Vocational Higher Secondary Education (VHSE)

SECOND YEAR

TEXTILE TECHNOLOGY

Reference Book

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Department of Education

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FOREWORD

Dear Learners,

This book is intended to serve as a ready reference for learners of vocational higher secondary schools. It offers suggested guidelines for the transaction of the concepts highlighted in the course content. It is expected that the learners achieve significant learning outcomes at the end of the course as envisaged in the curriculum if it is followed properly.

In the context of the Right- based approach, quality education has to be ensured for all learners. The learner community of Vocational Higher Secondary Education in Kerala should be empowered by providing them with the best education that strengthens their competences to become innovative entrepreneurs who contribute to the knowledge society. The change of course names, modular approach adopted for the organisation of course content, work-based pedagogy and the outcome focused assessment approach paved the way for achieving the vision of Vocational Higher Secondary Education in Kerala. The revised curriculum helps to equip the learners with multiple skills matching technological advancements and to produce skilled workforce for meeting the demands of the emerging industries and service sectors with national and global orientation. The revised curriculum attempts to enhance knowledge, skills and attitudes by giving higher priority and space for the learners to make discussions in small groups, and activities requiring hands-on experience.

The SCERT appreciates the hard work and sincere co-operation of the contributors of this book that includes subject experts, industrialists and the teachers of Vocational Higher Secondary Schools. The development of this reference book has been a joint venture of the State Council of Educational Research and Training (SCERT) and the Directorate of Vocational Higher Secondary Education.

The SCERT welcomes constructive criticism and creative suggestions for the improvement of the book.

With regards,

Dr. P. A. Fathima
Director, SCERT, Kerala

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PART - A

TEXTILE TECHNOLOGY

ABOUT THE COURSE

Vocational Higher Secondary Education in Kerala is a unique scheme of education which combines both vocational and academic stream of education. Learning vocational skills along with conventional academic education gives the students double advantage of vertical mobility as well as employability. It helps to develop vocational aptitude, work culture, values and attitudes of the learner and enhances his productivity. The vision of Vocational Higher Secondary Education in Kerala is to equip the youth with multiple skills matching the technological advancements and to produce skilled work force for meeting the demands of the emerging industries and service sectors with national and global orientation.

As India is emerging as a manufacturing hub to the world the demand for skilled manpower is on the rise. Kerala, traditionally known for its high quality man power all over the world can embark on this opportunity and equip our students with skills for the manufacturing sector and reduce the unemployment problems of the state. The Textile technology course in VHSE is one such course from the manufacturing sector.

Textile industry is the one of the oldest industries in India. The industry basically involves the manufacturing of various types of fabrics both natural and synthetic, production of machinery, and planning and development of new technology. The industry has categorized three areas of work namely research and development, manufacturing and merchandizing. It provides direct employment to 30 million people. Textile technology is the study of textile production , processing and its capability for the use of common man. It combines the principles of engineering with specific knowledge of textile equipments and textile process. Textile technology is deals with the application of scientific and engineering principles to the design and control of all aspects of fibre, textile and apparel process, its products and machinery. These include natural and man-made material, interaction of materials with machines, safety and health, energy conservation, and waste and pollution control. There wide scope for research in this area as the industry demands the need to improve currently available products and develop new ones.

Textiles are utilized for innumerable purposes other than the manufacturing of garments. They are used in the manufacture of carpets and furnishings like bed sheets and bed covers , quilts, table cloth, curtains ,towels etc. and is also used for making rags, dusters, tents and nets, kites, parachutes and so on. According to the usage, texture textiles are classified as Apparels, Furnishings , Technical textiles , Medical textiles, Agro textiles and Geo textiles.

This course is now offered in modular format consisting of four modules which focus on multi-skills development. One month On the Job training and Production cum training centers are also an integral part of the course which gives exposure to real time-work environment.

On the successful completion of this course, the candidate will be able to join textile industries as junior level technicians / operators and are also eligible for attending advanced courses on Textile Technology or any other courses that can be pursued after plus two science stream. A few institutes offering higher learning courses in Textile Technology are listed below.

1. Three Government polytechnic colleges in Kerala offer Diploma in Textile Technology
2. IEI offers Diploma and B. Tech. level courses similar to AMIE schemes
3. Various universities outside Kerala offer B. Tech. in Textile Technology
4. ATDC provides various Diploma Courses in Garment manufacturing Merchandizing, Pattern making etc. all over India
5. NIFT offers various Degree and Diploma courses related to Textile designing and Fashion Technology

Thus finally you have a wonderful opportunity to learn demand skills with higher learning opportunities. Come… let's explore the wonderful world of textiles!

1. Major Skills

- Warping Technician/Operator
- Sizing technician/Operator
- Weaving Supervisor/technician/Operator
- Dye house technician/Operator
- Textile Printer/Screen Printer

7. Syllabus:

Module 3 : Weaving technology

Periods: 340

Unit	Name of unit	Periods
1	Weaving preparatory processes:	100
2	Handloom	60
3	Power loom	140
4	Fabric structure	40

Module 4 : Textile dyeing and printing technology

Unit	Name of unit	Periods
1	Preparatory processes for dyeing and printing	100
2	Classification of textile dyes based on water solubility:	20
3	Dye application on cotton textile	120
4	Textile printing	100

PART - B

8. Overview of Module 3

The objective of the course is to introduce the basic concepts of woven fabric manufacturing to the sophomores of Textile Engineering/ Technology. The course material has been designed to create interest among students and hone their analytical ability.

After attending this course, the students will be able to understand and analyze the preparatory processes of weaving like winding, warping and sizing. They will also be able to analyse various mechanisms of shuttle looms like shedding, picking, beat-up, take-up and let-off.

More emphasis has been given to the fundamental aspects so that the students get the opportunity to think and learn rather than memorize and learn. All the equations have been derived in such a way that students can understand the contexts well and this has been supplemented with some numerical problems at the end of each module. Some mundane descriptive part which requires memorizing has been deliberately avoided. This pithy course material is not a substitute for standard text books. Students are suggested to read text books for the details.

a. Unit

Unit 1 : Weaving preparatory processes

Unit 2 : Hand loom

Unit 3 : Power loom

Unit4 : Fabric structure

Learning outcomes

Study of warp winding, warping, sizing, gaiting and weft winding and drawing-in process

Study of various types of handlooms, parts of handlooms and their functions.

Sketch the passage of warp yarn through a handloom.

Study of textile designs, drafts and peg plan.

Weaving practice on handloom

Study of various types of power looms and accessories. Functions of accessories.

Primary motion

Study of various types of shedding tappets, dobby and jacquards

Study of various types of Picking methods – Shuttle and shuttles

Study of Beating-up motion

Secondary motions

Study of Let-off motion, Study of take-up motion.

Auxiliary motions

Study of warp stop motion

Study of waft stop motion

Study of various types of fundamental weaves – Plain and its derivatives, Twills and modification of twill weaves.

3. Detailing of concepts

3.1. Weaving Preparatory

Study of weaving preparatory includes warp-winding, warping, sizing, gating, and weft-winding.

Winding

Objectives of Winding

To wrap the forming yarn around a package in a systematic manner or to transfer yarn from one supply package to another, in such a way that the latter is adequately compact and usable for subsequent operations.

To remove the objectionable faults present in original yarns.

Most of the textile winding operations deal with the conversion of ring frame bobbins into cones or cheeses. One ring frame bobbin (cop) typically contains 100 grams of yarn. If the yarn count is 20 tex, then the length of the yarn in the package will be around 5 km. As the warping speed in modern machines is around 1000 m/min, direct use of ring frame bobbins in warping will necessitate package change after every 5 minutes. This will reduce the running efficiency of warping machine. Therefore, ring frame bobbins are converted into bigger cones (mass around 2 kgs or more) or cheeses.

Ring frame bobbins are also not usaable as transverse or weft packages because they have an empty core, which requires a shuttle of bigger size thereby causing problems in shedding operations. Therefore, for shuttle looms, pirn winding operations are carried out to manufacture weft packages from cones.

Two basic motions are required for effective winding. First, the rotational motion of the package, on which the yarn is being wound. This rotational motion pulls out the yarn from the supply package. Secondly, traverse motion is required so that, the entire width of the package is used for winding the yarn. In the absence of the latter, yarns will be wound around the same region by placing one coil over the other which is not desirable.

During winding, the yarn can be withdrawn from the supply packages in two ways as depicted in **Figure 2.1**

Side withdrawal

Over-end withdrawal

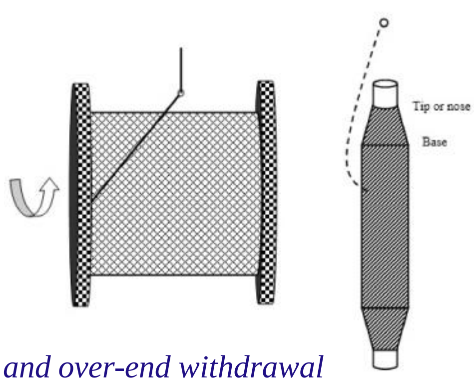


Figure 2.1: Side withdrawal and over-end withdrawal

Classification of Winding Principles

Primarily there are two types of winding principles as given below.

- Drum-driven or random winders
- Spindle-driven or precision winders

In a drum-driven winder, the package is driven by a cylinder through the surface or frictional contact as shown in Figure 2.5. Traverse of yarn is given either by the grooves cut on the drum as shown at the bottom of Figure 2.5 or by a reciprocating guide. In case of a grooved drum, the drum performs the dual function of rotating the package by surface contact and performing the traverse (Figure 2.6a). However, when a plain drum is used, it just rotates the package and traverse is performed by a reciprocating guide (Figure 2.6b).

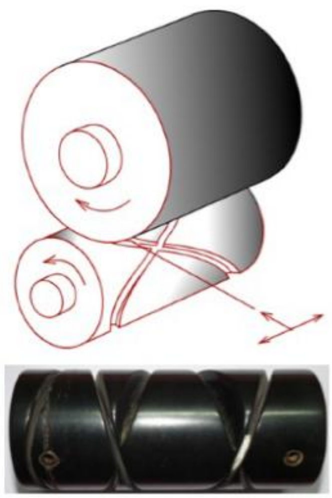


Figure 2.5: Drum-driven winder and grooved drum

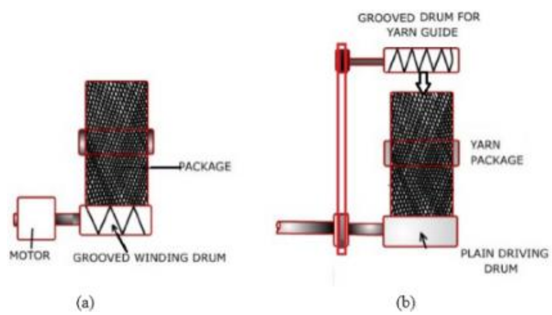


Figure 2.6: Types of drum-driven winder (a: grooved drum, b: plain drum)

In a spindle-driven winder, the package is mounted on a spindle which is driven positively by a gear system. If the r.p.m. of the spindle is constant, then the surface speed of the package will increase with the increase in package diameter. Therefore, principle wise, there could be two types of spindle-driven winders (Figure 2.7).

- Constant r.p.m. spindle winders
- Variable r.p.m. spindle winders

In case of the latter, the spindle r.p.m. is reduced with the increase in package diameter in such a manner that the winding speed remains constant.

Spindle-driven winders are also known as precision winders as a precise ratio is maintained between the r.p.m. of spindle and r.p.m. of traversing mechanism. This leads to maintaining a precise distance between adjacent coils, termed Gain of Wind. The precision winders thus permit precise laying of coils on the package and hence its name . Precision winders ensure a constant value of traverse ratio during package building. Precision winders are preferred for winding delicate yarns as the package is not rotated by the surface contact and therefore, the possibility of yarn damage due to abrasion is lower as compared to that of surface driven winders.

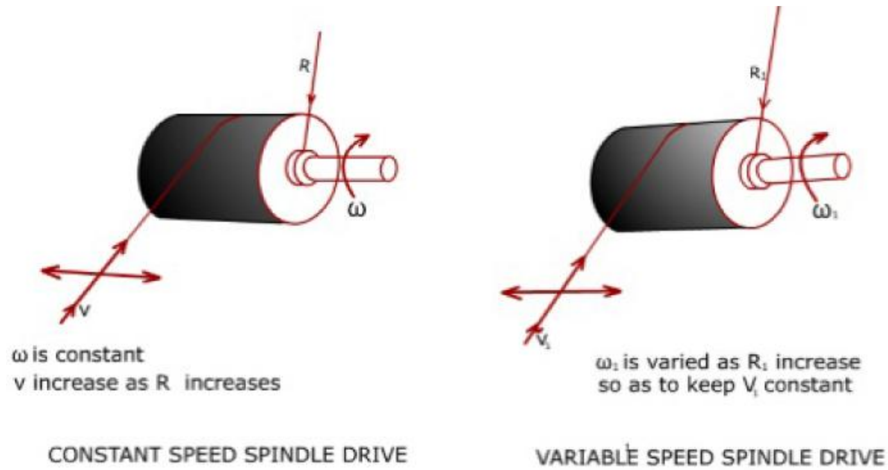


Figure 2.7: Spindle-driven winders

Drum-driven Winders

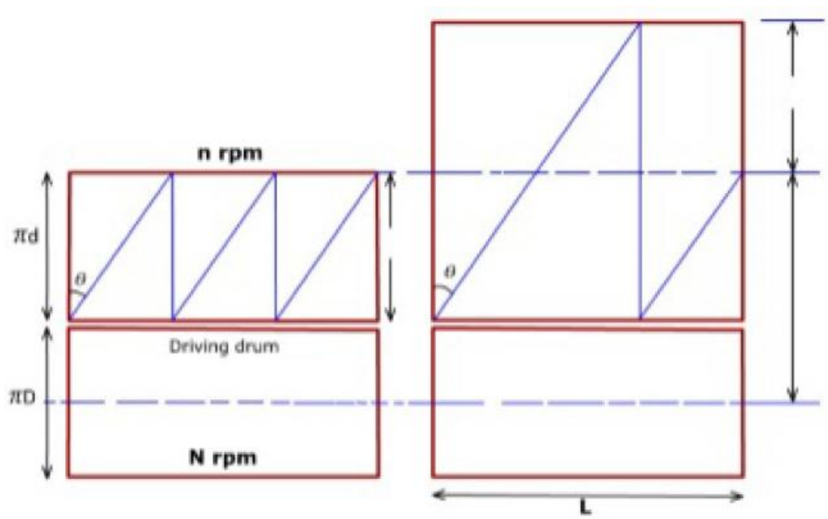


Figure 2.8: Principles of drum-driven winder

Let us consider that the diameters of the driving drum and package are D and d respectively (**Figure 2.8**). The r.p.m. of drum and package are N and n respectively. D is constant whereas, d increases with time due to the building of the package (formation of layers of coils). If there is no slippage between the drum and the package, then the surface speed of the drum and the package will always be same. So, $N \times D = n \times d$. The drum r.p.m. N is constant as it is getting drive from teh gear systems and thus n reduces with the time.

As the drum r.p.m. N is constant, for drum-driven winder, traverse speed and surface speed are also constant. Therefore, it gives constant angle of wind and winding speed.

Warp-winding include various types of hand-driven warp-winders.
Study about the main parts of hand-driven warp-winders

Objective of Warping

The objective of warping process is to convert the yarn packages into a warper's beam having desired width and containing requisite number of ends. Uniform tension is maintained on individual yarns during warping.

The yarns are wound on the warper's beam in the form of a sheet composed of parallel bands of yarns, each coming out from a package placed on the creel. A simplified view of the warping process is shown in Figure 3.1.

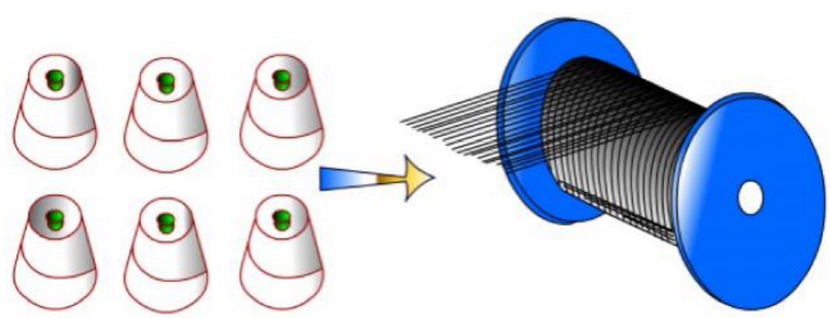


Figure 3.1: Simplified representation of warping process

Components of Warping Machine

- Creel (**Figure 3.2**)
- Headstock
- Control devices

Figure 3.2: A simple creel of warping machine

Types of Creel

- Single end creel
- Magazine creel
- Travelling or multiple package creel

Single End Creel

In single end creel, one package of the creel is used at one end of the warper's beam. Single end creel can be of two types-namely, truck creels and duplicated creels. The creel is movable in the case of former whereas, the headstock is movable in the case of latter. In truck creel, when the packages from the running creel are exhausted, it is moved sideways and the reserve creel moves into the vacant space (Figure 3.3). Thus, the time for removing huge number of exhausted package and replenishing them with full packages is saved. However, extra space is required for the reserve creel.

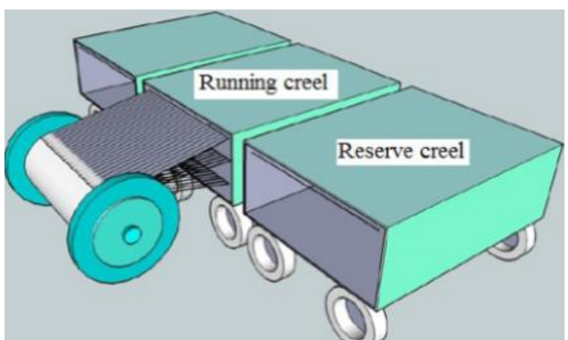


Figure 3.3: Single end truck creel

Magazine Creel

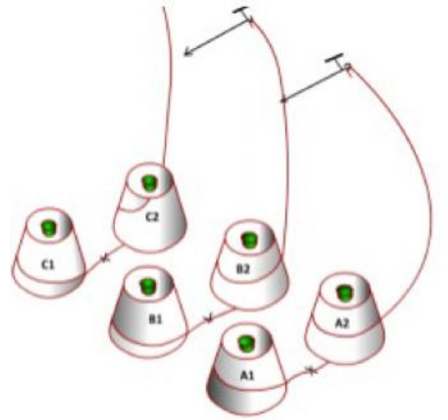


Figure 3.4: Magazine creel

In magazine creel, the tail end of the yarn from one cone is tied up with the tip of the yarn of another neighbouring cone. When the first cone is exhausted, the transfer of yarn withdrawal to the second cone takes place automatically and machine does not stop. This has been depicted in the **Figure 3.4.** Thus the creeling time is completely eliminated which helps to improve the running efficiency of warping process. However, due to sudden change in unwinding position and tension variation associated with this, some of the yarns break during the transfer (known as transfer failure). The magazine creel has a reduced capacity. If the creel has 1000 package holders, then the warp sheet can actually have 500 ends.

Travelling or Swivelling Creel

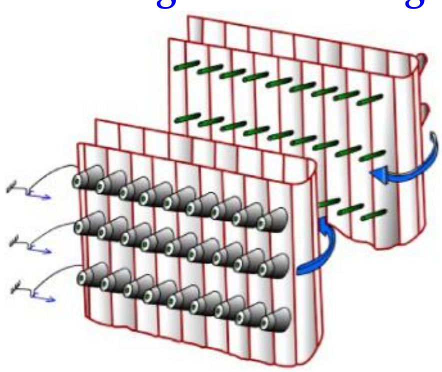


Figure 3.5: Swivelling creel

In swivelling creel, the pegs (package holders) with full packages can move from inside (reserve) position to the outside (working) position, when the running packages are exhausted. Thus considerable time is saved. Then the operator replaces the exhausted packages with full packages, when the machine is running. Figure 3.5 shows the swivelling creel.

Sectional Warping

Sectional warping is preferred to beam warping for multi-coloured warp. Here, the entire width of the warping drum is not developed simultaneously. It is developed section by section as depicted in the **Figure 3.6**. As only one section is built at a time, support is needed for one side of the drum. This is provided by making one side of the drum inclined. The inclination can be of - two types.

- Fixed angle
- Variable angle (7 0, 9 0, 11 0 etc.)

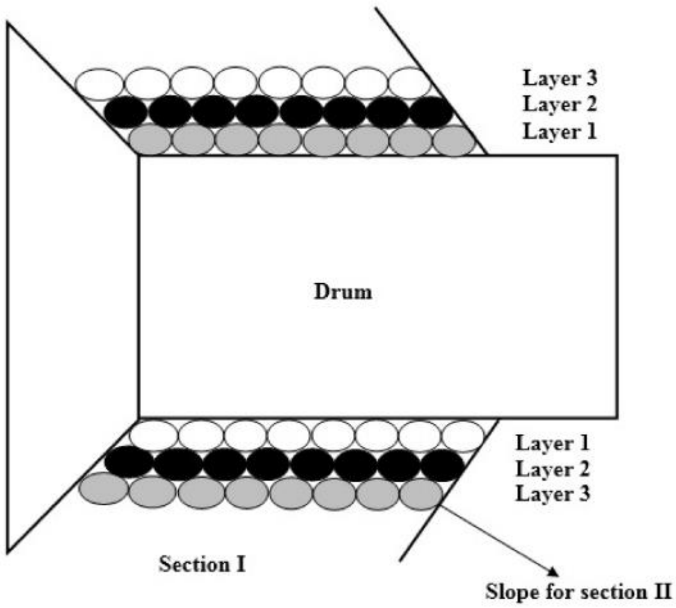


Figure 3.6: Schematic representation of sectional warping principle

As the winding of one layer is completed on the drum, the section of ends is given requisite traverse, so that the end at one extreme corner touches the inclined surface. Thus it gets support from the inclined surface.

As the process continues, the thickness (or height) of the section gradually increases. When requisite length has been wound in a section, next section is started by shifting the expandable reed assembly at a suitable distance.

The flow chart of the warping process can be represented as shown in Figure 3.8.

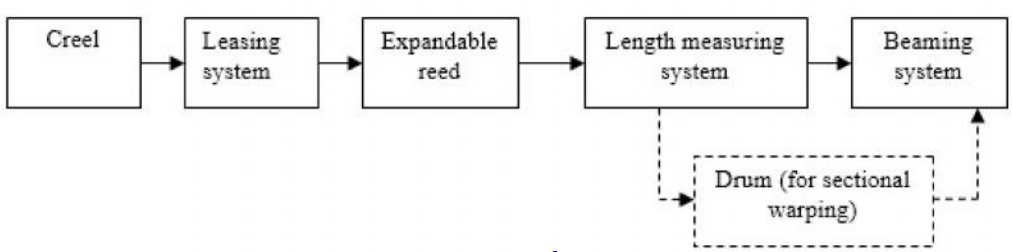


Figure 3.8: Sequence of warping process

Leasing: It is as ystem by which the position of the ends is maintained in the warp sheet. Generally, it is done by dividing the ends in to two groups (odd and even). If the odd ends are passing above the lease rods, then the even ends will pass below the rods. The relative positions of the ends get reverse in the case of second lease rod.

Expandable reed: It is used to control the spacing between consecutive ends. The two limbs of V shaped expandable reed can be expanded or collapsed as per the required spacing of ends. **Figure 3.9** shows the expandable reed and lease rods in a sectional warping machine.

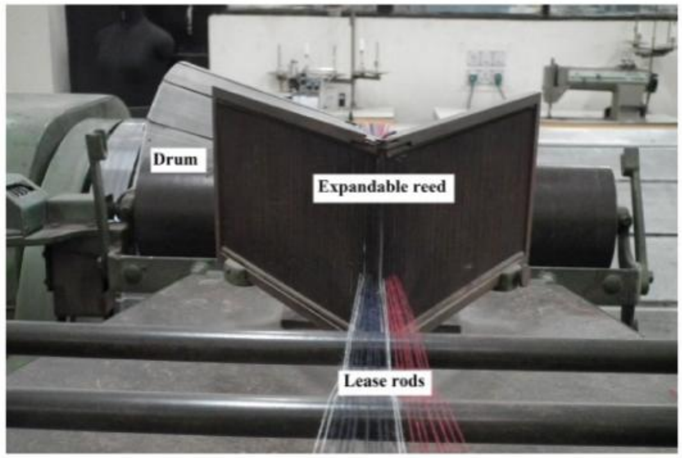


Figure 3.9: Expandable reed and lease rods

Beaming system: In the beaming process, all the sections are simultaneously transferred to the flanged warper's beam (**Figure 3.10**). The drum is rotated by the tension of warp sheet whereas, positive drives are given to the warper's beam. The speed of the beaming process in sectional warping is quite slow (around 300m/min).

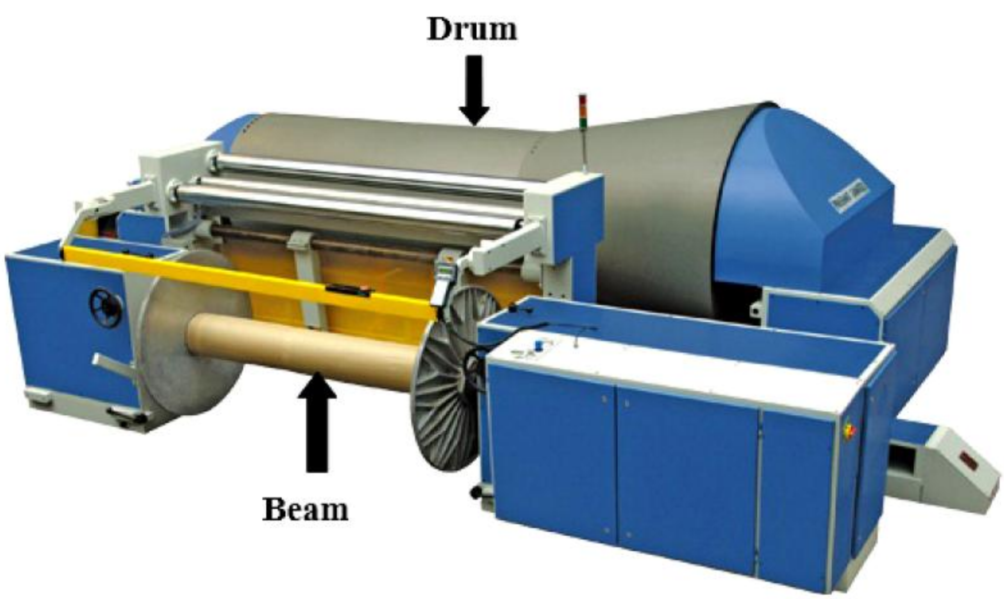


Figure 3.10: Sectional warping drum and beam

Warp Sizing

Objectives of Sizing

The objective of warp sizing is to improve the weaveability of yarns by applying a uniform coating on the yarn surface so that, protruding hairs are laid on the yarn surface.

During the weaving process, the warp yarns are subjected to abrasion from various loom components like back rest, heald eyes, reed, front rest etc. In shedding operation, warp yarns also abrade against each other. Size coating protects the yarn structure from abrasion. Therefore, the warp breakage rate in the loom gets reduced.

Benefits of Sizing

- It prevents the warp yarn breakage due to abrasion from neighbouring yarns or with back rest, heald eye and reed.
- It improves the yarn strength by 10 to 20%, although it is not the primary objective of sizing process.

Characteristics of Sized Yarn

- Higher strength
- Lower elongation
- Higher bending rigidity
- Higher abrasion resistance
- Lower hairiness
- Lower frictional resistance

Sizing Materials

Desirable Properties of Sizing Materials

The sizing material must fulfil some essential properties and at the same time it is expected that it will have some additional desirable properties. The sizing material must form a smooth and uniform coating on the yarn surface. This is known as film forming property. The coating will not only embed the protruding fibres (hairs) on the yarn body, but also protect the yarn structure from repeated abrasion during weaving. The size film should be adhered with the fibres strongly to prevent shedding (dropping of size film). The film should also have enough flexibility to cope with the flexing or bending of yarns around the back rest, heald eyes and other loom components. The non-exhaustive list of essential and desirable properties is given in Table 4.1.

Table 4.1: Essential and desirable properties of sizing materials

Film forming	Controllable viscosity
Adhesion	Easy removal and recyclability
Optimum penetration	Neutral pH
Film flexibility and elasticity	Non-polluting
Lubrication	Cheap
Bacterial resistance	

The specific requirements of sizing material properties will depend on the following factors.

- Type of fibre (cotton, viscose, nylon, polyester etc.)
- Type of yarn (ring, rotor, friction, air-jet etc.)
- Type of loom (shuttle, projectile, air-jet, water-jet etc)
- Construction features (weave, yarn counts and sett)

Composition of Sizing Material

The specific composition of sizing material depends on the fibre type, yarn type, yarn count, fabric sett etc. However, the materials can be classified under the categories of adhesive, softening agent, antimicrobial agent etc. The adhesive part is responsible for forming the film and adhering with the fibres. Softening agent makes the film flexible so that, the film can bend easily without forming cracks. Antimicrobial agents are added to mixture to avoid the action of mildew that grow on the size film. Sometimes, weighting agents and dyes are also added to fulfil specific requirements.

Cotton yarns, in general, are sized by the starch which forms the adhesive component of the size mix. The reason behind the popularity of starch can be attributed to the following factors.

- Starch is chemically more or less same with cotton and rayon and thus the adhesion is very good.
- Desizing is easy
- Relatively cheap
- Properties can be tuned to cope with the need

However, starch gives very stiff film. It has higher biological oxygen demand (BOD). Besides, cooking of starch is required to attain uniformity. In addition to, starch has poor bacterial resistance. Overall, the positive attributes of starch dominates over the drawbacks and thus it is still being used in the industry as the primary material for the sizing of cotton yarns.

The softening materials compensates for the abrasive and harsh feel that is provided by most of the starches. Softeners also lubricate the yarns so that, they can pass easily over machines parts without shedding. It also prevents the sticking of size ingredients over the drying cylinders. Mutton tallow which is composed of glycerides of palmitic, stearic and oleic acids is used as softeners. The proportion of softener in the size mix is very crucial as excess use of it deteriorates the strength of size film.

Sources of Starch

Starches are available from the seed, root or pith of plants. Corn, rice and wheat are the examples of seed starch. Potato and Tapioca starches are obtained from roots. Sago starch is obtained from pith. Starches are prepared by grinding the seed, root or pith into fine flour. When the flour is mixed with water and cooked, it produces a thick and smooth glutinous solution. Corn (Maize) starch is the most popular type of starch used in textile sizing. Around 50% of the corn is composed of starch. Corn starch is generally preferred for the sizing of coarse and medium count yarns. Potato yields around 20% starch. It is of slow congealing type and therefore gets more chance to penetrate within the yarn structure. It forms a smooth and pliable film on the yarn body. Potato starch is preferred for sizing finer yarns.

Polyvinyl Alcohol (PVA)

Polyvinyl alcohol (PVA) is a very versatile sizing material. It can be used for sizing cotton, rayon, polyester and their blends. It is manufactured by polymerizing vinyl acetate monomers and then substituting the acetate groups with hydroxyl groups by hydrolysis. The properties of the PVA are largely governed by the degree of substitution.

Sizing Machine

The sizing machine can be divided into four main zones as shown in **Figure 4.13**. The zones are

- Creel zone
- Size box zone
- Drying zone
- Headstock zone

The creel zone contains large number of warper's beam which can be arranged in different fashion depending on the design of the creel. Individual warp sheets emerging from the warper's beam are merged to form the final warp sheet which passes through the size box. During the passage through the size box, the warp sheet picks up size paste and holds a part of the paste after squeezing. Then the wetwarp sheet passes through the drying zone and winds on the weavers beam.

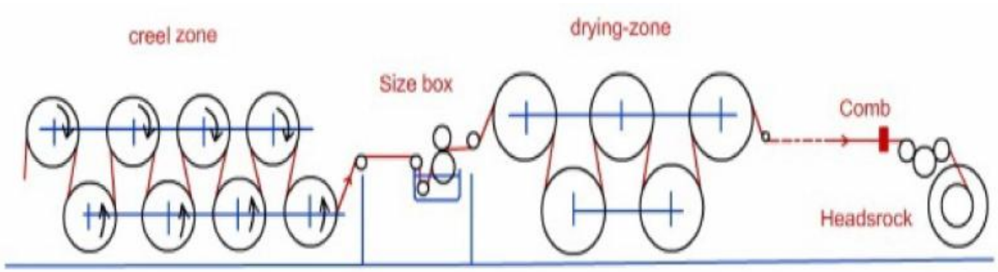


Figure 4.13: Zones of a sizing machine

Creel Zone

The creel zone of a sizing machine can have following types of design:

- Over and under creel (**Figure 4.14 and 4.15**)
- Equi-tension creel (**Figure 4.16**)
- Vertical creel (**Figure 4.17**)
- Inclined creel

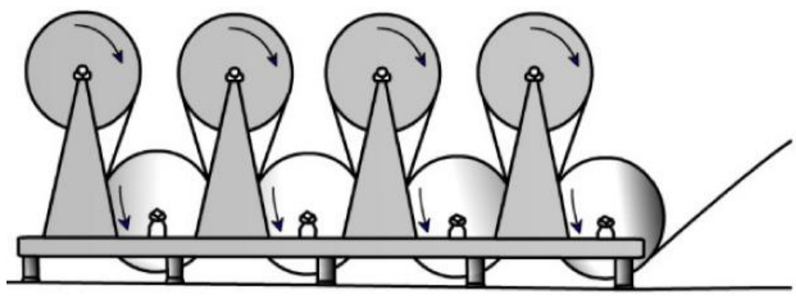


Figure 4.14: Over and under creel

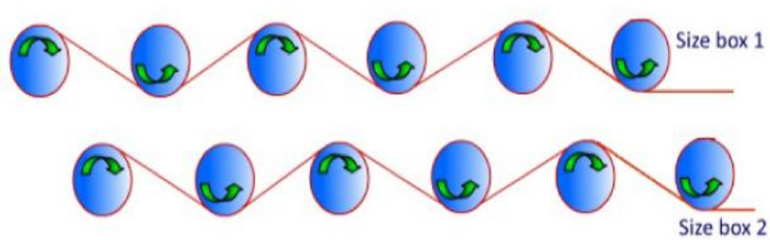


Figure 4.15: Over and under creel for two size boxes

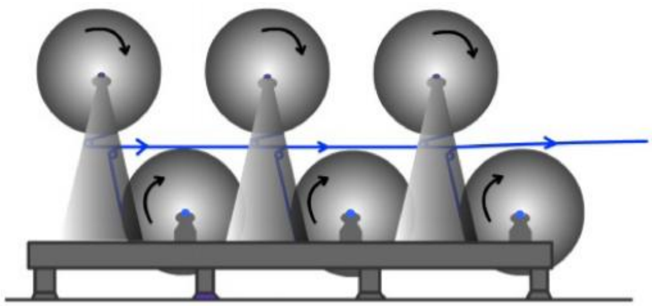


Figure 4.16: Equi-tension creel

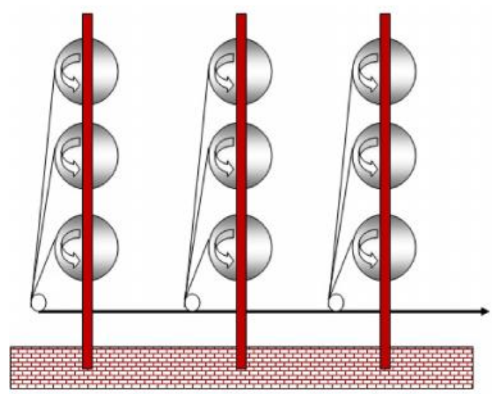


Figure 4.17: Vertical creel

In the case of over and under creel (Figure 4.14), the warper's beams are arranged in two rows, having different heights, in an alternate manner. The warp sheet coming out from the rearmost beam passes under the second beam and over the third beam and so on. The individual warp sheets coming out from the beams merge together to form the final warp sheet. The warp sheet coming from the rearmost beam definitely experiences more tension and stretch, than the warp sheet coming from the beam located nearest to the size box. The problem is partially mitigated when two creels are used, one for each of the two size boxes as shown in the Figure 4.15. If there are twelve beams, then six beams are mounted on creel one and remaining six beams are mounted on creel two, reducing the over and under movement of the warp sheet.

In the case of equi-tension creel (Figure 4.16) the pattern of movement of warp sheet is completely different from that of over and under creel. In equi-tension creel, warp sheet does not move over and under any beam. One small guide roller provided with every beam deflects the warp sheet towards the proper path. Here, the warp sheets are subjected to equal tension and stretch, irrespective of the position of the warper's beam.

Another improvement in this direction has been implemented in the inclined creel. Here the height of the beam changes based on its position, so that a constant inclination can be maintained in the path of the warp sheet.

All the designs, which have been discussed till now, requires considerable amount of floor space. This can be solved if vertical creels are used. In vertical creels, the beams are stacked vertically as shown in **Figure 4.17**.

It is very important to maintain adequate and uniform tension in the warp sheet during the entire sizing process. However, as the sizing process continues, the radius of the warper's beam reduces. Therefore, it is required to adjust the warp tension by adjusting either the dead weight suspended with the rope passing over the ruffles of the warper's beam (**Figure 4.18**) or by controlling the pneumatic pressure applied on the bearing region of warper's beam.

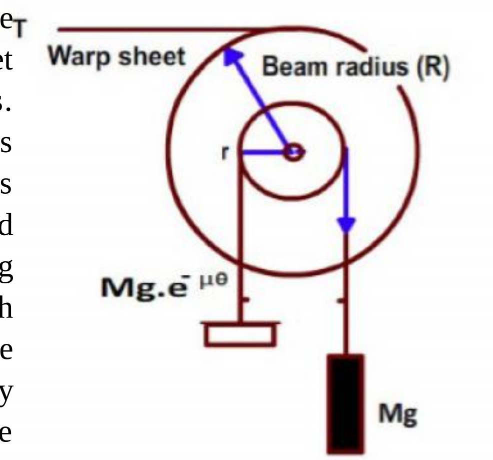


Figure 4.18: Warp tension control by dead weight system

Size Box Zone

This is the zone where the warp sheet is immersed into the size paste and then squeezed under high pressure, so that uniform coating of size film forms over the yarn surface. The process of immersion is called 'dip' and the process of squeezing by means of a pair of squeezing rollers is called 'nip'. The size box can have different number combinations of 'dip' and 'nip' to meet the requirement of various yarns. For filament yarns, 'one dip and one nip' is preferred (**Figure 4.19**) whereas for spun yarns made from staple fibres, 'two dip and two nip' is advisable (**Figure 4.20**).

Two dip and two nip process allows greater time for immersion of yarns within the size paste and thus this process forms more uniform coating of size film. When the yarns are squeezed by the first pair of squeeze rollers, yarns become compressed. When the yarns come out of the nip of squeezing rollers, they try to regain their original arrangement and therefore an inward pressure is created which causes more penetration of size materials into the yarn structure.

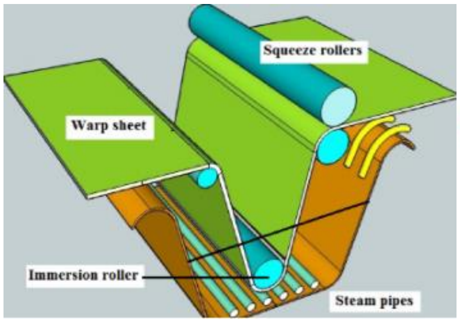


Figure 4.19:
One dip one nip size box

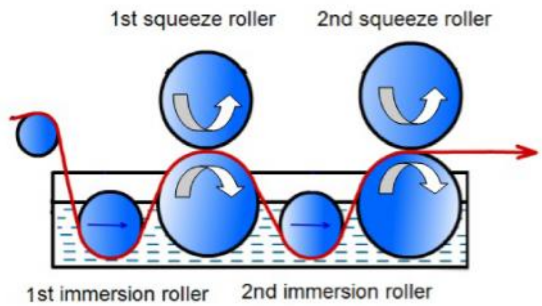


Figure 4.20: T
wo dip two nip size box

Important Parameters

The wet pick-up by the warp sheet is influenced by the following parameters:

i. Viscosity of size paste

Viscosity of a fluid indicates its resistance against the flow. The viscosity of the size paste is mainly influenced by the concentration (solid content) and temperature of size paste. Higher concentration implies higher viscosity. Viscosity of size paste reduces with the increase of temperature. The wet pick-up generally increases with increase in viscosity. Viscosity also determines the penetration of size paste within the yarn structure. If more penetration is desired, then viscosity should be lowered and vise versa. For bulky yarns, penetration is relatively easy and therefore, higher viscosity may be preferred.

Viscosity of size paste can be measured by Zahn cup. It is a stainless steel cup with a small hole at the centre of the bottom of the cup. A long handle is attached to the sides of the cup. There are five cup specifications, labelled Zahn cup #*N*, where *N* is the number from one through five. Large number cup sizes are used when viscosity is high, while low number cup sizes are used when viscosity is low. To determine the viscosity, the cup is dipped and completely filled with size paste. After lifting the cup out of the paste, the user measures the time until the paste streaming out of it breaks up, this is the corresponding 'efflux time'. Viscosity of the paste is calculated from the efflux time using standard formulae.

ii. Squeezing pressure

The squeeze pressure forces out the excess paste picked up by the warp sheet. Besides, the pressure distributes the paste uniformly over the yarn surface and causes size penetration within the yarn structure. Higher squeeze pressure reduces the wet pick-up and add-on%.

The effect of high pressure squeezing during sizing was investigated by Hari *et al.* [3]. It was found that for the same level of size add-on%, the high pressure squeezing facilitates better penetration of size within the yarn structure. However, the thickness of coating outside the yarn periphery reduces at high pressure squeezing. This reduces the dropping of size during weaving. The comparison of the size coating and penetration at high and lowsqueezing pressure is presented in **Table 4.5**.

Table 4.5: Comparison of high and low pressure squeezing

Pressure	Size coating (film thickness)	Size penetration
High	Low	High
Low	High	Low

Though there was no significant difference in the tensile properties of yarn sizes at high and low pressure, the weaveability of the former was much better than the latter.

iii. Hardness of Top Squeeze Roll

The bottom squeezing roller is made up of stainless steel. The top squeezing roller is having a metallic core part which is covered with synthetic material. If the hardness of the top roller is low, then there will be flattening of the roller. Thus the contact area increases which effectively reduces the pressure acting at the nip zone. Therefore, the size pick-up increases. In contrast, harder rollers give sharper nip and lower wet pick-up. The shore hardness of the top roller is around 45°.

iv. Thickness of Synthetic Rubber on the Top Roller

If the thickness of synthetic rubber cover on the top roller is greater, then the extent of flattening is more. This will reduce the nip pressure and thus the wet pick-up will increase.

v. Position of Immersion Roller

The position of the immersion roller within the size box is adjustable. when the height of immersion roller is lowered, then the residence time of the warp sheet within the size paste increases. This will lead to the increase in wet pick-up if other factors are constant.

vi. Speed of Sizing

Speed of sizing also influences the wet pick-up by the warp sheet.

- Higher speed reduces the residence time of the yarn within the paste which should reduce the wet pick-up.
- Higher speed increases the drag force between the warp sheet and size paste which should induce more flow of paste within the warp sheet.
- Higher speed reduces the time of squeezing, which should increase the wet pick-up.

The speed of sizing influences the wet pick-up based on the preponderance of the aforesaid factors. *In modern sizing machine, the practical speed can be around 100 m/min, though machine manufactures claim that the speed can be as high as 150 m/min.*

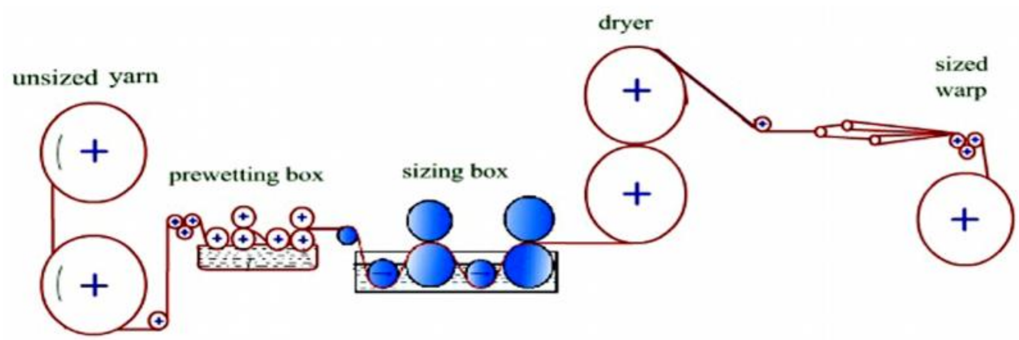


Figure 4.36: Simplified representation of pre-wetting process

2.5 Pirn Winders

Pirns are the yarn packages used within the shuttle to supply the yarns for pick insertion during weaving. The dimension of the shuttle is restricted by the shed geometry and the strain imposed on the warp yarns during shedding operation. The dimension of the pirn is governed by the dimension of the shuttle. Thus the pirn has to be a long and thin package. In contrast to cone winding, where the supply packages (ring frame bobbins) are small and the delivery packages are big, the supply packages are bigger than the delivery packages (pirn) in pirn winding. As the yarns have already been cleaned from slubs and other objectionable faults, no yarn clearing operation is required in pirn winding.

The winding principle of pirn is different from that of cones and cheeses. If a cross-wound package is made, then there will be a lot of tension variation during weaving. On the other hand, the parallel wound package gives rise to the problem of instability. Therefore, pirns are made by overlapping short, conical and cross-wound sections as shown in **Figure 2.20**.

The base of the empty pirn is generally conical. The pirn winding starts from the conical base and progressively proceeds towards the tip of the pirn. The distance travelled in one stroke of traverse is known as **chase length**. A layer of coil is laid on the conical base during the forward as well as backward movement of the traverse meachanism. Thus the conicity of the package is maintained and thus the tip of the cone formed by the coils of yarn, slowly proceeds towards the tip of the pirn. The process can be visualised as if one plastic cup (having a cone shape) is placed over the other and the process is continued to build a tall cylindrical column. This is depicted in **Figure 2.21**. For the ease of visibility, large gaps have been maintained between the two cones of coils and thus it seems that the overlapping between the two layers of coils is very low which is actually not true.

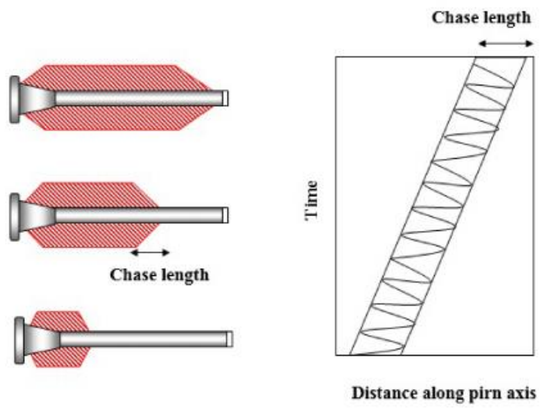


Figure 2.20: Stages of pirn winding

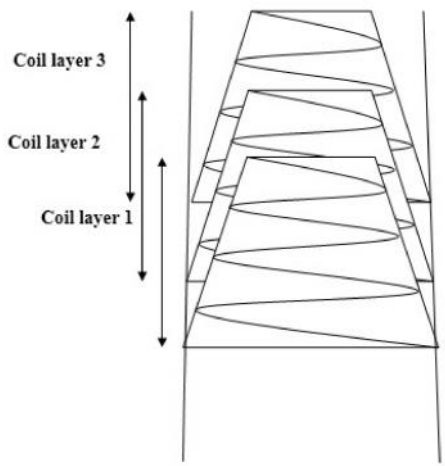


Figure 2.21: Building of a pirn

Pirns may generally be described as the following categories or types (**Figure 2.22**).

- Plain tapered pirn
- Pirn with partly formed (half) base
- Pirn with full base

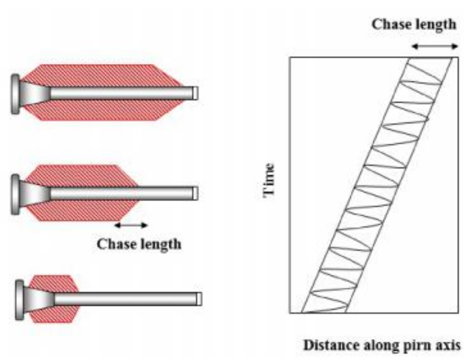


Figure 2.22:
Plain, half base and full base pirns

Yarn Tensioning

Objective of Yarn Tensioning

The primary objective of yarn tensioning is to build a package with adequate compactness.

Higher yarn tension than the optimum will result in a tighter package and vice versa. If there is any portion of yarn which is very weak from the tensile strength point of view (untwisted part of yarn) then it will not be able to sustain the applied winding tension and as a result, the yarn will break. This will lead to momentary stoppages in winding operation. However, this will preclude the possibility of yarn breakage in the subsequent processes like warping. As a rule of thumb, yarn tension in winding is around 1 cN/tex .

Types of Tensioning Devices

a. Additive type or disc type tensioner

b. Multiplicative type tensioner

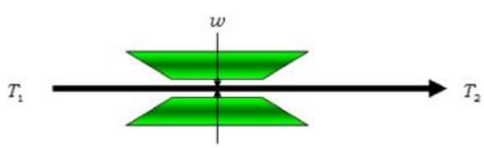


Figure 2.29: Additive type tensioner

In the case of former, the yarn is passed through two smooth discs, one of which is weighted with the aid of small circular metallic pieces (**Figure 2.29**). The weights can be changed easily, so that the tension in the output yarn can be adjusted as per the requirement.

In the case of multiplicative type tensioner, the yarn is passed round a curved or cylindrical element as shown in **Figure 2.30**.

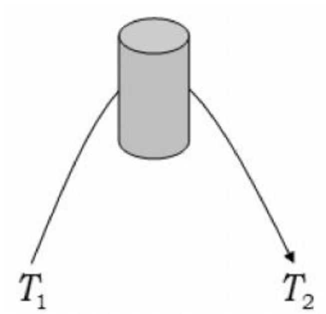


Figure 2.30: Multiplicative type tensioner

Figure 2.31 depicts the two situations with angles of wraps of ® and ® /2.

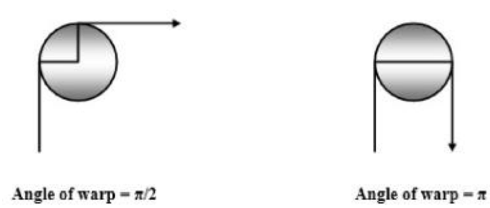


Figure 2.31: Different angle of warps

Relation between Input and Output Tensions in Multiplicative Tensioner

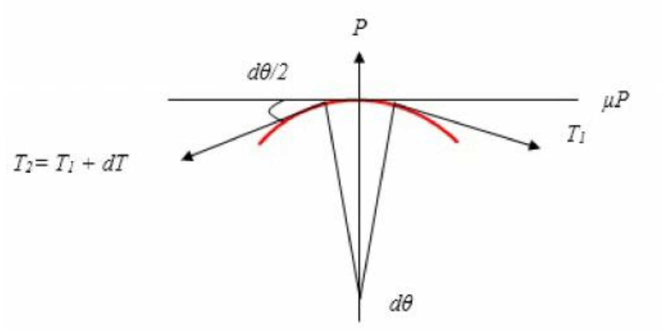


Figure 2.32: Schematic representation of yarn passing over a curved surface

The yarn passing over the curvature, is shown in red colour, which is considered to be part of the circle (**Figure 2.32**). The contact region between the curvature and yarn has created a small angle *d* at the centre of the assumed circle. The yarn tension in the input side is *T1* and tension in the output side is *T2*. The difference between *T2* and *T1* is *dT*. The difference between the horizontal component of *T2* and *T1* will balance the frictional resistance which will depend upon the coefficient of friction between the yarn and the tensioner (μ) and the resultant vertical component of *T2* and *T1*.

Tension variation duirng unwinding from cop build package

During the unwinding of yarns from cop build packages (ringframe bibbin, pirn etc) short term and long term tension variations are noticed. Short term tension variation arises due to the movement of the yarn from the tip to the base and vice versa (Figure 2.34 a). On the other hand, long term tension variation occurs due to the change in the height of the balloon formed between the unwinding point and the yarn guide (Figure 2.34 b).

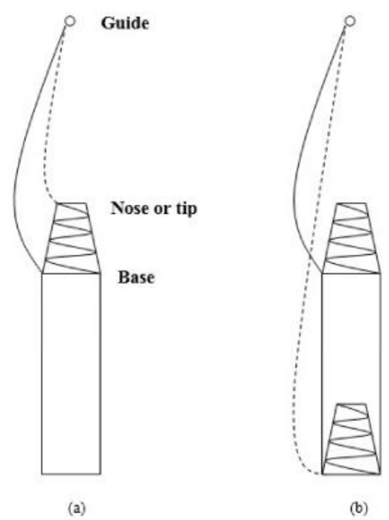


Figure 2.34: Short term and long term tension variation during unwinding

2.8 Yarn Clearing

The objective of yarn clearing is to remove objectionable faults from the supply package.

Ideally all the faults present in the yarn should be removed during the yarn clearing operation. However, a compromise is needed and only those faults which have the potential to disrupt the subsequent operations or spoil the fabric appearance should be attempted for removal during the winding operation. The compromise is done due to the following reasons:

- Removal of yarn faults during winding is associated with machine stoppages which reduce the machine efficiency.
- When a yarn fault is removed, the yarns are joined again by the knotting or splicing operation which actually introduces a new blemish in the yarn as the strength and appearance of the knotted or spliced region is not at par with the normal region of yarn.

Two principles are used in modern winders for the identification of yarn faults.

- Capacitance principle
- Optical principle

Both the principles have their inherent advantages and limitations. Capacitance system is based on the measurement of yarn mass at a given test length. In contrast, the optical system is based on diameter measurement.

Splicing

Splicing is the process by which two ends of the yarns are joined. In most of the machines dealing with spun yarns, pneumatic splicers are used. Robotic arms aided with air suction bring two ends of the yarns inside the splicing chamber. Then compressed air is jetted to create turbulence inside the chamber so that the yarn is untwisted. Then some fibres are removed from the yarn ends to give a wedge-shape appearance. Jetting of compressed air is done again to twist the two superimposed ends of the yarns (**Figure 2.45**). Splicing shows less severe fault in the yarn and the appearance of spliced portion of the yarn is checked with a yarn appearance board.

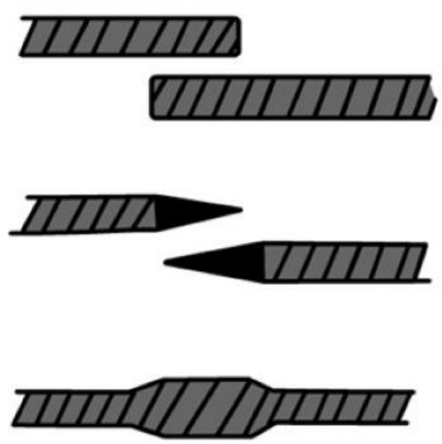


Figure 2.45: Steps of yarn splicing

Higher retained splice strength (85-90%) and lower splice breaking ratio imply good splicing performance.

Defects in Winding

Some of the major defects observed in the wound packages are as follows:

- Ribbon or pattern
- Stitches or jali
- Soft tip or base
- Slough off

The ribbons are formed when the coils of two successive layers rest over or are very close to one another as shown in **Figure 2.49**. This happens in drum-driven winder when the traverse ratio becomes an integer. Thick ridges are formed due to patterning and it mars the appearance of the package. Besides, the density of the package at the ribbon part becomes very high which causes problems in unwinding and dyeing.

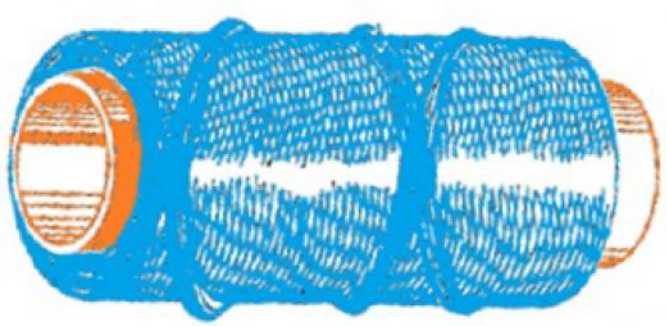


Figure 2.49: Package with ribbon or pattern defect

Patterning is prevented in some of the drum-driven machines by momentarily lifting the package from the drum and thereby creating some intended slippage. This causes a change in the yarn path from the anticipated one and thus patterning problem is avoided.

Stitches are formed when the yarn is wound beyond the boundary of the package. It may happen due to improper traverse guidance of the yarn at the edges of the package. If the winding tension is low, then the yarn may exceed the boundary line up to where it is supposed to travel. The improper contact between the package and the winding drum may also cause stitches.

If the pressure between the package and the drum along the line of contact is not uniform then the package may have different density at the tip and base regions. Higher contact pressure will lead to higher package density and vice versa. The alignment of the winding drum and the package must be correct to ensure uniform density along the axis of the package. The position of the yarn guide should be exactly at the centre of the winding drum so that the length of the yarn between the package and the yarn guide remains the same at the two extreme positions of traverse.

Slough off is the problem of removal of multiple coil from the package during high speed unwinding. If the package density or gain is not adequate, then slough off may occur when the wound package is used in the warping section.

Winding and Yarn Hairiness

The yarn hairiness increases due to winding. The reasons are as follows:

- Abrasion of yarn due to various machine parts
- Transfer of fibres from one section of the yarn to the other.

Research by Rust and Peykamian [3] has shown that yarn hairiness increases to a greater amount if the winding speed is high. During winding, redistribution of twist takes place. The twist flows to the regions with lower yarn diameters. This causes fibre transfer and increase yarn hairiness. Though the average helix angle remains unaltered after winding, the variation in twist angle reduces after winding which supports the fact that twist rearrangement takes place during winding.

Weaving technology

Weaving is the most popular way of fabric manufacturing. It is primarily done by interlacing two orthogonal sets (warp and weft) of yarns in a regular and recurring pattern. Actual weaving process is preceded by yarn preparation processes namely winding, warping, sizing, drawing and denting.

Winding converts small ringframe packages to bigger cheeses and cones while removing objectionable yarn faults. Pirn winding is performed to supply weft yarns in shuttle looms. **Figure 1.2** shows various yarn packages used in textile operations (from left to right: ringframe bobbin or cop, cone, cheese and pirn).

Warping is done with the objective of preparing a warper's beam which contains large number of parallel ends in a double flanged beam. Sizing is the process of applying protective coatings on the warp yarns so that, they can withstand repeated stresses, strains and flexing during the weaving process. Finally the fabric is manufactured on looms which perform several operations in a proper sequence so that, there is interlacement between warp and weft yarns and continuous fabric production.

Figure 1.2: Types of yarn packages

Weave Design

Fabric weave design implies the pattern of interlacement between the warp and weft yarns. The design influences the aesthetics as well as the properties of the woven fabrics. The design of woven fabrics is manipulated by changing the following two things.

- Drafting
- Lifting plan

The design is constructed on point paper by using cross (×) and blank. The cross means that the end is passing over the pick. The blank means the end is passing below the pick.

Drafting

Drafting determines the allocation of ends to healds i.e. which end will be controlled by which heald. Generally, drafting is made in such a way that minimum number of healds is required to produce a particular design. This implies that if the interlacement pattern of two ends is identical then they should be controlled by the same heald shaft. In the case of drafting, a cross means that the heald is up and a blank means that the heald is down.

Drafting is shown above the weave design.

Lifting Plan

Lifting plan shows the position of healds (up or down) for different peaks i.e. which heald or healds will be lifted by which pick. It is dependent on the design and the drafting.

Lifting plan is shown at the right hand side of weave design.

Straight Draft

In the case of straight draft, a diagonal line is created by the crosses (**Figure 5.1**). This implies that, generally, end one is controlled by heald one, end two is controlled by heald two and so on.

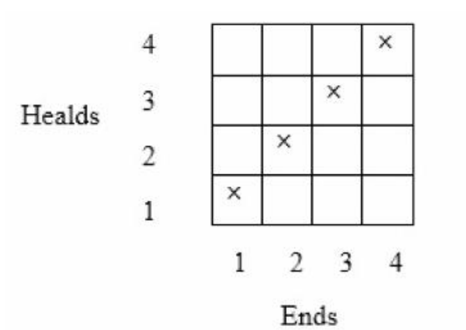


Figure 5.1: Straight draft

Pointed Draft

In the case of pointed draft, a pointed line is created by the crosses (**Figure 5.2**). The repeat of the design contains more than one ends with similar interlacement pattern. For example, in **Figure 5.2**, the interlacement pattern is same for ends 1 and 7 and thus they are allocated to one heald (heald number 1). It is also true for ends 2 and 6, 3 and 5, 4 and 8. Therefore, this design which is having eight ends in the repeat requires only four healds. Pointed twill weaves are made using pointed draft.

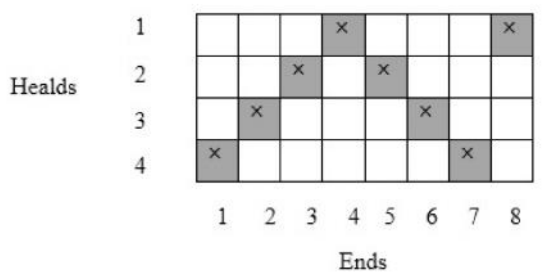


Figure 5.2: Pointed draft

Skip Draft

In the case of skip draft, two or more healds are controlled by a single shedding cam. Plain woven fabrics can be woven with two healds. However, for heavy (high areal density) plain woven fabrics, the number of ends is very high. It often becomes convenient to use four healds for the heavy plain woven fabrics. Therefore, the number of ends controlled by a single heald becomes less as compared to the situation with only two healds. The skip draft for plain woven fabrics with four healds is shown in **Figure 5.3**.

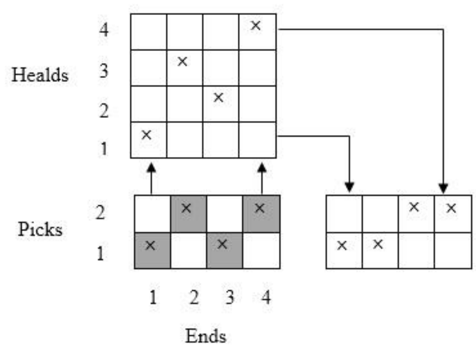


Figure 5.3: Skip draft

The allocation of healds is shown in **Table 5.1.**

Table 5.1: Assigning ends in healds for skip draft

End number	Heald number
1	1
2	3
3	2
4	4

So, the allocation of healds for ends 2 and 3 differs from that of straight draft. Lifting plan shows that for the 1 st pick, healds 1 and 2 are in up position and healds 3 and 4 are in down position. For pick 2, healds 1 and 2 are in down position and healds 3 and 4 are in up position. Therefore, the movement pattern of healds 3 and 4 is just opposite as compared to that of healds 1 and 2. Therefore, healds 1 and 2 can be tied or coupled together with ropes or strings and their shedding operation can be controlled by a single cam. Similarly, shedding operation of healds 3 and 4 can be controlled by another cam. Thus, skip drafting helps to reduce the number of mechanical components (cam, follower, treadle lever etc.) in the loom.

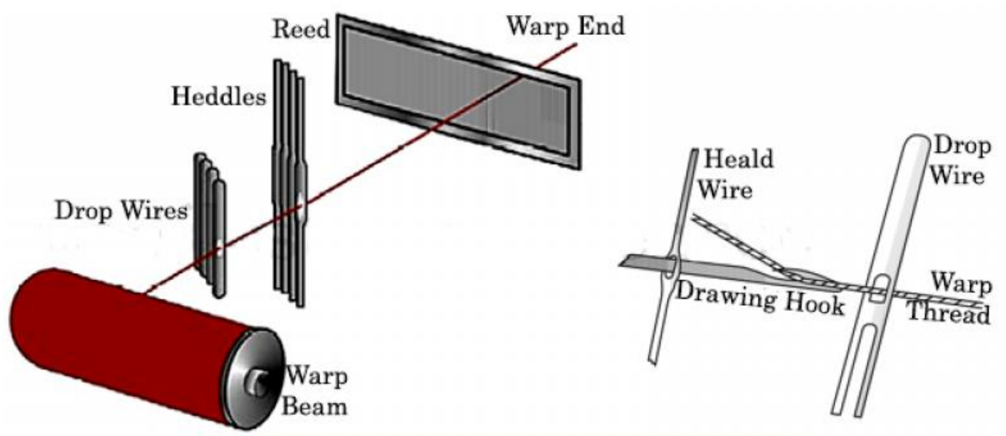


Fig: Schematic Diagram of Drawing in

Types of Looms

Hand Loom: This is mainly used in unorganized sector. Operations like shedding and picking is done using manual power.This is one of the major sources of employment generation in rural areas.

Power Loom: It was designed by Edmund Cartwright in 1780s (during the industrial revolution). All the operations of the loom are automatic except the change of the pirn.

Automatic Loom: In this power loom, the exhausted pirn is replenished by the full one without stoppages. Under-pick system is a requirement for these looms.

Multiphase Loom: Multiple sheds can be formed simultaneously in this looms and thus productivity can be increased to a great extent. It has failed to gain commercial success.

Shuttle-less Loom: Weft is carried projectiles, rapiers or fluids in the case of shuttle-less looms. The rate of production is much higher for these looms. Besides, the quality of the products is also better and the product range much broader compared to that of Power looms. Most of the modern mills are equipped with different types of shuttle-less looms based on the product range.

Circular Loom: Tubular fabrics like hose-pipes and sacks are manufactured by circular looms.

Narrow Loom: These looms are also known as needle looms used to manufacture narrow width fabrics like tapes, webbings, ribbons and zipper tapes**.**

Hand looms

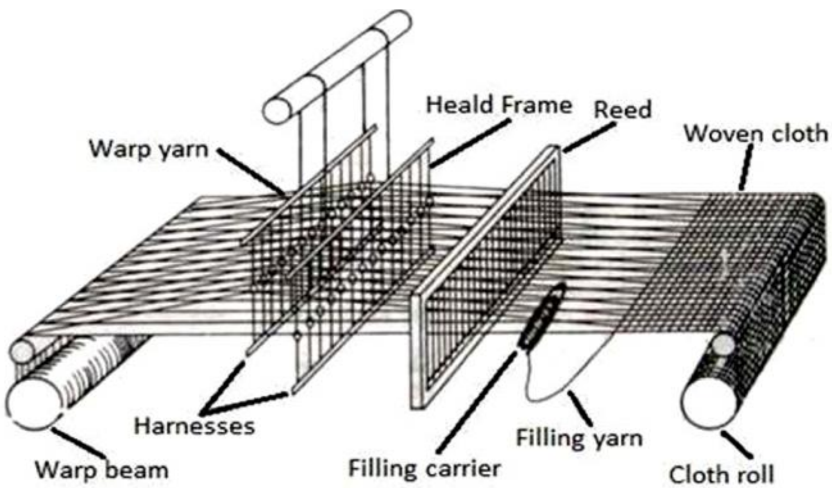


Figure: Basic structure of a loom

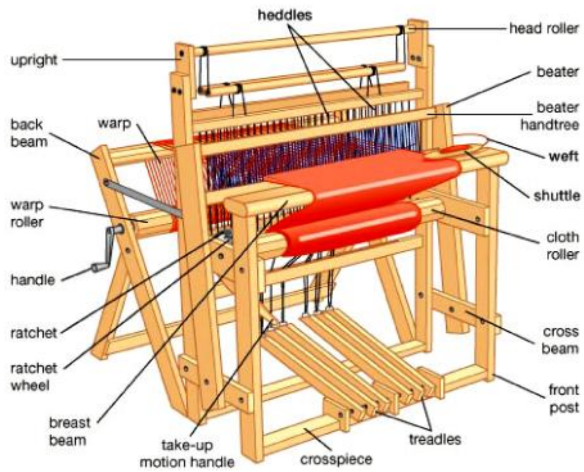
The terms 'hand-loom' and 'hand-woven' have different connotations. It is therefore necessary to define hand-looms more precisely and, in doing so, place them in three different categories. These categories are:

(i) Looms in which the primary and secondary motions are co-ordinate manually, and in which picking is performed without a 'fly-shuttle';

(ii) Looms in which the primary and secondary motions are co-ordinate manually, but in which picking is performed with a fly-shuttle;

(iii) Looms in which both primary and secondary motions are co-ordinate mechanically, and which include a fly-shuttle mechanism which is also operated mechanically. Looms of this type can usually be power-driven if fitted with a motor, although when classed as a hand-loom they are driven by human power acting via a treadle system.

(a) Category (i) hand-looms



Looms in category (i) are quite unsuitable for bulk production of the fabrics listed in Table I.1, even at the ‘small-scale’ level of 100,000 metres per annum. Picking speeds are much too low, being often less than 10 picks/min and, consequently, labour and other costs - such as those for factory accommodation and for work in hand - would be too high to make it worthwhile. No further consideration to these looms has therefore been given.

(b) Category (ii) hand-looms

More promising could be the use of looms in category (ii) but only for the ‘small-scale’ level of production. This category of loom can meet the production target if weaving speeds of around 40 picks/min can be maintained. However, only skilled weavers can be expected to perform at this level. Furthermore, good warp and weft preparation, as outlined in Chapter II, would be necessary.

(c) Category (iii) hand-looms

Looms in category (iii) could certainly meet small-scale production levels, since they can be operated at appreciably higher speeds (e.g. 80 picks/min). However, the maintenance of such a speed over a long period of time is dependent on the weaver’s skills and the quality of warp and weft preparation. In addition, the amount of physical energy expended in weaving, in unfavorable climatic conditions, must certainly not be overlooked if this option is to be seriously considered.

Economics of hand-looms

Estimates of the numbers of looms which would be required to weave each of the fabrics considered are provided in Table III.1. These estimates are based on a loom running efficiency of 50% for category (ii) looms and

75% for category (iii) looms. It must be stressed that these values are estimates since they are based on assumed running efficiencies.

While category (iii) looms are more efficient, they are also much more costly than category (ii) looms. Some unconfirmed reports suggest the costs to be greater by a factor of 10.

More recently, a loom similar to category (iii) looms has been developed in Nepal. However, it does not have mechanical take-up and warp let-off facilities, but may be available at a lower comparative cost. If this information is correct, such a loom would be expected to be intermediate in running efficiency, and the number required for each cloth type would be roughly mid-way between those quoted for categories (ii) and (iii) looms.

Power Loom

Primary Motions

Three primary motions are required in the loom for weaving.

- Shedding
- Picking
- Beat-up

Shedding is the operation by which the warp is divided into two parts, so that sufficient gap is created between them for the uninterrupted passage of the weft from one side of the loom to the other. Picking is the operation to transfer the pick (weft)from one side of the loom to the other. In shuttle loom, picking is done from both sides. However, in shuttleless looms, it is done from only one side of the loom (generally from left). Several systems are available for picking. Shuttle is the most traditional mode of picking and it is still being used in the industry. In shuttleless looms, following picking systems are used.

- **Projectile**
- Air-jet
- Water-jet
- Rapier

Beat-up is the operation to position the newly inserted pick up to the cloth fell i.e. the boundary up to which the fabric has been woven.

Secondary Motions

Two secondary motions are required in the loom for weaving.

- Take-up
- Let-off

Take up motions ensure the winding of fabric continuously as soon as it is produced. Ensuring uniform pick spacing is also another function of take up motion. When the fabric is wound by the take-up system, the tension in the warp increases and thus it is required to release the warp from the weaver's beam which is performed by the let-off motion.

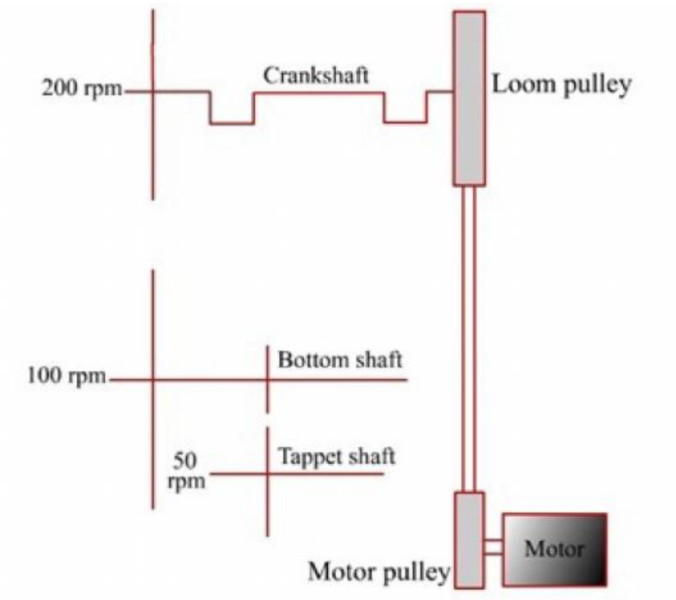


Figure 6.1: Transmission of motions in loom

The transmission of motions to some of the important loom components has been shown in **Figure 6.1**. The loom pulley (machine pulley) gets motion directly from the motor pulley. The crank shaft, which has to a special design, is connected the loom pulley. The revolution per minute (r.p.m.) of the crank shaft is equal with the loom speed (number of picks inserted per minute or picks/minute). The beat-up operation is done by the reed which is carried by the sley and the latter is connected to the crank shaft. One revolution of crank shaft causes one beat-up. Therefore, if 200 picks are being inserted per minute, 200 beat ups are required in one minute. Thus the r.p.m. of the crank shaft has to be 200.

Crank shaft is connected with the bottom shaft through gears. As the name implies, bottom shaft is positioned near the floor. Picking motion is originated from the bottom shaft in the case of shuttle looms. Two picking cams are mounted on the bottom shaft, one on each side. Therefore, one revolution of bottom shaft ensures the insertion of two picks. So, for inserting 200 picks per minute, bottom shaft should rotate at 100 r.p.m. The r.p.m. of bottom shaft is always half as compared to that of crank shaft.

In the case of plain weave, the healds return to the same position after every two picks. Therefore, two shedding cams can be mounted on the bottom shaft for controlling the healds. However, for other weaves, where more than two healds are required, a cam shaft (also known as tappet shaft) is used. For example, in the case of 3×1 twill weave,shedding cycle extends over 4 pick. In this case, 4 shedding cams are mounted on cam shaft which rotates at 50 r.p.m. The primary motions, their frequency and controlling loom shaft for plain weave and 3×1 twill weave are given in **Tables 6.1** and **6.2** respectively.

Table 6.1:
Frequency of primary motions and controlling shaft for Plain weave

Operation cycle	Frequency of operation	Loom shaft
Shedding	Once/2 pick	Bottom
Picking	Once/2 pick	Bottom
Beat-up	Once/ pick	Crank

Table 6.2:
Frequency of primary motions and controlling shaft for 3×1 twill weave

Operation cycle	Frequency of operation	Loom shaft
Shedding	Once/4 pick	Cam/tappet
Picking	Once/2 pick	Bottom
Beat-up	Once/ pick	Crank

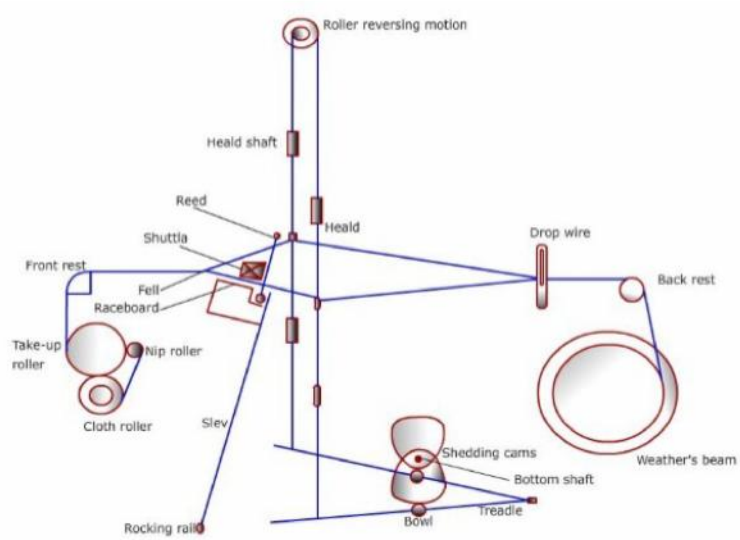


Figure 6.2: Cross-sectional view of loom

Cam Shedding Systems

The cross-sectional view of a plain loom with cam shedding mechanism is shown in **Figure 6.2**. Two shedding cams are controlling two healds through treadle levers. The tips of the treadle levers are connected to the healds with ropes and links. Each of the treadle levers carry one treadle bowl (pulley) which actually remains in contact with the shedding cams.

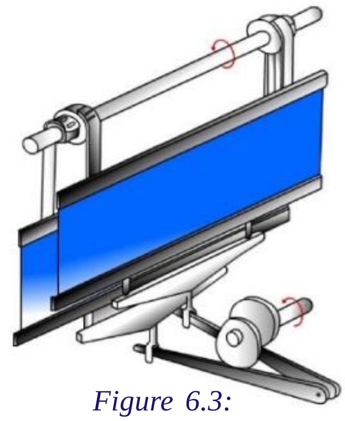


Figure 6.3: Cam shedding system

For plain woven fabrics, two shedding cams are positioned at 180° phase difference. Therefore, when one cam pushes the treadle bowl in the downward direction, the other cam accommodate the upward movement of the other treadle bowl. The upward movement of the heald is activated by the roller reversing mechanism which is positioned over the loom. Figure 6.3 presents another view of cam shedding system and roller reversing motion.

Negative and Positive cams

The cams used for shedding can broadly be classified under two categories. Negative cams can control only the one part (50%) of the movement of the healds (downward movement). The upward movement is ensured by the roller or spring reversing mechanism. When back heald is pushed downward, the reversing roller rotates clockwise. This causes winding of belts, connected to the front heald, on the reversing roller with smaller diameter. Thus the front heald moves upward. Similarly, when the front heald moves downward, the reversing rollers rotate anti-clockwise. So the belt, connected to the back heald, is wound on the bigger pulley of roller reversing system. As a result the back heald is lifted. Thus the entire system ensures upward and downward movements of the healds. So, the whole system can be classified as a positive system. Although the cams used for this are negative, they alone can ensure the downward movement of the healds.

Figure 6.4: A model of grooved cam

Positive cams can control the upward and downward movement of the healds.

Grooved cams (**Figure 6.4**) or matched cams are generally used as positive cams.

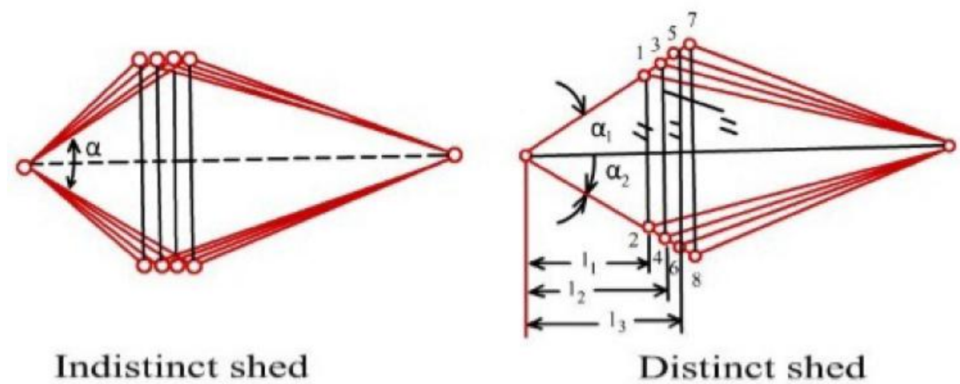


Figure 6.5: Indistinct (unclear) and distinct (clear) sheds

Distinct (clear) and Indistinct (unclear) Shed

If the extent of vertical movement of the healds during shedding is same, then indistinct or unclear shed is produced as depicted in the left hand side of **Figure 6.5**. In the case of indistinct shed, the position of the top shed line is different for different healds. Therefore, the shuttle actually get amount of space through which it has to travel. So, the possibility of abrasion and collision of the shuttle and shed line is higher.

In the case of distinct or clear shed, shown in the right hand side of **Figure 6.5**, the position of top shed line in the front part of the shed is the same irrespective of healds. This type of shed can be formed if the extent of vertical movement of the healds during shedding is changed based on their position. The first heald, which is nearer to the cloth fell, has the minimum vertical movement and the last heald has the maximum vertical movement. The shuttle gets more space to travel in the case of distinct.

Lift (throw) of the Cam

In the preceding section, it has already been discussed that a higher vertical movement is required for the back heald, so that a distinct shed is formed. However, the effective length of the treadle lever should be shorter for the back heald. Thus, if the lift or throw of the cams controlling the back and front heald is the same, higher vertical movement results for the front heald. This is just the opposite of the actual requirement. To overcome this problem, cam which is controlling the back heald should possess higher lift as compared to the cam controlling the front heald.

Let us consider the following parameters as shown in **Figure 6.6**.

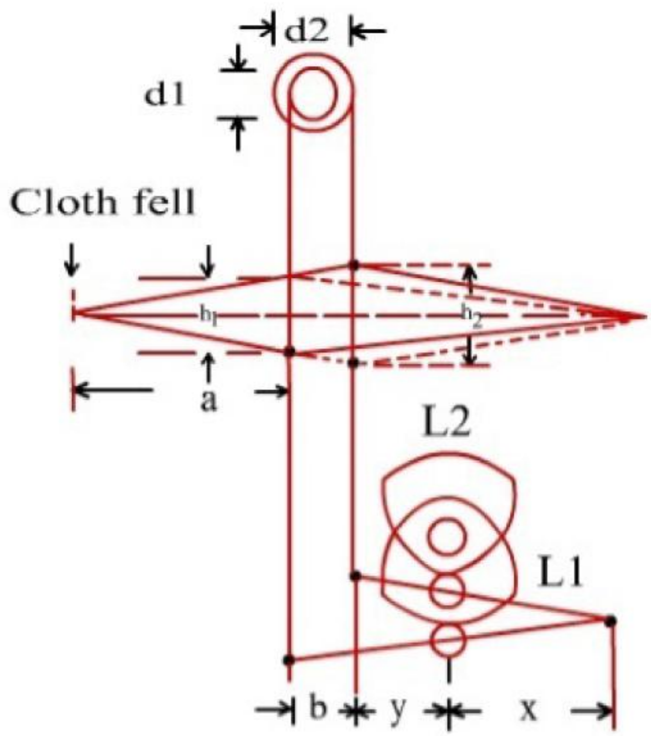


Figure 6.6:
Lift of the cams and movement of the healds

- *x* is the distance between the fulcrum point of treadle levers and centre of treadle bowl.
- *y* is the distance between the centre of treadle bowl and tip of the treadle lever tied with the back heald.
- *b* is the distance between the front and back heald.
- *a* is the distance between cloth fell and front heald.
- *h1* and *h2* are the lifts of the front and back healds respectively.

Diameter of the reversing rollers

The shaft carrying reversing rollers move clockwise and anti-clockwise to control the heald movement. The angular movement of the shaft during shedding is constant.However, it has to ensure that the back heald gets higher vertical movement than the front heald, so that a distinct shed is produced. This is attained by using two reversing rollers with different diameters. The roller with bigger diameter is connected to the back heald and vice versa. As the linear movement of reversing roller (angular movement × radius) is equal to the vertical movement of the corresponding heald

A simplified geometry of the shed is shown Figure 6.7.

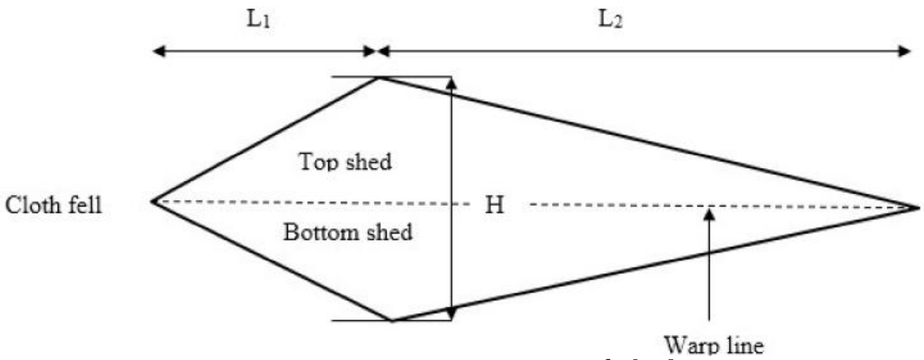


Figure 6.7: Geometry of shed

The main shed parameters are as follows:

- *L 1*: length of the front shed
- *L2*: length of the back shed
- *H* : shed height

When the healds are on the warp line (healds are levelled), the path taken by the warp is the shortest. However, as the healds move away from the warp line, the warp takes a longer path. Thus, warp yarns are extended which has to be compensated either by the extensibility of the warp or by the regulation of the yarn delivery system. If the length of the back shade increases, then yarn extension is reduced and this is preferred for weaving delicate yarns like silk. However, shorter back shed creates clearer shed and it is preferred for weaving coarser and hairy yarns. It is important to understand the factors which influence the degree of yarn extension during shed formation. A simplified mathematical model has been presented to relate the warp strain with the shed parameters.

Timing of Shedding

One pick is equivalent to one complete rotation of the crank shaft. The timing of the various loom operations are indicated corresponding to the angular position of the crank shaft as shown in the **Figure 6.9**.

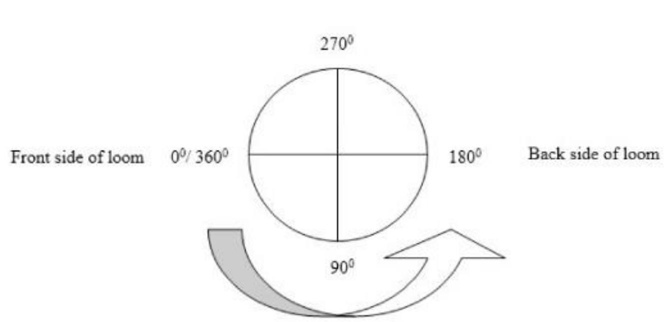


Figure 6.9: Different angular positions of crank shaft

When the crank points towards the front side of the loom (where the weaver stands), it is considered as 0° position of crank shaft. It is also known as front centre. When the radius of the crank points downwards, it is considered as 90° position of crank shaft. It is also termed as bottom centre. When the radius of the crank points towards the back side of the loom (towards the back rest), it is considered as 180° position of crank shaft. It is termed as back centre.When the radius of the crank points upwards, it is considered as 270° position of crank shaft. It is termed as top centre.

At 0°, the reed reaches the we most forward position and performs the beat-up. On the other hand, at 180°, the reed moves to the utmost backward position. The sley (and reed) moves forward and backward continuously during the entire 360° . However, the healds do not move continuously. When the shed is completely open, the healds remain stationary for some time, so that shuttle can pass through the shed without any interference. This is called the 'dwell' period of shed. Two types of shed timing (early and late) are generally used.

Early Shedding

The timing for early shedding is depicted in **Figure 6.10**. E and L represent the timing of shuttle entry and exit. The shuttle enters and leaves the shed at around 110° and 240° respectively. The shed is levelled (closed) at 270° . Then it starts to open as the two healds starts moving in opposite directions. The shed is fully open at 30° .Two healds are at two extreme positions at this moment (One heald is at the topmost position and another is at the utmost bottom position). From 30° to 150°, the healds are stationary.

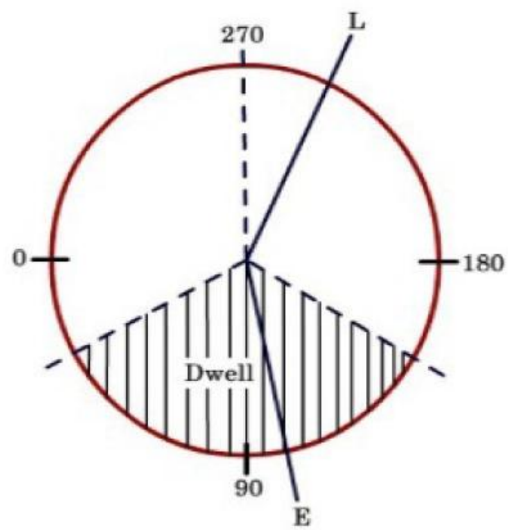


Figure 6.10:
Timing for early shedding

Therefore, the shed is fully open and at dwell during this period. After150°, the healds start to move in the opposite direction as compared to the movement between 270° and 30°. This means that the heald which was at the topmost position starts to descend and vice-versa. The shed is again levelled at 270°.

It is understood that when the shuttle enters the shed (110°), more than half of the dwell period is over. When the shuttle leaves the shed (240°), the shed is about to close. Therefore, there is a high probability that the shuttle will abrade the warp sheet, which is not desirable specially for the delicate warp yarns. However, this type of timing is advantageous for weaving heavy cloth. Because, during beat-up (0°), the shed is crossed and the newly inserted pick will be trapped by the crossed warp yarns. As a result, the pick will not be able to move away from the cloth fell even after the reed recedes. This facilitates the attainment of higher picks per inch which is required for a heavy fabric.

Late Shedding

The problem of abrasion between the warp and the shuttle can be minimised by adopting late shedding as shown in the **Figure 6.11**. In this case, the timing of shedding in delayed is such a way that the dwell period almost coincides with the timing of shuttle flight. The shed is levelled (closed) at 0° . Then it starts to open as the two healds move in opposite directions. The shed is fully open at 120°. From 120° to 240°, the healds are stationary. Therefore, the shed is fully open and at dwell during this period. The timing of shuttle flight (110-240°) almost coincides with the dwell time. After 240°, the healds start to move in the opposite direction and the shed is again levelled at 0°/360°.

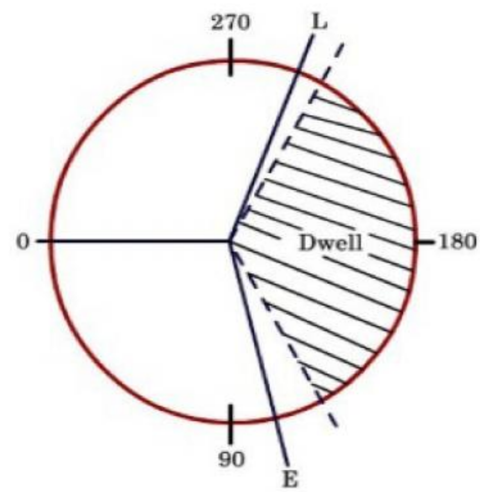


Figure 6.11:
Timing for late shedding

The beat-up occurs when the shed is levelled and healds are yet to cross each other. Therefore, this timing is not favourable for weaving heavy fabrics. However, this kind of timing is favourable for weaving delicate warp yarns and the possibility of abrasion with the shuttle is very low.

Effect of Shed Timing and Backrest Position

The early shedding coupled with raised position of the backrest results higher pick density in the woven fabric. **Figure 6.12** shows the normal and raised position of

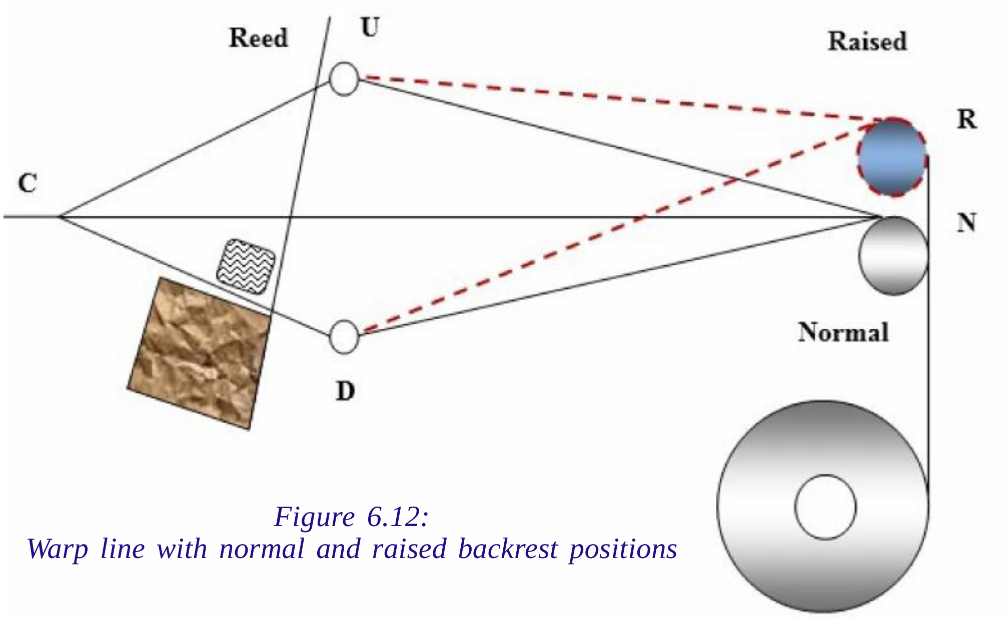


Figure 6.12:
Warp line with normal and raised backrest positions

the backrest. When the backrest is at normal position, the top and bottom sheds are symmetrica to the line CN which represents the warp line when the shed is levelled. In this case, the length of the two shed lines CUN and CDN are equal which signifies that, the tension in both the sheds (top and bottom) is equal. However, when the backrest is raised from its normal position, the length of shed lines become unequal. This is clearly visible from the fact that the length of the top shed line CUR is smaller than the bottom shed line CDR. Thus the tension in the top shed line will be lower than that of the bottom shed line.

In the case of early shedding, the shed will be levelled at 270° . At beat-up (360°), the shed is fully crossed i.e. the top shed line of the last pick has now formed a bottom shed-line and vice-versa. Thus the higher tension prevailing in the bottom shed-ends will force the newly inserted weft (circle)to more downwards from the cloth plane as shown in Figure 6.13a. This is be facilitated by the greater curvature attained by the top shed-ends, which are now under low tension. The previous pick (the second circle from the right) will be forced upwards with respect to the cloth plane but with a lesser magnitude. This process will be repeated after the insertion of each and every pick and as a consequence,

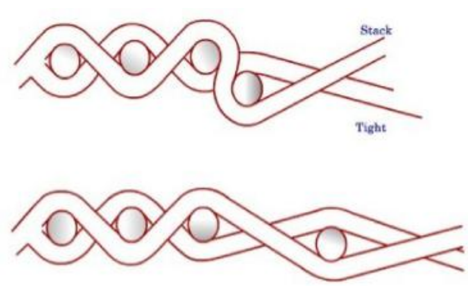


Figure 6.13. (a) Vertical displacement of newly inserted weft (b) Beat up at crossed shed

higher pick density in the fabric results. As the beat-up is performed at crossed shed, the newly inserted weft remains tightly meshed between the ends, as the reed pushes the former towards the cloth-fell against yarn-to-yarn frictional and bending resistances (Figure 6.13b). Once the beating is completed and sley starts its movement towards the back centre of the loom, newly inserted pick cannot spring back away from the cloth-fell as it is trapped in the crossed shed.

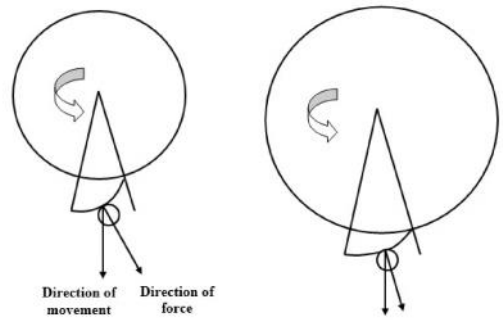


Figure 6.34: Influence of cam dimension on the steepness of cam contour

Dobby Shedding Systems

Limitation of Cam Shedding

The cam shedding system has limitation in terms of number of healds that can be effectively controlled during shedding. The problem arises when the number of picks in the repeat of the design is very high. Let us assume that the design is repeating 10 picks (8/2 twill). The number of healds required in this case will be 10 and to control these healds 10 cams are required. These cams will be mounted on the cam (or tappet) shaft which will rotate at one tenth r.p.m. as compared to that of crank shaft. Therefore, one rotation of the cam shaft will ensure insertion of 10 picks. As 360° rotation of the cam corresponds to 10 picks, one pick becomes equivalent to 36°. If the dwell is one third of pick, then the smallest dwell period (when heald is down) in this case will be = 1/3×36° + 36° = 48°. The duration of movement of heald (when the radius of the cam changes) will be 24° each for upward and downward direction.This will create the big dwell (when the heald is up) of 12° + 7×36° = 264°.

Now, the above calculation reveals that the follower has to move from the lowest position to the highest position within 24° span which is available for it. The follower follows the contour of the cam profile which becomes steep when the span available for movement is low. Besides, the force acts on the follower in a direction which is perpendicular to the tangent drawn on the cam contour. However, the follower has to move vertically up or down. Thus an angle is created between the direction of the applied force and the direction of the movement of the follower. This angle becomes even greater when the cam contour is steeper i.e. the span available for upward or downward movement is low which has resulted from the higher number of picks in the design repeat. This leads to the fact that only one component of the force applied becomes effective in creating the movement of the follower. Thus very high force is actually required to create the desired movement of the follower which may lead to wear and tear as well as vibration in the system.

One plausible solution to the aforesaid problem could be to increase the dimension of the cams (**Figure 6.34**). It can be observed that the cam contour, for a given span of follower movement, becomes less steep when the diameter of the cam increases. However, this may create another problem in terms of power consumption and space availability in the system.

Therefore, when the large number of healds is to be controlled by the shedding mechanism, Dobby system is preferred.

Keighley Dobby

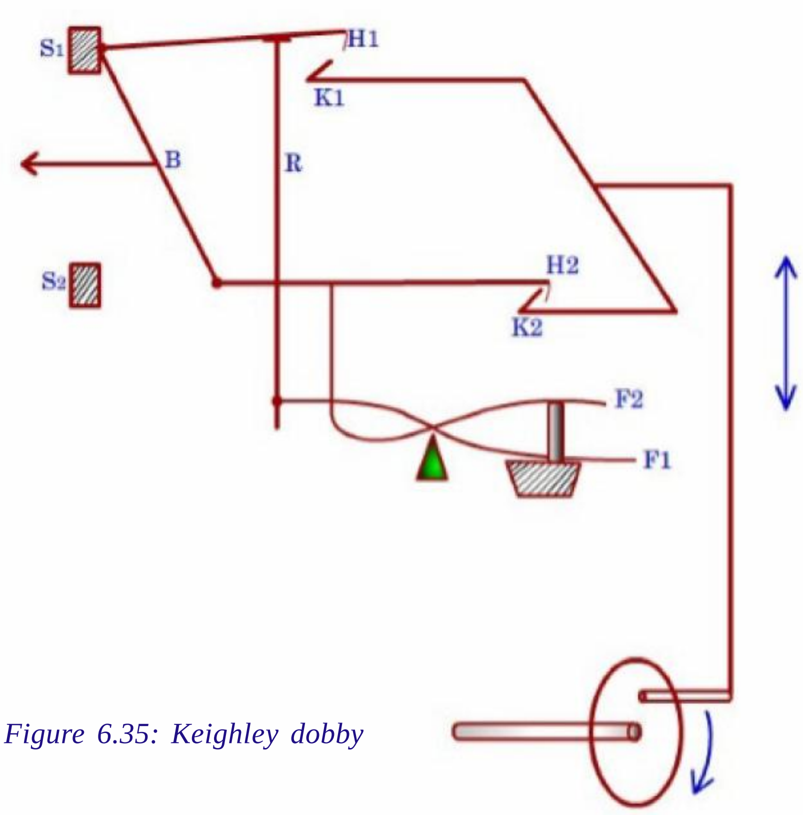


Figure 6.35: Keighley dobby

Keighley dobby is known to be a double acting dobby as most of the operations is done at half speed as compared to the loom speed (picks per minute). The basic components of Keighley dobby are as follows:

- Stop bars
- Baulk
- Hooks (two per heald)
- Knives (two for the entire dobby)
- Pegs on pattern chain

Figure 6.35 depicts the simplified view of the Keighley dobby.

The motion of the reciprocating knives (K1 and K2) originates from the bottom shaft of loom. As one revolution of bottom shaft ensures two picks, each of the two knives completes the cycle of inward (towards the left) and outward (towards the right) movements during this period. The two reciprocating knives are in completely difference phases. When one knife is moving inwards, the other knife is moving outwards. In **Figure 6.35**, knife 2 (K2) has a pulled hook 2 (H2) towards the right side. This has happened as there is a peg in the lag corresponding to the feeler 2 (F2). The peg has pushed the right end of the feeler 2 towards the upward direction. Thus the left end of the feeler 2 has been lowered. Hook 2, was also lowered on knife 2, when the latter had moved inwards. So, the lower end of the baulk (B) moves away from the stop bar 2 (S2). Thus the heald shaft is raised as it is connected to the midpoint of the baulk.

In the next part of the cycle, knife 2 will move inwards and knife 1 (K1) will move outwards. Now, there is no peg corresponding to the position of feeler 1 (F1). So, the right end of feeler 1 is lowered and left end of it is raised. As a result, the connecting rod (R) pushed hook 1 in the upward direction. So, when knife 1 performs its outward movement, it will not be able to catch hook 1. The top part of baulk will be resting on stop bar 1 and thus the heald will not be lifted for the next pick.

It is important to note that, when the heald is in the lower position for two consecutive picks, the top as well as the bottom end of the baulk will be resting on the respective stop bars i.e. S1 and S2. So, the midpoint of the baulk will not have any significant movement. On the other hand, if the heald is in raised position for two consecutive picks, then one end of the baulk will move away from the stop bar and other end of the baulk will move towards the stop bar. Thus the middle point of the baulk will not experience any significant movement as schematically shown in **Figure 6.36**. Thus the wasted movement will be very nominal. Therefore, the system will produce an open shed.

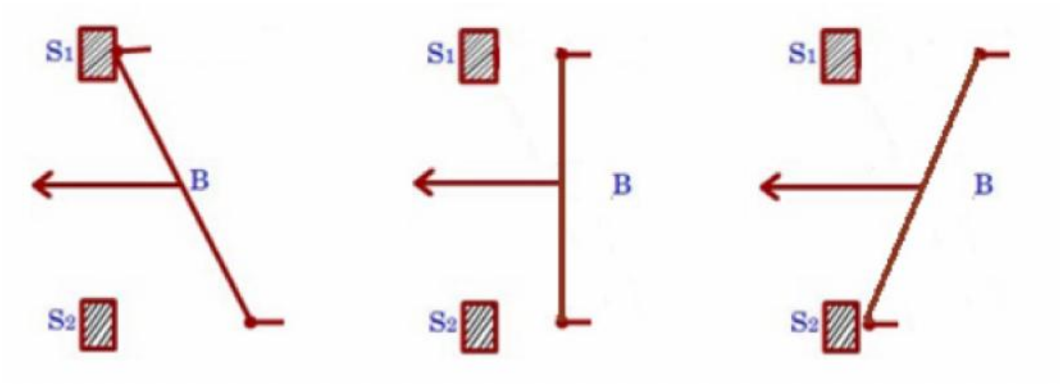


Figure 6.36: Open shed formation in Keighley dobby

System of Pegging

Picks	1	2	3	4	5	6	7	8
8		x				x	x	x
7	x				x	x	x	
6				x	x	x		x
5			x	x	x		x	
4		x	x	x		x		
3	x	x	x		x			
2	x	x		x				x
1	x		x				x	x
Ends	1	2	3	4	5	6	7	8

Figure 6.37: Point paper representation of 3/3/1/1 twill weave

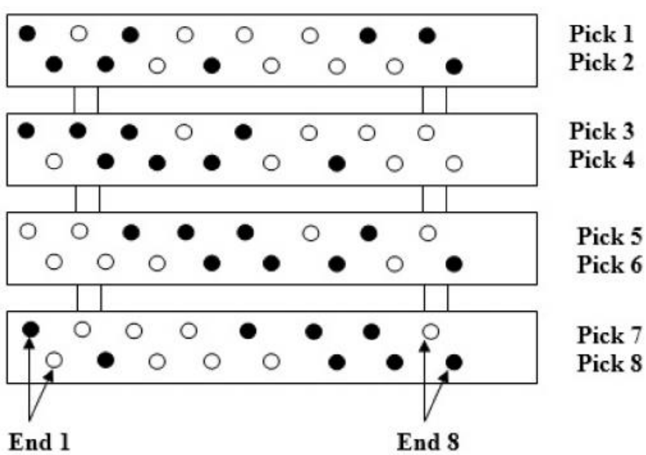


Figure 6.38: Peg plan for 3/3/1/1 twill weave

Twill weave (3/3/1/1) which repeats eight ends and eight picks (**Figure 6.37**) is considered here for demonstrating the pegging plan. The system of pegging is depicted in **Figure 6.38**. This design can be produced by using eight healds and a straight draft. The selection of heald movement is controlled by wooden pegs which can be inserted within the circular holes made on the wooden lags. The wooden lags are inked together into a lattice which is mounted on the pattern wheel (or barrel). The pattern barrel is rotated to a certain degree once in two peaks. For example, if the barrel is hexagonal, then it must rotate by 60° after every two picks. The presence of a peg within the hole results in the raised position of the heald and vice-versa. The position of two holes corresponding to the same heald is not in the same line. The lateral shifting of holes is done, so that two adjacent feelers can be accommodated.

Jacquard Shedding Systems

Introduction to Jacquard

Jacquard shedding system was developed by **Joseph Marie Jacquard (1752–1834)** who was a French weaver and merchant . In the case of cam and dobby shedding systems, large number of yarns passing through a heald is controlled as a group. Thus it precludes the possibility of controlling individual ends independently. Therefore,complicated woven designs cannot be made using cam or dobby shedding systems. With jacquard shedding system, individual ends can be controlled independently and thus large woven figures can be produced in fabrics.

Mechanical jacquard systems can be classified under three categories:

- Single lift and single cylinder (SLSC)
- Double lift and single cylinder (DLSC)
- Double lift and double cylinder (DLDC)

Single-Lift, Single-Cylinder (SLSC) Jacquard

Figure 6.41 shows the simplified side view of SLSC jacquard. If the machine has the capacity to handle 300 ends independently, then it requires 300 hooks (one per end) which are vertically arranged and 300 needles (one per hook) which are horizontally arranged. For example, the needles can be arranged in six rows and each row will have 50 needles. Viewed from the side only six needles (one per horizontal row) are visible. Hooks, which are connected to individual ends by nylon cord (harness), are also arranged in six rows and each row is having 50 hooks. One knife is responsible for controlling the movement (lifting and lowering) of one row of

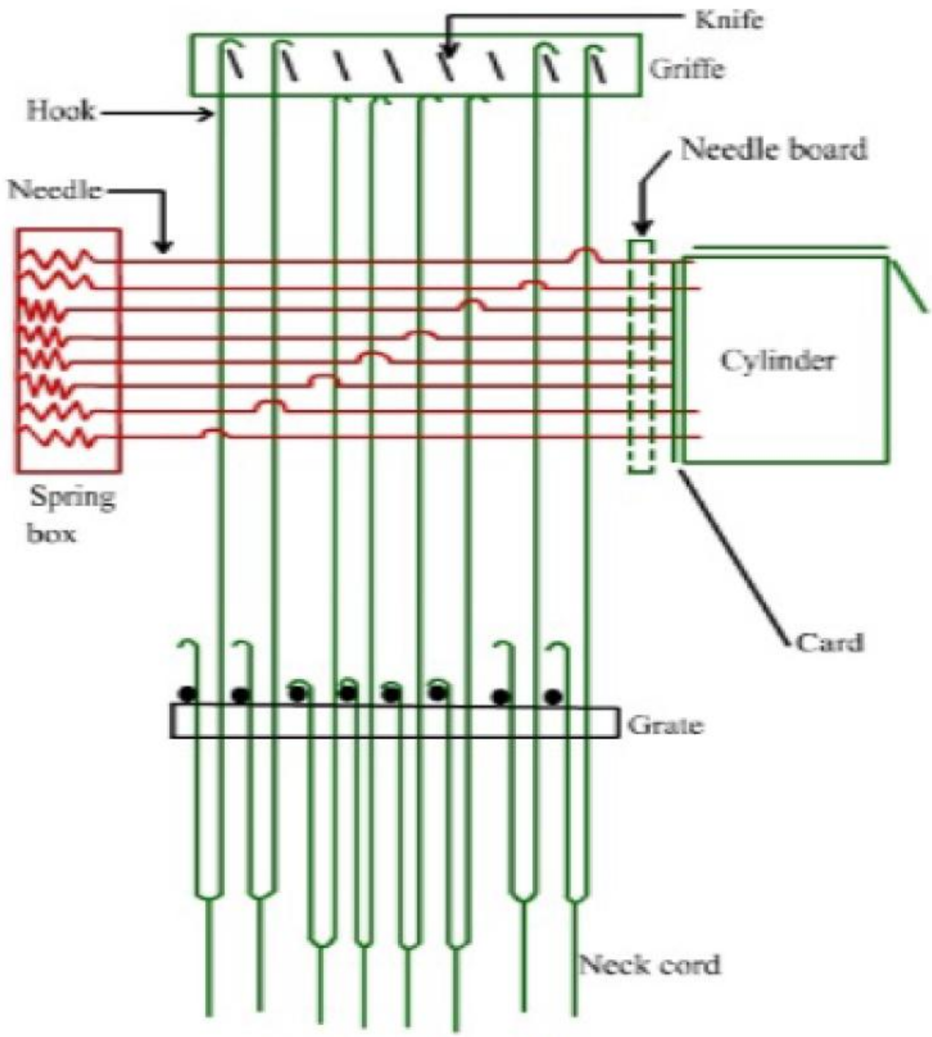


Figure 6.41:
Side view of single-lift single-cylinder jacquard

hooks. However, whether a hook can be lifted or not will be ascertained by the selection mechanism which is basically a punch card system mounted on a revolving cylinder having square or hexagonal cross-section. The needles are connected to the springs on the opposite side of the cylinder. Therefore, the needles always exert some pressure in the right hand side direction **(Figure 6.41).** So, if there is a hole in the punch card corresponding to the position of a needle, then the needle will be able to pass through the hole and thus the needle will remain upright making it accessible to the knife, when the latter starts its upward movement after descending to the lowest height. On the other hand, if there is no hole, then the needle will be pressed on the left side against the spring pressure. Thus the kink (which partially circumscribes the stem of a hook) present in the needle presses the hook on the left side tilting the latter a tilted from the vertical plane, so that the knife misses it while moving upwards. Therefore, the presence of a hole implies selection (ends up) and vice-versa. A hole in this case is tantamount to a peg used on the lag of a dobby shedding system.

In the case of SLSC jacquard, if the loom speed is 300 picks per minute, the cylinder will turn 300 times per minute (5 times per second) and the knives also reciprocate (up and down) 300 times per minute. Thus it hinders the high loom speed. When a particular hook (and the corresponding end) has to be in upward position in two consecutive picks, in between the two peaks, it descends to the lowest possible height (determined by the grate) and then moves up again. Thus it produces bottom closed shed. This happens as one end is controlled by a single hook.

Features of SLSC Jacquard

- 500 end machine will have 500 needles and 500 hooks
- Cylinder should turn in every pick
- Knives must complete the cycle of rise and fall in every pick
- Bottom closed shed is produced

Double-Lift, Single-Cylinder (DLSC) Jacquard

Double- lift, single-cylinder (DLSC) jacquard is shown in **Figure 6.42**. In this case, one end is controlled by two hooks which are again controlled by a single needle. For example, hooks 1 and 2 control end 1 and hooks 3 and 4 control end 2. Two sets of knives are used in DLSC jacquard and they move up and down (rise and fall) complete phase difference i.e. when one set of knives (K1 and K3) attain the highest position, the other set of knives (K2 and K4) attain the lowest position. At a given position, end 1 will be raised as hook 1 is lifted by corresponding knife K1. However, end 2 will not be raised as hook 3 is not caught by the knife K3. In the next pick, end 1 will be lowered as the needle F is pressed to the left due to the absence of a hole in the punch card. So, hook 2 becomes tilted and will not be raised by the knife K2. When the latter rises, Hook 1 will also descend along with Knife K1. Thus end 1 will be lowered. On the other hand, end 2 will be raised in the next pick as there is a hole in the punch card corresponding to the position of the

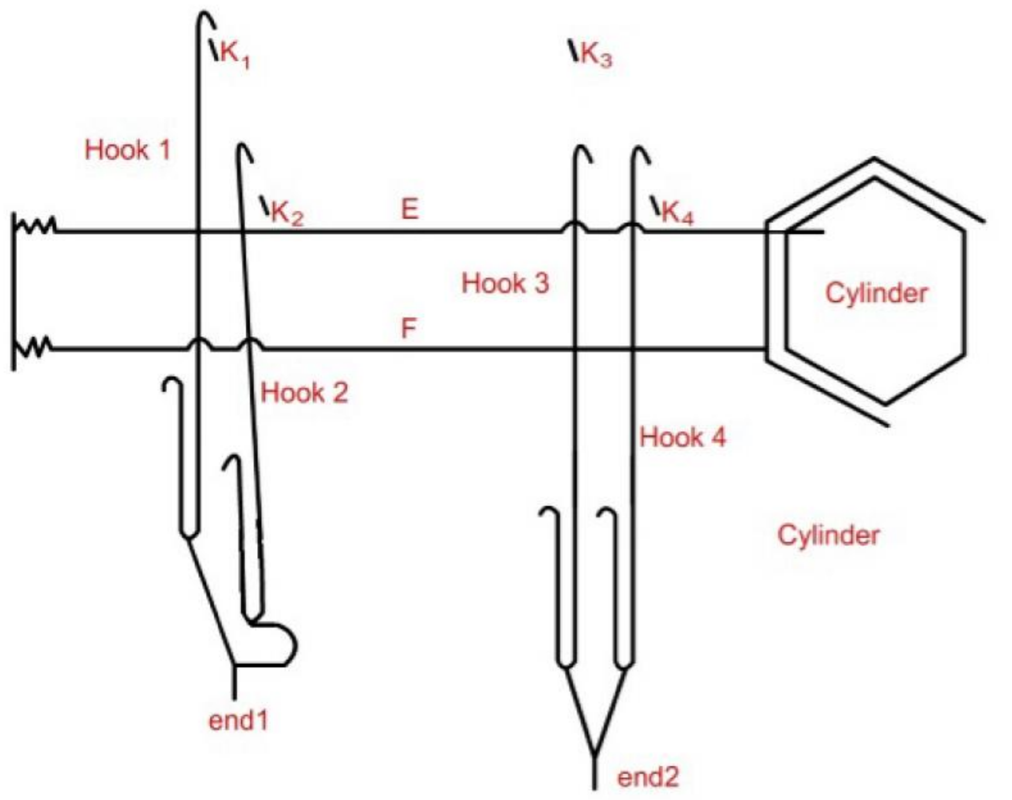


Figure 6.42:
Side view of double-lift single-cylinder jacquard

needle E. So, hook 4 is upright and it will be caught by knife K4 when the latter will move upwards.

In the case of DLSC jacquard, if the loom speed is 300 picks per minute then the cylinder will turn 300 times per minute but the knives will reciprocate (rise and fall) 150 times per minute. This is the advantage of DLSC jacquard over SLSC jacquard. DLDC jacquard produces semi-open shed because if a particular end has to be in the raised position for two consecutive picks, it will descend an to the middle point of its vertical path and then moves up. This happens when one of the hooks descends and the other hook moves up with respective knives and crosses at the middle of the vertical path. If the end has to remain in the bottom position for the two consecutive picks, it will remain at the bottom without any intermediate movement.

Features of DLSC Jacquard

- 500 end machines will have 500 needles and 1000 hooks
- Two sets of knives rise and fall in opposite phases
- Cycles of movement (rise and fall) of each set of knives spans over two picks
- Cylinder should turn with every pick
- Semi-open shed is produced

Double-Lift, Double-Cylinder (DLDC) Jacquard

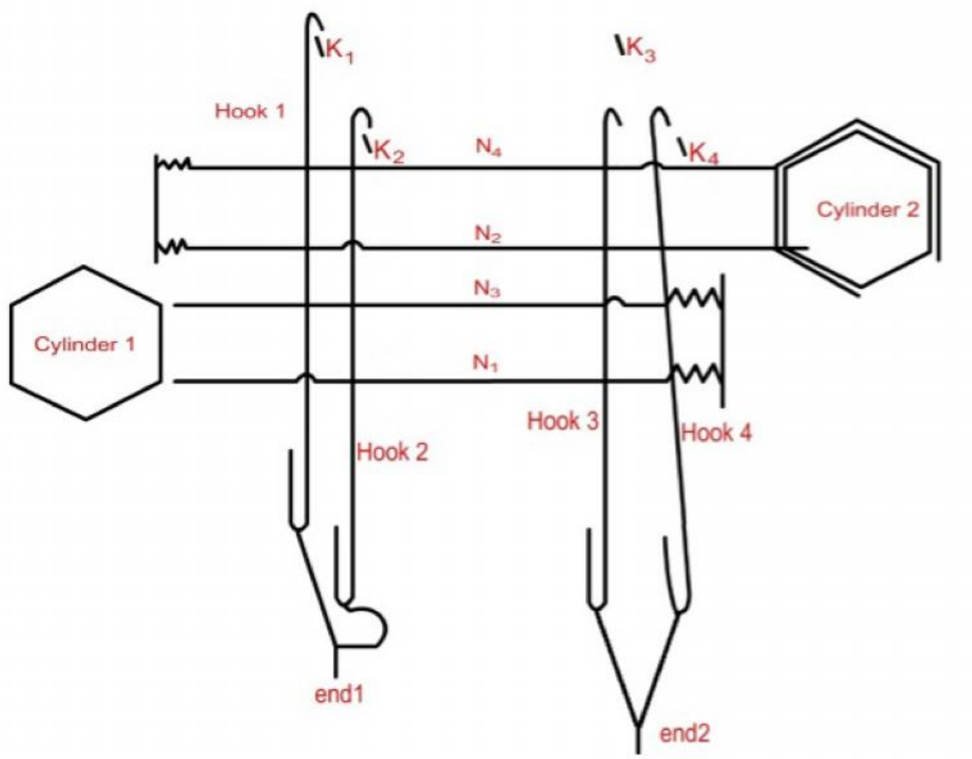


Figure 6.43: Side view of double-lift double-cylinder jacquard

Figure 6.43 depicts the double-lift, double-cylinder (DLDC) jacquard. In the case of (DLDC) jacquard, the number of cylinder rotation or turn and number of reciprocation cycle of knives is half as compared to that of SLSC. In this case, one end is controlled by two hooks as it was in the case of DLSC. However, each hook is controlled by separate needles. Hooks 1 and 2 control end 1 and hooks 3 and 4 control end 2. Needles 1, 2, 3, and 4 control hooks 1, 2, 3 and 4 respectively. The two needles (say N1 and N2) corresponding to a particular end (say end 1) are controlled by two cylinders in two picks. One of the needles (N2) is controlled by the right cylinder (cylinder 2) and the other needle (N1) by the left cylinder (cylinder 1). One cylinder carries the punch cards for even pick numbers like N, N+2, N+4, N+6 and so on. Here N is an even number. The other cylinder carries punch cards for odd pick numbers N+1, N+3, N+5 and so on.In one pick, either of the two cylinders performs the selection operation. DLDC jacquard is capable of handling the maximum loom speed (picks per minute), among the three types of jacquard.

Figure 6.43 shows that end 1 is in the raised position and end 2 in the lowered position in the current pick. End 1 continues to be in the raised position in the next pick as there is a hole in the punch card on cylinder 2 corresponding to the position of needle 2 (N2). So, hook 2 remains in the upright position and thus it will be raised by knife 2 (K2). On the other hand, end 2 continues to be in the lowered position as it is being tilted by needle 4 (N4) since there is no hole on cylinder 2 corresponding to the position of N4. So, knife 4 (K4) will miss N4 when the former rises in the next pick.

Features of DLDC Jacquard

- 500 end machines will have 1000 needles and 1000 hooks
- Two sets of knives rise and fall in opposite phases
- Cycles of movement (rise and fall) of each set of knives spans over two picks
- Cylinder should turn in alternate picks
- Semi-open shed is produced

Jacquard Harness

It is the system by which the ends are controlled during jacquard shedding with the help of nylon cords, heddles (heald eyes) and dead weights (lingoes). In the preceding part of discussion, it was considered that the capacity of jacquard is 300 ends. Now, if the fabric has 3000 ends then ten repeats of the design can be produced on the fabric. For example, if a floral pattern is woven on the fabric and it requires 300 ends, then 10 such floral patterns can be produced on the entire width of the fabric. It is assumed that the hooks of the jacquard are arranged in six rows and each row is having 50 hooks. Then each hook will effectively control 10 (3000/300)ends. The interlacement pattern of end 1, 301, 601, 901, 1201, 1501…….2701 will be identical and thus they can be controlled by hook no. 1 through 10 nylon cords.Similarly, hook no. 300 will control 10 ends namely end number 300, 600,

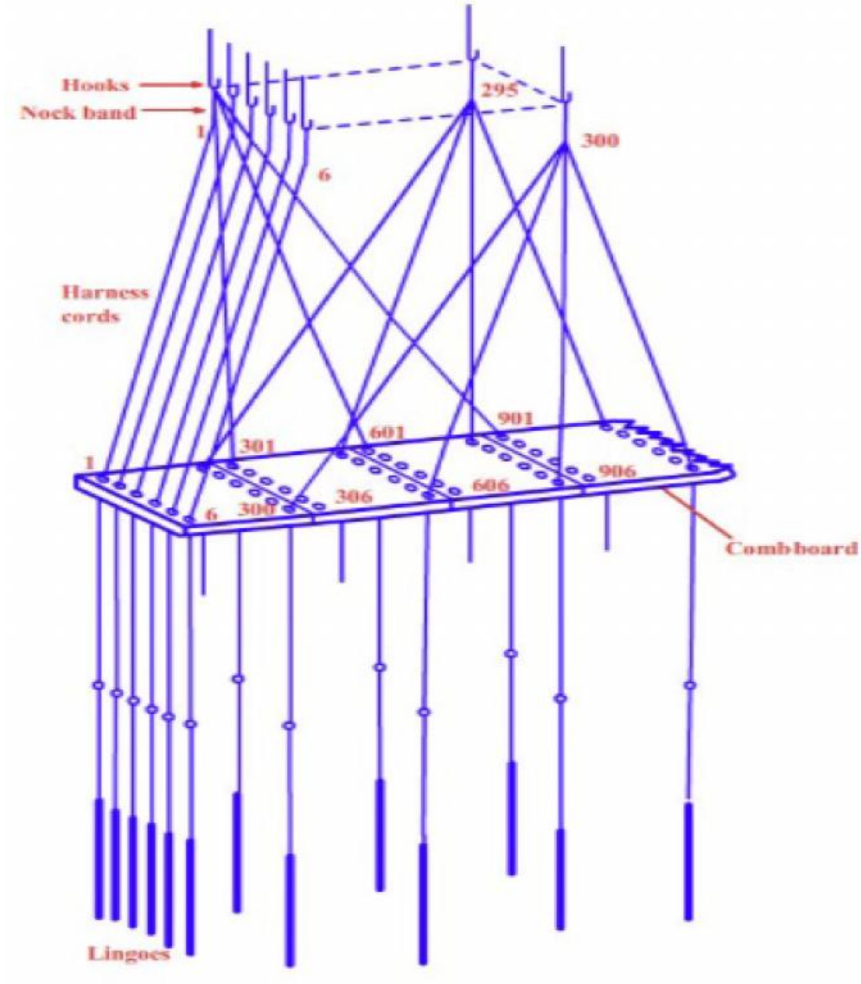


Figure 6.44: Jacquard harness

900,1200, 1500, 1800, ….., 3000. This has been depicted in the **Figure 6.44**. The individual harness cords pass through the perforations of a wooden or polymer board named comber board. The dead weights or lingoes pull the end downwards when it is not lifted.

Picking

Picking (Shuttle Picking Mechanism)

Objective of Picking

Objective of picking is to propel the weft carrying element (shuttle, projectile or rapier) or the weft yarn along the correct trajectory maintaining requisite velocity through the shed, in order to provide lateral sets of yarns in the fabric. In this module, picking will be discussed with respect to shuttle loom only.

Loom Timing

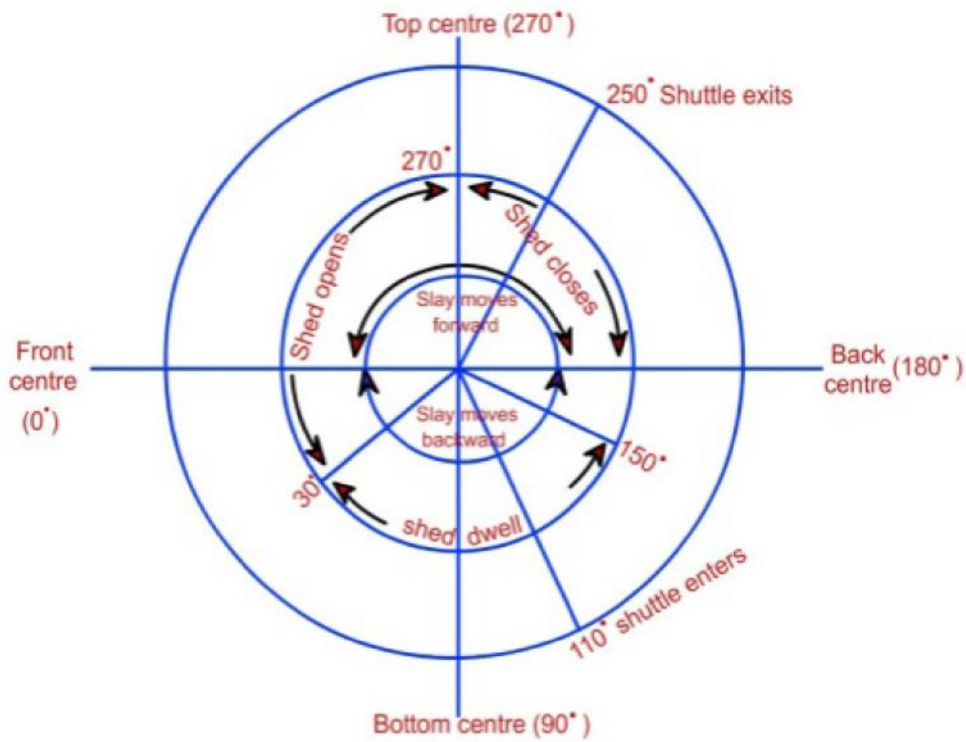


Figure 7.1: Loom timing diagram for shuttle loom (early shedding)

Loom timing is defined as the relative chronological sequences of various primary and secondary motions and is expressed in terms of angular position of crank. The loom timing is shown in the **Figure 7.1**.

Sley Motion

0° : Beat-up takes place and sley occupies its forward most position

180° : Sley occupies its backward most position

0°-180° : Sley moves backward

180°-360° : Sley moves forward

Picking and Checking

80°-110° : Picking mechanism operates

105°-110° : Shuttle enters the shed

240°-250° : Shuttle leaves the shed

270° : Shuttle strikes the swell in the shuttle box

300° : Shuttle comes to rest

Shedding (for early shedding)

30° : Shed is fully open

30° -150° : Heald dwell (shed remains fully open)

150° -270° : Shed closes

270° : Shed closed or shed level

270° -30° : Shed opens again (in the opposite direction)

Shedding (for late shedding)

120° : Shed is fully open

120° -240° : Heald dwell (shed remains fully open)

240° -360° : Shed closes

360° : Shed closed or shed level

360° -120° : Shed opens again (in the opposite direction)

The operations have been delayed by 90 0 in case of late shedding.

Take-Up

0° -10° : Take-up (intermittent type)

Classification of Shuttle Picking Mechanism

Shuttle picking mechanisms are broadly classified as cone over-pick and cone under-pick mechanisms. Several modifications of cone under-pick mechanism manifest as parallel-pick and link-pick.

Cone Over-Pick Mechanism

The cone-over pick mechanism is shown in the **Figure 7.2**. A picking cam attached to bottom shaft displaces the cone (picking cone) which is attached to the upright picking shaft. This causes rotation of the picking shaft. As a result, the picking stick, which is attached to the uppermost end of picking shaft, swings in a horizontal plane over the loom and transmits the motion to shuttle through the picking strap and the picker guided by a spindle. Picking strap is a leather or polymeric belt which is flexible. Here, picker is constrained by the spindle to move in a straight line which, otherwise would have followed a path of arc. Obviously, this restriction of path is achieved at the expense of some energy. Moreover, pairs of picking cam and the follower installed at either end of the loom have seldom ensured picking of equal strength (force). The cams responsible for impulsive rotation of the picking stick receive motion through the bottom shaft. However, allied system of picking varying elastic behavior (one of them is attached through a "stiff" short shaft while that at the further end through a long "flexible" one). All these warrant frequent adjustment of picking- strap or picking cam and nose settings. A system, where a different cam and follower pairs are used for each end makes the matter work enduringly with standardized settings. A cone over-pick mechanism on a loom is depicted in the **Figure 7.3**.

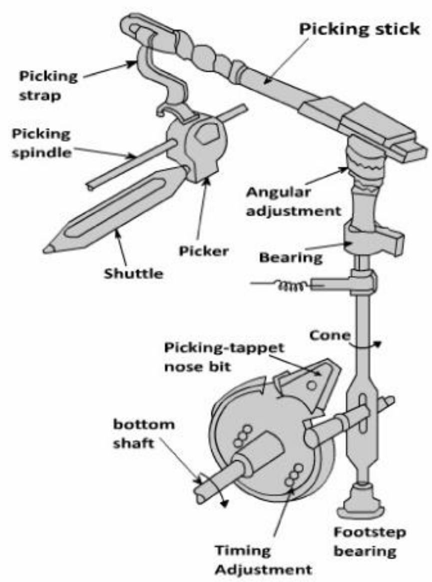


Figure 7.2:
Cone over-pick mechanism

Figure 7.3:
Cone over-pick mechanism on a loom

Possible adjustments for strength and timing of Over-Pick

- Shortening picking-strap increases the shuttle speed, but timing of picking advances.
- The picking tappet can be turned over the bottom shaft for the adjustment of picking timing.
- Lowering the picking cone in the slot increases the shuttle speed but timing of picking is delayed (**Figures 7.2 and 7.4**).

- Angular adjustment between picking shaft and picking stick also changes shuttle speed and timing (unpredictable).
- Large changes in shuttle speed for wider loom can be achieved by changing either nose bit or the entire picking cam.

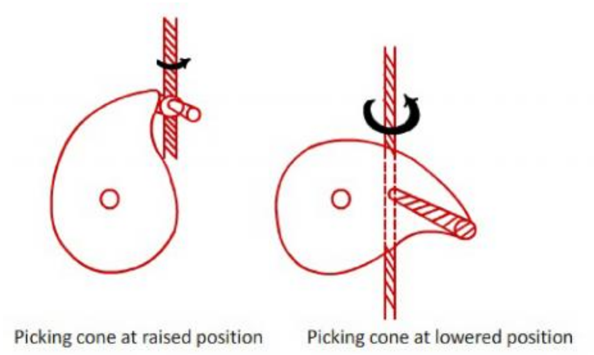


Figure 7.4: Adjusting the position of picking cone

With the advent of automatic looms which comes with battery or magazines, the replacement of over-pick system with cone under pick becomes inevitable. The latter provides space over and at one end of the loom erstwhile occupied by its over pick counterpart.

Cone Under-Pick Mechanism

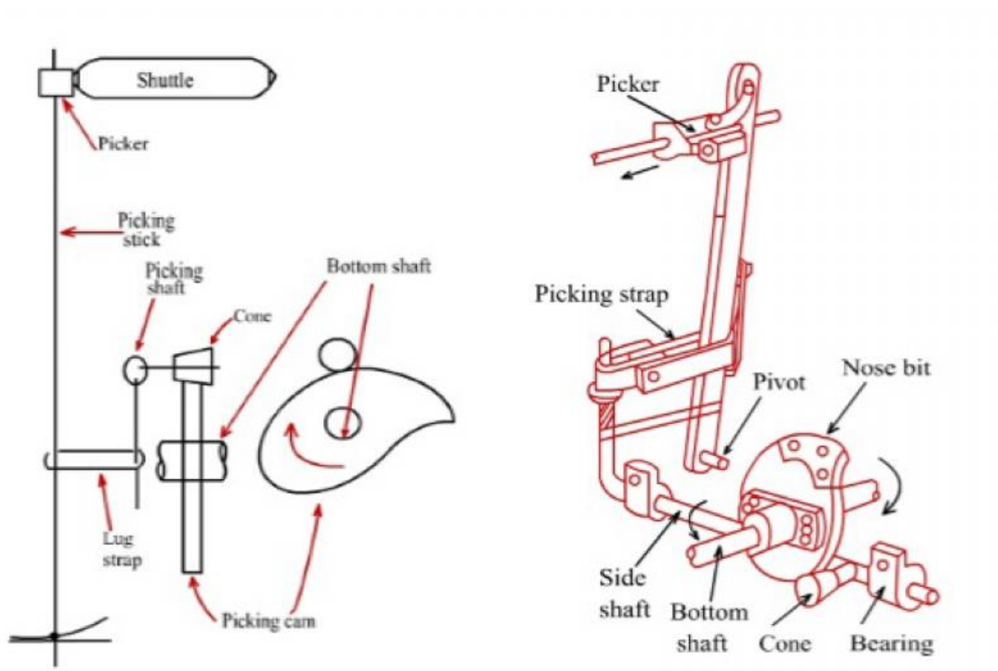


Figure 7.5: Cone under-pick mechanism

Cone under-pick mechanism is depicted in **Figure 7.5**. Here also a picking cam attached to bottom shaft displaces the cone, turning the picking shaft (side shaft) located horizontally. The other end of the picking shaft is connected to an upright picking stick through the picking strap (lug strap). This causes the picking stick to move in a vertical plane and transmits motion to shuttle by the picker attached to the upper end of it. In this system, the picking stick and other appendages are located below the shuttle trajectory, while picking cams and follower, as usual, below the loom and driven from the bottom shaft. The system is naturally suitable for automatic looms. Here picker slides over its spindle and picking timing is regulated by cam adjustment as in over pick motion. An almost inextensible lug strap allows shuttle speed adjustment either raising or lowering it around the picking stick. Absence of stretchable parts in under-pick system ensures the retention of correct setting over a long period in contrast to the cone over-pick mechanism. A cone under-pick mechanism on a loom is depicted in **Figure 7.6**.

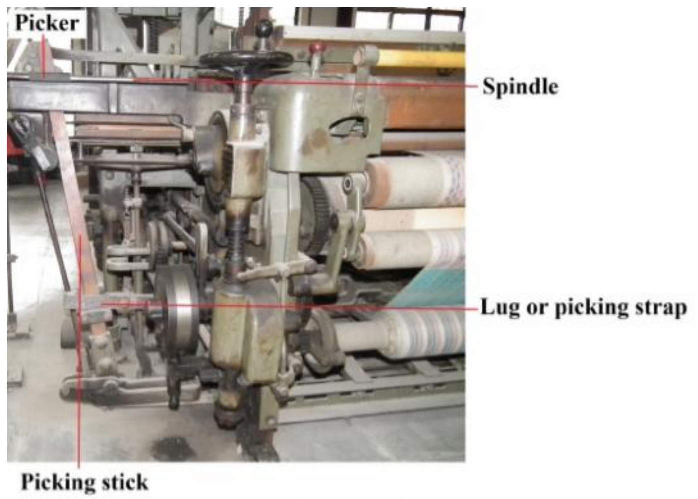


Figure 7.6:
Cone under-pick mechanism on a loom

Possible Adjustments for Strength and Timing of under-Pick

- Timing of picking is changed by turning the cam on the bottom shaft.
- Raising and lowering of the lug strap (picking strap) reduces and increases shuttle velocity respectively.
- Two independent adjustments for velocity and timing of shuttle make the under-pick system less complicated.

Shuttle Checking

Objective of Shuttle Checking

The objective of the shuttle checking is to retard the shuttle from nullifying its kinetic energy to zero.

Mechanism of Shuttle Checking

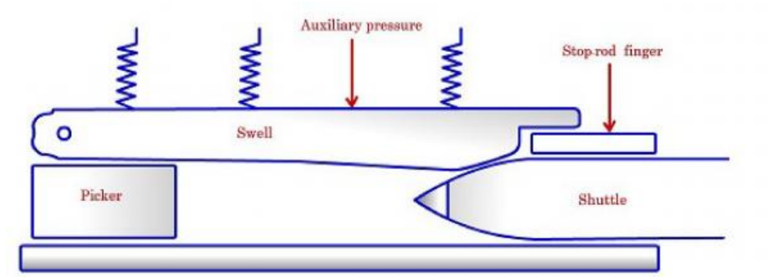


Figure 7.19: Checking of shuttle

The shuttle checking mechanism is shown in the **Figure 7.19**. The incoming shuttle gets rubbed on the spring loaded swell and thereby the frictional force slows down the shuttle velocity. The velocity of the incoming shuttle is reduced around 30% by the action of swell. The shuttle is finally stopped as it collides with the picker, which is cushioned by a suitable buffer system.

Beat up Motion

Objectives of Beat-up

The objectives of beat-up motion are as follows:

- To push the newly inserted pick-up to the cloth fell
- To ensure uniform pick spacing in the fabric

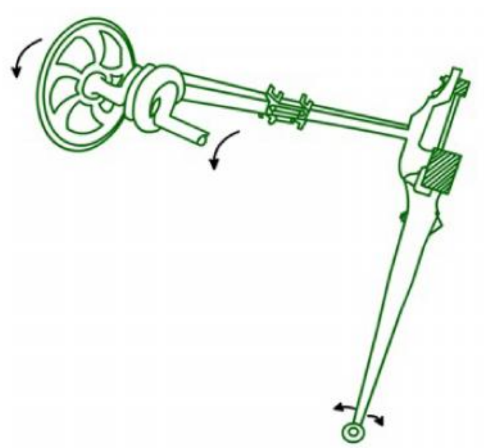


Figure 8.1: Sley motion

Sley Motion

Beat-up is done by the reed which is carried by the sley. Sley derives its rectilinear reciprocating motion from the rotating crank shaft through the connections of crank and crank arm which makes a four-bar linkage mechanism. This is illustrated in the **Figure 8.1.**

Expression of Sley Displacement, Velocity and Acceleration

Let us assume that the length of the crank and crank arm are respectively. A schematic diagram of sley movement is shown in the **Figure 8.2**.

Sley Eccentricity

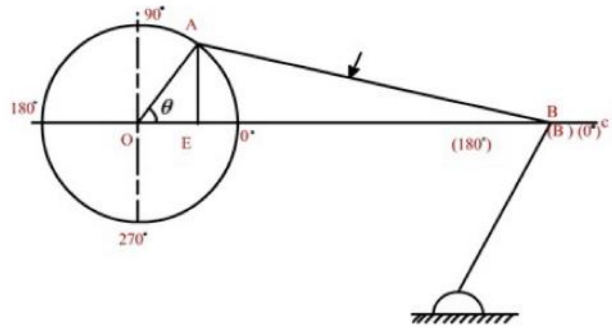


Figure 8.2: Schematic diagram of sley motion

As sley motion deviates from SHM, during its backward journey, sley covers more displacement from the rotation of crank shaft than the rotation of crankshaft. Similarly during its forward journey, sley covers less displacement from the rotation of crankshaft than the rotation of crankshaft. This difference in the sley displacement during its backward and forward movement is termed as sley eccentricity . In case of SHM, the displacement is same from 0°-90°, 90°-180°, 180°-270° and 270°-360°.

Table 8.1: Effect of sley eccentricity

Eccentricity value	Position of crankshaft at half of maximum displacement	Period during which the sley displacement is greater than half of maximum displacement	Position for crankshaft for maximum sley velocity
0.0 (SHM)	90 and 270	180	90 and 270
0.1	87 and 273	186	84 and 276
0.2	83 and 277	194	79 and 281
0.3	80 and 280	200	75 and 285
0.5	75 and 285	210	68.5 and 291.5

So, as the sley eccentricity increases, sley remains at the back side for a longer duration provding more time for the uninterrupted shuttle flight.

Secondary Motions

Take-up Motion

Objective of Take-up Motion

The objective of take-up is to draw forward the woven cloth as a new pick is inserted in order to maintain the line of fabric formation and pick spacing constant.

Classification of Take-Up

Take-up motion is classified as negative and positive take-up. Another way of classifying it is intermittent and continuous take-up. Intermittent take-up actuates itself only after newly inserted pick is beaten-up by the sley. On the other hand, continuous take-up operates continuously to draw the woven fabric. The presence of ratchet and pawl arrangement in the take-up mechanism makes it intermittent renders it to be whereas, the presence of worm and worm wheel renders it to be a continuous one.

Negative Take-Up

Attribute 'negative' justifies itself in the sense that no positive or direct motion is imparted to the take-up roller to wind up the woven fabric. In this system, shown in **Figure 9.1**, the motion of the rocking shaft actuates a system of levers and a ratchet- pawl mechanism, favored by gravity aided movement of dead-weights in turn transmits the rotational motion to take-up roller through a worm and worm-wheel.

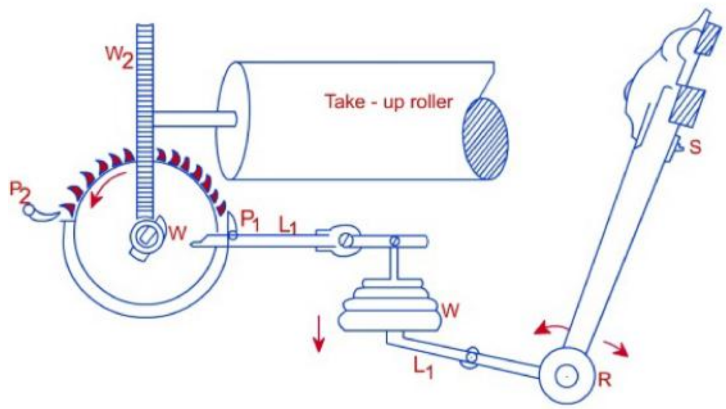


Figure 9.1: Negative take-up motion

Backward motion of the sley (S) or backward swing of the rocking shaft (R) keeps the weights raised through a lever (L1), thus the system remains inactive. Even when the forward motion of it sets free the weight system, the motion of the wheel train remain balanced with the warp tension. The impulsive blow of sley during beat-up brings the tension of the woven cloth close to zero. Weights (W) going down with gravity forces the pawl (P1) to turn the ratchet by one tooth through lever systems. Gear trains thus released, wind up the excess woven part of the cloth. Retaining pawl (P2) comes into play to prevent further rotation of gear trains.

With little control over uniform take-up or pick spacing, this system is only suitable for very coarse fabric like blanket.

Positive Take-Up

In positive take-up, motion gets transmitted to the take-up roller directly through gear train. The different types of positive take-ups are discussed below.

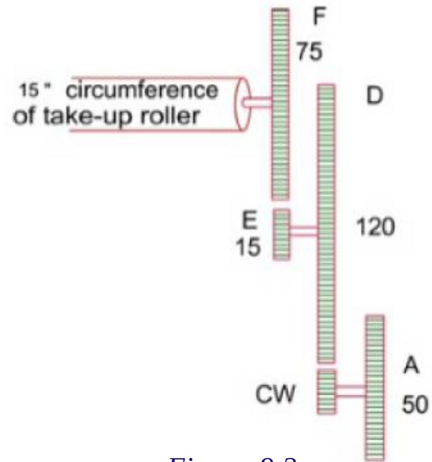


Figure 9.2:
Five-wheel take-up motion

Five-wheel Take-up

Five-wheel take-up motion is shown in **Figure 9.2**. The typical size of the gear is also given in the Figure. It is a positive intermittent type take-up motion. Wheel *CW* denotes the change wheel which is in the driver position for a five-wheel take-up. The amount of fabric take-up and the rotation required for the take-up roller after every pick is minuscule. This is achieved by making the driver wheels smaller than the driven wheels. The ratchet wheel A, having 50 teeth, is turned by one tooth for every pick.

The amount of cloth taken up for each pick that corresponds to the pick spacing, can be calculated as follows.

Pick spacing = $1/50 \times CW/120 \times 15/75 \times 15 = CW/2000$ inch.

Therefore, picks/inch or $PPI = 2000/CW$.

For example, in order to achieve 80 *PPI* the number of teeth in the change wheel will be $CW = 2000/80 = 25$

Seven-wheel Take-up

Seven-wheel take-up motion is shown in **Figure 9.3**. It is also a positive intermittent type take-up motion. Gear train for seven-wheel take-up motion is depicted in the **Figure 9.3a**. Here the position of *CW* is in driven position. For each pick, the ratchet wheel (A) is turned by one teeth.

The amount of fabric taken up for each pick which corresponds to the pick spacing can be calculated as follows.

Pick spacing = $1/24 \times 36/CW \times 24/89 \times 16/90 \times 15.05 = 1.015/CW$ inch.

Picks/inch or $PPI = CW/1.015$

or, $CW = 1.015\ PPI$

Therefore, the number of teeth in the change wheel is 1.5% higher than the *PPI* in the fabric in loom state. This 1.5% allowance is given for length wise fabric contraction, so that the teeth in the change wheel equals with the *PPI*, when the fabric is taken off the loom.

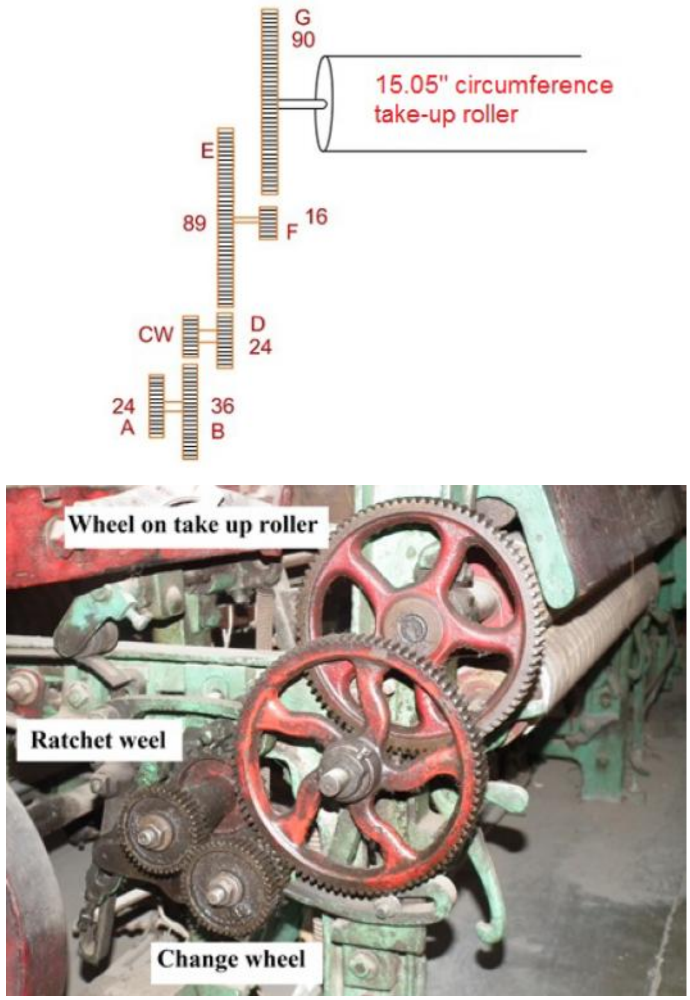


Figure 9.3:
Seven-wheel take-up motion
(a) Schematic (b) Mounted on loom

Any faulty gear wheel or eccentricity in a gear in the train can lead to periodic variation in pick spacing which produces fabric defect known as weft bar. If the wave length (a) of this periodicity ranges between 1/8 to 10 inch, the effect is readily seen in the fabric. Therefore, take-up systems are designed in such a way that the occurrences of such periodicities can be avoided. Calculation of a for different cases is discussed below.

Case I: One tooth of one wheel is faulty

If one tooth on wheel G is faulty, then it will create a jerk in the take-up system, whenever this faulty tooth meshes with wheel F. This happens just once in one complete revolution of wheel G. One rotation of wheel *G* means 15.05 inches of fabric take-up. Therefore, if one tooth of G is faulty, it produces a periodicity of = 15.05 inches. Therefore the fault will reappear after every 15.05 inches in the fabric.

However, the fault will be momentary and it will be spread over the fabric corresponding to the fabric take-up due to one tooth movement of wheel G. This can be considered as the width of the fault. Here the width of the fault will be = 1/90 × 15.05 inches = 0.167 inches.

Similarly, if one tooth on wheel F is faulty, then it will create a jerk in the take-up system, whenever this faulty tooth meshes with wheel G. This will happen just once in one complete revolution of wheel F. One rotation of wheel F means 15/90×15.05= 2.5 inches of the cloth will be taken up. Thus 1 faulty tooth of wheel F produces = 2.5 inches. Now, the width of fault will be same to that produced by a faulty tooth of wheel G. Because, irrespective of the presence of faulty tooth either on wheel G or on wheel F, the take-up system will experience the same jerk. As the motion is being finally transmitted to the take-up roller through wheel G, the width of the fault will be equivalent to fabric take-up due to one tooth movement of wheel G. So, the width of the fault will be = 1/90 × 15.05 inches = 0.167 inches.

As wheel F and E are in the same shaft, 1 faulty tooth of wheel also produces = 2.5 inches.

However, the width of the fault due to one faulty tooth on wheel E will be =1/89×15/90×15.05 inches = 0.028 inches.

Similarly, 1 faulty tooth of D or change wheel produces = 24/89 × 15/90× 15.05 = 0.676 inches. 1 faulty tooth of B or A produces = 36/*CW*× 24/89× 15/90×15.05 = 24.34/*CW* inches.

Let-off Motion

Objective of Let-off Motion

The objective of let-off motion is to maintain the free length of warp within the specified limits and to control the warp tension by means of feeding the warp at a correct rate to the weaving zone.

Classification

Let-off motion is classified as negative and positive let-off. In the case of negative let-off, warp is pulled from the warper's beam against a slipping-friction system. For positive let-off system, warp beam is rotated through driving mechanism at a controlled rate in order to maintain constant warp tension.

Negative Let-Off

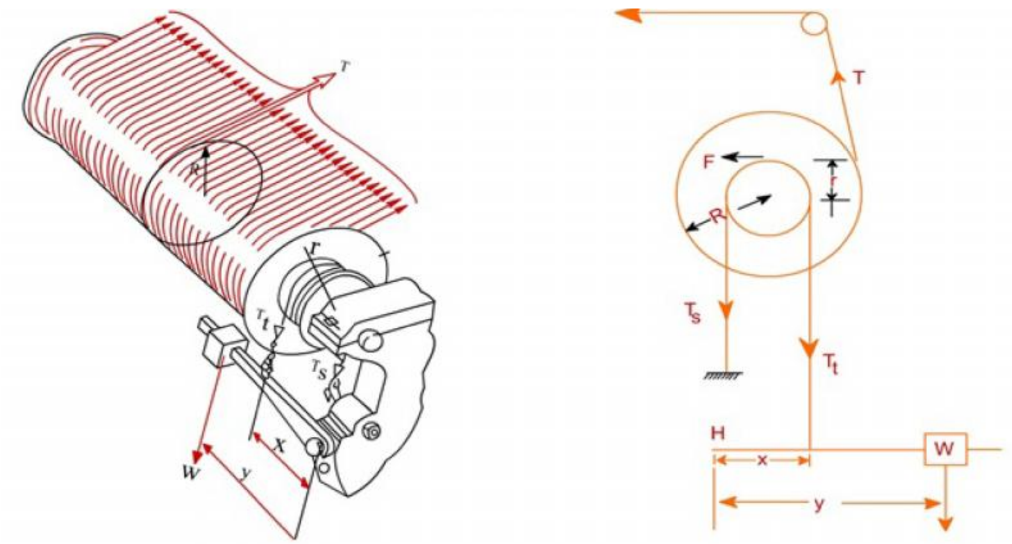


Figure 9.6: Negative let-off motion

The negative let-off mechanism is illustrated in the **Figure 9.6**. In this case, the warp is pulled off the warp beam and warp tension is governed by the friction between the chain and the beam ruffle.

The chain makes some wrap over the ruffle. Slack side of the chain is attached to the machine frame whereas, the tight side is attached to the weight lever. The lever is fulcrumed at one end with the machine frame. The other end carries dead weights.

Notations:

R = radius of the warp on the beam

r = beam ruffle radius

Tt = tension in the chain on the tight side (attached with the weight lever)

Ts = tension in the chain on the slack side (attached with machine frame)

W= weight

x = the distance between fulcrum point and chain on the tight side

y = the distance between fulcrum point and weight (variable)

T = tension in the warp sheet (variable)

F = frictional force at the beam ruffle

Positive Let-off

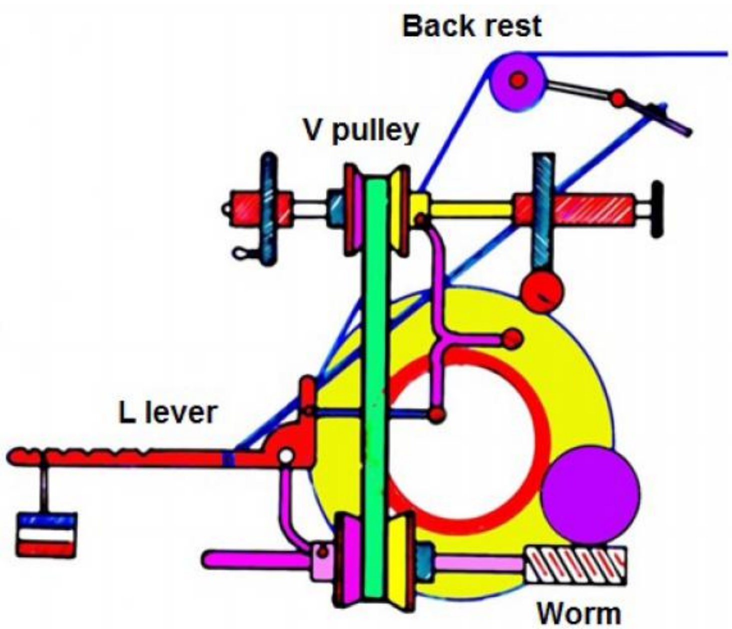


Figure 9.8: Hunt positive let-off motion

In the case of positive let-off warp, the warp tension is controlled by a mechanism which drives the warp beam at a correct rate. In most of the positive let-off systems, the backrest is not fixed but floating. It acts as a warp tension sensing mechanism. As the tension in the warp increases, the backrest is depressed. A Hunt positive let-off motion is ilustrated in the **Figure 9.8.** There are two split pulleys made out of V-pulley. Motion from crank shaft moves the top split pulley via a worm and worm wheel. Top pulley in turn drives the bottom pulley through a belt. As the tension on the warp increases, the back rest goes down and the L-type lever with weight lowers the diameter of the bottom pulley and essentially increases the diameter of the top pulley through necessary linkages. Now the bottom pulley moves at a faster rate than the earlier and the connecting worm to the beam drive moves much more to deliver extra warp in order to reduce the warp tension.

Auxiliary or Stop-Motions

These motions are used to stop the loom in the following cases.

- Shuttle trapping (warp protecting motion)
- Weft break (weft stop-motion)
- Warp break (warp stop-motion)

The classification of stop-motions is shown in **Figure 9.9**:

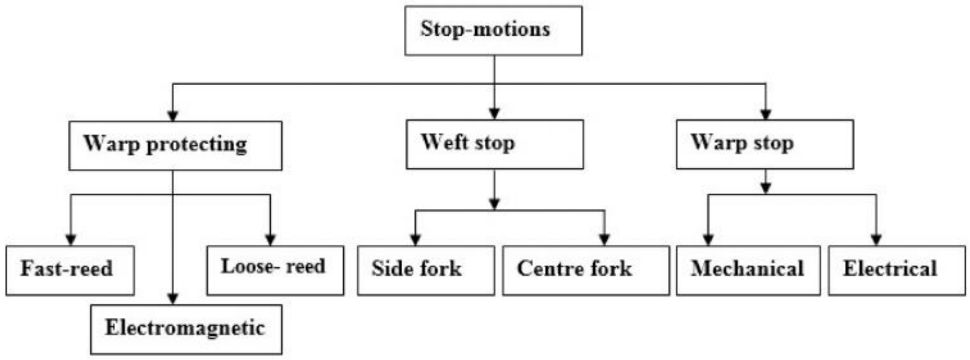


Figure 9.9: Classification of stop-motions

Warp Protecting Motion

It protects the warp sheet when the shuttle gets trapped inside the shed or it ricochets and comes back to the shed due to improper checking. If the beat-up is performed in this situation then a large number of warp yarns will break and the shuttle may get damaged. The role of warp protecting motion is to stop the loom, before beat-up, in such cases.

Fast-reed Motion

The working principle of fast-reed motion is shown in the **Figure 9.10**. The swell used for shuttle checking is attached to the back wall of the shuttle box. When the shuttle reaches the shuttle box safely, the swell retards the shuttle and in the process, the swell is displaced towards the left. Therefore, the finger-dagger assembly rotates anticlockwise. Thus when the dagger moves forward with the sley, it clears the frog which is fixed on the loom frame. If the shuttle is trapped inside the shed, then the dagger hits the frog when the sley assembly moves towards the right (front centre) for performing the beat up. The frog is connected to the starting handle of the loom. The loom is stopped immediately with a loud sound and it is known as 'bang-off'.

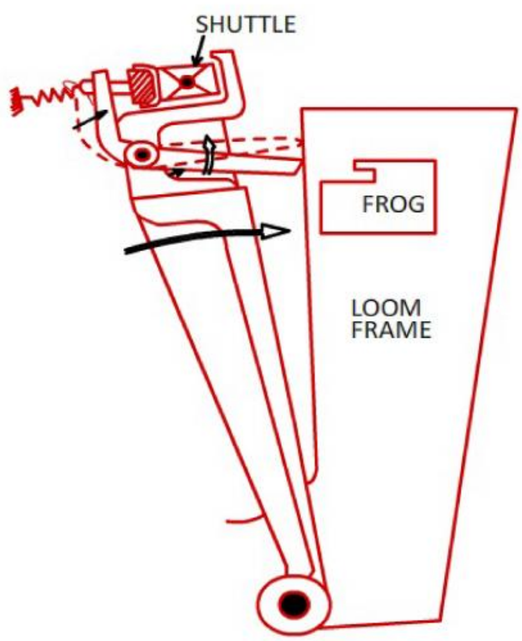


Figure 9.10:
Fast-reed warp protector motion

Loose-reed Motion

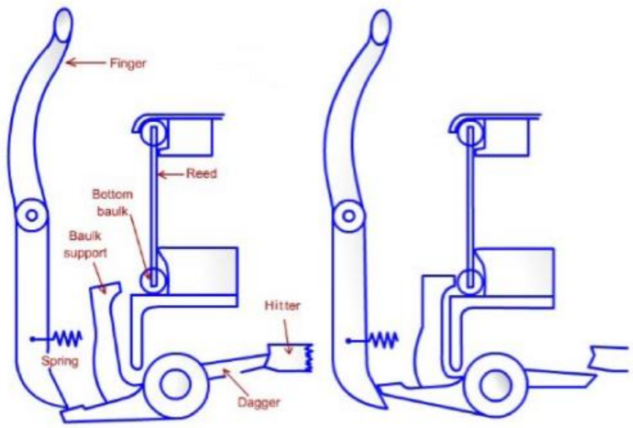


Figure 9.11: Loose-reed warp protector motion

Working principle of loose-reed motion is shown in the **Figure 9.11**. The reed is supported by two baulks. The top baulk is fixed whereas, the bottom one is loose. If the shuttle is trapped inside the shed, the reed experiences pressure, when it moves towards the cloth fell for performing the beat-up. This pressure rotates the bottom baulk support and the entire assembly in the anticlockwise direction as shown in the left side of **Figure 9.11**. So, the dagger moves up to the level of the hitter which is fixed on the loom. The loom is stopped as the dagger hits the hitter. When the shuttle reaches the destination properly, a situation similar to that depicted an the right side of **Figure 9.11** is created. The dagger passes beneath the hitter and the bottom baulk of the loose-reed is supported by finger for effective beat-up.

The comparison of fast-reed and loose-reed motions is presented in the Table 9.4.

Table 9.4: Comparison of fast-reed and loose-reed motions

Fast-reed	**Loose-reed**
Shuttle should reach the swell at 250° and should displace the swell completely by 270°.	No such limitation of timing.
Less time available for shuttle flight. So, there is a limitation on higher loom speed flight.	More time available for shuttle loom speed can be attained.
For the same loom speed, shuttle velocity will be relatively higher.	For same loom speed, shuttle velocity will be relatively lower.
Strain in the warp yarn is less in the case of shuttle trapping.	Strain in the warp yarn is high in the case of shuttle trapping.

Electromagnetic Warp Protection Motion

In this case, the shuttle and the crank shaft wheel carry magnets to create electromagnetic induction in the coils. If the shuttle does not arrive in the shuttle box, then the sequence of electrical signal generation is violated and the loom is stopped.

Warp Stop-Motions

Warp stop-motion stops the loom in the event of an end-break. The system is activated by lightweight metallic drop wires which have a profile shape. Two such drop wires or droppers are shown in the Figure 9.12. The large slot at the top is for the movement of the reciprocating bars, which are used in both mechanical and electrical warp stop-motions. Design (a) can be used when a single end is passed through the drop wires during the drawing-in operation. Design (b) can be used after the beam gaiting as it has an open-ended hole.

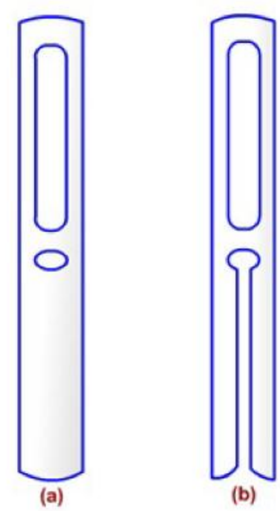


Figure 9.12: Drop wires

In the case of mechanical warp stop-motion, a reciprocating bar moves between two stationary bars. The bars have profiles like step waves. The sideway movement of the centre bar is equal to the width of a step. In the case of an end break, the drop wire will lose support from the tight yarn and will fall due to gravity. If it falls to the lowest possible height, then the reciprocating movement of the centre bar will be thwarted and the loom will be stopped.

In the case of electrical stop-motion, the drop wire acts as an element that makes or breaks an electrical circuit. In the case of warp break, the drop wire will complete an electrical circuit and activate a solenoid. The solenoid will attract a bar which will be hit by a knock-off lever. As a result, the bar will disengage the starting handle by means of some other levers. **Figure 9.13** shows the warp stop-motion mounted on a loom.


Figure 9.13: Warp stop-motion on a loom

Weft Stop-motions

Weft stop-motions stop the loom if the weft carried by the shuttle is broken. It is a very important motion as the beat-up without a pick, will necessitate adjustment of cloth-fell position before the restart of the loom. The problem of cloth-fell position adjustment will be relatively low in the following cases.

- Coarser yarn count
- Higher yarn hairiness
- Higher pick density

Side Weft Fork Motion

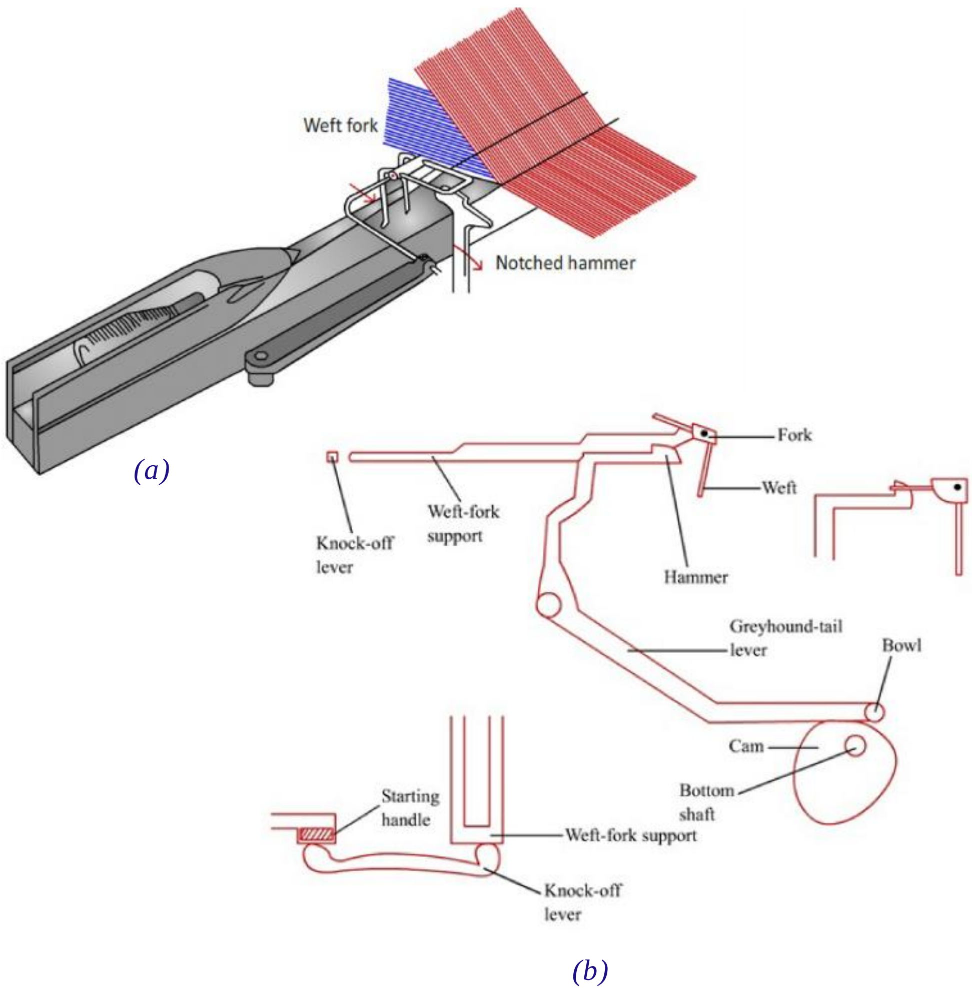


Figure 9.14:
(a) Side fork and notched hammer (b) Side view of side weft fork motion

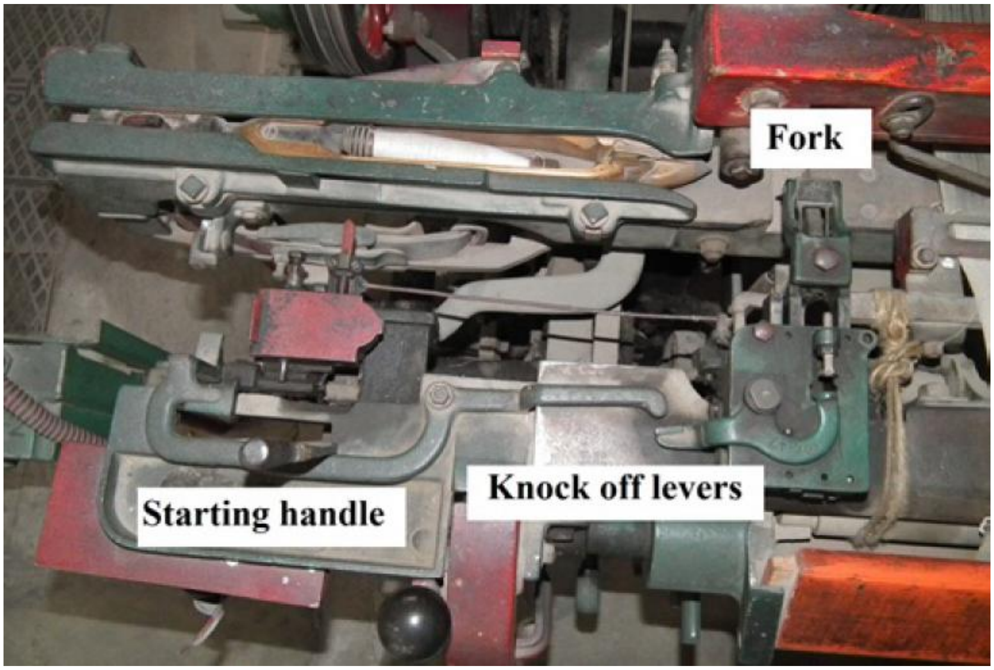


Figure 9.15: Top view of side weft fork motion

Side weft fork motion operates on the left side of the loom near the vicinity of the starting handle of the loom. When the shuttle reaches the shuttle box, after inserting an unbroken pick, the trail of pick pushes the lower end of the fork as the sley moves forward as depicted in the **Figure 9.14(a)**. This creates anticlockwise movement in the fork according to **Figure 9.14 (a).** However, the movement of the fork will be clockwise according to **Figure 9.14(b)**. From **Figure 9.14(b)**, it can be understood that the notched hammer moves towards the front of the loom, once in two picks, as it gets motion from a cam mounted on the bottom shaft. In the absence of weft break, the movement of the fork created by the push exerted by the pick clears the upper end of the fork from the notched hammer, when the latter is moving towards the front of the loom. Thus the loom continues to run. In the case of a weft break, the upper end of the fork is caught by the notch of the hammer. So, when the hammer is moving towards the front of the loom, the weft fork support pushes the knock-off lever and the latter dislocates the starting handle to stop the loom. **Figure 9.15** presents the top view of the side weft fork system mounted on a loom.

Center Weft Fork Motion

Side-weft fork system can detect the weft-break after the insertion of one or two missing picks. This problem can be mitigated by using centre-weft form motion which is mounted near the middle of the loom. It checks the weft-break at every pick and stops the loom before the beat-up in case of a weft break. Thus centre-weft fork motion is more efficient than the side-weft fork motion. **Figure 9.16** shows the centre-weft fork.

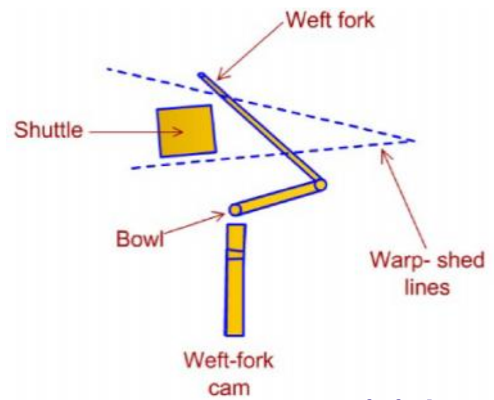


Figure 9.16: Center-weft fork

The centre weft fork is housed in a slot on the sley. The fork rotates clockwise to make a clear passage for the shuttle. This is done by the left ward movement of the weft fork cam. In the presence of a pick, the fork is supported by the former when the sley moves forward for the beat-up. If case of a weft break, the fork looses the support and thus weft-fork bowl will be lowered and trapped in a notch restricting the movement of a rod which finally creates the loom stoppage.

Fabric Stucture

Plain weave

It is the simplest possible and most commonly used weave. The repeat size is 2×2 as depicted in the **Figure 5.4.,** Which implies that the weave repeats on two ends and two picks. It gives maximum number of interlacement for the fabric and therefore the fabric becomes very firm. As the yarns are having maximum possible interlacements,the crimp in the yarns is also higher compared to other weaves. **Figure 5.5** depicts the interlacement pattern in a plain woven fabric.

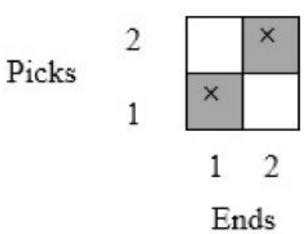


Figure 5.4: Point paper representation of plain weave

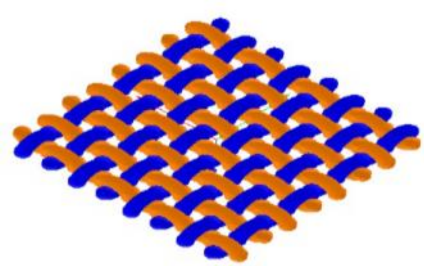


Figure 5.5: Interlacement pattern of plain weave (warp: orange and weft: blue)

Derivatives of Plain Weave

Warp rib, weft rib and matt (basket) weaves are the derivatives of plain weave. All these designs can be woven with two healds.

Warp Rib

In the case of warp rib, two neighbouring picks move in a group as shown in **Figure 5.6**. Prominent ribs become visible in the warp direction of the fabrics which is created by the floats of the ends. The picks undergo more number of interlacement than the ends and therefore the crimp in the weft yarns is higher than that of warp yarns.

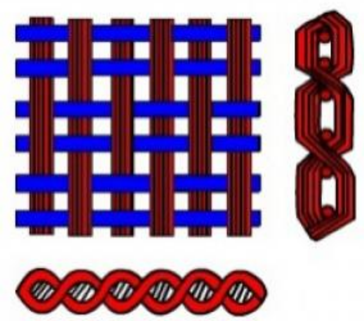


Figure 5.6: Interlacement pattern of warp rib

Due to the interlacement pattern, warp rib will have more tearing strength in the warp direction as compared to the plain woven fabrics having similar yarns and threads per inch. For warp rib fabrics, two neighbouring picks will resist the tearing force together in a pair resulting in higher tearing strength in warp direction as compared to equivalent (same yarn and same threads per inch) plain woven fabrics.

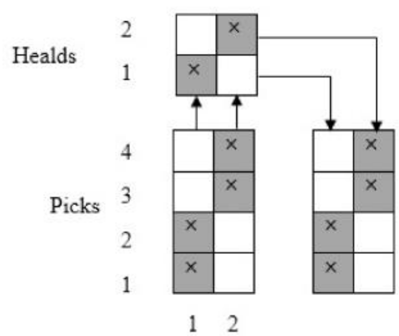


Figure 5.7: Design, drafting and lifting plan of warp rib

The design, drafting and lifting plains of warp rib is shown in **Figure 5.7**.

Weft Rib

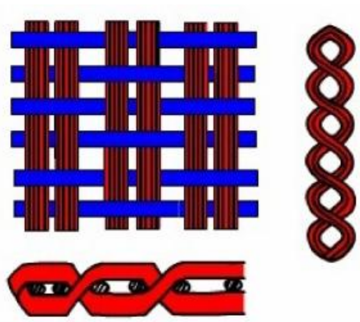


Figure 5.8: Interlacement pattern of weft rib

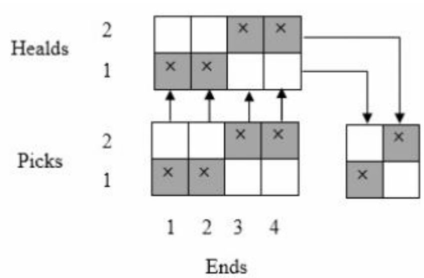


Figure 5.9: Design, drafting and lifting plan of weft rib

In the case of weft rib, two neighbouring ends move in a group as shown in **Figure 5.8**. Prominent ribs become visible in the weft direction of the fabrics created by the floats of the picks. The ends undergo more number of interlacement than the picks and therefore the crimp in the warp yarns is higher than that of weft yarns. Weft rib will have more tearing strength in the weft direction as compared to the plain woven fabrics having similar yarns and threads per inch.

The design, drafting and lifting plains of weft rib is shown in the **Figure 5.9**.

Matt or Basket Weave

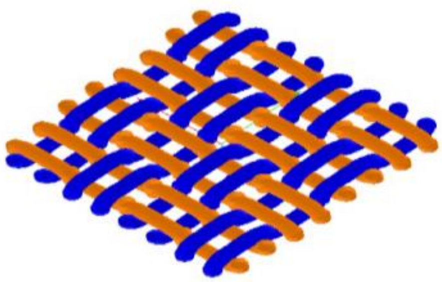


Figure 5.10:
Interlacement pattern of 2×2matt weave (warp: orange and weft: blue)

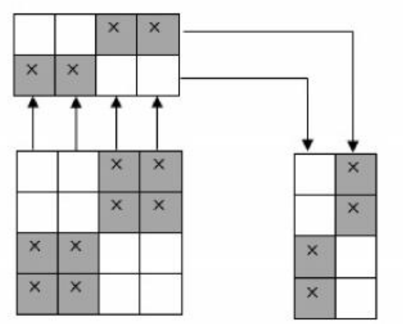


Figure 5.11:
Design, drafting and lifting plan of 2×2matt weave

In matt weave, multiple ends and picks interlace with each other in a group. The number of interlacement in the fabric is much lower than that of plain weave. In 2×2 matt weave, two ends and two picks form pairs and interlace in the form of plain weave as shown in the **Figure 5.10**. Therefore, the tearing strength of matt woven fabrics is higher in both directions as compared to that of equivalent plain woven fabrics. The design, drafting and lifting plains of 2×2 matt weave is shown in the **Figure 5.11**.

Twill Weave

Twill weave is characterised by a diagonal line in the fabric which is created by the floats of the ends or picks. The simplest twill weave is two up one down (or one up two down) which repeats on three ends and three picks. Based on the prominence of warp or weft floats, twill weaves are classified as follows.

- Warp faced: 2/1, 3/1, 3/ 2
- Weft faced: 1/2, 1/3, 2/3
- Balanced twill: 2/2, 3/ 3, 2/1 / 1/2

In warp-faced twill, the floats of ends predominate over that of picks. In contrast, the floats of picks predominate over that of ends in weft faced twill. In the case of balanced will, the floats of ends and picks are equal. **Figure 5.12** shows point paper design for a warp faced (2/1) and a balanced (2/2) twill. **Figure 5.13** and **5.14** depict the interlacement pattern for 2/1 and 3/1 twill fabrics respectively. It can be seen from **Figure 5.14** that there are long floats of warp (orange colour) over three consecutive picks visible on the face side of the fabric.

Twill weave has lesser interlacements than the plain weave. Thus the crimp in yarns for twill weave will be lower than that of plain weave. For equivalent fabrics, 3/1 twill will give higher tearing strength than 2/1 twill and plain.

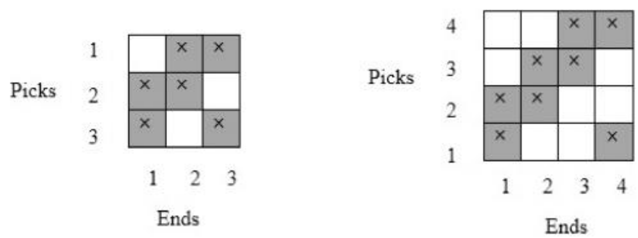


Figure 5.12: Warp faced (2/1) twill and balanced (2/2) twill

Pointed Twill

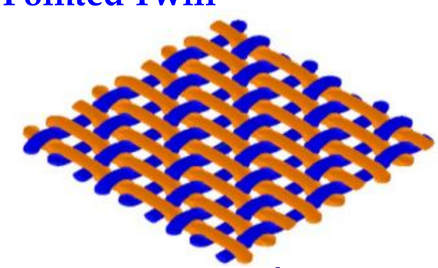


Figure 5.13: Interlacement pattern in 2/1 twill weave (warp: orange and weft: blue)

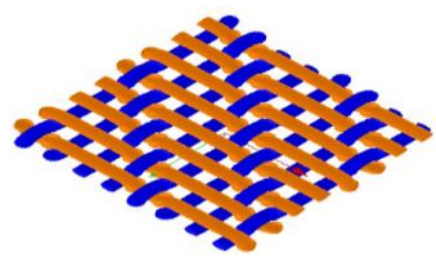


Figure 5.14: Interlacement pattern in 3/1 twill weave (warp: orange and weft: blue)

In pointed twill, there is no continuous line. However, the twill lines change directions at specific intervals and thus create pointed effect on the fabric. The design, drafting and lifting plan of a pointed twill based on basic 2/2 twill weave is shown in **Figure 5.15**. The 4th end is considered as the mirror line and the design is reversed in a way such that the interlacement pattern for the ends 5, 6 and 7 becomes identical with those of ends 3, 2 and 1, respectively. The interlacement pattern of end 4 and end 8 is same. The pointed twill is woven using the pointed draft as shown in **Figure 5.15**. The lifting plan resembles the left hand side of the design which is true for the pointed draft. **Figure 5.16** depicts the extended view of the same pointed twill.

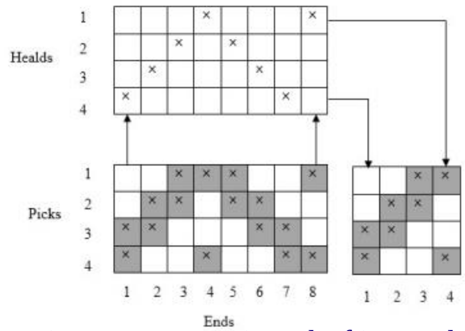


Figure 5.15: Design, drafting and lifting plan of pointed twill

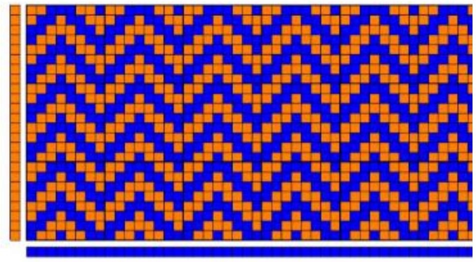


Figure 5.16: Extended view of pointed twill

Angle of Twill

The angle made by the twill line in the horizontal direction (weft direction) is known as angle of twill or twill angle (**Figure 5.17**). From point paper design, it seems that the angle will always be 45°. However, it is dependent on pick spacing, end spacing and move number of the design.

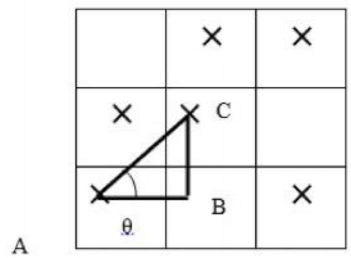


Figure 5.17: Angle of twill

Move number implies the movement of the starting point of the design in horizontal and vertical direction. Generally, for the construction of standard designs, move number 1 is used for both the directions. Therefore, the angle of twill depends on the ratio of pick spacing and end spacing as shown above. However, by using a high move number 2 in the vertical direction, steep twill can be produced which has angle of twill > 45°. On the other hand, by using higher move number in the horizontal direction, reclined twill can be produced which has an angle of twill < 45°.

Steep twill and reclined twill based on 3/1 twill weave is shown in that Figure 5.18. Different twill angles have been depicted in Figure 5.19.

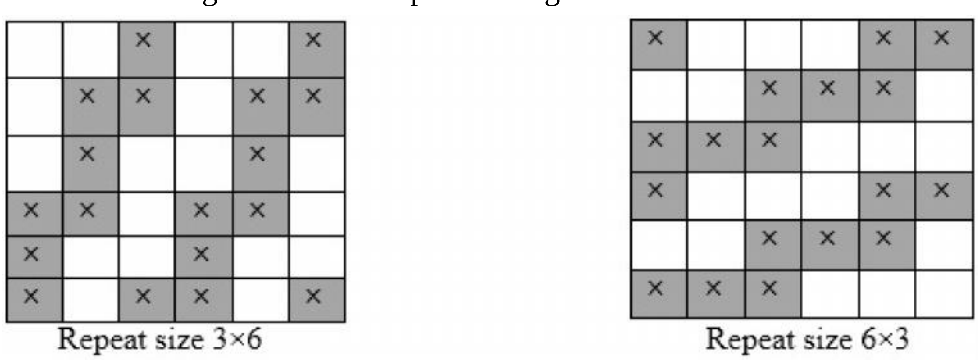


Figure 5.18: Steep and reclined twill

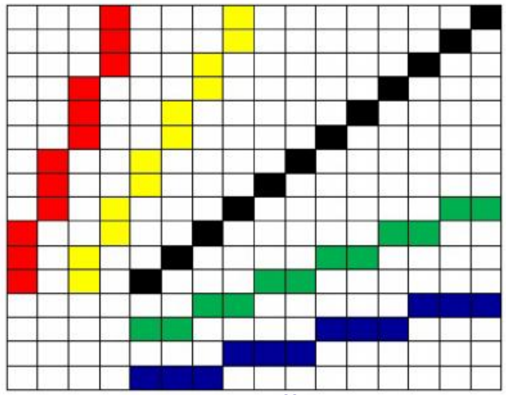


Figure 5.19: Different twill angles

Satin and Sateen Weaves

Satin and sateen weaves are characterised by the following features:

- Only one binding point in each end and pick within the repeat
- No continuous twill line
- Smooth appearance

Satin weave is warp-faced whereas, sateen weave is weft-faced. The fabrics have very smooth and lustrous appearance which is created by the long floats of either ends or picks.

For the construction of sateen weave, a feasible move number is chosen. Using this move number, only those points are marked on the point paper where the end is floating over the pick. For a seven-end sateen weave, probable move numbers are 1, 2, 3, 4, 5 and 6. The corresponding designs are shown In **Figure 5.20.**

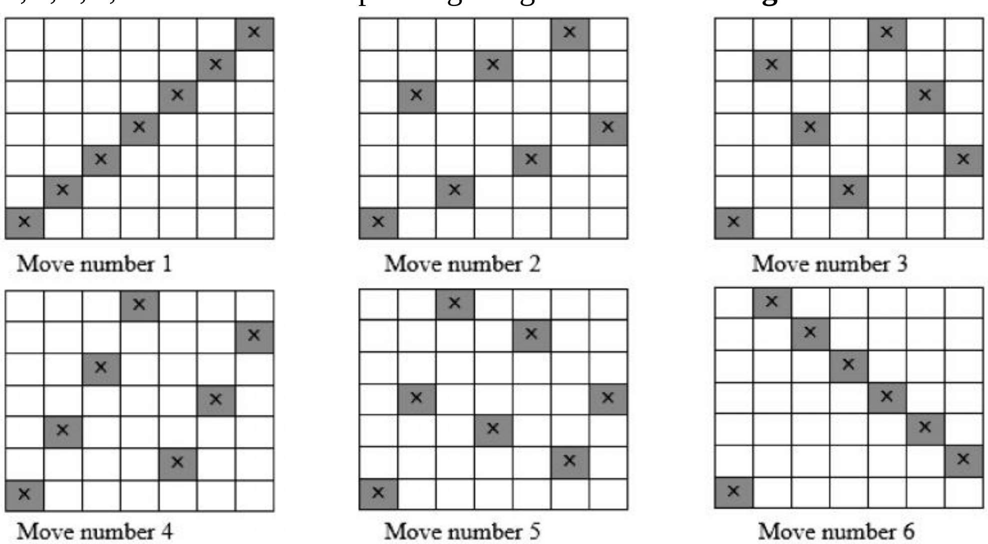


Figure 5.20: Seven-end sateen with various move numbers

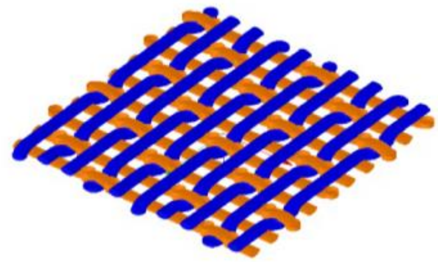


Figure 5.21: Five-end sateen (blue weft is at the face side)

It is observed from the above designs that the move numbers 1 and 6 (*n*-1, where *n* is the repeat size of the weave) produce twill weaves. However, move numbers 2, 3, 4 and 5 produce valid sateen weaves. On a point paper, the sateen weave (weft faced) can be converted to satin weave (warp faced) by interchanging the crosses with blanks and vice versa. The interlacement pattern of five-end sateen is depicted in the **Figure 5.21**.

Six-end Regular Sateen

It has been demonstrated earlier that if the move number is 1 or *n*-1, then twill weave is produced. Here, *n* is the repeat size of the design. If a six-end sateen weave is designed with move numbers of 2, 3 or 4, then the following interlacement pattern will be produced (**Figure 5.22**).

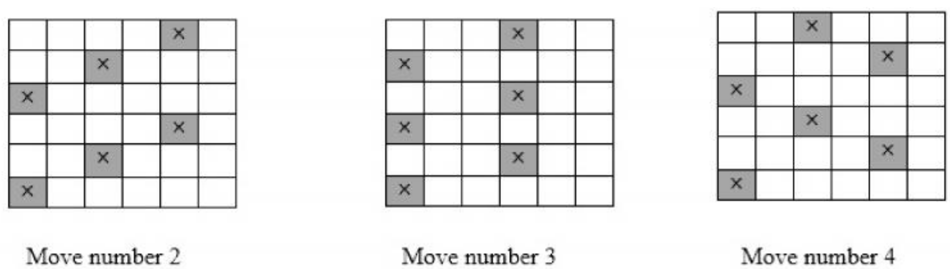


Figure 5.22: Six-end sateen

In all the three cases, there are certain ends without any interlacement. Therefore, these designs are practically not valid. Therefore, 6 end regular sateen (or satin) weave is not feasible.

Rules for Making Sateen Weave

1. Move number 1 and (*n*-1) cannot be used as twill weaves are produced.
2. Move number and repeat size of the design should not have any common factor.

It seems from the point paper design that a satin fabric will become Sateen if the fabric is reversed (turned upside down). However, practically it is not true. Because, satin fabric is warp-faced and to make the effect of the warp floates more prominent, following steps can be adopted.

- Use of coarser warp threads than the weft threads
- Use of higher ends per inch (*epi*) than the (*ppi*)

Therefore, even if the fabric is reversed, the effect of weft threads way not be very prominent as the picks are finer and *ppi* value is lower.

Some Fancy Weaves

Honeycomb

Honeycomb weave shows prominent diamond shapes on the fabrics created by the long floats of ends. Honeycomb weave having a repeat size of 8×8 is shown in the **Figure 5.23** with drafting and lifting plan. The design can be produced with pointed draft and thus the lifting plan resembles the left hand side of the design. The **Figure 5.23: Design, drafting and lifting plan of Honeycomb weave** and an extended view of the Honeycomb weave is shown in **Figure 5.24**.

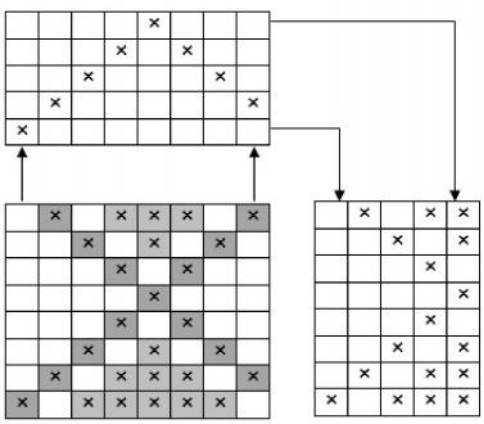


Figure 5.23: Design, drafting and lifting plan of Honeycomb weave

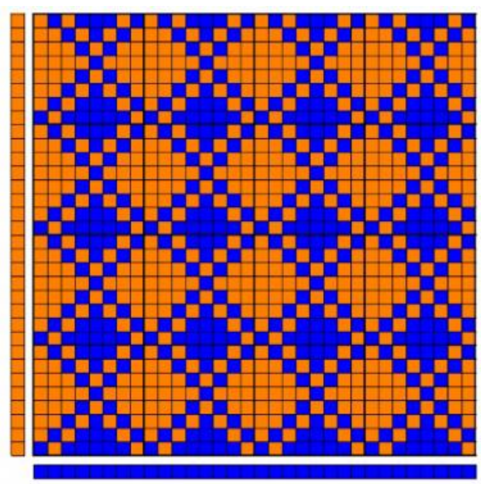


Figure 5.24: Extended view of Honeycomb weave

Mock Leno

In Mock leno weave, some of the ends have frequent interlacement whereas, the other ends have long floats. The fabric shows small holes created by the grouping of threads. A mock leno weave having a repeat size of 10×10 is shown in **Figure 5.25** along with drafting and lifting plan. Only four healds are needed as the interlacement pattern of the ends 1, 3, 5 are the same and they are allocated to heald 1. Similarly, the interlacement pattern of ends 2 and 4 are same and they are assigned to heald 2 and so on. **Figure 5.26** depicts the extended view of the Mock leno weave.

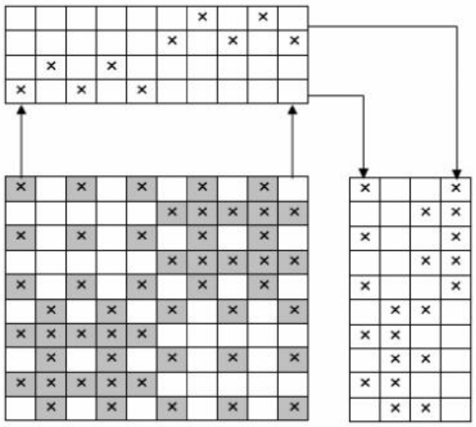


Figure 5.25: Design, drafting and lifting plan of Mock leno weave

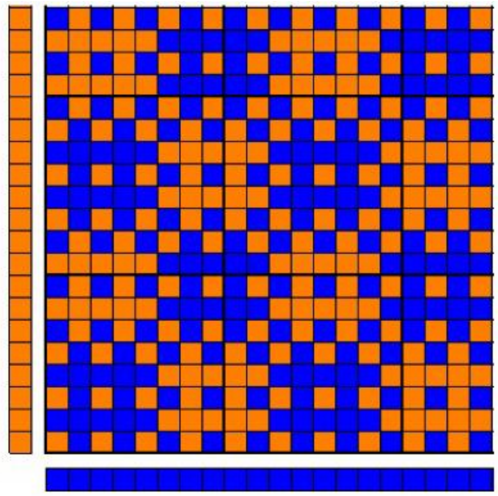


Figure 5.26: Extended view of the Mock leno weave

Huck-a-Back

Huck-a-back design has some similarity with Mock leno. A 10×10 Huck-a-back design is shown in the **Figure 5.27**. If the design is divided in to four quadrants, the top-right and bottom-left corners will be having similar interlacement pattern like Mock leno. However, the remaining two quadrants have plain weave like interlacement pattern. Therefore, some of the ends (end number 2, 4, 7 and 9) are having long floats followed by regular interlacements. The design shown below requires four heald shafts. **Figure 5.28** depicts the extended view of the Huck-a-back weave.

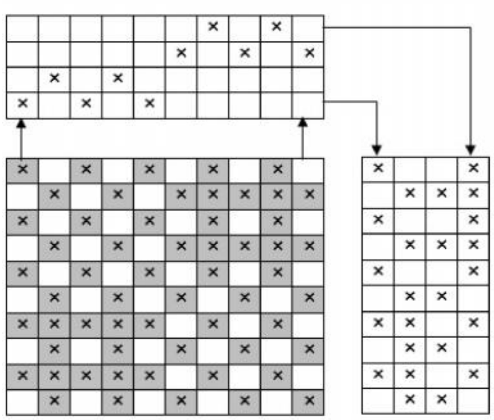


Figure 5.27: Design, drafting and lifting plan of Huck-a-back weave

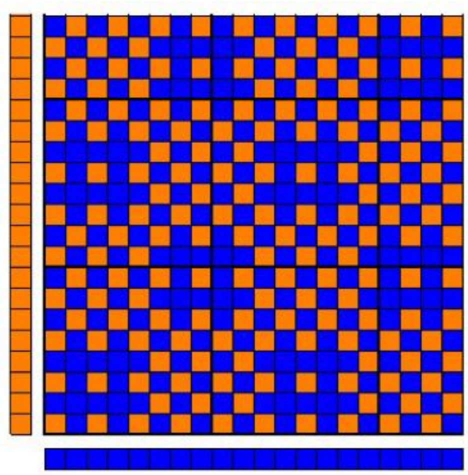


Figure 5.28: Extended view of the Huck-a-back weave

4. Detailing of practicals

4.1. Weaving preparatory process includes

Warp winding practice, Warping practice ,Different types of sizing, Preparation of size mixture for various types of yarn based on size recipe, Weft winding practice. placing of warp beam in the back frames with suitable components, leasing of warps. Drawing of warp ends though the male eyes of the healds as per the draft. Denting of ends through the reed. Selection of suitable reed and heald for particular quality of the fabric.

4.2. Handloom

Identify different types of hand looms and its parts - Sketch the passage of warp yarn in a hand loom and mark important parts and their uses - Preparation of various designs, identification of suitable drafts, preparation of peg plan and treadling plan using 2, 3 and 4 treadles.

Working of hand loom - Weaving practice in handloom with various designs, drafts, using peg plan, and treadling plan. Easiest methods of treadle operations.

4.3. Power loom

Timing & setting of Shedding, Picking & Beating. Study of plain tappet shedding mechanism :- Sketch and identify various parts of shedding mechanism. Dismantle and assemble the parts.

Study of cone over picking mechanism :- Sketch and identify various parts of cone over picking. Dismantle and assemble the parts.

Study of beating - up mechanism :- Sketch and identify various parts of beating-up mechanism. Dismantle and assemble the parts. Study of the setting which ensures proper working.

Sketch and study of let-off & take – up motions.

Working of powerloom - weaving practice in powerloom.

4.4. Fabric structure

Familiarize with the usage of design paper in textile design.

Analyze the fabrics of plain & its derivatives, twill and its modification.

Analyze the given sample of cloth for the following details, Ends & Pricks / Unit space. Draw the design, draft, lifting plan & denting plan of the sample cloth.

Determine the counts of heald and reed.

5. Assessment activities

Seminar

Project work

Written test

6. TE Questions

Define weaving preparatory process.

Mention the objects of preparatory process.

What are the objects of warp winding process?

What is sizing

What are the ingredients used in a size mixture?

What are the functions of ingredients in size mixture?

Explain the working of any one type of warping machine with the aid of a sketch.

Explain the working of tappet shedding motion with a neat sketch.

Explain the working of seven wheel take-up motion with help of a neat sketch.

9. At the end of the module 3

1. Extended activities

Field visits

Sample collection

Preparation of fabric samples record and design record

Chart preparation

2. List of practicals

Warp winding

Sectional warping

Calculations related to warping

Selection of suitable reeds for various types of warps

Identification of warping machine parts

Preparation of size recipe for various types of yarns.

Sizing calculations

Drawing-in and gaiting-in practice

Identify the parts of pirn winding machine

Identify the parts of handloom

Weaving in handlooms

Calculations related to Weaving

Identify the parts of power looms

Study of primary motions in power looms

Study of secondary motions in power looms

Study of auxiliary motions in power looms

Study of loom calculations in power looms

Study of production calculations in power looms

Study of various designs suitable for plain and twill looms.

10. Overview of Module 4

This module is designed to equip the learner with knowledge and skills required to work in a textile processing unit . The module consists of pre-treatment given to fabric/yarn for dyeing and printing. Study of various classification of textile dyes-based on solubility .Study of application of Direct dyes,Vat dyes and Reactive dyes on cotton material.

Study of various after-treatment given to direct dyed materials to improve their fastness properties.

Brief idea about textile printing. Study of various methods of textile printing.

Study of various styles of textile printing. Preparation of printing paste.After-treatment given to printed materials.

a. Unit

Unit 1 : Pre treatment given to textile materials for dyeing and printing

Unit 2: Classification of textile dyes

Unit 3 Dye application

Unit 4 Textile Printing

2. Learning outcomes

Study the objectives of de-sizing, chemicals used for de-sizing, various types of de-sizing.

Study the objectives of scouring, methods of scouring, chemicals used for scouring.

Brief study of machineries used for scouring.

Study the objectives of bleaching, classification of bleaching agents, various chemicals used for bleaching, method of bleaching.

Study various classification of textile dyes based on solubility.

Characteristics of direct dyes. Method of application of direct dyes on cotton. After-treatments given to direct dyed materials to improve their fastness to light, washing and perspiration. Reagents used in dyeing and after-treatments and it their functions.

Brief study of the characteristics of reactive dyes. Methods of application of reactive dyes on cotton. Reagents used in dyeing and their functions.

Brief study of the characteristics of vat dyes. Methods of application of vat dyes on cotton. Reagents used in dyeing and their functions.

Study the definition of textile printing and various methods of printing.

Study various styles of production of patterns on textile materials.
Preparation of printing paste. Ingredients used in printing paste and their function.
After-treatment given to printed materials.

3. Unit in Detail

Module 4

4.1 Preparatory processes for dyeing and printing

Any treatment, which is done before the actual (dyeing and printing) process**.**

Natural fibres and synthetic fibres contain primary impurities naturally, and secondary impurities are added during spinning, knitting and weaving processes. Textile pretreatment is the series of cleaning operations. All impurities which cause adverse effect during dyeing and printing are removed in the pretreatment process. Pretreatment processes include desizing, scouring, and bleaching, which make easy the subsequent dyeing and finishing processes.

4.1.1 Describe the grey fabric Desizing process

Study of various types and methods of desizing.

Conventional desizing of textile

Cold solutions of dilute sulphuric or hydrochloric acids are used to hydrolyze the starch;however, this has the disadvantage of affecting the cellulose fibre in cotton fabrics. Alternative eco-friendly desizing agents are available in the market in the form of enzymes. Complete removal of starch-containing size without fibre damage is best obtained by using enzymatic desizing agents.

4.1.2 Describe the grey scouring process and its objectives

Study of various types of scouring methods.

Study of chemicals used for scouring.

Scouring of cotton textiles is an essential treatment in textile wet processing to obtain sufficiently hydrophilic fabric. During scouring, waxes and other insoluble materials are removed from the cotton fibres. In nature, these non-cellulosic materials create a physical hydrophobic barrier to protect the fibre from the environment in course of its development. In aqueous textile processing, the waxes and pectins resist wetting and wicking, subsequently obstructing aqueous treatments. Conventionally, scouring is done with hot aqueous solution of NaOH to remove hydrophobic components from the primary wall and the cuticle .However, alkaline scouring is a non-specific process. The use of high concentrations of NaOH also requires neutralization of waste water. Even though alkaline scouring is effective and the cost of NaOH is low, the scouring process is rather inefficient, because it consumes large quantities of water and energy. It is clear that this process needs to be improved considerably to meet todays energy and environmental demands. In the last couple of years, a lot of research has been directed to replace this process with an enzymatic one. As far as scouring and bleaching is concerned, in earlier times this was supposed to be a two bath process, but currently majority of process houses do a one bath scouring and bleaching process. In the present time the above mentioned one stage scouring and bleaching process seems to be very ideal with respect to the age old processes that were used earlier.

4.1.3 Describe the grey bleaching process and its objects.

Study of bleaching agents

Bleaching is a chemical treatment that involves the removal of natural coloring matter from the material. The source of natural color is the organic compounds present in the material. On chemical bleaching, discoloration takes place by the action of bleaching agent. The material appears white after bleaching.

Textile bleaching is one of the stages in the finishing of textile material. All raw textile materials, when they are in natural form, are known as 'greige' material (pronounced grey-sh). This grey material will have its natural colour, odour and impurities that are not suitable for clothing materials. Not only the natural impurities will remain on the grey material but also the add-ons that were made during its cultivation, growth and manufacture in the form of pesticides, fungicides, worm killers, sizes, lubricants, etc. The removal of these natural colouring matters and added impurities from the grey textile materials is called scouring and bleaching.

Natural fibres

Natural fibres such as cotton, wool, linen etc. are off-white in colour due to colour bodies present in the fibre. The degree of off-whiteness varies from batch-to-batch. Bleaching therefore can be defined as the removal of these natural colour bodies. White is also an important market colour, so the whitest white has a commercial value. The process of removal of natural colouring matters from the grey material to make it into a suitable material is called bleaching.

Study of various methods of bleaching

Bleaching of textiles can be classified into oxidative bleaching and reductive bleaching.

Oxidative bleaching

Generally oxidative bleaching is carried out using oxidising or bleaching agents such as sodium hypochlorite, sodium chlorite etc

Natural fibres like cotton,jute,wool etc are all generally bleached with oxidative methods.

Reductive bleaching

Reductive bleaching is done with sodium hydrosulphite, which is a powerful reducing agent. Fibres like polyamides, polyacrylics and polyacetates can be bleached using reductive bleaching technology.

4.2. Classification of textile dyes based on water solubility

Textiles dyes are materials for the colouration of textiles by various means. Dyeing of material involves the colouration of material in the interior part also. For the penetration of the dye particles, various chemical reagents are used along with dyes. The colouring substances used for textile dyeing is known as textile dyes.

These colours are classified based on their solubility as soluble dyes and insoluble dyes.

The dyes which are soluble in water without the assistance of any chemical reagents are called soluble dyes.

The dyes which are insoluble in water are known as insoluble dyes, which require the assistance of chemical reagents .The insoluble form of dye converted in to soluble form by chemical reactions. This form of dye is easily soluble in water.

4.2.1 Describe the characteristic properties of soluble type of dyes

These dyes are easily soluble in water without the assistance of any chemical reagents. It is better used as wetting agents like turkey red oil, soap solution etc for the complete and even distribution of dye particles in water.

4.2.2 Describe the characteristic properties of insoluble types of dyes

Basically these dyes are insoluble in water. Chemical reagents are required to convert the insoluble form in to its soluble form. For example, in the dyeing of Vat dyes, the dye is converted in to its reduced form by using sodium hydrosulphate . This reduced form of dye is known as luco- compound .This form of dye gets easily dissolved in dilute alkali.

4.3 Dye application on cotton textiles

The common steps required for normal dyeing are :-

1. Dissolving the dye stuff
2. Preparation of dye bath.
3. Dyeing process.
4. Washing and after treatment
5. Study of concepts of ML ratio

Material Liquor ratio is an important factor to get even shades.If the solubility of the dye is more, higher ML ratio is required.

If the solubility of the dye is poor, less ML ratio is better.

Percent shade /Depth of shade

In dyeing, generally light, medium and deep shades are produced based on the end use of the product. 0.5% to 1% of shades are used for light shade, 2% to 3% are used for medium shades and 4% to 5% are used for deep shades.

Exhaustion of dye particles

The maximum exhaustion of dye particles in to the material is very important in dyeing process. To get maximum exhaustion ,exhausting agents are used in dyeing which have higher solubility property such as direct dyes.

Fastness properties

Some dyes have poor fastness properties to light, wash, perspiration ,rubbing etc. To improve the fastness properties of such dyes ,the dyed materials after washing is treated with suitable chemical reagents .

Strength of solutions

Dye solutions are prepared in various strengths according to our requirement. To measure milligrams of dyes is very difficult. Hence, dye solutions are prepared in specific strength.

Describe concept of dyeing

Dyeing is the process of applying textile colouring material in to textile material using chemical reagents and temperature. Dyeing includes dissolving of dye stuffs, preparation of dye bath, dyeing , washing and after treatments as required.

4.3.2 Describe the properties of direct dyes.

These dyes show direct affinity towards almost all textile fibres,but they are mainly employed for dyeing cheaper varieties of cotton because the colours produced are not fast. Due to this reason, direct colours are also known as cotton colours. They are soluble in water, the solubility being improved by adding sodium carbonate to the dye solution. The method of application of direct dye is very easy and the goods are dyed in the presence of an alkali and a salt. They give dull shades having very low fastness properties, which can be improved by various methods of after treatment. Some dyes contain primary amino group (NH_2), which can be converted to new colours like developed or coupled colours by suitable after treatment.

Direct dyes are highly soluble in water.

Direct dyes have direct affinity towards cellulosic materials.

It has poor fastness properties.

To improve fastness properties, after treatments are required.

Easiness in application.

It is cheaper than other dyes.

It is known as substantive dye because it can be used as an alternative for other colours.

Study the application of direct dyes on cotton textiles

1. Dissolving the dye stuff

Take the required quantity of dye stuff based on the weight of material to be dyed. Paste it well using a wetting agent and little water. Add required quantity of luke warm water and boil the whole solution until the dye is completely dissolved and a clear solution is obtained.

2. Preparation of dye bath

Calculate the required quantity of dye solution, sodium carbonate and sodiumchloride. Take the quantity of dye solution in a dye pot . Add the calculated quantity of sodium carbonate (1% -3%)as levelling agent to get an even shade.Make the required volume by adding water.

3. Dyeing process

Heat the dye bath after immersing the material to be dyed and gradually increase the temperature up to about 60^0C for about 45 minutes. Then remove the material and add sodium chloride solution (10% - 25%) as exhausting agent. Then re - enter the material and raise the temperature up to the boiling point for another 15 minutes. Constant stirring is required to get an even shade.

4. Washing and after treatment

After the completion of dyeing, the material is taken out of the dyebath and squeezed well. The material is then washed well with soap solution and finally with cold water thoroughly for the removal of chemicals and loosely held dyes from the surface. If required , the dyed material is to be after treated with chemical reagents to improve various fastness properties.

Various after treatments given to the direct dyed materials

1. To improve fastness to light – After treat with copper sulphate
2. To improve fastness to wash – After treat with potassium dichromate
3. To improve fastness to light & wash – After treat with copper sulphate and potassium dichromate
4. To improve fastness to perspiration – After treat with formaldehyde.

The thoroughly washed dyed material is treated with the required quantity of reagents along with water at required temperature. After 15 minutes, the material is taken out squeezed, and washed thoroughly.

4.3.3 Describe the properties of Reactive dyes

In all the cases of colouring mentioned above, dyeing is the physical absorption of dye or chemicals required for producing the colour. But in the case of reactive dyes, the dye molecules react with the fibre and form a bond of fibre and dye. The dyes are soluble and therefore, these dyes are very fast. They produce brilliant shades and are recommended for dyeing cotton,other cellulosic fibres,wool and silk. The reaction between fibre and the dye stuff takes place only in the presence of a reactive agent – an alkali. The alkalies used are sodium hydroxide and sodium phosphate. The dye bath is charged with sodium chloride in order to obtain sufficient absorption. The first reactive dye was marketed in the year 1956 by I.C.I under the trade name "Procion". Other companies have started manufacturing the dye and have given different names like - reactive, navictive and so on..

Characteristics of Reactive dyes

- Powder or liquid form
- Have excellent stability
- Have good solubility
- Low to medium substantivity
- Good compatibility
- Good diffusion and levelling properties
- Rapid fixation
- High degree of fixation
- Excellent washing fastness

Application of reactive dyes on cotton textiles

1. Dissolving the dye stuff

   Take the required quantity of dye stuff based on the weight of the material to be dyed. Paste it well using a wetting agent and little water. Add required quantity of luke warm water and boil the whole solution until the dye is completely dissolved and a clear solution is obtained.

2. Preparation of dye bath.

   Calculate the required quantity of dye solution, sodium carbonate and sodium chloride. Take the quantity of dye solution in a dye pot. Add the calculated quantity of sodium chloride and sodium carbonate. Make the required volume by adding water.

3. Dyeing process.

   Heat the dye bath after immersing the material to be dyed and gradually increase the temperature. Treat the material for about and hour. Constant stirring is required to get an even shade. The maximum temperature required is 100 ^{0}C.

   Assistants used for dyeing with reactive dyes

1. Salt:

NaCI is widely used for the dyeing reactive dyes.

Salt is used to increase the affinity of dye to fibre.

It decreases the hydrolysis rate of dyes.

It neutralizes the electro negativity of fibre surface when immersed in solution.

It puts an extra energy to push the due fibre polymer, ie, increases the absorption.

The amount of salt used depends upon the shade to be produced.

For light shade -10-20 gm/litre salt is used.

For medium shade-30-50 gm/litre is used.

For deep shade-60-100 gm/litre is used.

2. Alkali

Alkali is used for the following purposes.

Alkali is used to maintain proper pH in dye bath & thus to create an alkaline condition.

Alkali is used as a dye-fixing agent. Without alkali, no dyeing takes place.

The strength of alkali used depends up on the reactivity of dyes.

As a strong alkali, caustic soda (NaOH) is used to create pH 12-12.5 when the dye is of lower reactivity.

As a medium alkali sods ash (Na_2CO_3) is used to create pH 11-12 when the dye is of medium and high reactivity.

3. Urea:

Urea is used in continuous method of dyeing .It helps to get required shades of dye. To get a dark shade, more urea is used and for a lighter shade, less amount of urea is used.

4. Soaping:

By soaping, the extra colour is removed from the fibre surface thus wash fastness is improved .

Soaping increases the brightness and stability of dye.

Chemistry of reactive dyes

Reactive dyes differ from other colouring matters in the sense that they enter in to chemical reactions with fibre during dyeing and thus become part of fibre substance.

Reaction between cellulose & reactive dyes:

Dyeing of cellulosic fibres with reactive dyes consists of two phases:

1. Exhaustion phase, where dye is absorbed by material in neutral medium.
2. Fixation phase, where reaction between the dye and fibre takes place.

4. Washing and after treatment

After completion of dyeing, the material is taken out from the dye bath and squeezed well. The material is then washed well with soap solution and finally with cold water thoroughly for the removal of any chemicals and loosely held dyes from the surface.

4.3.4 Describe the properties of Vat dyes

Vat dyes have very high fastness properties. Hence, these dyes are very costly and are employed only for dyeing and printing high quality textiles. These dyes are insoluble in water. To dissolve the dye, two chemicals are required. Thechemicals required are

1. A strong reducing agent –so dium hydrosulphate ($Na_2S_2O_4$) and
2. An alkali – sodium hydroxide (NaOH)

The Vat dyes react with reducing agent (Sodium hydrosulphate ($Na_2S_2O_4$)) and form the reduced form of dye known as the leuco compound. This leuco compound is soluble in alkali (sodium hydroxide (NaOH)). The conversion of the Vat dye in to the leuco compound and the dissolving of leuco compound is a combined process. This is carried out in a special type of vessel, known as VAT and hence the name Vat dyes. Vat dyes are mainly used for dyeing and printing cellulosic fibres, especially cotton. They give bright shades and require different methods of application according to the types of vat dye being selected. Vat dyes are available in three classes.

They are:-

Anthraquinone Vat dyes

Indigoid Vat dyes

Sulphide vat dyes.

The most important natural colour Indigo belongs to Indigoid vat dye. Some selected vat dyes can be used for dyeing animal fibres - wool and silk without fibre damage. The important vat dye manufactures are CIBA,SANDOZ,ICI and IDI.

Study the application of vat dyes on cotton textiles

1. Dissolving the dye stuff

Take the required quantity of dye stuff based on the weight of material to be dyed. Paste it well with turkey red oil. Add required quantity of sodium hydroxide and water. Heat it up to required temperature. Then add sodium hydro sulphates and heat until the solution become clear.

2. Preparation of dye bath

The required quantity of water as per ML ratio.

The required quantity of vat dye solution is added to the dye bath containing the required amount of caustic soda and sodium hydrosulphate and water. Keep the bath at the recommended temperature.

The reducing and dyeing temperatures vary from dyestuff to dyestuff.

3. Dyeing process

The well scoured wet yarn is entered in to the dye bath and turned several times, so that the affinity of the colour remains uniform. The yarn is then kept completely immersed under the dye liquor and the dyeing is continued for one hour. The yarn is turned from time to time. Care should be taken to keep the bath at required temperature and also to keep the yarn thoroughly immersed under the liquor.

Required exhaustion agents or retarding agents are added to the dye bath depending upon the dyestuffs taken, during the entire dyeing period. Excess quantities of both sodium hydroxide (NaoH) and sodium hydrosulphate ($Na_2S_2O_4$) should be present in the dye bath in order to keep the dye in the soluble form. At the end of the dyeing the partly or completely exhausted dye bath must be kept in a distinctly reduced condition; otherwise oxidation of the residual vat dye takes place in the dye bath itself leading to the appearance of turbidity. This is ensured by adding sufficient sodium hydro sulphate. The dyed goods may then be removed from the dye bath and excess unexhausted vat dye, sodium hydroxide, sodium hydro sulphate are removed as far as possible from the goods.

4. Washing and after treatment

The dyed goods are rinsed with cold water and then subjected to oxidation treatment by exposure to atmospheric oxygen. This is called "air oxidation" or "airing". But the oxidation may be accelerated by using stronger oxidizing agent such as sodium per borate or hydrogen peroxide or sodium dichromate in the presence of acetic acid. This process is usually referred to as chemical oxidation.

5. Oxidation process

During the oxidation step, the sodium salt of leuco vat dye absorbed by the fibre is oxidized and converted into insoluble dye in the fibre. At the same time, the vatted dye contained in the residual liquor in the goods being dyed also gets converted into the insoluble form, which is loosely deposited on the fibre surface. This loosely deposited dye on the surface of the fiber has to be removed for achieving optimum fastness properties, especially rubbing and washing properties. This is achieved by soaping process. The dyed material is treated in hot soap solution or a synthetic detergent solution for 15 – 30 minutes. After the soaping treatment the dyed goods should be rinsed thoroughly and finally the dyed material is dried.

4.4 Textile printing

Textile printing is the process of producing definite patterns or designs in fabric using textile dyes . In properly printed fabrics, the colour is bonded with the fibre, so as to resist washing and friction. Textile printing is related to dyeing but if dyed properly the whole fabric is uniformly covered with one colour, whereas in printing one or more colours are applied to it in certain parts only, and in sharply defined patterns.

In printing, wooden blocks, stencils, engraved plates, rollers, or silk screens can be used to place colours on the fabric. Colourants used in printing contain dyes, thickeners to prevent the colour from spreading by capillary attraction beyond the limits of the pattern or design.

Traditional textile printing techniques may be broadly categorised into four styles:

- Direct printing: In direct printing, colourants contain dyes, thickeners, and mordants or substances necessary for fixing the colour on the cloth to be printed in a desired pattern.
- In the printing of mordant in the desired pattern prior to dyeing cloth, the colour adheres only where the mordant is printed.
- Resist dyeing: In resist dyeing, a wax or other substance is printed onto the fabric which is to be subsequently dyed. The waxed areas do not accept the dye, leaving un coloured patterns against a coloured background.
- Discharge printing: In discharge printing, a discharging agent is printed onto the previously dyed fabric to remove some or all of the colours.

Resist and discharge techniques were particularly fashionable in the 19th century, as were the combination techniques in which indigo resist was used to create blue backgrounds prior to block-printing of other colours. Modern industrial printing mainly uses direct printing techniques.

The printing process does involve several stages in order to prepare the fabric and printing paste, and to fix the impression permanently on the fabric.

- Pre-treatment of fabric
- Preparation of colours
- Preparation of printing paste
- Impression of paste on fabric using printing methods
- Drying of fabric
- Fixing the printing with steam or hot air (for pigments)
- After treatment process

Formerly, colours were always prepared for printing by boiling the thickening agent, colouring matter and the solvents, together, then cooling and adding various fixing agents. In the present time, however, concentrated solutions of the colouring matters and other adjuncts are often simply added to the cold thickenings of which large quantities are kept in stock.

4.4.1. Describe styles of textile printing; direct style, mordant style, resist style and discharge style

1. Styles of Printing

Textile Printing

- Textile printing is the process of applying colour to fabric in definite patterns or designs.
- In properly printed fabrics, the colour is bonded with the fibre, so as to resist washing and friction.
- In printing, wooden blocks, stencils , engraved plates, rollers, or silk screens can be used to place colours on the fabric.
- Colorants used in printing contain dyes thickened to prevent the colour from spreading by capillary attraction beyond the limits of the pattern or design.
- For cotton printing, vat and reactive dyes are generally used.
- Silk is usually printed with acid colours.
- Wool is printed with acid or chrome dyes, but before printing it is treated with chlorine to make it more receptive to colours.
- Manmade fibres are generally printed with disperse and cationic dyes.

All Styles of Printing

- Direct printing
- Resist printing
- In Heat-transfer printing, the design printing on a special type of paper & is transfer to the fabric under heat and pressure.
- Discharge printing
- Mordant printing

Direct Printing

- It is the most common approach to apply a colour pattern on fabric.
- It can be done on white or a coloured fabric.
- If done on coloured fabric, it is known as overprinting.
- The desired pattern is produced by imprinting dye on the fabric in a paste form.

- To prepare the print paste, a thickening agent is added to a limited amount of water and dye is dissolved in it.
- Earlier corn starch was preferred as a thickening agent for cotton printing.
- Most pigment printing is done without thickeners as the mixing up of resins, solvents and water itself produces thickening.

Resist Printing

- In this technique, a resist paste is imprinted on the fabric and then it is dyed.
- The dye affects only those parts that are not covered by the resist paste.
- After dyeing, the resist paste is removed leaving a pattern on a dark background.

Heat Transfer Printing

Transfer printing is the term used to describe textile and related printing processes in which the design is first printed on to a flexible non textile substrate and later transferred by a separate process to a textile

Sublimation Transfer

This method depends on the use of a volatile dye in the printed design. When the paper is heated the dye is preferentially adsorbed from the vapour phase by the textile material with which the heated paper is held in contact. This is commercially the most important of the transfer-printing methods.

Melt Transfer

This method has been used since the 19th century to transfer embroidery designs to fabric. The design is printed on paper using a waxy ink, and a hot iron applied to its reverse face presses the paper against the fabric. The ink melts on to the fabric in contact with it. This was the basis of the first commercially successful transfer process, known as Star printing, developed in Italy in the late 1940s. It is used in the so-called 'hot-split' transfer papers extensively used today in garment decoration.

Film Release

This method is similar to melt transfer with the difference that the design is held in an ink layer which is transferred completely to the textile from a release paper using heat and pressure. Adhesion forces are developed between the film and the textile which are stronger than those between the film and the paper. The method has been developed for the printing of both continuous web and garment panel units, but is used almost exclusively for the latter purpose. In commercial importance it is comparable with sublimation transfer printing.

Wet Transfer

Water-soluble dyes are incorporated into a printing ink which is used to produce a design on paper. The design is transferred to a moistened textile using carefully regulated contact pressure. The dye transfers by diffusion through the aqueous medium. The method is not used to any significant extent at the present time.

Discharge Printing

- In this approach, the fabric is dyed in piece and then it is printed with a chemical that destroys the colour in the designed areas.
- Sometimes, the base colour is removed and another colour is printed in its place.
- The printed fabric is steamed and then thoroughly washed.
- This approach is on decline these days.

Mordant Printing

- A mordant is a substance used to set dyes on fabrics or tissue sections by forming a coordination complex with the dye which then attaches to the fabric or tissue.
- It may be used for dyeing fabrics, or for intensifying stains in cell or tissue preparations.

4.4.2 Describe Methods of printing;

Handblock printing

Wood blocks for textile printing are commonly made of wood. They vary in size considerably, but must always be of two for three inches thick, otherwise they are liable to warping.

The wooden block, being plane, quite smooth and perfectly flat, next has the design drawn upon, or transferred to it. This is effected by rubbing off, upon its flat surface, a tracing in lampblack and oil, of the outlines of the masses of the design. The portions to be left in relief are then tinted, between their outlines, with ammonia cal carmine or magenta for the purpose of distinguishing them from those portions that have to be cut away. As a separate block is required for each distinct colour in the design, a separate tracing must be made of each and transferred (or put on as it a termed) to its own special block.

Having thus received a tracing of the pattern, the block is thoroughly damped and kept in this condition by being covered with wet clothes during the whole process of cutting. The block cutter commences by carving out the wood around the heavier masses first, leaving the finer and more delicate work to be done last so as to avoid any risk of injury it during the cutting of the coarser parts. When large masses of colour occur in a pattern, the corresponding parts on the block are usually cut in outline, the object being filled in between the outlines with felt, which not only absorbs the colour better, but gives a much more even impression than it is possible to obtain with a large surface of wood. When finished, the block presents the appearance of flat relief carving, the design standing out like letterpress type.

The printer commences by drawing a length of cloth, from the roll, over the table, and marks it with a piece of coloured chalk and a ruler to indicate where the first impression of the block is to be applied.

He then applies his block in two different directions to the colour on the sieve and finally presses it firmly and steadily on the cloth, ensuring a good impression by striking it smartly on the back with a wooden mallet. The second impression is made in the same way, the printer taking care to see that it fits exactly to the first, a point which he can make sure of by means of the pins with which the blocks are provided at each corner and which are arranged in such a way that, when those at the right side or at the top of the block fall upon those at the left side or the bottom of the previous impression, the two printings join up exactly and continue the pattern without a break. Each succeeding impression is made precisely in the same manner until the length of cloth on the table is fully printed. When this is done it is wound over the drying rollers, thus bringing forward a fresh length to be treated similarly.

If the pattern contains several colours, the cloth is usually first printed throughout with one, then dried, re-wound and printed with the second, the same operations being repeated until all the colours are printed.

Screen printing

Screen printing is a printing technique, whereby a mesh is used to transfer ink onto a substrate, except in areas made impermeable to the ink by a blocking stencil. A blade or squeegee is moved across the screen to fill the open mesh apertures with ink, and a reverse stroke then causes the screen to touch the substrate momentarily along a line of contact. This causes the ink to wet the substrate and get pulled out of the mesh apertures, as the screen springs back after the blade is passed.

Screen printing is also a stencil method of print making in which, a design is imposed on a screen of polyester or other fine mesh, with blank areas coated with an impermeable substance. Ink is forced into the mesh openings by the fill blade or squeezee and by wetting the substrate, transferred on to the printing surface during the squeegee stroke. As the screen rebounds away from the substrate, the ink remains on the substrate. It is also known as silk-screen, screen, serigraphy, and serigraph printing. One color is printed at a time, so several screens can be used to produce a multi coloured image or design.

Printing technique

A screen is made of a piece of mesh stretched over a frame. A stencil is formed by blocking off parts of the screen in the negative image of the design to be printed; that is, the open spaces are where the ink will appear on the substrate.

Before printing occurs, the frame and screen must undergo the pre-press process, in which an emulsion is 'scooped' across the mesh and the 'exposure unit' burns away the unnecessary emulsion leaving behind a clean area in the mesh with the identical shape as the desired image. The surface to be printed (commonly referred to as a pallet) is coated with a wide 'pallet tape'. This serves to protect the 'pallet' from any unwanted ink leaking through the screen and potentially staining the 'pallet' or transferring unwanted ink onto the next substrate. Next, the screen and frame are lined with a tape. The type of tape used in for this purpose often depends upon the ink that is to be printed onto the substrate. These aggressive tapes are generally used for UV and water-based inks due to the inks' lower viscosities. The last process in the 'pre-press' is blocking out any unwanted 'pin-holes' in the emulsion. If these holes are left in the emulsion, the ink will flow through and leave unwanted marks. To block out these holes, materials such as tapes, speciality emulsions and 'block-out pens' may be used effectively.

The screen is placed atop a substrate. Ink is placed on top of the screen, and a flood bar is used to push the ink through the holes in the mesh. The operator begins with the fill bar at the rear of the screen and behind a reservoir of ink. The operator lifts the screen to prevent contact with the substrate and then using a slight amount of downward force pulls the fill bar to the front of the screen. This effectively fills the mesh openings with ink and moves the ink reservoir to the front of the screen.
The operator then uses a squeezee (rubber blade) to move the mesh down to the substrate and pushes the squeegee to the rear of the screen. The ink that is in the mesh opening is pumped or squeezed by capillary action to the substrate in a

controlled and prescribed amount, i.e. the wet ink deposit is proportional to the thickness of the mesh or stencil. As the squeegee moves toward the rear of the screen the tension of the mesh pulls the mesh away from the substrate (called snap-off) leaving the ink upon the substrate surface.

8. Detailing of practicals

8.1 Grey cotton fabric desizing with rot steeping

Desizing is a process of removal of size material from the fabric for printing/dyeing. In weaving preparatory, the yarns (especially warp) are sized to increase the weavability. The added items are removed from the fabric for better result. There are many types of desizing methods. Most important is rot steeping.

8.2 Grey cotton yarn/fabric scouring process in open bath

Scouring/alikali boiling is the process of removal of insoluble impurities from the textile material using dilute boiling alkalies. The alkali converts the insoluble impurities into soluble at boiling temperature which are easily washable. In textile industry, a vessel known as Kier is used for alkali boiling / scouring, Hence the process is also known as Kier boiling.Generally two types of Kiers are used:

1. Open Kier
2. Closed Kier

8.3. Cotton textile bleaching with bleaching powder, peroxide and permanganate

Bleaching is a process of removal of natural colouring matter from textile materials using suitable bleaching agents. Bleaching agents are classified into two categories namely:

1. Oxidising bleaching agents
2. Reducing bleaching agents

Bleaching agents are also classified into –

Chlorinated bleaching agent and non-chlorinated bleaching agents.

Steps in bleaching:

Prepare the bleach solution

Take required quantity of prepared solution and add suitable chemical reagents.

Make the solution with sufficient quantity of water as per ML ratio.

Treat the material with the solution

Maintain the temperature as required

Keep time for each type of material

After completion, the material is taken out, squeezed well, washed and finally neutralized with mild acid.

Final wash

8.4. Dye application on cotton yarn sample with direct dyes and after treatment

1. Dissolving the dye stuff
2. Preparation of dye bath
3. Dyeing
4. Washing
5. After treatments

8.5. Dye application on cotton yarn sample with reactive dyes

1. Dissolving the dye stuff
2. Preparation of dye bath
3. Dyeing
4. Washing

8.6. Dye application on cotton yarn sample with vat dyes

1. Dissolving the dye stuff
2. Preparation of dye bath
3. Dyeing
4. Washing

8.7 Printing of cotton fabric with hand block printing method

1. Preparation of hand blocks
2. Preparation of table for printing
3. Preparation of printing paste

4. Printing
5. Drying and after treatments

8.8. Printing of cotton fabric with screen printing method

1. Preparation of screens for printing
2. Preparation of table for printing
3. Preparation of printing paste
4. Printing
5. Drying and after treatments

8.9. Printing of cotton fabric with Batik printing method

1. Melting of wax in suitable viscosity
2. Preparation of printing table
3. Placing of clothes on the table
4. Drawing of design
5. Dyeing with cold brand dyes
6. Removal of wax
7. Washing

8.10. Study of tie and dye on cotton yarn

It is a resist style of printing.

In printing, tie the desired position where the colour is not required.

Dye the tied material with suitable dye

26. At the end of the module 4

1. Extended activities

   Field visits

   Sample collection

   Preparation of Bleached, Dyed and printed sample record

   Chart preparation

2. List of practical

   Scouring

   Bleaching

Application of Direct dyes on cotton with minimum four colours (light, medium and dark shades)

After treatment to improve fastness to light

After treatment to improve fastness to wash

After treatment to improve fastness to light and wash

After treatment to improve fastness to perspiration

Application of reactive dyes on cotton with minimum four colors (light, medium and dark shades)

Application of Vat dyes on cotton with minimum four colors (light, medium and dark shades)

Preparation of printing table for block printing

Preparation of printing paste for block printing.

Print the sample cloth with direct dye (minimum four colors)

After treatment to material printed with direct dye.

Preparation of silk screen for textile printing

Preparation of screen printing paste .

Preparation of printing table for screen printing

Print the sample cloth with screen

After treatment for printed material

27. On -the- Job Training

To expose students to industrial/organizational experience and knowledge

To apply the management theories taught in lecture rooms in real industrial situations

To get a feel of work environment

To improve verbal/written skill with the interaction of industrial colleagues

To increase students job aspects

Activity

One faculty can be appointed as advisor for this industrial training.

Advisor can identify appropriate industry and co- ordinate the programme.

Report

At the end of the training, individual report shall be prepared and submitted by each student. The report shall include Nature and activity of industry/institution/collaborative work Knowledge gained from the industrial exposure Contribution to industry/ institution/society, if any, through the programme Experience gained after the industrial exposure

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