

K.S.RANGASAMY COLLEGE OF TECHNOLOGY

(Autonomous Institution)

TIRUCHENGODE – 637 215



Course Module

Knitting Technology

by

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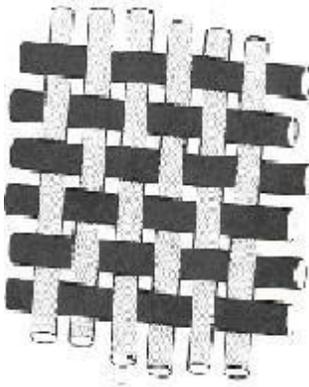
1. INTRODUCTION

There are *three* principal methods of *mechanically* manipulating into textile fabrics.

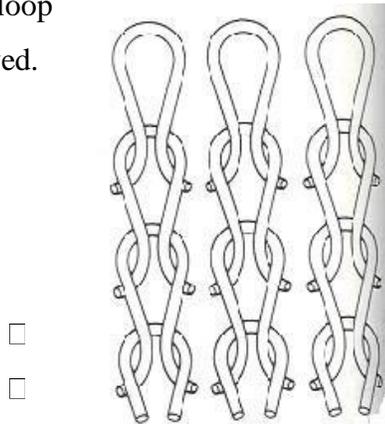
- I. **Interweaving** –the intersection of two sets of straight threads, warp and weft, which cross and interweave at right angles to each other.

- II. **Intertwining** and twisting includes a number of techniques such as braiding, twisting and knotting where threads are caused to intertwine with each other at right angles or some other angle.

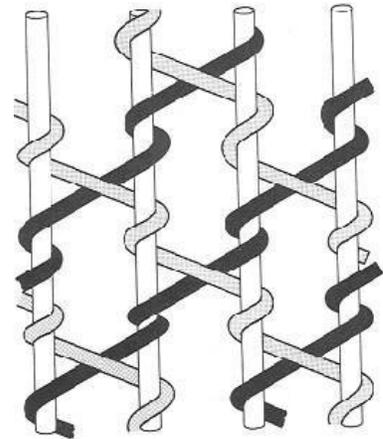
- III. **Interloping** consists of forming yarns into loops each of which is typically only released after a succeeding loop has been formed and intermeshed with it so that a secure ground loop structure is achieved.



Interweaving



Intertwining & twisting



Interloping

- Knitting is the most common method of interloping and is second only to weaving as a method of manufacturing textile structures.

What is knitting?

- ✓ *Knitting is the production of fabric by forming **loops** with yarn which are interlaced in a variety of ways to form the fabric. OR*
- ✓ *Knitting is the action of forming fabrics by the intermeshing of loops.*

1.1. EVOLUTION OF KNITTING TECHNOLOGY

- Traditional hand knitting existed as early as the 5th century
- Henry VIII was the first British monarch to wear knitted stockings.
- The first-hand knitted silk stockings appeared in England in 1550 and by 1561 Queen Elizabeth I was so impressed by their elasticity and fineness that she never again wore cut and sewn woven hose.
- The first real evidence of a **production knitting machine** was the **stocking frame**, invented by the **Revered William Lee in 1589**.its speed is 10 times the speed of traditional hand pin knitting. It laid the foundation for modern weft and warp knitting.

1.2. IMPORTANT DIFFERENCE BETWEEN KNITTED AND WOVEN FABRICS

1. Movement, mobility &elasticity: Weft knitted fabrics are constructed by the **interloping** of yarns, which produces fabrics with considerable **elongation**. Knitted fabrics tend to **mold and fit** easily to body shapes without **binding**. **Allowing freedom of body movement** without **permanent fabric deformation**. These fabrics are **soft** and usually **light weight**

Woven fabrics are

- usually, rigid
- do not mold to the body shape---

🚩 Warp knits tend to be more rigid than weft knits but not as much as woven fabric.

2. Recovery from wrinkling: knitted fabrics recover more readily than woven fabrics. In comparison, knitted fabrics take a less-sharp crease than woven fabrics. The wrinkle recovery property of knits is a factor in their **end uses**. For example, they are very suitable for **travel purpose**.

- 3. Design & pattern changes:** weft knit fabrics can be changed very quickly to meet fashion demands. Warp knits & woven fabrics require extensive mechanical machine adjustments for change of patterns and thus are less adaptable to rapid changes in fashion.
- ❖ Computer controlled warp knitting machineries and computer assisted design (CAD) systems for woven fabrics do allow for quick response to design changes.
- 4. Insulation and warmth:** Bulky knit fabrics provide excellent insulation in still air, because of insulative pockets contained in this type of construction. But because of the open structure, they are porous & provide breathing comfort because body movements cause the loops to expand & contract thus pushing air through close fitting garments. However, unless the fabric is heavily napped or foam laminated, it is a poor insulator in the wind, thus not wind proof.
- ✓ Woven fabrics when tightly woven provides a high degree of wind resistance

1.3. PROBLEMS OF KNITTED FABRICS

- Knit fabrics, particularly loosely knitted construction tend to **stretch out of the shape** and /or sag /snag on sharp articles.
- Due to loop breakage a hole in formed which start to run (laddering).
- Considerable shrinkage may occur unless a special technique for shrink proof is made.
- ❖ Knitted fabric garments should not be hung on hangers for long periods, but rather folded and stored.

1.4 COMPARISON

1.4.1 Comparison between Knitting and Weaving Machine:

KNITTING	WEAVING
1. Converting yarn into fabric by interloping using knitting elements.	1. Converting yarn into fabric by Interfacing warp & Weft

2. Capital investment is less due to less number of preparatory machineries requirement	2. The capital investment is high
3. Supply package is cone or warp beam	3. Supply package is sized yarn from beam and weft yarn from pirn
4. Productivity of knitting Machine is high	4. Productivity is less.
5. Simpler operation and faster production	5. Design modification is difficult
6. Require less labor	6. More labors are required

1.4.2 COMPARISON BETWEEN KNITTED AND WOVEN FABRICS:

KNITTING	WEAVING:
1. Generally coarser count is used.	1. All types of counts can be used
2. Moisture absorbency is more	2. Moisture absorbency will be less
3. Crease resistance is high	3. Crease resistance is less.
4. Fabric is thicker	4. Generally fabric is thin
5. No wrinkles formed. Ironing not required.	5. Requires ironing
6. Knitted fabric has good extensibility.	6. Extensibility is less
7. Pleat sharpness is less	7. Pleat sharpness is high
8. More permeability to air	8. Somewhat less permeability to air
9. Less stronger fabrics	9. Generally stronger fabrics
10. Any small defect occur in fabric it leads to more damage in cloth because it cannot be mended easily	10. No such problems.

1.5 IMPORTANT TERMS IN KNITTING

1.5.1 Knitting Element

- ❖ A generic term describing the loop forming parts of a knitting machine and those parts used to control and / or select the loop forming instruments. Example needles, sinkers, cylinder, cams etc.

1.5.2. Machine Knitting

- It is the process of formation of intermeshed loops for the formation of cohesive structure of knitted fabrics.

1.5.3. Knitting Machine

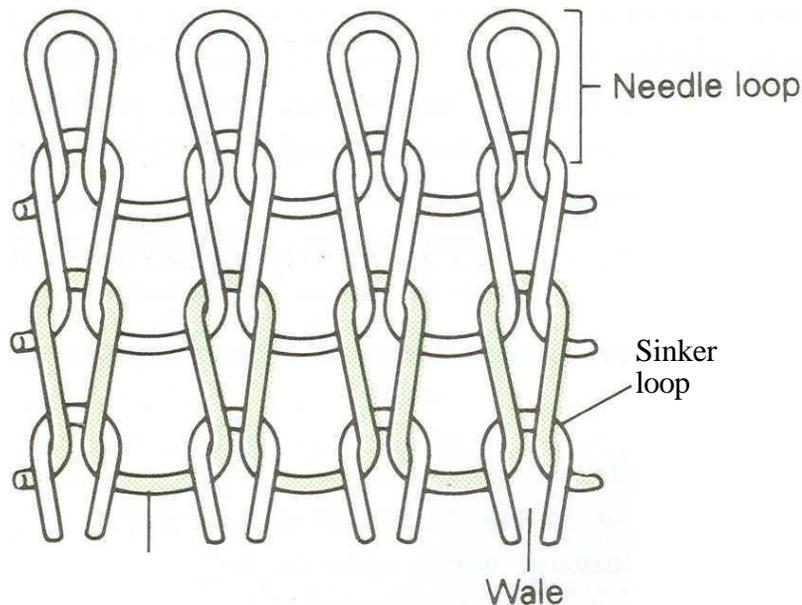
- It is a machine for the productions of fabrics or garments from yarns by warp knitting or weft knitting.

1.5.4. Knitted Loop

- The principal unit of a knitted fabric is known as the loop.

1.5.5. Knitted Loop Structure –

- The knitted loop structure may not always be noticeable because of the effect of structural fineness, fabric distortion, additional pattern threads, or the masking effect of finishing processes.



1.5.6. Course:

- Series of loops that intermeshes **horizontally** in a fabric is called as course.
 - ✓ A course determines the length of fabric and is measured in courses per inch

1.5.7. Wales:

- Series of loops that intermeshes **vertically** in a fabric is called as wales.
 - ✓ Wales determine the width of fabric and are measured as wales per inch.

Loop consists of two parts

1. Sinker loop

2. Needle loop

These two loops are simply known as knit loop.

1.5.8. Fabric Draw Off

- ✓ Fabric is always drawn from the needle on the side remote from their hooks.
- ✓ When two sets of needles are employed, either arranged vertically or at some other angle to each other, each set of hooks will face away from the other set and the fabric will be produced and drawn away in the gap between the two sets.

1.5.9. Technically Upright

- ✓ A knitted fabric is technically upright when its courses run horizontally and its wales run vertically with the heads of the needle loops facing towards the top and the course knitted first at the bottom of the fabric.

1.5.10. Machine Gauge:

- ✓ Gauge of the knitting machine is expressed in terms of needles per inch. Higher the gauge, higher the number of needles per inch and finer will be the fabric.

1.5.11. Texture:

- ✓ Courses per inch is said to be texture of the knitted fabric. The course and Wales per unit space (inch or Cm) determine the quality of fabric.

1.5.12. Single Jersey Fabric:

- ✓ A weft knitted fabric made on one set of needles is called as single jersey fabric.

1.5.13. Double Jersey Fabric

- ✓ A fabric made on two sets of needles is called as double jersey fabric, if fabric produced from this will reduce the natural extensibility of the knitted structure.

1.6 KNITTING NEEDLES

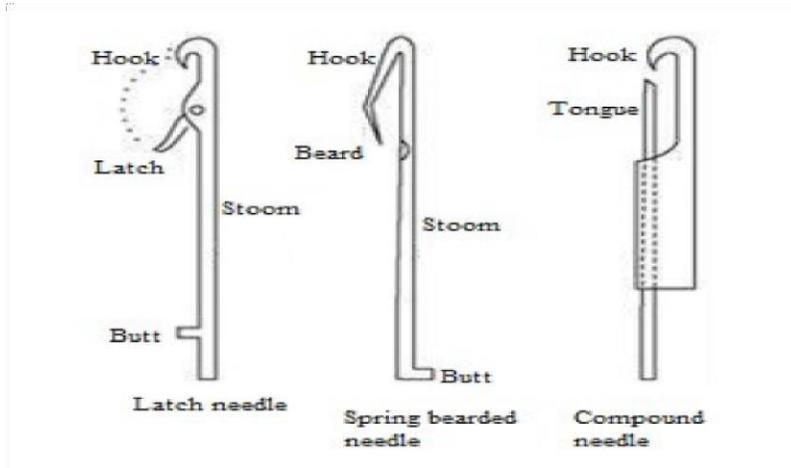
The hooked metal needle is the main element in a knitting machine. They are displaced vertically up and down and are mounted into the tricks or cuts of the knitting cylinder.

Different types of needles are:

1. Spring beard needle

2. Latch Needle

3. Compound Needle



1.6.1 Bearded Needle

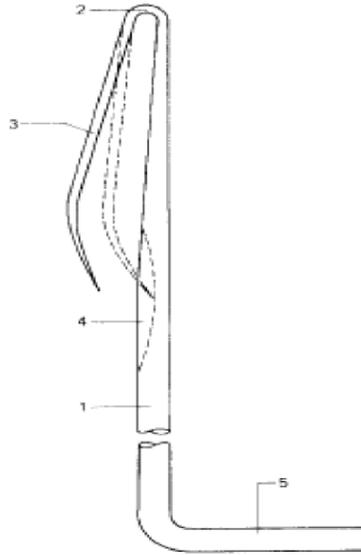
The bearded or spring needle was the first type of needle to be produced. It is the cheapest and simplest type to manufacture as it is made from a single piece of metal, in machine gauges as fine as 60 needles per inch, with the needles being pliered to ensure accurate needle spacing.

The bearded needle is essentially a frame needle, the needles being fixed to move collectively with the straight needle bar or being attached to a circular frame and revolving with it. When bearded needles are reciprocated in their bed, the action is a collective one because of the problems of individual pressing and needle movement. The serial action of weft knitting is thus achieved by other loop-forming and controlling knitting elements that form the yarn into new loops.

The main parts of the bearded needle

There are five main parts of the bearded needle are:

1. The stem, around which the needle loop is formed.
2. The head, where the stem is turned into a hook to draw the new loop through the old loop.
3. The beard, which is the curved downwards continuation of the hook that is used to separate the trapped new loop inside from the old loop as it slides off the needle beard.



4. The eye, or groove, cut in the stem to receive the pointed tip of the beard when it is pressed, thus enclosing the new loop.
5. The shank, which may be bent for individual location in the machine or cast with others in a metal 'lead'.

1.6.2 Latch Needle

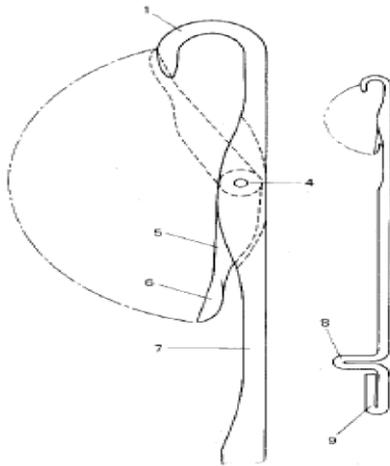


Fig. 3.3 Main features of the latch needle.

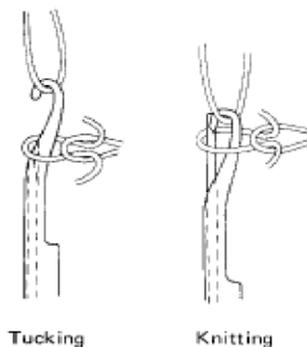
The latch needle has nine main features:

1. The hook, which draws and retains the new loop.
2. The slot or saw cut, which receives the latch-blade (not illustrated).

3. The cheeks or slot walls, which are either punched or riveted to fulcrum the latch blade.
5. The rivet, which may be plain or threaded. The latch-blade, which locates the latch in the needle.
6. The latch spoon, which is an extension of the blade, and bridges the gap between the hook and the stem covering the hook when closed, as shown in broken lines.
7. The stem, which carries the loop in the clearing or rest position.
8. The butt, which enables the needle to be reciprocated when contacted by cam profiles on either side of it, forming a track.
9. The tail, which is an extension below the butt, giving additional support to the needle and keeping the needle in its track.

1.6.3 Compound Needle

Compound needles consist of two separately-controlled parts – the open hook and the sliding closing element (tongue, latch, piston, plunger). The two parts rise and fall as a single unit but, at the top of the rise, the hook moves faster to open the hook and at the start of the fall the hook descends faster to close the hook. It is easier to drive the hooks and tongues collectively from two separate bars in warp knitting than to move each hook and tongue individually, as in weft knitting. A compound needle with a sliding latch was first patented by Jeacock of Leicester in 1856. It now dominates the warp knitting industry after suffering a set-back against high-speed bearded needle machines in the 1960s.



1.7 TYPES OF KNITTING

The knitting industry is divided into two distinct sectors, **weft knitting and warp knitting**.

1.7.1 Weft Knitting

- ❖ Fabric in which the constituent threads generally pass from side to side of the fabric, along the advancing line of construction. The structural threads being perpendicular to the fabric characterize weft knitted fabrics.
- ❖ One horizontal row of loops or 'course' of such a fabric is normally made from one or very few threads; the yarn goes back and forth across the fabric (weft ways) to make a flat fabric and goes round and round to make circular or tubular fabric.
- ❖ It is possible to knit with only one thread or cone of yarn, though production demands have resulted in circular knitting machines being manufactured with up to 192 threads (feeders).
- ❖ Compared with warp knitting, weft knitting is a more versatile method of fabric production in terms of both the range of fabric structures that can be produced and the yarn types that can be utilized.
- ❖ Weft knitting is the simplest method of converting yarn into a fabric.
- ❖ The basic stitches are plain, purl, interlock and rib.
- ❖ An extra yarn may be laid across, but not looped, to give greater stability.
- ❖ There are various types of wefts knitting machines to produce simple fabrics for seamless hose and underwear, complicated cloth; for fully fashioned hosiery, underwear and outerwear; and intricate design fabrics like interlock, double knitted etc.

1.7.2 Warp Knitting

- Warp knitting is characterized by the structural threads of the fabric running along the length of the fabric.
- On horizontal row of loops, or 'course', is made from many threads.
- Warp knitted fabrics are mainly flat, closer knit, ladders less easily and are more stable than weft - knitted.
- Extra inlaid weft yarns can be used to increase stability.
- Warp knitting is done on Tricot and Raschel machines both having different kinds of needles.

- In Tricot, one or more sets of yarns are used e.g.: two sets, one is knitted in one direction, the other the opposite.
- Many warp-knitted fabrics are 'locknit' construction; the stitches are locked to prevent runs (ladders).
- Warp knitting is the fastest method of converting yarn into fabric, when compared with weaving and weft knitting, though modern developments in weft knitting machines means that there is very little difference in terms of production between the two forms of knitting.

1.8 ELEMENTS OF KNITTED LOOP STRUCTURE

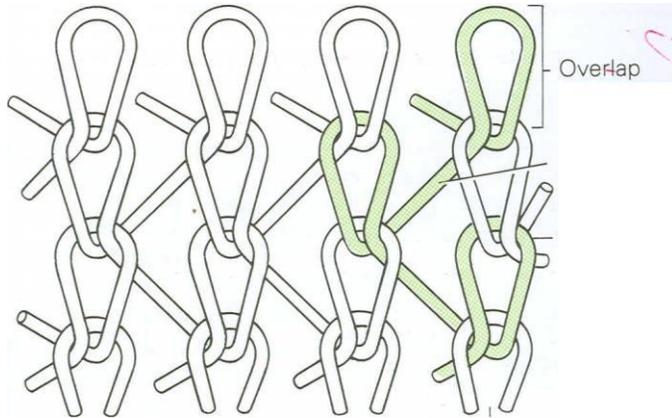
1.8.1 Warp Knitted Laps

Loops are termed laps in warp knitting because the guides lap the warp yarn around the needles in order to form the loops, the laps may be either open or closed. On the original warp frame (as on many present-day crochet machines) the needle bar was in a horizontal and not a vertical position with its beards facing upwards. To produce a needle loop it was thus necessary to swing the guide upwards and shog it over the top of the needle hence the term 'overlap' which refers both to the movement and to the loop which it forms. Similarly, the guides were slogged under the needles to new starting positions for the next overlap and this movement and the lapped thread it produces is still termed an 'underlap'. In the warp knitting cycle it is always understood that the overlap precedes the underlap.

A. THE OVERLAP

The *overlap* is a shog usually across one needle hook by a warp guide which forms the warp yarn into the head of the loop. The swinging movement of the guide to the hook side and the return swing after the overlap produce the two side limbs of the loop which has a very similar appearance on the face side of the fabric to a needle loop produced by weft knitting. Only exceptionally rarely are overlaps taken across two needles as this produces severe tension on the warp yarn and the knitting elements because the needles knock-over in unison. Double needle bar overlaps generally also have a poor appearance and physical characteristics because the second overlap will have a different configuration of underlaps to the first overlap. In the former, the underlap will be passing along the course to the next

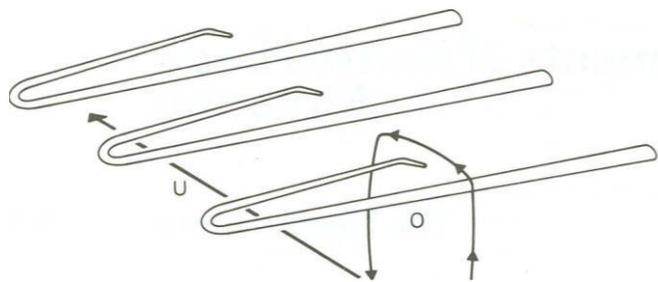
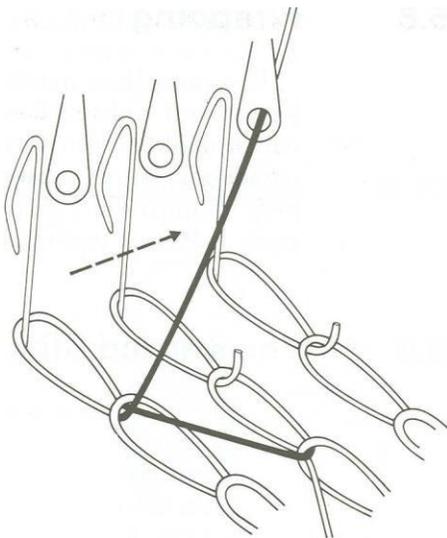
overlap in the same manner as a sinker loop whereas in the latter, the underlap will lap up to the next course in the normal manner of an underlap



B. THE UNDERLA

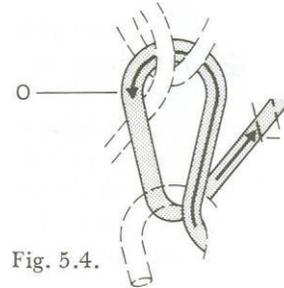
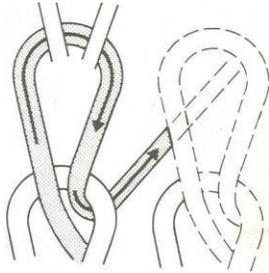
The underlap shog occurs across the side of the needles remote from the hooks, on the front of single bar and in the centre of double bar needle machines, it supplies the yarn between one overlap and the next.

Generally ranging from nothing up to three needles; in extent it can be 14 needle spaces or more, depending upon design of machine and structure, although efficiency and speed tend to be reduced. Underlaps as well as overlaps are essential in all warp knitted structures in order to join the wales of loops together, but they may be contributed by a different guide bar to those for the overlaps.



C. CLOSED LAP

A closed lap is produced when an under lap follows in the opposite direction to the overlap and thus laps the thread around both sides of the needles.



D. Open Lap

An open lap is produced either when the underlap is in the same direction as the overlap, or it is omitted so that the next overlap commences from the space where the previous overlap finished. Closed laps are heavier, more compact, opaque and less extensible than open laps produced from the same yarn and at a comparable knitting quality.

Rack: A working cycle of 480 warp knitted courses by the guide bars in warp knitting.

Run-in: Length of yarn required in inches (or centimeters) to knit a rack of 480 courses.

Note:

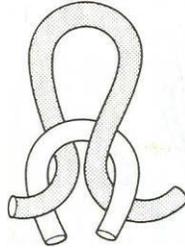
1. A longer run-in produces a loose fabric with big loops and a shorter run-in produces a tighter fabric with small loops.
2. Essential to measure and record the run-in whenever a new warp knit fabric is produced. Without this information it will be very difficult to reproduce the same fabric.

Run-in ratio: When a fabric is knitted with more than one guide bar, the relative amount warp fed through individual guide bars is very important for different fabric constructions and qualities. The ratio of warp yarn consumed by two guide bars to knit their respective

rack is called run-in ratio. (or) The ratio of run-in of the warp yarn of two guide bars is called run-in ratio.

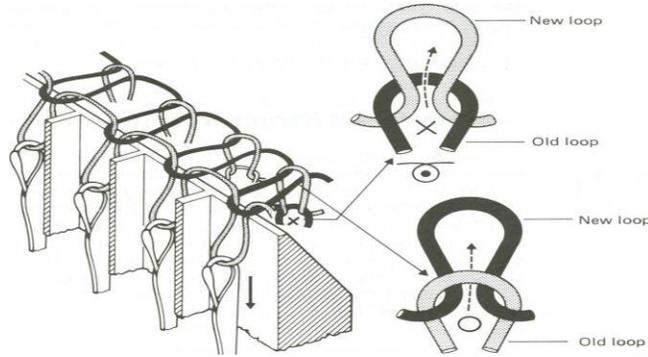
E. Wrapping

Wrapping is a method of patterning with warp threads on a single jersey weft knitted base structure using specially-controlled thread guides which make unidirectional warp knitted laps around selected needle hooks which are empty ('warp insertion') or already have a new weft knitted loop ('embroidery plating' or 'wrap striping'). The technique is used on some half-hose and circular single-jersey machines.



1.8.2 The Intermeshing Points of a Needle Loop

All needle loops or overlaps have four possible intermeshing points, 1 and 2 at the head, where the next new loop will be drawn through by that needle and 3 and 4 at the base where the loop has intermeshed with the head of the previously formed loop. The intermeshing at 1 and 2 are always identical with each other as are intermeshing 3 and 4 with each other. It is impossible to draw a new loop through the old loop so that its two feet are alternately intermeshed. It could only be achieved by taking the yarn package through the old loop. Although this would produce a locked loop, the package would not be large enough to provide a continuous supply.



A new loop can thus only be intermeshed through the head of the old loop in a manner which will show a face loop stitch on one side and a reverse loop stitch on the other side, because the needle hook is unidirectional and can only draw a new loop down through an old loop.

i. The Face Loop Stitch

This side of the stitch shows the new loop coming through towards the viewer as it passes over and covers the head of the old loop. Face loop stitches tend to show the side limbs of the needle loops or overlaps as a series of intermitting 'V's. The face loop-side is the underside of the stitch on the needle.

ii. A Balanced Structure

This is a double-faced structure which has an identical number of each type of stitch produced on each needle bed and therefore showing on each fabric surface usually in the same sequence. These structures do not normally show curling at their edges. Balanced structures need not, however, have the same design in colored yarns on either surface.

Face and Reverse Stitches on the Same Surface

These are normally produced on purl weft knitting machines which have double headed needles capable of drawing a face stitch with one hook and a reverse stitch on the other, so that intermeshing points 1 and 2 will not always be identical with intermeshing points 3 and 4.

3. BASIC MECHANICAL PRINCIPLES OF KNITTING TECHNOLOGY

3.1 ELEMENTS OF KNITTING

3.1.1 THE SINKER:

Sinker is the second primary knitting element. It is a thin metal plate with an Individual or collective action approximately at right angles from the hook side between adjoining needles.

The function of sinker is to

1. Help for loop formation
 2. Holding down
 3. Knocking over
- ❖ Loop formation is not a function of sinker; it will just sink the newly laid yarn into a loop.
 - ❖ Second function is to hold down the old loop
 - ❖ Third function is knocking over surface where its upper surface belly supports the old loop as the new loop is drawn through it.

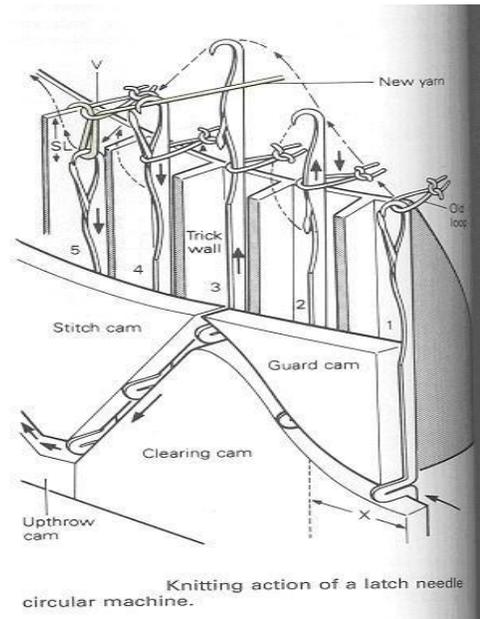
3.1.2 JACK:

Jack is a secondary weft knitting element which may be used to provide flexibility of latch needle selection and movement. It is placed below and in the same track as the needle presented. The needle may be controlled directly by its butt working in cam system (or) indirectly by the movement of jack.

3.1.3 CAM:

Cams are the device which converts rotary machine drive into a suitable up and down action for the needles or other elements. Cam is made of hardened steel and each needle movement is obtained by means of cams acting on the needle butts. Cam is said to be the "Heart of knitting machine"

Knitting cams are attached either individually or in uniform to a cam plate and depending upon the design of machine. At each yarn feed position there is a set of cams consisting of at least a raising cam, a stitch cam, and an up-throw cam whose combined effect is to cause a needle to carry out a knitting cycle. Removable cam section will be in each Machine to replace the knitting element known as "Gate".



a. RAISING CAM (OR) CLEARING CAM:

This cam cause the needle to be lift to either tuck clearing or loop transfer or needle transfer height depending upon the design.

This cam controls the upward movement of needles.

b. STITCH CAM:

This cam controls downward movement of needle. This controls the depth to which the needle descends and controlling the amount of yarn drawn into the needle loop. It also functions simultaneously as a knock over cam. It is to be adjusted for different loop lengths.

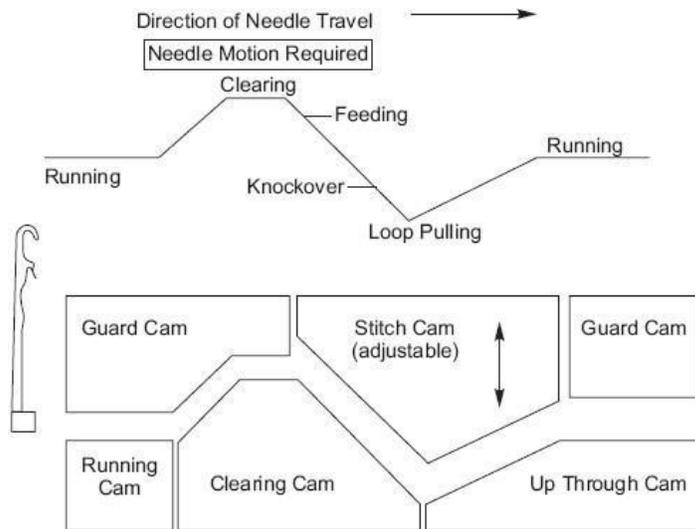
c. UPTHROW CAM (OR) COUNTER CAM:

This cam takes the needle back to rest position and allows the newly formed loops to relax.

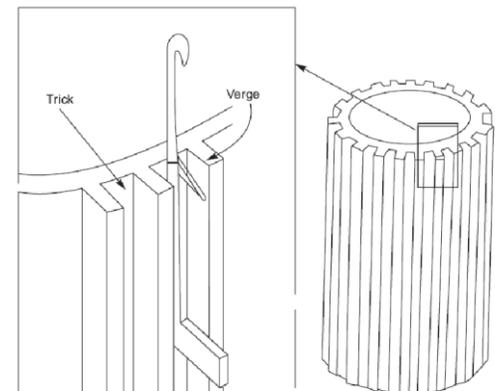
d. GAURD CAMS:

These cams are often placed on the opposite side of the cam race to limit the movement of butts and to prevent needles from falling out of track.

These knitting elements needle, sinker, cam & jack are the main part of the machine. Each knitting machine consists of three major elements. They are



1. Yarn supply elements
2. Knitting
3. Fabric take down & Collection



3.1.4 CYLINDER

- The cylinder is a steel circular bed having grooves/tricks/cuts/cuts on its outer periphery into which the needle are mounded.
- With the reference to the tricks the needles move vertically up and done by their butt being contact with the cam track.

3.2 THE LOOP FORMING CYCLE OF A BEARDED NEEDLE

There is only one principle in loop formation using bearded needle. To accomplish the goal of forming loops. Knitting machines rising bearded needles may vary slightly to perform the same principle. However, in most cases the machine was so designed that there are no movement in the needles (Fig. 3.1).

1. At the start of the cycle, the fabric loop is held in the hook of the needle at the top. The fabric loop is held in place with the help of the fabric take-up tension.
2. The fabric loop is pressed and therefore slides along the hook upwards. It stops until the fabric loop is on the shank of the needle, and cleared of the hook region. This stage is referred as clearing.
3. Feeding is done by wrapping a yarn around the shank of the needle at the point between the fabric loop and the tip of the beard.

4. Feeding is complete only when the new yarn is in the needle hook. But extra knitting element is required to move the yarn from the shank to the hook region.
5. A presser is required to push and close the beard such that the tip of the beard is hidden in the eye of the needle with the new yarn trapped in the needle hook. When the beard is pressed another knitting element is used to lift the fabric loop from the shank to the outside of the beard. This stage is known as pressing and landing.
6. After landing the presser releases the beard but the fabric loop is now wrapping around the hook on the beard. Yet another knitting element will then come into action to further lift the fabric loop towards the head of the needle. The action is completed when the fabric loop is eventually cast off from the needle. After which the fabric loop will be held by the new yarn and detached completely from the needle.

Loop Formation of Bearded Needle

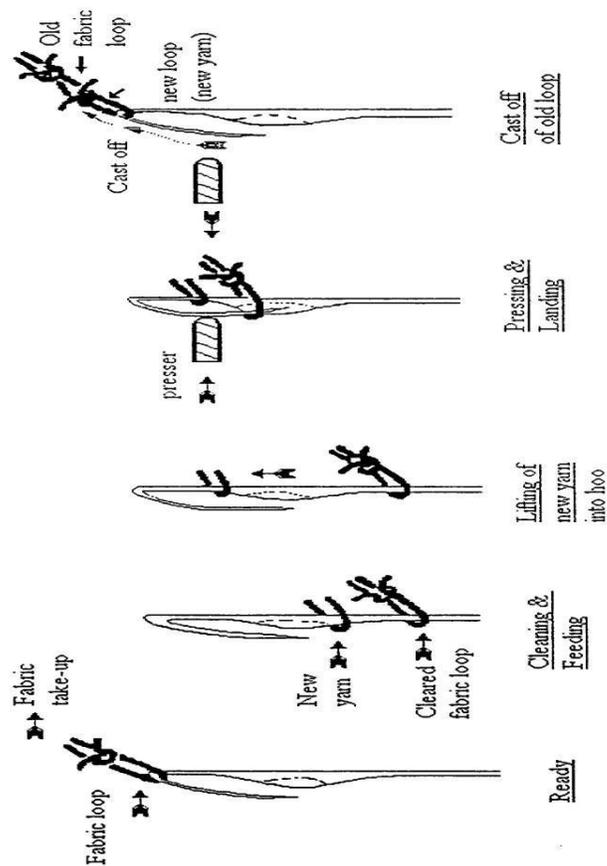


Fig. 7.1 Loop Forming Cycle of a Bearded needle

Loop Forming Cycle of a Latch Needle

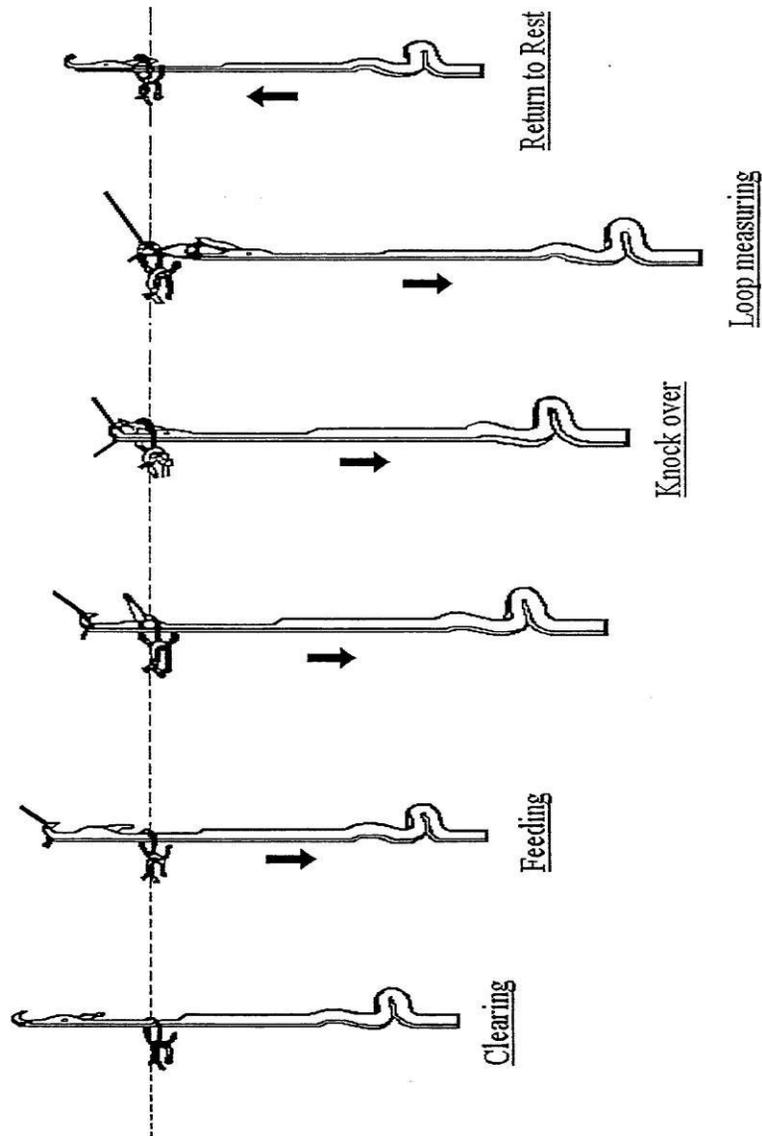
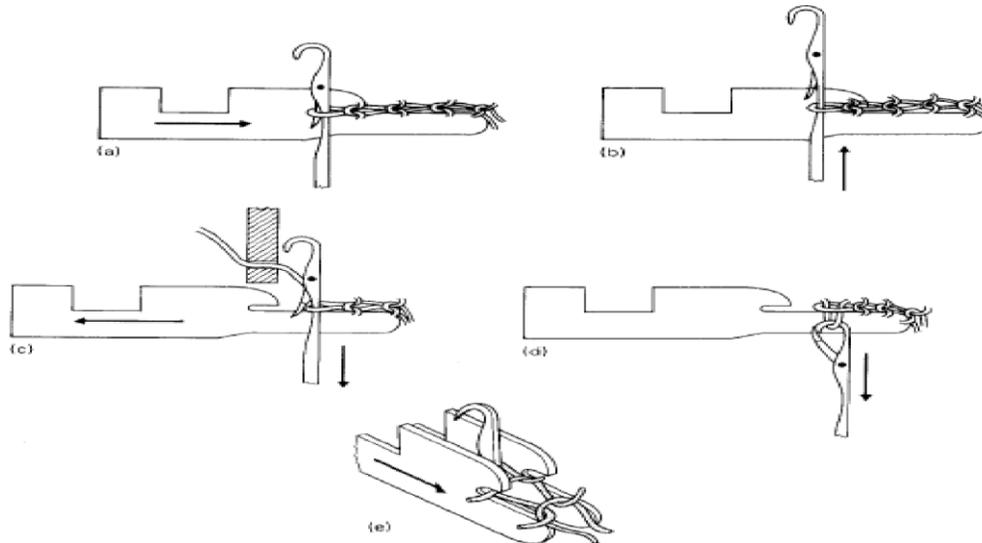


Fig. 7.2 Loop Forming Cycle of a Latch needle

- At the rest position the latch is open and the fabric loop is held by then needle hook.
- The fabric is held in position by the fabric take-down tension therefore the fabric loop slide so into the latch as the needle rises.
- The needle continues to rise and so the fabric loop slides beyond the latch onto the stem.
- Yarn feeding at the high position of the needle and the needled descends after feeding.

e. The descending needle causes the fabric loop to close the latch and hence pulling the new yarn through the fabric loop forming a new loop. The fabric take-down tension also causes the old fabric loop to slide onto the newly formed loop.

3.3 KNITTING ACTION OF SINGLE PLAIN KNITTING



3.4 The knitting action of Plain Jersey

Figure (a–e) shows the knitting action of a latch needle and holding-down sinker during the production of a course of plain fabric.

- (a) Tucking in the hook or rest position. The sinker is forward, holding down the old loop whilst the needle rises from the rest position.
- (b) Clearing. The needle has been raised to its highest position clearing the old loop from its latch.
- (c) Yarn feeding. The sinker is partially withdrawn allowing the feeder to present its yarn to the descending needle hook and also freeing the old loop so that it can slide up the needle stem and under the open latch spoon.
- (d) Knock-over. The sinker is fully withdrawn whilst the needle descends to knock over its old loop on the sinker belly.
- (e) Holding-down. The sinker moves forward to hold down the new loop in its throat whilst the needle rises under the influence of the upthrow cam to the rest position where the head of the open hook just protrudes above the sinker belly.

3.4 KNITTING ACTION OF THE CIRCULAR RIB MACHINE

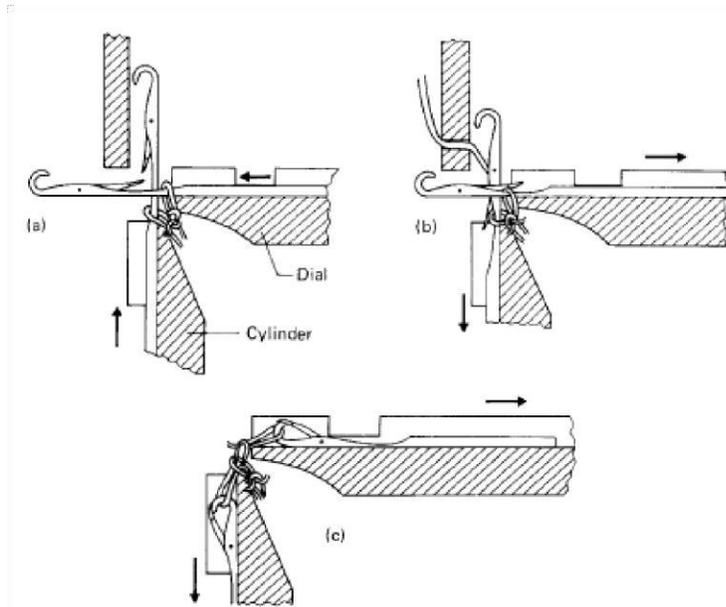


Fig.7.2 Knitting action of circular Rib Knitting The

knitting action of a circular rib machine is shown in Figure:

1. **Clearing.** The cylinder and dial needles move out to clear the plain and rib loops formed in the previous cycle.
2. **Yarn Feeding.** The needles are withdrawn into their tricks so that the old loops are covered by the open latches and the new yarn is fed into the open hooks.
3. **Knocking-over.** The needles are withdrawn into their tricks so that the old loops are cast off and the new loops are drawn through them.

Delayed Timing in Rib Knitting:

A little delay in dial needle during loop formation is called delay timing. First the cylinder needle will form the loop and then after the dial needle will produce the loop.

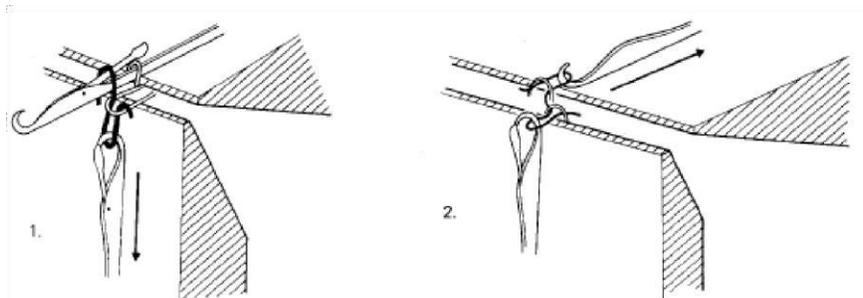


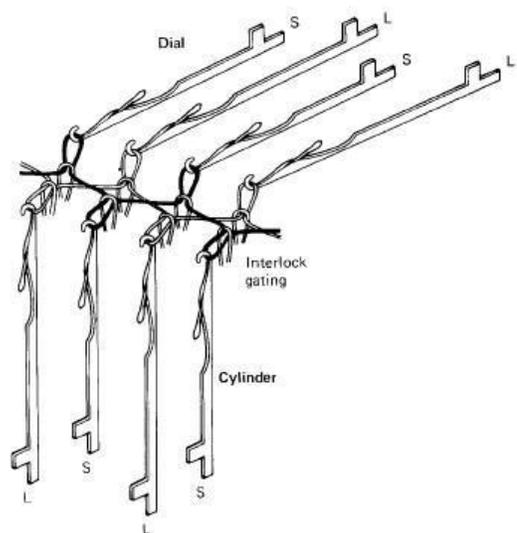
Fig. 7.13 Delayed timing.

Fig. 7.3 Rib knitting delay timing

3.5 KNITTING ACTION OF THE CIRCULAR INTERLOCK MACHINE

Interlock is produced mainly on special cylinder and dial circular machines. An interlock machine must have the following:

1. Interlock gating, the needles in two beds being exactly opposite each other so that only one of the two can knit at any feeder.
2. Two separate cam systems in each bed, each controlling half the needles in an alternate sequence, one cam system controlling knitting at one feeder, and the other at the next feeder.
3. Needles set out alternately, one controlled from one cam system, the next from the other; diagonal and not opposite needles in each bed knit together.



Originally, the interlock machine had needles of two different lengths, long needles knitting in one cam-track and short needles knitting in a track nearer to the needle heads. Long needle cams were arranged for knitting at the first feeder and short needle cams at the second feeder. The needles were set out alternately in each bed, with long needles opposite to short needles. At the first feeder, long needles in cylinder and dial knit, and at the second feeder short needles knit together; needles not knitting at a feeder follow a run-through track.

4. WEFT KNIT STRUCTURES

4.1 CLASSIFICATION OF WEFT-KNIT STRUCTURES

In woven fabric structures, three weaves, are called basic weaves viz. plain, twill and satin. It is considered that in single layer fabrics all other modification of the structures are derivatives of plain, twill or satin weaves. In a similar way in a weft knit structures the following four structures are considered as basic weft knit structures. On the other hand fabrics are produced either by forming loops on one side of the fabric only or on both sides. These two possibilities give four basic classes of weft knitted fabrics, namely **plain, rib, purl and interlock** which are widely used in their simple forms, but also provide a basis for the production of an infinite variety of weft knitted structures, by using types of stitches other than knit stitches. Four primary structures - plain, rib, interlock and purl - are the base structures from which all weft knitted fabrics are derived. Each is composed of a different combination of face and reverse meshed stitches knitted on a particular arrangement of needle beds. Each primary structure may exist alone, in a modified form, with stitches other than normal cleared loops, or in combination with another primary structure in a garment length sequence.

Plain single-jersey is the simplest weft knitted structure that it is possible to produce by the needles knitting as a single set, drawing the loops away from the technical back and towards the technical face side of the fabric.

Rib requires two sets of needles operating in between each other so that Wales of face stitches and Wales of reverse stitches are knitted on each side of the fabric.

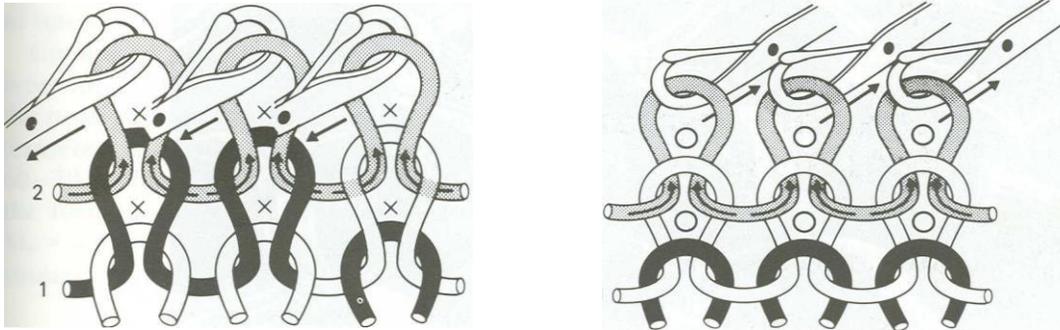
Interlock was originally derived from rib but requires a special arrangement of needles knitting back-to-back in an alternate sequence of two sets so that the two courses of loops show Wales of face loops on each side of the fabric exactly in line with each other thus hiding the appearance of the reverse loops.

Purl is the only structure having certain Wales containing both face and reverse meshed loops. Although normally knitted on machines employing double-ended latch needles, some V-bed flat machines with rib loop transfer and racking facilities can knit structures of this type.

Single-jersey machines can only produce one type of base structure. Rib machines, particularly of the garment producing type, can often produce sequences of plain knitting. Interlock machines can sometimes be changed to rib knitting, whilst purl machines are capable of producing rib or plain knitting sequences during the production of a garment or other knitted article.

4.2 PLAIN KNIT STRUCTURE OR SINGLE JERSEY

Plain (the stocking stitch of hand knitting) is the base structure of ladies' hosiery, fully fashioned knitwear and single-jersey fabrics. Its use in ladies' suiting was popularized by Lily Langtry (1852-1929) known as the 'Jersey Lily' after her island birthplace.



a) The technical face of plain

b) The technical back of plain

Fig 8.1 Plain fabric

Other names for plain include stockinette whilst in the U.S.A. the term '**shaker stitch**' is applied to it when knitted in a coarse gauge of about 3.5 needles per inch (25 mm).

Its technical face (Fig. 8.1 a) is smooth, with the side limbs of the needle loops having the appearance of columns of Vs in the Wales; these are useful as design units when knitting with different colored yarns. On the technical back, the heads of the needle loops and the bases of the sinker loops form columns of interlocking semi-circles (Fig. 8.1 b) whose appearance is sometimes emphasized by knitting alternate courses in different colored yarns.

Plain can be unraveled from the course knitted last by pulling the needle loops through from the technical back or from the course knitted first, by pulling the sinker loops through from the technical face side. Similarly, if the yarn breaks, needle loops successively unmesh down a wale and sinker loops unmesh up a wale, this structural breakdown is termed **laddering** after 'Jacob's Ladder!' It is particularly prevalent in ladies' hosiery where loops of fine smooth filaments are in a tensioned state, to reduce this tendency certain ladder-resist structures have been devised. The tendency of the cut edges of plain fabric to unravel and fray when not in tubular or flat selvedge form can be overcome by securing them during seaming.

Plain is the simplest and most economical weft knitted structure to produce and has the maximum covering power. It normally has a potential recovery of 40 % in width after stretching.

4.3 RIB FABRIC

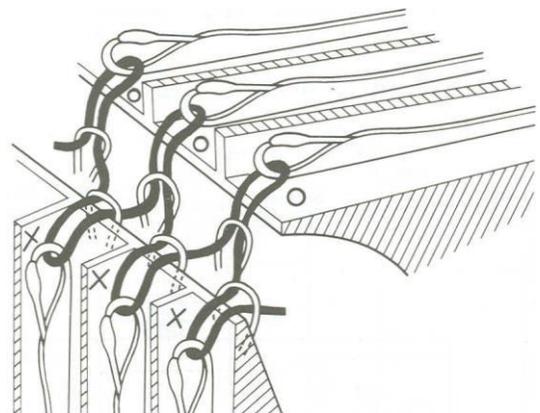
The simplest rib fabric is 1 X 1 ribs. The first rib frame was invented by Jedediah Strutt of Derby in 1755 who used a second set of needles to pick up and knit the sinker loops of the first set. It is now normally knitted with two sets of latch needles (Figs 8.2).

Rib has a vertical cord appearance because the face loop Wales tend to move over and in front of the reverse loop Wales. As the face loops show a reverse loop intermeshing on the other side, 1 X 1 rib has the appearance of the technical face of plain fabric on both sides until stretched to reveal the reverse loop Wales in between.

1 X 1 rib is produced by two sets of needles being alternately set or gated between each other. Relaxed 1 X 1 rib is theoretically twice as thick and half the width of an equivalent plain fabric, but it has twice as much width-wise recoverable stretch. In practice 1 X 1 rib normally relaxes by approximately 30 per cent compared with its knitting width.

1 X 1 rib is balanced by alternate wales of face loops in each side, it therefore lies flat without curl when cut. It is a more expensive fabric to produce than plain and is a heavier structure; the rib machine also requires a finer yarn than a similar gauge plain machine. Like all weft-knitted fabrics it can be unroved from the end knitted last by drawing the free loop heads through to the back of each stitch and it can be distinguished from plain by the fact that the loops of certain wales are withdrawn in one direction and those of others in the opposite direction, whereas the loops of plain are always withdrawn in the same direction from the technical face to the technical back.

Rib cannot be unroved from the end knitted first because the sinker loops are securely anchored by the cross meshing between face and reverse loop wales, this characteristic, together with its elasticity, makes rib particularly suitable for the extremities of articles such as tops of socks, the cuffs of sleeves, rib borders for garments, and stolling and strapping for cardigans. Rib structures are elastic, form-fitting, and retain warmth better than plain structures.



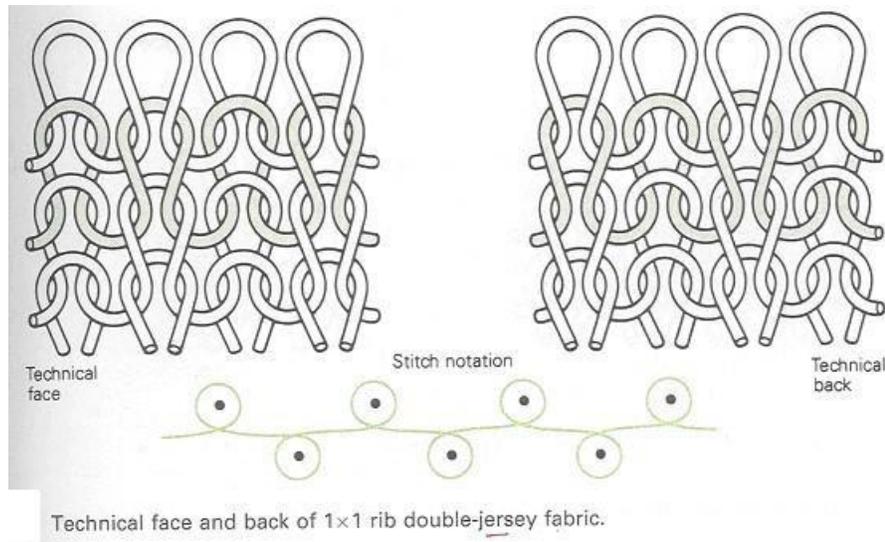


Fig 8.2 1 x 1 rib fabric

4.4 GENERAL PROPERTIES OF RIB FABRIC

PROPERTIES:

- ❖ It is a reversible fabric that means it has the same appearance on face & back of the fabric, both sides showing face loops only. The back loops can be seen only if the fabric is stretched width way.
- ❖ It has excellent widthwise extensibility.
- ❖ As there are face loops and back loops side by side, the fabric does not curl at the edges
- ❖ Wale lines on ribs run lengthwise on both sides can be seen prominently. No course lines are seen.
- ❖ It is not ready to unravel the structure from **start**. It only unravels from the **end** knitted last.
- ❖ Rib knits are warm
- ❖ Rib is expensive than plain and it is a heavier structure.
- ❖ Output is less. Ribs knitted fabrics are costlier.
- ❖ Rib knits are usually found on the lower edges of sweaters, sleeves of the wrist line and at neck line, cuffs, stockings, socks etc.

Tubular cover courses

A direct change of knitting from 2 X 2 to 1 X 1 rib brings every third needle into action, but at the first course the limbs of the loops produced on those needles open out producing apertures between every two wales which spoil the appearance of the structure. This problem is overcome by knitting a tubular course of single jersey on all needles in one bed then on all needles in the other bed. On each side the sinker loops draw the Wales together and prevent the loops on the newly introduced needles from forcing the Wales apart.

4.5 INTERLOCK

Although the American Scott and Williams Patent for interlock of 1908 was extended for 20 years, underwear manufacturers found the needles expensive, especially on the larger 20 inch diameter model, suitable hosiery twist cotton yarn only became available in 1925, and the first stationary earn-box machine appeared in 1930. Originally interlock was knitted almost solely in cotton on 20 gauge (needles per inch) machines for underwear, a typical weight being 5 ozs per square yard using 1/40's S cotton, but from the 1950s onwards 18 gauge machines were developed for knitting double jersey for semi-tailored suiting because the open width fabric could be finished on existing equipment. As the machines became more versatile in their capabilities, the range of structures became greater.

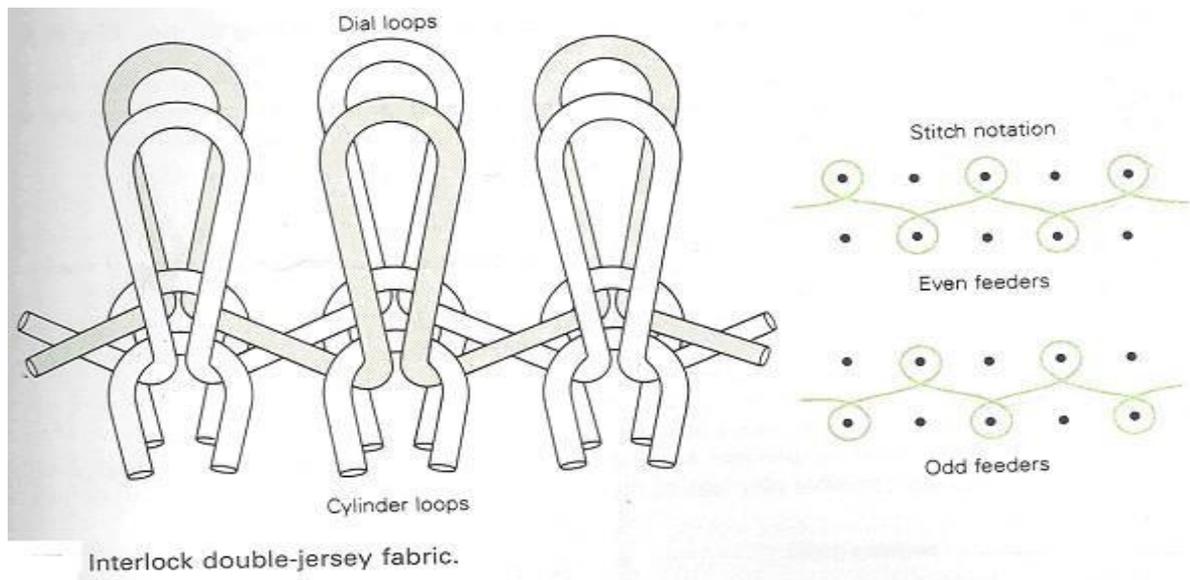
Interlock has the technical face of plain fabric on both sides but its smooth surface cannot be stretched out to reveal the reverse meshed loop wales because the wales on each side are exactly opposite to each other and are locked together (Fig.8.5). Each interlock pattern row (often termed an, '-interlock course') requires two feeder courses each with a separate yarn which knits on separate alternate needles producing two half-gauge 1 X 1 rib courses whose sinker loops cross over each other, thus odd feeders will produce alternate wales of loops on each side and even feeders will produce the other wales.

Interlock relaxes by about 30-40 per cent or more compared with its knitted width so that a 30-inch diameter machine will produce a tube at 94-inch open width which finishes at 60-66 inches wide. It is a balanced, smooth stable structure, which lies flat without curl. Like 1 X 1 rib, it will not unrove from the end knitted first but it is thicker, heavier and narrower than rib of equivalent gauge, and requires a finer, better, more expensive yarn.

As only alternate needles knit at a feeder, interlock machines can be produced in finer gauges, with less danger of press-offs than rib. Interlock knitting is, however, more of a problem than rib knitting because productivity is half, fewer feeders can be accommodated, and there are finer tolerances. When two different-colored yarns are used, horizontal stripes are

produced if the same color is knitted at two consecutive feeders and vertical stripes if odd feeders knit one color and even feeders knit the other color. The number of interlock pattern rows per inch is often double the machine gauge in needles per inch.

The interlock structure is the only welt knitted base not normally used for individual needle selection designs because of the problems of cylinder and dial needle collision. However, selection has in the past been achieved by using four-feeder courses for each pattern row of interlock. Long and short cylinder needles not selected at the first two-feeder courses for colour A being selected at the second two feeders for colour B.



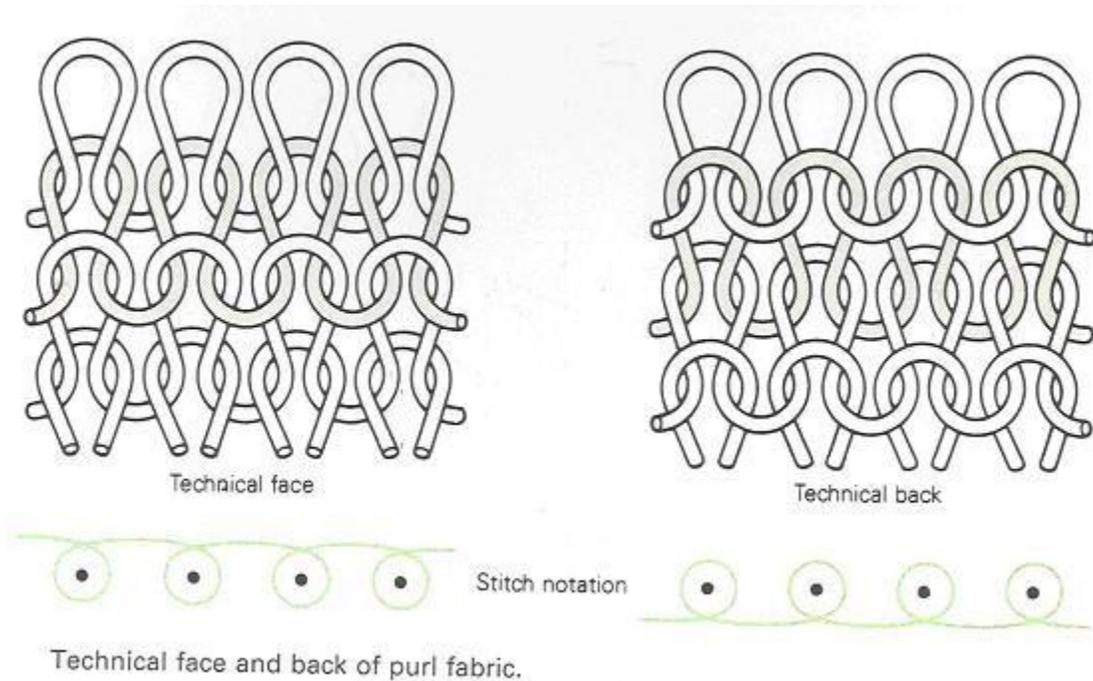
4.5 Interlock Structure

Eight lock is a 2 X 2 version of interlock which may be produced using an arrangement of two long and two short needles, provided the tricks are fully cut through to accommodate them and knock-over bits are fitted to the verges to assist with loop formation on adjacent needles in the same bed. It was first produced on double-system V -bed flat machines having needles with two butt positions each having its own cam system, giving a total of eight locks, four for each needle bed and making one complete row per traverse, 4 X 4 and 3 X 3 arrangements can also be produced. It is a well-balanced, uniform structure with a softer, fuller, handle and greater width-wise relaxation and more elasticity than interlock. Simple geometric designs with a four wale wide repeat composed of every two loops of identical colour can be achieved with careful arrangement of yarns.

4.6 PURL FABRIC

Purl was originally spelt 'pearl' and was so named because of the similar appearance to pearl droplets.

Purl structures have one or more wales which contain both face and reverse loops which can only be achieved with double-ended latch needles or by rib loop transfer. The semi-circles of the needle and sinker loops produced by the reverse loop intermeshing tend to be prominent on both sides of the structure and this has led to the term 'links-links' being generally applied to purl



fabrics and machines. Links is the German word for left and it indicates that there are left or reverse loops visible on both sides.

The tricks of the two needle beds in purl machines are exactly opposite to each other and in the same plane so that the single set of purl needles, each of which has a hook at either end, can be transferred across to knit outwards from either bed (Fig. 8.7). Knitting outwards from one bed, the needle will produce a face meshed needle loop with the newly-fed yarn whilst the same needle knitting outwards with its other hook from the opposite bed will produce a reverse meshed needle loop. As the needle moves across between the two needle beds, the old loop slides off the latch of the hook which produced it and moves along the needle towards the other hook which it cannot enter because it will pivot the latch closed (an action which must not occur until the new yarn has been fed to this hook).

4.7 REPRESENTATION OF WEFT KNITTED STRUCTURE

A stitch is a basic repeating unit in any knitted structure. There are **four main** methods to represent the knitted structure by notations

1. Verbal
2. Graphic or line diagram
3. Symbolic
4. Diagrammatic

a. Verbal:

This method is the simplest one where the name of the structure is sufficient to describe the structure (or) where a simple description of the knitting elements and knitting sequence is sufficient to visualize the construction. It describes the structure in a definition form and so the technical knowledge of knitting is absolutely essential. Therefore this method is not suitable for beginner

b. Graphic or line Diagram:

This method is very useful for simple structures and could be easily understood by a beginner or even by -a layman who has no knowledge of knitting. This graphic method is confusing & time consuming for complex structures. However it has been most widely used to represent simple weft knitted structures.

c. Symbolic Representation:

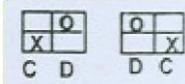
The symbolic method is good for simple and complex structures alike conventionally the following symbols are used.

The four basic structures can be represented symbolically as follows. 1.

Plain single jersey 

2. 1 X 1 rib 

3. 1 x 1 purl structure
1 structure  interlocks

4. 
C- CYLINDER
D- DIAL

 Face loop
 Back loop
 Tuck loop
 Float

 KNIT 1 x
 TUCK
 MISS
SYMBOLIC

d. Diagrammatic Representation:

Here a distinction is not made between a face loop & back loop, but it could be understood by following the knitting operates represented by diagrams of knitting needles. In diagrammatic represented a dot represents a needle.

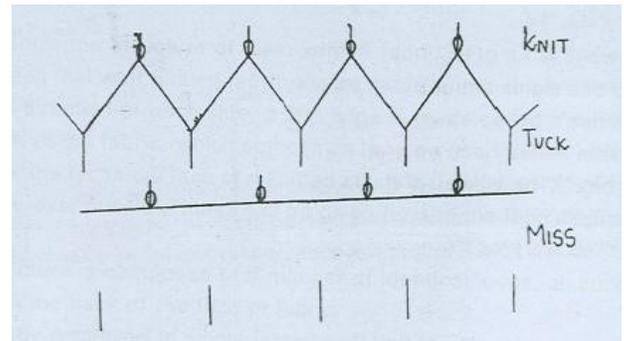
A loop round the dot represents a knit stitch



A tuck is represented by the symbol.



Afloat is represented by the symbol



4.8 COMPARISON BETWEEN SINGLE KNIT AND DOUBLE-KNIT FABRIC

SINGLE KNIT FABRIC	DOUBLE KNIT FABRIC
1. Requires one needle set to produce fabrics	1. Requires two needle sets to produce
2. The appearance of face & back differ	2. Appear identically on both sides
3. The edges of the fabric tend to curl	3. Fabric does not curl at edges
4. Fabric can be unraveled course by course from either end	4. Fabric can be unraveled but only from the end knitted last
5. Widthwise extensibility is approximately twice that of length direction	5. Extensibility of the fabric in widthwise is approximately twice that of single jersey and same to lengthwise.
6. The fabric thickness is approximately twice the dia. of yarn used	6. Fabric thickness is approximately twice that of single jersey.
7. Suitable for lady's stockings Men's & ladies' Shirts, Underwear	7. Suitable for Socks. Outerwear, Innerwear & Sports wear

8. Single jersey Machine will produce single knit fabric	8. Rib, interlock, purl Machine will produce double knit fabric.
9. Production will be high	9. Production will be less

4.9 Stitches Produced By Varying the Timing Of The Needle Loop intermeshing

Weft knitted stitches described so far has been composed entirely of knitted loops. A knitted loop stitch is produced when at each yarn feed, a needle receives a new loop and knocks over the old loop which it held from the previous knitting cycle, so that the old loop now becomes a needle loop of normal configuration.

Other types of stitch may be produced on each of the four-needle arrangement base structures by varying the timing of the intermeshing sequence of the old and new loops. These stitches may be deliberately selected as part of the design of the weft knitted structure or they may be produced accidentally by a malfunction of the knitting action so that they occur as fabric faults. When these stitches are deliberately selected, a preponderance of knitted loop stitches is necessary within the structure in order to maintain its requisite physical properties. Generally, the needles produce knitted loop stitches prior to the commencement and at the termination of these selected stitches and there are usually certain needles which are knitting normally during the same cycles as these stitches are produced.

Apart from the knitted loop stitch, the two most commonly-produced stitches are the float stitch and the tuck stitch. Each is produced with a '**held loop**' and shows its own particular loop most clearly on the reverse side of the stitch as the limbs of the held loop cover it from view on the face.

4.6.1 THE HELD LOOP

A held loop (Fig. 9.1) is an old loop which the needle has retained and not released and knocked over at the next yarn feed. A held loop can only be retained by a needle for a limited number of knitting cycles before it is cast-off and a new loop drawn through, otherwise the tension on the yarn in the loop becomes excessive even though there is a tendency to rob extra yarn from adjacent loops in the same course. The limbs of the held loop are often elongated as they extend from its base intermeshing in one course to where its head is finally intermeshed a number of courses higher in the structure, alongside it in adjacent wales there may be normally knitted loops at each course.

A held loop may be incorporated into a held stitch without the production of tuck or miss stitches in either single- or double-faced structures.

In single-faced structures it can only be produced on machines whose feeds or needles have a reciprocating action so that the yarn only passes across needles which are knitting, otherwise a float stitch would be produced. Held stitches of this type are used for producing three-dimensional shaping such as heel and toe pouches for footwear, held loop shaping on flat machines and designs in solid colour intarsia. Held stitches are produced in double-faced structures by holding loops on one bed whilst continuing to knit on the other thus producing horizontal welt and cord effects.

4.9.2 THE FLOAT STITCH

A float stitch (Fig. 9.1) is composed of a held loop; one or more float loops and knitted loops. It is produced when a needle (M) holding its old loop fails to receive the new yarn which passes, as a float loop, to the back of the needle and to the reverse side of the resultant stitch, joining together the two nearest needle loops knitted from it.

The float or welt stitch (Fig. 9.1) shows the missed yarn floating freely on the reverse side of the held loop which is the technical back of single jersey structures, but is the inside of rib and interlock structures.

The float extends from the base of one knitted or tucked loop to the next and is notated either as an empty square or as a by-passed feed point; it is assumed that the held loop extends into the courses above until a knitted loop is indicated.

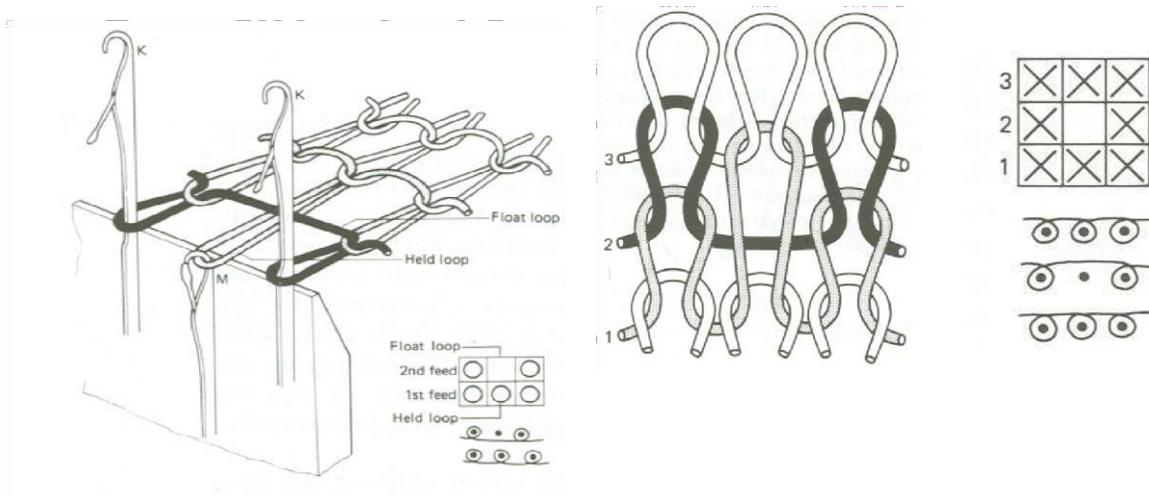


Fig. 9.1 Miss or Float Stitch

A single float stitch has the appearance of a 'U' shape on the reverse of the stitch. Structures incorporating float stitches tend to exhibit faint horizontal lines, they are narrower because the wales are drawn closer together and the held loop robs yarn from adjacent loops thus reducing width-wise elasticity and improving fabric stability.

Under normal take-down tension and yarn elasticity the maximum number of successive floats on the same needle is four. Six adjacent needles are usually the maximum number for a continuous float because of reduced elasticity and problems of snagged threads, especially in continuous filament yarns and coarse gauges. Missing is useful for hiding an unwanted coloured yarn behind the face loop of a yarn of a selected colour when producing jacquard designs in face loops of different colors.

The miss stitch can occur accidentally as a fault as a result of incorrectly set yarn feeders.

4.9.3 THE TUCK STITCH

A tuck stitch is composed of a held loop; one or more tuck loops, and knitted loops (Fig.

9.2). It is produced when a needle holding its loop (T) also receives the new loop which becomes a tuck loop because it is not intermeshed through the old loop, but is tucked in behind it on the reverse side of the stitch (Fig. 9.2).

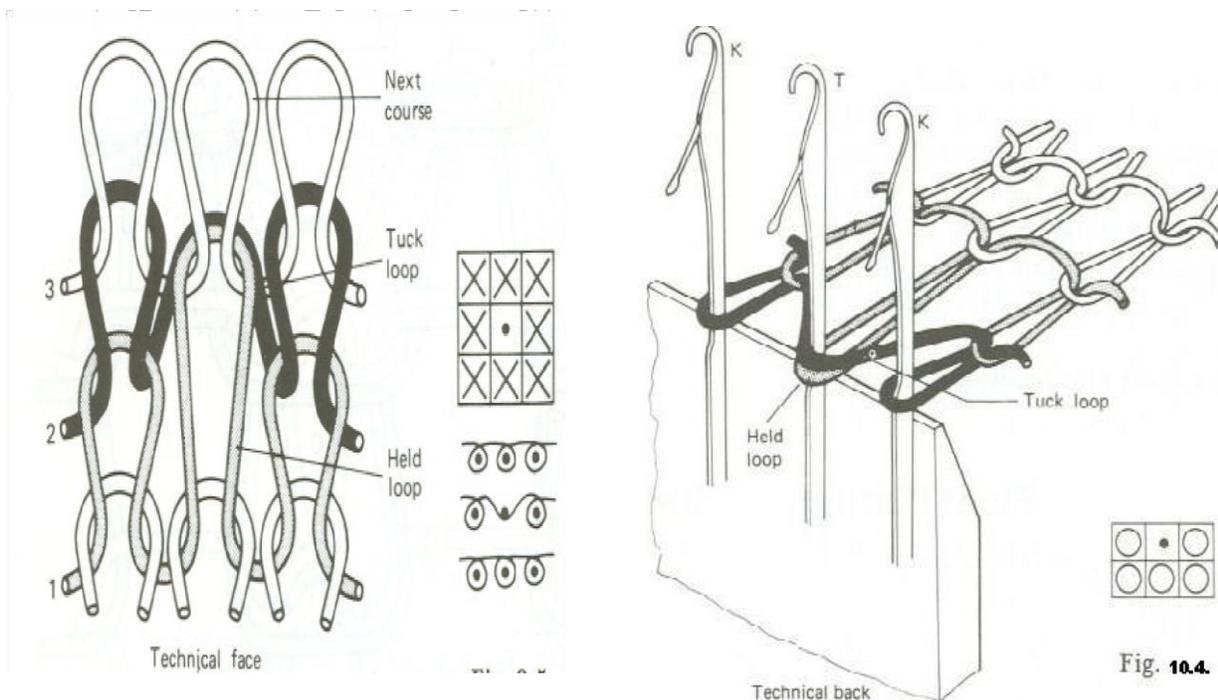


Fig 9.2 Tuck stitch

Its side limbs are therefore not restricted at their feet by the head of an old loop so that they can open outwards towards the two adjoining needle loops formed in the same course. The tuck loop

thus assumes an inverted V or U-shaped configuration as the yarn passes from the sinker loops to the head which is intermeshed with the new loop of a course above it in the normal manner so that the head of the tuck is on the reverse of the stitch. The side limbs of tuck loops thus tend to show through onto the face between adjacent wales as they pass in front of sinker loops.

Tuck stitch structures show a faint diagonal line effect on their surface. In analysis, a tuck stitch is identified by the fact that its head is released as a hump shape immediately the needle loop above it is withdrawn, whereas a knitted loop would require to be separately withdrawn and a miss stitch would always be floating freely on the technical back.

The tuck loop configuration produced by two different knitting sequences

1. By commencing knitting on a previously empty needle (Fig. 9.2). As the needle was previously empty there will be no old loop in the wale to restrict the base of the first knitted loop and in fact even the second loop tends to be wider than normal. The effect is clearly visible in the starting course of a welt. By introducing rib needles on a selective basis an openwork pattern may be produced on an essentially plain knit base.
2. By holding the old loop and then accumulating one or more new loops in the needle hook. Each new loop becomes a tuck loop as they and the held loop are knocked-over together at a later knitting cycle and a new loop is intermeshed with them. This is the normal method of producing a tuck stitch in weft knitting.

Successive tucks on the same needle are placed on top of each other at the back of the head of the held loop and assume a straighter and more horizontal appearance theoretically requiring less yarn. Under normal conditions, up to four successive tucks can be accumulated before tension causes yarn rupture or needle damage, the limit is affected by machine design, needle hook size, yarn count, elasticity and take-down tension. Each side of the head of a tuck loop is held by a sinker loop (S) from the course above. When tucking occurs across two or more adjacent needles, the head of the tuck loop will float freely across between these two sinker loops, after which a sloping side limb will occur. Dependent upon structural fineness, tucking over six adjacent needles is usually the maximum unit before snagging becomes a problem.

A tuck loop is notated either as a dot placed in a square or as a semi-circle onto a point, whilst the held loop is assumed to extend from the course below the tuck up to the course where the next knitted loop is notated and where it intermeshes.

Tuck stitches may occur singly, across adjacent needles, or on the same needle at successive knitting cycles.

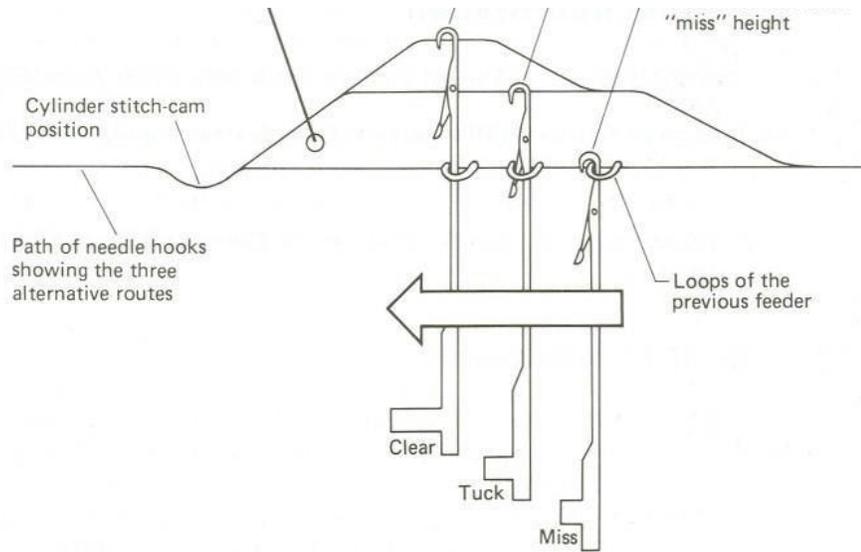


Fig 9.3

Knitting needle

at

different height

In this illustration the needles have been turned 90° in order to show the position of the latch in relationship with the loop of the previous feeder

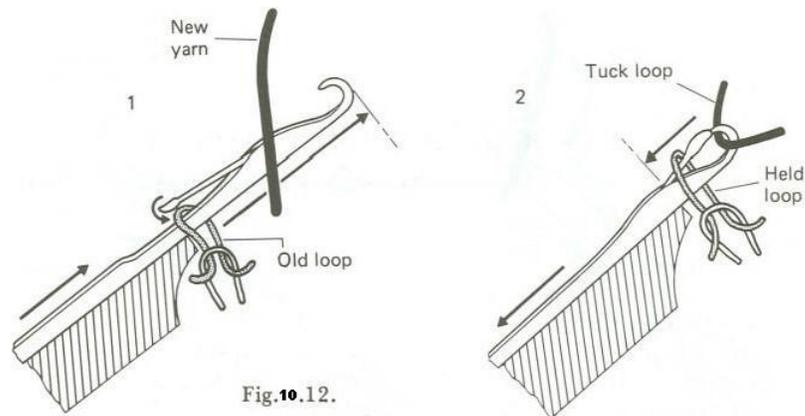


Fig.10.12.

Exercise for part one

Part I:- Explain

1. Distinguish between weaving and knitting
2. Compare woven and knit fabrics with respect to following points (i) Properties (ii) Production rates (iii) Raw material (iv) End uses
3. List down various knitting elements on single jersey machine and state function of each of them
4. Describe method of determining stitch length of a weft knitted structure. Explain how stitch length affects various properties of knitted fabric
5. Why is knitting an important form of fabric formation
6. Define the following terms
 - a. Open loop
 - b. Needle loop
 - c. Sinker loop
 - d. Knitted loop
 - e. Underlap
 - f. Overlap
 - g. Course
 - h. Wale
 - i. Stich density
 - j. Double jersey
 - k. Single jersey
 - l. Closed loop
 - m. Face loop
 - n. Back loop/weft purl loop
 - o. Technical face
 - p. Technical back
 - q. Machine gauge
 - r. Knitting notation
 - s.
7. Explain the features that may be used to classify a weft knitting machine
 - a. The needle bade
 - b. The number of needle bades
 - c. The shape of the bade
 - d. Types of structure produced
 - e. Design elements
8. Distinguish between latch and bearded needles
9. Explain the action of the following on weft knitting machines
 - a. Latch needle
 - b. Came
 - c. Bearded needle

- d. Sinker
10. With a well labelled diagram describe the came set up and the functions of each came on circular knitting machine
 11. Write short notes on the following in regarding to circular knitting machine
 - a. Creels
 - b. Cylinder
 - c. Dial
 - d. Cam
 - e. Feeders
 - f. Strippers
 - g. Take down and cloth winding mechanism
 12. Explain the features of a v-bed flat knitting machine
 13. State the advantages of using a flatbed machine
 14. State the commonly knitted structures on flat knitting machine
 15. Explain the following terms
 - a. Drop or press off stitch
 - b. Held loop
 - c. Float stitch
 - d. Tuck stitch
 16. Describe briefly the four main knitting structures in weft knitting
 - a. Plain
 - b. Rib
 - c. Interlock
 - d. Purl
 17. Differentiate between the following
 - a. Plain and rib structure
 - b. Interlock and purl
 18. State the main functions of loop transfer
 19. Describe the three types of loop transfer stitches used in weft knitting

Part-2 chose

1. Name the part of the needle that interacts the cam profile
 - a. Hook
 - b. Latch
 - c. Stem
 - d. But
2. Name the cam responsible for the latch opening of the needle during knitting action
 - a. Raising cam
 - b. Upthrow came
 - c. Guard cam
 - d. Clearing cam
3. Name the com responsible for controlling the loop length
 - a. Clearing cam
 - b. Stitch cam
 - c. Upthrow cam
 - d. Raising cam

4. Mach pairs

Column 1	Column 2
A. Clearing cam	1. Protect the needle from losing the cam track
B. Raising cam	2. Help in knocking of the old loop
C. Stitch cam	3. Help in opening of the latch during knitting
D. Guard cam	4. Reciprocate needle to maximum height

- a. A-2, B-4, C-3, D-1
 - b. A-1, B-4, C-3, D-2
 - c. A-2, B-3, C-1, D-4
 - d. A-4, B-3, C-2, D-1
5. The directions of the sinker and the needle movement in the circular knitting machine
 - a. Vertical and Horizontal respectively
 - b. Horizontal and vertical respectively
 - c. Both horizontal
 - d. Both vertical

6. Mach the pairs

Column 1	Column 2
butt	1. Reciprocating movement
Throat	2. Loop holding
Belly	3. Sinker loop formation

- a. A-2, B-3, C-1
 - b. A-1, B-2, C-3
 - c. A-3, B-2, C-1
 - d. A-1, B-3, C-2
7. What does the E10 represents weft knitting machine
- a. 10 needles per inch
 - b. 10 needles per millimeter
 - c. 10 needles per cent meter
 - d. 5 needles per inch
8. For E6 and the E14 weft knit machines, the thicker of the yarn should be
- a. More than E6 than E14
 - b. Less than E6 than E14
 - c. Same E6 and E14
 - d. Yarn thinness does not depend on machine gauge
9. Name the needle which results maximum yarn rubbing
- a. Compound needle
 - b. Latch
 - c. Bearded
 - d. None
10. Identify the needle which is self-acting during loop formation
- a. Bearded
 - b. Latch needle
 - c. Compound
 - d. None
11. Which machine gauge will produced bigger loop length
- a. E6
 - b. E8
 - c. E12
 - d. E16
12. On a multi-feeder circular knitting machine

- a. Only cylinder is rotating
 - b. Only cam is rotating
 - c. Both cylinder and cam is rotating
 - d. None
13. In a plain single jersey fabric
- a. The wales and courses at edges curls from technical back to technical front
 - b. The wales and courses ta edges curls from technical front to technical back
 - c. The wales at the edge curls from technical front to technical back while the course at the edge curls technical back to technical front
 - d. The wales at the edge curls from technical back to technical front while the course at the edge curls technical front to technical back
14. In double jersey fabric made on the V-bed flat machine
- a. The wales and courses at edges curls from technical back to technical front
 - b. The wales and courses ta edges curls from technical front to technical back
 - c. The wales at the edge curls from technical front to technical back while the course at the edge curls technical back to technical front
 - d. The fabric dose not curl from the edge
15. A weft knit constriction technical back loops in alternative wales. Select the machine used for knitting
- a. Single flat bed
 - b. V-bed machine
 - c. Interlock circular machine
 - d. Purl knitting machine
16. A weft knitting constriction technical back loop in alternative courses. select the machine used for knitting
- a. Single flat bed
 - b. V-bed machine
 - c. Interlock circular machine
 - d. Purl knitting machine
17. On interlock circular knitting machine
- A. Needles on both bed are facing each other

- B. Needles on the front bed shifted one fourth of the pitch with respect to the back bed
- C. Needle on the front bed is shifted half pitch with respect to back bed
- D. Needles on the front bed is shifted three-fourth of pitch with respect to back bed

18. Match the pair

Column 1	Column 2
A. Only cylinder	1. Purl knitting
B. Cylinder and diel	2. Single bed circular machine
C. Long butt and short butt needles	3. Double bed circular machine
D. Double latch needle	4. Interlock circular machine

- a. A-1, B-4, C-3, D-2
- b. A-1, B-4, C-2, D-3
- c. A-2, B-3, C-4, D-1
- d. A-4, B-3, C-2, D-1

19. During knitting on V-bed flat machine

- A. Needles on both bed are facing each other
- B. Needles on the front bed shifted one fourth of the pitch with respect to the back bed
- C. Needle on the front bed is shifted half pitch with respect to back bed
- D. Needles on the front bed is shifted three-fourth of pitch with respect to back bed

20. Name the structural element that reduces the extensibility of a weft knit fabric along courses

- a. Loop
- b. Tuck
- c. Float
- d. None of these

21. Name the weft knit constriction that is made on double bed machine by stitching technical loops in alternative wales

- a. Rib
- b. Plain
- c. Purl

d. Interlock

22. Select the cam used for making tuck in weft knitting structure

- a. Upthrow cam
- b. Stitch cam
- c. Clearing cam
- d. Guard cam

23. Match the pairs

Column 1	Column 2
A. Plain single jersey	1. Thick and extensible lengthwise
B. 1*1 rib	2. Thick and extensible widthwise
C. Interlock	3. Thin and unstable at the edge
D. Purl	4. Thick and fairly rigid both length and widthwise

- a. A-1, B-2, C-4, D-3
- b. A-3, B-4, C-2, D-1
- c. A-2, B-3, C-4, D-1
- d. A-3, B-2, C-4, D-1

24. Increasing loop length in weft knit fabric result in

- a. Higher gram square meter (GSM) of the fabric
- b. Higher fabric width
- c. Lower fabric width
- d. Lower fabric length

25. Which design have highest GSM

- a. 1*1 rib
- b. 2*2 rib
- c. 3*3 rib
- d. 4*4 rib

26. Which jacquard design can be made using single bed

- a. Tubular jacquard
- b. Float jacquard

- c. Brid Eye jacquard
- d. Direction selection jacquard

27. Match the pairs

A .Wale spacing	1. Building block of knitted fabric
B. Stitch density	2. Distance between centers of neighboring wale lines
C .Loop	3. Distance between canthers of neighboring course lines
D. Course spacing	4. Number of loops per unit area of fabric

- a. A-2, B-3, C-1, D-4
- b. A-2, B-4, C-1, D-3
- c. A-2, B-4, C-1, D-2
- d. A-2, B-3, C-4, D-1

28. Number of binding zones of a knitted loop is

- a. 2
- b. 4
- c. 8
- d. 6

29. Fabric becomes

- a. Wider and more porous through introduction of tuck stitches
- b. Wider and more porous through introduction of float stitches
- c. Narrower and thicker through introduction of float stitches
- d. Narrower and thicker through introduction of tuck stitches

30. Effect of direction of yarn twist and direction of rotation of cylinder rotation is such that

- a. Z-twisted yarn causes positive angle of spirality and clockwise rotation of cylinder causes negative skew angle
- b. S-twisted yarn causes positive angle of spirality and clockwise rotation of cylinder causes positive skew angle
- c. S-twisted yarn causes negative angle of spirality and anticlockwise rotation of cylinder causes negative skew angle
- d. Z-twisted yarn causes positive angle of spirality and clockwise rotation of cylinder causes negative skew angle

Part II warp knitting technology's

1. WARP KNITTING

Warp knitting represents the fastest method of producing fabric from yarn. Warp knitting differs from weft knitting in that each needle loops its own thread. The needles produce parallel rows of loops simultaneously that are interlocked in a zigzag pattern. Fabric is produced in sheet or flat form using one or more sets of warp yarn. The yarns are fed from warp beams to a row of needles extending across the width of the machine.

Warp knitting is defined as a loop forming process in which the yarn is fed into knitting zone, parallel to the fabric selvedge. In warp knitting, fabric is made by forming loops from yarns coming in parallel sheet form which run in the direction of fabric formation (like warp in weaving). Every needle is fed by a separate yarn for loop formation. In order to connect the loops into a fabric, the yarns are shifted (shogged) between the needles. In this manner the needle draws the new loop through the loop formed by another yarn in the previous knitting cycle. For the purpose of shogging, each yarn passes through a guide fitted on guide bar. Large numbers of yarns in parallel sheet form are supplied from warp beam. Hence warping is essential in warp knitting. Warp knitting machines are flat and comparatively more complicated than weft knitting machines. A few of the popular warp knitted structures are locknit, sharkskin, queenscord, double atlas, velour etc.

- Warp knitting is characterized by the structural threads of the fabric running along the length of the fabric.
- On horizontal row of loops, or 'course', is made from many threads.
- Warp knitted fabrics are mainly flat, closer knit, ladders less easily and are more stable than weft - knitted.
 - Extra inlaid weft yarns can be used to increase stability.
 - Warp knitting is done on Tricot and Raschel machines both having different kinds of needles.
 - In Tricot, one or more sets of yarns are used e.g.: two sets, one is knitted in one direction, the other the opposite.
 - Many warp-knitted fabrics are 'locknit' construction; the stitches are locked to prevent runs (ladders).

Warp knitting is the fastest method of converting yarn into fabric, when compared with weaving and weft knitting, though modern developments in weft knitting machines means that there is very little difference in terms of production between the two forms of knitting.

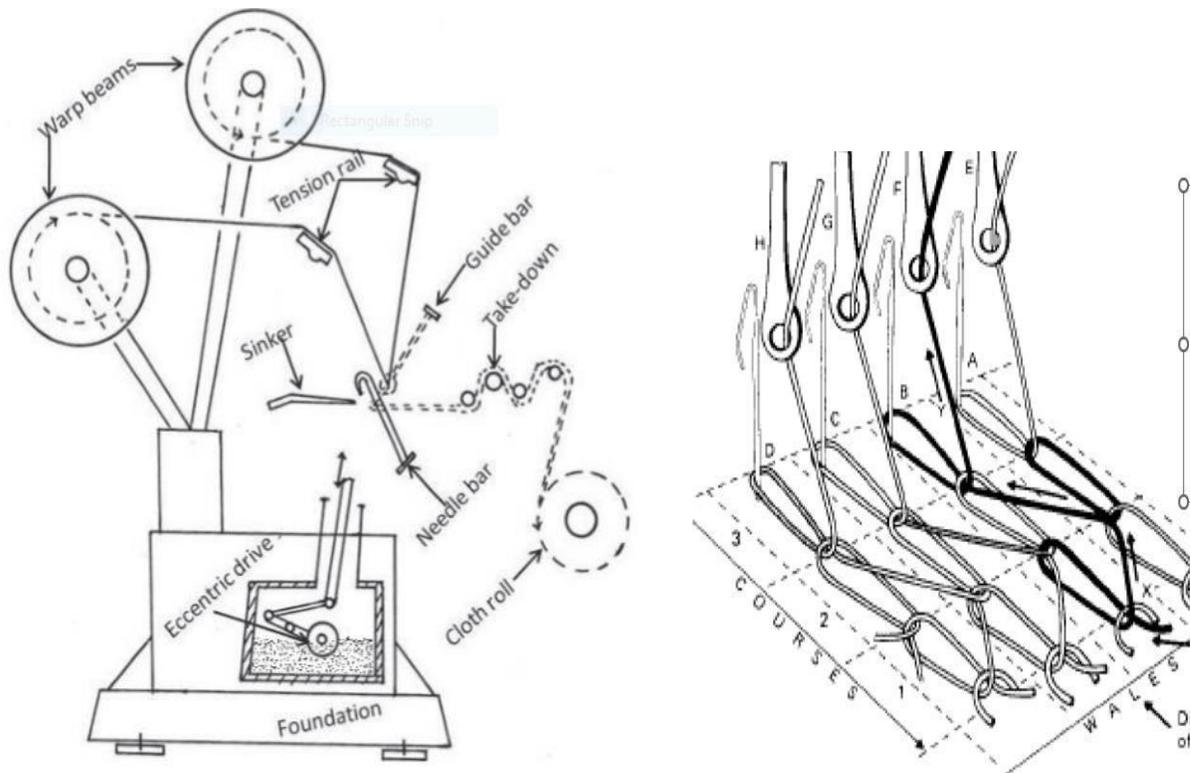


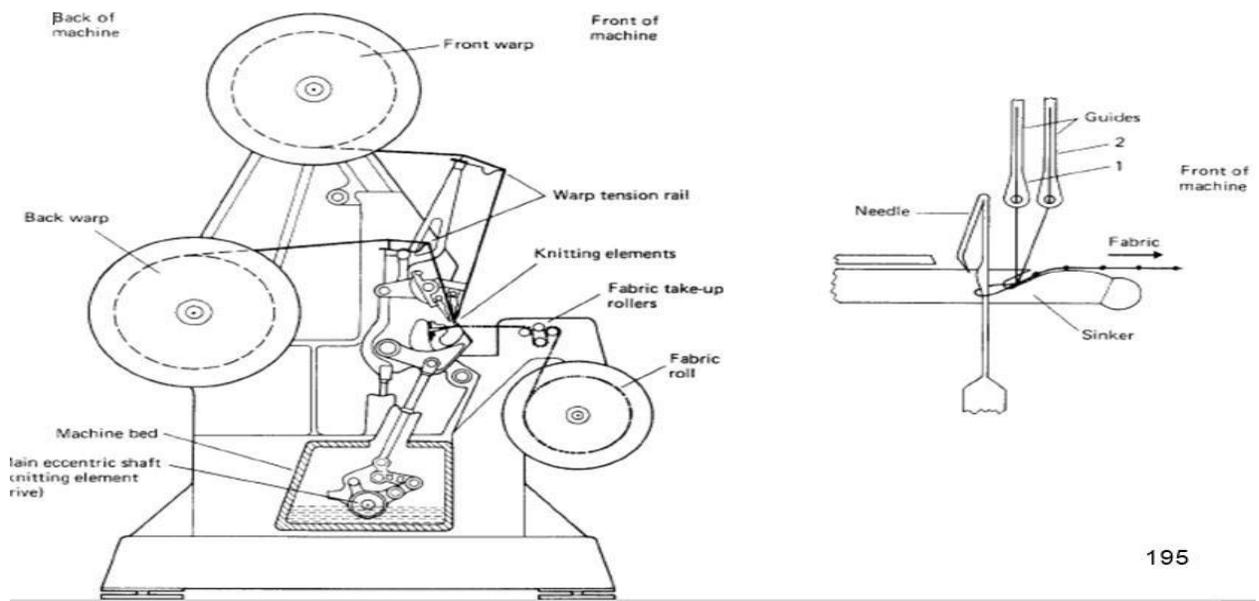
Fig. Line diagram of different elements and zones of a warp knitting machine

1.1 Types of warp knitting:

Based on the features of warp knitting, the machines available are classified into two categories, namely Tricot and Raschel. Both Tricot and Raschel may be made with either single needle bar or double needle bar. A brief classification of warp knitting machines has been given in Fig 1.4. In the past, it was usual to distinguish between Tricot and Raschel by the needle used in each machine type. Tricot machines were equipped with bearded needles while Rachel machines only used latch needles. With the production of modern warp knitting machines, however, the compound needle replaced the bearded needle in Tricot and penetrated into the Raschel as well. The classification of warp knitting machines by the needle type is therefore no longer possible. An accurate definition can be made by regarding the type of sinkers with which the machine is equipped and the role they play in loop formation. The sinkers used in Tricot knitting machine control the fabric throughout the knitting cycle. The fabric is held in the throats of the sinkers while the needles rises to clear and the new loops are

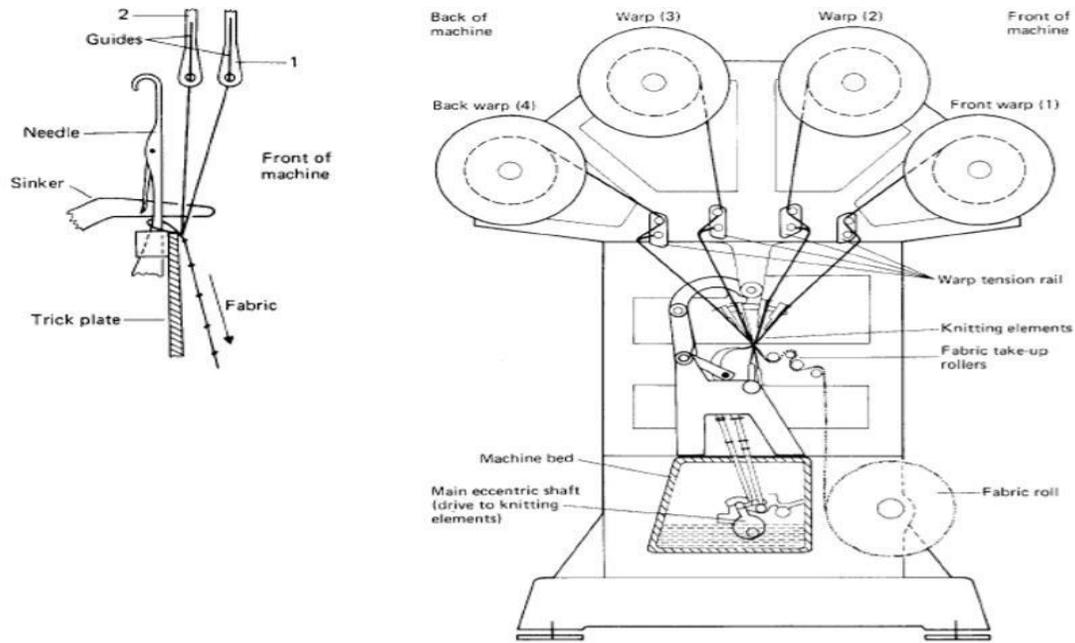
formed/knocked over in between them. In Raschel knitting machine, however, the fabric is controlled by a high take-up tension and the sinkers are only used to ensure that the fabric stays down when the needle rise. The other differences in features along with the above mentioned two features of these two types of machines are given below. With the help of line diagram, the different elements and zones of a typical warp knitting machine is shown in Fig. 2.5 and only the knitting zones of Tricot and Ras

Tricot Knit: Tricot fabric is soft, wrinkle resistant & has good drapability. Tricot knits are used for a wide variety of fabric weights & design. It makes light fabric weighting less than 4 ounce/square yard. Some examples of tricot fabric are sleepwear, boluses, dresses etc.



Raschel Knit:

The Raschel knit ranks in importance of production with tricot but it makes varieties of products ranging from laces, power nets for foundation garments, swimwear to carpets. Raschel knitting is done with heavy yarns & usually has a complex lace-like pattern.



Crochet Knit: This basic stitch is used in hand crochet. This construction is used in a wide variety of fabrics ranging from nets & laces to bed spreads & carpets, various types of edgings or trimmings lace are also produced.

Milanese Knit: The Milanese stitch produces a fabric very similar to tricot. It can be identified by the fine rib on the face & a diagonal pattern on the back. However, Milanese fabric is superior to tricot in smoothness, elasticity, regularity of structure & friction resistance

1. Characteristics of Tricot and Raschel Warp Knitting Machine

Tricot machines Characteristics

- ❖ Compound sinker bar (2-point knock over).
- ❖ Warp beams are placed mainly at the back of the machine or perhaps above the machine.
- ❖ Needles can be changed from the front side of the machine.
- ❖ Up to 5 guide bars are used at the moment.
- ❖ Use of compound needles.
- ❖ Starting-up without fabric take-up possible.
- ❖ Only pillar loops cannot be knitted (only by support through inlay motion),(lateral 2point knock-over)
- ❖ Angle between incoming yarn sheet and fabric take-up is 90° (considerable needle stress).
- ❖ Simple machine construction.
- ❖ Short run-in of the threads because of the beam positions.

- ❖ High number of courses possible up to total stop of the beams (for pleats) because working without fabric take up is possible.
- ❖ High yarn run-in is possible (overfeed).
- ❖ Handling of the knitting elements from the knitter's side possible. □ Piles for terry effects are possible.
- ❖ Simple construction of pile fingers for plush.
- ❖ Soft fabric touch.
- ❖ The two major classes of warp knitting machines are tricot and raschels
- ❖ (In some countries tricot machines are termed automatic warp knitting machines).
- ❖ Tricot machines
- ❖ The maximum number of guide bars are four, majority of tricot machines employ only two guide bars.
- ❖ In the past, the two-guide bar tricot machine proved most popular in E 28 and E 32 gauge, with knitting widths of 84 and 168 inches using 40-denier nylon.
- ❖ It is possible to knit from 10-denier nylon up to 1/20's cotton count.
- ❖ Machine gauges can range from E 10 for coarse staple fibre yarns to E 20–E 24 for textured yarn fabrics and E 36–E 44 gauge for fine fabrics, in knitting widths up to 260 inches (660 cm).

Disadvantages of Tricot machines

- ❖ Problems with small number of stitches and reduced yarn run-in (fabric take-up 90°) (high tension for the needle, loose selvages lead to yarn twisting and fault).
- ❖ Processing of elastomeric yarn mainly possible only as loop.
- ❖ Net constructions are difficult to be made since the knock-over of the Wales connection is not possible (lateral 2-point knock-over).
- ❖ Processing of filler yarns is very difficult (see fabric take-up, 90°).
- ❖ Common machine gauges from E 24 to E 40.

Raschel machines Characteristics

- ❖ Separate knock-over bar (trick plate) 3-1point knock-over and stitch comb bar.
- ❖ Warp beams are placed on the top of the machine.

- ❖ Needles have to be changed from the back side of the machine (due to the knock-over comb bar).
- ❖ Nowadays up to 78 guide bars are possible.
- ❖ Usage of compound needles and sometimes of latch needles.
- ❖ Loop formation without fabric take-up is not possible; main knock over at the front edge (take-up).
- ❖ Angle between incoming yarn sheet and fabric take-up is 170° (low needle stress).
- ❖ High take-up tension allows the production of open fabric structures and the manufacture of elastomeric inlays (power net) as well as the production of elastic pleated fabrics.
- ❖ Vertical laying-in (filler threads) can be processed (170° fabric take-up).
- ❖ The high yarn tension does not affect the needles directly. Hence, low stitch densities and short yarn run-in possible at high fabric stability and low needle stress.
- ❖ Various materials can be used: film tapes, glass, aramid, carbon, metal wires.
- ❖ Wide range of gauges.

Disadvantages of Raschel machines

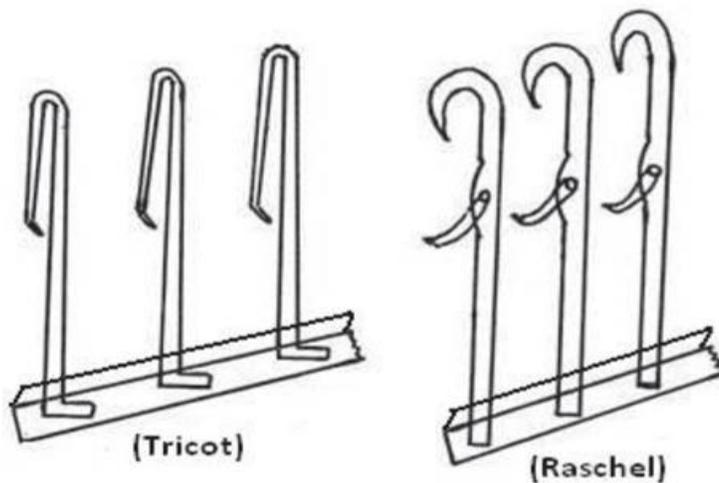
- ❖ Starting-up only with fabric take-up possible.
- ❖ Loose yarn run-in (overfeed) and high stitch densities (velvet, pleats) are not possible fabric touch less soft.
- ❖ Longer yarn path due to beam positions.
- ❖ Changing of needles only from the back side.

2. PRINCIPLES OF LOOP FORMATION OF WARP KNITTING

The needle bar is lifted up and lowered down for the purpose of loop formation. In order to feed the yarn to the needle for loop formation as well as to connect the adjacent wales, the guides of a guide bar are required to execute a compound lapping movement. This compound lapping movement is composed of two separately derived motions – swinging and [shoggingslogging](#). There are three possible arrangements of lapping at successive courses which may be used alone or in combination. The ultimate pattern or structure of the fabric depends on the nature of movements of the guides. So, control of nature of movements of the guides is very much important. The controlling mechanisms like pattern wheel, pattern chain links and electronic jacquard are generally used in warp knitting machines for imparting necessary motions to the guides.

Knitting Elements of Warp Knitting

In both Tricot and Raschel, yarns coming from the beam as parallel sheet are converted into fabric by loop formation before being wound in open width form on the cloth roller. Although the said two types machines differ to certain features, their loop formation technique is almost similar and the functional elements required for the purpose are as discussed in the undergoing. Needles and needle bar – All the three types of needles (bearded, latch & compound) as described while discussing weft knitting are used in warp knitting as well. Whatever may be the type of needle, all the needles move up and down together for loop formation, i.e., all the loops in a course are made simultaneously. So instead of giving motion to the individual needles, all the needles are connected/fixed to a bar called needle and the needle bar is lifted up and lowered down by means of a cam fitted outside the machine, generally at the driving side. Needles are set in tricks cut in the needle bed of the machine.



Presser bar – In order to close the hook for casting-off of the old loop in Tricot machine, some closing element (Presser bar) is must. The elements needed in Tricot machine are set in a separate bar across the full width of the machine which also get motion from a cam or crank fitted on the main shaft. The presser bar closes the hook of the bearded needle when the same moves downward after catching of the new yarn for loop formation. Latch guard or wire – In Raschel machines, when the loops of the fabric clear the latches, the later have sometimes the tendency to flick back and close the hooks of the needles. A closed hook does not receive a new yarn. So a steel wire stretched across the whole width of the machine, parallel to the needles, is used as latch guard to stop the flicking latches.

Sinkers and sinker bar – The sinker is a thin plate of metal which is placed between every two needles. The sinkers are usually cast in units (Fig. 12.4), 1 inch long, which in turn are screwed into a

bar called sinker bar. The sinkers are given almost linear horizontal (forward and backward) motion through the sinker bar. The drive generally comes from a crank or eccentric arrangement. The neck and the throat of the sinker are used to hold down the fabric while the belly of the sinker is used as a knocking over platform.

Guides and guide bars – Guides are thin metal plates drilled with a hole in their lower end through a warp end may be threaded if required. The guides are held together at their upper end in a metal lead of 1 inch width (Fig. 12.5) and are spaced in it to the same gauge as the machine. The leads in turn are attached to a horizontal bar to form a complete guide bar assembly bar, so that the guides hang from it with each one occupying a position at rest midway between two adjacent needles. In this position the needles do not receive the warp yarns. The needles only receive the warp yarns in their hooks if the guides wrap or lap the yarns across the needles. For the purpose, the guide bars are given a compound lapping movement. The number of guide bars in a machine is equal to the number of warp beams and each guide bar contains guides equal to the number of yarns in each warp beam. All guides in a conventional guide bar produce an identical lapping movement at the same time and therefore have requirements of same warp tension and rate of feed although yarns may differ in Colour and composition. But the two guide bars may have different lapping movement where requirement of warp feed and warp tension may vary also.

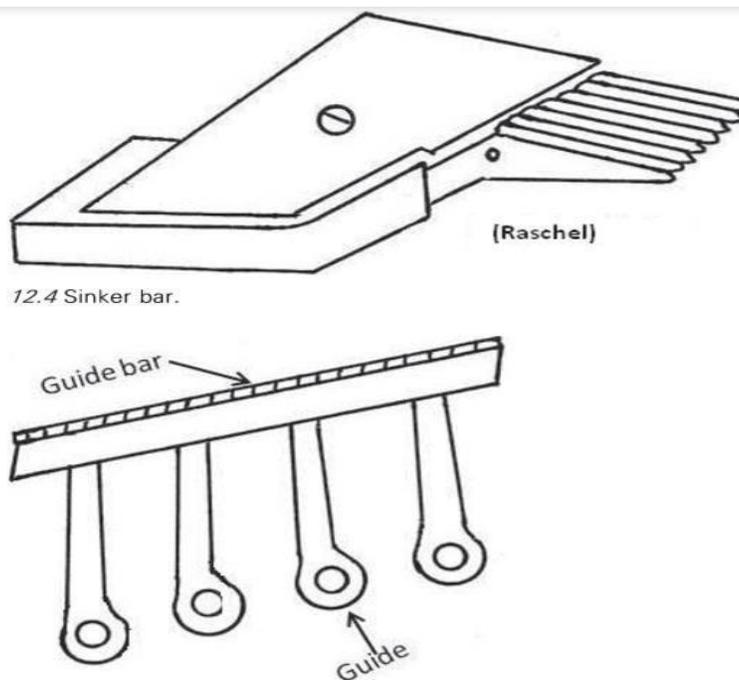


Fig. 1.7 guides and guide bars

Trick plate – The other name of needle bed is trick plate. Tricks or grooves are made on the bed for

properly accommodating the needles so that they can move up and down freely without having any lateral tilt.

WARP BEAMS

The required numbers of yarns are wound as parallel sheet of warp on a flanged beam under uniform tension for supplying of yarn in the knitting zone at a constant rate and tension. The warp beams (Fig. 12.6) in knitting are similar to the beams used in weaving but the technique of preparation may differ. There is no need of sizing but application of certain amount of oil/wax on warp may improve the knitting performance. Both sectional warping and direct warping are applicable depending upon nature of warp to be produced. Utmost care should be taken particularly for staple yarns so that variation of yarn diameter and presence of defects such as slubs, knots etc. shall be minimum in the final beam. Content of yarn in the beam depends on the fineness and density of yarn and flange diameter. The beam width (flange to flange) is generally equal to the width of needle bar. However, for easy manipulation of the beams, particularly in wider machines, two or more sections of beams are used instead of one wider beam. The number of full width beams in the machine is equal to the number of guide bars. The beams are situated at the top of the back side of the machine.

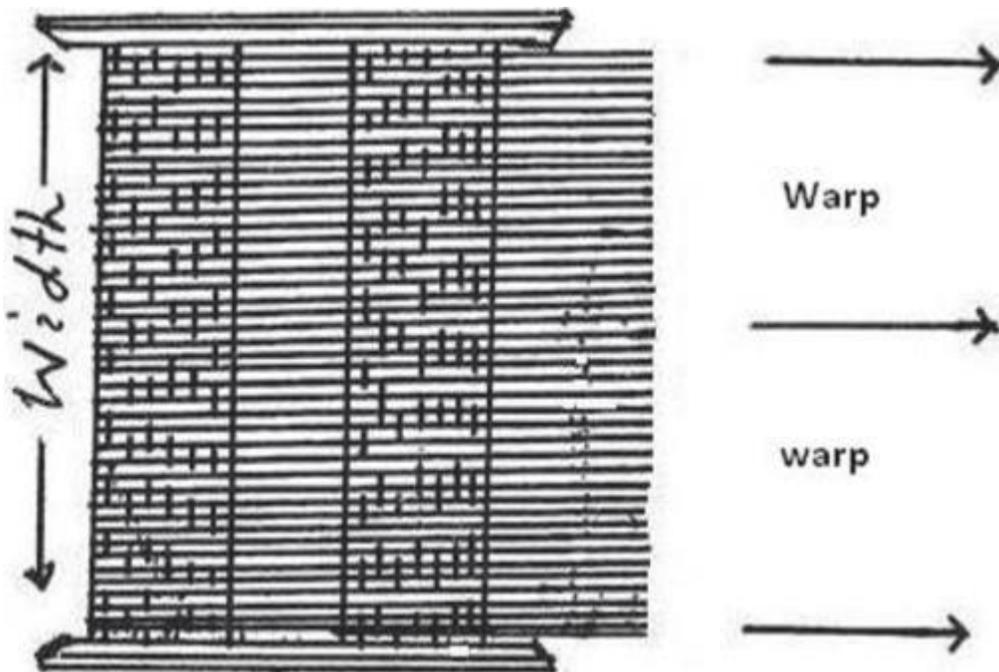


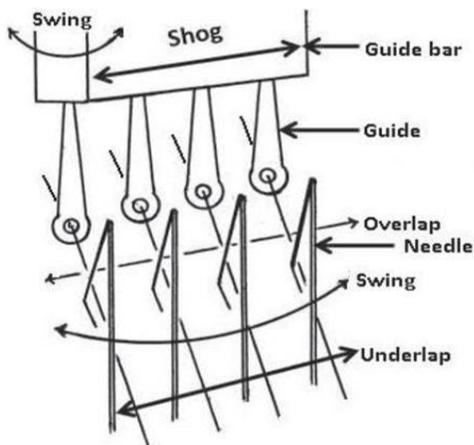
Fig. 1.8 warp beam containing parallel sheet of yarn

Needle bar movement

The needle bar is lifted up and lowered down for the purpose of loop formation. During upward movement, the old loop is cleared and needle catches the yarn wrapped around it by the guide and forms the new loop during the downward movement. Such movement is imparted on the needle bar by means of a cam or eccentric fitted on a shaft called eccentric shaft. The shaft extends to the full width of the machine and the cam is located outside the machine, generally at the driving side. The cam is kept in an enclosed oil bath in order to have less vibration, noise, heat generation but higher life.

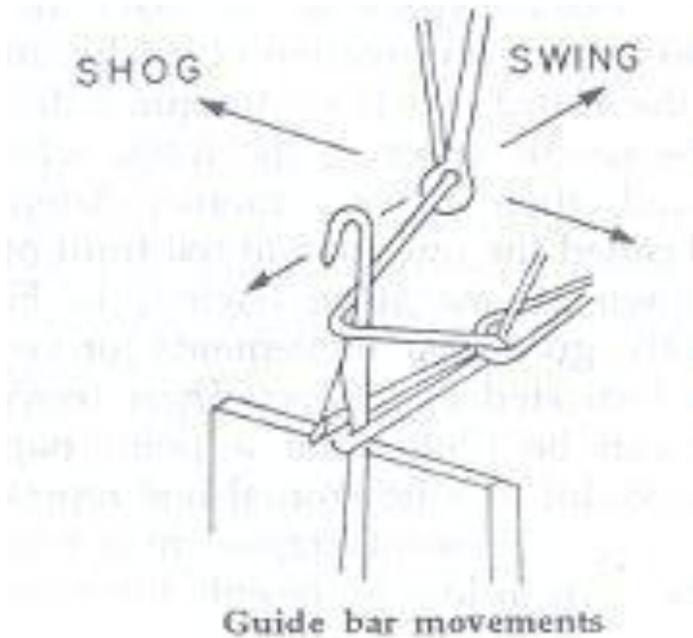
Guide bar movement

In order to feed the yarn to the needle for loop formation as well as to connect the adjacent wales, the guides of a guide bar are required to execute a compound lapping movement. This compound lapping movement is composed of two separately derived motions – swinging and slogging. A swinging motion and a slogging motion act at right angle to each other in order to form overlap and underlap.



Warp knitting cycle

The action of guides to knit a warp knit course and its intermeshing with the previously formed course. It normally comprises of a backward swing, an overlap, a forward swing and an underlap of the guide bars.



Swing and Shog: Swing and shog are the two different direction of guide bar movement's right angle to one another in warp knitting.

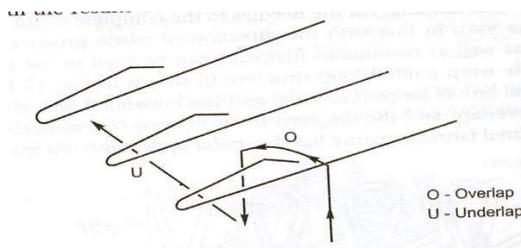
Swing: It is the longitudinal movement of the guides with warp threads between the needles.

1. **First or Backward swing:** Motion of guide from forward most position to the rear of the machine between two adjacent needles for an overlap.
2. **Second or Forward swing:** Motion of guide from rear side of the machine to forward most position between two adjacent needles to complete one knitting cycle.

Shog: Sideway movement of the guide to form an overlap or underlap. Takes place in right angle to swing or parallel to the needle bar.

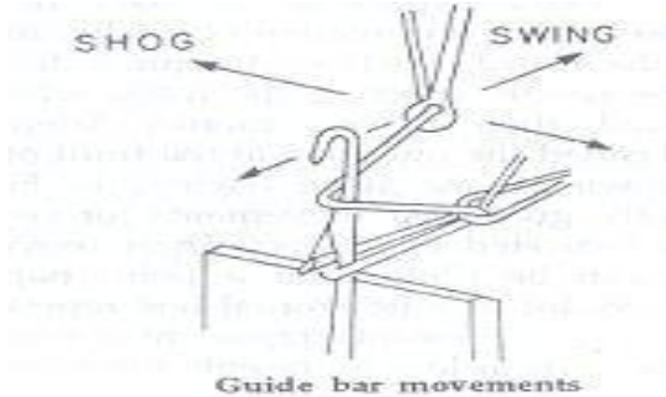
There are two types of shogs required to complete a warp knit cycle namely,

1. Overlap shog
2. Underlap shog



1. **Overlap shog:** Simply called overlap.

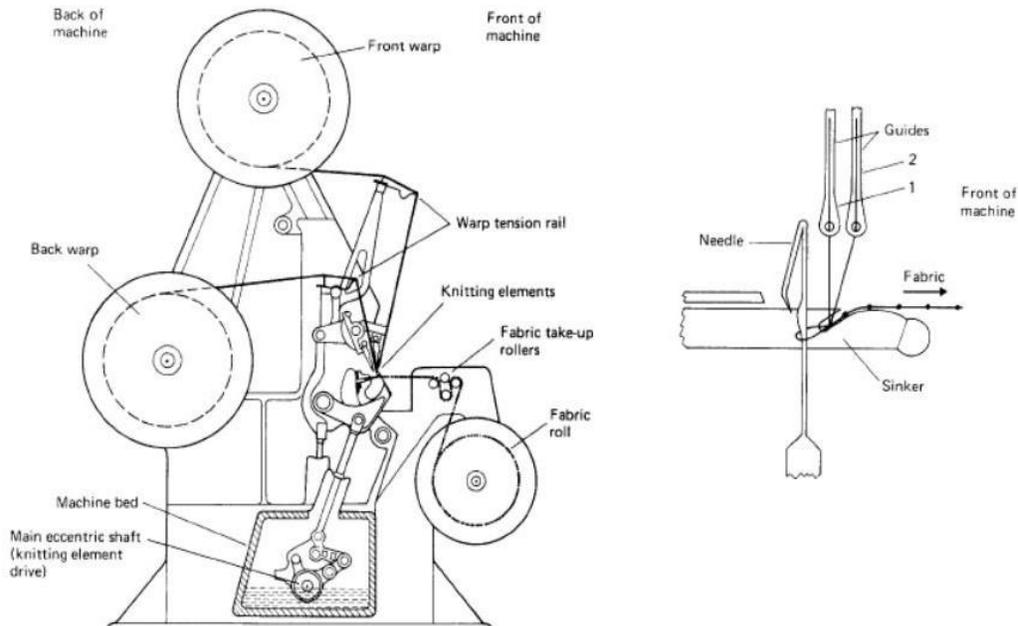
- ❖ First sideways movement of the guide in front (beard side or hook side) of the needle.
- ❖ Part of an action to wrap the thread around the needle to form a warp knit loop.
- ❖ Takes place after backward swing or first swing.



Underlap shog: Simply called underlap.

- Second sideways movement of the guide at back side of the needle away from the beard or hook.
- An action to form the loop portion that connects two adjacent loops.
- Takes place after forward swing or second swing.

The tricot machines



Tricot Machine Knitting Cycle with Breaded Needle

The different stages in loop formation using bearded needle as shown in Fig. 13.6 are as follows. Only one guide bar has been considered for making the diagrams.

The rest position (a)

- The needles have risen to $\frac{2}{3}$ of their full height from knock-over and have their beards towards the back of the machine.
- The pressers withdrawn and the guides are at the front of the machine.
- The sinkers are in forward position, holding the old overlaps in their throats

Backward swing and overlap shog (b, c).

- The guides Swing through the needles to the beard side
- Shog to side, yarn overlaps across the beards

The return swing and second rise (c, d).

- The guides swing to the front
- The needles rise to their full height so that the newly-formed overlaps slip off the beards onto the stems above the old overlaps.

Pressing (e).

- The needle bar/needles descends so that the open beards cover the new overlaps.

- There is a slight pause whilst the presser advances and closes the beards.

Landing (f).

- As the sinkers withdraw, the upward curve of their bellies lands the old overlaps onto the closed beards.

Knock-over and underlap shog (g).

- The presser is withdrawn
- The continued descent of the needle bar causes the old overlaps to be knocked-over
- The underlap shog which can occur at any time between pressing and knock-over

The sinkers now move forward to hold down the fabric loops and push them away from the ascending needles, which are rising to the rest position.

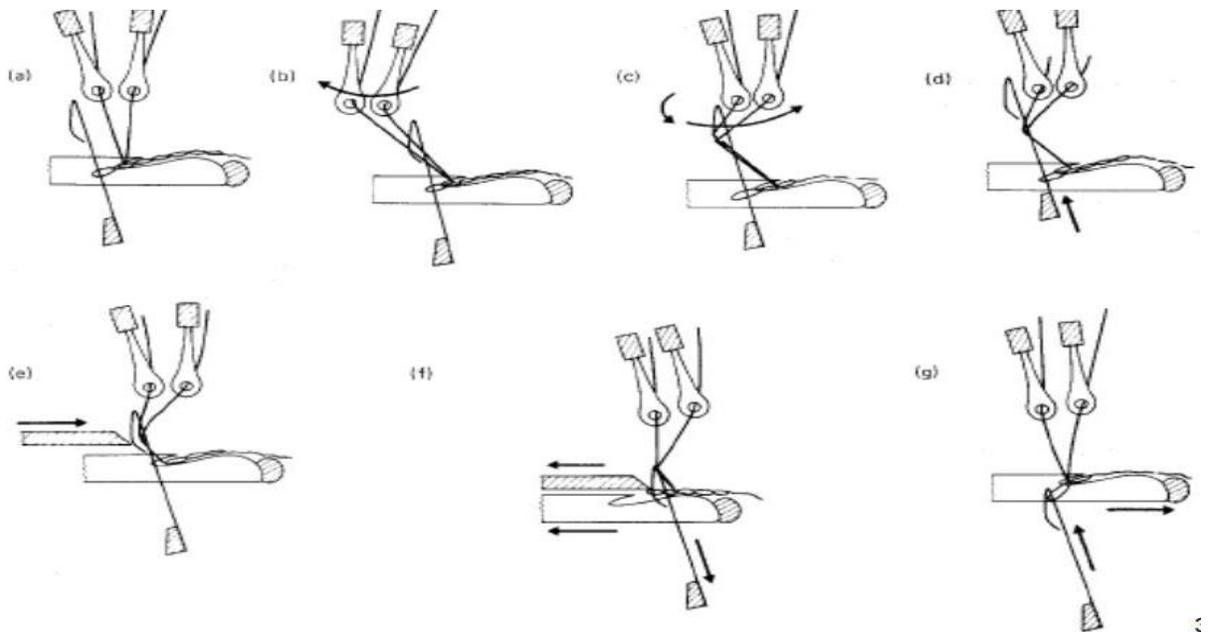


Fig. Tricot machine knitting cycle with braided needle

Raschel Machine Knitting Cycle with Latch Needle

The loop forming cycle of Raschel machine using latch needle and one guide bar is shown in Fig. 13.7. The main stages are as following:

1. Holding down.

- The guide bars are at the front of the machine, completing their underlap shog.
- The sinker bar moves forward to hold the fabric down whilst the needle bar starts to rise from knocks-over.

2. Clearing

- As the needle bar rises to its full height, the old overlaps slip down onto the stems after opening the latches,
- The sinker bar then starts to withdraw to allow the guide bars to overlap.

3. Overlap.

- The guide bars swing to the back of the machine and then shog for the overlap.

4. Return swing.

- As the guide bars swing to the front, the warp threads wrap into the needle hooks.

5. Latch closing.

- The needle bar descends so that the old overlaps contact and close the latches, trapping the new overlaps inside.
- The sinker bar now starts to move forward.

6. Knocking-over and underlap.

- As the needle bar continues to descend, its head passes below the surface of the trick-plate, drawing the new overlap through the old overlap which is cast-off
- As the sinkers advance over the trick-plate, the underlap shog of the guide bar is commenced.

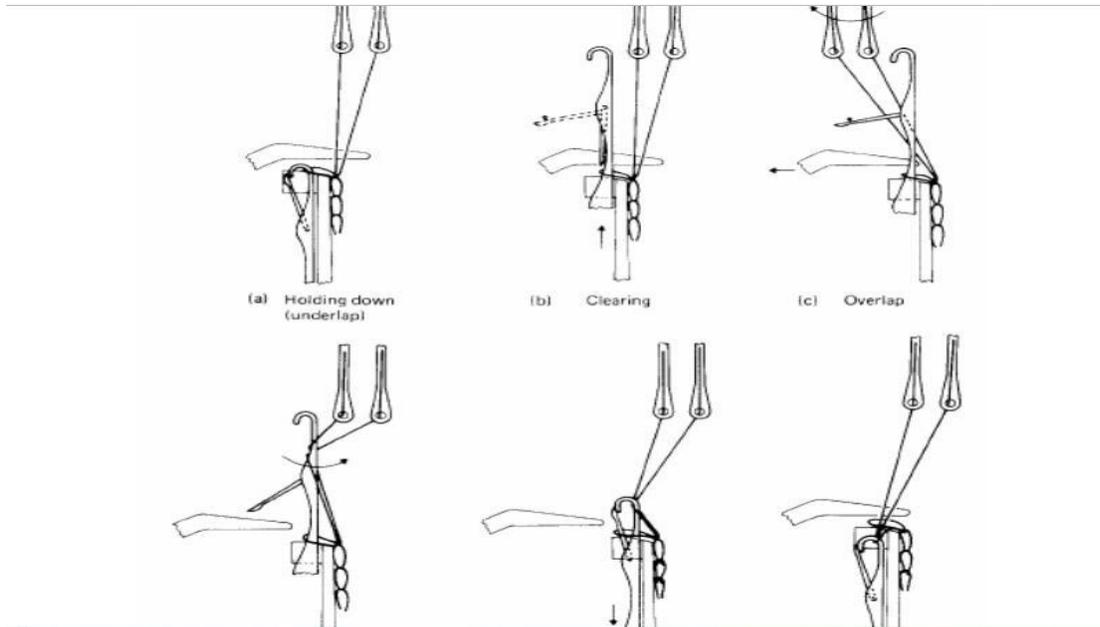


Fig Raschel machine knitting cycle with latch needle

(a) The guide bar is at front of the machine completing its underlap shog. The sinker bar moves forward to hold the fabric whilst the needle bar starts to rise from knock-over.

(b) The needle bar rises to its full height and the old overlaps slip down onto the stems after opening the latches which are prevented from flicking closed by latch wires.

(c) The guide bars swing to the back of the machine and then shog for the overlap. The sinker bar then starts to withdraw for allowing the guide bar to overlap.

(d) The guide bar swings to the front to wrap the warp threads into the needle hooks.

(e) The needle bar descends; the old overlaps contact and the latches are closed. The sinker bar now starts to move forward.

(f) The needle bar continues to descend and its head passes below the surface of the trick plate drawing the new overlap through the old overlap which is cast-off and as the sinkers advances over the trick plate.

The knitting action of the compound needle warp knitting machine

1. Needle rise and guide bar swing.

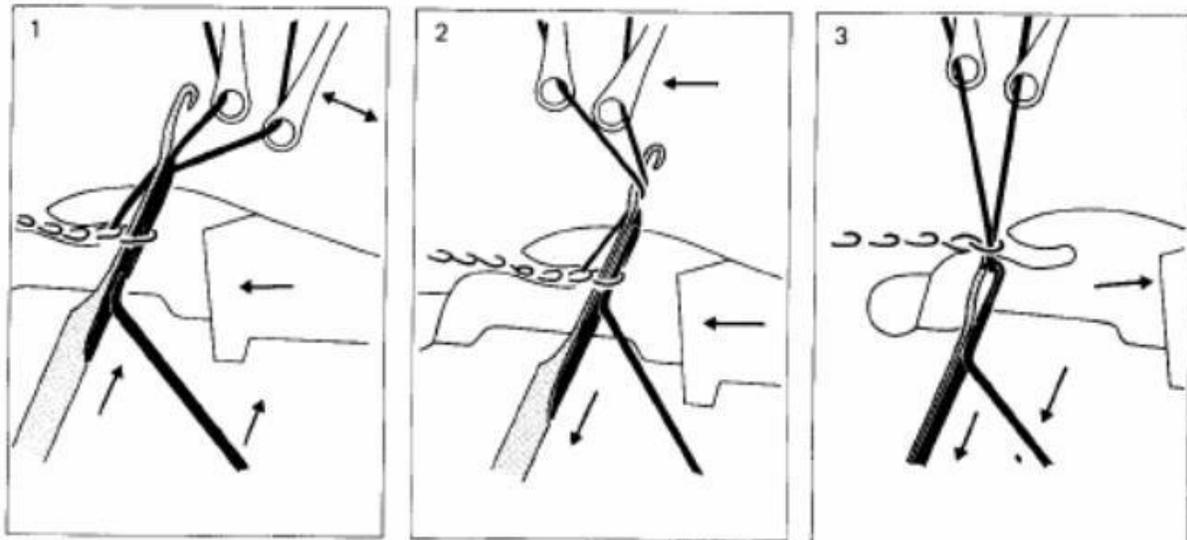
- With the sinkers forward holding down the fabric,
- The hooks and tongues rise, with the hook rising faster, until the head of the latter is level with the guide holes and is pen.
- The guides then swing through to the back of the machine

2. The overlap and return swing.

- The guides shog for the overlap and swing to the front of the machine;
- Immediately, the hooks and the tongues start to descend with the tongues descending more slowly, thus closing the hooks.

3. Landing and knock-over.

- The sinkers start to withdraw as the needles descend so that the old loop is landed onto the closed hook and then knocked-over as it descends below the sinker belly.
- At this point the underlap occurs before the needles begin their upward rise and the sinkers move forward to hold down the fabric

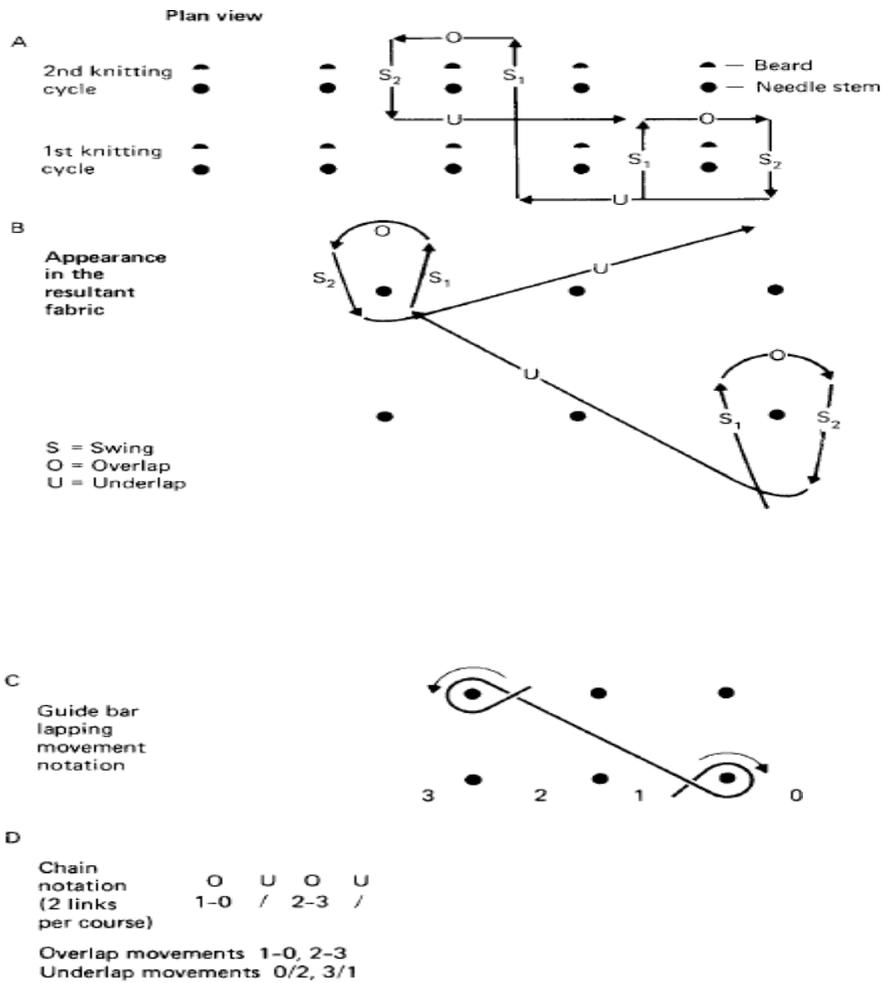


The development of lapping diagrams and chain notations

Lapping diagrams are drawn around horizontal rows of points that represent needles in plan view, usually assuming the pattern mechanism to be on the right. As the guides position themselves in the spaces between needles, the positions between the vertical columns of points can be given chain link numbers commencing with the '0' position, which is to the right of the right-hand column of points.

Provided the direction and extent of the overlaps are correctly indicated in the lapping diagram and chain notation, the underlaps will always be correctly positioned as each extends from the end of one overlap to the start of the next.

Figure .A represents a diagrammatic plan view of a two-course repeat sequence. S1 and S2 represent the swinging motions and O and U represent the overlap and underlap shogs at each course. In the lapping diagram (Fig. C), the first overlap will be drawn in a curve over a point from space '1' to space '0' and the second from space '2' to space '3'. The lapping diagram is completed by joining the overlaps to each other with underlaps and the chain is notated as 1-0/2-3/ where - represents an overlap and / an underlap. The shogging movements are produced by the transition from one link to the next, whereas the swinging motions occur whilst the push-rod roller of the guide bar is in the center, so that no shog is produced.

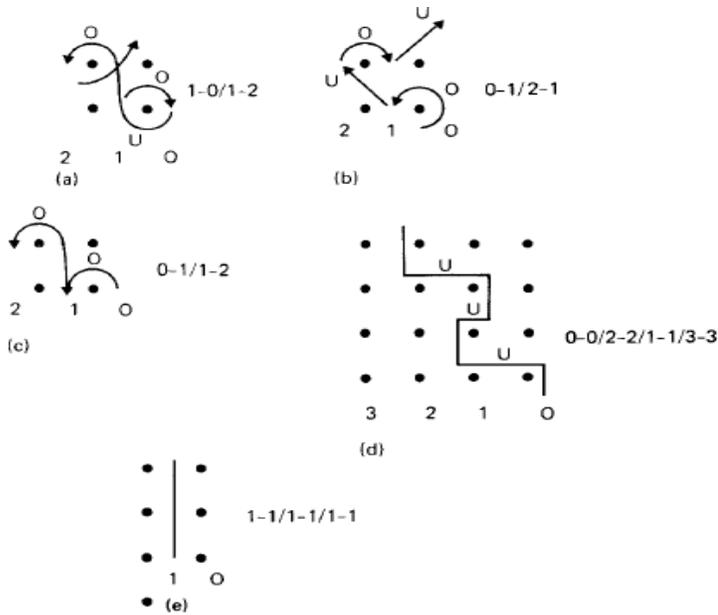


The five basic overlap/underlap variations

All guide bar lapping movements are composed of one or more of the following lapping variations:

- 1 An overlap followed by an underlap in the opposite direction (closed lap) (Fig. a).
- 2 An overlap followed by an underlap in the same direction (open lap) (Fig. b).
- 3 Only overlaps and no underlaps (open laps) (Fig. c).
- 4 Only underlaps and no overlaps (laying-in) (Fig. d).
- 5 Neither overlaps nor underlaps (miss-lapping) (Fig. e).

Movements 4 and 5 require the overlaps of another guide bar in front in order to hold them into the structure.

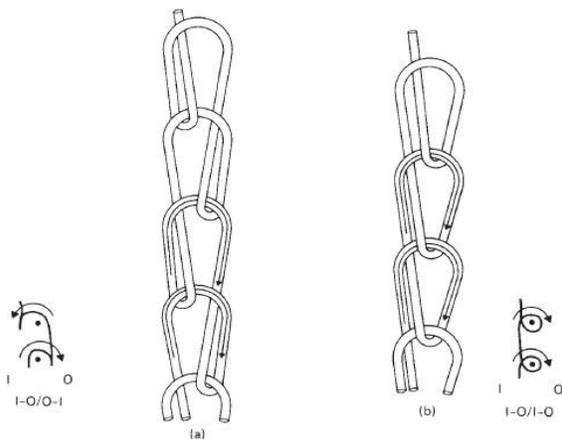


The direction of lapping at successive courses

When using either open or closed laps there are three possible arrangements of lapping at successive courses, which may be used alone or in combination:

1 The pillar stitch. In the pillar or chain stitch, the same guide always overlaps the same needle. This lapping movement will produce chains of loops in unconnected wales, which must be connected together by the underlaps of a second guide bar.

Generally, pillar stitches are made by front guide bars, either to produce vertical stripe effects or to hold the inlays of other guide bars into the structure. Open-lap pillar stitches are commonly used in warp knitting. They can be unroved from the end knitted last. Closed-lap pillar stitches are employed on crochet machines because the lapping movement is simple to achieve and is necessary when using self-closing carbine needles, which must always be fed with yarn from the same side (Fig.).

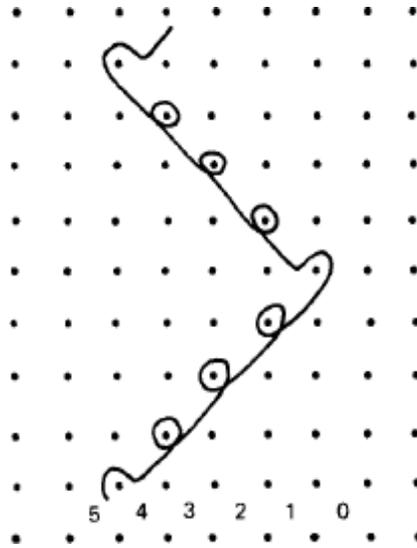
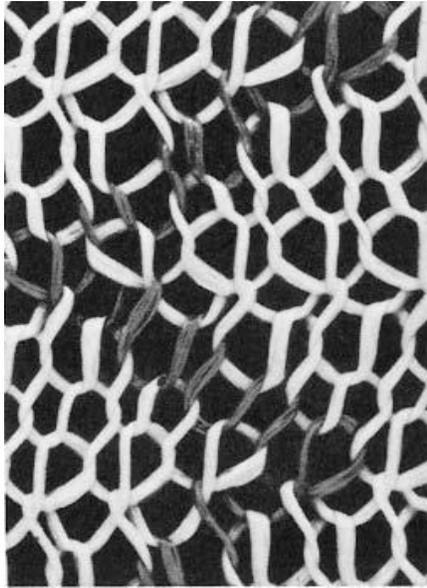


2 Balanced advance and return lapping in two courses. Many tricot structures are based on this type of lapping movement. Its extent may be described by indicating the number of needles underlapped, followed by the number of needles overlapped (usually one). With a fully-threaded guide bar every one needle space increase in the underlap movement will cause an extra warp thread from that bar to cross between each wale.

Tricot lapping or 1 * 1 is the simplest of these movements, producing overlaps in alternate wales at alternate courses with only one thread crossing between adjacent wales. Two threads will cross between wales with a 2 * 1 or cord lap, three threads with a 3 * 1 or satin lap, four threads with a 4 * 1 or velvet lap, and so on.

Each increase in the extent of the underlap tends to make the structure stronger, more opaque and heavier. The increasing float of the underlap has amore horizontal appearance, whilst overlaps produced by the same thread will be separated from each other at successive courses by an extra wale in width.

3 Atlas lapping. This is a movement where the guide bar laps progressively in the same direction for a minimum of two consecutive courses, normally followed by an identical lapping movement in the opposite direction. Usually, the progressive lapping is in the form of open laps and the change of direction course is in the form of a closed lap, but these roles may be reversed. From the change of direction course, tension tends to cause the heads of the loops to incline in the opposite direction to that of the previous lapping progression. The change of direction course is normally tighter and the return progression courses cause reflected light to produce a faint, transverse shadow, stripe effect. The underlaps on the technical back give the appearance of sinker loops in a spirally weft knitted structure. With a single guide bar having different colored warp threads, zigzag effects can be produced. This is sometimes termed *single atlas* or *Vandyke*. More elaborate geometrical patterns can be achieved with patterned warps using atlas lapping on two or more guide bars. Atlas is also the base for many simplex and all Milanese fabrics.



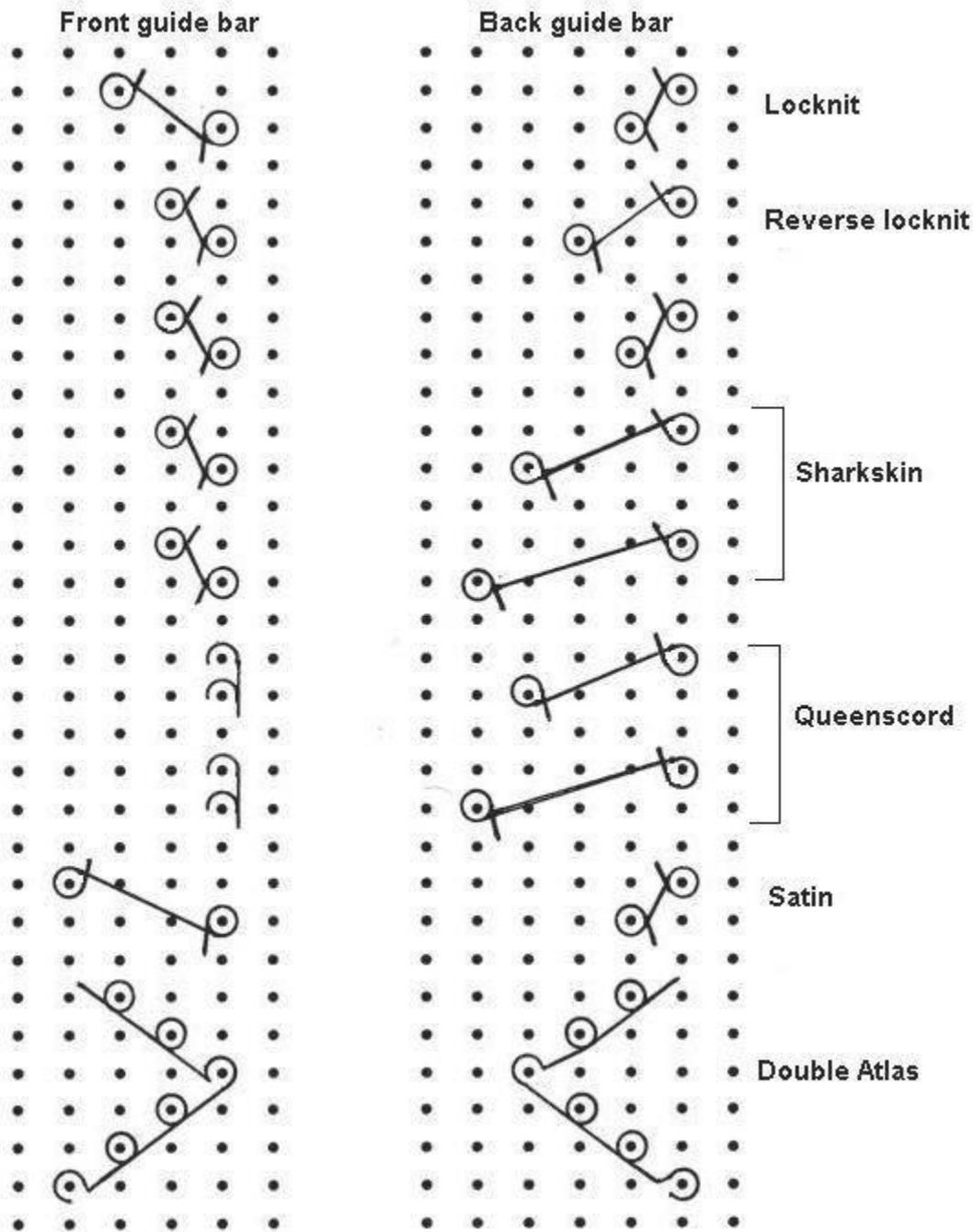
Warp Knitted Structures and stitches

It is experienced by many knitters that production of warp knitted fabric may be possible by using only one guide bar with necessary underlaps and overlaps. However, these fabrics are not commercially viable on account low strength, lack of stability, less cover, distortion of the loops etc. Moreover the fabric is like a film and the production technology does not provide patterning facility. A reasonably stable warp knitted structure with desired properties can be produced with minimum two guide bars. So most of the warp knitted structures are produced in machine provided with minimum two guide bars. Addition of guide bars improves the stability and other desired properties as well as the patterning facility. But presence of too many guide bars makes the machine complicated and costly. So selection of number of guide bars in the machine is very important for producing warp knitted structures.

Types of stitches and structures

The popular warp knitted structures are mainly produced with two full guide bars. The structures are based on two-course repeat cycle and direction of lapping changes in every course. The two guide bars should invariably make different lapping movement otherwise the resultant structure would be equivalent to the structure produced with single guide bar. The proportion of yarns in the fabric is influenced by the extent of underlap and overlap of the guide bars. The presence of yarns in the face or back side of the fabric depends on the controlling guide bar. Under normal conditions the threads of the front guide bar dominate on both face and back sides of the fabric. Considering two guide bars (front guide bar and back guide bar), the nature of guide bar lapping movement is for producing some of the popular warp knitted structures. The resultant appearances of those structures have been shown

later.

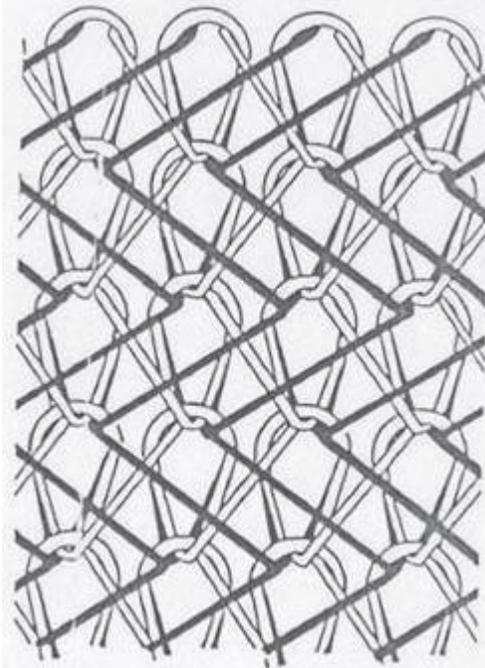


A few popular warp knitting structures

Locknit:

- Most popular of all warp knitted structures, accounts for 70 to 80%.

- Longer overlaps of the front bar (shogs 2 needle spaces) on the back improve the extensibility, drape ability and soft handle.



- Preferred machine gauge is 28 and a wale per inch in fabric is about 37.
- Mainly nylon filament is used, sometimes spandex is used at the back.
- GSM depends on filament denier. A few popular GSM are 30, 32 and 152 made from filament denier of 20, 40 and 70 respectively.
- High elasticity makes it suitable for intimate wears.
- Fabric has a tendency to curl near the selvedge, which can be overcome by heat setting as, yarns are thermoplastic.

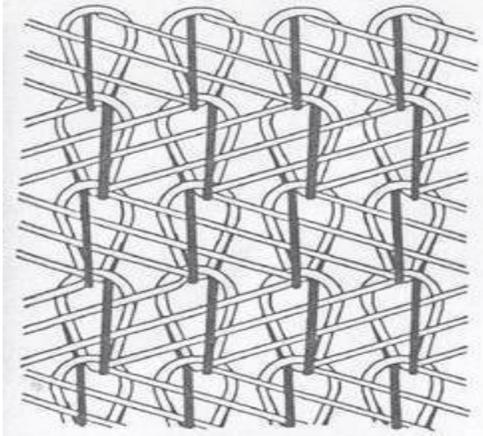
Sharkskin:

- Back guide bar underlap up to 3 needle space.
- Rigid and heavier fabric.
- Suitable for print base fabric.

Queenscord:

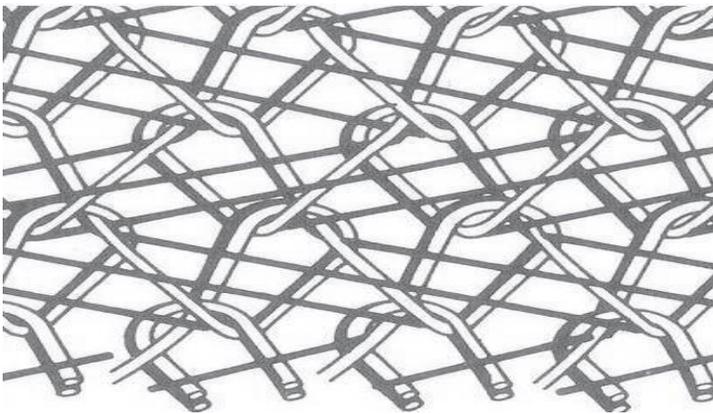
- More rigid than sharkskin fabric.
- Front bar produces shortest possible underlap.
- Pillar stitch structure.
- Shrinkage is up to 6% only.

- Some cord effect along the wales.



Velour or Velvet:

- The long overlap (6 to 8 needle space) of the front guide bar forms pile on the technical back of the fabric.
- Piles may be brushed i.e., cut or cropped by knife to produce velvet like appearance during finishing.
- Satin stitch
- 40 to 60 denier nylon in the body or ground structure and 55 to 100 denier viscose/acetate in piles.



Double atlas:

- Two guide bars atlas lap in opposition with identically balanced lapping movement
- Balanced symmetrical design including checks, diamonds, circles etc.
- Intense and paler colour effect on the surface from threads of different colour
- Attractive handle, drapeability and elastic recovery.

QUALITY CONTROL IN KNITTING

Introduction

It is now a well recognized fact that uniformity of structure is conducive to the consumers' acceptance of the product but unfortunately the quality control programme is often practiced in the breach than in the observance. The final product is the result of the controlled programme at three important areas of product manufacturing, namely, (i) the raw material i.e. the fibres and yarns from which the fabric is to be made, (ii) machine maintenance and machine settings for smooth and faultless running of the processes adopted during the manufacture of the product, and (iii) various parameters, determining the knitting quality, such as stitch length, run-in ratios, courses and wales per unit space, stitch density, weight per linear length, yield etc. The knitting quality can be assessed by both subjective and objective tests. Assessment of fabric hand, feel, bulk or aesthetic are the subjective properties while stitch length, run-in ratios, weights etc. are objective properties, which can be precisely stated in quantitative terms. A well-coordinated programmer of the above mentioned areas and effective control constitute a sound management. This will help in achieving standards for production, quality, maintenance, machine efficiency and cost standards,

IMPORTANT YARN PROPERTIES FOR KNITTING

Work of rupture: The processes of warping and knitting involve strains on the yarn. Warping imposes a tensile loading but knitting imposes a combination of bending, torsion, compression and sheer strengths, repeating many times a second, with changing intensity, Within a knitting cycle **two peaks** of tension are reached

- (i) When the guide bars pass through the needles and
- (ii) When the needles draw the loops.

The yarn is thus loaded and unloaded more than 25 times per second if the speed of the machine is about 1,500 courses per minute. Thus, it is important that toughness or work of the rupture property of the yarn should be of high value, for the yarns meant for knitting. Yarns, having high value of work of rupture, will absorb the energy put into stretching it during the various phases of knitting. High tenacity materials are not necessarily tough e.g. glass fibre. Loading and unloading may not result in a direct break of yarn but fatigue in yarn may lead to yarn failure below its tenacity value.

Elongation: Yarns featured by low elongation will knit poorly regardless of its strength. The ability to elongate and yield to the load is an essential characteristic of warp knitted yarns to survive the strains of loop formation. In fact, the property of work of rupture depends mainly on elongation and strength of the fibres.

Tenacity: High tenacity value does not mean necessarily that the yarn is of good quality for knitting. Fibre glass has the highest tenacity; 6.5g/denier while acetate has tenacity of 1.4g/ denier. But acetate knits quilt well and not the fibre glass. Of course, some minimum tenacity is desired. The minimal for Raschel will be higher than the minimal for tricot-knitting (Yarn has to operate the latches, in case of Raschel). As mentioned above, more than in knitting, warping process - requires tensile strength. Thus, the minimum tenacity of the yarn should be determined by the requirements of the warping process.

Bending and flexural rigidity: These two parameters of the yarn indicate the resistance of yarn to bending or flexing, respectively: For the same yarn, the bending and flexural rigidity will vary with the denier of individual filaments, cross-section, and twist, frictional and other properties. The rigidity of the low twist multifilament yarn is a sum of rigidities of the component filaments. For a given denier and rigidity, the lower the filament count the less the danger of breakages.

Torsional rigidity: The resistance of yarn to twisting is known as torsional rigidity of the yarn. It depends on the modulus of material, shape factor, area of cross-section, number and denier of individual filaments, twist, frictional and other properties. A yarn with high torsional rigidity will cause knitting difficulties.

Regularity: The appearance of the fabric to the consumer is greatly influenced by the regularity of the material used. A variation in the yarn diameter, particularly of continuous filament yarns, is likely to produce streaks in the fabric, thus creating 'seconds'. It is, therefore, necessary to maintain a uniform denier of the filament.

A number of electronic instruments are now available for checking the diameter of the yarn.

Resiliency: The greater the resiliency the more resistance is offered by the yarn to rupture under the influence of fluctuating tensions.

Though the desired yarn properties for knitting have been mentioned here, it is not implied that yarns having all these properties will only produce **best knitted fabric**. In fact, cotton, which is not much ideal for knitting, produces a satisfactory fabric while fabric made from certain strong cellulose fibers do not produce good appearance in fabric.

Control of Fabric Quality

A technician in charge of the quality control system should first prepare specification sheets of the fabrics to be knitted. These specifications should include (i) yarn specifications, (ii) knitting machine settings, (iii) fabric details, (iv) finishing details and (v) final examination specifications.

i. yarn specifications includes

(a) Supplier's name, (b) count or denier, (c) oil content, (d) twist, (e) crimp-rigidity and, (f) Color
On this sheet the technician should make a mention of 'tolerances' allowed for each specification.

ii. **Knitting machine setting** sheet should give, information on (a) diameter, (b) gauge (c) knock over time (d) dial height (e) take-down tension (f) stretch board width (g) needle set-out (h) machine speed (i) yarn speed (j) course length (k) yarn tension (l) cam setting etc.

iii. **Fabric details** should include (a) CPI off machine (b) WPI off machine (c) stitch density (d) weight per square meter (e) width off machine and (f) fault rate standard.

iv. **Finishing details** should give the type of finish required

v. **Final examination** specification should include (a) weight per linear meter (b) width (c) standard piece weight (d) length (e) per cent finish loss (f) fault allowance etc.

Thus, after deciding the specifications at each stage the next step to follow is to keep a routine inspection programme of the machine and fabric during knitting. Once, the machine has been set up, to the specifications and an initial fabric has been tested and found to be satisfactory, it is necessary to carry out inspection and testing procedures as per schedule fixed. Inspection of yarn on machine will include correct yarn and colour being creeled, proper threading through stop motions and guide eyes, quality of knots, cone damage, and bad winding etc. Knitting head inspection will include proper setting of positive feed drive and its speed being synchronized in relation to the machine speed; correct tensioning of the yarn etc. When using a positive feed tape system, it is very important to maintain even tensions before the yarn enters the tape wheels.

There should be no Slippage between the tape and the feed wheel.

Inspection of the fabric will include check for uneven fabric, for patterning of colored fabrics, for ladder running, for oil staining, for proper take-down tension for bairiness etc.

Knitting faults can occur at any time and if there is no regular examination of the fabric to detect and rectify such faults, rejection of substantial, quantities of fabric can result. One suggested formula for the frequency of this inspection of the fabric, while the machine is in operation is as follows:

$$\text{Inspections per hour} = \frac{\text{Length of fabric knitted per hour}}{1.15 \times \text{Length of fabric hidden by machine head}}$$

A defective take-down mechanism may cause tight and soft areas if it is pulling unevenly. It is better practice to note the weight used or the number of springs used for future reference for even take-down

The dial and cylinder relationship should also be inspected. On most of the machines it is possible to raise or lower the dial in relation to the cylinder. However, it is advised not to alter this setting. (Usually, the normal distance is 1/G inches, where G is the gauge of the machine). If the positive feed is feeding positively then the average loop length cannot change, no matter whether the distance between dial and cylinder is changed. Only temporary distortion of loops may take place on the machine. The dial and cylinder relationship should be inspected at least once a year.

The 'rpm' at which the machine runs is also important. For some critical fabrics the machine might have to run slower than normal. Thus, it is absolutely necessary to prepare technical data sheet for each knitting machine for the production of quality cloth.

Control of Yarn Tension during Knitting

Yarn tension affects the knitted fabric quality, particularly the dimensions of the fabrics. If too much tension is applied during knitting, the yarn may break or holes may appear in the fabric. If enough tension is not applied, the yarn may snag and snap and drop-stitches may result. Yarn tension affects dimensions up to 20 per cent. Yarn tension depends mainly on (a) yarn variables and (b) machine variables. Yarn variables include (i) yarn colour, (ii) yarn count, (iii) yarn twist, (iv) moisture content (\.) yarn lubrication and (vi) package hardness, Machine variables include (i) stitch cam setting; (ii) take-down tension, (iii) stretcher board, and (iv) machine gauge.

The object of constant tension on knitting machine is to steady the yarn between the yarn packages and needle. For all general purposes, the running tensions in the range of 3 to 8 g. are adequate to give necessary control .Any increase in tension result in reduced stitch length. Different fibre materials require different tension. The following tensions in grammes may be recommended as a guideline for running tension. Cotton: 5 to 8, Wool 1to 2, Viscose rayon: 4 to 7, Class: 6 to 8, Nylon 6 to 8, and Polyester: 3 to 4.

Increase in tension may cause yarn stretch needle flinging and robbing back of yarn. If the tension in the yarn is low, the needle has a tendency to overshoot the cam slot and go down further due to

the inertia of high speed of the working of the cylinder. Of course, cam groove is the limit to which extent the needle can go down.

Tests for Weft-knit Quality

To assure quality production, it is necessary to emphasize the importance of continuous on-the-spot inspection of the cloth as it comes off the machine. It is also essential that post-inspection of the fabric rolls, after doffing, is carried out. It is possible that a knitter may miss faults during on-the-spot inspection because of the difficulty in focusing on revolving fabrics. By post-Inspection process, the adverse trends can be seen and reported to the appropriate authority before further pieces are knitted.

The usual method of examination of fabric is to feed the fabric over a lighted frame of a table specially prepared for quality inspection. Usually, colored thread tag is attached to identify the fault-Position. The operative should be seated far enough back from the fabric to observe all the examining area without undue eye or head movement.

The speed of the fabric passing the viewing point is also of vital importance. Normally, ten to twelve meters per minute is suitable speed for single colored fabrics. Complex fabrics, like blister may be required to be run at half this speed.

A number of tests are available for checking the finished fabric after knitting such as (a) fabric yield (b) fabric appearance, (c) fabric pilling, (d) fabric extension (e) air permeability), (f) fabric skewness etc.

(a) Fabric Yield: Piece weight gives a correct idea about the quality of the fabric. Sometimes sample knitting is first resorted to. A course is marked and the machine is run through the required number of revolutions, marking the last course. The fabric is cut and weighed to determine the yield and width.

The use of piece weights, as a method of checking yield, is preferable to the method of determining the weight of a small square or circular sample cut out from the piece. The recent trend is to fit the revolution-counters on machines (similar to pick-counters on looms) which enables an accurate number of courses to be knitted per piece. Checking this record with the weight of the piece enables one to ascertain the quality doubly. It is, however, to be noted that fabric weights are affected by moisture content. Hence, moisture meters which are designed to quickly establish fabric moisture content should be used in the case of fabrics made from natural fibres, at the time of checking the piece weight.

(b) Fabric Appearance: This is a subjective test and much depends on the acceptability standards predetermined by the inspection staff. Expected fault rates per hundred kilogramme may be determined, based on the standards achievable under good working conditions. (Of course, all efforts should be made to improve upon the fault-rate standards with better care and attention).

(c) Fabric Pilling: The resistance of knitted fabric to pilling (forming small 'beads' of fibrous material on the face of the fabric) is important, particularly for those fabrics which are subjected to rubbing action in wear. The Pillbox test has been accepted as the most satisfactory way of testing for the pilling propensity. The method consists of testing of about 12cm x 12cm (5 inch x 5 inch) pieces of fabric to be sewn on to 15cm. long tube of rubber and placing them inside a cork-lined box. The box is rotated for a given number of revolutions. The pills seen on the surface of the fabric samples are then compared with three standard photographs showing the grade of the fabrics as per degree of pilling.

(d) Fabric Extension: Extensibility is a peculiar characteristic of knitted fabric. However, the amount of extensibility expected of a fabric depends on the end-use. For example, extensibility of a double-knit fabric needs to be low for many of the uses to which the fabrics are put to. Sometimes garment makers also stipulate requirements for fabric extensibility.

Usually, an Extension Tester (one of the commercial testers is Fryma Extension Tester of British make) is used wherein a sample piece is applied between two jaws in the machine. A uniform weight is applied to the fabric and the percentage extension is measured.

(e) Air-permeability: Air permeability of knitted fabrics is usually greater than that for a similar weight woven material. If attempts are made to reduce the air permeability of knitted fabrics to that of the woven, then the properties of stretch recovery and crease resistance are adversely affected. As such there are no known standards of air permeability values though testing methods of air permeability have been standardized (e.g. BS 3217:1960). A test can, therefore, be applied only where a standard has been agreed by the knitter with the customer. The test consists of clamping a sample between two circular discs and drawing the air through the fabric by a suction pump, the area of fabric being specified. The apparatus measures the rate of flow of air through the fabric.

(f) Fabric Skewness: Because of the variety of stress inherent in knitted fabrics, as a result of knitting and finishing processes, the course lines or pattering across the fabric width are not straight but curved. This skewness or bows can create problems for garment makers. There is no standard

method specially meant for measuring the skewness of knitted fabrics BS 2819; 1968 can well be used for knitted structures also.

Besides the above mentioned tests, there are numerous tests for quality control but it is not intended to provide encyclopedic information on tests. Hence a brief reference to some vitally important tests has been made. Tests and inspections are of no use if the results that fall outside the specification tolerances are not communicated to the personnel who can remedy any defect. Speed of reporting is also essential, to take effective steps so that continuation of the defect is avoided.

Sometimes a few comparisons are made to evaluate between machines and between yarns, e.g. an experiment can be performed to (i) analyze the fault-rates of different yarn suppliers on fabrics of similar knitted on the same type of machine, (ii) analyze fault-rates for the same yarn and fabrics knitted in different machines of the same type and (iii) analyze the fault rates for the same yarn and pattern knitted on machines of different types.

Quality of Warp-knits

The measurement of warp-knitted fabric quality is complex, due to the fact that in most of these structures, there are two or more threads in each loop. Besides, the overlap may be of one needle space but underlaps from one course to the next course may vary from course to course. The yarn lengths required may, therefore, vary from course to course. In woven structures, ends per inch and picks per inch along with the count of warp and weft usually determine the quality of the Woven structures.

In case of knitted structures courses per inch (cpi) and wales per inch (wpi) will vary according to whether the structures are under strain or fully relaxed. During relaxation, whether dry, wet or full, the cpi may decrease and wpi may increase or vice versa as the loops recover from distortion; but the loops per square inch (stitch density) may remain the same. Thus, the measurement of cpi and wpi may be comparable only if the counting is carried out under the same strained conditions. Therefore, 'stitch density' (product of cpi and wpi in free state of fabric) is a more accurate and constant parameter since it does not vary to the same extent as the cpi and wpi counted separately.

In weft knitted structures, therefore, stitch density, instead of cpi and wpi, is noted for fabric designing and calculations are based mainly on this parameter.

In the case of warp-knitted fabrics, the length of yarn required to form a course or a number of courses is an accurate measurement of fabric quality. The basic measurement taken is the length of yarn in inches taken from each beam to the needles during one 'rack' of 480 courses. This length of yarn used for 480 courses is termed as 'run-in' or 'runner length'. The figure of **run-in** will vary according to the lapping movements made by various guide bars. If one of the guide bars makes larger underlaps than the other, the run-in for the former will be greater than that for the latter. Similarly, if the run-in per rack is increased, larger loops will be obtained, resulting in a reduction of the courses per inch in the finished fabric and slacker fabric with a lighter weight per unit area.

Normally, except for some simple structures, the guide bars make different lapping movements. There are still no hard and fast rules which can determine the run-in for two bars which would be ideal under a given set of conditions. It is not only that the total run-in for two bars is required to be determined but it is the division of the total run-in for two bars to insure that the loop construction is perfectly balanced; i.e. the loops are vertical in position and as full and round as possible. Suitable Warp ratio is still determined by trial and error method than by calculations. The calculations of the correct ratio between the respective runner lengths of two or more guide remain one of the secrets of warp knitting with manufacturer having its own method of determination decided from years of experience. Another important factor to be remembered is that a certain amount of tension is always applied to the knitted fabric as it leaves the needlebar. This will have some effect in pulling the loop-size in a vertical way. It is, therefore, necessary to make adjustment in the run-in; otherwise the elongation of each loop will result in reduction in the width of the fabric.

DEFECTS IN KNITTED FABRIC: CAUSES AND REMEDIES

INTRODUCTION

The knitting industry has undergone a phenomenal change in the recent years at the global level. The demand for cotton knitwear is on the increase in domestic as well as export market. Nowadays consumer has become more conscious and demands quality fabric without any faults. It is also a fact that defects in fabric whether it is knitted or woven cannot be eliminated fully. But the frequency of these defects can be reduced to a considerable extent if proper attention and necessary actions are taken at the appropriate time. Defects mainly arise due to the four main factors namely:

- Raw Material
- Machinery
- Method
- Men

Therefore, it is very essential to find out the cause of these defects in time and prevent them in future production. This portion deals with reasons, different defects and their remedies during knitting and wet processing.

DEFECTS DURING KNITTING

Raw material:

In knitting process, yarn is a raw material. If we compare two processes of fabric making, weaving and knitting in terms of yarn quality, we see that the yarn for knitting requires some special characteristics over weaving yarn. One of the reasons of this is, because in knitting the yarn consumption rate is very high, it may be about 150m/end/inm. These rates of yarn consumption are approximately ten times greater than in weaving. In knitting machine, yarn is used directly from a cone, without the benefit of prior inspection available during warping, thus placing very high demands on the quality of yarn. The great variety of knit products which are now made, require that the yarn are suited to each particular need.

Most important quality requirements for the knitting yarn are

- Soft twist
- Better evenness
- Free from neps & foreign matters
- Better colour fastness properties (for dyed yarn)
- Better elasticity and elongation
- Low co-efficiency of friction

The main defects which arise by defected yarn on inferior quality yarn are as under:

- | | |
|-------------------------------|-----------------------------|
| F. Thick places | K. Spun in coloured yarn. |
| G. Press-off | L. Holes |
| H. Thin places | M. Mixing of different lots |
| I. Presence of foreign fibres | N. Knots |
| J. Slubs | O. High trash content |

Uneven yarns and yarns with high level of thick places will cause uneven formation of loops and thick places and will appear as a predominant defect on the fabric. If there is a yarn count variation, the stripes type defect will occur in the fabric. This defect increases with increase of count variation.

In general, the defects due to raw material will appear on the fabric horizontally.

The raw material defects will ruin the appearance of the fabric and in some cases it will break the needles.

Effect of yarn count, Evenness and imperfections

These are the most important and major defects that come across during knitting.

A little variation in yarn counts reflects on knitted fabric as dark or light stripes.

Similarly, if the yarn is uneven this will reflect as cloudy or wavy appearance to the fabric.

The imperfections such as slubs, thin places, black seed coats, and white neps are higher than these defects not only affect the appearance of the fabric but, also create problem during knitting by causing damage to the needles.

Effect of twist

As it is already stated that soft twist is must for knitting. High twist yarns will snarl during knitting and this may cause faults in the fabric or even damage the needles. This defect may also increase the curling of the fabric; which in turn, creates problems during laying up and cutting of fabric for the garment making.

Friction

It is well known fact that yarn comes in contact with several guides during feeding it to the knitting elements. When this yarn is converted in to loops, it passes through a number of needles and sinkers. Hence, the maximum tension developed in the yarn mainly depends upon the coefficient of friction of the yarn against metal and it should not exceed 0.17. if it exceeds the tolerance limit breakage of yarn during knitting may increase which results into the reduction of knitting performance and spoil the appearance of the fabric To cope with this problem yarn should be properly lubricated with wax during winding.

Effects of Different cotton mixing on performance of yarn during knitting

It is well known fact that different cotton fibers have different dye absorption characterizes. Therefore, yarn of essentially the same nominal count, spun out from different cotton mixing of yarns supplied by different mills should not be mixed on the knitting machine. The defect is not to be seen in the grey fabric. Once the fabric is scoured, bleached and dyed, alternate bands of light and dark shades positions appears in the course- wise direction of the fabric.

Effect of Damaged Cone

It has been seen that during transportation, yarn package or cone damaged. It is better to avoid such cone during knitting of good quality fabric; otherwise, it may increase breakage of yarn which ultimately spoils the look of the fabric. Besides these, there are many factors like spoiled yarn, extended knotting length during winding, high trash content in yarn, mixing of foreign material during spinning and knitting which may impart defects in knitting fabrics.

DEFECTS DUE TO WRONG METHODOLOGY

Sometimes, it has been seen that the knitter knowingly avoids adopting a correct methodology due to pressure of buyers. A few of the examples are as follows:

- Selection of wrong Count of yarn for existing knitting machines in the plant which may lead to damage knitting elements and spoil the appearance of resultant fabric.
- Knitting grey yarn adjacent to the knitting machine which was engaged in dyed yarn. Due to this reason, fluffs of dyed yarn may fly and accumulate on white or grey yarn and hence appear as a defect due to foreign material.

To avoid this, a partition in the form of curtain should be used between two machines, which are engaged in white and dyed yarn.

DEFECTS DUE TO MACHINE

Following are the defects, which reflect due to knitting machinery:

Needle Defects

Defects due to needles are as under:

- Broken hook and broken butt- which appear as a ladder in the fabric and are called ladder defect.
- Broken latch- accumulation of loops and finally breaks the hooks and appears as long rib in the fabric.
- Bent latch -appear as a line of drops or holes in the fabric.
- Chipped spoon_– appear as a fizzy line in the fabric. □ bent hook - appears as a line of drops or holes in the fabric □ Tight needle- improper loop formation and missed loop.

Barre Defects

This defect is reflected as horizontal bars. The main cause of this are;

- ✓ Variation in stitch cam setting
- ✓ Unequal setting of knock-over depth on the dial and cylinder at different feeders.
- ✓ Slippage in the fabric take-down rollers
- ✓ Chipped bearing and belt slippage
- ✓ Variation in take down tension

Uneven Fabric Take-down Tension

Variation in fabric take-down tension will cause bow effect in the fabric. Much improvement has been made in this system to avoid such variations and these developments have been incorporated in the latest models of knitting machines.

Gatting of Needles

The gatting of needles is to properly set in the case of rib and interlock machines. Otherwise defects like loop bursting and missing of loops will occur in the fabric.

Timing of Needles and Sinker

In the case of single jersey machines, the timing of sinker with respect to needle is to be set to the desired level for a better knitting performance. Improper setting of sinker timings will create problems such as miss loops, loop bursting etc

Dial Height

The height of the dial should be set to the recommended level to minimize any increase in the take- down tension on the dial needles and thereby keeping the uniformity of the shape of loops. **DEFECTS DUE TO MEN**

Following are the main defects, which are caused by men engaged in knitting process:

- ✚ Handling the yarn packages with soiled hand
- ✚ Mixing of cone yarns of different counts during loading the knitting machine with your packages.
- ✚ Spilling the oil on the fabric during lubricating the machine
- ✚ Improper cleaning of the machine and excess oiling will cause the oil line.
- ✚ Improving setting of the stitch cam which might cause the barre effect
- ✚ Keeping the fabric rolls on the dirty floor
- ✚ Delay in attending the fabric damage due to needle

DEFECTS DUE TO CHEMICAL PROCESSING

Defects can occur in knitting fabric at any stage of wet processing and on many occasions it is not possible to ascertain the exact cause. However if every process is strictly controlled, damage can be reduced to minimum. Following are the some defects which generally occur during processing:

- | | |
|---------------|------------------|
| a. Distortion | f. Elongation |
| b. Creases | g. Patchy dyeing |
| c. Tendering | h. Tailing |

d. Streaky dyeing

i. Deformity

e. Abrasion

j. Enablement

The various aspects of operational and technological consideration which would provide sufficient insight into understanding of the problems and also in finding solutions as follows:

loading of the Dyeing machine

Following are some precautions to be taken while loading:

- For a given winch, there are instructions to load only a certain length depending on the weight per linear meter of the fabric. Do not exceed the length/ rope strand.
- The fabric needs to be guided in a bunch and not twisted while loading.
- The liquor level at the trough should be sufficient to cover the strands of the rope
- Also, for a given width and volume of the winch, the number of strands is also determined. Do not exceed these in order to increase production.
- Check if the winch is running loose of the fabric (slippage). If so, provide some lapping which would improve frictional forces to avoid the slippage.

If care is not taken during loading, it would cause:

- Abrasion □ Crease mark
- Uneven dyeing □ Rope mark
- Fabric entanglement (which causes dark and light effect on fabric).

Addition of chemical and colour

- Additions are to be made when the machine is in operation and the, fabric is in motion.
- Addition should be made only in the, separate compartment.
- Addition should be administered in the predetermined sequence and role.
- No addition should be in a solid form
- Temperature rise should be pre-selected and controlled for the rate and duration.
- The rinsing, fixing, soaping process should all be standardized followed up.

Selection of Colours

In case of reactive dyestuff, the selection of the colour would take into account the exhaustion, reactivity, and substantively characteristics_of the dyestuff. A reactive colour could be highly exhaustive but if its reactivity is medium or low, it would mean that you will be able to exhaust most of colour from, the bath to the substrate i.e. fabric but, due to lower reactivity, the amount of the dye that has actually reacted with the cellulose would be lower and therefore much of

the unfixed (unreacted) colour Will wash off while soaping. In another words, the wash fastness shall be poor and the colour shall run every- time your wash the fabric. If, on the other hand, one has a highly reacting colour with low exhaustion, this would result in the colour reacting with the fabric even while in the process of adsorption and, at more favorable sites like the amorphous region, the colour will strike and cause patchy dyeing. Due to high reactivity, it is also possible for the colour to react with water and thus cause yet another dimension to the wash fastness problem. A colour with a high substantively can, cause problem to the migration and the levelling characteristics, resulting in tailing, unevenness, etc. Therefore, the reactive colour should have a reactivity curve which is close to the exhaust curve, so that any washing-off of the un-reacted colour is facilitated within minimum energy and effort. The present dyestuff manufacturers shade cards do give certain information on this area and they should be made use of.

WEFT-KNIT FABRIC DEFECTS

Though the raw material is properly chosen and the machines are set and maintained properly, defects are likely to occur in the resulting fabric which should be corrected or prevented from occurring. Some of the most common defects are (a) vertical lines, (b) horizontal lines, (c) holes and cuttings, (d) drop-stitches, (e) distorted stitches (f) press-off etc.

Fabrics defects on latch needle sinker top jersey machine and their probable causes:

A. Vertical lines :

- i. bent needles,
- ii. worn needles,
- iii. wrong needle, i.e. needle size not appropriate with the cut of the machine,
- iv. dirt in trick slots,
- v. defective or worn-out trick walls,
- vi. bent hooks,
- vii. chipped latches, butts or broken spoons,
- viii. stiff sinkers or stiff needles ix. sinkers ride high because of dirt
- x. Needles too loose or too tight in trick slots etc.

- B. **Horizontal lines:** (i) Uneven yarn, (ii) uneven yarn tension, (iii) Uneven stitch length, (iv)uneven take-down tension, (v) mixed yams, (vi) loose stitch cams, (vii) uneven twist in yarn, (viii) poor winding from cones, etc.
- C. **Holes and cuttings:** (i) weak yarn, (ii) yarns with bad knots and slubs, (iii) lint in yarn guide or eye-pots, (iv) stitch drawn too tight, (v) stiff latch, (vi) unsuitable yam number, (vii) machine running too fast, (viii) rough sinkers, (ix) carriers set wrong (x) take-down mechanism too tight (xi) misaligned cones, (xii) needles too tight in their slots, etc.
- D. **Drop-stitches:** (i) slack yam tension, (ii) Stiff latches, (iii) take-down mechanism too loose, (iv) needle timing set wrong, (v) needle slots clogged with dirt, (vi) machine running too fast, (vii) positive feed slippage, (viii) wrong stitd1 setting etc.
- E. **Distorted stitches:** (i) bad or bent needles, (ii) incorrect positive feed setting, (ii).uneven yam tension, (iv) bent trick walls, (v) needle timing wrong, (vi) improper stitch cam settings, etc.
- F. **Press-off:** When an end of yarn breaks out the needle will knock over its previous loop without forming a new stitch. This is called an 'end out' .If this end out occurs in succession on a number of needles, it is called a 'drop out' or a 'press off'. The main causes of press off are (i) faulty stop motion, (ii) plugged yarn guide with lint. (iii) bad Yarn, (iv) machine running fast, (v) bad knots and slubs etc

Fabric defects on Rib, interlock and Double-knit machine

- A. **Vertical lines:** (i) Dirty needles and slots,(ii) faulty needles, (iii) gaiting off centre for dial and cylinder (iv) cylinder and dial height not properly set, and all other causes which are listed in the case of single jersey fabrics.
- B. **Horizontal lines:** All causes mentioned earlier for single jersey fabrics, and dial not horizontal, dial or cylinder becoming oval-shaped, stitch cam settings for dial and cylinder, not equal and timing out of sequence.
- C. **Holes and cuttings:** All causes mentioned earlier for single jersey fabrics, and thread guides not allowing dial latches to open, thread guides too near needles, positive feed system operating improperly, excessive tension, dial height too low or high, yarn threaded wrongly, gaiting not correct etc.
- D. **Drop-stitches:** Besides the causes mentioned for this defect in single jersey, the following are the additional causes: (i) dial latch closing under yarn carrier (ii) dial

height too high, (iii) fabric too loose, (iv) positive feed slippage, (v) yarn in wrong hole of carrier, etc.

- E. **Unwanted tuck stitches:** (i) dial stitch-cams not pulled in far enough, (ii) yarn too coarse, (iii) yarn too dry, (iv) take-up roller slipping, (v) needle latches, (vi) stiff latches, (vii) loose rivets (viii) opened-out hooks, (ix) worn hooks; (x) height set too low, (xi) defective needles, (xii) needles move too freely in their slots etc.
- F. **Loading up :** (i) faulty take-down mechanism (ii) incorrect selection of pattern; i.e., incorrect of needles knitting dial to cylinder, (iii) yarn too heavy for the cut of the machine, (iv) excessive tucking or too much blister pattern in the fabric (v) failure of needles to clear, etc.
- G. **Bursting:** (i) quality becoming too tight, particularly because of blister feeds, (ii) stiff needle latches, (iii) uneven tension, (iv) insufficient take-down, (v) feeder too far from the cylinder needles, (vi) thread guide not covering dial latches and (vii) over feeding by the positive feed mechanism.

Electronics are finding application in defect detection devices also. For example, circular knitting machines can be fitted with a photo-electric quality control apparatus which checks the fabric, coming off the machine for drop-stitches, holes etc. The device illuminates the tubular knit goods from within, the rays penetrating the fabric being registered by a photo-electric cell in a fixed head scanner. Fluctuations in light pattern caused by defects are transformed into electric impulses which are amplified by a transistor circuit, to activate a stop-motion.

COMMON FAULTS OF WARP KNITTED FABRICS

- A. **Dropped stitches:** The most common defect in Raschel fabrics is dropped stitches either all over or along the same wale. There are a number of causes for the same and some are listed here: (i) excessive warp sheet tension; (ii) guides too high or too low; (iii) shag too early; (iv) faulty chain links; (v) faulty latch guide wire mounting; (vi) insufficient needle to guide clearance; (vii) guide bars not horizontal; (viii) guide bars not parallel to the trick plate; (ix) insufficient take-up pull; (x) too shallow knock over; (xi) worn push rod slides; (xii) guide bar springs too weak or too strong; (xiii) bent guides or needles; (xiv) excessive twist in yarn; (xv) loose ends; (xvi) slubs and knots

in the yarn; (xvii) unequal take-up; (xviii) poor warping process; (xix) faulty laying-in; (xx) mis-knitting; (xxi) mistakes in pattern drawing etc.

- B. **Yarn breakages:** (i) Yarn tension too high; (ii) swing of the guide bars too small; (iii) shag too early or too Late, giving impact loading; (iv) wrong chain link assembly; (v) guide bar return spring too weak; (vi) sinkers in wrong position and come in touch with the beard needles and (vii) crossed yarn while rethreading.
- C. **Yarn loading:** (i) Insufficient take-up pull; (ii) tight quality fabrics; (iii) too shallow knock over; (iv) needles not rising high enough; (v) excessive warp tension and (vi) broken or bent latch.
- D. **Cutting and whiskering:** (whiskering means fraying of the individual filaments after breaking.) (i) Excessive wear tension; (ii) faulty guide bar gaiting (iii) guide bar not horizontal; (iv) defect in pattern drive mechanism such as wrong links, worn slides, weak guide bar springs etc., (v) excessive speed; (vi) worn guide holes; (vii) bent needles and guides; (viii) worn sley holes and (ix) damaged trick plate.
- E. **Horizontal streaks:** (i) Periodical fluctuations in tension of rotating of beams, which may be due to unbalanced beams, or bent beam spindles and (ii) faulty let- off motion.
- F. **Vertical streaks:** (i) Tight and slack winding on beams; (ii) tension on the sheet of warp, not being uniform because of "valleys and ridges" on the surface of wound beam.

Exercise part two

1. What is Warp Knitted Fabric?
2. **Distinguish between the warp and weft knitting**
3. How is warp knitted fabric produced?
4. What is Tricot Knit Fabric?
5. classify warp knitting machines.
6. What is Raschel Knit Fabric?
7. Distinguish Tricot and Rachel warp knitting machines.
8. List down various applications of warp knitted structures
9. Define the terms overlap and underlap in warp knitting.
10. List the important yarn properties required for warp knitting.
11. State the function of pattern drum on warp knitting machine. Draw diagrams of all types of chain links used on Tricot machine

12. Discuss the five basic overlap/underlap variations with diagrams.

13. Suggest lapping diagram for following chain notations of warp knitted fabric, i. 1-0/1-2// ii.1-2/1-0//

Chose

1. In a tricot warp knit machine suggest the motions of the different parts

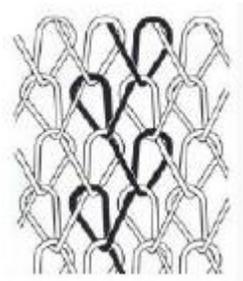
Guide	Nearly vertical line
Sinker	Nearly horizontal line
Needle	Nearly circular arc

- a. A-3, B-2, C-1
- b. A-3, B-1, C-2
- c. A-2, B-3, C-1
- d. A-2, 8-1, C-3

2. Sinkers help in

- a. Only casting off the old loop on Raschel machine
- b. Casting off the old loop and holding down the new loop on Raschel machine
- c. Casting off the old loop and holding down the new loop on tricot machine
- d. Only holding down the new loop on tricot machine

3. To make the warp knitting shown



- a. Each needles are interact with one guide bare
- b. Each needles are interact with two guide bare
- c. Each needles are interact with three guide bare
- d. Each needles are interact with four guide bare

4. Suggest the correct statement the movement of guide bar on the tricot machine

- a. Overlap is a swinging motion form back to front of the needle
- b. Overlap is a swinging motion form front to back of the needle
- c. Overlap is a shogging motion in the front of the needle
- d. Overlap is a shogging motion in the back of the needle

Reference

1. Circular Knitting, C. Iyer, B. Mammel and W. Sehach, Meisenbach Bamberg
2. Flat Knitting, Samuel Raz, Meisenbach GmbH, Bamberg
3. Handbook of Technical Textiles, A. R. Horrocks & S. C. Anand, Woodhead Publishing Limited, Cambridge in association with The Textile Institute, Abington
4. Knitted Fabric Production, Prof. P. K. Banerjee, Department of Textile Technology, I. I. T., Delhi
5. Knitting – Reference Books of Textile Technologies (e-book), Carmine M. & Paola Z., Fondazione, ACIMIT, Milano, Italy
6. Knitting : Fundamentals, Machines, Structures and Developments, N. Anbumani, New Age International Publisher, New Delhi
7. Knitting Technology, David J. Spenser, Woodhead Publishing Limited, Cambridge, Pergamon Press
8. Knitting Technology, Prof. D. B. Ajgaonkar, Universal Publishing Corporation, Mumbai
9. Warp Knitting Production, Dr. S. Raz, Verlag Melliand Textilberichte GmbH, Heidelberg
10. Warp Knitting Technology, D. F. Palling, Columbine Press (Publishers) Ltd., Buxton, U.K., 1970
11. Wellington Sears Handbook of Industrial Textiles, S. Adanur, Technomic Publishing Co. Inc., Lancaster, Pennsylvania, USA