and associated processes

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.

DEVELOPMENT TRENDS IN SIZING AGENTS

by

J. Żądło

Modification of starch sizing agents

Progress in the field of warp-sizing substances is evident mostly in the production and introduction in the textile industry of new and better ones.

The use of water-soluble sizes is increasingly common. Among the best known of these are synthetic vinyl compounds such as polyvinyl alcohol, polyacrylic acid and polymetacrylic acid, derivative styrene and maleic anhydride, derivative cellulose such as carboxy-methyl cellulose, methyl cellulose or methylhydroxyethyl cellulose. Ester and ether starches are also widely used because of their many advantages and low cost.

Sizes based on ether and ester starches are superior to those made from common and modified starches. They are produced in several varieties, with different properties, and under various commercial names such as Noredux (Eastern Germany), Solvitose (Netherlands) and Ten-o-films (United States). Solvitose, for example, is produced in five varieties that vary in adhesiveness, solubility and application. Solvitose H4 is used for sizing viscose and mixed yarn; Solvitose R for rayon; Solvitose P for synthetic yarn, both continuous-filament and staple; Solvitose X1 for cotton and staple rayon yarn and Solvitose XO for wool yarn.

The greatest advantage of ether and ester starches is their solubility in water and good adhesion to the yarn. They can easily be removed from the fabric, thus eliminating additional de-sizing processes, thereby lowering the costs of finishing and sizing.

Ether and ester sizing starches possess lower viscosity than the common starches. For this reason they have good penetrative ability, especially at higher temperatures. If required, their concentration may be lowered without risk of the warp being inadequately sized. Ether and ester starches, even in diluted solutions, show good adhesiveness to the yarn. Furthermore, they improve the abrasion resistance of warp yarn, considerably reducing their breakage in weaving.

Differently from conventional starches, ether and ester starches can be heated for several hours without noticeably affecting the final quality of sizing.

All of these merits of soluble sizes made from ether and ester starches make them appropriate for use with cotton yarn, with which they produce far better sizing than do natural and modified starches. They can also be used for sizing staple rayon at a lower degree of concentration.

Ether and ester starches are to be preferred over the generally used cellulose ethers because of their better penetration into the yarn and particularly into dyed yarn, which usually has a reduced ability to accept sizings. Better penetration is important in sizing warps for coloured woven fabrics. In addition, ether and ester starches produce less dust than conventional ones in the weaving process.

Special requirements for sizing yarns made from synthetic fibres

The sizing of warp yarns made from synthetic fibres serves the same purpose as in all other yarns, namely, the preparation of the yarn for weaving by making it resistant to abrasion in the heddle and reed, as well as to interfriction and shuttle friction.

The sizing process tends to bond the loose fibre to the body of the yarn and to create a protective film on its surface. Owing to their physico-mechanical properties, synthetic yarns require the careful application of size.

The small swelling ability of the synthetic yarn and its poor absorption of water-soluble size complicate the application of substances that form water-soluble films. This poor absorption necessitates the use of highly concentrated sizes with great adhesiveness. Sizing must be carefully controlled, especially in the treatment of continuous-filament yarn, to avoid the bonding of adjacent ends, which causes both difficulty in shedding and warp breakage in the weaving process.

Differently from the case with yarns made from natural fibres, synthetic yarns are sized not so much to strengthen them as to cause their component fibres to cohere and to form an elastic film on their surface. Since synthetic yarns are more flexible than natural-fibre ones, the sizing film must also be more flexible.

Requirements for sizes for the treatment of synthetic yarns are different for continuous-filament and for spun yarns. Owing to the non-parallel positioning of its fibres in the yarn and its crimpy form, spun yarn has greater size-absorbing ability than does continuous filament yarn.

Because of their great proportion of loose fibres, spun yarns should be treated with sizes that possess sufficient viscosity to form a coating film. A size with too low a viscosity, although it may have a good penetration into yarn, does not form a sufficiently strong film on the yarn and thus does not ensure abrasion resistance.

For synthetic yarns, sizes must be used that are adapted to the specific properties of the fibres. The starch sizes based on gelatin formerly used have proved to be inadequate. Also, poor results have been obtained with modified substances such as starch and cellulose ethers. These substances have inadequate adhesion to smooth synthetic fibres and small flexibility, so other sizes must be applied. The most suitable sizes for synthetic yarn are the synthetic ones that were developed recently and are now widely used.

The choice of the correct size depends on the type of manufactured synthetic yarn (polyamide, polyacrylonitrile, polyester). Size formulation depends on the yarn count, warp density and fabric structure. The concentration of size for treating synthetic yarns must be considerably greater than for sizing yarns made from natural fibres and rayon.

Trends in the development of synthetic sizes

The rapid development of the production of synthetic fibres has required new technological methods for sizing processes. Synthetic yarns, because of their special properties, cannot be sized with the traditional substances used for yarn made from natural fibres and rayon.

Synthetic sizes that will permit the proper sizing of synthetic yarns are required. Many countries now produce numerous kinds of synthetic sizes for yarns made of various synthetic fibres. Production of these substances is being continuously developed, and new methods for producing better and cheaper ones are being investigated.

While there is no doubt that synthetic sizes will be used increasingly, it is difficult to foresee the future trends of their development. On the basis of present achievements in this field, however, the most promising group would appear to be the substances based on vinyl compounds.

Synthetic vinyl compounds have their greatest application in sizing synthetic yarns. This group of compounds contains polyvinyl alcohol, polyacrylic acid, polymetacrylic acid and sodium as well as ammonium salts, partially hydrolized polyacetate vinyl and polyacrylic methyl, sodium and ammonium salts and some copolymers such as acrylic acid with styrene and copolymer metacrylic acid.

Polyvinyl alcohol is an excellent substance for sizing polyamide yarns. Sizes based on this synthetic resin have varying viscosities in water solutions that are independent of the degree of polymerization. The best-known substances in this group include the many types of Vinarols (Eastern Germany), Elvanols (United States) and Vibatex (Switzerland). These substances are made either in a fine powder form or as a highly concentrated fluid easily dissolved in water, and these aqueous solutions possess high viscosity.

Polyvinyl alcohols have good adhesion to fibres and form a very flexible and strong film on the yarn. This makes them suitable for sizing all kinds of hydrophobic synthetic fibres.

Fabric de-sizing creates no problems, since polyvinyl alcohol films dissolve readily in hot water. Polyvinyl alcohol can also be used as a bonding medium, and for this reason substances based on it can be used in mixtures with a set amount of starch and similar substances.

Lately, an increasing number of sizes are used that are made from salts, copolymer styrene and maleic anhydride. Monosodium salts of this copolymer, known as Stymer S (United States), are used for sizing polyamide and acetate yarns. Stymer S has a great swelling ability in cold water and quickly dissolves in hot water.

Water solutions of Stymer S have excellent anti-electrostatic properties and are very durable. There is a great range of sizes that contain substances based on polymer acrylic acid and polymetacrylic acid that show perfect adhesion to polyamide fibres as well as good glueing properties. A limitation of these sizes consists in their great acidity, which necessitates the use of acid-proof materials in sizing equipment.

All of the above-mentioned synthetic sizes are more expensive than sizes based on starch, and consequently they are not used for sizing yarns made from natural fibres. However, a slight addition of synthetic substances to starch sizes gives excellent results in such yarns.

TRENDS IN THE DEVELOPMENT OF AUTOMATIC SIZING CONTROL IN CONNEXION WITH THE INTENSIFICATION OF WEAVING PROCESSES

by

J. Żądło

Automatic control of size preparation and its application

The growing intensification of weaving processes requires higher quality of sized warp, the quality of which depends mainly on proper and uniform application of size on the yarn. This is difficult to achieve since it depends on many factors in the process of sizing that are undergoing change. Assuring steady concentration of size does not guarantee its steady application to the yarn because changes in viscosity occur with gradual size consumption from the size-box.

The best answer, up to this time, to the problem of assuring steady application of size to the yarn is Shirley's automatic size-box. A schematic diagram of the operation of this device is presented in figure 1.

The size-box (1) is supplied with highly concentrated size through the lower inlet pipe (2). The amount of dry sizing substances supplied to the size box in a unit of time equals the amount of dry sizing substances needed for the required size percentage on the yarn that passes through the size-box during this time. The size in the size-box is continuously diluted by water flowing through the upper inlet pipe (3) in order to maintain a constant volume of the sizing liquor in the box.

If, during the process of sizing, the size take-up is greater than required, the size concentration in the box increases and the required percentage of size on the yarn is kept steady. Regulation of size percentage on the yarn is done by appropriate choice of the concentration of size supplied to the box by the lower inlet pipe (2) or by changing the volume of size flow per unit of time. The box described can be used with all kinds of warps and in all sizing conditions, assuring constant size percentage on the yarn, regardless of changes in size viscosity, temperature and squeezing conditions.

Shirley's size-box can be constructed in two versions. In the first, size preparation takes place in an ordinary kettle in which the size concentration after boiling is considerably greater than required. The boiled size is supplied to the box and diluted there with water. In the second version, the size is prepared automatically. With this system, dry sizing substances are automatically fed at a controlled rate to a small-capacity slurry mixer from which they are delivered to the dilution chamber of the size-box.

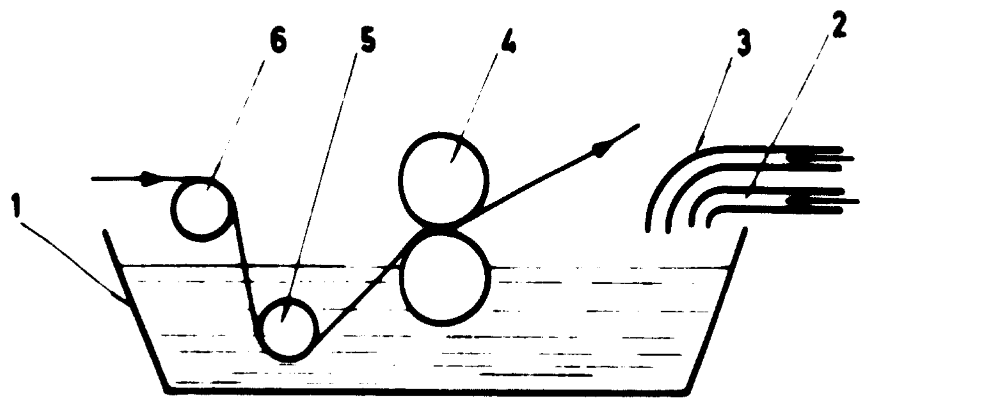

Figure 1. Diagram illustrating the principle of automatic regulation of sizing: (1) size box, (2) size supply pipe, (3) water supply pipe, (4) squeezing rollers, (5) immersion rollers, (6) guiding rollers

Automatic control for stretch and tension of sized warps

During the sizing process, there is considerable stretching of the yarn, which lowers its elastic properties. For this reason it is important to keep the yarn stretch in the particular sizing zones, and especially in the wet zones, on the lowest level. On the other hand, in certain zones, for example, the splitting zone, higher tension is required; otherwise the splitting of sized threads will be difficult.

Sizing machines therefore must be divided into zones with various stretch and tension values. It can be generally accepted that, in zones where yarn is in a dry state, proper minimum stretch suffices to assure efficient operation of the sizing process, thus causing sufficient tension to avoid looseness of threads and their tangling during the sizing process.

This problem is different in zones where the yarn is subjected to warmth and humidity, which usually give additional stretch to the yarn. For this reason, the best solution is to assure steady tension of the yarn in these zones.

The stretch-regulation attachment in each particular zone of sizing can be of several different kinds. Most commonly used are variable-speed gear boxes (type P.I.V.), but these have the disadvantage of being inexact. However, accuracy of regulation can be increased by coupling these transmissions to planetary gears. An interesting device to regulate stretch has been developed by the Shirley Institute and is shown in figure 2.

This mechanism makes it possible to regulate the yarn stretch within the limits from −2 per cent (shrinkage) to +8 per cent (stretch), with an accuracy of 0.1 per cent. The solution described above makes possible the regulation of stretch by hand and, once fixed, the stretch is kept on a constant level regardless of the magnitude of yarn tension.

Devices designed to regulate yarn tension are more complicated than those for stretch, since they have tension indicators and gear-control mechanisms. A mechanism for automatic tension control is diagrammed in figure 3.

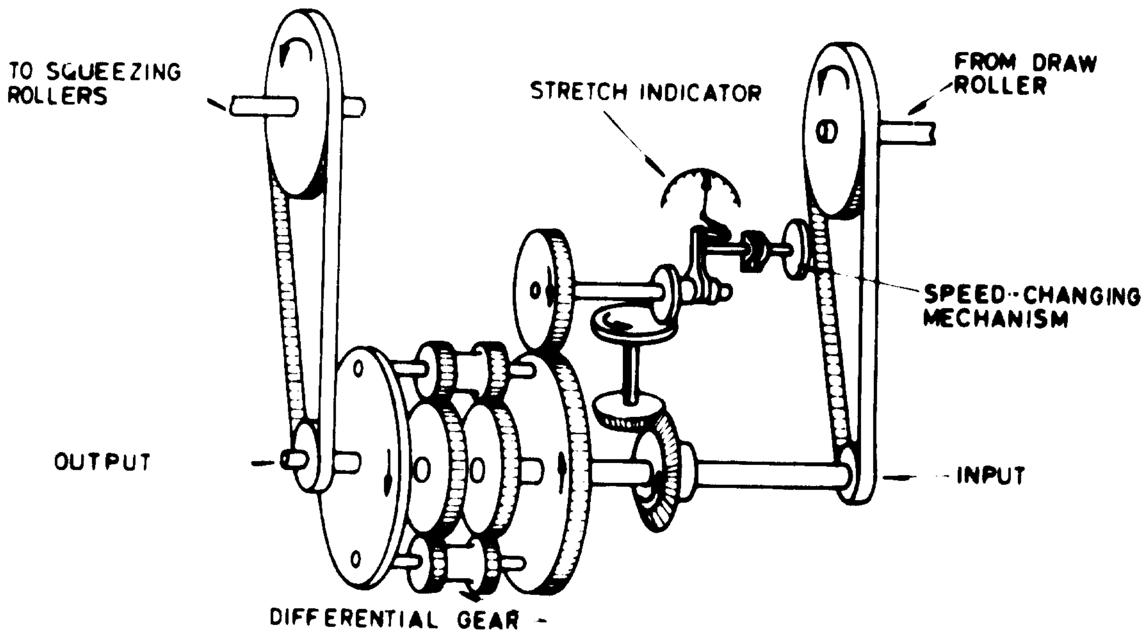

Figure 2. Diagrammatic representation of the Shirley stretch regulator

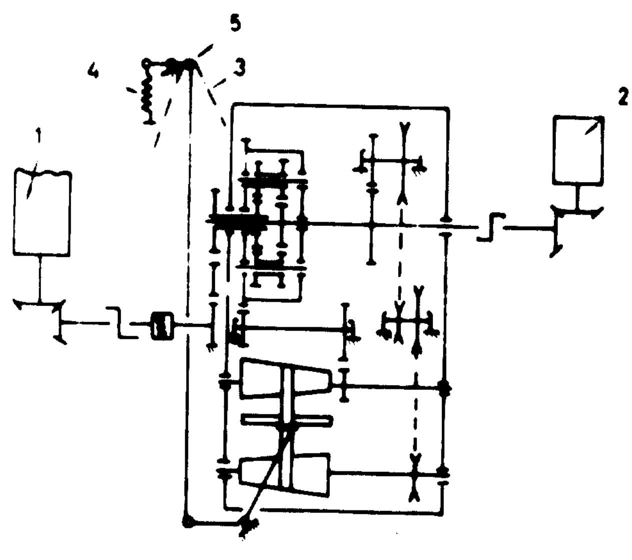

Figure 3. Automatic regulator of warp tension in the drying chamber of a sizer of the Zeller type: (1) squeezing rollers, (2) warp beam, (3) warp, (4) spring, (5) tension gauge

The operating principle of the tension regulator is as follows: prior to sizing, the device is fixed by means of a spring (4) to the degree of tension that should be maintained during the sizing of complete lots of warp. Any variation in warp tension during sizing will cause motion of the roller of the tension gauge (5), which is connected to the elements for variable-speed transmission. As a result, the variable-speed transmission changes the circumferential speed of the lower squeezing rollers. The drying chamber receives varied amounts of warp, and the tension corrects itself to the predetermined level. The attachments described keep a steady tension on the warp in particular zones with variable stretch.

Automatic moisture controllers for sized warp

The moisture in sized warps is an important parameter in sizing; the output in the weaving process depends on it. Without the use of proper warp-moisture measuring instruments, it cannot be ascertained whether the amount of moisture is exactly correct. Control measuring devices can be used in measuring and controlling systems. In the first case, the size operator controls the speed according to a gauge indicator; in the second case, the control of sizing speed to obtain the needed moisture operates automatically. As a rule, all types of devices can operate by both systems. Moisture measurement of sized warp can be done by various intermediate methods, which in most cases are based on the measurement of certain electrical values. Three basic methods of warp moisture measurements are employed at present: *(a)* the "resistance" method, *(b)* the "capacitance" method, and *(c)* the "electrostatic-charge" method.

In the resistance method, the interdependence between warp moisture and its electrical resistance is exploited. The resistance of sized warp can be measured in a longitudinal direction or through the warp sheet. In the capacitance method, the interdependence between capacitance of sized warps and its moisture is exploited. In the electrostatic-charge method, the interdependence between the electrical charge accumulation volume on the warp and its moisture is used. The methods listed above have various sensitivities, and their range of application depends upon the type of yarn being processed.

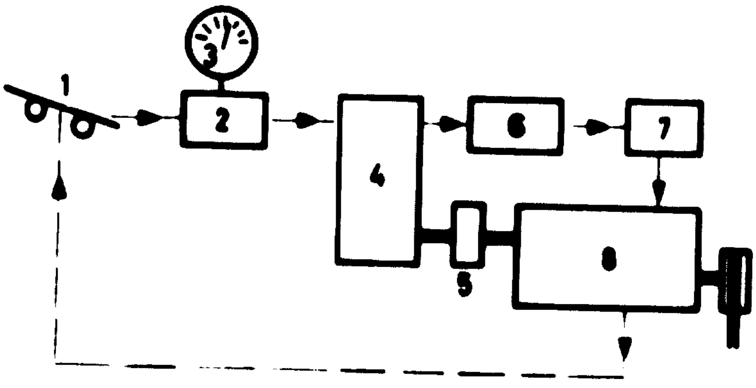

Figure 4. ***Schematic diagram of an automatic moisture controller:*** *(1) resistance detector, (2) measuring unit, (3) moisture indicator, (4) control unit, (5) output shaft, (6) delay switch, (7) pilot motor, (8) continuously variable speed-control gear*

Figure 4 shows a typical automatic moisture-control system. Deviation from the right moisture is detected at point (1). The resistance magnitude is converted by the apparatus (2) into a current suitable for feeding the indicator (3), which is calibrated in moisture percentage. This current is also passed on to the control unit (4), which uses it first to assess the extent and direction of the deviation in moisture condition from the desired condition and then to convert the deviation into an impulse having a duration proportional to the deviation and a sign depending upon its direction. The frequency of the impulse is controlled by the rate of passage of the warp through the machine, information on which is supplied to the control unit by the output shaft (5) of a continuously variable speed-control gear (8) inserted in the main drive to the machine.

Normally, impulses will occur at intervals corresponding to the passage of successive lengths of warp, each equal to the length of warp in the drying unit. Each impulse drives the pilot motor (7) in one direction or the other, depending upon the sign of the impulse.

The purpose of the pilot motor is to drive the speed-adjusting knob on the speed-control gear (8) for the duration of the impulse so as to change the speed of the machine to the correct extent and in the right direction to correct the deviation. The effect of the speed correction is to alter the moisture condition of the warp as detected at (1), thus completing the cycle of operations. The delay switch (6) automatically blocks the transmission of any impulse to the pilot motor for a preselected time following any period of stoppage or "crawl" of the machine.

A simplified control system is also often used. Such a controller applies only short impulses of fixed duration to the pilot motor, each impulse being sufficient to alter the machine speed by an amount calculated to change the moisture condition of the warp to only a small extent.

As in the more elaborate controller, the impulses are timed to occur at intervals corresponding to the passage of successive lengths of warp equal to the drying length. With a properly chosen control instrument, the moisture fluctuation of warp can be kept within the limits of ±1 per cent.

In addition to the previously listed methods for warp moisture measurement, new ones are being elaborated that can be widely used in the future. One method involves the use of a humidity-sensitive element to measure the relative humidity of the air immediately in contact with the warp.

Numerous attempts have been made to produce a satisfactory moisture-measuring instrument based on this principle, but a really adequate solution to this problem awaits the introduction of a reliable and durable humidity-sensitive element that will also have a sufficiently rapid response to changes in both humidity and temperature.

The other method involves the measurement of the magnitude of the magnetic resonance of the hydrogen nuclei in the water that is present in the warp. The electronic equipment for doing this is rather elaborate, bulky and costly, since a radio-frequency spectrometer is used. In applying the apparatus to measure the dryness of a warp, an arrangement must be made to pass a portion of the warp through a high-frequency coil situated within a powerful magnetic field.

The resonance signal obtained from the water is said to be readily distinguishable from the one caused by the hydrogen in the solid matter of the sample, but some confusion could arise from the presence of variable amounts of hydrogen in any fat or oil present in the size.

Another method of measurement of warp moisture consists in the application of radioactive isotopes. Radioisotopic methods for measuring some values in the textile industry are described elsewhere in this publication.[1]

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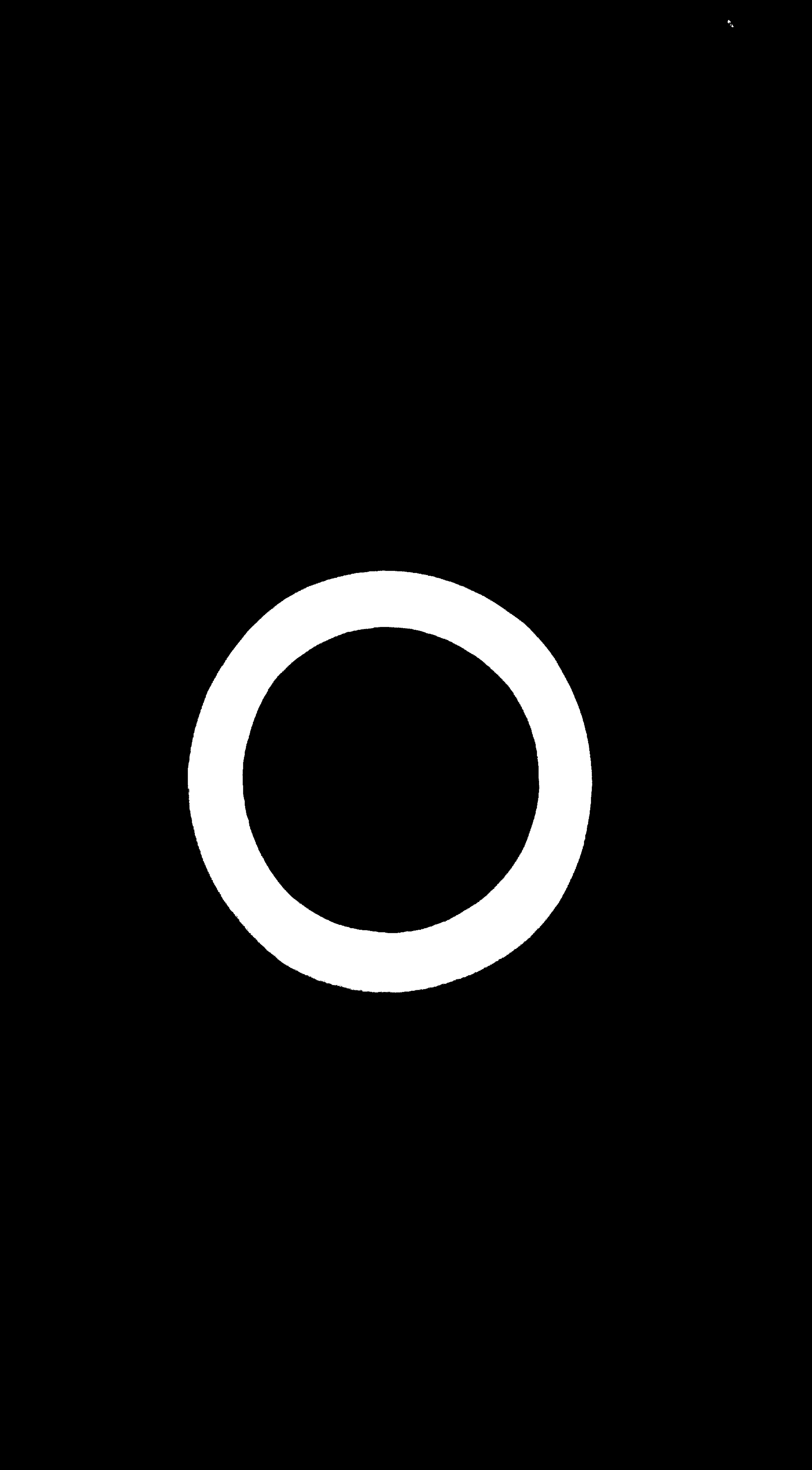
[1] J. Żądło "Development Trends in the Construction of Common Sizers", pp. 9–12.



DEVELOPMENT TRENDS IN THE CONSTRUCTION OF COMMON SIZERS

by

J. Żądło

Increasing sizing speed

Until quite recently, the type of sizer commonly used was a machine with a chamber dryer. This system limits the speed of sizing because its evaporative ability is low. Furthermore, chamber drying is uneconomical.

Replacement of the chamber dryer by the multi-cylinder dryer became possible only after the problem of the wet warp sticking to the cylinder surface was solved by coating the first few cylinders with a plastic (Teflon). This improvement has made possible an increase in sizing speed, since the wet warp can pass from one cylinder to the next without sticking to their surfaces. The sizers presently constructed have from seven to nine cylinders, but the number can vary according to the requirements.

The evaporation ratio of the modern multi-cylinder dryer is considerably greater than that of the conventional chamber dryer. With chamber dryers, the sizing speed in most cases does not surpass 40 to 50 m/min, but the multi-cylinder dryer makes possible sizing speeds in the range from 150 to 200 m/min.

Multi-cylinder dryers are more economical than chamber dryers because they consume less steam per pound for the evaporation of water from the warp. The evaporation ratio for modern multi-cylinder dryers is from 1 to 1.5 pounds of steam per pound of water evaporated, whereas for chamber dryers this ratio approaches 3 pounds of steam per pound of water.

Owing to the steady increase of synthetic fibre use, and in connexion with the growing demand for warp quality, the tendency to limit the application range for particular sizers has arisen.

At present, sizers are built for the sizing of strictly determined types of warp so as to ensure their highest quality. Sizing other types of warps on those sizers is not advised, as they are intended for yarn with definite properties. It is for this reason that other types of sizers are built for the processing of linen, cotton, wool, rayon and synthetic yarns.

Also, in connexion with the appearance on the market of wider looms and the increased demand for wide fabrics, wider sizing machines are being constructed.

Some firms are now constructing sizers with maximum widths up to 3,600 mm; not long ago widths did not exceed 2,000 mm.

Quality improvement of sized warps

Recently manufactured sizers differ to a great extent from those built only a few years ago. Intensive investigation of warp sizing, which is continuing in a number of countries, is giving us better knowledge of the effects of particular mechanisms and ways of sizing on warp quality and weaving efficiency.

Investigations on new technical improvements in the most important elements in sizers are proceeding in two principal directions: to diminish warp stretch and to ensure uniformity of distribution of size on the yarn.

Modern sizers are divided into several zones, in which different stretches and tensions are applied to the warp. Tensions and stretches in particular zones are adjusted in such a way that their lowest value falls in unwinding and drying zones. Stretching of the warp in these zones causes a permanent decrease in the elasticity of the yarn, which should be avoided in view of the need for this quality in further processing.

Most processed yarns in the textile industry shrink after wetting and drying. These properties are exploited for the construction of new driving systems for drying cylinders; these driving systems are known as relax drives. Application of relax drives permits the shrinking of the warp in the drying zone because the individual drying cylinders have different circumferential speeds.

The relax drive considerably improves the warp quality since, instead of stretching the warp, it gives it contraction and, as a result, increases the elastic properties of the yarn.

In other types of size, zones of stretch and tension can be decreased by the automatic control of warp tension. Such tension regulators are already in use in modern sizers. Those devices are being continuously improved; work in this field has not yet been completed.

A wide range of new constructions for particular mechanisms intended to improve the uniformity of size application is being developed. To these groups of devices should be added, first of all, a hydraulic or pneumatic squeezing roller system, which gives a more satisfactory expression of size as compared to the old weighing loading system.

The most important advantage of the pneumatic loading system consists in the possibility of automatic changes of pressure in case of alteration in sizing speed. By applying the automatic pressure control, it is possible to ensure the uniformity of size application independently of sizing speed. The upper squeezing rollers in modern sizers are covered with a cushion made from natural and synthetic rubber of varying hardness, ensuring better distribution of size.

In modern sizers additional splitting rods that serve for preliminary separations of warp ends are placed before the dryer. In the zone of preliminary separation for certain kinds of warp, rotating brushes and smoothing rollers are applied that make for better adhesion of loose fibre to the body of the yarn. A typical example of an arrangement for the brushing and smoothing of the sized yarn is shown in figure 1.

Self-brushing systems are used for the same purpose. Figure 2 shows a diagrammatic representation of one of the many kinds of these devices.

This device, elaborated by the Shirley Institute in Manchester, consists of four rollers numbered (1) to (4) in figure 2. The warp passes underneath all of the rollers and around roller (4) and then is divided by rollers (3) and (4) and finally meets again on roller (1), from which it travels in the original direction.

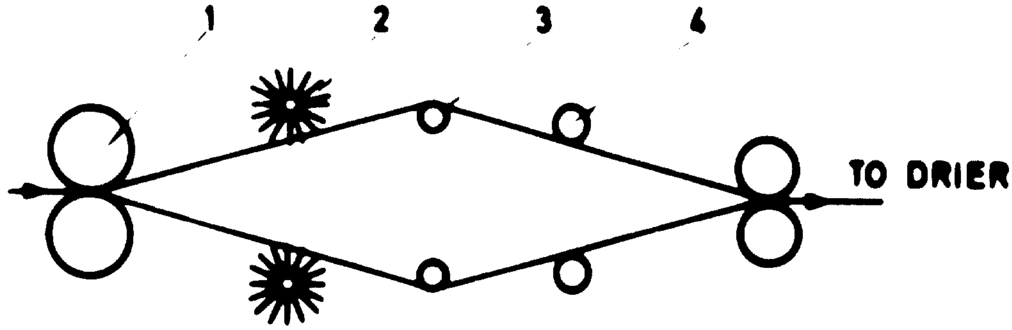


Figure 1. Arrangement for the splitting, brushing and smoothing of sized yarn: (1) squeezing rollers, (2) brushes, (3) splitting rods, (4) smoothing rods

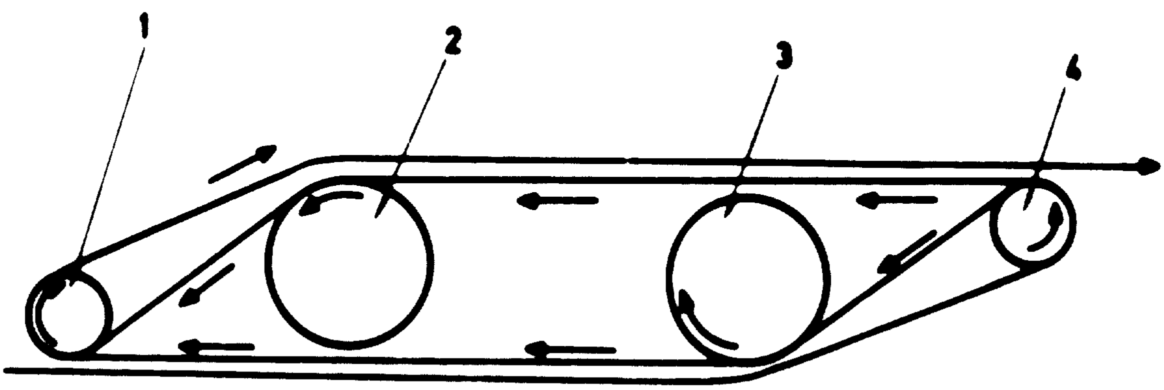


Figure 2. Diagram of a self-brushing device: (1), (2), (3) and (4) are rollers

The two adjacent warp sheets always move in opposite directions, thus producing the brushing effect and causing the adhesion of loose fibres to the body of the yarn. Self brushing invariably brings about reduction in dust and in the warp breakage rate in weaving.

The splitting of warp ends after drying creates no problem in the case of yarn made from natural fibres, although it can cause trouble in the case of rayon, which is treated with sizes that possess greater adhesiveness. In order to avoid this difficulty, preliminary splitting and preheating of the split warp are performed before drying. Preliminary pre-heating of split warp prevents the adhesion of warp ends after they are reunited on the drying cylinder. Figure 3 diagrams a warp-separation process that incorporates pre-heating prior to drying.

Among the new devices for improving warp quality are those for cooling the drying chambers after stoppage of the sizer, as elaborated by Hibbert in the United Kingdom. These prevent over-heating of warp in the drying chamber. The time to cool the drying chamber to room temperature is about one second. The drying chamber is provided with guiding rollers covered with plastic (Teflon) to prevent the warp from sticking to the roller surfaces.

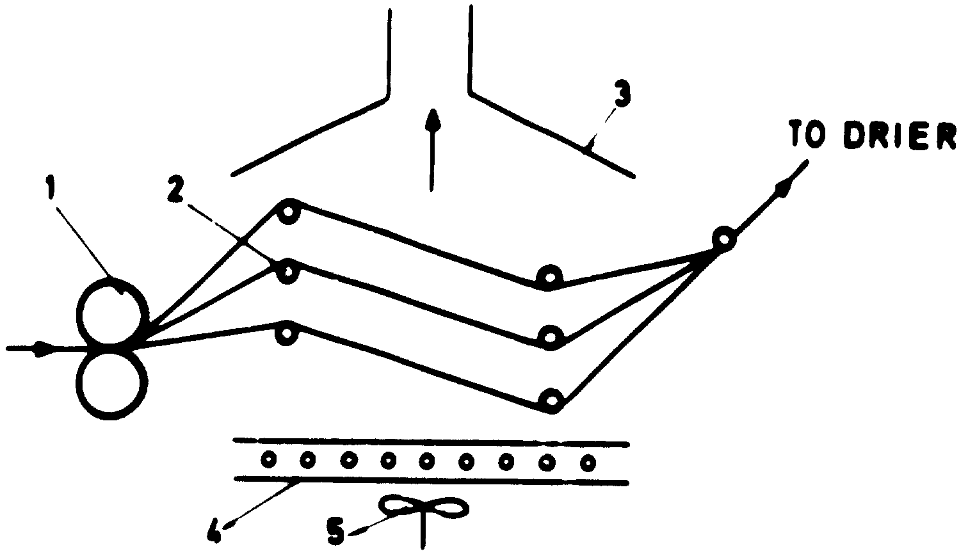


Figure 3. Diagram of a warp-separation process incorporating a pre-heating stage prior to drying: (1) squeezing rollers, (2) splitting rods, (3) exhaust, (4) radiator, (5) fan

Introduction of radioisotopic measuring methods for sizing processes

Despite growing progress in the automation of sizing process and the application of a range of control and measurement devices, there is still some risk that certain parameters of sizing may become uncontrollable. In certain cases, the measurement of some sizing parameters is possible only after sizing has been completed, which is of little practical use.

For example, to measure the amount of size deposited, a sample of the warp must be cut out and desized. Another method consists in determining the weight of warp before and after sizing. In both of these cases the size deposit can be determined only during or after the sizing process. This limits the possibility of carrying out sizing quickly and efficiently.

This difficulty makes it necessary to seek new methods for the continuous measurement of certain parameters in the sizing process. One such method consists in the application of radioisotopic appliances. This method can be successfully applied for continuous measurement of size deposits and warp moisture immediately after squeezing as well as after drying.

With this method, the measurement of irregularity of size deposit, warp moisture and changes in concentration of size in the box can be made possible. Such a method of sizing control will be the more widely used because it permits continuous measurement during the actual sizing process. It also permits early recognition and elimination of existing disturbances in sizing. This method is trouble free and eliminates any waste of yarn, because the taking of samples is not necessary.

NEW TRENDS IN THE TECHNOLOGY OF WARP SIZING

by

J. Żądło

For many years, warps were sized by traditional methods with the use of various water-soluble sizing substances and conventional sizing machines. Only in recent years, owing to the development of synthetic yarns and of new sizing substances, has research begun on new methods for sizing warps that are entirely different from those used previously. The six most important of the new methods are *(a)* dry sizing, *(b)* sizing in a single-end form, *(c)* sizing from a warping creel, *(d)* wet sizing in a cold process, *(e)* semi-dry sizing, and *(f)* emulsion treatment.

Dry sizing of warps

Aqueous solutions of size are very inconvenient to use, not only because of the need for drying but also because they cause swelling of yarn during the sizing process. The traditional sizing process for warp is also inconvenient for the weaving room because it requires special machines and equipment that take up much space. In addition, the preparation of water-soluble sizes is time absorbing, and the extraction of surplus water is expensive.

For this reason a tendency has arisen over the last few years to replace the sizes used up to now with other substances that do not require the preparation of aqueous solutions but only the intermediate applications of anhydride substances to the yarn.

The first trials have proved that further researches must be continued in two directions; one to find and produce appropriate size substances, the other to construct suitable machines for size application, as the existing sizers for wet sizing can no longer be used. Preliminary trials have shown that, for dry sizing, water-soluble synthetic waxes must be used.

Waxes of these kinds, with appropriate parameters, assure the creation of a flexible film on the yarn surface, thus providing sufficient abrasion resistance. However, they do not increase the breaking strength of the yarn. For this reason all investigators have limited their trials to synthetic continuous-filament yarn and bast fibre yarns, since they do not require increased breaking strength but only protection against abrasion.

Trials made in Austria and the United Kingdom on synthetic filament yarn and rayon have shown that, for dry sizing, the best materials are waxy substances with a melting point of about 172°F or those that can easily be washed off in water and are colourless.

From current publications, it can be assumed that the problem of finding substances for the dry sizing of synthetic continuous-filament yarns and bast fibre yarns is near solution.

On the other hand, the problem of dry sizing staple yarns has not yet found a satisfactory solution. The second important problem in this connexion is the method for application of waterless size onto the yarn. On the basis of trials, it is claimed that this problem is more difficult than the elaboration of a suitable size substance. In any case, it has not yet been successfully solved.

The equipment for size application used in Austria and the United Kingdom have two box padders whose heated boxes contain melted waxy substances at temperature 205°F.

According to the type of yarn, the warp is passed through one or two boxes, whence it is led between squeezing rollers that are covered with special soft rubber. The size deposit on the yarn is controlled by the adjustment of a knife that retains a surplus of size on the immersion roller. After leaving the squeezing rollers the warp passes through two heated smoothing rollers and is next cooled by a stream of cold air.

From the time it enters the box until it leaves the smoothing rollers, the warp passes without any tension. The working speed is from 45 to 150 m/min. This equipment is suitable for sizing synthetic filament yarn and rayon. According to the literature, the uniformity of size application is not yet fully satisfactory.

The problem of construction of sizers for use in dry sizing has been attempted by such firms as Rüti and Benninger in Switzerland and West Point in the United States. The first of those firms presented a prototype of such a dry sizer at the Textile Machinery Exhibition in Milan, Italy, in 1958, but it showed some faults in construction and needed further elaboration.

Sizing in a single-end form

The process of sizing in a single-end form is applied mostly for sizing synthetic filament yarns of low twist. This kind of yarn cannot be processed on normal sizers because, during warping, single filaments break and become tangled. This tangling creates difficulties in weaving and also lowers the quality of the fabric. Furthermore, the splitting rods used in normal sizers can remove the protective film from the yarn, sometimes even over long distances.

Single-end sizing can be done in several ways. One of them consists in the use of special sizers that can be used by yarn producers and textile firms. According to this method, each individual thread is passed separately through the size solution and then squeezed, dried and wound up. This sizing method produces a uniform coating on the yarn and avoids the sticking together of adjacent ends.

The single-end sizer works on the following principle: The warp ends go from the bobbins through a pair of rollers, the lower of which is immersed in size, while the top roller serves for squeezing. After passing through the rollers, the thread reaches the drying unit, which can be the heat radiator or a small electric drier.

The dried thread next goes through the smoothing rollers and is then wound onto the bobbin. The amount of size deposited is regulated by an adjustable thread-wrapping angle on the immersion roller and also by regulation of the sizing speed.

The drying temperature can vary within the limits from 212° to 318°F. Sizers of this type can operate at speeds ranging from 50 to 300 m/min., depending on the drying condition. The limited speed of this system is its greatest disadvantage.

In Eastern Germany, the sizing of continuous-filament yarn in single-end form is carried out during the twisting process. The low twisting speed permits sizing of the yarn without drying. The yarn is wound onto perforated bobbins that allow air-drying of the yarn. Afterwards the yarn can be rewound at a speed up to 400 m/min, and the yarn can be lubricated during warping.

The device for the application of size on the yarn during the twisting operates on the following principle. The size is applied on the threads by means of immersion discs, just before winding. In order to keep the size at a steady temperature and to protect it from impurities, it is stored in a tightly enclosed container.

Because of the sizing conditions and the special properties of polyamide yarns, only water-soluble synthetic sizes with high adhesion and the ability to form a strong elastic film can be used. The required properties are possessed by sizes based on water-soluble resins. Of the vinyl derivates, polyvinyl alcohol is generally used.

Sizes based on polyvinyl alcohol require the addition of softeners and surface-active agents. Softeners are used in order to impart an appropriate sliding property to the yarn and also to provide greater flexibility of the film. Surface-active agents give a better size penetration into the yarn. In addition to the above-mentioned size ingredients, anti-electrostatic agents are also added.

For sizing continuous-filament yarn in single-end form, sizes based on polymers of acrylic acid or metacrylic acid and ready-made sizes such as the British one called Synsize W, which is based on a wax-protein emulsion, are also used.

Sizing from a warping creel

The traditional method of warp sizing has the great disadvantage that, since a great number of ends must pass through the sizer while close to each other, there is adhesion of adjacent ends, which consequently must be separated by the splitting rods. The splitting of glued ends causes serious damage to the film of size, thus causing considerable difficulties in weaving such as yarn breakages and the formation of dust. This problem can be overcome in the processing of staple yarn and highly twisted continuous-filament yarn. In the case of low-twist or twistless continuous-filament yarn, however, these difficulties are so great that yarns of these kinds cannot be sized on the traditional sizers.

Single-end sizing is slow and therefore very costly. For these reasons new and cheaper methods for sizing these yarns are being sought. The best results in this field have been obtained in Japan, where a sizer has been constructed for sizing directly from the warping creel, thus eliminating a separate warping process. In view of the fact that this machine performs both sizing and warping, it can be called a warping-sizing machine.

This machine operates on the following principle. Cones are placed on the warping creel in numbers ranging from 1,000 to 1,200. The yarn from the cones is passed through the size-box and drier and is then wound onto a warping beam. The warp ends wound on the warping beam are brought together into a ready warp with a required number of ends on a special winder.

The number of warping beams from which warp ends are joined into a single loom beam depends on the required numbers of ends in a warp. It can be seen that, by this method, the adhesion of adjacent ends is avoided, since the distance between them is considerable. With the help of a suitable splitting and guiding device, the proper coating of each end is ensured, and the sticking together of the adjacent ends is avoided.

The second technological aspect in sizing directly from the warping creel is the elimination of a technological process normally carried out on unsized yarn.

It is well known that each technological operation carried out on the yarn causes it to stretch and consequently lowers its elasticity, which should be kept as high as possible. The literature shows that, in the traditional warping and sizing process, the yarn elasticity is reduced by 35 per cent, while in sizing directly from warping creel it is lowered by only 20 per cent. This considerable difference in elasticity has a very great influence on the breakage rate in weaving.

Warps sized directly from the warping creel have a lower breaking tendency and, at the same time, yield fabrics of better quality than traditionally sized warps. Warping-sizing machines are manufactured by the firm of Tsudakoma in Kanazawa (Japan). These machines are built both for the Japanese home market as well as for export, mainly to Europe and the United States. They are generally used for sizing synthetic continuous yarn, but recently they have been increasingly used for sizing cotton yarns.

Wet sizing in a cold process

Research on a new sizing method is being conducted in Eastern Germany. This method consists in spraying the warp with a cold size solution by means of a special nozzle working under pressure. The warp is dried in the open air, without the need for extra drying equipment. In order to speed up moisture evaporation, an air exhaust ventilation from the drying zone is applied. This sizing method has been tried on wool warp with good results.

Work on the process is continuing with the aim of adapting it to the sizing of cotton and rayon staple yarns. Special sizes are used, which are continuously being improved. It is expected that this sizing method can be widely applied, as it has considerable advantages over the conventional sizing method. The most important of these advantages are the elimination of a costly drying process and a saving of work-room space.

Semi-dry sizing

In Japan, a new, so-called "semi-dry" sizing method has been patented. This warp-sizing system consists in the application of highly concentrated water suspensions of ungelatinized starches or modified starches. The viscosity of the suspensions is as low as 5 centipoises at 10 per cent concentration and less than 10 centipoises even at 60 per cent concentration. Gelatinized wheat starch is of 1,000 centipoise viscosity at 10 per cent, and for this reason it cannot be used for sizing.

The sizing process is carried out in the following way. Yarn drawn from the creel passes in sheet form through the size-box, where the size is applied to the yarn. Yarn coated with size is gelatinized by steam or hot air sprayed from nozzles placed in upper and lower parts of the gelatinizing section so as to ensure the formation of a uniform coating. After coming out of the gelatinizing section, the yarn is dried and wound into warping beams. This method has not yet been applied on an industrial scale.

The creators of this method claim that it will be better than other methods for sizing long, hairy spun yarns. Tests are being made to determine the suitability of this method for many types of yarns, including continuous-filament yarns.

Emulsion treatment

In the Soviet Union, a method has been elaborated for the treatment of warp by emulsion, which replaces sizing process. This method has also been tried in Eastern Germany with good results. It is used for woollen yarns and is carried out during warping.

At present, work is continuing to construct a machine for this process. While testing this method, the following emulsion recipe has been used:

Ingredients	*Percentage*
Gas oil	2.40
Olein	0.48
Triethanalomine	0.24
Ammonium hydroxide	0.14
Water	96.74
	100.00

While it is feared that this system may cause the formation of mildew on the yarn, it seems to be an interesting one.

TRENDS IN THE INTENSIFICATION OF LOOM PERFORMANCE, INCLUDING SHUTTLELESS LOOMS

by

H. Bergiel

The loom is the basic machine in weaving. At present there are about 2 million looms in operation throughout the world, half of them being automatic and over 2 per cent of them being of the shuttleless type. About 160,000 shuttle looms and 8,000 shuttleless looms are produced yearly by loom manufacturers.

Paradoxically, while the number of looms in operation steadily decreases, the demand for textiles continues to increase. This phenomenon is explained by the increased efficiency and better use of the production potential of looms. Efficiency has increased because of the greater percentage of automatic looms, the number of which grew by 50 per cent between 1930 and 1956, while that of modernized looms increased by 24 per cent.

Figure 1 shows the declining trend in world production of shuttle looms from 1955 to 1970.

The next observation to be made with regard to weaving techniques is the very wide variation in the types of weaving equipment in use in various countries.

Contemporaneously with the most modern and most highly efficient shuttleless weaving machines, looms built in the previous century, and even hand looms, are still in operation. This divergence is reflected in differences in weaving techniques and in outputs per machine or per operator.

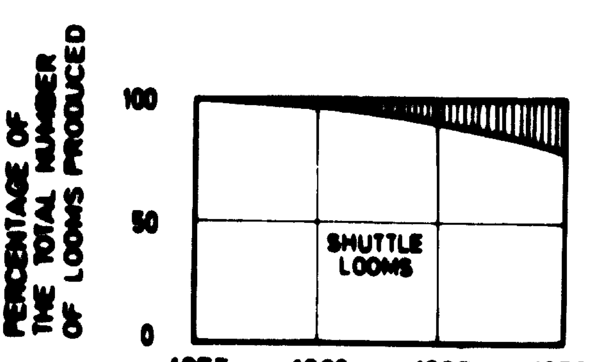
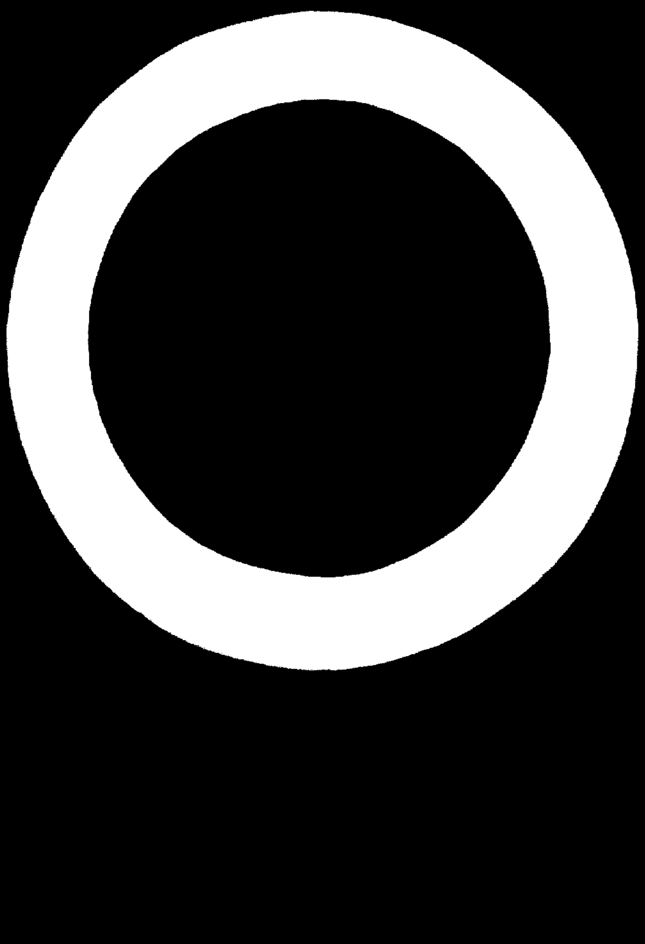


Figure 1. Decline in the world production of shuttle looms during 1955 to 1970 (Source: O. Talávašek (1963) "Technical Problems of Some Weaving Systems" Textil *12, 457 [in Czech])*



Recent years have seen important developments related to the intensification of weaving processes. These developments have been in progress since shuttleless machines were first produced commercially about twelve years ago. Figure 2 illustrates this phenomenon, showing the increase of the output (weft length per minute) from 1900 to 1965.

Within the last ten years, about 11,000 shuttleless weaving machines have been put into operation, replacing, because of their higher efficiency, about 16,500 shuttle looms. This means that each year 1,650 ordinary looms (about one per cent of the total) are replaced by shuttleless ones.

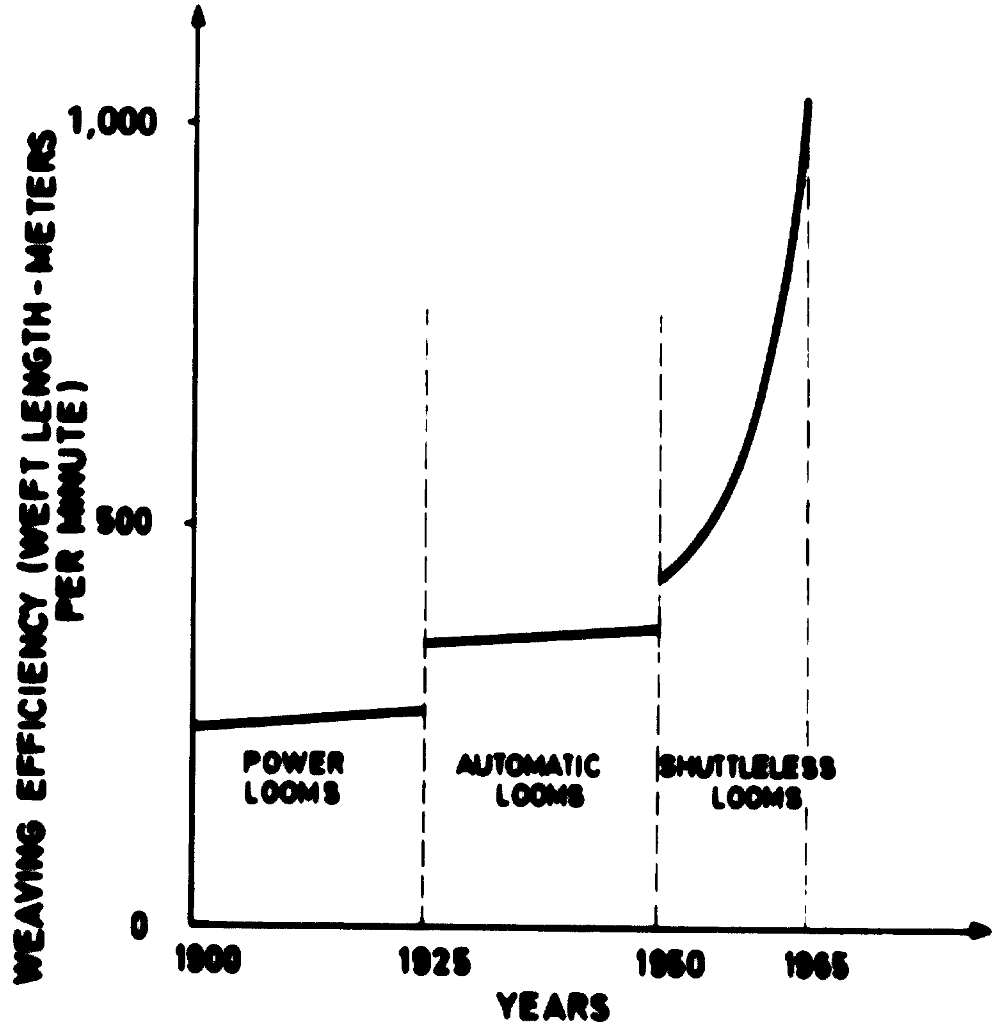


Figure 2. Increases in loom output (weaving efficiency) from 1900 to 1965

Despite the considerably improved efficiency of shuttleless machines, the number of which constantly increases, the textile industries of the most developed countries, which have an old tradition of loom engineering, still keep the shuttle loom as a basic weaving machine.

Within the last three years, shuttleless looms designed on the basis of a conventional power loom with a modernized feed and picking motion have attracted much attention. Representative of the type of looms with modernized picking motion are the Saurer G. 1. (Switzerland) and the Zangs and Scheffel machines (Federal Republic of Germany).

In addition to the efforts to modernize the feeding systems of shuttle looms, new and more efficient automatic looms are being introduced, and old power looms that are still in good condition are being automated. Very often, automatic looms are equipped with weft cop magazines or the Unifil single-spindle winders made by Leesona in the United States. At the end of 1964, in Western Europe alone, there were over 15,000 looms equipped with the box loader and 40,000 with the Unifil device.

Despite these developments in intensified weaving techniques, there is still a big demand for woven fabrics. To cover this demand, some types of fabrics, until now produced by weaving only, such as fabrics for ladies' *lingerie*, some overcoatings and some special-purpose fabrics, began to be manufactured by other techniques that are characterized by great outputs, but which yield products for definite end-uses. Among these products may be mentioned knit goods, non-woven web fabrics, non-woven yarn fabrics of the Eastern German Malimo, Maliwat or Malipol types and non-woven bonded and (if the web is of thermoplastic synthetics) welded fabrics.

However, these new techniques, used on an industrial scale, have by no means diminished the role of the weaver. Woven fabrics continue to be the most versatile textiles because they are composed of two systems of thread. They continue to comply best with requirements of the user with regard to wearing, aesthetic and hygienic properties. Consequently, it would be quite wrong to consider weaving as obsolete. On the contrary, this technique now seems to be under rapid development. Evidence for this is the fact that recent loom designs are based on new ideas, and incessant work is going on to develop a new system of inserting the weft into the shed and of forming a woven fabric. The best of these achievements are being attained in countries that are well developed industrially and that have long experience in loom engineering. In addition to the countries of Western Europe (Belgium, the Federal Republic of Germany, France, Italy, Spain, Switzerland and the United Kingdom), one can list here Czechoslovakia, Japan, the Soviet Union and the United States.

Textile machinery exhibitions also give evidence of developments in loom designs. In 1963, at Hanover (Federal Republic of Germany), out of 35 manufacturers exhibiting 170 very modern looms, no fewer than 12 showed a total of 30 new models of shuttleless looms, among which was the Sulzer Model TW 1155 weaving machine that operated at a speed of about 1,000 metres of weft per minute.

Weaving plants may be automated either by fitting a device for the automatic replenishment of weft to the existing power looms or by putting highly efficient automatic looms into operation.

The choice of these two ways—modernization of old looms, or installation of new ones—depends upon the condition of the existing equipment. If the existing looms are considerably worn, the cost of the weft-replenishing device being high and overhaul expenses being great, the installation of new automatic machines may be more economical than the installation of various supplementary devices.

It should also be remembered that it is not worth while to automate looms that produce multi-coloured woven fabrics. Among producers of automatic weft-replenishment consoles for single- or multi-colour weaving are Valentin, Fischer, Schönherr (Federal Republic of Germany), Snoeck (Belgium), Galileo (Italy) and Crompton-Knowles (United States) as well as Textima (Eastern Germany).

The up-to-date automatic looms produced by Western European manufacturers, such as Northrop (United Kingdom), Picanol (Belgium), Rüti (Switzerland), as well as those from the United States (Draper) and from Japan, run at high speeds (up to 260 rev/min when the reed width is 120 cm) and even as high as 300 rev/min, as is the case with the Picanol President and Rüti Bau-LXB machines.

It is also interesting to note the trends in the designs of broad weaving machines (up to 330-cm reed width). Saurer, a Swiss model, permits the weaving of two or even three fabrics, side by side (multi-track weaving). The increased working width of the loom allows a great increase in weaving efficiency. At a speed of 140 rev/min the loom with a 330-cm reed width achieves the output of 460 metres of weft-length per minute, a rate that is equivalent or even superior, to that of some shuttleless looms.

The automation of power looms does not, as a rule, increase the intensity of weaving but accounts only for an increased general output factor and for a very distinct saving on manpower, since an operative can tend several tens of automatic looms instead of only from two to six ordinary mechanical looms.

Tending to shorten the time of loading of weft pirns into containers (of either the revolving or trough types) for automatic weft replenishment, and in order to lower the production cost of the fabric, many loom manufacturers provide their machines with special box loaders. These loaders are produced by such European manufacturers as Brügg, Fischer, Roscher, Rüti, Saurer and Valentin, by Draper in the United States and by several in Japan.

One box-loader contains from 100 to 140 weft pirns, and a spare box-loader may be placed on the loom. The principle of operation is the same for almost all types of box-loaders, although there may be some differences in their construction details. The pirn passed from the box-loader is held up by a clamp, and then the so-called "tip-bunch" is peeled off, mechanically or pneumatically, and held tight by a "grab". After the end of the weft yarn has been caught, the exchange of pirns takes place. The use of box-loaders requires the use of pirns with a tip-bunch of yarn, which in turn requires the use of special winding machines. The looms should also have a device for putting the weft pirns into the box-loaders.

The installation of box-loaders is very advantageous in countries with high labour costs or wherever labour is in short supply. The coarser the weft yarn, the greater the economy effected by the use of box-loaders.

Considerable advantages can be gained with the use of Unifil pirn winders. These winders permit the reduction of the number of weft pirns per loom from 300–500 to only 30, with a simultaneous decrease of the tip-bunch (less waste) and less floor space (otherwise needed for weft winding frames), less space for stocks of weft and pirn stripping, and the elimination of all other costs for fitting, maintenance and personnel. Single-spindle Unifil weft winders may be fitted to almost any modern automatic loom, only one problem remaining, namely, that of the synchronization of the speeds of the winder and the loom. However, this problem is being dealt with successfully by loom manufacturers. Nevertheless, the cost of fitting the Unifil winder is considerable; the price of a single one, with a complete set of ancillary parts, pirns included, amounts to almost $1,000 which is equivalent to one fifth to one sixth of the cost of an automatic loom.

The reduction in the number of preparatory processes also contributes much to an increase of weaving efficiency. Similarly to the elimination by Unifil pirn winders of a separate preparation of weft pirns, attempts are being made to prepare weft for automatic weaving directly on ring spinning frames. Here also the economic benefits would be considerable.

The developments already mentioned regarding the increased efficiency of shuttle looms are accompanied by systematically increased loom speeds, and research is under way on means to permit further increase of loom speeds and on perfection of these machines. The great difficulty to be overcome in this research is the vibration caused by great speed. Some remedy for this has already been found, as, for example, with a mechanical device developed by the Southern Machinery Co. (United States) which is available under the trade mark Vibratol. To eliminate vibration, some new looms already in operation are supplied with sley blocks and the brackets of the picking mechanism are made from light-weight alloys. This permits good beating-up of the sley at high loom speeds.

Experiments are made for replacing the mechanical energy required for the picking motion by some other source of energy, for example, by heat (of an internal combustion engine), electricity or compressed air. To secure the smooth and continuous operation of the picking mechanism, its already obsolete parts used conventionally until now, as well as ancillary equipment made of not very durable materials such as wood, leather and cordage are being replaced by new ones made of plastic. Loom components that are subject to great dynamic loads while the loom is in operation are made of high-strength alloys, well-hardened metals and the like.

Various means are being worked out to suppress noise made by operating looms. Such noise adversely affects the health and work efficiency of the operatives. A new branch of science is being developed, called ergonomy, which deals with various factors that may affect the efficiency of labour as, for example, the aesthetics of the work-place and the shape and colour of the machines and other equipment.

All of the efforts of designers and technologists to improve as much as possible the efficiency of the weaving process must necessarily lead to new and often very complicated loom designs and to the use of new materials in their construction. However, any loom, even if very well designed, built of best possible materials and faultlessly assembled, will not fulfil all expectations unless it is operated under proper conditions.

The setting of the loom, which until now was based on a circular scheme of co-operating motions done by means of various mechanical devices, fails wherever the dynamics of the process deviate essentially from static conditions. A very short duration of particular loom motions makes the use of normally applied measurement methods very difficult. Under these circumstances new methods for loom settings, which have been worked out by Szosland of the Łódź Polytechnic School and which are based, not on intuition, but on instrument readings, are of particular significance. These methods have been worked out in detail and checked by mill practice and are well appreciated by their users.

One of the methods for the control and adjustment of the picking motion consists in keeping to the required velocity and the dynamics with which a pick is started. The first parameter is an indirect measure of the dynamic load of the picking mechanism, added to which is one of two magnitudes that determine the conditions of the flight. The second parameter (the dynamic momentum of the flight) is decisive as regards the correct entry of the shuttle into the shed.

The first parameter, that is, the velocity, is measured with a system worked out by Szosland and called "optical radar". Its operation is diagrammed in figure 3. A beam of light sent from a special optical system is thrown at the shuttle, which is in flight, and to which two reflective foil strips are attached at a set distance from each other. The beam reflected by the strips is registered on the screen of an oscilloscope

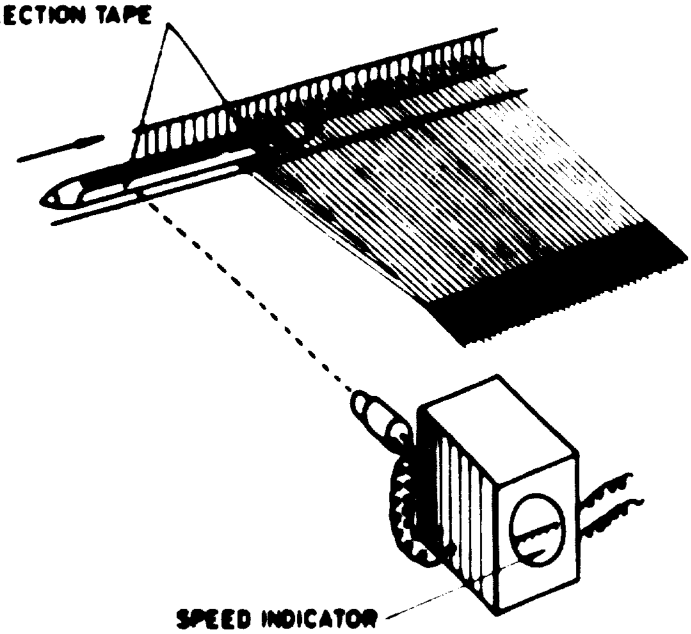


Figure 3. "Optical radar" for measuring the speed of the picking motion

or by an electronic counter, thus permitting determination of the speed of the shuttle.

Another instrument to measure shuttle speed is a speedometer, particularly applicable in mill conditions. It is a dynamic measuring system shown schematically in figure 4. It is first calibrated by means of the optical radar and then placed in the shuttle instead of a weft-pirn.

These two methods measure the speed at which the shuttle flies in the shed and provide information about flight obstructions.

The starting point of the flight is easily marked with a drop of a washable dye placed on the shuttle and left behind by it at the entrance into the shed, that is, on the selvage.

Another factor that affects the operation of the loom is the way with which a shuttle is set in its box. A correct distribution of the shock force with which a shuttle acts on the main box blocking blade and the picker affects very decisively the life of these parts and the performance of the loom. The specific steps of shuttle positioning may be examined by Szosland's method by means of an original measuring device, applicable in mill conditions. This is a peak-acceleration meter placed in the shuttle that emits light signals. The flashes showing while the shuttle is in flight are the evidence that the acceleration of the picking motion surpasses the assumed value.

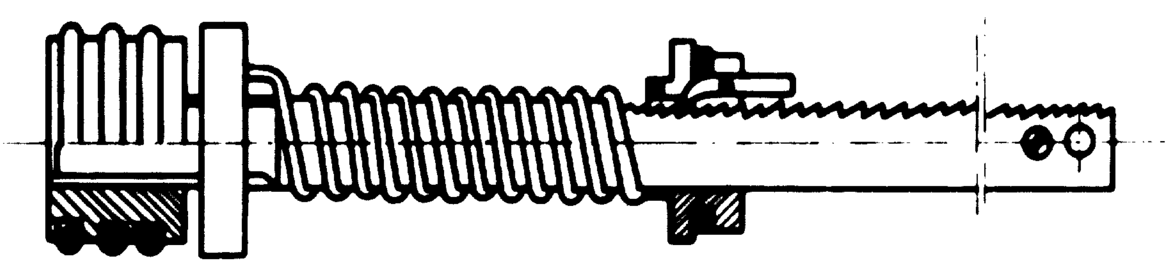


Figure 4. Speedometer for measuring the velocity of the picking motion

Some other original methods worked out by the Chair of Weaving at the Łódź Polytechnic School should be mentioned: *(a)* assessment of longitudinal vibrations of the picking mechanism by recording of the shuttle trajectory; *(b)* study of the power consumption of the loom, two problems being considered, namely, power demand for specific loom mechanisms and irregularity of the transistory angular speed of loom shafts; and *(c)* estimation of dynamic changes in the warp tension and control of the density of weft picks at the take-up motion with a feedback.

All of the trends in improvements in weaving processes discussed above may apply to a country only when the following factors have been considered: *(a)* degree of development of the local textile industry, *(b)* type and condition of the looms existing there, *(c)* demand predicted in consequence of demographic expectations, *(d)* reserve of manpower, *(e)* ratio of direct labour costs to over-all manufacturing costs per unit of product, *(f)* trade relations with countries where looms are produced, *(g)* requirements of customers with regard to textiles, *(h)* the level of development of the local clothing industry, and *(i)* the economic situation of the country in question.

Of all of these factors, the most essential are those of a technical and economic nature. If, for example, the existing looms are in good condition and manpower is in short supply, it would seem to be advisable to modernize the looms by fitting them with automatic weft-replenishment devices.

For countries in which the textile industry has not yet developed satisfactorily, the installation of either new, high-efficiency automatic looms or of shuttleless looms may be considered. The choice will depend upon economic factors.

To sum up the discussion, it can be said that the decision to be made regarding the most suitable ways to increase weaving efficiency in a given country must be preceded by a thorough investigation of all of the factors that might make the attempt not worth while. Such an effort would be uneconomical if at specified economic conditions, the invested capital is not returned quickly enough.

As far as Poland is concerned, such investment may be considered as paying rapidly, since the capital invested is covered within no more than five years.

In Poland, work is also in progress to adjust mechanical and automatic looms for shuttleless weaving. Two new prototype looms have already been developed, one by Szosland and the other by designers at the LZPB Obr. Pokoju cotton mill in Łódź.

The adaptation of the Polish Saurer 100W loom to a gripper insertion of weft has nearly been completed by the Central Bureau of Textile Machinery Design (CBT).

DEVELOPMENT TRENDS IN THE DESIGN OF SHUTTLELESS LOOMS

by

H. Bargiel

The first attempts to insert weft pulled from a "cheese" package of yarn placed at the side of the loom were made by Seaton in the United Kingdom as long ago as 1896. Seaton tried to propel weft across the shed by means of a needle-gripper. In Germany, Gabler, in 1926, applied two rapiers, one of which entered the shed from one side and passed the carried weft end at the middle of the shed to the other rapier, which finished the pick, returning it to its initial position at the other end of the loom. In 1928, Rassman, in Switzerland, designed a gripper loom and later improved it. At the same time, in Sweden, Peterson experimented with the pneumatic insertion of weft, whereas Gourdon, in France, did the same with electricity. In 1887, Herold and Richard, in the United Kingdom, built the first circular loom. It was improved in France by Meticontin, by Saint Frères and by Jabouley (1928–1929).

After the lapse of nearly twenty years, studies on shuttleless loom designs began again, and the first gripper machines (Sulzer in Switzerland) and jet (Kovo and Maxbo in Sweden) and rapier looms (Draper in the United States) appeared. They were well appreciated because of their greatly increased weaving efficiency, which much surpassed that of shuttle looms. However, owing to an insufficient supply of ancillary equipment they could not be used on a large scale. Only standard fabrics, mostly of a plain weave and of one colour, could be woven on them.

Loom manufacturers saw bright prospects for shuttleless machines and worked hard on further developments. Thanks to their efforts these machines became more and more versatile. It is now possible to process on them multi-colour yarns of various counts and composition, with practically unlimited weave patterns. However, since the selvages are made not in the usual way, they may often still be a problem in gauze weaves. Some difficulties must also be overcome because of the large size of the machines (for example, rigid rapier looms). However, these brawbacks are gradually being overcome. Trends in further developments in this respect are now distinctly seen. Gripper, jet and rapier looms will be used on an ever larger scale. The multi-shed weaving machines that are still in the experimental stages of design, such as those of Cerdans in Spain and of Gentilini in Italy, appear to be particularly promising.

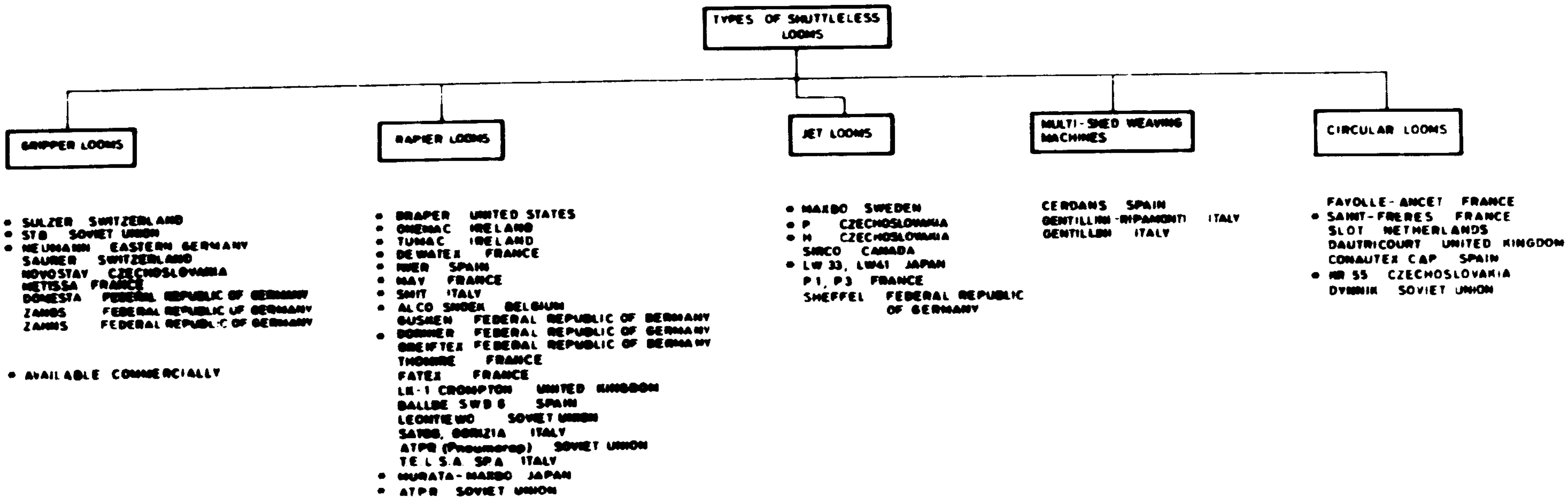


Figure 1. *Systematics of shuttleless looms*

Systematics of shuttleless looms

Shuttleless looms can be divided into five types as follows: *(a)* gripper looms, *(b)* jet looms--pneumatic (single- and multi-nozzle) and hydraulic (single- and multi-nozzle), *(c)* rapier looms with rigid, elastic or pneumatic rapiers, *(d)* multi-shed weaving machines, and *(e)* circular looms. Of these five types, only the first three are of any real importance in the industry.

Figure 1 illustrates the above classification and also lists the more important designs and their manufacturers. The asterisk at the left side indicates those that are already available commercially. These are discussed below.

Gripper looms

The design of these looms (as well as of the jet looms) is very similar to that of shuttle looms. In them the shuttle is replaced by a light gripper, the weight of which, depending on the construction of the picking mechanism and on the type of the loom, ranges between 40 and 500 g. The specifications of some gripper looms are presented in table 1.

The gripper is propelled by means of a lever-eccentric mechanism, a torque-shaft, or pneumatically. It flies across the loom inside the shed because of the initial velocity actuated by the picking mechanism (maximum speed up to 25 m/sec).

The gripper can either move freely, like the ordinary shuttle (Saurer, Zangs, Bonnard Claes), or along a special track (Sulzer, Neumann, STD). The control of the gripper flight is done in various ways. Most usually guide jaws are set in a row close to each other so that they look like a comb and form a tunnel through which the gripper flies.

The picking mechanism can be located at one side of the machine so that, to secure continuity of weaving, a greater number (9 to 17) of grippers is required. After a gripper completes its pick, it is returned to the picking mechanism by means of a conveyor (Sulzer, STD). There are also designs in which weft is inserted from both sides (Neumann, Novostav), so that only one gripper is needed.

The gripper can drag behind it either a cut-off weft end or a weft loop that straightens during the flight across the shed. The gripper may grasp and release the weft end either in flight or after it has stopped.

The picking mechanism is usually stationary, being separated from the sley, which is usually propelled by cams that control its motion.

Operation of the Sulzer gripper loom

The loom is fed from cone packages of weft located at the left side of the machine. Weft is inserted by grippers (9 to 17), each of which is 9 cm long and weighs 40 g. The flight of the gripper is caused by a torque shaft. After the flight is completed the grippers are carried back to the feed end (figure 2). In the case of machines for multi-colour weaving (from two to four colours) there are at most four cones at the feed end, a special feeder ram passing the specified colour of weft to the gripper.

TABLE 1. SPECIFICATIONS OF SOME GRIPPER LOOMS

Characteristics	*Manufacturer*				
	Gebr. Sulzer AG Switzerland	*Engineering Works of the USSR*	*VEB Webstuhlbau Germany (Federal Republic)*	*Adolph Saurer Switzerland*	*Elitex Prod. — Kovo Czechoslovakia*
Model and trade-mark	3 widths, 20 various models	STD, 3 widths 9 models	Model 4405 Neumann system	Model G. 1	Novostav model
Working width (cm)	216, 280, 330	175, 216, 250, 330	180, 220	110, 180	165, 215
Rev/min	280, 240, 220	260, 220, 200, 170	160, 140	300, 240	210, 200
Weaving efficiency: weft length (m/min)	605, 672, 725	455, 475, 500, 560	288, 308	330, 420	345, 430
Shedding mechanism	External cams for 14 heddles, heddle-actuating mechanism for 18 heddles	External cams for 10 heddles	External cams for 8 heddles, heddle mechanism for 20 heddles	External cams, heddle-actuating mechanism, jacquard mechanism	Cams for 6 heddles, heddle-actuating mechanism for 16 heddles, jacquard mechanism

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4. Weaving and associated processes

Picking method	Pick-and-pick	Pick-and-pick	Pick-and-pick	Plain	Pick-and-pick
Number of colours or yarn types	1, 2 or 4	1, 2 or 4	4—12	1	8
Yarn type	Cotton, worsted, woollen, rayon filament and staple	Cotton, worsted, woollen, rayon filament and staple	Cotton, worsted and woollen	Cotton, staple rayon, worsted and blends	Cotton and man-mades, staple and filament, bast fibres
Yarn count (Nm)	Cotton and man-mades 1—160; woollen 1—20; worsted up to 70; filament up to 300	Cotton and staple man-mades up to 54; woollen 8—16; worsted 24—52	1—16	As for Saurer shuttle looms	10—150
Number of picks/cm	4—96	6—65	5—72	As for Saurer shuttle looms	4.5—240
Weight of fabric (g/m^2)	Cotton 40 to 350; worsteds 80 to 350; woollens 100 to 610	—	Woollens to 360; blankets to 700	Up to 300	100—350

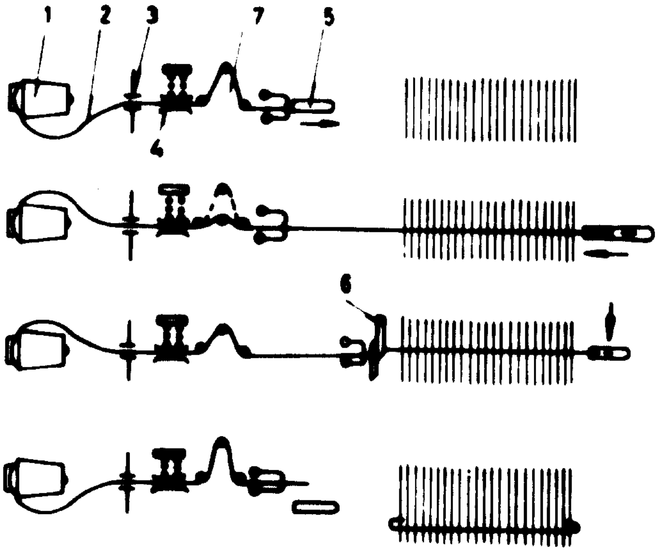


Figure 2. Schematic diagram of the operation of the Sulzer loom: (1) cone, (2) weft thread, (3) guide, (4) tensioning device, (5) gripper, (6) thread cutter, (7) thread compensating device

Colour selection is done by means of a chain-selector with adjustable links. The repeat in the weft colour may be as high as 200. The loom may be set for any colour weaving. The Sulzer loom can weave several fabrics at the same time (multi-track weaving).

Neumann gripper loom–Model 4405

Instead of a shuttle, there is a gripper, weighing 210 g. It inserts weft into the shed, first from the left and then from the right of the loom. At either side of the loom there are six cone packages of yarn which may be of different colours. Six additional cones are placed as a reserve. The selection of the required colour is done by the heddle shaft mechanism, actuated according to paper card patterns of the Verdola type. The maximum weft colour repeat is 12.

STD gripper loom

The design and operation of this loom is similar to that of the Sulzer machine described above.

Novostav gripper loom

The design of this loom is based on the construction of the Utas II automatic loom, the sley of which has been redesigned to adapt it for operation with a gripper.

The loom is fed from either side in succession, the weft pulled from the cone packages being inserted by a gripper and set into flight pneumatically. The air required for the drive of the gripper is compressed directly by the loom. Once the gripper has completed the pick, it is put into a revolving picking mechanism that turns around when the sley is stationary and prepares the gripper for the next flight.

Rapier looms

In looms of this kind the weft is inserted either by a single or elastic arm (rapier), or by a pair of them, the weft carried by one being taken over by the other in the centre of the shed. This method shortens the time required for return of the rapier to its initial position. Flexible rapiers permit a saving of floor space. The characteristics of some rapier looms are presented in table 2.

Rapier looms work similarly to shuttle looms by successive cycles of insertion and beating-up of the weft. Figure 3 illustrates schematically the operation of a loom with two elastic rapiers that pass the weft to each other in the fabric width. The loom is fed from either side.

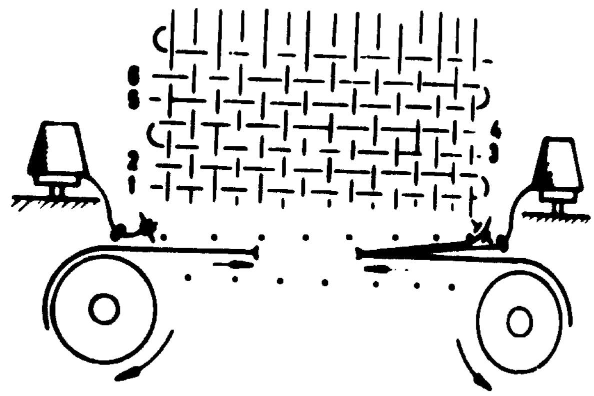


Figure 3. Schematic diagram of the operation of a shuttleless loom with two elastic rapiers: (1) to (6) sequence of picking

Figure 4 shows the operation of rigid rapiers, with weft being taken over in the middle of the shed. The weft is inserted from both sides. The speed of the rapiers is shown on the diagram at the bottom of the drawing.

The rapier system has been somewhat modified by insertion of weft by the pneumatic rapier method. The usual rapiers are replaced here by two tubes inserted

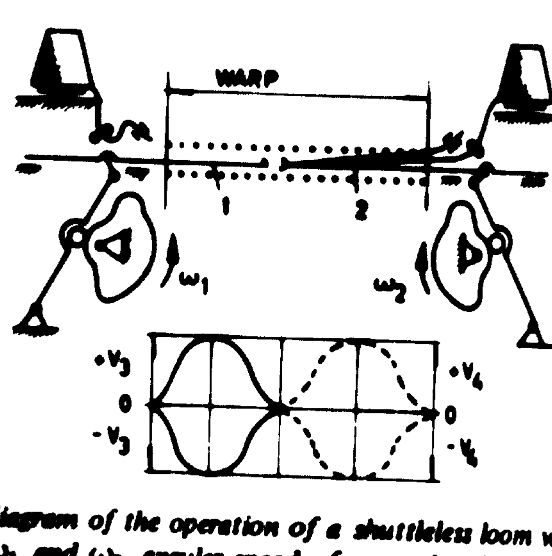


Figure 4. Schematic diagram of the operation of a shuttleless loom with two rigid rapiers: (1) and (2), rigid rapiers; ω_1 and ω_2, angular speed of cams that drive the rapiers; $+V_3$ and $+V_4$, linear speed of rigid rapiers (1) and (2) on entering the shed; $-V_3$ and $-V_4$, linear speed of rigid rapiers (1) and (2) on leaving the shed

TABLE 2. CHARACTERISTICS OF SOME RAPIER LOOMS

Characteristics	*Manufacturer*			
	Draper Corp. *USA*	*Società Macchine per l'Industria Testile (SMIT)* *Italy*	*Iwer Maquinaria Textil del Norte* *Spain*	*SACM (Société Alsacienne de Constructions Mécaniques S.A.)* *France*
Model and trademark	DSL — 5 models DSL-W — 3 models	Model TS 1	Universal Iwer, models 120, 150, 180	Type MAV, 3 different models
Working width (cm)	112, 118, 128, 164, 210, 230	210—430 at 20 cm intervals	120, 150, 180	180, 206
Rev/min	270 at 112-cm width 220 at 210-cm width	190 at 220-cm width 150 at 430-cm width	140[a] 280[b] 130[a] 240[b] 120[a] 230[b]	220, 220
Weaving efficiency: weft length (m/min)	270—460	420—650	168[a] 336[b] 195[a] 360[b] 216[a] 415[b]	396—450

Shedding mechanism	Internal cams for 8 heddle shafts	Heddle mechanism for 28 heddle shafts, jacquard mechanism	Cams for 8 heddle shafts, heddle mechanisms for 25 heddle shafts, jacquard mechanism	Internal cams for 6 heddle shafts, mechanism for 16—18 heddle shafts, jacquard mechanism
Picking method	Plain	Pick-and-pick	Pick-and-pick	Pick-and-pick
Number of colours or yarn types	1	1+8	8	4
Insertion of weft by . . .	Bilateral elastic rapiers	Bilateral elastic rapiers	1 or 2 rigid rapiers from the side	Bilateral rigid rapiers
Yarn type	Cotton and staple fibres	Cotton and man-made staple and filament, worsted and woollens, jute	Any, including glass fibre	Cotton and staple or filament man-mades, worsted-type blends
Yarn count (Nm)	5—100	1—20 (eventually up to 60—2)	Any	5—300
Number of picks/cm	4—96	3.3—60	1.6—64	5—80
Weight of fabric (g/m²)	16—400	300—700	600	Up to 400

[a] With 1 rapier.
[b] With 2 rapiers.

into the shed from both sides simultaneously. The weft is blown by air into one tube and then sucked into the second rapier tube. Having entered the shed, the tubes form a track along which the weft is blown.

Draper DSL rapier loom

The operation of this machine is diagrammed in figure 5. The weft is fed from the right side of the loom, being pulled from one of two cone packages placed there. The end of the yarn on this cone is tied to the beginning of the yarn on the second one, so that both cones form the joint reserve of weft. The elastic rapier on the right side takes the end of the weft and carries a specified length of it to the middle of the loom, where the yarn is taken over by the second elastic rapier. The rapiers are separated from the sley. The loom is of topless construction.

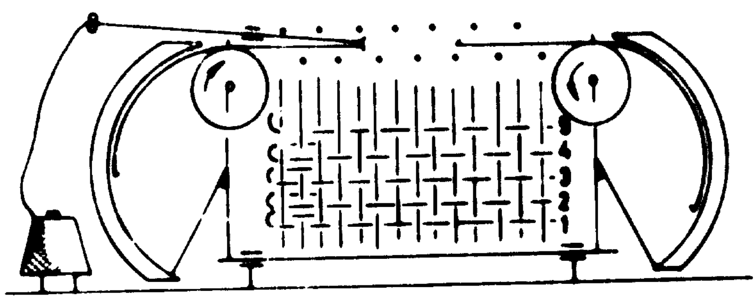


Figure 5. Schematic diagram of the operation of the Draper loom: (1) to (5) sequence of picking

Universal Iwer rapier loom

The operation of the Universal Iwer loom is diagrammed in figure 6. The insertion of weft is done by one or two rigid rapiers located on the right side of the loom. When two rapiers are used, they are actuated in succession, so that the weaving efficiency may be nearly doubled. The loom can weave a maximum of eight weft colours. On the left side of the loom there are eight cone packages of weft, the ends of which are tied to the front ends of eight reserve cones. The specified colour is passed to the rapier by a special selector. After the pick is completed, the ends are

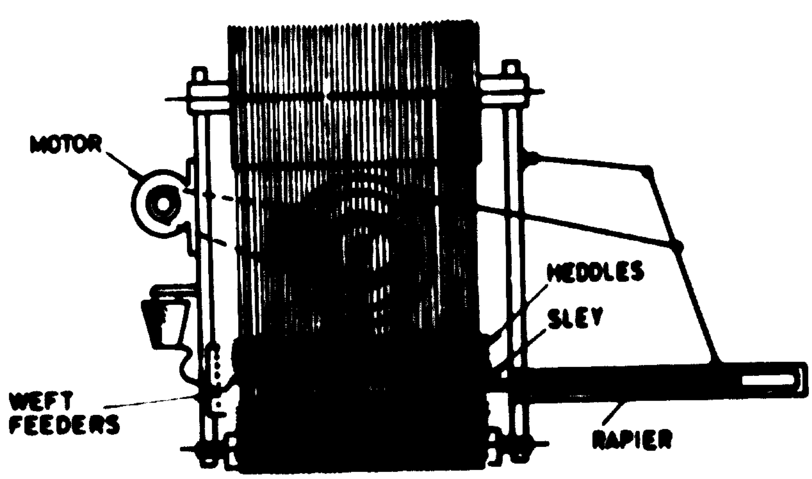


Figure 6. Schematic diagram of the operation of the Universal Iwer loom

cut. The maximum speed of the rapier after two-fifths of its pick amounts to 10.82 m/sec. Such a low speed permits the weaving of even very fine yarn counts. With a full stock of weft the loom can run 200 hours with no replenishment. Two or even more picks can be inserted into the shed at one time. Looms are layed out in pairs to reduce the floor-space requirement.

Jet looms

In jet looms, the weft is inserted by a jet of air or water. The designs known until quite recently use water jets from a single stationary nozzle. Air jets can be run in single or multi-nozzle systems.

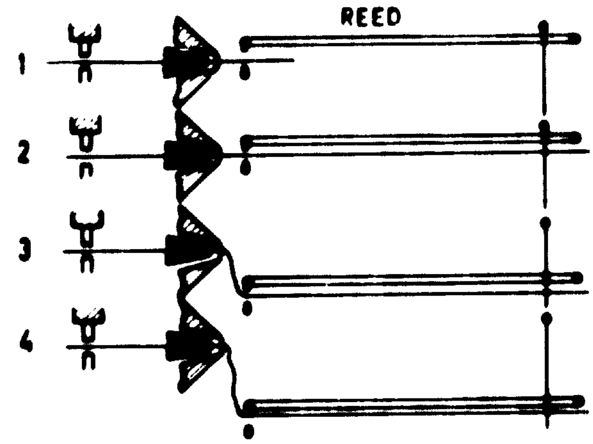


Figure 7. The flight of the weft in a single-nozzle jet loom: (1) to (4) are phases of the weaving cycle

With a single-nozzle system, pneumatic (air-jet) looms such as that shown in figure 7, the working width of which is over 40 cm, have special tracks (ribbed channels) to guide the air blown from the jet nozzle. Such channels are not required with the multi-nozzle (Scheffel) system, since the nozzles are located along the track of the weft flight, thus securing the guiding of yarn in sheds even as long as 535 cm. In both single- and multi-nozzle systems, the pick is measured up to the reed width before it is completed.

Since the picking mechanisms operate independently from the sley, the latter is light and permits an increase in the revolutions per minute of the machine. The characteristics of some jet looms are presented in table 3.

Circular looms

Circular looms are usually composed of several segments (machines) arranged along a circular line, with a common mechanism for insertion of weft. A schematic drawing of such a loom is shown in figure 8. The pick is made by several grippers which carry the yarn along the progressively formed shed.

The grippers are propelled mechanically or electromagnetically. These looms have a very high weaving efficiency and require very little floor space.

However, present trends in loom development, as well as research and design studies, reveal beyond any doubt that circular looms have practically no future.

TABLE 3. CHARACTERISTICS OF SOME JET LOOMS

Characteristics	*Manufacturer*			
	Elitex Prod. — Kovo Czechoslovakia	*Nissan Motor Co. (formerly Prince Motors Ltd.) Japan*	*Elitex Prod. — Kovo Czechoslovakia*	*Walter Scheffel Germany (Federal Republic)*
Model and trade-mark	Hydraulic models: H-105, H-125, H-145	Hydraulic models: LW-33, LW-41	Pneumatic single-nozzle type: models P-105, P-125	Pneumatic multi-nozzle type: P-01, P-02, P-03, models MI, MA
Working width (cm)	105, 125, 145	105, 145, 165	105, 125	127, 178, 305, 508, 535
Rev/min	550, 500, 400	500, 450, 400	450, 400	190 at 200 cm width
Weaving efficiency: weft length (m/min)	577, 580, 625	525, 650, 660	470, 550	—
Shedding mechanism	Internal cams for 8 heddle shafts or heddle shaft mechanism for 12 shafts	Internal cams for 8 heddle shafts	Internal cams for 5 heddle shafts	Cams, heddle shaft mechanism for 20 shafts, jacquard mechanism

Picking method	Plain	Plain	Plain	Pick-and-pick
Number of colours or yarn types	1	1	1	Type P-02 (1 colour) Type P-03 (8 colours)
Yarn type	Hydrophobic man-mades, staple and filament	Hydrophobic man-mades, staple and filament	Cotton, man-mades or their blends	Any, except horse hair
Yarn count	15—200 den	Filament fibres: 10—1,000 den of staple fibres: from 50 Nm	30—50 Nm	Any
Number of picks/cm	5—95	5—60	5—90	3—36
Weight of fabric (g/cm^2)	Up to 200	Up to 200	Up to 200	Any

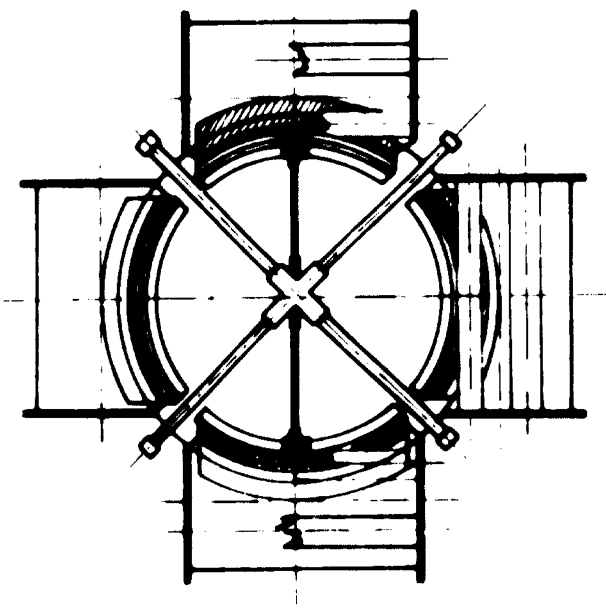


Figure 8. Schematic drawing of gripper propulsion in the Conautex-CAP circular loom

Those that have already been introduced to the industry (Fayolle-Ancet, Saint-Frères, Dautricourt, Slot, Conautex-CAP), despite their high weaving efficiency, are being applied only in the weaving of bast fibres sheds in the production of packing materials (sacks) made from coarse yarns. The principal limitation of such looms is that the number of picks per unit length of the fabric cannot be high. This results from the difficulty in beating up the weft.

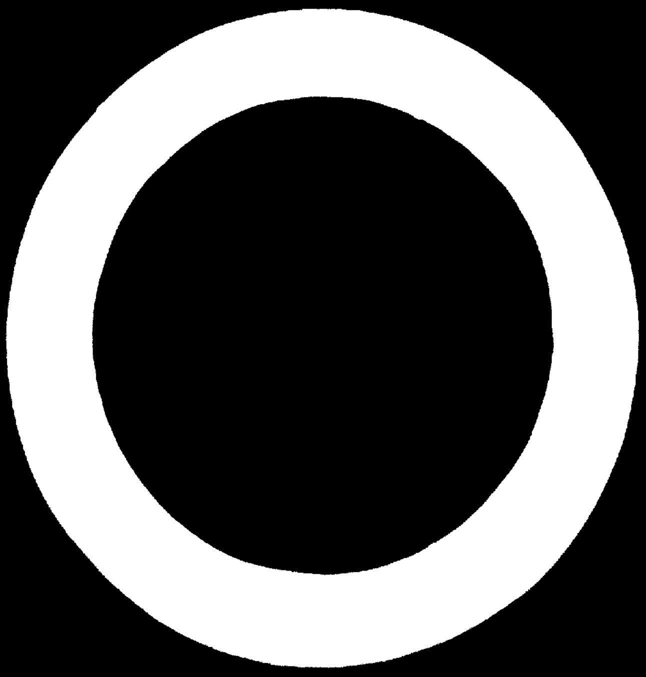
Future dev lopment of shuttleless looms

In spite of the fact that the weaving efficiency of shuttleless looms is already 1.5 to 2 times higher than that of conventional looms, they are still being improved. Further developments can be predicted when their following advantages are taken into account: *(a)* increase of weaving efficiency (output), *(b)* greater versatility and *(c)* simplified construction.

The highest possible efficiency has certainly not been achieved as yet, but intensive work to that end is in progress. Whenever a new model appears, it has higher speed, owing to various improvements and new construction ideas, such as the measuring up of the weft before its insertion and sley drive. Recent models of the Sulzer TW 1155 and some Japanese hydraulic looms have achieved experimental production rates as high as 1,000 metres of weft length per minute.

To make the loom more versatile, attempts are being made to increase the working width (in jet looms), to have more weave patterns and colours and to apply more types of yarn of various fibres and counts. One tendency is to design looms capable of weaving both light-weight and heavy-weight fabrics.

In Japan, the Nissan Motors Company recently fitted a vacuum squeeze roller to their hydraulic loom, so that yarn spun of non-hydrophobic fibres such as cotton and wool can be used for weft without the moisture content of the taken-off fabric surpassing 7 per cent. The same machine builders are now experimenting with a hydraulic loom for four-colour weaving.



The shuttleless looms produced today are very complicated and consequently very expensive. Their high price affects the weaving costs very greatly. Efforts are made to lower these costs by simplification of loom construction; that is, by making them with fewer components, so that they will be more sturdy and reliable.

Formation of selvages on shuttleless looms

Since there is no conventional shuttle and the weft is pulled from a large, stationary package of yarn, the way a selvage is formed in a fabric produced by a shuttleless loom is quite different from the conventional way. Indeed, there are six different ways in which this can be done, as shown in figure 9.

(a) The ends of each pick, or of every second one, are inserted into the next shed and worked into the fabric. The fabric has thus more picks per unit length at its selvages. This makes weaving more difficult, but the selvage looks neat and is strong (Sulzer loom). See sketch 3 in figure 9.

(b) The ends of each pick are tucked in at the next shed, the next pick starting where the previous one ended. These selvages have a good appearance and have the same density as the rest of the fabric, but are not as strong as those made in the previous case with Sulzer looms (Neumann loom). See sketch 6 in figure 9.

(c) Weft length equal to double the width of the fabric is inserted into the shed as a loop from one side only. The selvage on one side is thus normal, whereas the selvage on the other one is formed on the gauze weave principle (rapier looms on Devas' patent; for example, the Draper loom). See sketch 2 in figure 9.

(d) Weft length equal to twice the width of the fabric is inserted into the shed as a loop and is fed from both sides of the loom. In consequence, a half-open selvage is formed. It looks neat, is tough and has a normal density (Saurer, Dornier and Gusken looms). See sketches 4 and 5 in figure 9.

(e) The selvage is formed by an additional strong thread that is plaited between the adjoining picks. This makes a neat and tough selvage but one with greater density than the background fabric (Devas' and Fayolle-Ancet patents for looms, such as the Smith). See sketch 1 in figure 9.

(f) Selvages are formed at either side of the fabric in a gauze weave. These selvages are strong enough for finishing processes but their appearance is poor (jet looms). See figure 10.

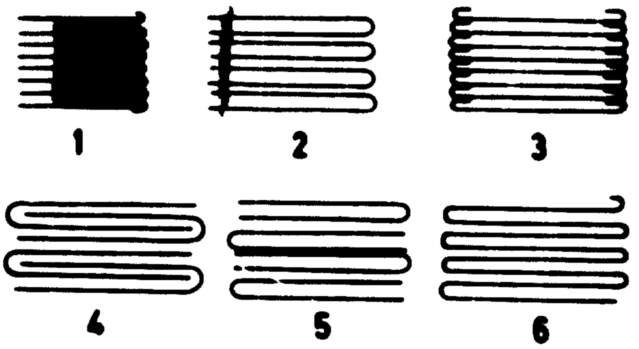


Figure 9. Six ways of forming selvages with shuttleless looms (see text)

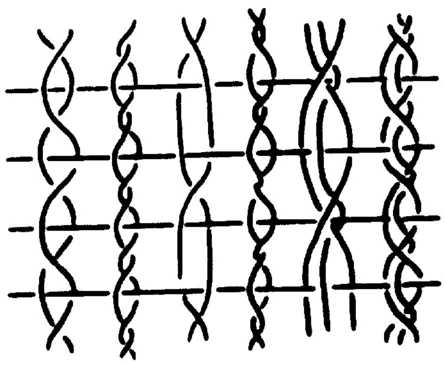


Figure 10. Some gauze weaves used to form open-end selvages

As can be seen from the foregoing, both technology and aesthetics must be considered in relation to selvages. The technology, which is important in finishing processes, is adequate; selvages are now sufficiently tough. The aesthetics, however, are unsatisfactory in some cases. This applies particularly to fabrics with selvages made by gauze weaves. Customers demand fabrics with selvages similar to the conventional ones, and possibly with inscriptions on them (this applies particularly to wool fabrics). Consequently there have been attempts to adapt to shuttleless looms a jacquard mechanism for selvage captions as, for example, with Sulzer gripper machines.

Their poor selvage formation is one of the reasons why shuttleless looms are not yet very popular.

Factors influencing the economic effects of industrial use of shuttleless looms in various countries

A comparison (table 4) is made with the three following basic assumptions:

(a) Production per year: 15 million running metres of fabric;

(b) Type of fabric: shirting (88-cm width);

(c) Floor space required for one shuttle loom, Model K 58, 10.9 m^2 and one shuttleless pneumatic loom, Model P 105, 7.3 m^2;

Additional floor space is required: with P 105 looms, 200 m^2 for compressors; with K 58 looms, 500 m^2 for pirn winding.

The total floor space required:

with K 58 looms		
for 833 looms, 10.9 m^2 each		9,100 m^2
for weft pirn winding		500 m^2
	Total	9,600 m^2
with P 105 shuttleless looms		
for 410 looms, 7.3 m^2 each		3,000 m^2
for compressors		200 m^2
	Total	3,200 m^2

Thus, the floor space saved by using P 105 looms rather than K 58 looms equals 6,400 m^2 that is, 66 per cent.

The comparison shown in table 5 reveals that, by the installation of P 105 pneumatic looms, capital investment may be reduced by 25 per cent.

TABLE 4. OUTPUT OF A SHUTTLE LOOM AND A SHUTTLELESS LOOM

Characteristics	*Model K 58 (shuttle)*	*Model P 105 (shuttleless)*
Working width of the loom (cm)	113	105
Speed (rev/min)	210	400
Coefficient of useful work-time (per cent)	75	80
Number of picks/hour	9,450	19,200
Production of one loom per year at 2-shift workday (running metres)	18,000	36,560
Required number of looms to produce 15 million running metres of fabric in a year	833	410

TABLE 5. COSTS OF A SHUTTLE LOOM AND A SHUTTLELESS LOOM

	Model K 58 (shuttle)		*Model P 105 (shuttleless)*	
	Number or m²	*Cost (1,000 Czech crowns)*	*Number or m²*	*Cost (1,000 Czech crowns)*
Looms	833	11,954	410	11,685
Fitting (with electric installation)	—	1,250	—	615
Number of winding heads	112	795	—	—
Pirn strippers	2	35	—	—
Air-conditioning	9,600	2,880	3,000	900
Compressor (including electricity)	—	—	—	1,090
Dust exhausters	—	—	410	1,025
Total cost	—	16,914	—	15,315
Gross floor-space of weaving sheds	9,600	8,640	3,000	2,700
Net floor space for compressors	—	—	200	260
Over-all cost		25,554		18,275
Cost saved				7,279

Operating costs of weaving sheds equipped with shuttle looms and shuttleless looms

It has been shown that, in several respects, shuttleless looms are more economical than shuttle looms. Their operating costs are also lower. For example, the electric power requirements for the two plant systems discussed are 1,322 kW for a plant with K 58 shuttle looms, including winders and air-conditioning, and 1,076 kW for a plant with P 105 shuttleless looms, including compressors and air-conditioning. This means that the demand for electrical power at a P 105 plant is 18.6 per cent lower than for a K 58 plant.

The manpower requirement for the shuttle looms is 230 operatives, and for shuttleless P 105 looms 125 operatives, meaning that cost of labour in the latter case is lower by 45 per cent.

The comparison has shown that, when all factors are taken into account (primary and running costs together), the expenses for a weaving shed with shuttleless looms are much lower than those for a plant equipped with conventional shuttle looms.

This calculation purposely refers to Czechoslovakia, since both types of looms used in the comparison are produced in that country. This makes all the data used very comparable.

Of course, the conclusions can be quite different if the price of shuttleless looms is drastically higher than that of shuttle looms, and it might be even worse if the producer of fabrics and the manufacturer of looms are in different countries with diverging economic systems. Shuttleless machines are expensive, and the rate of exchange may be very unfavourable for the fabric producer. In any case, it is universally believed that investment in shuttleless loom installation is justified where operating costs, particularly wages, are very high.

Shuttleless looms are also to be preferred in countries which are beginning to develop their textile industries, since new developments in weaving techniques may soon render conventional equipment obsolete.

PRESENT TRENDS IN STUDIES OF NEW WEAVING TECHNIQUES

by

H. Bergiel

Multi-shed weaving machines

Although no multi-shed weaving machine has yet been used commercially and the prototypes are still on trial, this variation of the weaving principle is considered to be very promising. With it, the fabric is not woven in cycles, as in the conventional shuttle looms, or in shuttleless machines, but continuously. This continuity of operation is achieved by various means.

The Cerdans multi-shed weaving machine

The maker of this machine is Construcciones Mecánicas Cerdans A.S., Barcelona, Spain. The machine is a bilateral weaving aggregate. It has 40 warps, which are controlled by needles that make successive wavy sheds. The weft is inserted simultaneously by 280 carrying grippers.

Instead of shuttles the machine has weft carriers, each of them fitted with a small weft pirn. The pirn is wound with a weft length that equals the width of the fabric.

Empty pirns are replaced by full ones by means of a system of selectors and spindles acting as a set, pulling the weft from cones and winding it up on pirns. The selectors pick the required colour and count of yarn.

The grippers with full pirns move in single file along the width of the machine at a distance of 150 mm from each other. After the completion of the pick, the pirn has become empty and is replaced by a full one, its gripper-carrier passing to the other side of the machine, then returning to its initial position and thus finishing one full work cycle.

Weft-carriers move within a tunnel formed by cut-in stationary plates, the carrier speed being about 2 m/sec.

The pick inserted into the shed is then beaten up by plates that propel the weft-carriers, the beating occurring immediately after the carrier has passed. A 15-cm length of weft is beaten up each time.

Shed sections are formed by a system of needles similar to those used in knitting. These needles have knee-like bends that fit into grooves of a system of flat links (1) that are joined to form a sort of chain, as shown in figure 1. This chain moves

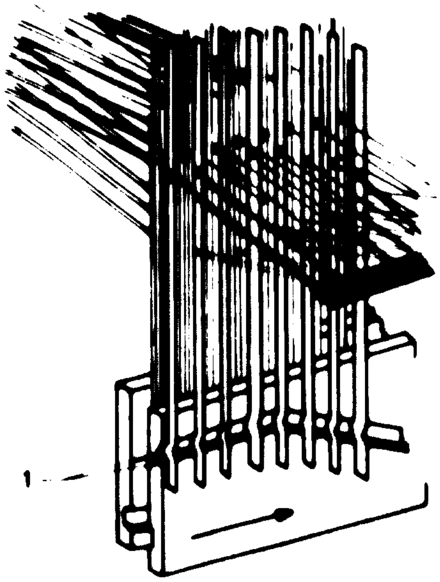


Figure 1. Shed formation by needles with eyelets and knee-like bends at their butt ends

alongside weft carriers, forcing the needles up and down, thus forming a wavy shed. The machine can run at various speeds, 2 m/sec being considered as the optimum.

The output of the machine can be calculated as follows. Carriers move at 150-mm intervals. At either side of the machine there are 20 fabrics of 1-m width (total of 40 m, 280 weft carriers being in operation). Since the carriers move at a speed of 2 m/sec, this means that 560 m of weft per second are inserted. The weaving efficiency of the machine is thus 33,600 m/min.

Comparing the above data with the efficiency of a conventional loom that weaves a fabric of 100-cm width at a speed of 280 picks per minute, 40 such looms will insert 11,200 picks per minute. The efficiency of the Cerdans weaving machine is thus approximately 300 per cent greater than that of a conventional loom.

The Gentillini Ripamonti multi-shed weaving machine

This machine is made by Industria Electromecanica Metalurgica, Ripamonti-Orseni, Italy. It is composed of two principal parts: a drum with discs, along the circumference of which the warp ends run, and a device for the insertion of the needles (metal tubes) that carry the weft into the shed. The machine has none of the mechanisms that characterize conventional looms, such as heddles, sley, reed and shuttle.

The warp goes from the warp-beam onto the circumference of discs (there is one disc for every end). The discs form one common disc drum. Between the warp discs there are disc separators that push the inserted weft up to the edge of the fabric. The warp discs have on their circumference 24 or more indentations (figure 2).

Sheds are formed in succession by an appropriate position of warp disc indentations in relation to one another. The weft is inserted into the sheds formed in this way by needle tubes (figure 3). Each needle pulls the weft from a separate package. The disc-drum revolves with the weft packages, making about 0.5 revolutions per second. Meanwhile, the needles introduce weft into successively formed sheds.

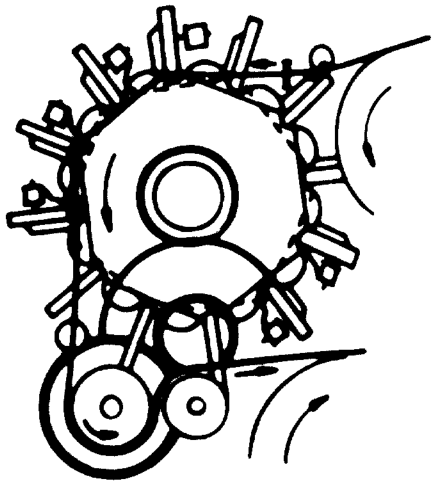


Figure 2. Formation of sheds by warp discs

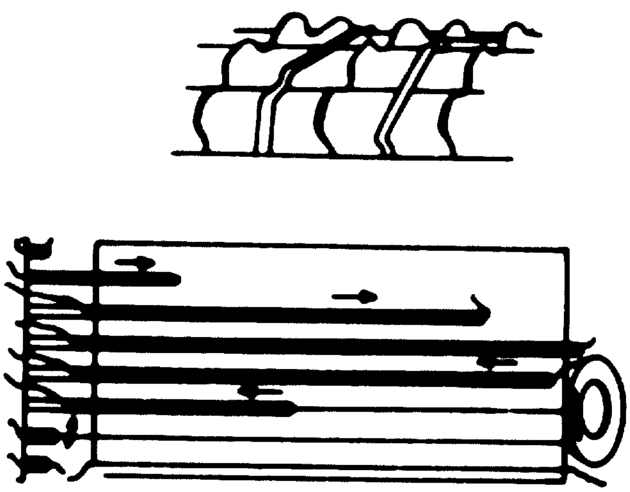


Figure 3. View of warp discs and insertion of weft by needles

Up to 48 weft picks are inserted with each revolution of the drum. The output is about 0.5 running metres of fabric per minute, or even more. Twenty different colours can be used for the weft. The picking is of a pick-and-pick type. If the machine is fully loaded with weft, it may run for 24 hours without interruption. Various widths of fabric can be woven with various types of yarn.

The fabric may have from 16 to 28 picks per centimetre. The number of ends is limited because of difficulties in the operation of sufficiently thin discs.

The Gentillini multi-shed weaving machine

This machine is arranged vertically. A shed is formed perpendicularly and is very low. Warp ends are threaded through special needles in order to form a wavy shed. The reed also makes a wavy movement, beating up the weft to the edge of the fabric in a wavy way. Each time a shed is formed, a weft container drops inside it by gravity. The weft container is light and small and contains a measured-up length of weft equal to the width of the fabric being produced.

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

TRAINING FOR INDUSTRY SERIES No. 3

THE ŁÓDŹ TEXTILE SEMINARS

4. Weaving and associated processes

UNITED NATIONS
New York, 1970

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FOREWORD

This publication is the fourth 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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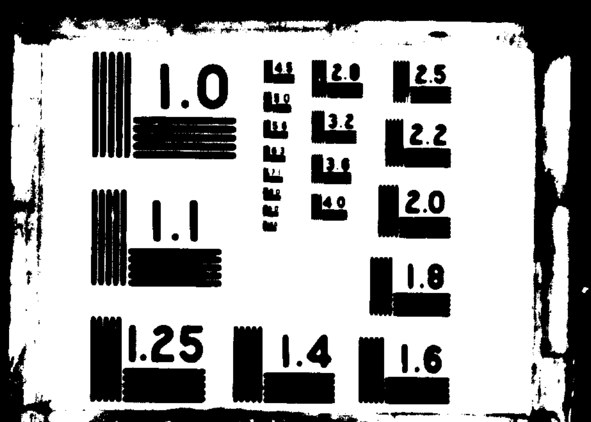


At the height of the machine (4 metres), more than ten weft containers are in operation, inserting ten weft-picks at a time. The machine can weave several pieces of fabric simultaneously. Warp can be let off from several beams. Several weft colours can be used.

The carriers that drop down after insertion of their weft load are automatically refilled and return to the upper part of the machine, to be dropped into the shed at the right time, with the required length and colour of weft. This machine requires one-third less floor space than the conventional loom.

Research work is also under way in Czechoslovakia and in the Soviet Union to develop a plain, multi-shed loom. These two countries have co-operated to construct a trial model of such a machine. The insertion of weft into the shed is done by suitable weft carriers, propelled along a sectional shed by magnets located on an endless chain. A carrier speed of 1.5 to 2 m/sec has been achieved in the course of the experiments. The work-stand is operated with 10 to 12 carriers. The width of the trial fabric was 100 cm, and weft was beaten up by flats or pinned combs.

Multi-shed weaving machines are still being developed and would seem to have very wide application in the future. Their commercial use may be expected as soon as the following problems are solved: beating up of the weft, increase in the number of warp ends per unit width of the fabric, and simplification of the construction of the loom.

Studies on new methods of weft insertion into the shed and on beating up of the weft

New methods of weaving are constantly sought so as to achieve better parameters of weaving processes. One of the most recent concepts of weft insertion is that of Vincent of the Manchester University Textile Department. His idea is based on the known principle that, if the thread starts with a suitably high velocity, it may have any required average speed over a definite distance. Yarn quality does not matter in this case. For instance, cotton yarn of 170/2 Nm may cover a distance of 1,524 mm at an average speed of 30.5 m/sec if its initial velocity is 62.2 m/sec.

Experiments have shown that it is possible to thread a ring of 44 mm diameter, thrusting towards it a cotton yarn of 5 Nm from a distance of 1,830 mm at a velocity of 64 m/sec.

The same result could be achieved with a cotton yarn of 85 Nm from a distance of 1,520 mm. The method consists in thrusting a weft yarn by friction discs located at one side of the loom, revolving very quickly and pressing hard against each other (figure 4).

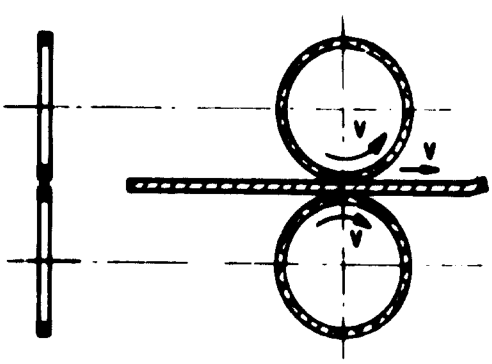


Figure 4. Thrusting of weft yarns by friction discs

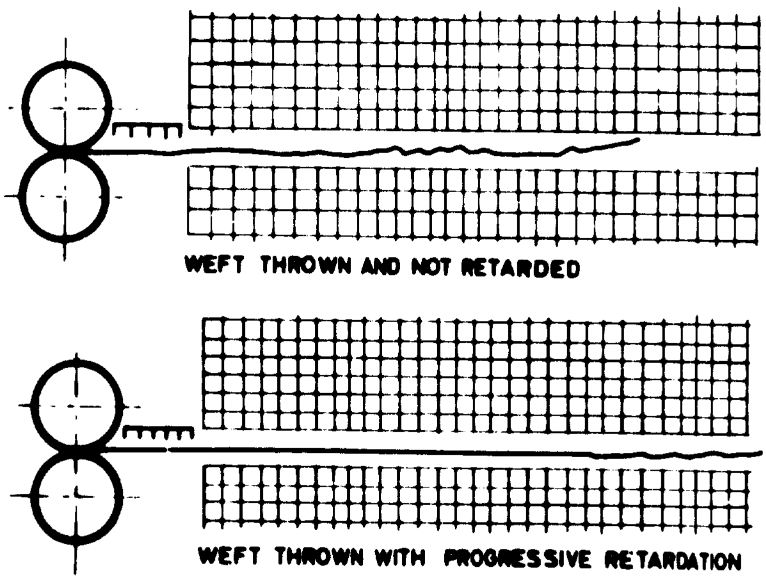


Figure 5. Slackening of the weft yarn in flight

Figure 5, which is based on photographs, shows that the weft yarn is straight as it starts its flight but becomes slack after having covered a distance of 1,067 mm. This difficulty was eliminated by a progressive reduction of weft speed, the weft being thrust by a friction device composed of two cones (figure 6).

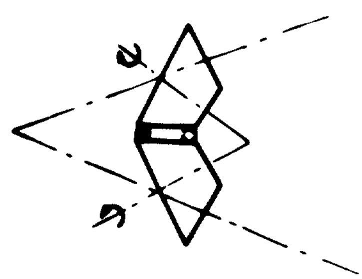


Figure 6. Slackening of the weft yarn reduced by a friction device

A combined weft guiding can also be applied: First, the flight is started by a friction device and then the weft end completing the pick is caught; second, the weft end is sucked in at the end of the pick; and third, the weft end is partially pulled in. Such a method permits 500 picks per minute to be made. It is suitable for weaving heavy-weight fabrics with coarse yarn.

The method developed by Ignatienko in the Soviet Union applies a gripper which drags weft by one end at great speed, stopping suddenly at the entrance to the shed and thrusting the free end of the weft into it in a way that resembles the cracking of a whip (figure 7). The weft flies across the shed at a speed of 27 m/sec.

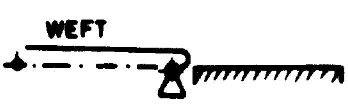


Figure 7. Weft insertion by the method of Ignatienko

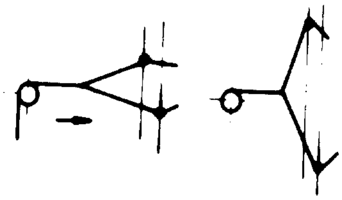


Figure 8. Beating-up weft by the method of Jis and Zmatlik

In Czechoslovakia, Jis and Zmatlik have suggested a method of beating up in which the pick of the weft is pushed up to the edge of the fabric by the warp ends of a shed that opens widely (figure 8).

In the United Kingdom, Laithweit has developed a method of weaving that consists of a swinging arrangement of the warp-fabric system (figure 9). The sley is stationary, the beating up being effected by the swings of the system.

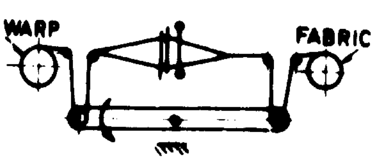
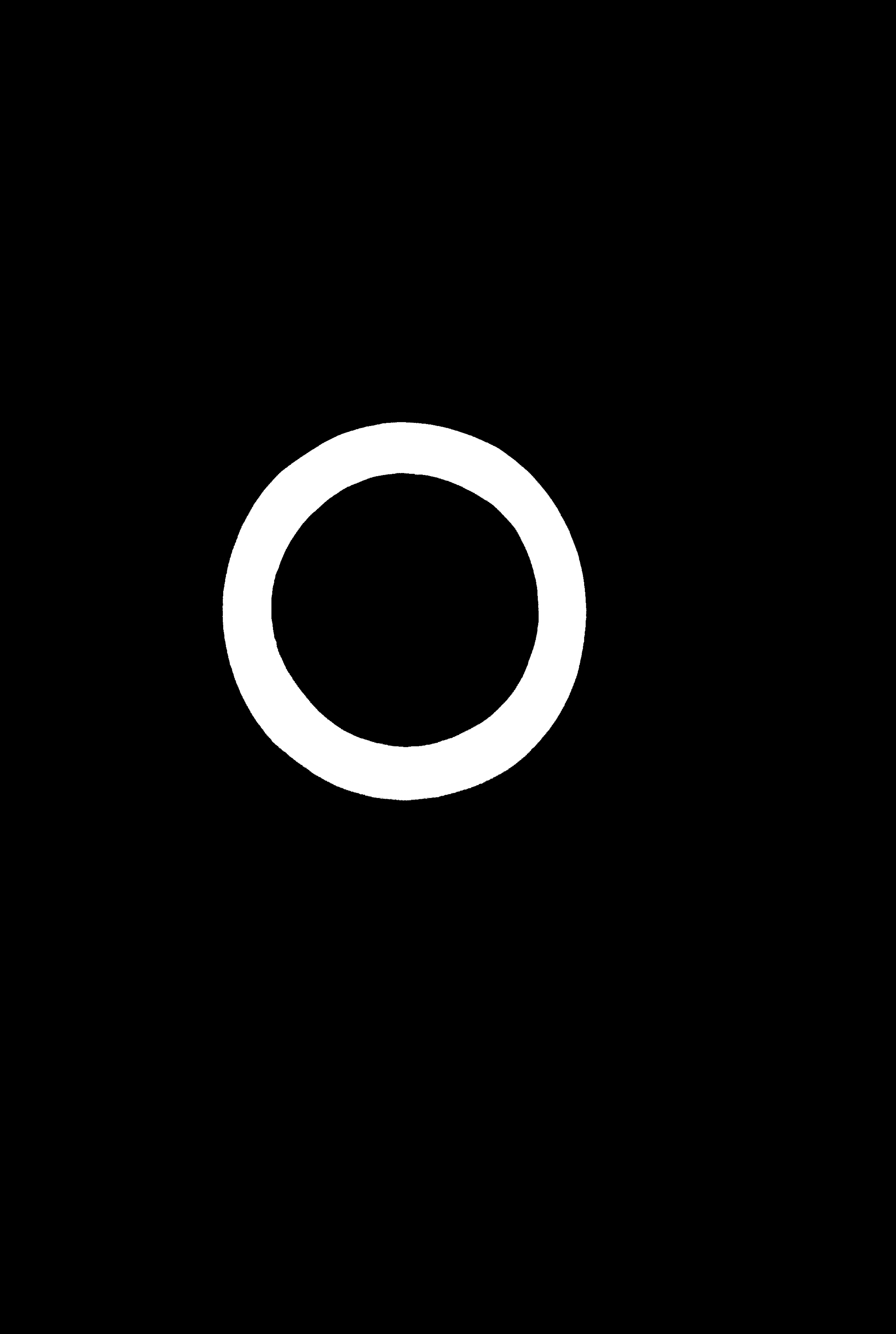


Figure 9. Weaving by the method of Laithweit

The weaving systems discussed above are by no means the only ones by which the output and efficiency of a weaving shed can be increased. Of particular interest is a new method worked out in Poland by Szosland and Wrocławski for performing the beating-up motion. It is called a "vibration method", since the sley moves with low frequency and large amplitude, and the reed receives an additional vibratory motion, which is of high frequency and small amplitude. This permits reduction of the weight of the sley and better filling of the fabric.



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