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STRENGTHENING OF THE RAMIE TECHNOLOGY

DEVELOPMENT CENTRE, CHANGSHA, HUNAN PROVINCE

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Appendix 1 "Considerations on Ramie Weaving"

to final report by Mr S W McMahon

Prepared for the Government of China by the

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* The document has not been edited.

CONSIDERATIONS ON RAMIE WEAVING

1. INTRODUCTION

According to the plan of the UNDP Project - 'Strengthen China Ramie Technology Development Centre', the author arrived in U.K. on 6th August 1993 and will work on ramie weaving - related aspects for six months in Bolton Institute of Higher Education under the direction of Mr Steve McMahon. This is the author's first report following his first month's stay.

In the first month, the author's main work is to consult some relevant reference works and papers on winding, warping, sizing and weaving to enhance his knowledge. The author feels that he has achieved great benefit in this month. In this report the author covers his understanding and some ideas or opinions about improving China's ramie weaving efficiency and quality combining his original and new knowledge with existing practice in the Chinese Ramie Industry.

The representative ramie product involved in this report is 36 Nm pure ramie plain, the specification of which is 52 ends in x 58 picks in $^{-1}$ (20.4 ends cm $^{-1}$ x 22.9 pick cm $^{-1}$); 27.8 Tex x 27.8 Tex x 50" (127 cm) width. The representative ramie mill is Zhuzhou Ramie Textile Printing & Dyeing Mill (henceforth referred to as Zhuzhou Mill), which has 650 looms and produces about 14,000,000 metres of ramie fabric every year and is one of the largest ramie mills in China.

2. WINDING

The aim of warp winding is the production of yarn packages for beam-warping. The packages produced must have substantial yarn content to minimize creeling time and maintain the headstock in production, and must be capable of being unwound at high speeds. They must be in good shape and of suitable density and even tension. The above are the basic wound package requirements. The author considers it is also important to minimize the increase in yarn hairiness when winding ramie yarns.

At present, most of the ramie mills in China are equipped with 1332M grooved drum winders. This kind of winder is manual and has 100 spindles.

2.1 Yarn Tensioning in Winding

The tension of yarn during winding is a very important parameter which affects the shape of packages and also their yarn content and density. It is essential that the tension of the yarn during winding the whole package be consistent as far as possible. The yarn tensions of every spindle should also be consistent.

The type of tension unit adopted on the 1332M winder is the disc tensioner in which yarn passes round a capstan post and at the same time passes between dead-weight loaded discs mounted on the capstan. The weights loaded by the discs should be the same for each spindle and be suited to the wound yarn. However, in Zhuzhou Mill soft or flattened packages can be observed. Undoubtedly, a major cause is differences in tension from spindle to spindle. This phenomenon is very harmful to the following processes and should be prevented.

2.2 Yarn Clearing and the Vulnerability of Knots

The purpose of yarn clearing is to eliminate the worst yarn imperfections. It is achieved by passing the yarn through some form of variable aperture or comb clearer, or an electronic clearer. However, the yarn imperfections eliminated by the clearer are replaced by knots which are themselves irregularities and excessive fault clearing associated with the introduction of a large number of knots is unlikely to improve weavability.

In Van Harten's study [1], having compared a cleared yarn with the same yarn in uncleared conditions, Van Harten found that there were fewer breaks caused by imperfections during weaving, but as there were far more knots, the total break figure for cleared yarn was slightly higher. Other researchers have produced similar results. Optimum yarn clearing, therefore, has been defined as the best compromise between the faults which can be allowed to remain in the yarn and the number of knots which have to replace yarn faults.

Especially for ramie yarns, in the author's opinion the concept of "the best compromise" should be carefully researched. Ramie yarns have many more imperfections than other yarns. If all imperfections were eliminated, a large number of knots would be produced and the breaks during weaving would increase. Moreover, the knots will make the warp ends cling more frequently. Partly for this reason now in Zhuzhou Mill no clearer is adopted for coarse yarns and products of low quality requirements. Electronic clearers are adopted for fine ramie yarns such as 36 Nm.

At present, pneumatic piecing devices have been very popular in cotton mills. The potential for their introduction into ramie winding should be investigated. The author thinks that they could be of great benefit by decreasing end clinging and lowering breakage rates during weaving.

2.3 Influence of Winding on Yarn Hairiness

The most difficult point of ramie weaving lies in overcoming the hairiness of ramie yarns. However, winding is a main source of increasing yarn hairiness. Ellis [2] pointed out that winding would generate a 100-400% increase in the hairiness of typical ring spun yarn depending mostly on the type of fibre being processed. He didn't experiment with ramie yarns, but it is likely that winding will influence seriously ramie yarn hairiness. The magnitude of the increase, however, depends on the type of slub catcher used, its setting, yarn speed, the type of spindle drive etc. The author considers that the main factors may be :

(i) Slub Catcher

The influence of the slub catcher on yarn hairiness is the most serious, especially when aperture or comb clearers are used. For this reason, Zhuzhou Mill has made no use of mechanical clearers, and only adopts electronic clearers for fine ramie yarns.

Experience has proved that an excess of clearing ramie yarns can only do harm to weavability.

(ii) The Type of Spindle Drive

On the 1332M winder, yarn take-up form the ring tube is achieved by frictional contact with a grooved drum. Because a cone is wound, sliding friction must take place between the surface of the package and the surface of the drum. There is only one point at which the surface speed of the cone is the same as the surface speed of the drum. Friction will also take place between the groove of the drum and the yarn. The friction effects will be to increase hairiness. The author, therefore, supposes that positive spindle drive winders may be more suitable for ramie yarns, although they are both complicated and expensive.

3. WARPING

The objective of warping is to present a continuous length of yarn to the subsequent process with all the ends continuously present and with the integrity and elasticity of the yarn preserved. The importance of warping quality cannot be over-emphasised. Only by relying on excellent warping quality can one obtain efficient sizing. Chen Zuchu [3] lists the basic beam quality requirements :

(i) The beam should be of regular build and have suitable density and yarn content.

(ii) Every end in the beam should have been subjected to the same tension and elongation as far as possible.

(iii) The tensions applied, resulting elongations and yarn contents of every beam should be consistent.

Initial investigations in Zhuzhou Mill suggest that at present variation in tension is a significant problem during warping. This seems to be attributable to misthreaded and incorrectly set tensioners and the existence of flattened wound packages. Therefore it is necessary that the management and maintenance of the tensioners and the quality of wound packages be improved.

Another problem is high breakage during warping. This makes the warper brake and restart frequently, which will certainly influence the quality of beams. This may be attributable to irregular yarn strength and the entanglement of the hairiness between unwinding yarn and the surface of the package. The author considers that decreasing properly the warping speed may improve matters. If lower breakage ratios and better quality do result from a lower warping speed the production of warper may not be influenced greatly due to the reduction in stop time.

4. SIZING

4.1 The Purpose of Warp Sizing

Sizing is undoubtedly a vital precess for effective weaving, particularly for ramie weaving. Poor sizing condition which last only a minute will cause problems for several hours in weaving. According to the ramie yarn properties of hairiness, low regularity and low elongation at break, the following sizing aims have to be reached to enable ramie yarn to withstand the rigours of thousands of tension and abrasion cycles.

(i) Causing protruding hairs to adhere to the body of the yarn and applying a protective coating to the yarn.

(ii) Reducing stretching of yarn during sizing as far as possible.

(iii) Increasing the strength of yarn and improving the strength irregularity of yarn.

4.2 The Choice of Suitable Sizing Materials

There are many papers which give minute descriptions of various adhesives.

such as natural starches, modified or etherized starches, PVA, CMC etc However, to make the choice of adhesive or adhesives for ramie yarn, the characteristics of the ramie yarn have to be considered.

Starch is the most popular sizing agent for cellulosic fibres, such as cotton. It proves economical and satisfactory. But if starch is used alone for ramie yarn sizing, the hairiness of yarn is hard to be overcome, and the surface film of sized yarn is brittle and has abrasion resistance.

Razelle [4] outlines the advantage of PVA (poly vinyl alcohol) :

(i) excellent adhesion to many substrates.

(ii) effective in improving the abrasion resistance of size yarn.

(iii) low size add-on levels required.

(iv) less shedding at the sizing machine, loom and inspection area.

SCMC (sodium carboxymethel cellulose) has similar advantages to PVA. The mixture of starch, PVA and SCMC has been found to be particulary useful for ramie yarns. PVA and SCMC often improve the imperfections of starch and give sized yarn a smooth, flexible and abrasion resistant coating. Now most ramie mills in China use this kind of mixture for sizing ramie yarns. However, the imperfections of ramie yarns have not been fully overcome by using this size mixture. The experimentation to find size agents more suitable for ramie yarns should certainly be carried out.

In some papers concerning sizing, it is mentioned that chemically modified starches produce lower viscosity and are easier to prepare. They sometimes give advantages over unmodified starches. Hari and his co-workers [5] showed that hydroxyethyl starch gives better performance than the starch size at any relative humidity for cotton yarn. The yarn sized by hydroxyethyl starch has higher moisture regain, breaking extension and flexibility. These are of great importance for ramie yarns. In the author's opinion, therefore, the experiment to replace natural starch by modified starch for ramie yarns should be carried out.

The lubricant is also an important composition of size mixing. It reduces fibre-to-yarn friction and also loom-to-yarn friction during weaving. Zhuzhou Mill uses pork fat oil as lubricant for ramie yarns. According to their experience, pork fat oil has similar effect to tallow.

4.3 Hairiness

The most important problem of ramie yarn sizing is obviously how to decrease yarn hairiness. This is the key to improving the weavability of sized ramie yarn.

Mohamed's paper [6] lists the most important sizing conditions affecting yarn hairiness as :

(i) Squeeze roller pressure.

(ii) Yarn spacing on the drying cans and in the size box.

(iii) Wet splitting and degree of predrying.

(iv) Yarn separation after drying.

The squeeze roller pressure not only affects the wet pick-up and hence the size add-on, but it also affects the degree of size penetration and encapsulation. Too low a wet pick-up can result in too little size coating on the outer surface of the yarn. On the other hand a high wet pick-up can result in a low degree of size penetration into the yarn structure. On the G142 and G146 slashers used in Zhuzhou Mill, two pairs of squeeze rollers are adopted. An arrangement for the roller pressures is that the pressure of the first pair of rollers is greater than that of the second pair of rollers. This arrangement seems reasonable and should enable a proper balance to be struck between penetration and encapsulation.

4.3.2 Yarn Spacing

Yarn hairiness is directly proportional to the splitting force. This is the opinion of many authors. Dr D.L. Nehrenberg [7] suggested that a sizing machine should have 50% open space on the drying cylinders when sizing cotton yarn for shuttle loom, but when sizing for air-jet weaving the spacing should be increased to 67% - 80% open space. The author considers that for sizing ramie yarn, the spacing should be much more than for cotton yarn because the ramie yarns have more and longer hairs. For 36 Nm ramie plain cloth in Zhuzhou Mill, the total number of ends is 2,600, the width of the yarn sheet in the sizing box and the drying area is 1,800 mm, and the diameter of the yarn is approximately 0.21 mm. Therefore, the open space is

$$\left(1 - \frac{0.21 \times 2600}{1800}\right) \times 100\% = 69\%$$

It is quite clear that this open space is too small for ramie yarn. End breaks in the splitting rods can often be observed.

There are two ways to reduce yarn occupancy; multiple size boxes and separated end drying. Reduced occupancy would not only decrease the hairiness of yarn, but also allow sizing speed to be increased. However, it is difficult to employ multiple size boxes in the ramie mills in China, owing to the limitations of the sizing machines.

4.3.3 Wet Splitting and Predrying

It is believed that wet splitting is very helpful to reducing the splitting force after drying, thus decreasing the hairiness of sized yarn. Zhuzhou Mill employs two wet rods and divides the sheet into three layers in front of the drying chamber.

The G146 slasher used in Zhuzhou Mill has a hot-air predrying section. The predrying section helps to prevent sticking between the yarn and the drying cans, and between the adjacent yarns. It evidently benefits hairy ramie yarn.

Glemo Inc. of Paterson [8] introduced a new oven for predyring prior to the steam cans. The oven consists of two banks of infra-red heaters over and under the yarn sheet. This predrying motion gains likely advantages over the hot-air one, for its efficiency is higher and it can automatically turned down when the machine is at crawl-speed or stopped. However capital and running costs are high.

4.3.4 Yarn Separation after Drying

On leaving the drier the sized yarns must be separated into individual ends prior to beaming. The easier the separation, the less hairiness there is in sized yarn. D.L. Nehrenberg [7] points out that the splitting forces at the lease rods should preferably be less than 2.0 cN per thread. In practise, yarn separation usually produces much hairiness. This is the reason why the hairiness of ramie yarn sized in single-end sizing machines is much less than that of ramie yarn sized full-scale sizing machines. In the one-thread slasher, the yarn is immersed and dried perfectly, and splitting is unnecessary.

For difficult separation, in addition to wet splitting and separated end drying, R.A. Schutz [9] introduced another solution by sizing half the beams separately from the other half and then combining them in beam in the manner shown in Fig 1. The author considers this method probably is helpful in sizing ramie yarns and worthy of investigation.

4.4 The Control of Sizing

Most of the papers on warp sizing relate to the introduction of various sizing control system. Most of the systems presented use sensors to measure yarn hairiness and evenness, yarn tension, size pick-up, size box and drying can temperature,squeeze roller pressure, yarn moisture content, and speed, etc.

Obviously the effective control of all sizing parameters is very important. One of the most significant developments in sizing in recent years has been the application of computer control. Unfortunately, most of the control systems of the machines which are currently being used in China are poor.

4.4.1 The Control of the Percentage of Size

The percentage of size is one of the most important parameters of sizing. Strauss [10] notes "Too little size does not give the yarn the necessary abrasion resistance to withstand loom rubbing forces. Too much size produces an inelastic, brittle yarn that will rapidly stress fatigue and fail during weaving". Fig 2. shows the general relationship between warp breaks and the amount of size on the yarn. Therefore, we know that the percentage of size much be accurately controlled in order to gain effective weaving.

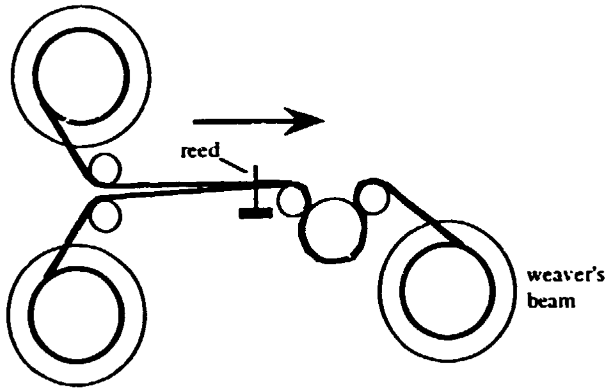

Figure 1. Arrangement for Double Beaming

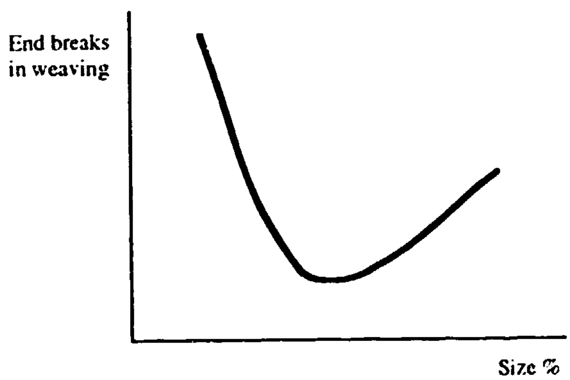

Figure 2. The Classic Weavability Curve

There are many factors affecting the percentage of size: size viscosity; running speed; squeeze roller pressure and surface characteristics; concentration of size in the beck and so on. It is important to control effectively each factor in order to achieve ideal percentage size add on.

In Zhuzhou Mill there are many difficulties in controlling size add-on. For example, the pressures of squeeze rollers cannot be automatically varied when the machine is at crawl speed; viscosity and temperature in the beck must be manually controlled,the speed of the machine changes frequently because of yarn breaks or other causes. Therefore, for perfect control of the percentage of size in Zhuzhou Mill, there are many improvements to be made.

4.4.2 Control of Warp Tension and Stretch

Under most conditions, we should expect the yarn strength to increase slightly after sizing, but it is more important that the yarn loses a minimum of elongation. If sizing causes too much elongation loss, elasticity will decrease, inhibiting the yarn's ability to withstand the continuous stretching forces during weaving. Since ramie yarn has the property of low elongation at break, it is especially necessary to pay attention to the control of warp tension and stretch.

There are three zones where tension and stretch control are of importance. Firstly, there is the unwinding zone between the back beams and the nip of the squeeze rollers, secondly, there is the drying and splitting zone between the nip of the squeeze rollers and the draw roller; and thirdly, there is the winding zone between the draw roller and the weaver's beam.

4.4.2.1 Control of Tension in the Creel

Yarn tension in the unwinding zone is mainly caused by the mass and inertia of backbeams in the creel. The mass and inertia also determine of the braking torque needed to stop the beams on a crash stop. G142 and G146 slashers gain certain braking torques by means of adjusting the resistance of the bearings of back-beams.

The changes in warp tension during unwinding of the back-beams can affect the tension in the warp in the drying and splitting zones. Moreover, if the sheets of yarn leaving the individual backbeams are not tensioned to about the same extent the backbeams will not empty together and some yarn will be wasted. Therefore control is very desirable. Walter N. Rozell [4] and D.L. Nehrenberg [7] recommended that minimum tension should be applied measured: values should be between 0.4 and 0.8% stretch in this area.

During normal running of a slasher, if the braking force applied to the backbeams remains constant, the tension of warp sheet will increase with reducing diameters of the backbeams. In order to make the tension of warp constant, adjustment to the resistances is necessary periodically during the run. This adjustment in Zhuzhou Mill is done by the operatives. The operative can make the warp sheets of every backbeams have the same tension by their experience, but it is less easy to make the tension of the whole warp sheet constant during the run.

Therefore, in order to allow uniform control of ramie yarn stretch between the creel and the size box, the slasher creel should be equipped with a self-adjusting braking system.

4.4.2.2 The Tension in the Drying and Splitting Zone

In the drying and splitting zone, some form of tension and stretch control is also important. Control in this region is necessary to ensure not only that tension variations do not exceed the permissable range, but also trouble-free splitting and efficient drying.

Provided that the let-off tension is controlled, the total tension in the drying and splitting zone can be regulated by adjusting the ratio of the surface speeds of the squeeze rollers and the draw roller. On G142 or G146 slashers, there is a sideshaft driven from the front of the machine, on which are mounted a gear-train to drive the draw roller at the front of the machine and the squeezing rollers at the size box at the back of the machine. The ratio of the surface speeds of the squeezing rollers and the draw roller can be adjusted by changing a pinion in the gear-train or altering the amount of cloth wrapped on the draw roller.

On G142 or G146 slasher, there is also a weight roller to compensate for tension variations and ensure that the variations of splitting forces have no influence on the tension in the drying section (shown in Fig 3).

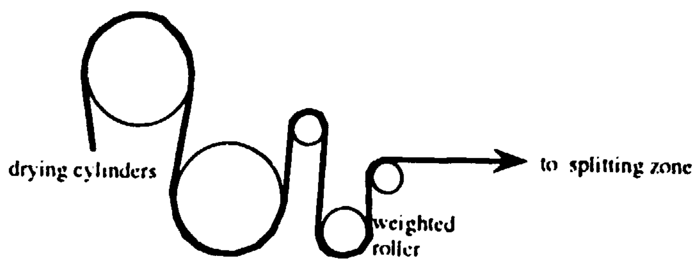

Figure 3. The Tension in the Winding Zone

4.4.2.3 The Tension in the Winding Zone

In the winding zone, a correct control of tension, combined with suitable press-roller conditions, ensures that weavers' beam will hold as great a length of warp as possible and unwind satisfactorily during weaving.

On G142 and G146 slashers, friction-drive motions still are used to control the winding tensions.

4.4.3 Control of Warp Moisture

The moisture content is one of important parameters of sized yarn, especially sized ramie yarn. It is a known fact that a high moisture content increases extension and strength in ramie yarns. The moisture content also affects the properties of the size film. A size film that it is too dry is more brittle and easily cracks during weaving. Moreover, overdrying always involves an unnecessarily reduced rate of warp production and a waste of energy. However, if warps leave the drier with too much moisture, ends may be stuck together giving trouble in weaving, or there may be a risk of mildew.

In Zhuzhou Mill, the methods of finding the amount of moisture in warp is by weighing a sample of it in the moist and dry states, although the G142 and G146 slashers are equipped with moisture measuring instruments. These instruments are based on the measurement of the electrical resistance of the warp. However, they have not met with a great deal of success. The operatives in Zhuzhou Mill often control the moisture of sized ramie yarns by their experience instead of the instruments. They often adjust the moisture by means of controlling the speed of the machine.

The author considers that methods of adjusting the moisture of warp by changing the speed of the machine isn't a very good idea. When the speed of the slasher changes, the percentage of size of yarn also will vary, not only the moisture of yarn. Moreover, it is impossible, except by instrumentation, for the operatives to know when a warp is dried to the correct condition. To date, there have been many kinds of moisture measuring instruments, and there are many papers on which describe new moisture measuring instruments. Therefore, to improve the quality of sized ramie yarns, it is necessary that dependable moisture measuring instruments are employed in the slasher for controlling accurately the moisture of sized ramie yarns.

5. WEAVING

Excellent weaving means low end breakage rates and high fabric quality. At present, however, the most serious problems of ramie weaving are the high end breakage rates and poor fabric quality. The main causes of poor weavability, as mentioned earlier, are hairiness, low regularity and low elongation at break. Of these, excessive hairiness of ramie yarn causes the greatest reduction in weavability.

Ramie mills in China generally use 1515 looms for ramie weaving. This kind of loom, designed originally for cotton and cotton blend weaving, has automatic shuttle-change. How to apply them more successfully for ramie weaving is a problem being faced by the ramie mills of China.

5.1 Yarn Hairiness

Each point of the warp end is subjected to repeated elongation from the warp beam to the cloth fell. The warp end also is subjected to shock by the moving elements (shuttle etc). These are just two main reasons why a warp end can break in weaving. The exceptional hairiness of ramie yarn aggravates not only alternate elongation, but also shocking of warp ends. This is because that the hairiness often causes yarns to cling, some yarns not being separated during shed opening and forming a "Y". The existence of "Y's" during shed opening extends the amplitudes of yarn tension variations due to elongation, and also increases the possibility that the warp ends are shocked.

Sizing theoretically reduces this factor, but it does not always succeed completely, especially since in the case of ramie yarns it is difficult to reduce hairiness to an acceptable level. Therefore, it is important to use loom settings which minimise effects of hairiness as far as possible.

5.2 The Length of Shed

A. Barella and his co-workers concluded [11] "Yarn/yarn friction produces a more drastic effect on yarn hairiness and pilling than does yarn friction against a metal edge". Therefore, if the length of shed is shortened, yarn/yarn friction will be reduced and the chance of yarn clinging will also be reduced. In fact, for a shuttle loom, there is only the possibility of shortening its back shed. Another benefit from a shorter back shed is the larger back shed angle. The larger back shed angle produces a larger force component contributing to the release from clinging.

In Zhuzhou Mill two lease rods are used in each loom for 36 Nm pure ramie plain in order to shorten the back shed (shown in Fig 4.)

Zhuzhou Mill's experience shows that the introduction of lease rods does help to obtain a clearer shed and lower the end breakage rate for ramie weaving. However, there are two other effects. Firstly, the warp tension and elongation are increased during weaving. Secondly, when ends are raised and lowered, the length of the back shed in fact alters, and the tension of warp alters. Mr S. McMahon shows a similar view in his report [12].

The author has proposed that the lease rods be replaced by the restrictor rods (shown in Fig 5). The restrictor rods shorten the length of back shed as well. They, however, will not make the length of back shed alter when ends are raised and lowered. Besides, the restrictor rods nip the warp ends very loosely and the friction between warp ends and the smooth restrictor rods can hardly prevent the warp behind the rods from elongation. Therefore, the restrictor rods will not cause the tension and the elongations to increase too

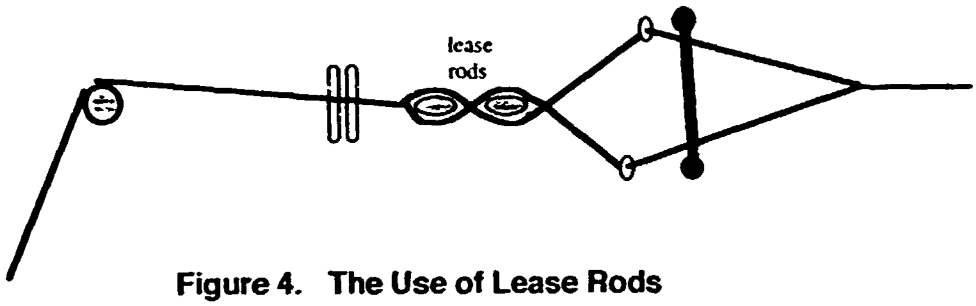

Figure 4. The Use of Lease Rods

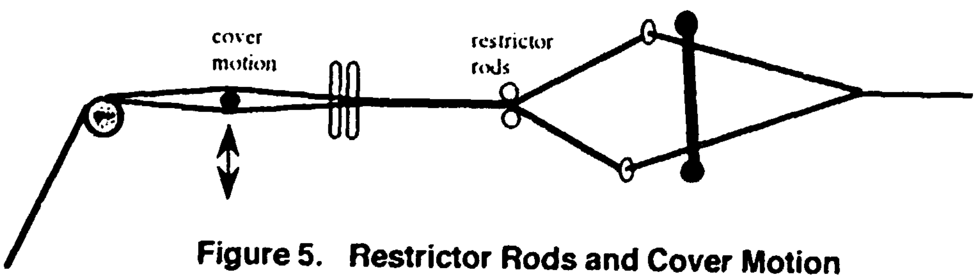

Figure 5. Restrictor Rods and Cover Motion

greatly when the shed is open. Mr S. McMahon [12] proposes to make the rods free to rotate. If so, the restrictor rods will have much less influence on the tensions and the elongations when the shed is open.

5.3 Type of Shed

Weaving takes place generally with a asymmetrical shed. R. Marks and A.T.C. Robinson's book [13] describes minutely the method used to gain an asymmetrical shed by raising the "normal" position of the back-rail, and the functions of an asymmetrical shed. In brief, an asymmetrical shed can improve the fabric cover and make it possible to obtain a closer pick-spacing. In weaving the plain ramie cloths, pick-packing is not a problem, but fabric cover is. Zhuzhou Mill depends just on raising the back-rails to ensure good cover.

However, the asymmetrical shed has two problems in weaving ramie cloths. First, in an asymmetrical shed, the upper shed is slack and the lower one tight. The slack upper warp ends are unfavourable for splitting entangling fibres when the shed is opening. Second, the very tight lower ends increase the amplitude of tension variations when the shed is open.

Mr S. McMahon [12] offers a solution using a cover motion. The shed is symmetrical during weaving and only at the instant of beat-up the cover motion operates to make the tension of upper and lower sheds different. This is a good idea and may have positive benefits. However, using the arrangements shown in Fig 5, a layer of warp ends always is tight and another one always is slack. This situation isn't obviously the ideal solution for ramie weaving.

Oldrick Talavasek and Vladimir Svaty's work [14] introduces a kind of lease rod form called a cradle (shown in Fig 6). This kind of lease rods are made to move to increase alternately the tension of even and odd warp ends. If the cam is re-designed to make the moving rod ordinarily be at a standstill at a certain position where the shed is symmetrical and swing accordingly only at the instant of beat-up, this kind of lease rod form may be helpful to ramie weaving.

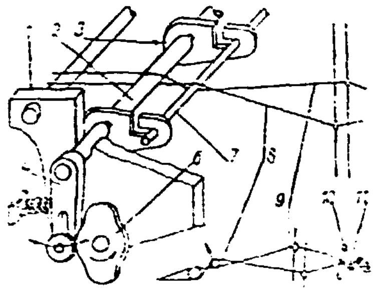

Fig 6. The Lease Rod Cradle (14)

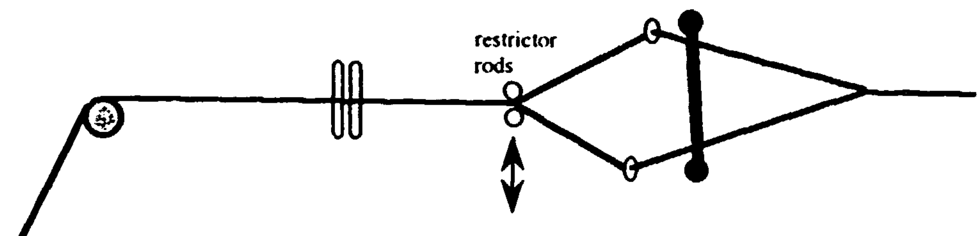

Figure 7. Moving Restrictor Rods

The author, however, proposes a new solution which may be more advantageous (shown in Fig 7). The restrictor rods are improved to make them capable of moving vertically, in addition to rotating freely and being adjusted easier. Ordinarily the restrictor rods are located at a certain position and play two roles :

(i) Limiting the length of back shed.

(ii) Forming a symmetrical shed.

Only at the instant of beat-up are the restrictor rods raised to form an asymmetrical shed.

5.4 The Function of a Compensating Back-Rail

Talavasek and Svaty explained the back rail performance in detail and point out two functions of the back-rail :

(i) to control the warp tension either by its position or with the oscillating back-rail by its movement.

(ii) to sense the warp tension for the warp let-off motion, when the latter is used.

Now we focus our discussion on the compensating function of the oscillating back-rail. On the 1515 loom, the cam mounted on the crank shaft controls the back-rail's oscillation to equalize warp tension. It is well known that the warp tension is the smallest when the shed is closed, larger when the shed is open, and at the peak during beat-up. In fact, for ramie weaving, it is of benefit to splitting entangling fibres and shuttle flight that the upper and lower warp sheds have larger and similar tensions when the shed is opening. But the tension peak during beat-up should be reduced to minimize the amplitude of tension variations. In the author's opinion, therefore, it may be appropriate that the compensating back-rail is timed so that it is at the lowest position at the instant of beat-up (0°). Especially when the restrictor rods or the cover motion, etc. exist and raise during beat-up as mentioned earlier, such timing of the compensating back-rail is more necessary.

5.5 The Main Faults in 36 Nm Pure Ramie Plain

At present, the main faults in 36 Nm pure ramie grey plain are stitching, cracks, and weft bars.

The pick spacing is related to cloth fell displacement at beat-up, which has been described in detail by R. Marks and A.T.C. Robinson [13]. Any disturbance of the cloth fell position will produce a variation in pick-spacing, which if severe enough, will produce a fault in the fabric, i.e. weft bars.

It is obvious that any variation in the rate of take-up or in the rate of let-off must cause a change in cloth fell position and therefore a change in pick-spacing. However, when the take-up motion and the let-off motion are operating correctly the main source of variation in pick-spacing may be :

(i) Loom stoppages.

(ii) Clinging ends.

During a loom stoppage, the warp and fabric tension will tend to fall owing to creep, and there may also be a movement of the cloth fell. When the loom is restarted, a fault in pick-spacing called a starting place, a type of weft bar, may result. Therefore, if the end breakage can be lowered, weft bars in ramie fabric will be reduced.

Clinging ends may result in cracks. This is because the clinging ends have higher tensions and pull the cloth fell towards the reed. When the entanglement is released, the tensions reduce and the cloth fell moves further from the reed. Such displacement of the cloth fell produces cracks.

The cause of the stitching faults can basically be attributed to the clinging ends. too. Because the warp ends cling to form "Y" in the shed, the shuttle may pass under or over all of the clinging ends causing the stitch.

It has been seen that all the faults mentioned above seem to be related to end clinging. Therefore, restraining the disturbance of hairiness is also the key to minimising the faults.

6. CONCLUSION

The suggestion and opinions offered in this report are only tentative. Some of them need to be proved by experiment or practice

In this report the author's main opinion are :

(i) For ramie winding, the best compromise between yarn faults and knots should be paid great attention to. Irregular and incorrect yarn tension should be eliminated. In future practice, the influence of winding on yarn hairiness is worth investigation.

(ii) The improvements which should be made in ramie warping are mainly improved control of yarn tension and lowering end breakage rates. Decreasing properly the warping speed may be an acceptable way of lowering breakage.

(iii) The most important problems of ramie yarn sizing is how to decrease excessive yarn hairiness. In addition to making suitable choice of sizing materials, the key to decreasing yarn hairiness in sizing may lie in increasing the open space on the drying cans and in the size box.

Control of sizing parameters control is also a main factor that influences the quality. At present, however, the control conditions in the ramie mills of China are poor and should be improved.

(iv) Excessive yarn hairiness still is the most malignant factor. In ramie weaving, high end breakage and many fabric faults can all be attributed to end clinging. Suitable warp line setting seems to be of great importance to coping with the problems of hairiness. Having analysed the characters of some settings, the author proposes the following shed arrangement for ramie weaving :

A pair of restrictor rods is adopted to shorten the length of back shed and form a symmetrical shed. At the instant of beat-up the restrictor rods are raised to form an asymmetrical shed to gain good fabric cover. The compensating back-rail is timed so that it is at the lowest position at the instant of beat-up to limit the amplitude of tension variations.

The above arrangement needs to be proved by experiment.

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