

HARYANA STATE BOARD OF TECHNICAL EDUCATION**DIPLOMA IN TEXTILE TECHNOLOGY (NSQF LEVEL-4)****KNITTING TECHNOLOGY**

E - Content

Course Title:	Knitting Technology Theory
Semester:	3rd
Department:	Diploma in Textile Technology (HSBTE Punchkula)
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Prepared as per the latest NSQF Level-4 Curriculum for Textile Engineering & Technology Diplomas.

DETAILED CONTENTS**UNIT I*****Introduction to Knitting Process***

Definitions- Knitting, course, wale, loop, weft knitting, warp knitting, stitch, stitch length, stitch density, single jersey fabric, double jersey fabric, yarn liner density, GSM, Gauges, stitch density, cams, plating, racking, laying-in, long and short butt needles.

Comparison of weaving with Knitted fabric in relation to yarn, feed material, preparatory processes, industry structure, machines, fabric properties, end use, labor, maintenance, cost effectiveness. Comparison of weft and warp knitting.

UNIT II***Weft Knitting Machines***

Introduction and classification, Knitting Elements. Needles and its types. Parts of latch needle, spring bearded needle and compound needle. Their advantages and disadvantages. Knitting cycles of latch needle, spring bearded needle and compound needle.

Basic shapes of wire butt and flat stock latch needle. Sinker- function, shapes, detailed description. Cams and general description of cam. Passage of material through flat bed knitting machine. Passage of material through circular knitting machine.

UNIT III***Weft Knit Fabric Stitches***

Knitted fabric representation – verbal, symbolic, diagrammatic, graphical. Knit, tuck and float stitch – Representation, characteristics and uses. Special Stitch- Laying-in, Plating, Openwork Structures.

UNIT IV***Type of Knitted Fabric***

Plain knitted fabric – knitting cycles, characteristics, ornamentation, derivatives and its end uses. Rib knitted fabric – characteristics, derivatives and its end uses. Interlock knitted fabric – characteristics, ornamentation, derivatives and its end uses. Purl knitted fabric – knitting cycles, characteristics, ornamentation, derivatives and its end uses.

UNIT V***Hosiery***

Hose, half hose, manufacturing process of hose. Modification in heel and toe: Y-heel, gusset

toe, scotch heel.

Calculation

Calculation related to production, weight per linear yard, no. of needles required, width of fabrics.

Quality requirements of knitted yarn. Faults in knitted fabrics.

PRACTICAL EXERCISES

1. To study Yarn parameters for hosiery yarn.
2. To study Parts and knitting cycle of latch needle.
3. To introduce terms for single and double hook latch needle according to ISO. Classification of cross section of hook, hook position, hook shapes, latch shapes, latch fit and butt shapes.
4. To study Sinker shape, functions, and have detailed description of its part.
5. To construct Sinker for plain, plush and fleece.
6. To study Cams (needle sinker control unit) and its type (sliding cam, flexible cam, changeable cam).
7. To study rib setting of cylinder and dial with synchronous and delayed timing.
8. Passage of material through flat bed knitting machine with specific stress on cam system (single and double), direct and indirect yarns feed.

9. To draw cardigan stitches, racked and ribbed structure in flat bed knitting machine.
10. To study mechanically and electronically controlled flat bed jacquard knitting.
11. To study knitting cycle of flat bed purl knitting machine.
12. Passage of material through circular knitting machine.
13. To construct and develop a plain knitted fabric.
14. To study cam arrangement and construct a rib knitted fabric or interlock knitted fabric.
15. To study basic element and camming arrangement of garment length machine.
16. To discuss the production and development of heel and toe.
17. To discuss the production of hosiery.
18. To discuss different types of heel and toes.
19. To prepare special designs like horizontal stripping, intarsia and individual stitch selection.

RECOMMENDED BOOKS

1. D. B. A. Ganokar, "Knitting Technologies" by Universal Publishing Corp, Bombay.
2. Mark and Spancer, "Knitting Technology" by Woodhead Publishing Limited.
3. J. E. Booth, "Textile Mathematics Vol-III" by Textile Institute Manchester.
4. David J. Spencer, "Knitting Technology" by Woodhead Publishing Ltd., Pergamon Press
5. Iyer/Mammel/Schach, "Circular Knitting" by Meisenbach Bamberg.
6. Iyer/Mammel/Schach, "Technical dictionary for knitwear and Hosiery production" by Meisenbach Bamberg.
7. Knitted Fabric by AICTE.
8. Sunil K. Puri, "A Guide to fully fashioned sweater Manufacturing" by Woodhead Publishing India in Textiles.

SUGGESTED WEBSITES

1. <https://www.youtube.com/channel/UCnPu8vcBvMdV5wtPTxC4uLA>
2. <https://textilelearner.net/what-is-textile-basic-textiles/>
3. <https://textilestudycenter.com/>
4. <http://swayam.gov.in>

UNIT I:INTRODUCTION TO KNITTING PROCESS

Knitting is as popular method of fabric construction, as weaving. The popularity had grown since last three decades, and in recent years knitting has overtaken over weaving. The major reasons are:

1. Now all type of yarn including manmade can be used for knitting a garment.
2. There has been more versatility in production of different fabrics. Now almost all type of suiting, shirting, or furnishing fabrics can be made from knitting.
3. The characteristics of easy to wash-n-wear, wrinkle free, stretchable fabric, make it best for casual wear, inner wear, ladies wear and sportswear.
4. Also the loops generated help in more warm wear and absorbency purpose.

1.1 Definitions

In case of weaving we have warp and weft thread. But in case knitting we call them course or wale. Knitting is done by formation of loop or stitch. *Loop* or *stitch* is the basic or fundamental unit of a knitted fabric. It is formed by bending of yarn. *Knitting* is defined as intermeshing of loops. A row of loops intermeshed along the fabric width or in horizontal direction is called as a *Course* (not weft). A row of loop along the fabric length or in vertical direction is called as a *Wale* (not warp). Knitting is done by two ways, course wise as well as wale wise. If knitting is done along the width or the fabric, or course wise then it is *Weft knitting*. If knitting is done along length of the fabric, or wale wise then it is called as *Warp knitting*. Now a day weft knitted was done till last few years. Now warp knitting has also taken up. The properties of warp knitted fabric lies between a weft knitted and a woven fabric structure.

Warp knitting

A method of making a fabric by normal knitting means, in which the loops made from each warp are formed substantially along the length of fabric.

Weft knitting

A method of making a fabric by normal knitting means, in which the loops made from each weft are formed substantially along the width of fabric.

Single jersey fabric

A weft knitted fabric made on one set of needles.

Double jersey fabric

A weft knitted fabric made on two sets of needles, usually based on rib or interlock gaiting, in manner that reduces the natural extensibility of the knitted structure. These fabrics can be non-jacquard or jacquard.

Course

It is a row of loops across the width of the fabric. Courses determine the length of the fabric, and are measured as courses per centimeter.

Wale

It is a column of loops along the length of the fabric. Wales determine the width of the fabric, and are measured as wale per centimeter.

Stitch density

It is the number of stitches per unit area of a knitted fabric (loops/cm²). It determines the area of the fabric.

Stitch length

It is the length of yarn in a knitted loop. It is the dominating factor for all knitted structures. In weft knitting, it is usually determined as the average length of yarn per needle, while in warp knitting, it is normally determined as the average length of yarn per course.

Yarn linear density

It indicates the thickness of the yarn and is normally determined in tex, which is defined as the mass in grams of 1 lm of the material. The higher the tex number, the thicker is the yarn and vice versa.

Overlap

Lateral movement of the guide bars on the beard of hook side of the needle. This movement is normally restricted to one needle space. In the fabric a loop or stitch is also termed as overlap.

Underlap

Lateral movement of the guide bars on the side of needle remote from the hook or beard. This movement is limited only by the mechanical considerations. In the fabric, it is the connection between stitches in consecutive courses in a warp-knitted fabric.

Tightness factor

A number that indicates the extent to which the area of a knitted fabric is covered by the yarn. It is also an indication of the relative looseness or tightness of the knitting.

$(K = \text{TEX}^{1/2.1} - 1)$

Area density

A measure of the weight of the fabric (g.m⁻²)

Cams

Knitting cams are the simplest design element on any knitting machine. Depending on the machine design these are fixed, adjustable or exchangeable. Different designs can be produced by combination of knit, tuck and miss cams.

Long and short butt needles

The principle of butt length is that the element with the longest butt is always contacted first as a cam is brought into operation and the shortest butt is only affected when the cam is fully in action. This method employs different butt lengths and cam thickness.

Different butt height (Multi Cam tracks)

These are used to obtain a large number of small designs. Each needle has a top butt at a common height and each needle also retains one of four available butts which will travel in its track. The needle will be lifted by the lower butt to tuck or clear by the individual cam acting upon it each feeder.

Plating

The plating yarn carrier/ feeder is designed to take advantage of the fact that two yarns which are feed simultaneously into the hook of the needle tend to appear on different sides of the loop surface according to their initial placing in the needle. When placed into the hook, the yarn which is placed higher appears in the rear of the combined loop structure. The yarn placed lower dominates at the face side of the combined loop.

Two different yarns (of different properties) are supplied separately to influence their relation position on surface, but knitted together. Normally used to produce fancy color effects, modify the wearable properties, lace work etc. the yarn positioned towards the needle hook with is visible on back surface of fabric.

Racking

Flat knitting machines are capable of producing a unique range of racked structures based on the facility of racking one needle bed by one or more tricks with respect to other in either direction as and when required. The structure created by this principle is called as then racked stitch.

Tracking elements

With this facility a knitting machine can select needles to transfer this loops to needles in the opposite bed, thus providing increased design possibilities for purl effects, cable and other cross over stitches, selvedge edge shaping, a hole or lace design, etc.

Drop stitch

A stitch dropped accidentally causes a fault in the fabric in the form of a ladder, but a controlled procedure in which loops are dropped is used to increase the size of certain selected loops and so to pattern the fabric.

Pattern wheel

It is simple device which occupies a minimum space and easy to operate. The technique makes use of one pattern wheel at each feeder. Metal bit is placed in the wheel trick which lifts the needle to knit/tuck heights. Two types of bits can be used for knit and tuck selections. Where the trick is left blank the needles are left down. Each pattern wheel makes one row of design and the depth of the pattern is equal to the number of pattern wheels in the machine.

Pattern drum

Each drum has a matrix of holes, in each of these holes a pin (peg) can be inserted. In this case a pattern jack, lying behind is deflected and presses its adjoining selector into the cylinder. The

needle arranged above the selector would then make no stitches. The absence of a pin means that the jack is not deflected, it is now possible for the selector to run with its lower butt and guide the needle above it into knitting position.

Pattern comb

This system provides knit, tuck and miss selections by using a pattern comb at each feeder. Half tooth produces tuck whereas full tooth makes float on the fabric. Fully removed tooth guides the selector to move the needle to knit height. Maximum number of wales and courses in the design will be equal to the number of tooth in the comb and total numbers of feeders in the machine.

Laying-in

A yarn is laid inside the knitted structure but never formed into a knitted loop. It can modify the properties such as stability, elastic, stretch and recovery, weight, surface appearance, handle, surface properties. Normally the yarn due to certain properties like thickness according to gauge, weak in strength, in elastic in characteristics cannot be knitted normal fashion and is thus put in.

Open work structures

Laces, inner and outerwear of ladies garments. Plush and pile constructions for swimmers, bathing clothes, Housecoats

1.2 Comparison of Knitted fabric with Woven fabric

1.1.1 Similarities of Knitted fabric and Woven Fabric:

1. Both are fabric forming methods.
2. Fabrics formed from both can be used for wearing purpose, and furnishing.

1.1.2 Differences of Knitted fabric and Woven Fabric:

Sr. No.	Knitted fabric	Woven fabric
1	Weft knitted, or knitted fabric can be made from a single yarn.	Woven fabric can be made from two sets of yarn, warp and weft.
2	Knitting is defined as intermeshing of loops.	Weaving is defined as interlacement of warp and weft.
3	A knitted fabric is stretchable. It thus forms shape fitting property. Hence it can be used for innerwear, sportswear, and ladies garments.	Woven fabrics are rigid, and cannot be stretched.
4	Knitted fabrics are less elastic. They recover little less to their original position after they are stretched.	Woven fabrics have higher elasticity. It means when stretched they recover to almost the original position.
5	The structure due to loop formation is such that there are no wrinkle formations in a	Woven fabric, especially the warp is highly twisted, and is harsh in feel.

	knitted fabric. It does not require ironing, and is ready to wear after washing only.	Woven fabrics need to be ironed after washing.
6	A knitted fabric has disadvantage. If a single loop or yarn is broken then the whole fabric starts to open, developing a hole in fabric.	Any breakage in woven fabric can be mended, and it does not spread very easily to whole fabric.
7	Knitted fabrics are difficult to tear. The pressure applied is distributed to the whole fabric.	Woven fabrics can be torn easily like a paper, by holding between two fingers.
8	The yarns used for knitting are less twisted, and thus produce a fabric that is soft in feel.	The yarns used for knitting are more twisted, and thus produce a fabric that is soft in feel.
9	A knitted fabric with same wt./yard is more fuller.	A woven fabric with same wt./yard is more intact than a knitted fabric.
10	Knitted fabric has loops. Air can pass very easily through them.	Woven fabrics are less permeable to air. Air cannot pass through the fabric easily.
11	However the structure also helps to make air packets. This helps in retaining warmth of the body. Hence the knitted fabrics are also used for sweater.	No warmth retaining quality is there in woven fabric due to its structure.
12	Knitted fabric can be made on simple machines without any preparatory process.	Woven fabric can need preparatory processes like winding, warping, sizing.
13	The loop structure of knitted fabric helps in absorbency of water.	Due to more twisted and a tight structure these fabrics are less absorbent.
14	Design on knitting can be changed very easily.	To change design on a weaving machine, or loom, warp beam is to be changed if it is warp wise. If the change is in weft, then design on shedding mechanism (dobby, jacquard) is to be changed. It requires extra effort.
15	Thus this can be started with very less investment and space.	Hence a lot of investment of money and space is required for its set up.

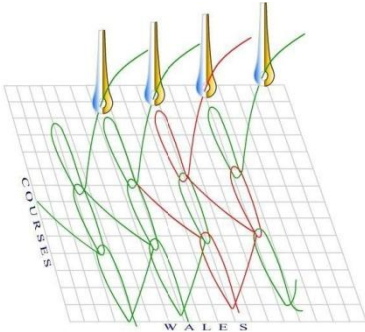
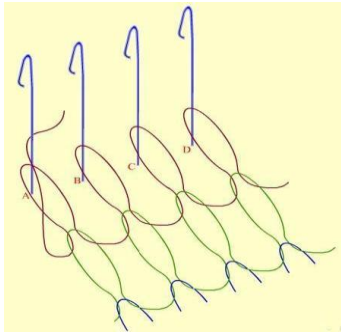
In brief knitted fabric is extensible (shape fitting property), wrinkle free, wash and wear, softer, fuller, thicker, less bending length, casual wear, less elastic. It has disadvantages like laddering, bagging, or deformation, difficult in cutting and tailoring

1.3 Comparison of warp and weft knitting

1.3.1 Similarities of weft knitted fabric and warp knitted Fabric:

1. Both are used for wearing purpose.
2. Both can be wash and wear. It means no ironing is required.

1.2.2 Differences of Knitted fabric and Woven Fabric:

Sr. No.	Warp Knitting	Weft Knitting
1	Single yarn can make the whole fabric.	The number of yarns required is equal to the number of needles.
2	The fed material is cone or cheese.	The fed material is by beam.
3	The fabric is constructed weft wise, or course wise.	The fabric is constructed warp wise, or wale wise.
4	Needles knit sequentially, that is needles knit one after the other.	Needles knit concurrently, that is all needles knit together.
5	The production is less than warp knit.	The production is very high than weft knitting.
6	Loop structure: 	Loop structure: 
7	The fabric prepared may be low quality than warp knitted.	The fabric prepared of very even quality.
8	Production speed decreases with increase in the design.	Production speed do not decreases much with designing.
9	No preparatory process is required. So the	Preparatory process is required. So the

	extra investment of machine, space, man power is not there.	extra investment of machine, space, man power is not there.
10	Machines are low cost	Machines are high cost.
11	A less skilled labour can operate.	A skilled labour is required to operate.
12	Due to these reasons the fabric produced is less in cost.	Due to these reasons the fabric cost is high.
13	The fabric is more stretchable width wise and length wise than warp knit.	The fabric is less stretchable width wise and length wise than weft knit fabric.
14	Difficulty in cutting and tailoring.	Easy in cutting and tailoring.

Links for the above in videos are:

UNIT II WeftKnitting Machines

There are two types of knitting, weft and warp knitting. Weft Knitting machines are classified as per the bed shape in which needles are fitted. There are basically two types of knitting machines, *flat bed knitting machine* and *circular bed knitting machine*. The numbers of beds are either one or two. A single bed is required to knit the simple plain knitted structure. Only *plain knitted fabric* is made on single bed knitting machine, and thus form only one layer of loops. It is thus called as *single jerseyknitted fabric*. The bed is named as *single flat bed* in flat bed. In circular knitting machine this single bed is named as *cylinder*.

Other knitted structures are in two layers. Thus two beds are required for knitting other knitted fabrics or structures, i.e. rib, purl, or interlock. In all other fabrics (rib, purl, and interlock), the loops used for fabric formation are constructed on two beds, that is in two layers, and are thus referred as *double jersey knitted fabrics*. In flat bed knitting machines, these are called as V-shaped flat bed. L-shaped flat bed (for rib and interlock). For making a purl fabric, the two beds in flat bed are at 180°. The two beds in circular knitting machine is named as *cylinder* and *dial*. Both beds are at right angle to each other in all type of machines.

Warp knitting machines are of two types, *tricot* and *raschel*.

2.1Elements or Parts of knitting machines

Knitting elements are the main part of the machine. For the weft knitting machine the knitting elements essentially consists of

- i. Needles
- ii. Sinkers (for the single jersey machine only)
- iii. Cylinder
- iv. Dial (for double jersey machine)
- v. Cams

A knitted fabric is made by *needle* movement. The needles move up and down vertically. While going up they clear the old loop to make the fabric, and then while coming back they hold the new yarn from the yarn feeder, to make next loop. The movement of the needles is vertical but this movement is generated by the *cam*. The cams moves in horizontal direction, and has specific space cut between them. The needles have a hook at the top for formation of loop, and had a protruding surface at the bottom, called as the butt portion. This protruding portion, or the butt passes through the gap of the cam. This cut makes the butt move up and down, and also the needle. The yarn is fed from the *creel*. In case of weft knitting the *feed package* is cone or cheese. In warp knitting it is a beam. The yarn is then passed through *guide*, and then through *tensioner*. The material or yarn is fed to the needles by *yarn feeder*. The needles are fitted into the *bed* of the machine. Bed may be *flat* or *circular*. In case of circular knitting machine if set of needles is single, then the bed is called as *cylinder*, and the second bed is called as *dial*. The needles move up and down to form a stitch. This movement to the needles is provided by the *cam*. The fabric made is then held by weight or take down mechanism.

2.1.1 Sinker

One of the most important element after needles. It is a thin metal strip adjusted between each needle to hold down the stitch and adjust stitch length also (the web portion). The belly is

used to hold the fabric that is knitted. The butt portion provide the to& fro horizontal motion with the help of sinker cam.

It performs one or more of the following function:

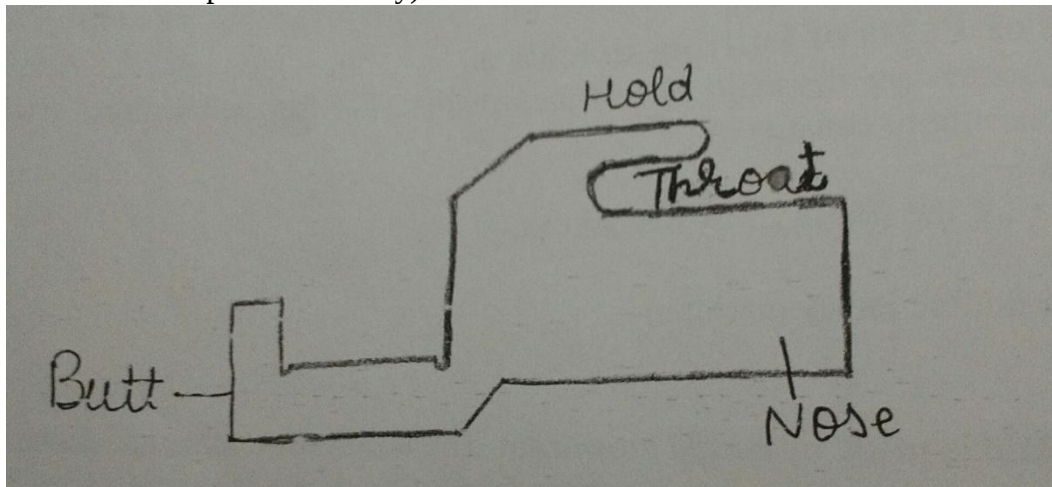
- Loop formation
- Holding down the loop
- Knock over of loop

The sinker has two main functions and these are:

- To hold the fabric loop in a given position whenever the needles rise.
- To provide a surface over which the needles draw the loops.

Other advantages of using sinkers include:

- i. The control exerted by the sinker allows minimum tension on the fabric producing a good quality fabric with even loops.
 - ii. Fine adjustments in quality and those required in the knitting of certain difficult turns and structures are possible.
- Facilitates the setting-up of the machine after a partial or full press-off (after the latches have been opened manually).



2.1.2 Cylinder and Dial

The circular needles bed in which the needles are disposed vertically is called the cylinder. The slots (grooves) cut in the cylinder to receive needles are called “tricks.” The cut (gauge) of circular knitting machine is based on the number of “cuts” (or) slots in the space of one circumferential inch on the periphery of cylinder [outer surface of the cylinder]. Machines are built as low as 4 needles per inch to as high as 28 to 32 needles per inch. The gauge of the cylinder can be approximately decided if the count and the material of the yarn is known. Thus for single cotton yarn

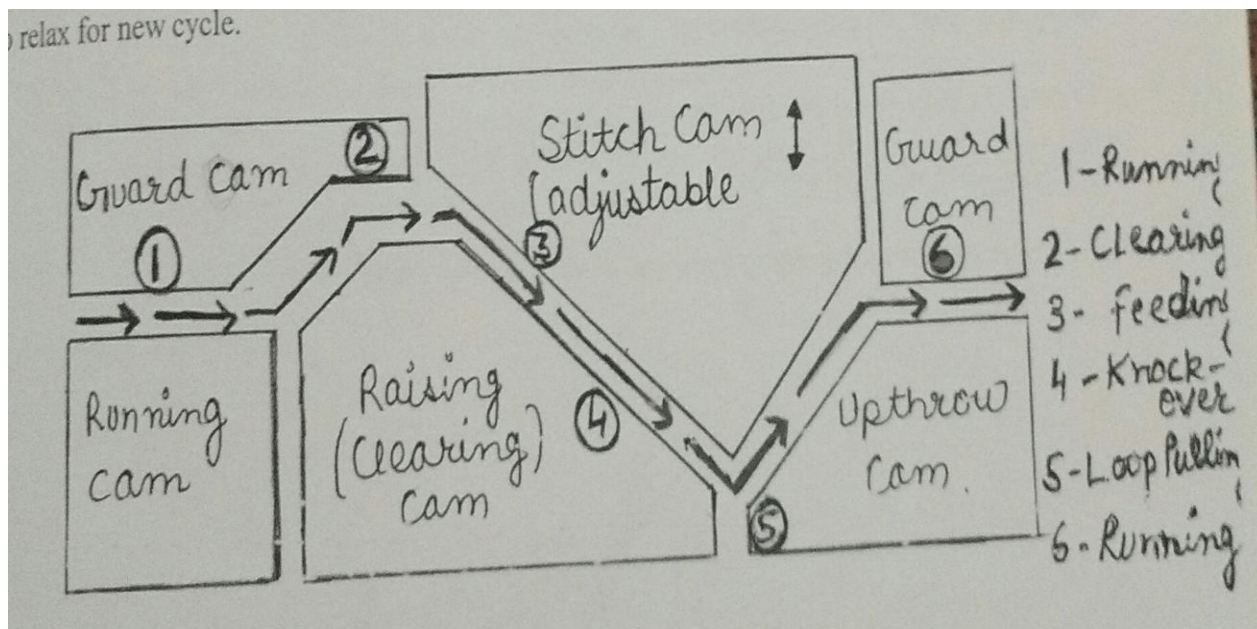
$$\text{Count} = \frac{\text{cut}^2}{6}$$

Cylinder diameters vary according to the type of goods to be manufactured. The diameter varies from about 1cm to about 75 cm. Small diameter machines have less number of feeds than big diameter machines. The speed of the machines is about 20 to 40 rpm for a 60 cm diameter machines.

The dial is another needle bed used only in double jersey knitting machines. The dial is a steel disc in which slots are cut radiating from the centre. Hence it is housing for horizontal needles. The number of slots per unit space conforms to the cylinder gauge in most places.

2.1.3 Needle cam

The cams are made of hardened steel and each needle movement is obtained by (needle) means of cams acting on the needle butts. The tracks in the cams are formed by screwing small steel parts with the cam plate in the desired manner. These steel parts are called as cams. Different types of cams are screwed for giving movement to the needle. The upward movement of the needle is obtained by the rising cams. Cams controlling the downward movement of the needles are called stitch cams. *Stitch cam* controls the length of yarn to be drawn or the loop length. Now, the stitch cams are held in a cast iron removable section screwed to the cylinder cam ring and are adjustable in a vertical direction. *Guard cam* helps to keep the needle butts in their race way (track). *Running cam* or *up throw cam* keep the needle butts at a low level until they meet the next rising cam. It helps the needle to return to rest position to relax for new cycle.



2.2 Needles

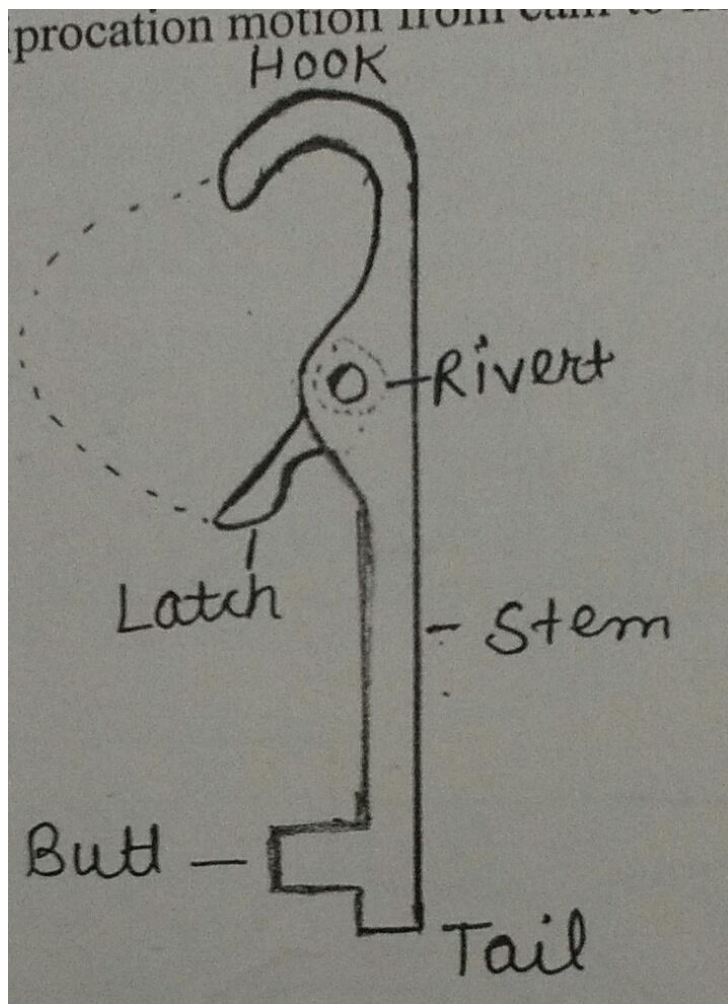
There are three types of needles in common use today in knitting industries.

1. Latch needle
2. Spring bearded needle
3. Compound needle

i. Latch needle

It is mostly widely used in weft knitting. Also called as “self actuating” needle because they require no external element (sinker) to close the hook. The swing of latch solves the purpose. It consists of a hook at the top of the needle, and the space between the hook and the needle stem can be bridged by a latch which swings freely. Latch needles are given individual movement sliding in grooves, and these grooves are normally called ‘tricks’. The stem is a straight portion of the needle with a protruding butt, some distance from the end of the needle. The reciprocating movements to the needles are given through this butt part of the needle.

Main parts of Latch needle



Hook: draw and retain new loop.

Slot: that receives latch blade.

Rivet: used to retain the latch blade.

Latch blade: help in knock-over of old loop.

Latch spoon or cup: helps to cover the gap between the hook tip and stem to knock-over old loop

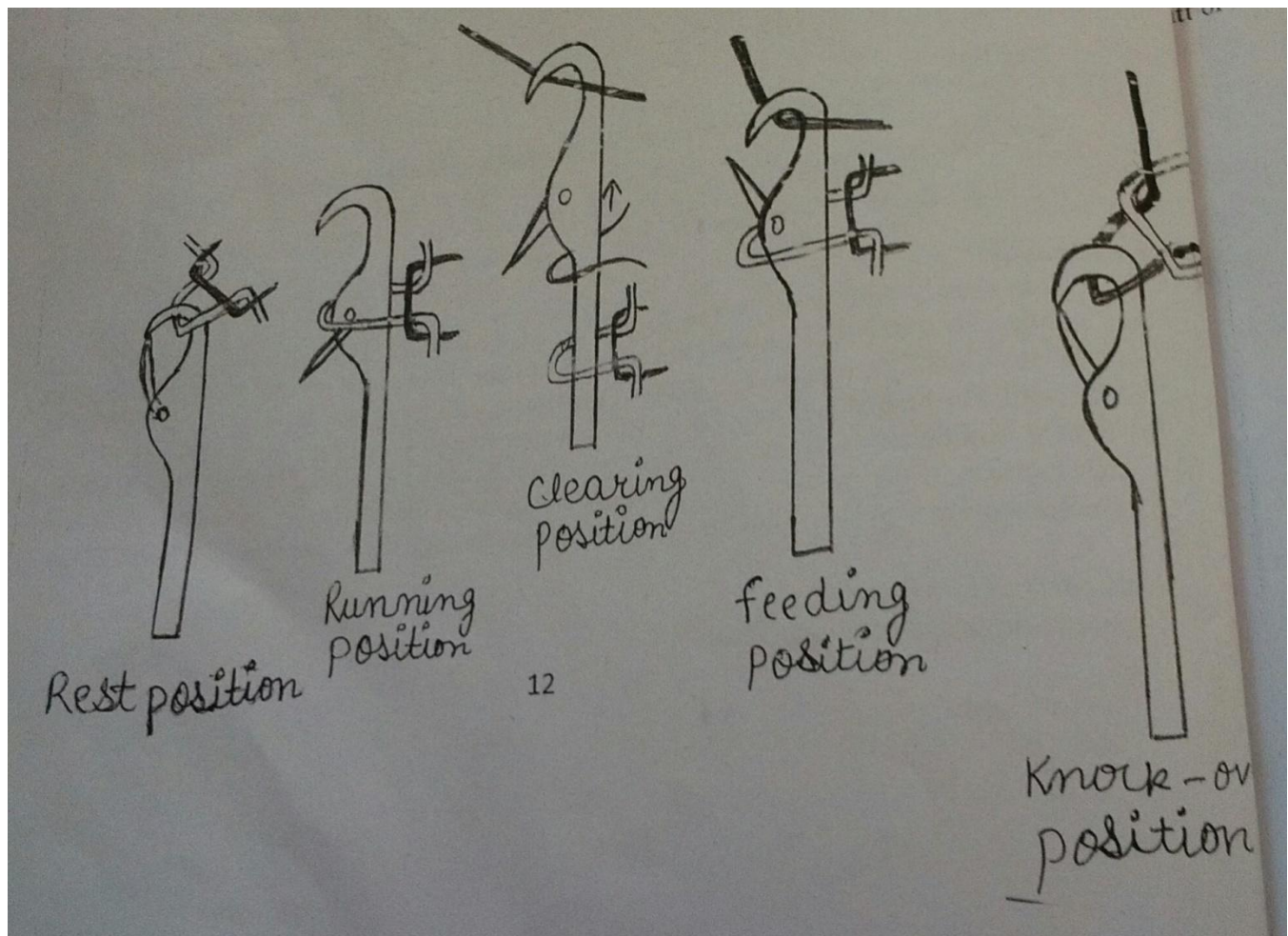
Stem: holds the last loop of fabric during rest or clearing position.

Butt: converts rectilinear motion to reciprocation motion from cam to needle

Tail: extension of the butt

Knitting cycle of Latch Needle

A latch needle knitting cycle can be explained by 5 different positions.



Rest position: Needle hook is in level of top merge of trick. The loop previously formed is in hook and needle is in position to move up.

Running position: The needle gets upward movement with the butt by pressing it against clearing cam. The latch opens. The old loop starts descending on to latch.

Clearing position: The needle is at top most position. The old loop is cleared from latch and is on to stem. The hook is ready to take new yarn.

Feeding position: Needle starts to descend down. New yarn is fed in the hook. Old loop starts to move up on stem.

Knock over position: Latch closes. Needle reaches to the downmost position as per the stitch size. If the stitch length required is high then needle is pulled more down.

ii. Spring bearded needle

Bearded needle was the needle used in first knitting machine known as stocking frame. Needles having a long terminal beard that can be flexed by an action known as pressing. It can be made from single piece of metal in a machine gauge as fine as 60 needles per inch. This is the oldest needle which is simple in construction and cheap in manufacture

The bearded needle, which was invented by the reverend William lee in 1859, consists of hook with the top curved part continued downwards and finished with a point. It is this downward continuation that is called the beard. Opposite the point of the beard is a groove cut into the needle stem. This is called the eye of the needle.

Main parts of spring bearded needle

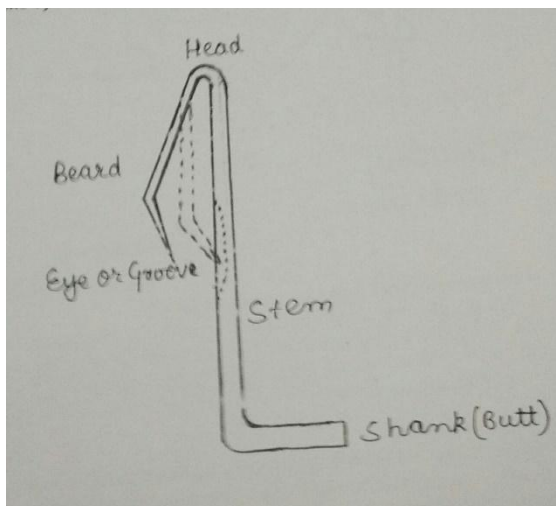
Head:

Beard:

Eye or groove:

Stem:

Butt or shank:



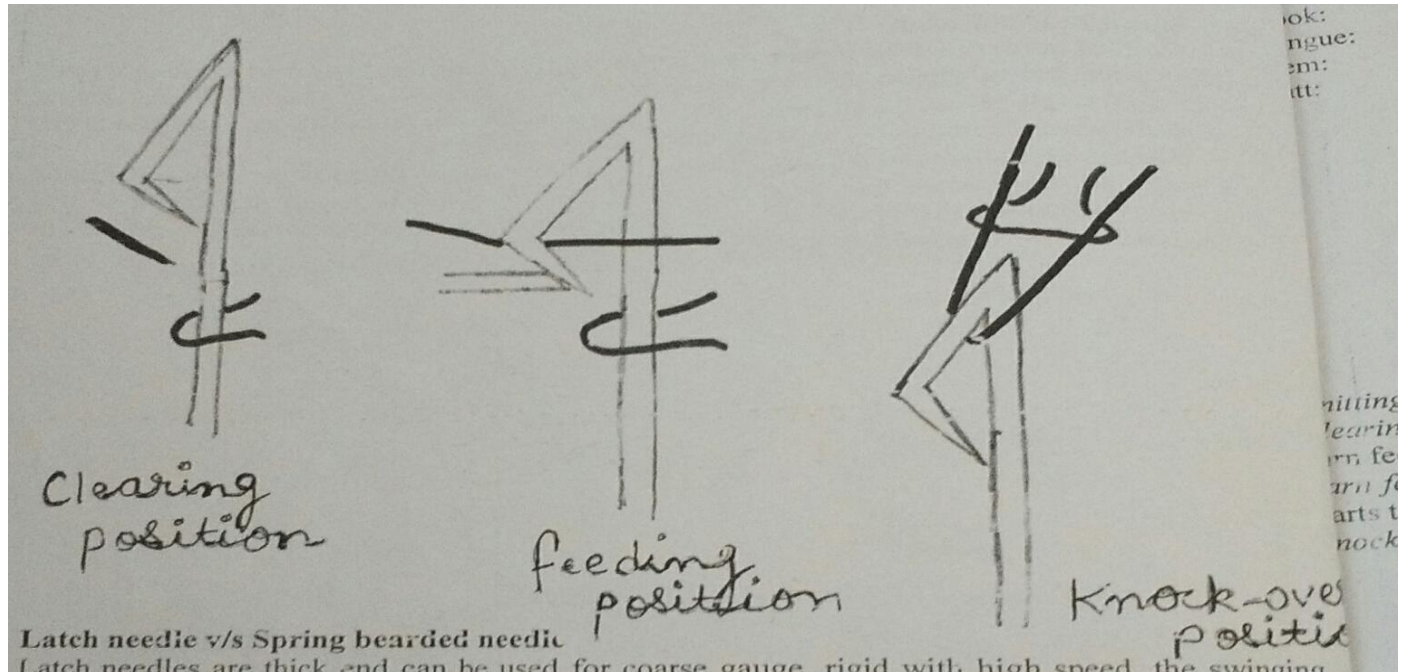
Knitting cycle of Springbearded needles

Clearing position: The old loop is round the stem of the needle and the yarn is fed at A higher point on the needle stem and kinked into a loop. Each wale in the fabric requires a separate needle.

Feeding position: The needle is now moved down until the newly formed loop is under the beard and this time the beard is pressed. A metal bar is used to exert pressure on the needle beard so

that the point is pressed into the eye of the needle. Closed and the old fabric loop moves to the outside of the needle beard. When the fabric loop has been launched in this position the pressure on the beard can be released.

Knock over position: The needle now moves to its lowest position drawing the new loop through the old fabric loop which is now cast-off. The needle now returns to start another course.

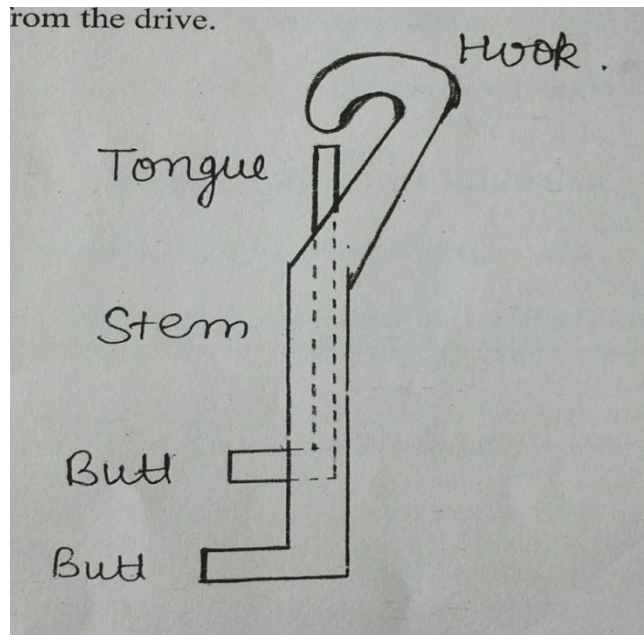


Latch needle v/s Spring bearded needle- Comparison

Latch needles are thick end can be used for coarse gauge, rigid with high speed, the swinging movement of needle becomes difficult. Latch needle takes longer time to knit the loops. Chances of accumulation of fluff or lint are there on latch. But they are self- actuating and do not require external agencies for knocking over of loop. They are expensive to manufacture.

iii. Compound needle

Both bearded and latch needles were found to have limitation in their operating speeds. Speed of bearded needle is restricted because of an external element, presser whereas the swinging action of the latch causes damage to the yarns at very high knitting speed. To overcome these difficulties many attempts were made to develop a compound needle though no type has been found suitable in weft knitting but it is gaining popularity in warp knitting machines. The compound needles which comprises two parts- the hook and tongue. These two parts rise and fall together but as the hook moves at a faster rate, it is open at the top of rise and closed at the bottom of fall. There are two types of compound needle in common use today: (1) tubular pipe and (2) open stem pusher type needles. Tubular pipe needles consists a hollow steel tube in which the tongue member is inserted and the tongue slides inside the tube. In open stem pusher type of compound needle the tongue slides externally along a groove on the edge of the hook member. Compound needles combine the merits of both latch and bearded needles with less strain on the yarn and higher speeds. These needles are expensive to manufacture because each part requires separate and precise control from the drive.

Main parts of compound needles

Hook:

Tongue:

Stem:

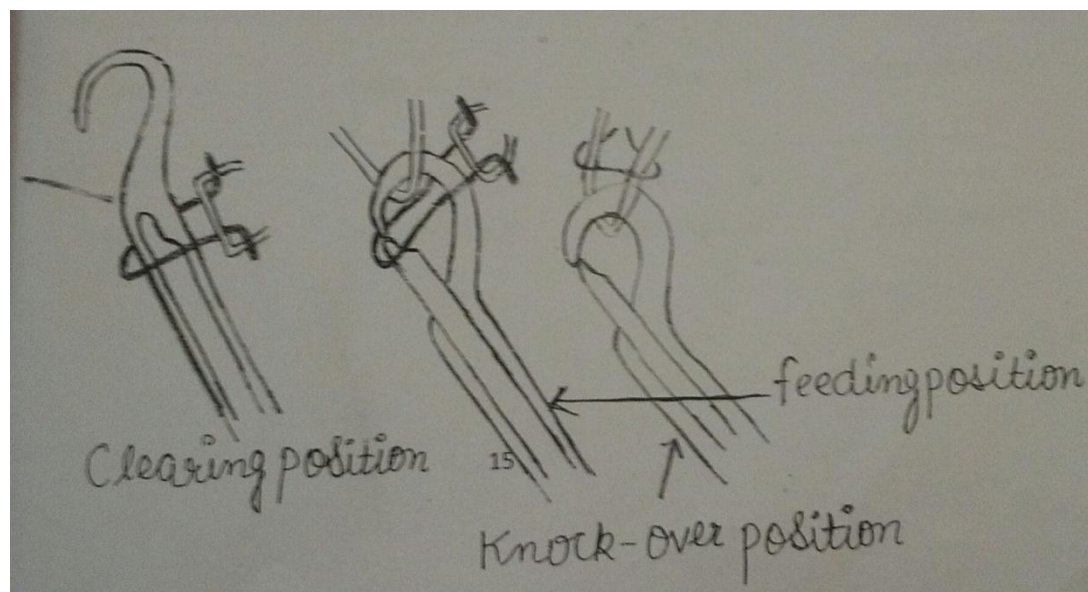
Butt:

Knitting cycle of Compound needle

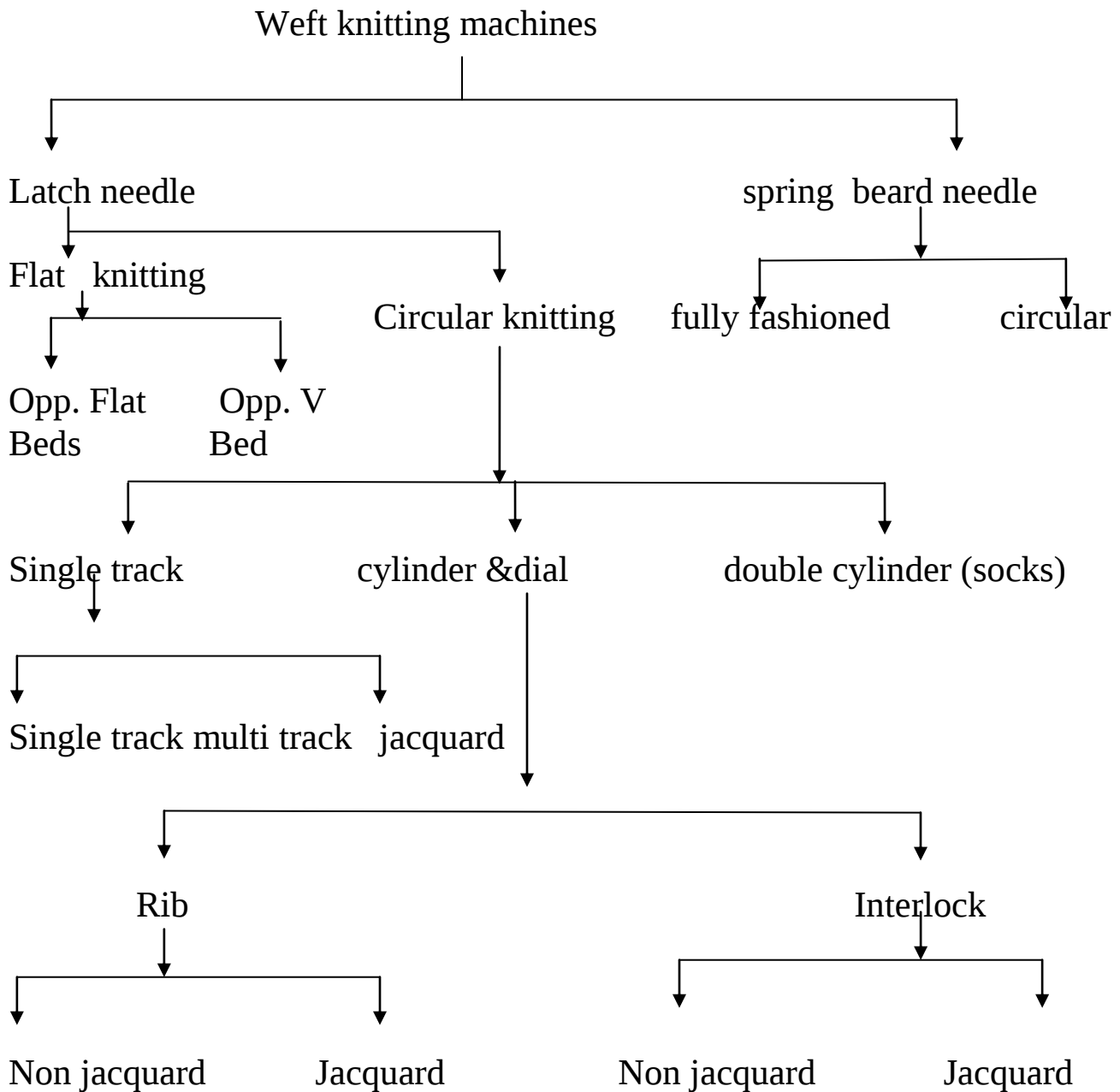
Clearing position: The old yarn is cleared. The tongue is in the stem. The needle starts to descend. The yarn feeder approaches with yarn.

Yarn feeding position: The feeder passes the descending hook, providing it with the yarn. The tongue starts to rise.

Knock-overposition: The new yarn is pulled to maximum.



2.2 Classification of Weft knitting machines as per needles



2.3 Flat bed knitting machine

These machines are commonly used for producing weft knitted fabrics. In the open width form. The basic types of flat knitting machines available are:

1. Rib flat knitting machines (“V” Bed machines)
2. Purl flat knitting machines.

Initially hand operated flat knitting machines were developed and its production were very low hence power driven v-bed flat knitting machines are mostly used in the industries. This machine are used for producing collars, cuffs, sweater, pull, over, mufflers and head caps, from cotton and woolen or acrylic yarns.

2.3.1 Passage of material through V-shape flat bed knitting machine

Yarn path: flat machines are usually equipped with a bobbin stand(2) and support(1) mounted behind the needle bed. The bracket (3) is fitted with the following

A yarn guide ring(4) directly above the package support

A yarn tensioning device(5)

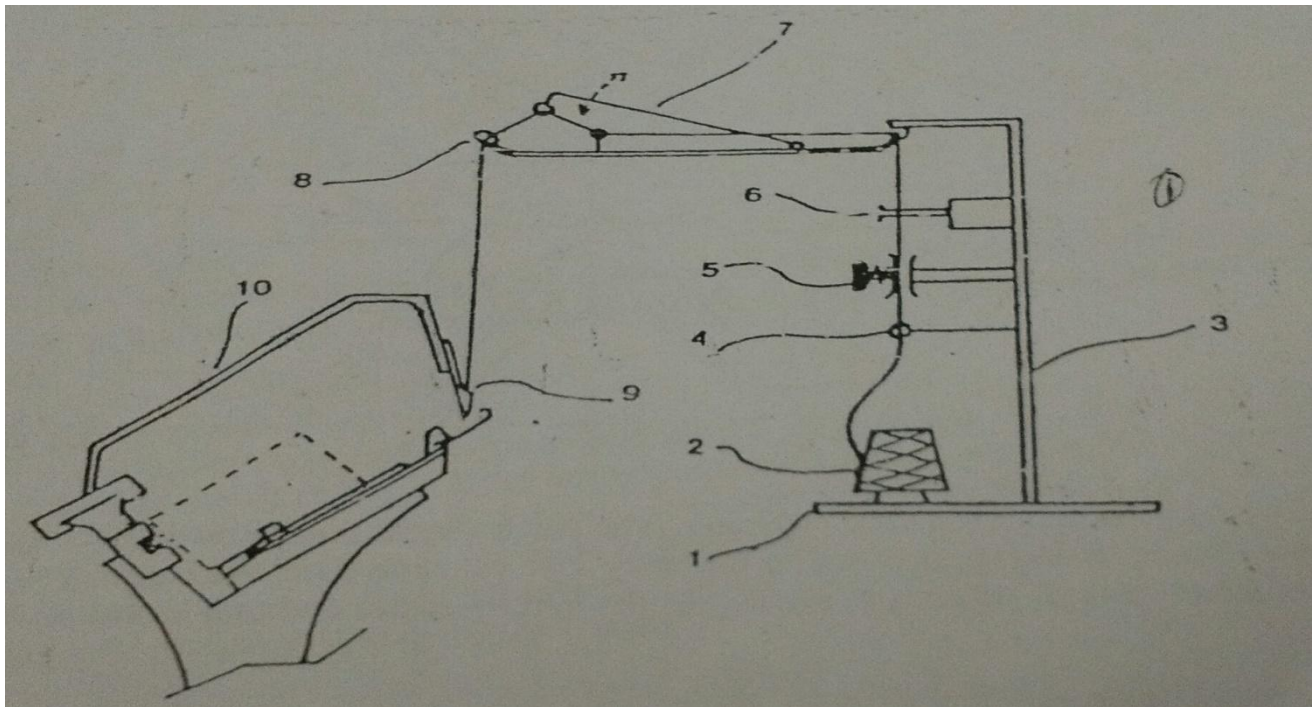
A knot stop motion(6)

A Spring arm tensioner usually coupled with a yarn break stop motion(7) and delivery pot-eye(8)

The yarn is then feed to the yarn guide (9) at the end of the yarn carrier (10).

Before the yarn reaches the yarn carrier as it passes through a cymbal tensioner which may be adjusted to provide the correct knitting tension. A stop motion is used here to stop the machine if there is any big knot or slub in the yarn.

The spring tensioning arm comprises a steel arm fitted with a pot eye through which the yarn passes. This eye is always drawn upwards by the adjustable spring tension on the rod and serves to absorb the excess yarn feed as the carriage reaches the end of its traverse. This is being done in order to maintain the required constant tension on the yarn as the carriage reverses its movement.



Needle arrangement

A rib knitting machine must have two sets of needle which are interposed between each other in “rib gating”. Each set of needle is supported by one needle bed and these are designated the front needle bed and back needle bed respectively. In each bed the needles are placed in parallel tricks found on a flat metal plate. The needle hooks face outwards from the needle bed and the needles can move freely up and down in their tricks.

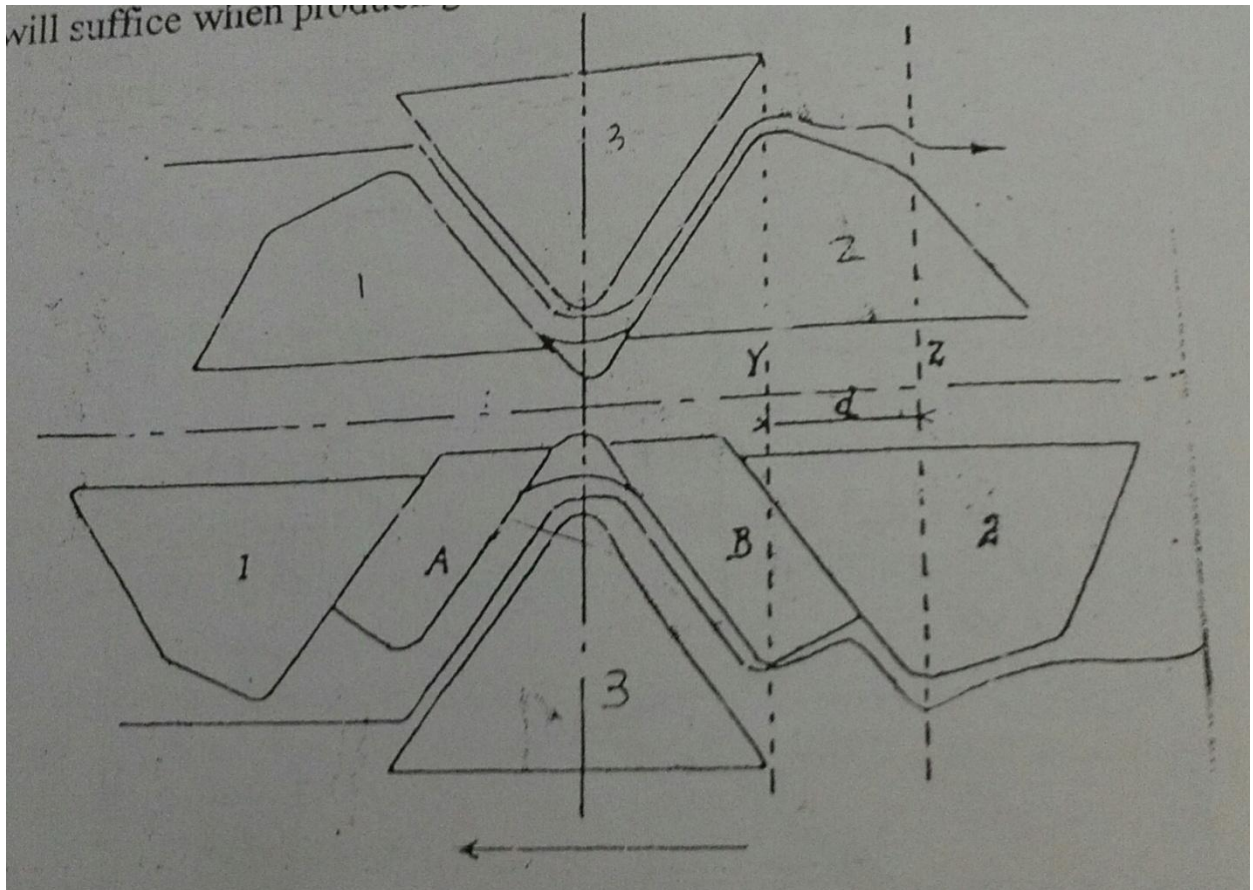
A plate called a needle cover bar prevents the needles being tilted by the fabric take down tension. The blade separating two adjacent needles is called the trick wall. At the end of each trick wall a tooth called a “knock-over comb”. At the lower end of the needle a spring maintains the needle butt at a fixed height. These springs are also held in position by a covering bar. The maximum working width on a flat knitting machine is equal to the needle bed width.

Cam arrangement

In the knitting machines the needle bed is stationary and hence the needles are vertically displaced within its tricks to form the loops. For raising the needles a triangular shape cam (upper part is smoothly grounded) is arranged so that it points upwards, while its base is just below the level of the needle butts. When this cam is moved from left to right the needle butts will be pushed upwards.

When the needles have been raised the stitch cam(1) acts on the needle butt causing them to be lowered. Having knitted by moving the cams from left to right, knitting must now take place as the cams move in the opposite direction. To allow this another stitch cam(2) must be added to the cam system and is placed to the right of the raising cam. These three cams are mounted in a carriage that can slide along the needle bed in both directions. Further two auxiliary cams(a) and (b) are also fitted in the front bed cam system to delay the knock over of front bed needles. In order to control the needles in both beds simultaneously two sets of cams must be employed. These cams are mounted on a carriage and slide

over both needlebeds as the carriage makes its traverse. Only one end of yarn is required to form each course so one yarn carrier will suffice when producing rib fabric.



The fabric take down roll

On simple machines, take down tension is applied to the fabric by suspending a comb and some weights from it. More sophisticated have mechanical take down rollers. Take down tension is designed to exercise a tension on the loops held on the needles to ensure correct knock-over and to avoid problems like difficulty in maintaining the fabric level, raising and lowering of loops along with the needle movement.

2.3.2 Extra of Flat bed Knitting Machine

Stitch cam setting

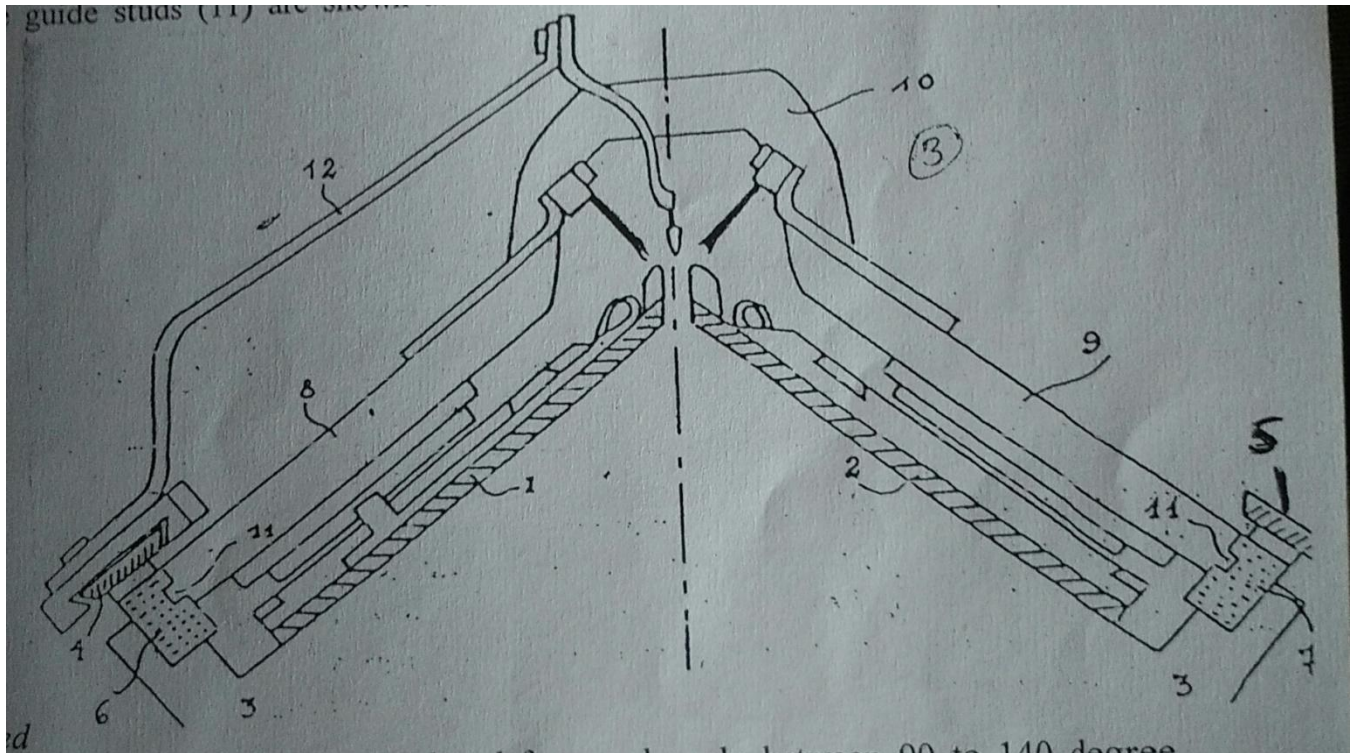
The stitch length determines the fabric tightness. The stitch length is governed by the position of the stitch (knock-over) cam. If this cam is set at the very low position then the loops drawn by the needles are long. Conversely a high stitch cam setting results in the needles drawing short loops.

The level of the stitch cam is adjusted by translating the entire cam up or down a slot. For this purpose the cams are fitted with studs that fit in the slots and allow this movement. During the cam

displacement, side of the cam that acts on the needles always remains in the same plane and the cam track width is not reduced.

Cross section of machine

In cross section, the front (1) and back (2) needle beds supported by the machine frame (3). The guide bars on which the yarn carrier travels are illustrated at (4) and (5). The carriage moves along the tracks (6) and (7). The carriage consists of two cam plate blocks (8) and (9), joined by the bridge (or blow) (10). The carriage guide studs (11) are shown at base of each needle bed. The yarn carrier is indicated by (12).



Inclination of needle bed

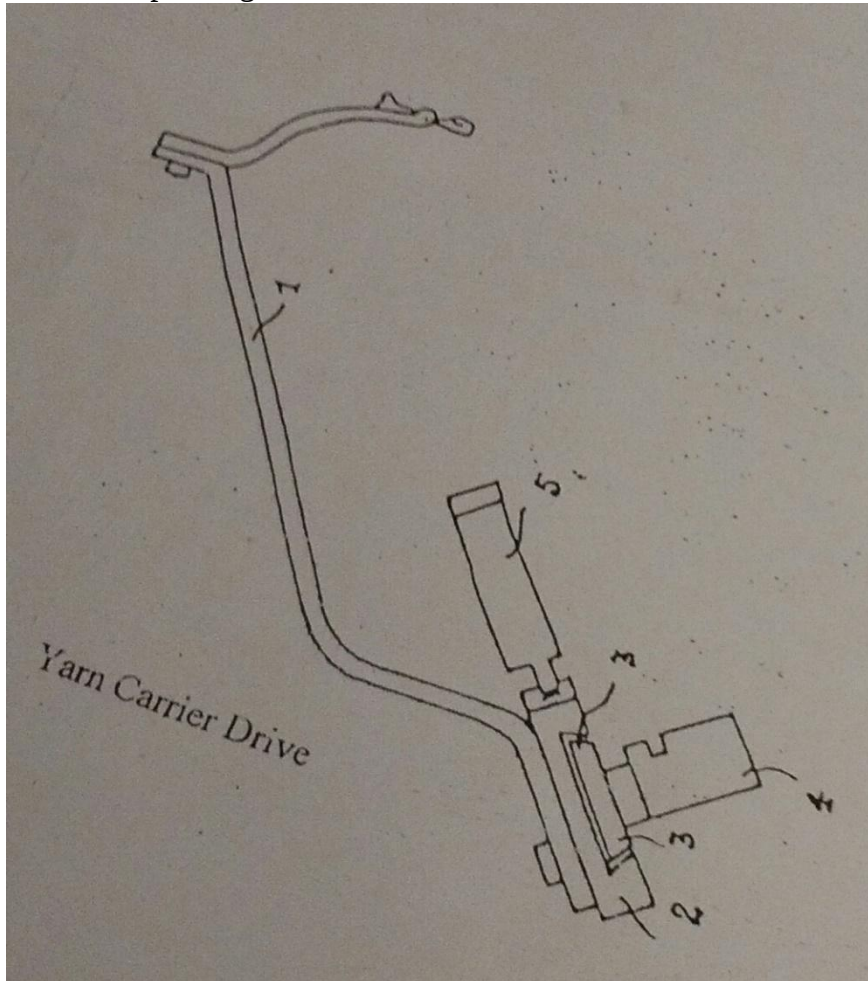
The front and back needle beds are inclined and form an angle between 90 to 140 degrees depending on the manufacture. This angle facilitates the feeding of yarn and gives greater stability to the carriage.

Yarn carrier (Low bow Machine)

Figure shows the yarn guide (1) mounted on the driving box (2) which slides on guide bars (3). The guide of the yarn guide is fixed on the guide bar of the carriage (4). Two conditions must be met:
 -feeding must be delayed with respect to axis of symmetry of the cam system.
 -At the end of each course the yarn guide and carriage must be independent of each other.
 The pump is fixed to the carriage at the central axis of one cam plate. It acts on the shoulders of the guide box during its traverses and drives the carrier.

The figure shows the front view of the yarn carrier box. Considered a carriage traverses from right to left. The piston acting on shoulder A will drive the yarn guide and its box. During left to right traverse the piston drives the box by acting on B. If a release plate (3) is positioned on the guiding bar

facing the yarn guide, the piston will follow inclined plan (4) and release the yarn carrier. Similar plates positioned at each end of the knitting width so that the yarn guide may be inactivated within a few centimeter of the operating needles.



2.4 Circular weft knitting machines

They are basically classified into four types according to the type of knitting element used and their arrangement.

1. Plain knitting machines (single jersey) used for producing plain-knit fabrics.
2. Rib knitting machines (double jersey) used for producing rib knit fabrics.
3. Interlock knitting machines (double jersey) used for producing interlock fabrics.
4. Purl knitting machines (double jersey) used for producing purl fabrics.

The continuous rotary motions of circular knitting machine enable two types of machine to be made. They are

- Revolving needle bed machines with fixed cam tracks.
- Revolving cam box machines with fixed needle beds.

There are two types of machine movements in circular knitting machines

Revolving needle or cylinder machines

The cams are stationary and the cylinders with trick having needles fitted in it are moving in the grooves (path) of the cams. The butt portion of the needle moves in this trick getting reciprocating motion.

Most circular machines are of the revolving needle bed type. Here the needle bed, fabric and the take up system rotate while the yarn packages, cam box and yarn supply system remain stationary.

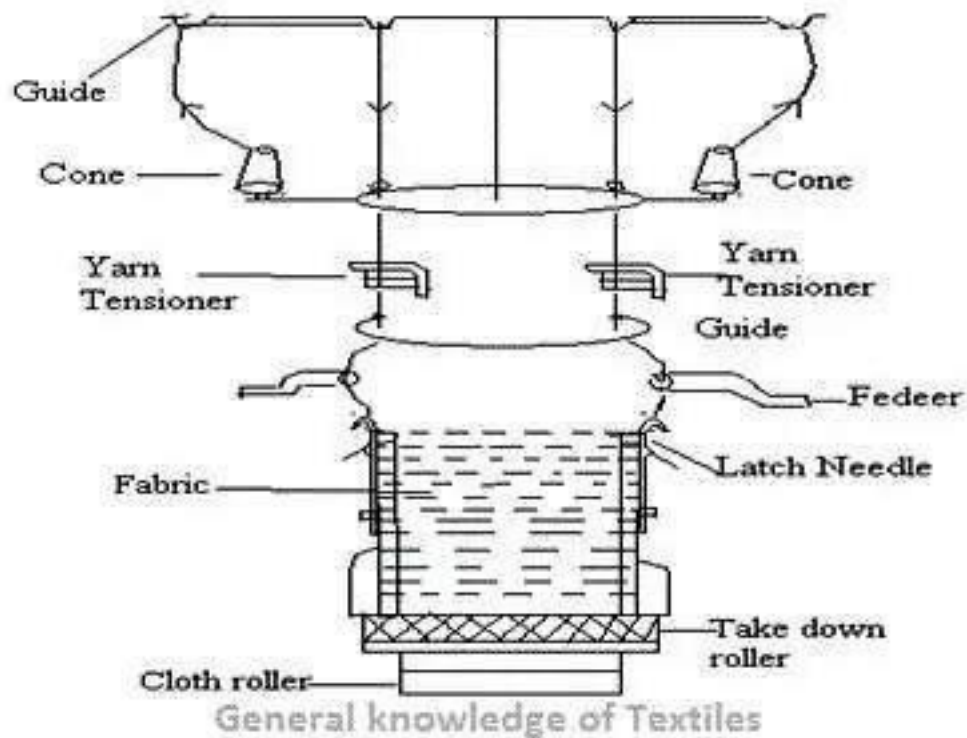
Reciprocating or rotating cam box machines

The bed with the needle is stationary in horizontal movement and the cam revolves. In this case the yarn feeder or creel must move with cam. Mostly used system but not preferred in large diameter and multi creel supply.

The raising or running cam helps the needle to either tuck or clear the loop. On Machines of the revolving cam box type fabric and needle beds remain stationary while the bobbin frame rotates with the yarn guides and cam boxes.

2.4.1 Passage of material through a circular knitting machine

The given diagram shows the general description and passage of material through a circular knitting machine with revolving needle beds. The machine frame is the body of the machine. The needle beds are supported in the centre of this frame.



Knitting process

Diagram of Circular knitting machine

Single knitting is fitted with a sinker and cylinder beds whereas rib and interlock machines have both a cylinder and a dial. The needles are inserted into the tricks of the needle beds. The needles are controlled by fixed cams.

The yarn packages are set at upper part of the machine on the bobbin stand. The yarn is unwound overhead, following the packages axis to the yarn break stop motion placed at the top of machine. The yarn then returns down through a guide to the middle stop motion. Then the yarn is delivered to the yarn guides by a yarn feeding system. Now the yarn guide feeds the yarn to the knitting elements where the fabric is being knitted. Then the knitted fabric goes down inside the cylinder towards the centre of the machine.

A spreader fixed inside the fabric tube prevent the formation of creases, as the fabric is drawn into the take down device which provides the tension necessary for stitch formation. The fabric is collected on a roll winding mechanism.

UNIT III: WEFT KNIT FABRICSTITCHES

Loop or the stitch is the fundamental unit of a knitted fabric. Use of different stitches makes different types of fabrics and their derivatives.

3.1 Knitted fabric representation

A Stitch is the basic repeating unit in any knitted structure. It should be possible to represent the stitch notation in order to record in a readily understandable form. The layout of the stitches will form the basic repeat of a particular structure.

There are four ways to represent the knitted structures as given below:

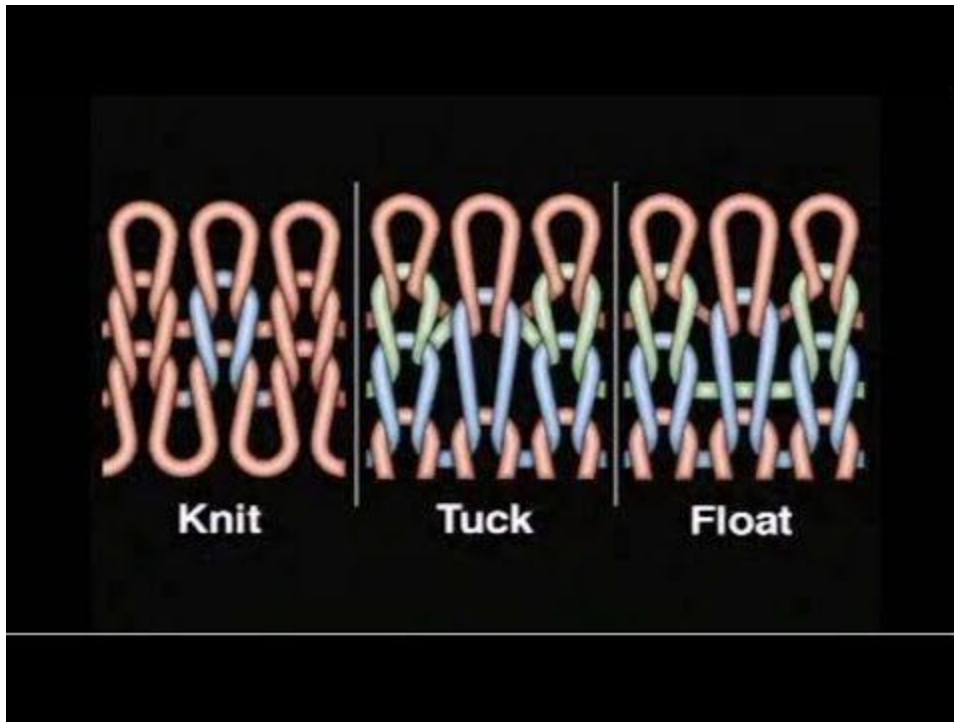
- i. Verbal representation.
- ii. Diagrammatic
- iii. Graphical representation (or) line diagram.
- iv. Symbolic

3.1.1 Verbal representation

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. Example- knit, tuck, float, face loop, back loop..

3.1.2 Diagrammatic representation

It shows the actual picture of the stitch. But this is one the most difficult and time consuming method of representation. So other methods had been drawn to simplify the drawing of the complex structures. Example is shown in the given picture



Knit , Tuck and Float Stitches

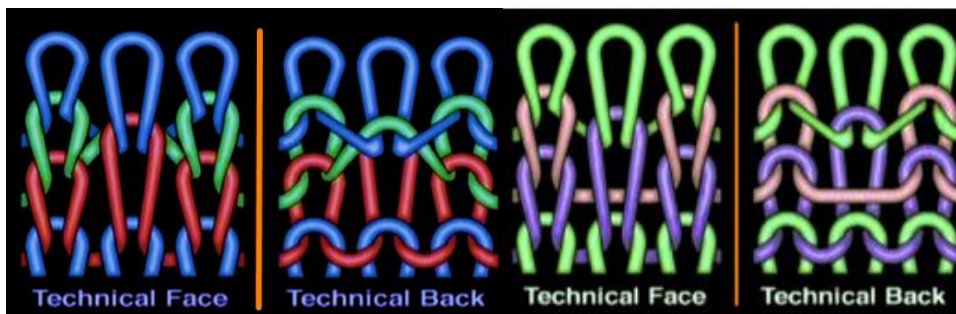


Fig: Technical face and back of Tuck Stitch **Fig: Technical face and back of Float Stitch**

3.1.3 Graphical representation

This method is very useful for simple structures and could be easily understood by a beginner. A double line representation may be used to show the dimension of the knit yarn, but preferably a single line is used to represent the structures, as this method is less time consuming.

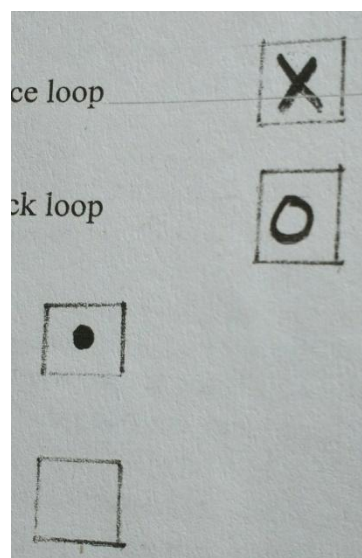
Knit stitch: Face X loopBack O loop

M – Miss



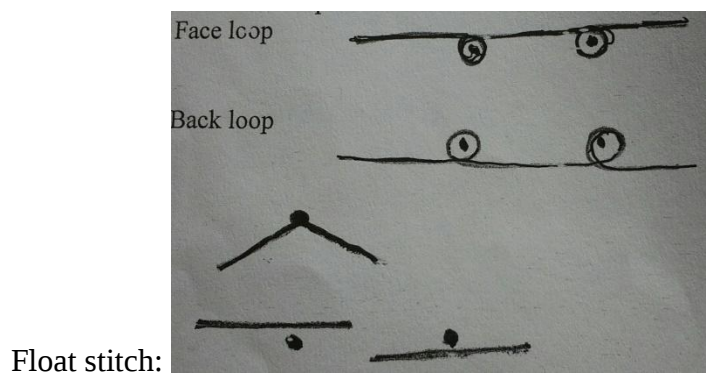
T- Tuck





3.1.4 Symbolic representation

This shows the movement of the loop around the needle.



3.2 Types of stitches

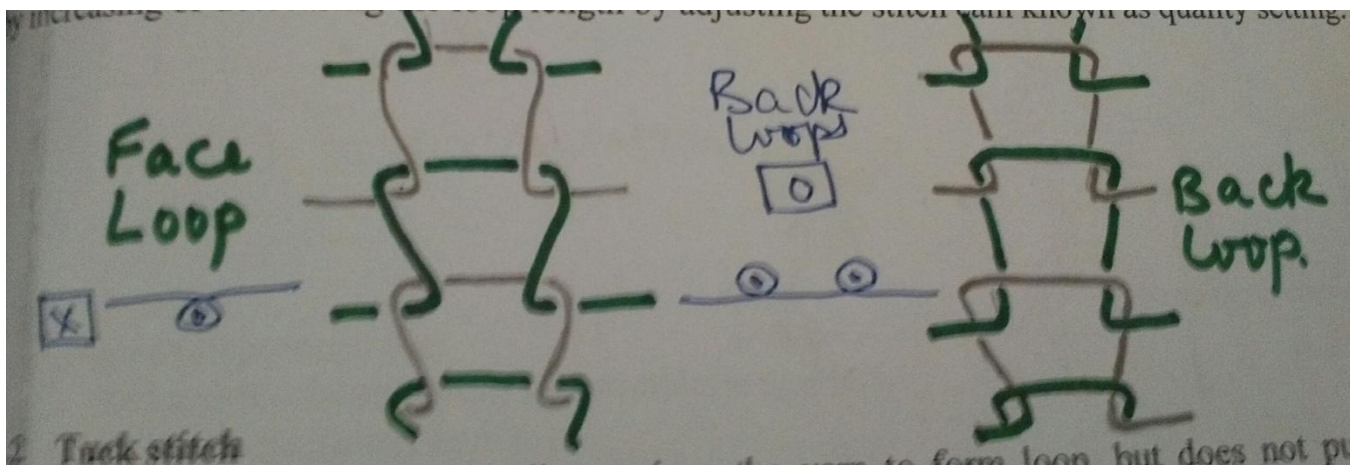
Except the normal face or back loops, the two loop stitches that change the structure and properties and develop variety in knitted fabrics are float and tuck stitches.

In a needle there is loop inside, and the new yarn is fed in to make a new loop. The combination of old and the new loop can form 4 combinations with old loop knocked over & new yarn fed (knit), old loop remains in the hook & new yarn fed (tuck), old loop remains in the hook & no new yarn fed (float), and old loop knocked over & new yarn not fed (not possible).

3.2.1 Knit stitch

This is the normal stitch that we see in a knitted fabric. It has a face and a back. The side of the fabric that appears to be normal is the face side of the loop, and that appears to be back of the fabric is formed by back loops. The combination of these *face* and *back* loops help in making of different basic knitted fabrics.

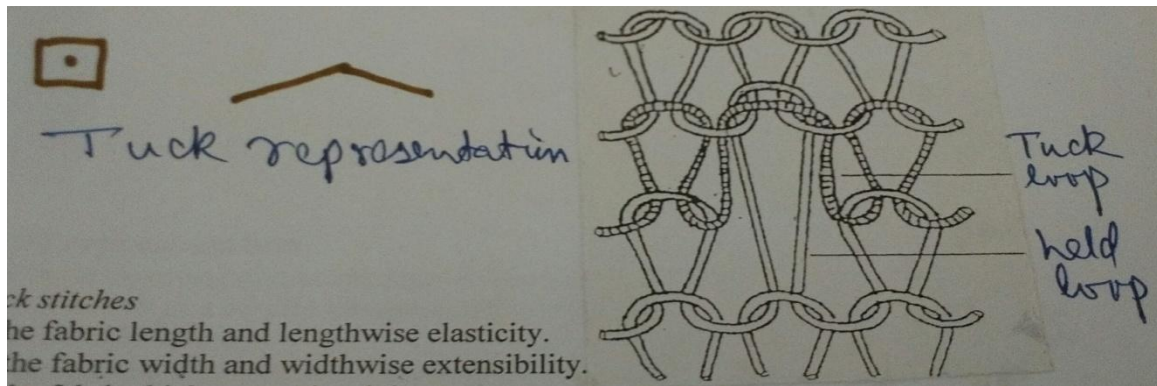
This loop is produced by clearing the old loop from the hook or latch by raising needles and feeding the new yarn to form new loop on the same needle. If the loop is drawn towards the face of the fabric, it is called as face(front) loop, and the loop drawn at the back side is known as the Reverse(back) loop. This stitch is used for plain fabric in all knit structures. Loose and tight knitting can be done by increasing or decreasing the loop length by adjusting the stitch cam known as quality setting.



3.2.2 Tuck stitch

This stitch is formed when the last loop is held along with the next loop. It means two loops of different courses are held together. This helps in developing derivatives of different basic knitted fabrics.

It is formed when the needle receives the yarn to form loop, but does not pull through the previous loop. The needle is not raised sufficiently so that the old loop is not cleared but raised enough to receive newly fed yarn.



Characteristics of tuck stitches

- i. Reduces the fabric length and lengthwise elasticity.
- ii. Increases the fabric width and widthwise extensibility.
- iii. Increases the fabric thickness and weight.
- iv. Produces three dimensional effects on the fabric. Produces open and more porous fabric.
- v. Show faint diagonal line effect on the surface of the fabric.
- vi. Assumes an inverted u shape configuration.

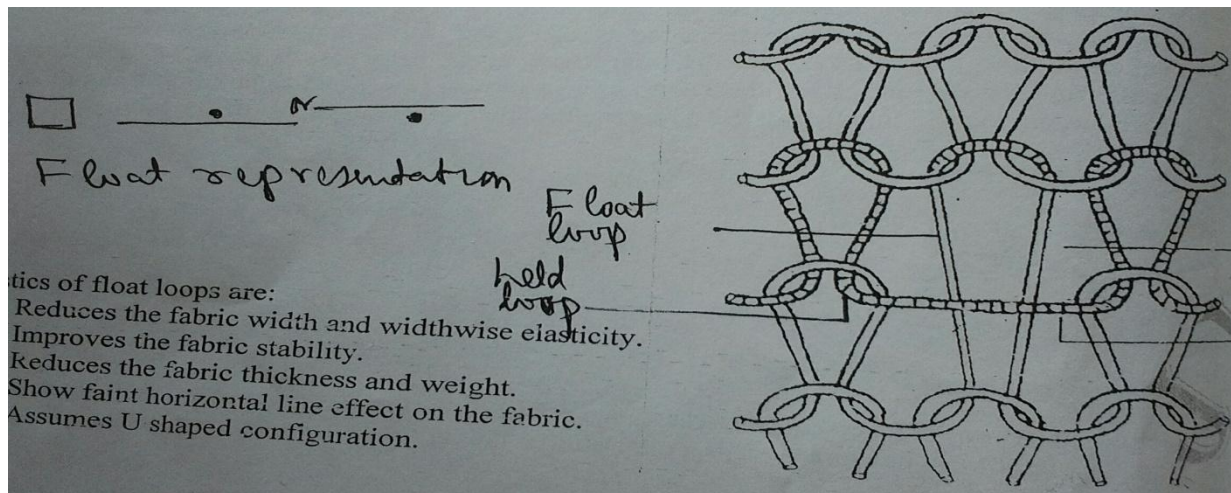
Uses of tuck stitches

- i. To shape the fabric.
- ii. To increase weight and thickness of fabric.
- iii. Used to develop load resistance.
- iv. To develop surface appearance. To arrest floating loops at the back of fabric.

3.2.3 Miss or Float stitch

It is formed when a stitch is not formed. In this case either the new stitch is formed on its place by use of another yarn, or the loop from the last course that is below it takes its place. Like a tuck stitch, it also helps in developing derivatives of different basic knitted fabrics.

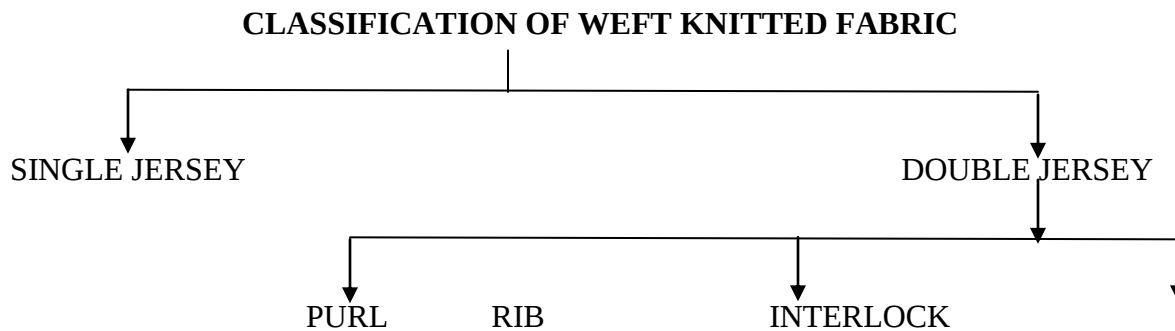
A float stitch is formed when the needle retains the old loop in the hook and also does not receive the new loop. It is mainly used for surface appearance. The unwanted coloured yarn is hidden behind the face loop. It can be done at a maximum of six adjacent needles. Makes fabric thinner of less loops, narrower, less extensible because less yarn is available with the loops, lighter.

**Characteristics of float loops are:**

- Reduces the fabric width and widthwise elasticity.
- Improves the fabric stability.
- Reduces the fabric thickness and weight.
- Show faint horizontal line effect on the fabric.
- Assumes U shaped configuration.

UNIT IV: WEFT KNITTED FABRIC

While discussing various stitches, we had discussed that various stitches form different type of knitted fabrics. Combination of face and back loops of a simple knit stitch form the different type of knitted fabrics, and its combination along with tuck and float stitches form different derivatives of these knitted fabrics. Normally there are four type of knitted fabrics, plain, rib, purl and interlock. The basic knitted fabrics are:



Single Jersey fabric (Plain)

In single jersey knitting, only one set of needles are used. Needles are arranged in a needle bed which may be either flat or circular. These machines have one needle for every wale in the fabric and between each needle there is a sinker, which has two functions: to hold the fabric down when needle rises and to provide a surface over which the needle draws the loop.

Double Jersey fabric

Double knit fabrics are weft knitted structures which require two sets of needles either in circular or flat forms. Double jersey fabrics such as rib and interlock can be produced on both flat and circular machines. In the case of circular machines the second needle bed is equipped in the form of a dial i.e. a flat disc is placed on top of the cylinder. In the case of purl machines the two needle beds can be flat or circular equipped with double ended latch needles. In the circular version of the purl machines the second set of needles is in the form of a second cylinder superimposed above the first.

4.1 Plain knitted fabric

It is the simplest and most widely used knitted fabric. It is developed by using knit stitches side by side, horizontally as well as vertically, to form knitted fabric. It is made on single set of needles. The fabric can be made on flat knit or in circular (tubular) form. Since this is the only knitted fabric made in single layer, it is also called as *single jersey fabric*.

4.1.1 Characteristics of plain knitted fabrics

- i. It is produced on a single set of needle.
- ii. The structure is simplest and most economical in weft knitting.
- iii. It can be unraveled from the course knitted last.
- iv. The structure is of nearly two yarn diameter thick.
- v. When the fabric is cut, the fabric curls towards back from sides.
- vi. It has maximum covering power.
- vii. It can be stretched in most directions upto 40% depending on yarn parameter.
- viii. It can recover 40% of stretched width wise depending on yarn parameters.
- ix. The count suitable for knitting.
 $N_e = G^2 / 18$ (Gauge/N.P.J.)
- x. Uses: Knitted footwear, all types of fully fashioned garments, body panels of garments

4.1.2 Knitting cycle of plain knitted fabrics

- i. *Rest position*: The loop previously formed is in the hook and the needle is in the position to move up.
- ii. *Running position*: The needle gets upward movement with the butt by pressing it against clearing cam. The latch opens. The old loop starts descending onto the latch.
- iii. *Clearing position*: The needle is at top most position. At this stage the needle ascends to clear the latch of the loop and the hook is ready to take the new yarn.
- iv. *Feeding position*: The needle starts to descend. The hook holds the new yarn. The old loop starts to slide up closing the latch and new yarn inside the hook.
- v. *Knocking over position*: The further descend of the needle results in the old loop being disengaged from the end of the hook and also a new loop being formed at the end of hook.

4.1.3 Ornamentation of plain knitted fabrics

- i. *Horizontal strips* can be produced by using different color yarns on different feeder or different courses.
- ii. *Zig-zag effect* can be produced by using differently twisted (s-z) yarns in different courses in groups. It is visible wale wise
- iii. *Use of fancy yarns* like Grandville, knops, corkscrew, gimp yarns can be used to replace simple yarn to produce a fancy sort of fabric.
- iv. *Plated jersey fabric* by using two different yarns with one yarn being visible on the surface.

4.1.4 Derivatives of plain knitted fabrics

S. no.	Name of derivative	Feed no. 1	Feed no. 2	Feed no. 3	Feed no. 4
i.	Fred Perry	K T	K K	T K	K K

ii.	Single Lacoste	K T	T K	K T	T K
iii.	Double Lacoste	K T	K T	T K	T K
iv.	Weft locknit	K M	K K	M K	K K
v.	Cross Miss	K M	M K	K M	M K
vi.	Birds Eye	K M	K M	M K	M K
vii.	Mock Rib	MMM KKK	KKK MMM	MMM KKK	KKK MMM
viii., ix.,x.	Twill effect				
xi.	Simple Crepe				
xii.	Cellular Blisters				
xiii.	Accordion Fabric	KKKKK	KMTMK	KKKKK	----

The Graphical representation of the following is shown below:

K – Knit



M – Miss



T- Tuck



Knit and Tuck combinations

i. Fred perry

X	X
*	X
X	X
X	*

ii. Single lacoste

*	X
X	*

iii. Double lacoste

*	X
*	X
X	*
X	*

Knit and Miss combinations

iv. Weft locknit

X	X
	X
X	X
X	

v. cross miss

	X
X	

vi. Bird eye

	X
	X
X	
X	

vii. Mock rib

X	X	X			
			X	X	X
X	X	X			
			X	X	X

Knit and Miss/ Knit miss & Tuck (Twill effect) combinations

viii.

		X	X
	X	X	
X	X		
X			X

ix.

	*	X
*	X	
X		*

x.

	*	X	X
*	X	X	
X	X		*
X		*	X

Extra*xi. Simple crepe*

X	X	*	X
X	X	X	*
	*	X	X
*	X	X	X

X	X	*	*
X	X	*	*
X	X	*	*
X	X	*	*
*	*	X	X
*	*	X	X
*	*	X	X
*	*	X	X

xiii. Accordion Fabric

X	X	X	X	X
X		*		X
X	X	X	X	X

Accordion Fabric is a combination of Knit, tuck and float. The design is produced by selection of knit and float. The floating threads are held in place on technical back by tuck stitches.

a. Straight accordion: Every odd needle is had an extra butt in line with a tuck cam i.e. the tuck are normally made on alternate with those of knit and float on each course.

b. Alternate accordion: This has a better distribution of tuck stitches. Here, odd needles tuck at odd courses while the even needle tuck at even courses. It means that tucking occurs on same needles at alternate courses.

Both of these (above) have tuck stitch together causing distortion.

c. Selected accordion: The accordion fabrics not falling in the above two categories falls in it. the design is developed by knit and float, and elimination of float is achieved by use of tuck stitch.

4.2 Rib knitted fabric

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

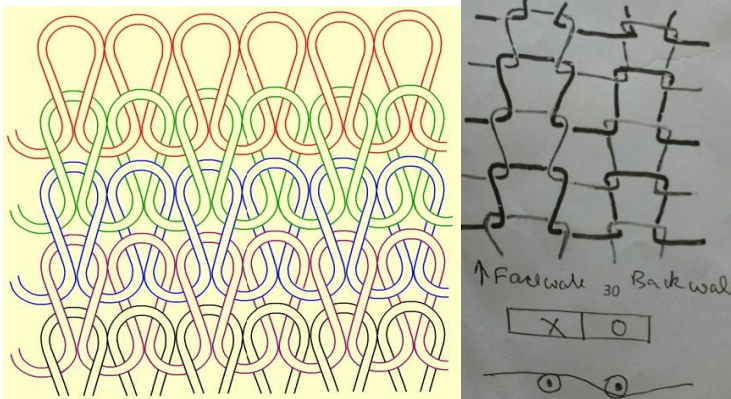
This fabric can be developed by knitting face and back loop alternatively. It means that odd number of wales (vertical column of loops) will be made of face loops, and the next or even wales (vertical column of loops) will be of back loops. This will be made on two sets of needles, and is thus

in two layers. It is called as *double jersey knitted fabric*. One knitting face, and other knitting back loops in the same row, means face and back loops alternately. This fabric shows horizontal lines (vertical gap type), and is very stretchable widthwise. All extremities in knitted fabrics like collar, end of the sleeves, and the bottoms of the T-shirts, sweaters are made of rib. It is extremely stretchable widthwise. Due to this, it is also used for ladies wear and shape fitted fabric.

4.2.1 Characteristics of rib

- i. The fabric has a vertical cord like appearance as the face loop wale tends to move over and in front of the reverse loop fabric.
- ii. The stitch lies in two planes.
- iii. The simplest rib fabric is 1x1 with technical face appearance on both sides
- iv. It is produced on two sets of needles.
- v. The fabric is twice as thick and half the width as plain structure in relaxed state.
- vi. However, it has twice as much as width wise recoverable stretch.
- vii. The fabric is balanced and has no tendency to curl without cut.
- viii. They have an extensibility, better elasticity and retain warmth properties.
- ix. Count suitable for rib knitting can be

$$Ne = G^2/8.4 \quad G = \text{needle/inch}$$
- x. Uses: Due to unroving and elastic properties it is used in borders and colors, tops of socks, cuffs of sleeves, border of garments or in cardigans. They are also used for preparing ladies tops winter wears as they give shape fitting properties.
- xi. Rib structure representation



4.2.2 Knitting cycle of rib

Running position: The hooks of cylinder and dial hold the old loop. The loop starts to descend onto stem.

Clearing position: Needles on both beds are moved further away to clean the plain and rib loops formed in the previous cycle with a time lag.

Yarn feeding: The yarn is received first by one needle (cylinder) and then by other hook in the dial. The old loop in the stem starts moving up and about to close hook with latches.

Knock over cylinder: The old loop is knocked over the cylinder while the dial needle follows.

Knock over dial: The adjacent dial needle now knocks over the old loop in order to convert the yarn fed to new loop.

4.2.3 Derivatives of rib knitted fabrics

Simple Variations

i. Swiss rib

2/2 Rib

X	X	O	O
---	---	---	---

ii. English rib

2/3 Rib

X	X	O	O	O
---	---	---	---	---

iii. Derby rib

6/3 Rib

X	X	X	X	X	X	O	O	O
---	---	---	---	---	---	---	---	---

Knit and tuck combinations

iv. Half cardigan or royal rib

It is produced by knitting face wale on one set of needles and by tucking on alternate course on back wale. The fabric is wider as no legs, and thicker than 1x1 rib

X	*	X	*
X	O	X	O

Needle 1 2 3 4

v. Full cardigan or polka rib

It can be obtained by tucking on alternate courses in both the face and back wale i.e. when one set of needles (either front or back) is tucking the other set will knit. For the next course, the other set will tuck, while rest will knit.

*	O	*	O
X	*	X	*
*	O	*	O
X	*	X	*

Both of these types are used to produce body panels and sleeves of heavier type of knitwear. The other popular variations are next two.

vi. Fisherman knit (on 2x2 rib)

X	X	*	*
X	X	O	O

vii. Sweater stitch

*	*	X	X
X	X	*	*

Knit and Float combinations

viii. Half milano

	O
X	O

ix. Full Milano

X	
	O
X	O

x. Swiss double pique: It is very stable, used extensively in women's dresses and suiting. It is prepared on four courses and a narrower and heavier fabric is produced.

\

			O
X		X	O
	O		
X	O	X	

xi. French double pique: It is modified (from) form of Swiss double pique. In second course only even number dial needle knit while in fourth course only odd numbers dial needle knit.

	O		
X		X	O
			O
X	O	X	

Knit, tuck and float combinations

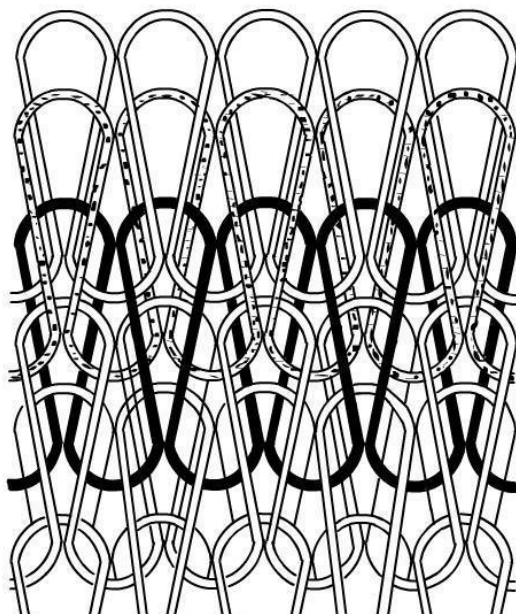
xii. Knop effect:

X	O	X	O
X	O	X	O
X		X	*
X		X	*
X		X	*
X		X	*
X	O	X	O
X	O	X	O
X	*	X	
X	*	X	
X	*	X	
X	*	X	

4.3 Interlock Fabric

The fabric is obtained by interlocking of two 1x1 rib structures such that in a wale, the face loop of one fall directly in front of the back loops of the other fabric, and the case is reverted in the next wale.

This fabric is combination of two ribs fitted or fixed in a single fabric. A rib fabric shows vertical line type gaps. The other rib fabric fits into the first one in this gap, and thus appear as a plain fabric from the front and the back. This fabric is therefore equal to two fabrics in thickness and weight.



4.3.1 Characteristics of Interlock fabric

- i. The fabric is a combination of two 1x1 rib structure embedded into each other in an alternate sequence.
- ii. The two courses (for different set of needles) of loops show wale of face loop on each side of fabric, exactly in line with each other. The reverse loop of other set is thus hidden.
- iii. It is a double jersey fabric.
- iv. The fabric shows only technical face of plain fabric on both sides.
- v. The machine has two feeders; two sets of needles (short and long), two different can tracks.
- vi. There are two feeders running simultaneously, one helping to produce 1x1 rib on one set (long) of needles, and the other simultaneously allowing other (short) set of needles to prepare 1x1 rib so that they show being embedded.
- vii. The fabric cannot be unraveled from the yarn knitted last and is ladder resistant.
- viii. A balance fabric, with smooth stable structure.
- ix. It doesn't curl from edges.
- x. The fabric is heavier, narrower and thicker than rib of equivalent gauge.
- xi. Productivity is half to that of rib.
- xii. Horizontal stripes are produced if two consecutive feeders have the same coloured yarn and vertical stripes will be produced if odd and even feeders have different yarn colour.

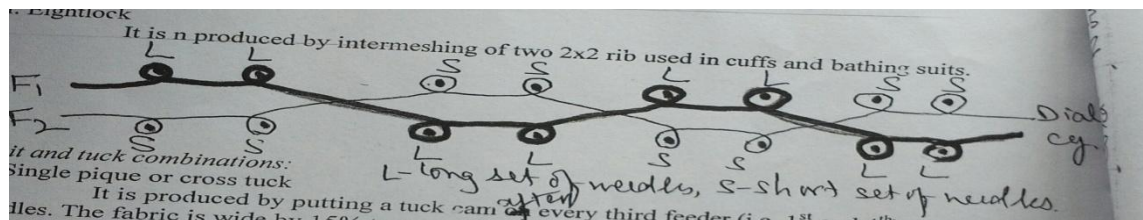
- xiii. End uses: Undergarments, outer wears, such as polo shirts, sports jackets ladies sweat and children sleep wears.
- xiv. Properties of Interlock fabric: Firm fabric, lustrous, soft look, strong, tendency to acquire original width, heavier, ladder resistant and balanced does not curl edges.

4.3.2 Derivatives of interlock fabric

Simple Variations:

i. Eightlock

It is produced by intermeshing of two 2x2 rib used in cuffs and bathing suits.



Knit and tuck combinations:

ii. Single pique or cross tuck

It is produced by putting a tuck cam on every third feeder (i.e. 1st and 4th) only on dial needles. The fabric is wider by 15% to normal interlock.

iii. Taxi pique

Tucks on both cylinder and dials on every third feed. The fabric is wider and bulkier.

iv. Pin tuck

Tuck with two consecutive feeders in every six feeds only on back needles.

Knit and miss combinations:

v. Cross miss

The fabric has miss stitch on every third feed on dial needles. It is lighter in weight.

vi. Panto di roma (4 feed)

vii. Panto di roma (6 feed)

viii. Piquette

Reversible weft miss structure with light cord effect.

ix. Cortina

x. Bourrelet fabrics

It has pronounced horizontal cord at regular intervals produced by knitting excess courses on cylinder needles. The cord course may be of different colour than ground. Interlock rather than

rib bourrelet is preferred because it is softer, smoother, has more regular surface, and less elasticity.

- a. Jersey cord b. super nova

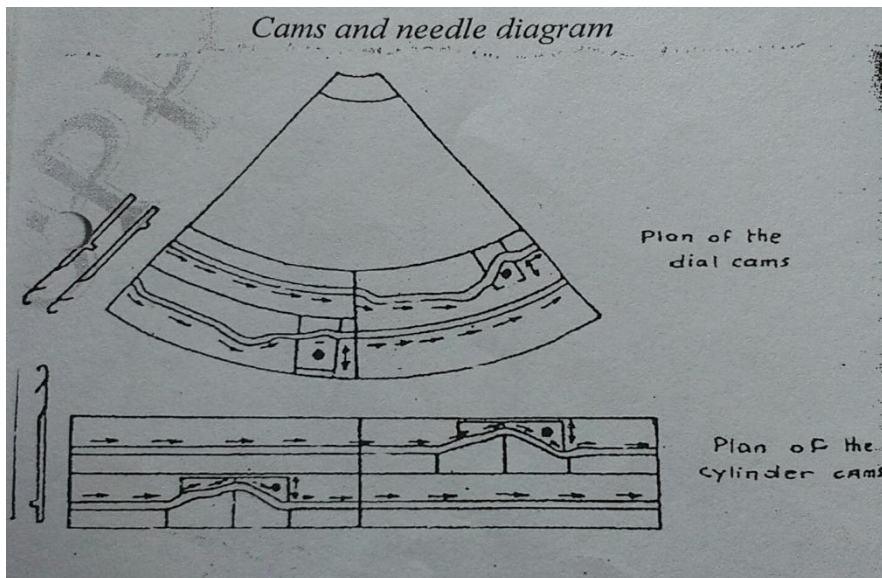
Feed number	Single Pique	Taxi Pique	Pin Tuck	Cross miss	Panto di roma (4 feed)	Panto di roma (6 feed)	Pique	Cortina	Bourrelet fabrics	
									Jersey Cord	Super Nova
8										
7										
6										
5										
4										
3										
2										
1										

4.3.3 Production of Interlock fabric

It can be produced on circular knitting machines (with two tracks cut in cams of cylinder and dial) or double system v-bed machines. Two separate sets of long and short needles run in each of the cam tracks feeding simultaneously one after the other.

- a. There should be two beds with alternatively one long and one short needle, adjacent to each other. The long set of needles of one bed should face short set of needles so that only one of the two can knit at any feeder.
- b. One cam system controls knitting at one feed and other at next feeder.
- c. The alternatively set needles work for one feeder either long or short.

Cams and needle diagram



4.4 Purl Fabric

In a purl fabric courses are knitted with face and back courses alternately, or horizontally. A 1x1 purl structure has both face and reverse loop stitches in the same wale.

This fabric is made by knitting alternate courses (horizontal row of loops) of face and then back loops. It appears like purl or as if the fabric is being worn from reverse. The machine used is has two beds fitted at 180° to each other and forms a double jersey fabric.

4.4.1 Characteristics of Purl fabric

- i. The fabric produces a course wise effect.
- ii. In 1x1purl fabric alternative courses are knitting in opposite direction i.e. 1 face and 1 back .
- iii. The appearance is like technically back of a knitted fabric.
- iv. Both face and back loop are seen in a single wale.
- v. The fabric produced has a balanced structure and has no tendency to curl at edges.
- vi. The fabric has a good cover.
- vii. Thickness is double to the plain knitted fabric i.e. same as rib structure.
- viii. It has double lengthwise elasticity and widthwise elasticity same as plain knitted fabric. Fabrics are full, lofty and soft handle.

- ix. Thickness is double to the plain knitted fabric i.e. same as rib structure. In relaxed state, the face loop will cover the back loop thus increasing the thickness.
- ix. End uses: Children wear, sports shirts, goes sweaters.
- x. Design of Purl

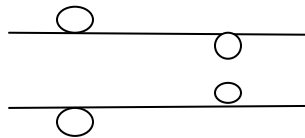
X	X
O	O



4.4.2 Derivatives of Purl fabric

Moss stitch

O	X
X	O



4.4.3 Production of Purl fabric

There are two types of pure knitting machines. Flat Purl, that has two horizontally opposed needle beds, and circular purl machines with two superimposed cylinders on above the other.

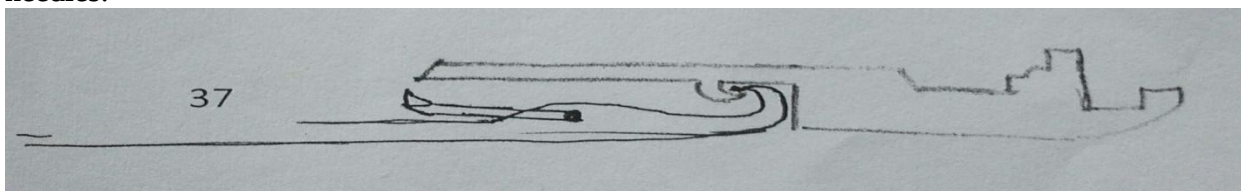
It usually made on a machine fitted with double ended needle shows the cross section of the knitting elements of purl machine. The two needle beds are set at 180° to each other i.e. in a straight line, with a gap between, straddled by a double ended latch needle. There is cam carriage which moves from right to left and left to right alternately, above the needle beds. The carriage has cams which activate the needles in knitting action.

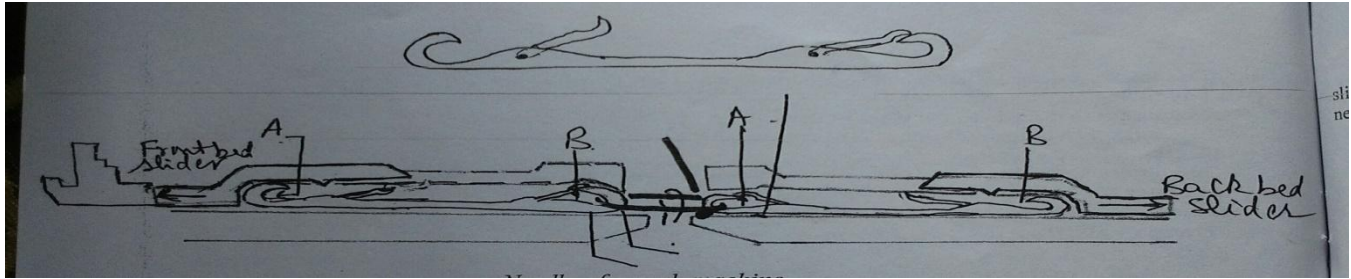
The pure knitted fabric is produced on flat bed knitting machine with needles having hooks on both ends. To support such needles two beds are required in the same plane with trace opposite to each other to allow sliding of needle. Each hook is used alternately to produce face and back loops in alternate courses. The needles do not have butt for movement but *jacks* helps to work as butt using hook opposite to that of knitting hook.

A notch underside of the front end of the slider just fits over the hook of the needle. Butt of jacks work in the track.

The special features of a purl machine are:

- i. needles used has two hooks, one on each end, and is without butt. They operate with sliders.
- ii. These sliders indirectly performs the knitting action of needles by either seizing or releasing the needles.





Needle of a purl machine

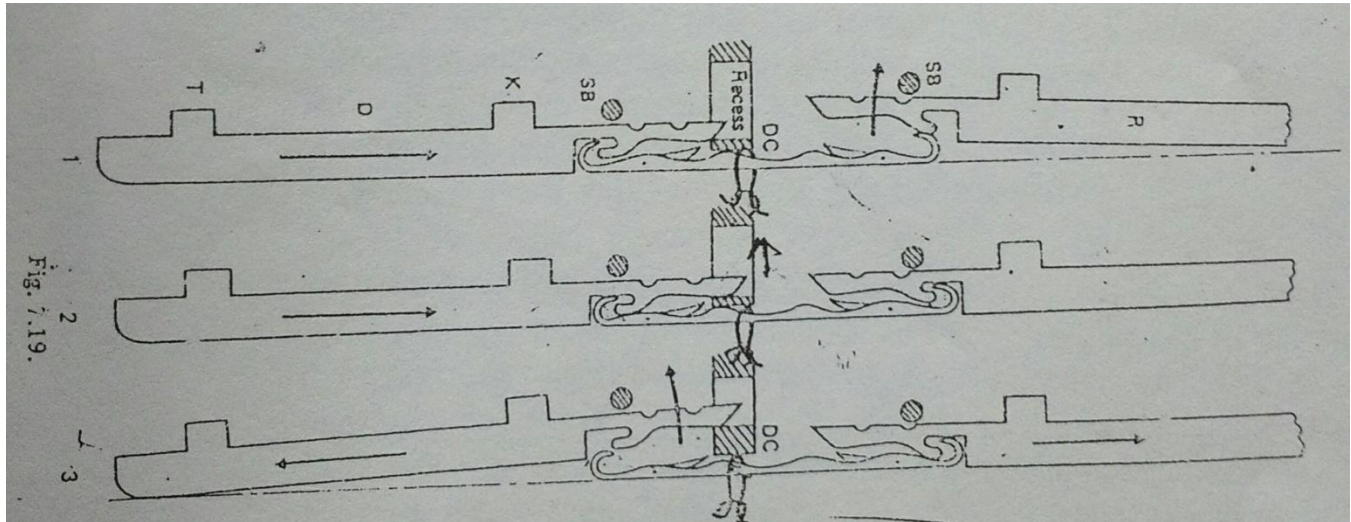
- iii. The needle bars are placed horizontally with tricks opposite to each other.

Knitting cycle of purl fabric

In knitting cycle of a *Flat bed purl knitting machine*, to form purl stitch, the needle is required to slide from one bed to another after knitting each course.

- i. the double headed latch needle is in its rest position in the front bed and held by front bed slider.
- ii. The delivery slider (d) advances with the needle so that the nose of the slider which is extended into a latch guard, penetrates the profiled recess of the delivery cam. The outer hook of the needles comes in contact underneath the head of receiving slider (R), pivot it out of the cylinder momentarily.
- iii. The receiving slider engages the needle hook under the influence of coil spring board (SB) which ensures that the slider's head are depressed into contact with the needle hooks.
- iv. As slider (D) revolves with the cylinder, it passes along the wall of the dividing cam (DC) which increases in thickness, so that the slider is pivoted outward and disengaged from the needle hook. Slider D then returns to its cylinder while R retire into its cylinder taking the needle with it ready for the next knitting feed.
- v. The yarn carrier then feeds yarn in the hook of the opened front end of the double headed latch needle. The needle is retracted to rear bed by stitch cam to knit plain faced loop fabric.

In figure, a jack or slider used on a *circular purl knitting machine* is shown. In this case the sliders have butts, a knitting butt (A) near to its tail. Each butt is controlled by its own cam track. The needle base are in two cylinders superimposed one above the other.



The Use of Dividing Cams

Figure illustrates the transfer action, using dividing cams on a revolving double-cylinder machine with internal holding-down sinkers and stationary cam-boxes. The dividing cam principle for slider disengagement was, until recently, in widespread use on half-hose machines although it had already been replaced on the double-cylinder garment length purl machines which succeeded the original Spensa purl machine.

The dividing cam is an internally profiled cut-through recess in a flat plate attached horizontally and externally to the cylinders at a position half-way between them. There is a recess cam position for the top cylinder and another for the bottom cylinder in a different position in the same plate. The principle of the dividing cam operation is that it forms a wedge shape of increasing thickness between the upper surface of the needle hook and the under surface of the extended nose of the delivering slider pivoting it away from the cylinder so that it disengages from the needle hook.

1. The delivering slider (D) advances with the needle so that the nose of the slider, which extended into a latch guard penetrates the profiled recess of the dividing cam. The outer hook of the needle contacts the hook underneath the head of the receiving slider (R), pivoting it out of the cylinder, but it immediately returns and-
2. It engages with the needle hook under the influence of a coil spring band (SB) which surrounds each cylinder and ensures that the slider heads are depressed into contact with the needle hooks.
3. As slider D revolves with the cylinder, it passes along the wall of the dividing cam (DC) which increase in thickness, so that the slider is pivoted outwards and disengages from the needle hook. Slider D then returns to its cylinder whilst slider R retires into its cylinder taking the needle with it ready for the next knitting feed.

UNIT V Quality control & Production of knitted fabric

5.1 Hosiery

This term specifically refers to knit coverings for the feet and legs but can be generally applied to all types of knitted goods and fabric.

They are mostly knitted on small diameter circular knitting machines. The machines have a master control. The automatically initiates operation and also changes stitch length necessary to produce garment length knitting cycle. Hosiery is available in different foot sizes. The commonly used hosiery articles are as below. They are categorized as per length articles.

Hose: the covering having a length above the knees.

Three-quarter hose: The covering of knitted fabric of knee length (approx twice the foot length).

Half hose: The knitted fabric covering of feet ranging between 7 inch and 9 inch and 11 inch and 15 inch. They are up to nearly half the knee length.

5.1.1 Machine used

1. Single cylinder; ladies, seam less hose, tights
2. Cylinder and dial.
3. Double cylinder: man half hose

The hand powered socks knitting machine was patented by Henry Grisuuold in 1870. It has a small diameter latch needle cylinder with the single rotating cam and feeder system. This could be oscillated to produce heel and toe pouches. An attachable dial was available to prepare rib top of socks.

5.1.2 Production of hose

The hose is produced from top rib to the down heel that is later on stitched. To produce top rib the dial is attached and sometimes an extra elastomeric yarn is attached for producing better grip. The yarn from dial is then transferred to the normal knitting till the heel portion is to be knitted.

In production of standard heel and top, half of the courses will be in oscillating knitting; and may require 60% of the machine operating time. the operation although is automatic, is time consuming and expensive.

Producing heel, the oscillation of feeder takes place on half of the needle knitting pouches. The remaining needles (nearly half), are raised into a high inactive cam track. By introducing a cam.

During *narrowing*, the leading needle in each direction of oscillation is lifted up to join the other needles in the in active track by the action of one or two side pickers that are alternately in action, according to the direction of oscillation. The picker operates throughout the pouch formation process. When widening takes place down pickers is introduced. This down picker lowers two needles at a time and putting them into action.

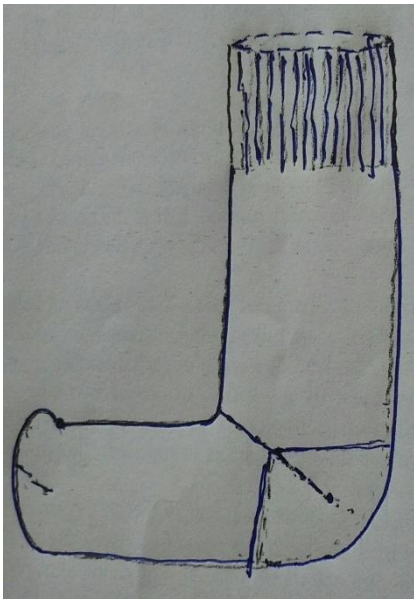
To produce *standard heel(or toe)*, half of the needle are raised and rest half the needles knit. The narrowing down of the heel section takes place by getting one needle out of action from each side, with each oscillation. Narrowing occurs till one third of the needles remain in action. The needles lifted out of action has yarn automatically wrapped over it in form of a tuck stitch. This makes heel joint stronger. Widening then takes place with needle brought down from each side with each oscillation until all the heel section needles are brought back into action (i.e. half the total needles).similarly, a toe pouch can be knitted.

If the same set of needles, as used earlier, are repeated then the seam will be top (preferred in socks). If the use of other half set of needles is made then the seam will be underneath (in hose).

5.1.3 Modification in heel or toe

To the basic pouch, particularly on hose, modifications are done to improve fit and appearance.

- i. *Y- heel*: Narrowing down takes place to $\frac{1}{3}$ of the needles. Extra fabric is then knitted by widening for 12 courses, and again narrowing it to $\frac{1}{3}$ of needles of next 12 courses. The normal widening is then carried out.
- ii. *Gusset toe*: A toe knitted in reverse, after $\frac{1}{3}$ of the needles left, a group of needle is collectively introduced. Then single needle narrowing occurs for the next 12 courses. Then the rest of the needles required to be lifted (to make $\frac{1}{3}$) are taken out of action. The normal pouch widening then take place to half of the needle.
- iii. *Scotch heel*: they are fully fashioned seam less hose on flat knitting machine made as tubular fabric. Narrowing of fabric is carried out for a few courses (normally 9 to 10). Then approximately $\frac{1}{3}$ rd of the loops from each side of the needles are taken out and held on two wires. Knitting is continued on the middle portion and on each course one loop is transferred to each wire from the bed producing narrowing of fabric with twice as many courses as wale in the width. The edge which was taken out is then resumed on needles and turn in the heel is made. Normal knitting is resumed.



5.2 Knitting calculations for weft-knits

In any manufacturing process, the calculations regarding production, efficiency and material requirements are of primary importance. The organization of machinery requirements, raw material requirements and the costing of the finished products, so as to determine the competitive selling price, will mainly depend upon the correct calculations. Knitting manufacturing is no exception to this rule. Methods of calculating production and efficiency of machines, used for weft knitting, are given as illustrations. Though the metric system of weights and measurements is used in India, the textile industry in general and the knitting industry in particular, has not yet fully adopted this system. The calculations are usually done in 'foot-pound' system at the shop floor and only the last figures are

converted into metric system from the British system of weights and measurements. In a majority of examples solved in this chapter, therefore, the British system of weights and measurements is used with a few examples also solved in metric units and in direct system of yarn numbering.

Before dealing with the examples, a definition of gauge of knitting machines is given here:

5.2.1 Machine gauge

Circular weft knitting machines: Gauge is defined as the number of tricks per circumferential inch. It is also known as the 'cut' of the machine. In two sets of needles are used as in rib or interlock knitting machines, the second set of needles is not taken into consideration in determining the gauge. Sometimes, however in giving the gauge of a circular rib or interlock machines the gauge number is repeated e.g. 18x18 rib, 22x22 interlock etc.

5.2.2 Relation between yarn number and machine gauge

It is not possible to knit a large range of yarn counts on machine of one gauge. Owing to the lack of standardization of the proportion of thickness of the needles and sinker to the total needle spacing, a relation between the machine and yarns used on them can be approximately dependable. Even yarns are not standardized for strength, diameter, twist and bending strain. The type of stitches used also plays its part. A machine cannot be expected to knit up as coarse a count of yarn for tuck stitches as a plain stitch. The correct gauge of a given type of machine for knitting up a given yarn can only be found by practice. However, some formulae based on experimental results are given here as a rough guide.

$$\text{Worsted yarn number} = \frac{(\text{needles per inch})^2}{\text{Constant}}$$

The constants for different stitches are: plain jersey 14, 1x1 Rib 6, 2x2 Rib 8, Interlock 10. By substituting the proper constant, the estimated gauge can be calculated. If cotton yarns are used for rib and interlock structures then a constant 8.4 can be taken (alternatively, cotton count can be converted into worsted yarn number and the above formula and constant can be used)

For flat 1x1 rib machine

$$\text{Worsted yarn number} = \frac{(\text{Gauge})^2}{9}$$

For French circular sinker wheel machine

$$\text{Worsted yarn number} = \frac{(\text{Gauge})^{2*}}{28}$$

Or $\frac{(\text{Gauge})^{2**}}{47}$

5.2.3 Calculations of weft knitting machine and fabrics

The linear production of a circular weft-knitting machine depends on

- i. number of feeders
- ii. Number of revolutions per minute
- iii. Efficiency
- iv. Number of courses per inch (C.P.I.)
- v. Stitch length
- vi. Stitch length in inches
- vii. Number of needles
- viii. Yarn number in indirect system (count)

Then the following formulae can be used to find various quantities:

1. Yards of knitted fabric per hour

$$= \frac{\text{no. of feeders} \times \text{no. of r.p.m} \times \text{efficiency} \times 60}{\text{No. of C.P.I} \times 36 \times 100}$$

2. Production per hour in lbs

$$= \frac{\text{no. of feeders} \times \text{no. of R.P.M.} \times \text{efficiency} \times \text{stitch length (in)} \times \text{no. of needles} \times 60}{\text{Count} \times \text{yards per hank} \times 36 \times 100}$$

$$= \frac{\text{no. of feeders} \times \text{no. of R.P.M.} \times \text{efficiency} \times \text{stitch length (in)} \times \text{no. of needles}}{\text{Count} \times 50400} \quad \text{FOR COTTON}$$

(840 yards = 1 hank)

$$\text{Or } \frac{\text{no. of feeders} \times \text{no. of R.P.M.} \times \text{efficiency} \times \text{stitch length (in)} \times \text{no. of needles}}{\text{Count} \times 33600} \quad \text{FOR worsted}$$

(560 yards = 1 hank)

Example1. A circular weft-knitting machine having 20 feeders, running at a speed of 25 rpm, is knitting fabric with stitch length equal to 0.15 inch with 756 needles in the machine. The efficiency of machine is 84% and the count yarn knitted is 18s. The fabric is knitted with 24 courses per inch. Calculate the production in yards and pounds per hour.

1. Yards of knitted fabric per hour

$$= \frac{20 \times 25 \times 84}{60 \times 24} = 29 \text{ YARDS}$$

2. Production per hour in lbs

$$= \frac{20 \times 25 \times 84 \times 0.15 \times 756}{18 \times 50400}$$

= 5.25Lbs.

Weight per linear yard

Instead of determining the stitch length, sometimes stitches per foot are determined. This is obtained by placing two marks on the yarn at a distance of one foot, as it approaches the needles and counting the number of needles between the marks as the yarn is knitted into cloth. This should be repeated several times to assure accuracy. To calculate the weight per linear yard by this method, the following formula can be used.

Weight per linear yard in lb

$$= \frac{\text{total needles} \times \text{courses per inch} \times 36}{\text{Stitches per foot} \times 3 \times 840 \times \text{cotton count}}$$

$$= \frac{\text{total needles} \times \text{CPI}}{\text{St/ft} \times \text{cc} \times 70}$$

Example2. A Single jersey fabric is made on a machine with 2040 needles with 28 courses per inch from 17s cotton count yarn and 80 stitches per foot. Calculate the weight per linear yard.

$$\begin{aligned} \text{Weight per linear yard} \\ &= \frac{2040 \times 28}{80 \times 70 \times 17} = 0.6 \text{ lbs} \end{aligned}$$

Example3. If four samples of four square inch each, weigh 32 grains (total weight) and the jersey fabric is 16- inch tubing, determine the weight per linear yard.

$$\begin{aligned} \text{Weight per linear yard} \\ &= \frac{9 \times 2 \times 16 \times 2}{1750} \end{aligned}$$

$$= 0.33 \text{ lbs}$$

Calculation of yarn diameter assuming a specific volume of 1.1

Indirect system

$$\text{Yarn dia. } d = \frac{1 \text{ inch}}{K \sqrt{N}}$$

Direct system

$$\text{yarn dia. } d = \frac{\sqrt{N} \text{ inch}}{K}$$

System	Value of K	System	Value of K
Cotton count	28	Denier	2036
Worsted count	22.8	Tex	678.6
Yorkshire skein woolen	15.4		

Example4. A 490- needle machine is knitting 25s cotton count yarn. What will be the theoretical width of the fabric?

$$\begin{aligned} \text{Yarn diameter} &= \frac{1}{28 \sqrt{N}} \\ &= \frac{1}{28 \sqrt{25}} \\ &= \frac{1}{140} \text{ inch} \end{aligned}$$

$$\text{Width of one wale} = 4 \times d = 4 \times \frac{1}{140} \text{ inch}$$

$$\begin{aligned}\text{Width of fabric} &= \text{needles} \times \text{wale spacing} \\ &= 490 \times \frac{4}{140} = 14 \text{ inches}\end{aligned}$$

Example5. What difference will be produced in the width of the fabric by changing from 36s c.c. to 25s c.c. if the width of the fabric is 20 inches with 36s count?

$$\frac{\text{Width of old fabric}}{\text{Width of new fabric}} = \frac{\sqrt{\text{new yarn number}}}{\sqrt{\text{old yarn number}}}$$

$$\begin{aligned}\frac{20}{x} &= \frac{\sqrt{25}}{\sqrt{36}} \\ : x &= 20 \times \frac{6}{5} = 24 \\ : \text{width of the new fabric} &= 24 \text{ inch.}\end{aligned}$$

Example6. What number of needles will be required in a cylinder to produce a fabric of 12 inch wide using 16s yarn?

$$\begin{aligned}\text{Yarn diameter} &= \frac{1}{28 \times \sqrt{16}} \text{ inch} \\ &= \frac{1}{112}\end{aligned}$$

$$\text{Width of one wale} = 4 \times \frac{1}{112} \text{ inches}$$

$$\begin{aligned}\text{No. of needles} &= \frac{\text{width of fabric}}{\text{Wale spacing}} \\ &= 12 \times \frac{112}{4} = 336\end{aligned}$$

$$\text{Total no. of needles in the cylinder} = 2 \times 336 = 672$$

5.3 Quality requirements of knitted yarn

1. *Yarn evenness:* Better knitting performance and better fabric appearance can be achieved with yarns having better evenness. Yarn containing large knots and slubs will result in excessive needle breakage, causing drop stitches and holes.
2. *Twist:* Soft twisted yarn give soft handle and bulkiness to the fabric. High twisted yarn make fabric rough and these yarns get snarled during knitting causing needle damage and fabric faults. Generally, the twist factor in hosiery yarn ranges from 3.0 to 3.4 luster and hand of fabric are affected by amount of twist.
3. *Count variation:* Higher count variation in yarn show thick and thin places in the knitted fabric.
4. *Neps and foreign matters:* Selection of fibers and processing in blow room, carding and combing departments should be given careful consideration for the better appearance of the fabric. The foreign matters present in the yarn such as jute, hair, coloured yarn, rubber, plastic pieces, cloth pieces, polypropylene etc should be removed in blow room and winding processes.
5. *Thick and thin places:* Higher number of thick and thin places and the undrafted places affect the knitted fabric appearance. Thick places due to poor opening and carding and undrafted places may damage the needles and thus result in fabric defects as well as increase in stores expenditure.

6. *Elasticity and elongation*: Higher tenacity of yarn does not always give good knitting quality. A good hosiery yarn should possess enough elongation to withstand tension during knitting and knitting action by the needles. The elasticity of yarn varies with humidity and temperature, spinning technique, single or doubled yarn with high (or) low twist.
7. *Resistance to friction*: During knitting, the yarn passes through several paths, and this will increase the friction unless the yarn and the paths are polished (or) smooth. Therefore the yarn to metal friction should be reduced to a considerable extent, otherwise yarn breakages, will occur and hence fabric damage.
The low coefficient friction value of less than 0.2 can be achieved by waxing the yarn either by passing through wax in winding or by wax emulsion method.
8. *Moisture content in yarn*: A very dry yarn impairs extension characteristics and also leads to fluff build up. On the other hand the coefficient of friction of the yarn increases with increasing moisture content. Moisture content in the yarn should be 10 to 14%.
9. *Winding package buildup*: knit yarn packages are generally offered with a iconicity of 5* 57' instead of 9*15'. A high friction yarn produces a harder package due to higher winding tension and this will knit a tighter structure. The package hardness can be assumed at around 0.4 kg/dm² for the practical purposes. The winding faults such as tight cones, soft cones, uneven winding, loose ends, double ends, thick places, thick knots, etc should be avoided.
10. *Knots and splices*: Generally the knot size will be about 4 to 5 times the yarn diameter, but in the spliced yarn, the diameter at the spliced point will not exceed more than 1.5 to 2 times the yarn diameter. Therefore, for knitting spliced yarn is an advantages than knot yarn. Generally, combed yarns offer a clean appearance, better lusture than carded yarns. Combed yarns are used in quality knit wear while carded are used for cheap varieties. Some knitters even use mercerized (or) gassed and mercerized yarn to make superior quality outerwear fabrics for export markets.

5.4 Control of fabric quality

A technician in charge of the quality control system should first prepare specification sheets of the fabrics to be knitted.

1. *Yarn specifications include*: supplier name, count, twist, colour. On this sheet the technician should make a mention of 'tolerances' allowed for each specification.
2. *Knitting machine setting sheet* should give information on diameter, gauge, knock over time, dial height, take down tension, needle specification, machine speed, yarn speed, course length, yarn tension, and cam setting.
3. *Fabric details* should include CPI of machine, WPI of machine, stitch density, weight per square meter, width of fabric and fault rate standard.
4. *Finishing details* should give the type of finish required.
5. *Final examination specification* should include weight per linear meter, width, standard piece weight, length, percent finish loss, fault allowance.
6. *Inspection of the fabric* will include check for uneven fabric, for patterning of coloured fabrics, for ladder running, for oil staining, for proper take down tension for barrenness.

5.5 Faults inknitting

Faults in weft knitting production can be caused in various ways and quite a few of them cannot be related to just one cause. These faults can be due to one or more of the reasons:

1. Material
2. Man
3. Method
4. Machine

Most of the faults related to Method and Machine can be attributed to have been occurring due to Man. The source of faults could be

- Faults in yarn and the yarn package
- Yarn feeding and yarn feed regulator
- Machine setting and pattern defects
- Machine maintenance
- Climatic conditions in the knitting plant

The faults can appear coursewise (horizontally), or walewise (vertically). Horizontal lines can appear due to material (uneven yarn, mixed yarns, uneven twist in yarn, poor winding from cones), machine (uneven stitch length, uneven take-down tension, uneven stitch cam). Vertical lines appear due to machine i.e. needles (bent needle, bent hooks, chipped latches, butts or broken spoons, worn needles, wrong needle, i.e. needle size not appropriate with the cut of the machine), trick slots (dirt in trick slots, defective or worn-out trick walls, needles too loose or tight in tricks), sinkers (stiff, sinkers ride high because of dirt).

Faults are very difficult in nature and appearance and are often superimposed. **Faults due to**

5.5.1 Material

Material used in knitting is yarn. It is used in cone or cheese form. Yarn faults show coursewise or horizontal appearance in knitted fabric. It is called as Barre Effect (Horizontal bars of real or apparent variation in dye depth extending across the full width of the fabric. It may be narrow or wide bands. or variable in thickness).

Fault category (YARN FAULTS)	Appearance, cause and remedies
Unevenness	Will appear as cloudy or wavy appearance in fabric.
Yarn count variation	Will appear as dark and light strips in fabric. Can cause holes, and bad appearance in fabric.
Spun-in (colour fiber)	Causes to appear as different colour fibre in the fabric.
Foreign matter, lint, bad knots and slubs	Will cause holes and cutting in fabric.
Short thick places, Short thin place	Will show as small strips. Thin places will also increase breakage during knitting, holes and cutting. Thick places can affect needle.
Long thin place, Long thick places	Will show on fabric as cloudy or wavy appearance. Long thin place will increase breakage during knitting, holes and cutting. Thick places can cause needle damage.
Twist	High twist yarn will cause snarls during knitting. It may also damage needles. This defect will increase curling of fabric causing problems in cutting and laying up of fabric.
Friction	Friction is an important factor in knitting. The yarn is less twisted and soft. It passes through many guides at high speed leading to friction. The friction between yarn and metal should not exceed

	0.17 otherwise it will lead to fly generation, spoiling of yarn leading to spoiled appearance of fabric, fly generation during knitting. So, yarn should be properly lubricated. .
Cotton mixing	If not properly mixed, the cotton from different filed has different dye uptake. It will lead to alternate bands of light and dark shades appearing coursewise.
Damaged or soiled cones	Will cause breakages during knitting. A soiled cone will also show the stain marks in fabrics.
Periodic variation	Appears in the yarn due to some defect of gear or roller in Spinning. It will show as patchy fabric.
Holes and cutting	weak yarn, yarns with bad knots and slubs, lint in yarn guide or eye-pots, stitch drawn too tight, stiff latch, unsuitable yarns number etc.
Bareness	Horizontal bars of real or apparent variation in due depth extending across the full width of the fabric May be narrow or wide bands. Or variable in thickness. May occur on a set or a variable frequency. Caused in the case of bulked yarns by a variation in bulk

5.5.2 Man

Oil spots or oil marks	Oily spots on fabric. Oil mark spread across the fabric at the end of the piece and possible spreading through other layers.	Mainly due to oil dripping onto the fabric as a result of over oiling of the knitting machine and a failure to remove the surplus oil, or malfunction of oiler. Spilling the oil on the fabric during lubricating. Failure on the part of the knitter, when doffing of the machine, to remove surplus oil from the end of the bar prior to removing the bar from the piece. Oil is spread across the inside layers or layers and may migrate to other layers.
Bareness	Horizontal bars of real or apparent variation in due depth extending across the full width of the fabric May be narrow or wide bands. Or variable in thickness. May occur on a set or a variable frequency	Improper setting of stitch cam. May be caused in the case of bulked yarns by a variation in bulk
Oil line	Vertical oily lines running down on or more wales. Intense at the one end and fading away.	Excessive oil on the needle. Improper cleaning of machine.
Dirty fabric		Keeping the fabric on the dirty floor.

		House keeping not proper.
Soiled yarn	An obvious dirty streak or streaks along a course or courses, or indeterminate length and coverage	Contamination of cones due to miss-handling with soiled hand.
Moiré marks	Water marks similar in appearance to ant forgery engravings on paper money	This fairly uncommon fault occurs when fabric processing a pronounced warp ways or weft ways rib structure is held under pressure with itself while standing or during finishing. Produces a visible wave form between embossed and non embossed sections of the fabric
Count mix up	Horizontal lines visible in fabric.	Either by wrong sticker of count on cone. Or while hadling, adding of a different count cone.

5.5.3 Methodology

Wrong count selection	Spoiling of the appearance of fabric. The fabric may appear too tight or loosely knitted.	Wrong (course or fine) count is selected for knitting a fabric. The fabric may appear too tight or loose
Different coloured fly knitted	Fluff of dyed yarn visible in the fabric (esp in grey fabric)	Different coloured yarn knitted in adjacent machines. Low house keeping. The fluff of one may accumulate in the other yarn.

5.5.4 Machine

The faults may come may appear in fabric horizontally or vertically. Horizontal faults appear due to cam or take down mechanism. Vertical faults appear due to needles.

Bareness	Horizontal bars of real or apparent variation in due depth extending across the full width of the fabric May be narrow or wide bands. Or variable in thickness. May occur on a set or a variable frequency	Due to variation in stitch cams used, unequal setting of knock-over on dial and cylinder at different. Feeders. Slippage or variation in take down mechanism.
Ladder defect	Appearance of distorted vertical loops.	Broken hook, broken butt.
Bow defect	The fabric appears to be bent towards one side.	Variation in take down tension.
Missing loops		Gaiting in rib or interlock. Timing of needles and sinker.

Drop stitches	Ladder of length dependent upon the vigilance of the knitter	slack yarn tension, stiff latches, take down mechanism too loose, latch not opened, needle timing set wrong, needle slots clogged with dirt, machine running too fast, positive feed slippage, wrong stitch setting
Distorted stitches		bad or bent needles, incorrect positive setting, uneven yarn tension, bent trick walls, needle timing wrong, improper stitch cam setting
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	faulty stop motion, plugged yarn guide with lint, bad yarn, machines running fast, bad knots and slubs
Loop accumulation	Bunch of loops appear	

5.6 Robbing back

As the needle moves down, it needs more yarn to pull down. This yarn has to be pulled through the yarn fed to the other needles and hence a very high tension has to be developed to draw the yarn in then direction. Yarn is, therefore withdrawn from the loops already knitted, as it is easier to do so. A certain amount of yarn is thus 'robbed' back from the loops already knitted. The actual stitch length is therefore reduced to less than the theoretical stitch length, even at the minimum tension of say 2g. The minimum length robbed back is about 30 per cent of the theoretical stitch length.

At the much higher tension, this robbing back can occur from the yarn fed to the preceding needles. If one loop is to knock over successfully some of this robbing must occur, otherwise it will never be able to slide over the hook and latch. However if a very high tension develops, the yarn breaks or becomes distorted. To avoid this, the stitch should be knitted at low tension depending upon the strength and elongation of the yarn.