Science and Technology of Weft and Warp Knitting
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Lecture - 35
Weft Knitting - Revision

Welcome students. Now, we are moving to week number 8. So, far from week number 1 to week number 7, we have covered several aspects of weft knitting including its science, principles, technology, design and engineering. So, before I move to next topic, let's do a quick revision of whatever topics we have covered so far. I know there are so many topics we have covered in weft knitting.

So, it is always important that you put everything in on the same page so that you can connect the dots of each topics because if you really want to be an expert in weft knitting, you need to take science, technology, design and engineering parallelly, then only you will be a real expert in this weft knitting. So, let's do the quick revision and I hopefully with this revision you would be able to connect each and every lecture which we have covered so far throughout this course.

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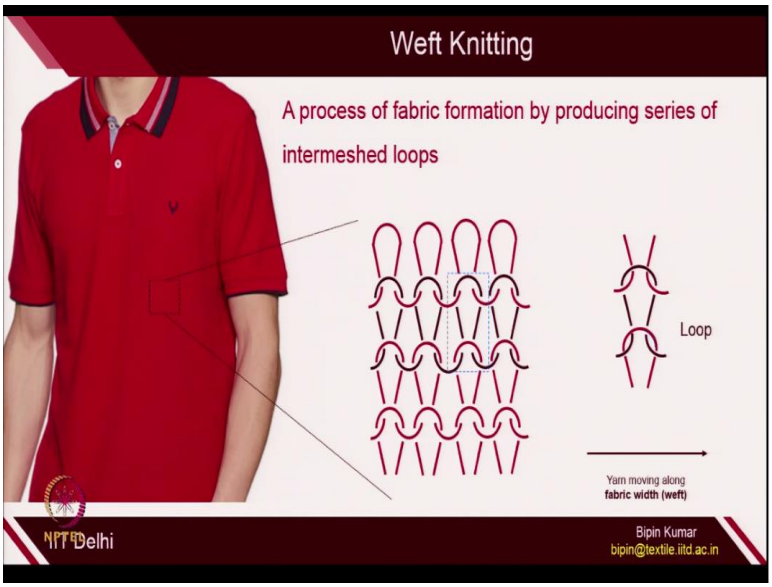

So, weft knitting, we started this lecture by introducing you a normal T-shirts in our daily routine, which is nothing but a knitted structures. We define this knitted structure as a fabric formation by producing intermeshed loops. So, if you see the fabric using microscope, you

will get that there is certain kind of loops, which are intermeshed inside this. So, if you see a weft knitted structure, it is nothing but intermeshing of loops.

So, the fundamental block, which is used to make a knit structure, is a loop and this loop are actually intermixed with an old loop at the feet position and at the head position intermeshed by new loop. So, for a perfect stable loop structure, you can see there are 4 intermeshing points because of that the loop architecture is like that. If you remove any one of the intermeshing loops like if you remove the old loop or if you remove the new loop from the main loop, the structure of the loop will not be stable.

So, to start with knitting, you need to first understand the importance of the structures, the importance of loop geometry and in the process of weft knitting, we have also seen that these loops are actually connected along a row. So, this row is nothing but the it is analogous to a weft direction in a weaving. So, that's why this type of structures where the yarn is moving along the row or along the weft directions, this type of knitting is called weft knitting.

So, here the direction of yarn is from left to right or right to left. So, that's why this is called weft knitting. So, we started this course by introducing weft knitting, which is the yarn movement along fabric width. In the weft knitting, we focused mainly on loop formation, engineering aspects. We showed you lot of technologies related to weft knitting fabric production. We also showed you lot of designs.

And we also showed you lot of engineering aspect, how you can control the structure and its property. So, let's do a quick recap of all of those concepts which we have covered in this course.

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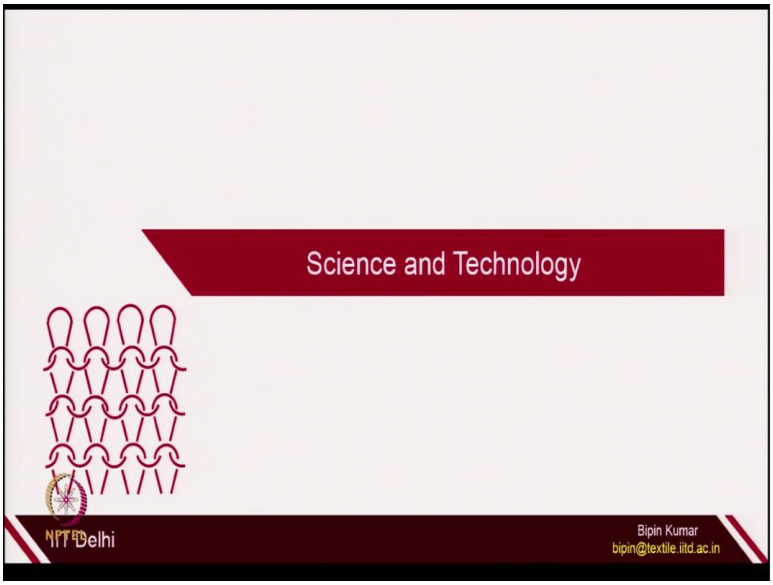

So, first part was science and technology. So, whenever you do any course in textile engineering, you need to understand its science because that's very much important because once you understand the science or the principle of formation of that particular structure or that particular finishing process or that particular yarn spinning process, it will be very helpful for you to understand the technology aspects.

So, whatever technology we are looking in daily routine, it comes actually from the science aspect. So, science is the pillar or the foundation of anything, any technology which is generated in today's world.

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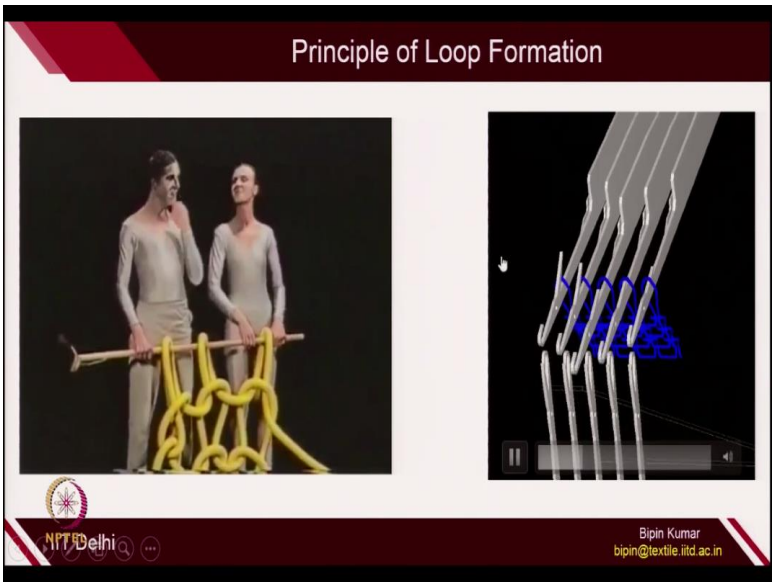

So, in weft knitted structure also, we try to understand the principle of loop formation. So, if you see, I showed you a very simple animations, how you create a loop in a weft knitted

structure. So, here there is 2 jokers, they are actually making the loops. So, the yarn is actually getting pulled from one side of the loop to the other side. So, this is how you actually create a loop inside a fabric structure.

And then you can see, you are moving along the row from left to right or right to left. So, this is how you are making the loops in a weft knitted structure. So, this principle is very important, how you actually make the loops in a knit structures. Once this principle is clear to you, you can formalize this kind of movements because this is all a mechanical movement. Now, the mechanical technology is so strong that you can replicate the entire movement of hands with the help of some kind of mechanical assemblies.

So, the same formation of loops can be done with the help of needles. So, whatever these 2 people in the animation is doing, the same thing the needles can be doing with a much uniform and an accurate way. So, you can see it here in the animations also the same thing, it is catching the yarn, pulling the yarn from one side of the loop to the other side. So, this is how you create loops in a weft knitted structure.

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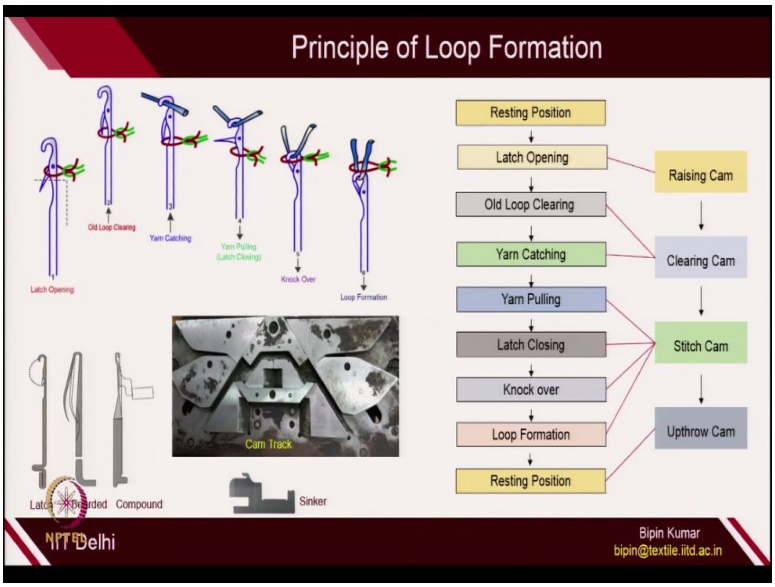

So, principle of loop formation is extremely important in understanding the knitting. So, we have seen that the needle play a very very important role in loop formation. So, needle is the heart of knitting. So, we started from the old loop, then old loop is clear, then new yarn is catched by the needle and then the yarn started pulling this yarn through the old loop and then old loop is knocked out from the needles.

So, this sequence starting from clearing of old loop, catching of yarn, pulling of yarn, knocking out of loop and formation of loop from the needle is important and this sequence has to be followed for formation of any loop in a knit structure, in a weft knitted structures and we have seen that needles and cam actually operates together to make the sequence happen in a machine.

So, we have 3 types of needles usually used in knitting; latch needle, beard needle and compound needle. Latch become very very popular because it is a self-actuating needles. The latch automatically opens automatically closes because the nature of the needle is like that so you do not need any additional movement for latch closing and opening. The loop itself helps to open the latch here and you can see here the loop itself helps to close the latch.

So, that's why it is a self-acting needle, so it is very very popular and cam is extremely important to make sure the needle follow this sequence. So, the cam designing is extremely important. I discussed this in many lectures. Cam designing for circular bed, cam designing for flat bed, cam designing for V-bed. We also have seen the additional element which is called sinker, which is mostly popular in circular knitting machine.

If you recollect the week number 2, we described like in certain machines like circular machines, sinker play a very important role in holding the loops, formation of sinker loops and giving support surface to the fabric. So, each of these 3 elements; needle, cam and sinker, they work together in a synchronized way for the formation of loops on machines and the sequence should be very accurate.

So, you start from the latch opening which raising cams is doing, so raising cam is this one, you can see it here. So, this is the first time the needle bed interacts. Then, old loop is getting cleared in this process, which is due to clearing cam. So, this is the clearing cam, this part which I am showing in the arrow. So, old loop is cleared this and after that yarn is getting catched somewhere at this position.

And stitch cam this part is the most important cam in the cam jacket which helps in yarn pulling, latch closing, knocking of old loop and finally loop formations and finally the resting position is received once the needle bed interacts with the upthrow cam. So, the sequence of

this height, which is received by the needle, is done because of the placement of the cam in a certain way.

The raising cam first interact with the needle, then clearing cam, then stitch cam and then upthrow cam and they are placed in such a way that all of these functions are achieved during loop formation. So, this principle is very important and based on that different technologies has been derived. So, we have also covered many technology aspects in weft knitting.

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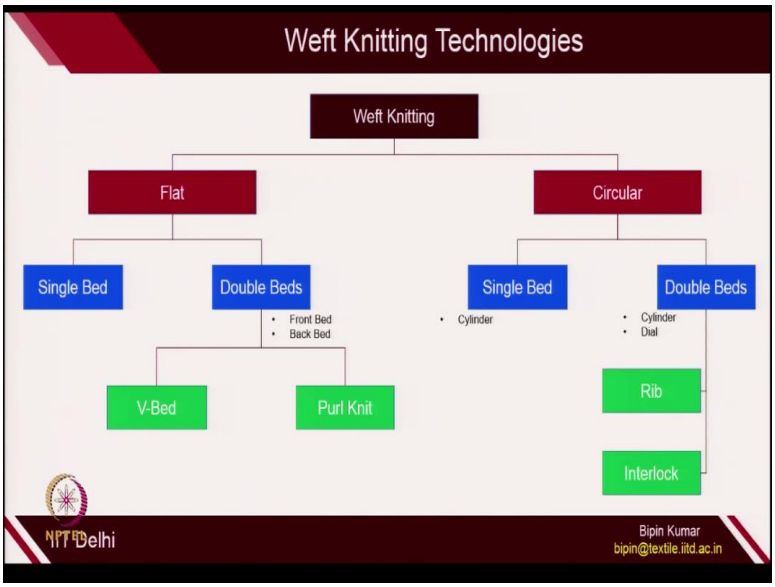

So, in weft knitting we have seen flat knitting, so where the needles are placed on the flat bed. We have also seen technologies related to circular knitting where the needles are placed on a circular bed just like cylinder. So, in flat also we have seen single bed knitting where there is one set of the needles is operating and double bed knitting where you have two sets of needles, front bed and back bed.

So, in double bed category also we have seen V-bed where both the beds are placed at 90 degree each other in the form of inverted B and we have also seen the purl knitting machines, which creates purl fabrics alternating courses are technical front and back and this is done by the help of double latch needle. So, these are the technologies which you will find in daily routine. I am not going in the functioning of these beds but overall technologies is defined in terms of flat knitting machines and circular knitting machines.

In circular knitting machines, we have also seen the machines related to single bed where there is only one cylinder. We have also seen machine related to 2 beds where there is a

cylinder and dial. So, in double bed circular knitting machines we have seen machines rib where needles are placed in the form of rib gating and interlock machines where needles are facing each other and there are 2 sets of needle long bed needle and short bed needles.

So, in weft knitting whatever company you follow, their technologies actually falls in some of these categories. Nowadays, full garment machines are also coming which is little bit complicated but overall the principle of loop formations remains same and either it will comes on the flat knitting or circular knitting. I have shown you the lab demo of operation of these machines. I have also shown you what type of fabric samples which you can create on these 2 types of machines. Let's do a quick recap of all those.

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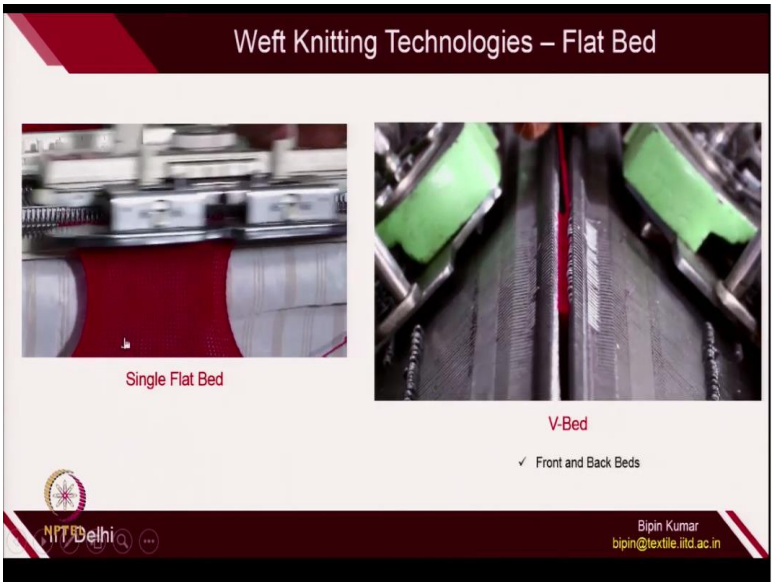

So, in flat knitting technologies, I have introduced you a single flat bed, which is the most popular one and so many type of simple garments like sweaters, T-shirts can be formed on single flat bed machines. So, here you can see the cam jacket is moving from left to right and right to left and you are creating fabrics. So, you can change the width, you can change the color, you can do the narrowing, you can do the widening of the fabrics with the same machines.

And the second machine is the V-bed machines where there is 2 beds. One is front bed, the other one is back bed. It depends on where you stand in front of the machines. Here, 2 sets of needles are operating simultaneously. So, here needles are not facing each other because if they will face each other, they will collide. So, these are the 2 technologies in flat knitting categories.

In V-bed, there are lot of innovations has been done and jacquard knitting machine has comes in the pictures in which you can individually control each needle of each bed. So, that really gives you a lot of design possibilities, but we have shown you the working principles and we have shown you the demos and we have also analyzed the fabrics which has been produced in both of these two beds.

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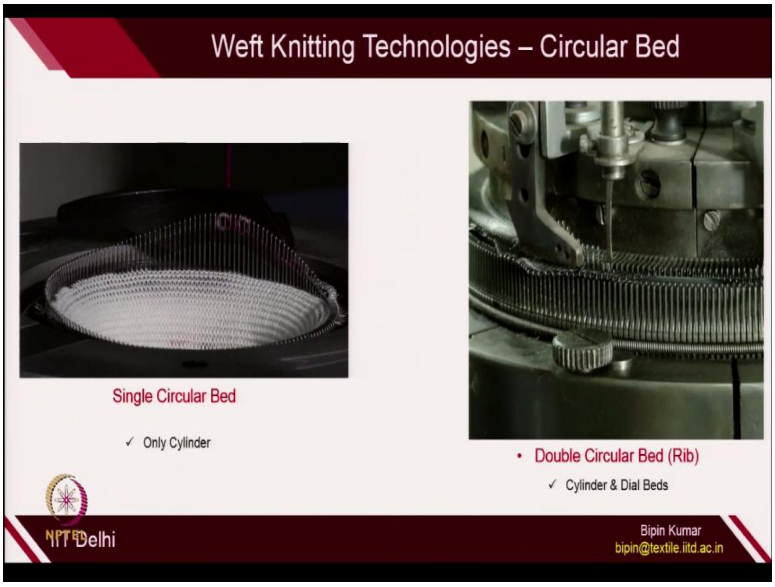

In circular knitting also I have introduced you 2 types of bed. One is single circular bed, so where you have just 1 cylinder, you can see it here just 1 cylinder and the cam is rotating and cylinder is fixed and the needles are catching the yarn and forming the loop. Double circular bed, you have 2 beds, one is cylinder bed and the other one is dial bed where the needles are placed in the radial directions.

So, you can see the needles are placed in radial direction, the other one is the needles are placed in cylinder directions. So, this is the double bed circular knitting machines. So, if you know the principle of loop formation of any one of the bed, they just remain same for all of the technologies which is there in weft knitting. The only difference is how you are placing the needles. So, the gating machine gauge, the placements becomes a key aspect which you should look in any weft knitting technologies.

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Now, once the technology aspect is clear, then we move to designing the structure and doing its analysis. That is the most important aspects because as a engineer, once you have understand the science and technology, you should use your own creativity to design the fabric and get correct engineered products depending on what type of applications you want to achieve.

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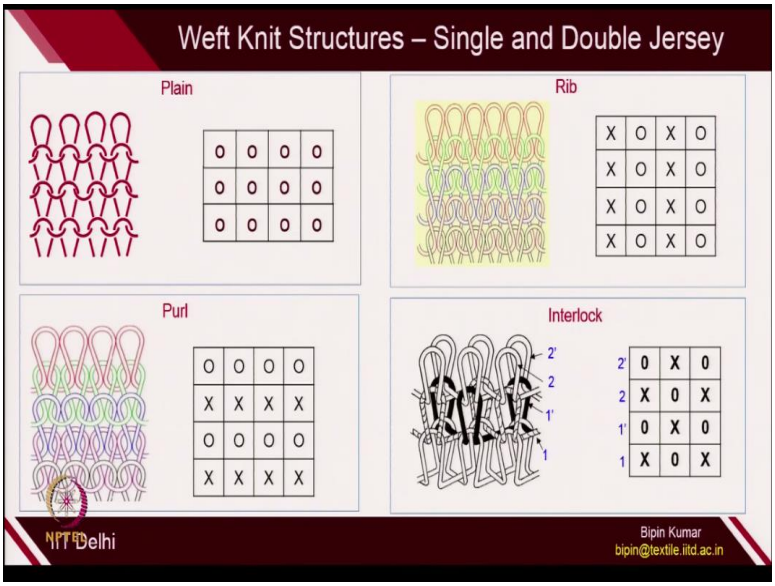

So, in the designing and analysis part, I have shown you there are like 2 types of fabric structures, which you can create. Single jersey structure and double jersey structures; so in single jersey structures we usually create either technical front loops or technical back loops. So, this type of fabric is called plain knit structures and the other categories are double jersey structures, which where you are using the capability of both technical front loop and technical back loops together.

So, there is certain limitations when you create plain fabrics because of the curling I showed you like how the plain fabric curls from the edges and because of that the fabric remain highly unstable during sewing and many other purposes. So, that's why the edges of the fabrics we need to make sure they remain stable. So, there double jersey structure comes into the pictures.

And because of the limitations of single bed, the technology moves towards the development of double bed and in the double bed machines, usually we create double jersey structures where you have the combination of technical front and back loops on the same surface. So, the first structure is the rib structures where in the same course you have technical front loops and back loops, technical front loops and back loops in the same course.

In the second structures, is the purl structure where alternating courses are technical front and back. So, here you have technical front loops, second course you have technical back loops, then front loops and back loops. So, this comes under category of purl structures. The third structure which is the combination of 2 ribs is called interlock structures. So, this is usually created on interlock circular knitting machines.

We can also create this on jacquard knitting machines but the idea here is here we have to create 2 rib structures using 2 yarn feeds. So, in the same course, half of the needles will be operating, in the next course second half of the needles will be operating from both the bed. So, this is how you create the interlock structures. We have also seen how these 4 structures, the properties are different.

Interlock fabrics are non-extensible and very heavy. The thickness is also high. If you see the rib structures, it is more extensible especially in width directions. Plane fabric is the lowest thickness and it curls from the edges. There is lot of difference you can observe in all of these 4 structures. They play a very important role, it depends entirely on the designer aspects like how you want to place each of these structures at different segments of your T-shirts or sweaters or any garments which you create from weft knitting technologies.

Apart from these type of structures, we also focused on some other aspects where we can control the elements inside the knitted structures.

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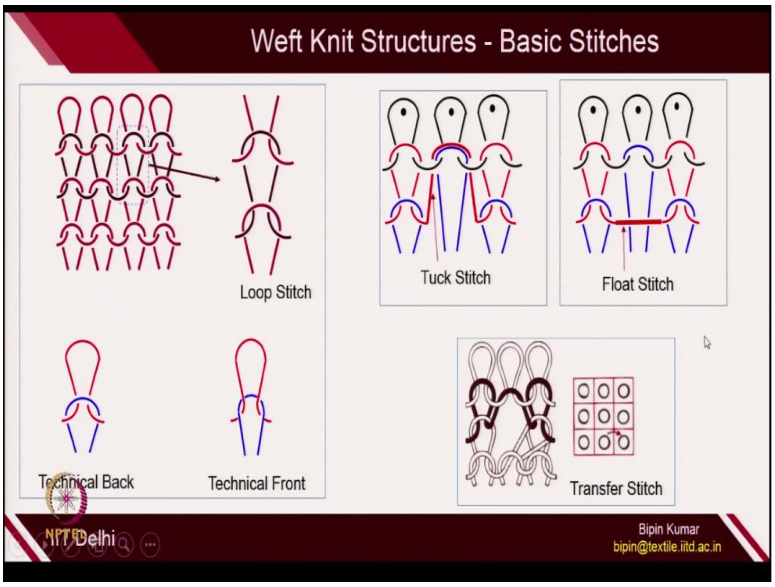

So, we discussed about the basic stitches, the principle of basic stitches where the normal type of garments you can either find technical back loops and front loops but in reality when you are going for more advanced structures, you need to use the potential of other stitches like tuck stitches which is you can see here the old loop and the tuck loop, they are held together in the needles.

And here the tuck loop is open up because there is no old loop, which is holding the legs of a tuck loop. So, tuck stitches I have already described. Sometimes, we intentionally put tuck stitches inside the fabric structures to get some property. In float also we can sometimes intentionally want the yarn to be floated so that we can control the extensibility or we can control the stretchability of the fabric or we can hide certain yarns from one side to other side.

Float stitch is also very popular. We also describe the importance of transfer stitches where you can transfer the one loop from one column to other column because of that you create a half loop where you can see this black one, this head is intermeshed but the legs are open because the old loop is missing for the black loop here at this point because of that you can create a pointelle, you can create a hole inside the fabric structure.

So, irrespective of whatever structure you see in knitting, they will made up of all of these 4 basic stitches either technical back stitch, technical front stitch, tuck stitch, float stitch or transfer stitch. So, irrespective of any structure which you see in daily routine, they will be

having the combination of these types of structures. If it has only technical match, it will become a plain loop.

If it has the combination of both together, it will be a rib or double jersey structure. Sometimes if you want cable, pointelle, you need to include transfer stitches as well. The idea here is you need to understand the principle of formation of these types of stitches.

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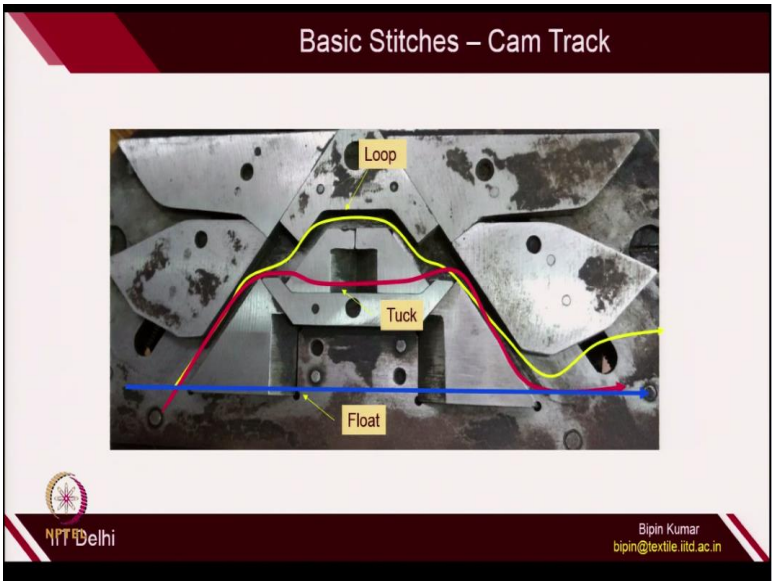

We also have given you demonstration how you can create loop stitch, tuck stitch and float stitch. So, in case of loop stitch, all the cams are activated and needle beds actually follows this path, it hits the raging cam, then clearing cam, then stitch cam and finally it hits the upthrow cam to get back to its original position. So, in this case, you are creating loop stitch, that loop stitch could be either technical front loops or technical back loops.

The second stitch is tuck stitch where you actually deactivate the clearing cam, you create a tuck loop, here the needle does not rise to the maximum height, so old loop is not cleared, it only just catches the yarn, keeping the old loop still in the head and finally the last loop is the float loop where raising cam is deactivated and finally you get a structure where there is a float. So, these are the 3 cams profile which is important for creation of a loop, tuck and float in a fabric structure.

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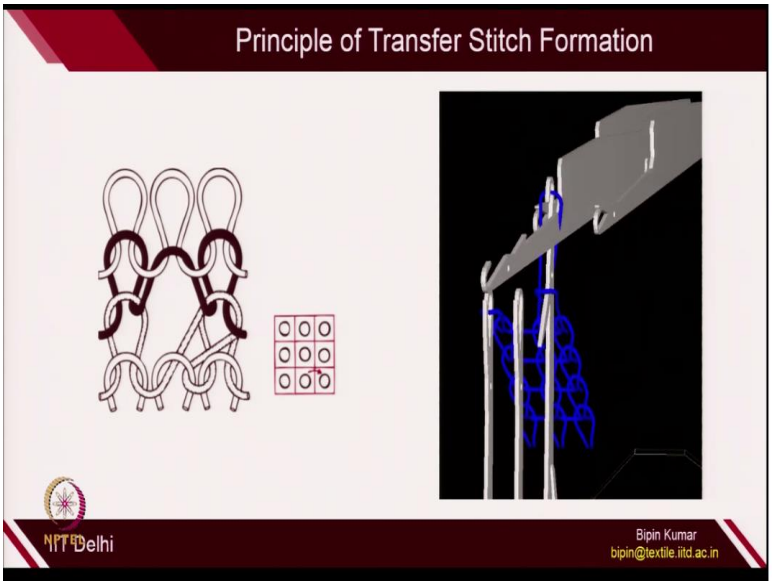

We also have demonstrated you the principle of transfer stitch formation. If you really want to transfer the stitches from one column to other column, the machine should have the potential of racking and loop transfers. So, this is how you can do it. So, the first the loop is transferred from one bed to other bed and then with the help of racking, the bed can be shifted and again with the help of transfer function the loop can be transferred from one column to other column.

So, this is how you create a transfer stitch in the fabric structure. So, these 4 principles it should be clear in your mind that how you create loop, tuck, float and transfer. Once that is clear to you, you can create any fabric design and it will just depends on your imagination and the capability of technologies that you are interacting and you can create any type of knit structures.

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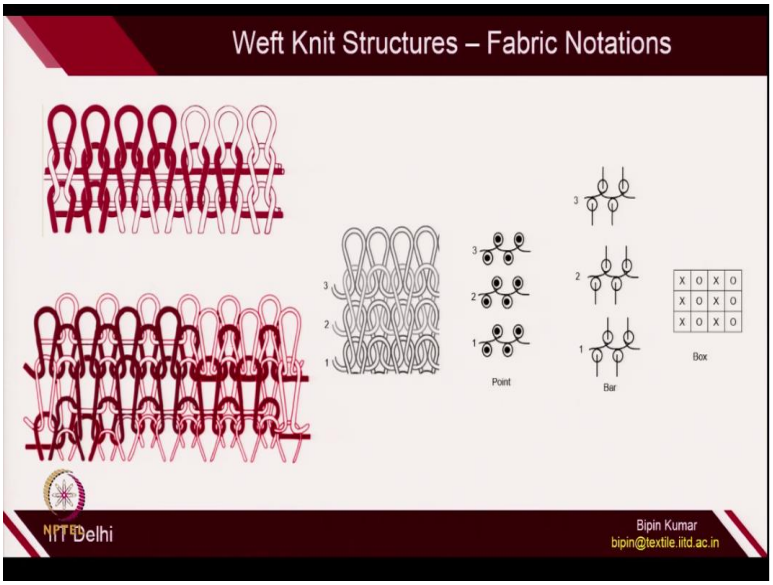

So, the structures could be very complicated. You can see it here, sometimes you can create jacquard fabrics, sometimes you can create normal front and back loops but whenever we create a fabric structures, it's practically impossible for a human to draw these types of diagrams if the structures become heavily complicated. So, that's why in real world we use fabric notation to describe the weft knitted structures.

And notations that can be done with the help of point diagram, bar diagram and box diagram. So, I have shown you lot of examples, how you can actually represent a fabric structure with the help of point diagram. So, where you have points represent the needles and the path of the yarns can be followed depending on whether the loop is technical front or back. The most simple one is the box diagram where each box represents the loops whether it is a technical front loop or technical back loops.

If it is a tuck loop, you can simply place dot, if it is a float you can simply put blank box over there and in case of bar diagram also you can replace the needle with the help of bar. If you go to any country, any region, anywhere in the world, they will be following either of any one of these notations. So, if this thing is not clear to you, you must remember and understand the principle as well as designing aspects of fabric notations.

So, once this is clear, any literature which you follow in knitting it will be a very cakewalk for you because once you know in which course what type of loop stitches is being formed, you can visualize the entire fabric structure in one go. So, once designing aspects is clear,

once notation is clear, you can create any number of fabrics and try to understand its properties.

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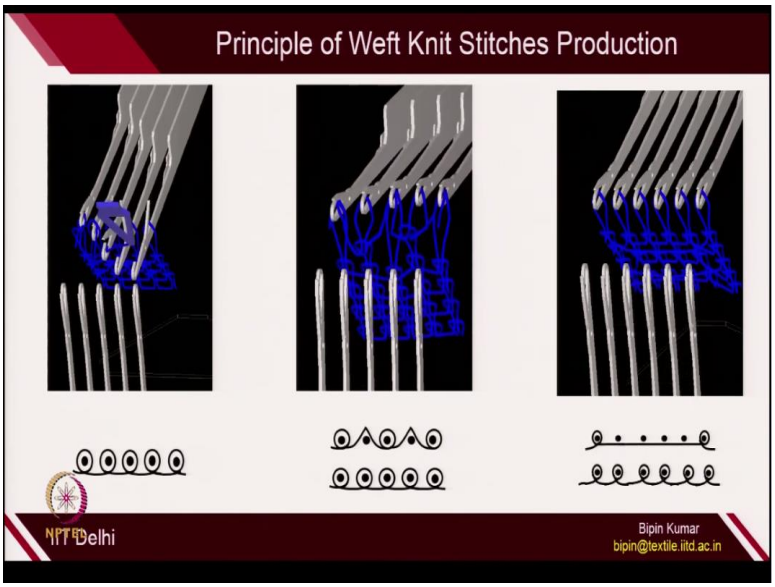

Here, I have given you some hint like how you can create a normal plain fabric, how you can create tuck stitches and how you can create float stitches with the help of technology itself. So, here the first video is showing, every course it is making technical back loops because we are actually using back bed. So, you can see it here, all are making same course. If you want to create tuck, if you follow the principle, again if you see the notation, the first course is making loops.

Second course, alternate needles are making tuck in the same bed. So, here the animations should be clear to you, so you can see the first course is making loops, so this is the first course. In the second course you can see this needle, so here this alternating needles are making tucks. So, you can see 2 heads here. So, you created loop, then you are going to create tuck.

So, you can see here. This needle is having 2 heads. This needle is also having 2 heads and this needle is also having 2, so alternating needles are having tuck. So, once tuck is formed, you can again run the machine on the loop form and here you can see the float has been created. So, first course normal loop, the second course the float. So, you can see the first course is normal loop, so this is the first course and second course is float.

So, here you can see these 4 needles. So, these 4 needles does not move at all. So, this is how you create a float architecture. So, once principle is clear, it's up to you what type of fabric structure you want to create. So, these structures will not only be different in terms of looks but also their property will be different. So, I have given in the lectures also, I have shown you how their property will change when you have tuck loops and float loops and normal loops in a fabric structures.

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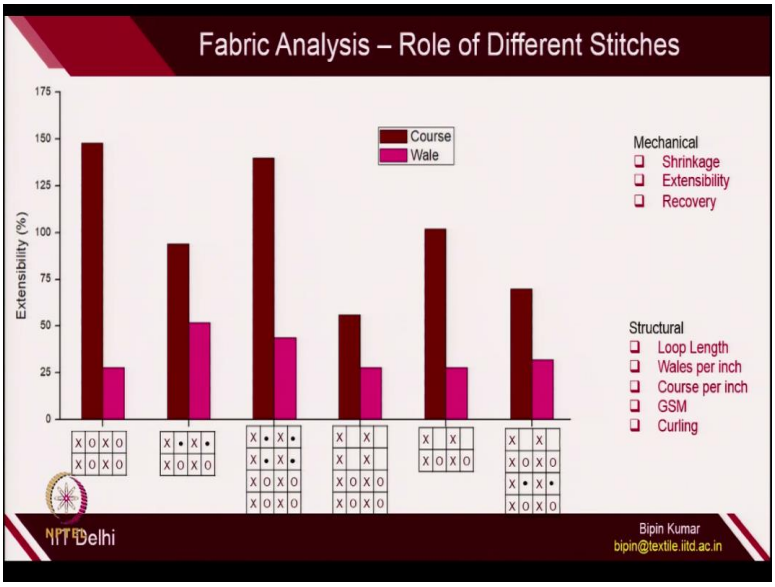

So, fabric analysis we have done like how you can control the extensibility. Extensibility indicates how much you can extend from its original length in course wise and wales wise. So, you can see here for a normal rib structures, the extensibility in course direction is very high but once you have float, the extensibility in course direction is reduced. You can imagine how important is these stitches in the fabric structures.

They are not just for designing but they are also useful in engineering aspects by controlling the properties of fabric depending on the user's requirement. So, I discussed about lot of mechanical properties that could be controlled by the help of stitches. You can control the shrinkage, you can control the extensibility, you can control the recovery aspects. Also, you can control the fabric permeability by controlling wales per inch and course per inch.

You can control the GSM; you can control the curling aspects of the fabrics. So, all will depends on what type of stitches you are putting inside the fabric structure. So, I request you all, you just not only remember these aspects but also try to make these fabrics and do some

analysis yourself because then only you will appreciate the importance of these stitches in the fabric designing as well as fabric engineering.

Once design engineering and technology and science is done, I also introduced some of the calculation aspects. It's rarely you will find any important book where all the calculations will be listed in the same platform.

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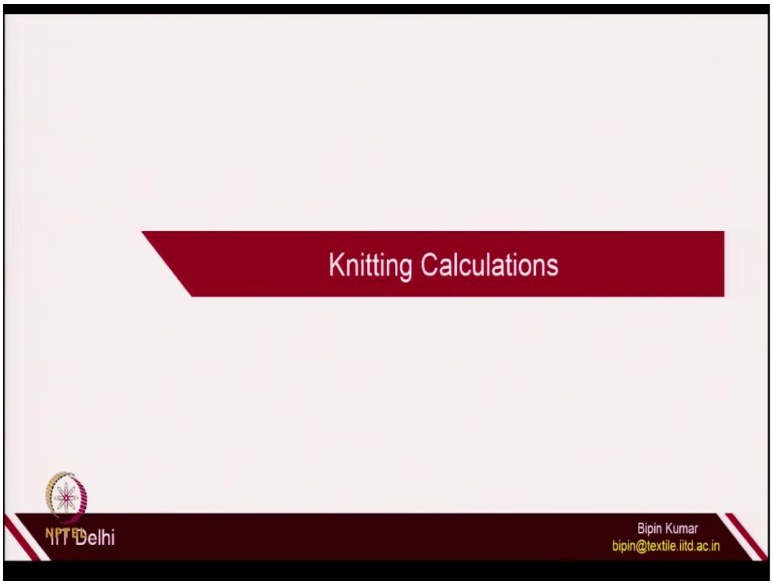

Because you have seen in knitting, there are different varieties of fabric structures and each structure has its own importance and it again depends on the creativity. So, it's very difficult for anyone to give the formula, which is applicable to all type of structure or all type of technologies. So, that's why knitting calculations is very restricted and they are just proposed for only simple type of technology or simple type of fabric structures.

So, I also picked some of the important topic where I used plain fabric and flat bed and single bed circular knitting machines and I proposed some of the calculations related to simple fabric structures and simple weft knitting technologies.

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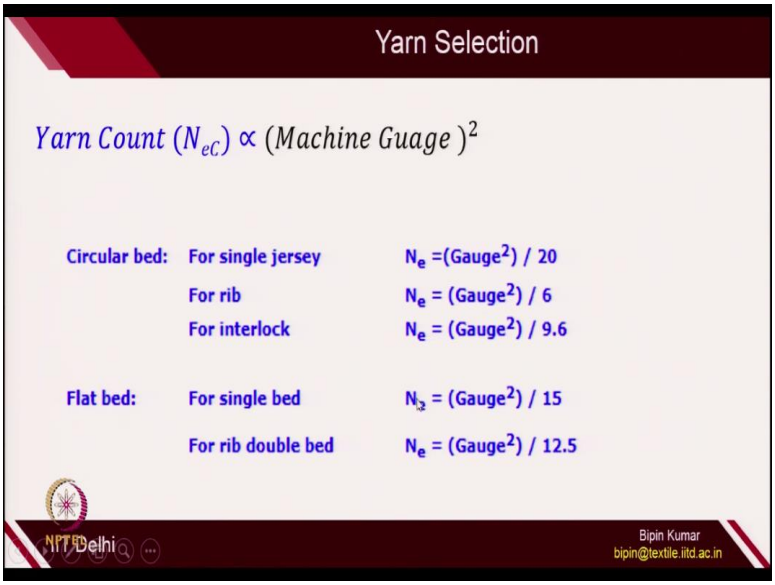

Those calculations are first one what type of yarn count we should be selecting because yarn count we cannot run any yarn on any technology, so it is very important, you need to understand the machine gauge, machine gauge is nothing but the number of needles/inch which is there on the machine bed. So, depending on the distance between 2 needles, you need to decide the diameter of the yarn.

And diameter of yarn is again related with the count, so the count whatever count you want to select, it is directly proportional to the machine gauge square. So, for different technologies for different designs, you need to have different formulas. Please remember, these formulas are just empirical formulas, it has come from the experience. This is nothing to do with the theory or any science which is involved here.

It is purely based on experience and empirically they have derived. The users have used different counts of the yarn and they realize for a particular gauge only this type of counts can be used. For example, for single jersey circular bed, the **yarn count = (gauge)^2/ 20**, for flat bed if you are using single jersey fabric, the **yarn count = (gauge)^2/ 15**. So, you can see for the single jersey fabric when you are using single bed and circular beds, the count is different.

So, in circular **yarn count = (gauge)^2/ 20**, in flat **yarn count = (gauge)^2/ 15**, so it again depends on how smoothly you can run a particular yarn on the machines, this is again depends on the experience of the technicians which is running the machine. So, this comes from a vast year of experience, they have done it for like 20, 30 years and they come up with

these type of useful relationship. Please remember when you change the yarn type or when you change the twist in the yarn, these relations might not be valid.

So, this is just for your simple understanding but these relations will keep on changing depending on the technology as well as depending on which type of fiber and twist you are imparting in the yarn. So, for example the formula can be different for cotton yarn, the formula can be different for wool yarn, the formula can be different for high twisted yarn, low twisted yarn. So, again this is very important for all of you to realize the important of yarn selection.

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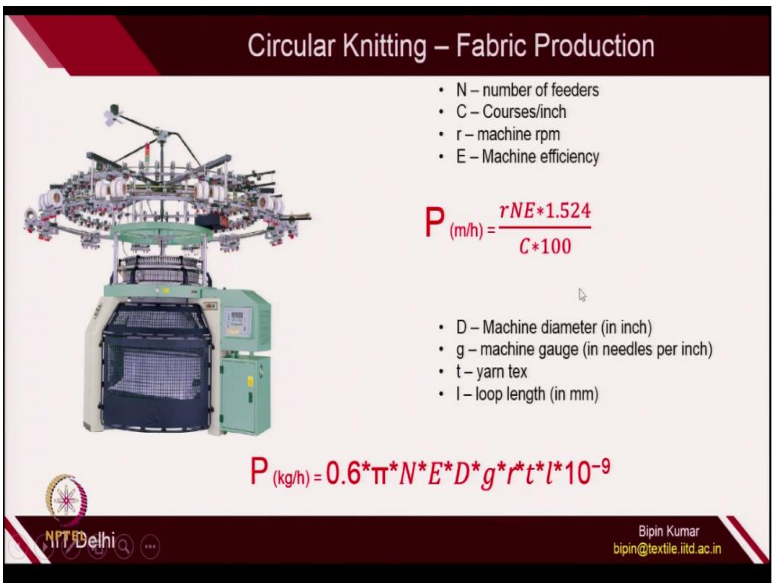

The second thing which I focused was the fabric production because company is mainly interested is how fast you can produce the fabric. So, we give you some of the important relationship where the production can be realized with the help of machine variables and fabric variables. So, if you know the **course/inch** and the rpm of the machine and number of feeders of the machine, you can find out the production in **meter/hour**.

If you want to find the production in **kg/hour**, again with the help of some other parameters, the relation is given to you. I have also given you some of the examples; we solved this in the class also. I hope you can revise those examples for getting understanding of this fabric production on circular machine.

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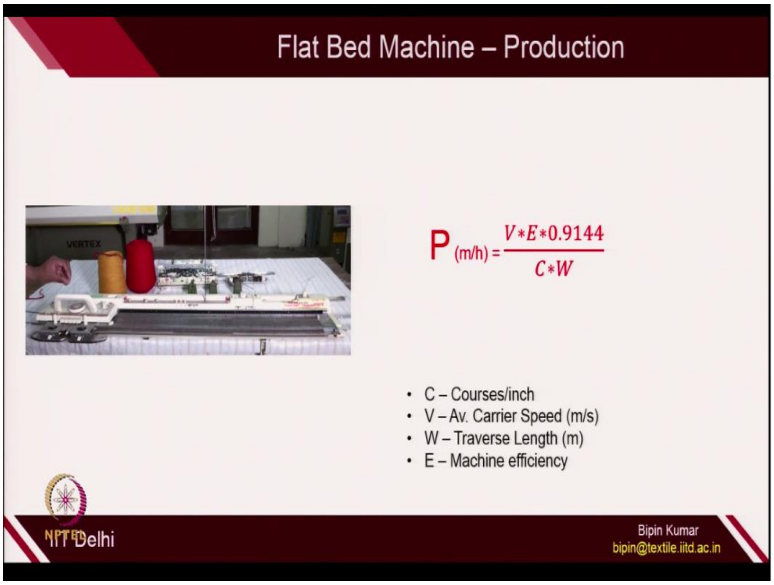

Similarly, on flat bed machines, again you can calculate the production in **meter/hour** and **kg/hour**. The formula is given to you V is the carrier speed, E is the efficiency of the machine in percentage, C is the **course/inch** and W is the transverse length, how much needles you are using on the bed and how much length it is acquiring on the bed. So, with the help of these simple formulas you can calculate the production on particular technologies.

Please remember, production will keep on changing depending on the design of the fabric. So, whatever formula I am giving to you, it is not applicable for all the designs and all the technologies. So, please you need to derive these formulas depending on what type of technologies you are using for fabric production and what design you are creating on the machine. So, I have given you the process of derivation of these 2 formulas.

So, once you know that process, you can derive the equations for other type of technologies as well. So, please follow the same process in the production calculation on different technologies.

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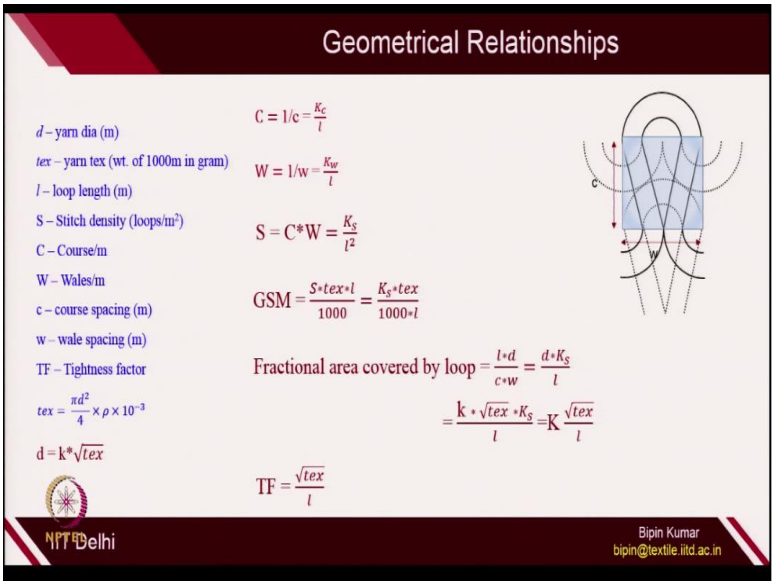

Other thing I described was geometrical relationship for finding the relation of loop length with other fabric structural parameters. So, we found like some scientists in 1950s and 60s, they found that the loop length is the most important parameter in a knit fabric and most of the structural characteristics can be explained by loop length. So, they proposed especially it was the Munden who proposed Munden constants through which once you know the Munden constant, you can find out the course per inch of the fabric using loop length.

Similarly, you can found wales per inch of the fabric using loop length, you can find stitch density which is number of **loops/inch^2** with the help of loop length, you can also calculate the GSM. **GSM = gram/meter^2** of the fabric with the help of Munden constant, yarn tex and loop length.

We have also introduced the importance of tightness factor, which relates how tight is the fabric is like it actually relates how much area the yarn is occupying in the fabric surface. So, fractional area is actually related with the tightness factors with some constants. So, if you know the tightness factor, you can derive lot of physical properties like which fabric will be more porous, which fabric will be more permeable if you know the tightness factor.

So, **Tightness factor = tex$^{1/2}$/loop length**. So, again if you see all these relationship, loop length becomes a very key parameter. So, that's why this type of geometrical relationship is extremely important and very useful in comparing fabric properties. Please remember again, these type of formulas are only valid for simple type of plain knit structures.

This is not applicable for all the fabrics where you have tuck design or float design or where you have transfer designs. There you need to go for different types of derivations especially all these derivations is only applicable for plain fabrics. So, I have given you the step-by-step derivations of each of these formulas. So, once you want to derive for any other fabric designs, please follow the similar steps.

And you can follow some other literature's which is available and you can get some other geometrical relationship for other type of fabric structures.

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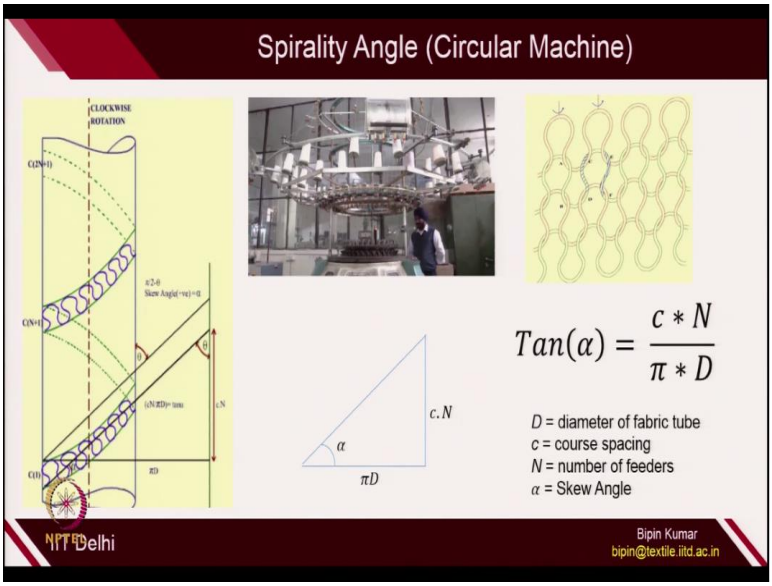

Last because circular machine is very much used where multiple feeders are used in the same course, so that's why spirality angle, so the yarn which is used to make one course. The course actually follows the spiral path because of the nature of the fabric production. So, you can see the course actually follow certain angle, so the symmetric of the fabric is lost. So, that is called spirality.

So, you can have positive spirality, you can have negative spirality, so depending on the rotation of the fabric and number of the feeders, diameter of the machine and the course spacing you can get the spirality angles. So, if you want to minimize the spirality, you can go for S-twisted yarn or Z-twisted yarn depending on what type of spirality you are creating because of fabric production on multi-feeder circular machines.

This is again a very small topic. There are lot of other calculations related to knitting is there in the literatures but I think that is not the part of the scope of this particular course. I

recommend all of you to please follow those derivations and calculations from other literatures and try to understand the other aspects. So, I have carefully selected those topics which I can relate with my previous lecture. So, that's why I have chosen some of these topics in knitting calculations.

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After that, once the basic science, technology, design and engineering was covered, I jumped to advanced knitting technology and design where I have given you the importance of advanced machine which is you can find in the market especially jacquard knitting machines where you have many advanced functions especially racking and loop transfer which is not possible in manual V-bed machine.

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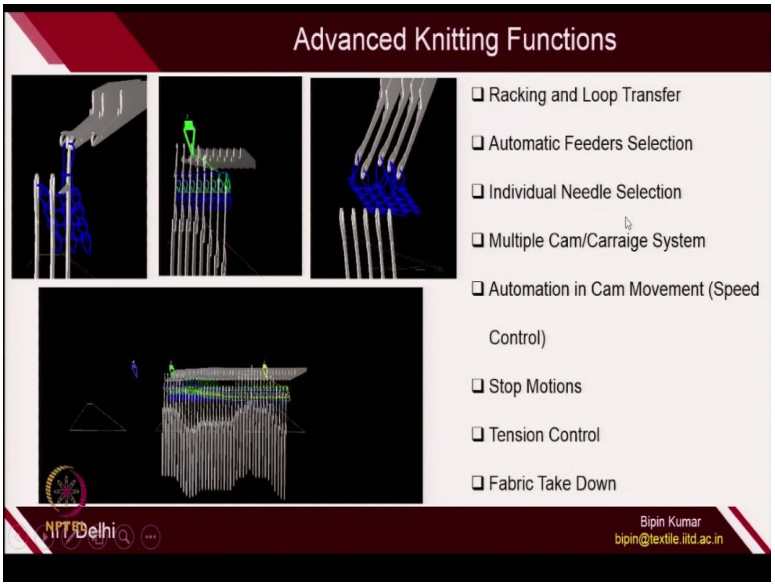

You have automatic feeder selection, individual needle selection multiple cam carriage systems, automation in cam movement, stop motion, tension control, fabric takedown. So, all these advanced functions is now coming in weft knitting and each of these functions are helping users or designers to achieve more complicated fabrics and also achieve more uniform fabrics.

For example, racking and loop transfers, you can see it here this is the racking when the loop is transferred from one bed to other bed. So, this is again very advanced function and the other one is automatic feeder selection. So, in the second video you can see, anytime you can select any feeders depending on what you want to create. If you want to create stripe design, you can play with multiple feeder selections.

You can also create individual needles for any stitch formation, which is not again possible on manual V-bed machines. So, here you have individual control on each needle. For example, you can see this all is making loop but here you can see one is making tuck and one is making float. So, individual needle selections is also possible in advanced knitting. Multiple cam and carriage systems, so here you can see for increasing the production, you can have multiple cams in the same carriage.

So, in one go you can create 3 courses. So, here you can see 3 cams are moving left to right with the help of 1 carriage. So, sometimes you can have 2 carriages and multiple cams. In this case, the production will be very faster. Automation in cam movements, you can see automatically the machine is catching each feeder, so this process is automated. You don't need to use your hand, so automatically speed can be controlled.

There are lot of stop motions because of any time, if any yarns particularly break, automatically the needles will stop so that you cannot get any kind of defect in the fabric. You can also have tension control systems with the help of disc tensioners. The other mode of tension controls which is out of the scope of this particular course but again tension control is important because if you want smooth running of fabric production on the machine, it is very very important that the tension in the yarn should be uniform and controlled.

So, that's why tension control unit is extremely important and this option is available in advanced knitting machines. Fabric takedown, sometimes in manual V-bed machines, we use

dead weight for pulling the fabrics, but now that can be taken care with the help of rollers. So, fabric takedown is also very important and these type of functions are now coming in the market and if you go and buy any type of knitting technologies, please try to understand these functions and their potential and limitations.

Just simply you cannot blindly go to the market and buy any technology that is ridiculous. So, that's why you need to really understand each of these importance of these functions of the knitting.

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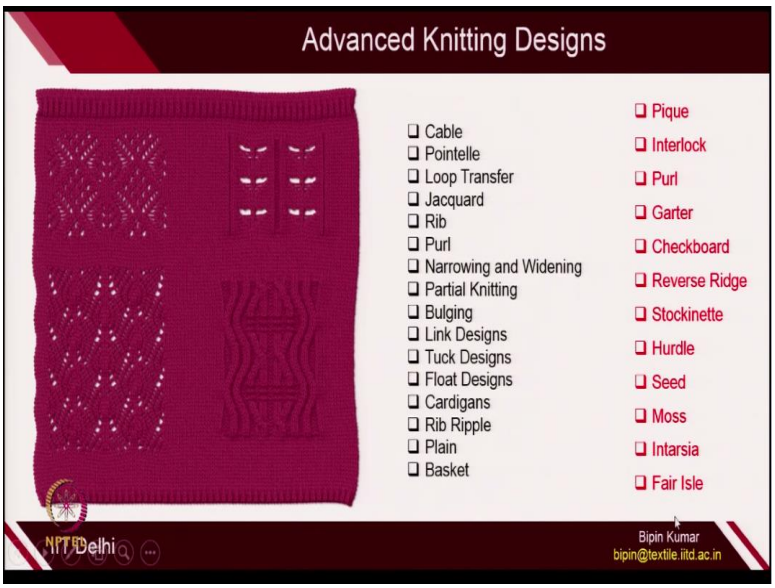

Once you have the advanced knitting machines especially jacquard knitting machines, you can create any type of design which you can think of just by the help of those 4 stitches which I mentioned, the loop stitch, tuck stitch, float stitch and transfer stitch. So, in the course, I showed you actual fabric samples and their animations like cable, pointelle fabrics, loop transfer, jacquard, rib, purl, narrowing and widening, partial knitting, bulging, link design, tuck designs, float designs, cardigans, rib ripple, plain, basket.

The list is unlimited. I am again repeating, knitting gives you a lot of flexibility and it's totally depends on the users or technicians what type of fabrics he wants to design. So, in this course, it is practically impossible to cover all type of knit design which is available in the market but if you understand the science which is if you understand how the loops is created, how floats is created, how tuck is created, how technical front loop is created, how technical back loop is created, you could be potentially able to form any type of fabric structures.

The only thing matters for you is to understand which needle should be doing what on the bed. If that thing is clear to you, you can simply give the command and automatically that type of fabric is coming. In the literatures, you will be finding many generic names. I again repeating do not get confused with this generic name. This generic name is having no meaning; they have just defined without any scientific understanding.

It is again depends on the market size but again the basic science and principle remains same. So, if you see pique design, this is again not a new type of weft knitting structure, it is simply the combination of technical front and back loops. So, if you know which course is doing what, you could be able to generate pique structure.

Interlock structures again nothing new, you are using multiple feeders at a time and selectively in certain regions instead of making jacquard, you can selectively only make the loops in certain regions that's called interlock. You have also seen the purl; these names sometimes are very confusing. Garter, checkboard, reverse ridge, stockinette, hurdle, seed, moss, intarsia, Fair Isle.

If you see these words, these words are limited in knitting literature. So, I only expect you to follow these words, try to understand their knitting pattern, you only try to understand their knitting pattern. So, once that knitting pattern is known to you, you simply feed to the machine. The machine will give you that fabric in front of you. Many hand knitting techniques, they usually use these type of generic names.

Because the market is run by these type of words, so again this generic name has no technical importance according to me but definitely from market point of view these designs are important, they have some important names, how they have derived, why this name is called, there is no scientific background out of this. So, I expect all of you whenever you need or read any knit structure in the literatures please try to focus on the notation part, try to focus, how, what is the actual fabric notations.

Once that notation is clear to you, these names will be just a simple dictionary word for you nothing important. So, I hope that should be clear to you.

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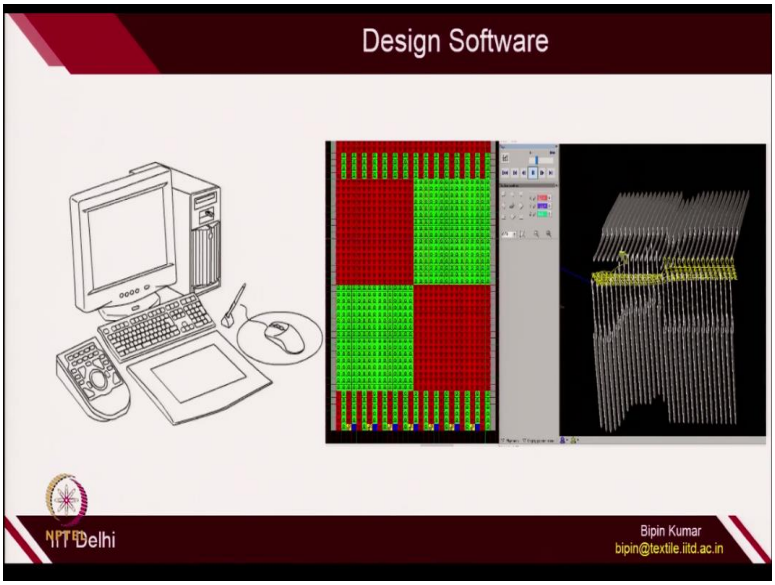

Again, I have also shown you the importance of design software especially nowadays design software is coming where depending on your creativity; you can actually see the simulation of how in a particular course what needle should be doing. So, I have already shown you like so if you feed the command, you can see for each course how the needle should be working. So, this is really very important.

Before making the fabric itself, you can actually see or visualize the knitting action as well as knitting fabric. So, that is really very powerful tool, which is now available in the market and if you get the chance to operate on these design software, I expect you to please learn this because this is the fundamental thing and if science is clear, this design software is additional tool which will enhance your knitting capabilities.

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So, with this once science, technology, design and engineering aspect is clear to you, you can go for applications. So, you have seen knitting is mostly used in garment applications where you create T-shirts, sweaters, undergarments, hosieries, stockings but you can also think weft knitted structure for technical applications.

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So, since the time is limited in this course, probably in the last week, week number 12, I will be focusing on some application aspects where I will show you how you can use knitting for electronic textile development. This is the future of knitting, actually if you have the good background of electronics and computer science, you can actually insert material sensors inside the knit structures and you can go for health monitoring products.

You can also think for designing sports garment with unique properties, unique capabilities if your design and engineering aspects of knitting is clear to you. So, this is more technical applications, it's not garment applications where design is not important rather the capability of the structure or the engineering aspects is very important. So, in the last week, if I will have time I will try to cover some of these products in the lecture itself.

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Nowadays, especially for last 5 to 6 years, shoe uppers has become very important, you might have seen these shoe uppers, again this is nothing but a weft knitted structures with the help of fusing yarns and normal yarns. I will try to show you some of the samples also, how we create it. If you know pointelle, if you know jacquard design, if those things are clear to you, the shoe uppers is just like a cakewalk for you.

Narrowing widening, it is a combination of narrowing widening, cable, pointelle, jacquard, technical front and technical back loops. So, this shoe applications again a technical applications. Now, it's very much used in the market.

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Again, the other application is the composites where you can design the structure for composite applications and the next structure is cut resistance, again a very good technical

product. If I will get time, I will show you technical products, how you can use the structure for controlling the shear resistance of the fabric. So, these are technical aspects.

So, once things are clear to you, I would expect all of you who is listening to this course to explore the knitting potential in new domains, not just restrict yourself with simple machine or technologies. Keep looking; keep venturing new and new ideas, new and new applications. So, with this I am ending weft knitting technologies.

Now, we are going to move to a new aspect of technology, which is warp knitting, which is even more complicated, interesting and I hope you will like the next lecture. So, thank you very much. Enjoy knitting. Thank you very much.