Science and Technology of Weft and Warp Knitting
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Module - 5
Lecture - 23
Fabric Analysis - Shrinkage (Relaxation)

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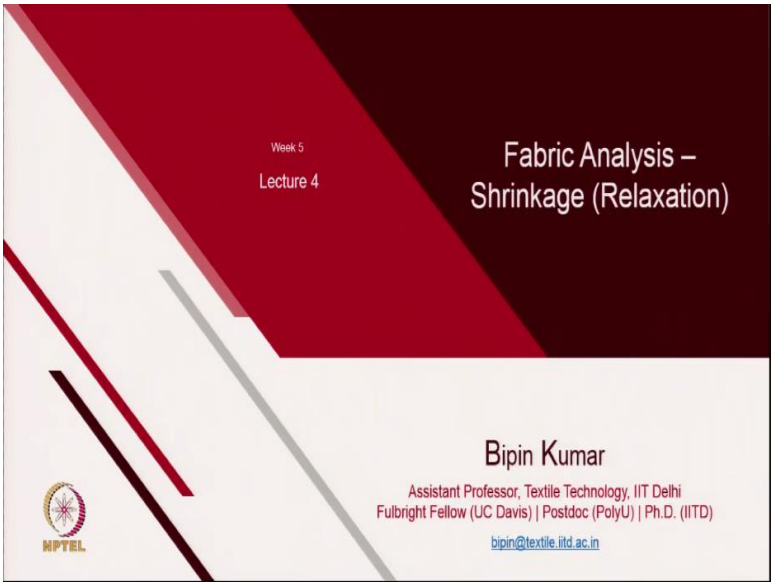

Welcome participants. Now, we are going to move in lecture number 4. Today, a topic I have chosen is shrinkage performance of the fabric. In reality, whenever you create any knit fabric on the machine, you will observe that, once you take out the fabric from the machine, it will try to shrink. And shrinkage is extremely important from garmenting point of view. Because, whenever we want to create garment for a perfect body or we need to create size of the fabric.

And if the fabric shrinks in certain way, it will be extremely difficult for the designer to knit the fabric size. So, it is very important that you should understand how the fabric shrinks along course direction and wales direction. And what is the role of stitches in deciding the shrinkage performance of the fabrics.

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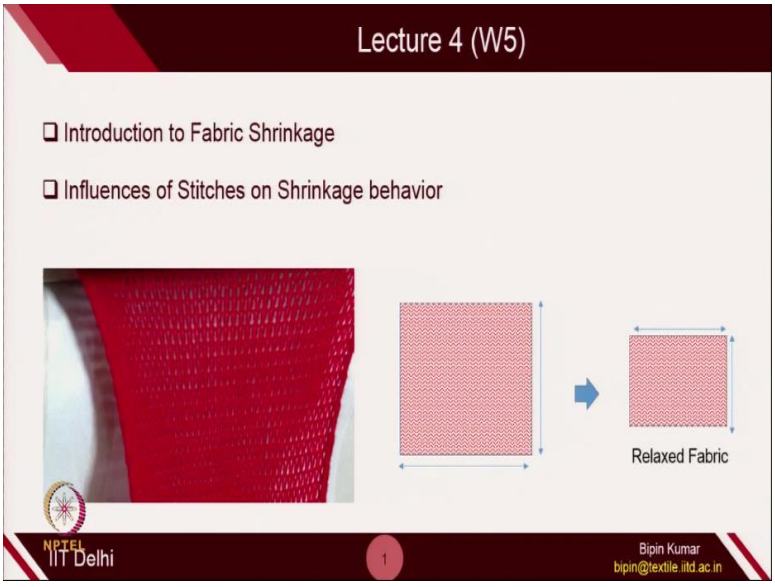

So, in this particular lecture, I am going to first introduce you what is fabric shrinkage; what do you mean by that; and what are the influences of different stitches like loop, tuck and float on the fabric shrinkage. So, on the machine, whenever you make fabric, you will observe that, after you take out the fabric from the machine, and if you place it in a table, the fabric will relax.

Because of that, fabric will try to shrink in all directions. So, this is the shrinkage performance of the fabric. And shrinkage is extremely important. For example, let's suppose, if you want to create 2 meter length of the fabric. You need to run the machine for certain time. You have to create certain number of courses. So, when you are making the fabric on the machine, you created let's suppose 200 courses of the fabric.

And once you take out the fabric, you will observe that 30% of the length has been lost. So, in that case, it is very much important that you should have some kind of understanding for achieving a particular length and width of the fabric; how many needles you should be selecting on the machines and how many courses you should run on the machine to achieve particular dimensions of the fabric. So, that's why, shrinkage become extremely important. So, in this particular lecture, we are going to observe these shrinkage performance of the fabric.

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So, first, let's try to see why there is relaxation; why the fabric relax in both wales direction and course directions, once you take out the fabric from the machine.

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(Video Starts: 03:09) So, if you see the fabric on the machine, you apply dead weight at the bottom. And you keep running the carrier from left to right and right to left. So, yarn during the knitting are extremely in stress conditions, because you are pulling the fabric from the bottom. So naturally, the fabric is under stress condition. Each yarn, you can see, each yarn are being pulled at the bottom side.

This is how you apply the dead weight in the fabric and the fabric is under tension conditions. So, the moment you take out this fabric and remove the dead weight, you will observe the fabric will try to relax. **(Video Ends: 03:58)** So, this is relaxation, causes the shrinkage in the

fabric. And if you careful see this video, at the knitting zone, when the needle is making the loop and when the fabric width is much, much higher at the knitting zone near the needle, but when you go down, you can see the fabric width is reducing.

So, you can see here, the fabric width is this much. But if you see at the knitting zone, the fabric width is more. So, the moment the yarn is moving away from the knitting zone or dead weight zone, you will observe the fabric try to shrink. And why this shrinks? Because naturally, you are keeping the yarn under very stress condition. So, the moment you release the stress, after taking out the fabric from the machine and removing the dead weight, you will realize the fabric will relax.

And during this relaxation, fabric shrinks in both length direction and width direction. So, this is called shrinkage of knitted fabric. And shrinkage is very, very important from garmenting point of view. So, a worker who is standing in front of the machine, he should be knowing how many needles he should select on the machine and how many courses he should run on the machine to achieve certain dimension, meaning certain length and width of the fabric.

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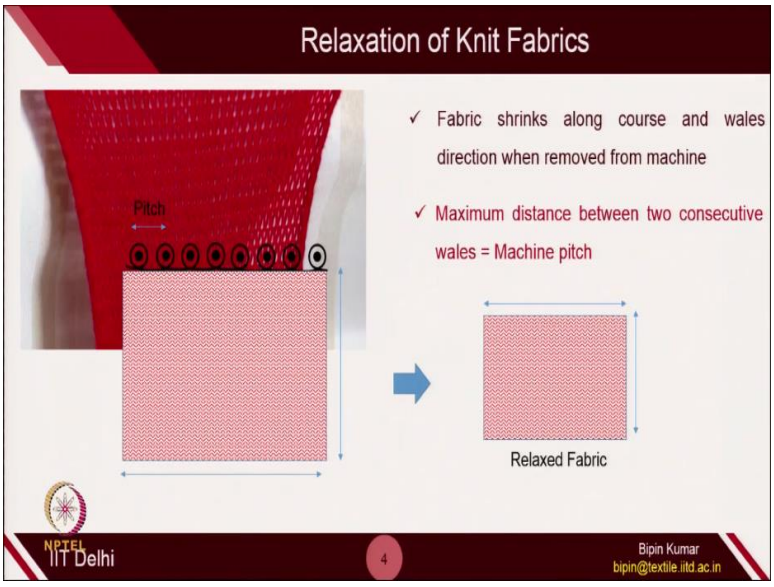

Fabric shrink both in course direction and wales direction. And in this lecture, we will try to understand why, how much the fabric will shrink; how it relates with the stitches; how the tuck, float and loop controls the shrinkage. **(Video Starts: 05:46)** Shrinkage, if you see on the machine, near the knitting zone; you have selected, let's suppose 20 needles. So, distance between 2 columns is naturally; it should be equals to the machine pitch.

If you remember machine pitch definition, it is the distance between 2 consecutive needles. So, this is the distance between 2 consecutive needles which is called machine pitch. So naturally, **(Video Ends: 06:13)** if you have selected 8 needles on the machine, so the width of the fabric should be 8 times pitch. So, maximum distance between 2 consecutive wales should be 8 times pitch according to this diagram.

But, once you take out the fabric, place it on a table, you will realize, the fabric will shrink in width direction. So, this is because of stress relaxation in the yarn which is there on the machine. So, this is called relaxation. And we need to see how much the fabric relax, both under wale direction as well as under course direction.

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So, this is important from the sense that, whenever we want to create any garment, we need to fix the dimensions. And to create certain dimensions, we need to observe how many needles you should select, so that it will give you appropriate amount of width and certain amount of length. So, number of carrier drivers and needles has to be appropriately selected. So, you cannot select these randomly.

So, to achieve this, you have to be very clear understanding of how much fabric shrinks, once you take out from the machine. So, fabric shrinkage behavior is very much important. And any researchers who is doing knitting and making any garment, he should be aware of that.

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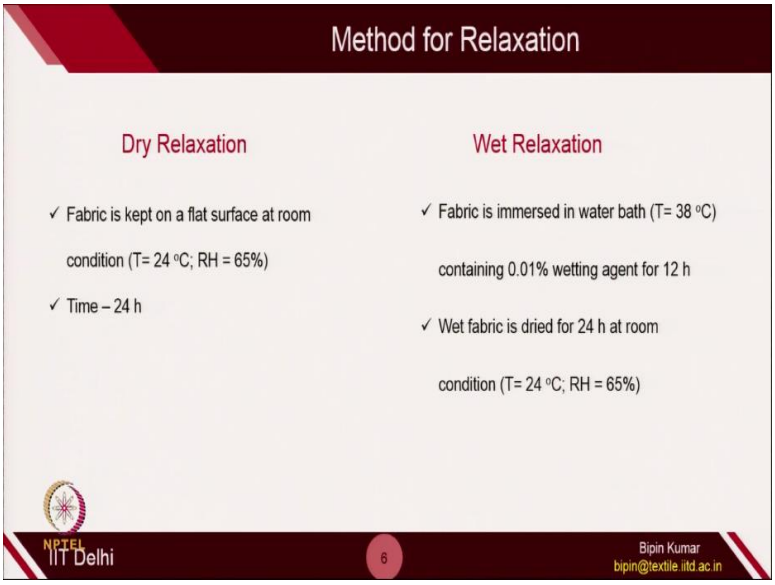

In relaxation, whenever the moment you take out the fabric from the machine, you can place it on a table, you can go for relaxation. There are 2 methods through which you can relax the fabric, because the yarn in the fabric are under very high stress conditions. So, you need to give sufficient time to the fabrics, so that it can relax. So, you can go for dry relaxations where you can keep the fabric which is produced on the machine immediately on a flat surface and a, at a room temperature conditions like 24 degrees celsius and relative humidity to 65%.

And you can keep the fabric for 24 hours. And you will realize, the fabric will keep shrinking. And after 24 hours, you will take out the fabric and measure its dimension. So, thats will be the actual length and width of the fabric that you will create on the machine. If you go, you can also go for wet relaxation. In most of the companies, they follow wet relaxation methods, because this is more close to reality.

So, whenever you produce fabric on the machine, you can go and immerse the fabric in the water bath at certain temperature with certain wetting agents. You can keep the fabric under water for 12 hours. After that, you can take out the wet fabric and go for dry relaxation for 24 hours. So, this is done just to make sure the fabric remain stable after multiple use. Because, if the moment you take out the fabric from the machine and you if you make a garment, you will realize, the garment size will reduce after some time.

So, you will not wanted that. Because, you always want that the fabric size should be stable, your garment size should be stable and it should not also shrink even after washing. So, that’s

why, 2 methods are always followed in companies as well as by researchers. Before doing analysis of any fabric of knitting, you always relax the fabric first; and then you go for a structural characterization.

You cannot immediately measure the loop length or GSM of the fabric, just taking the fabric immediately after it is being formed on the machine. So, you always give some time to the knitting fabric for relaxation, which is very, very important. And it should be done in a very systematic way.

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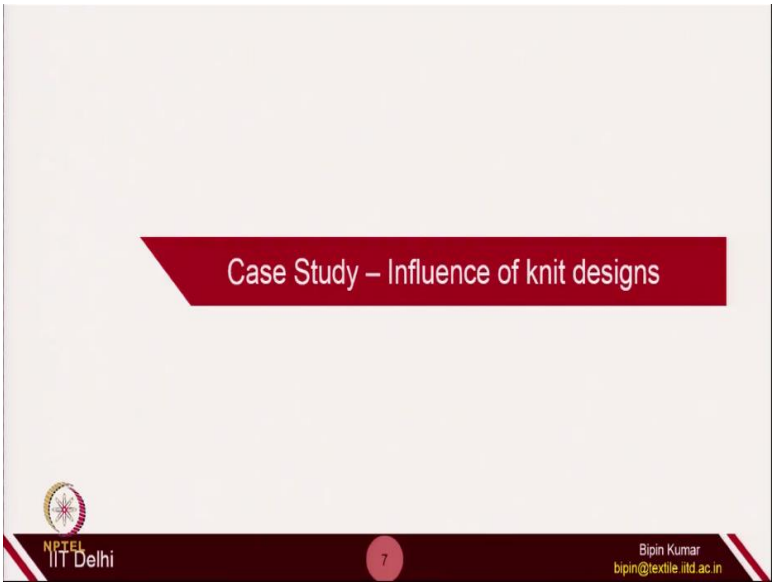

I am going to show you some of the basic knit designs, how much they shrinks when I prepare those fabrics from the machines. A small case study, I have few fabric samples also. And how the knit designs actually influence these shrinkage performance.

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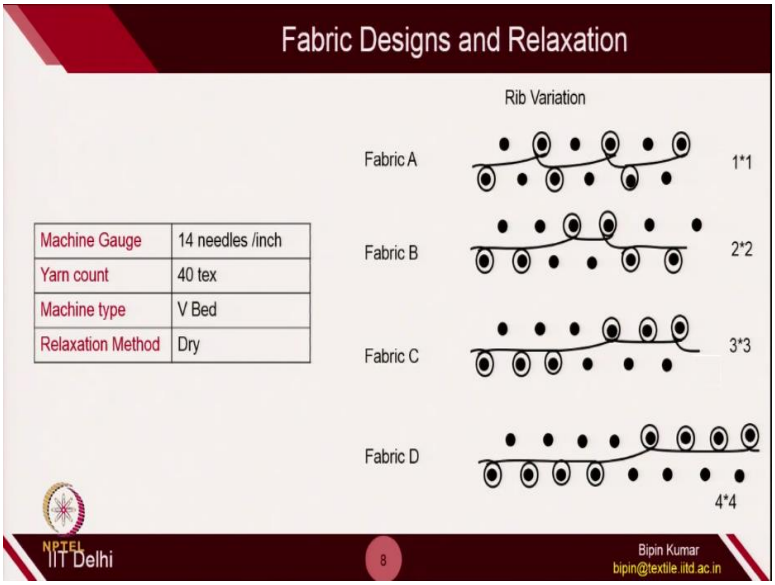

This is the way I created the fabric designs. So, the machine that I used was 14 needles per inch. Yarn count was 40 tex. The machine type was V-bed. And after forming the fabric on the machine, I relax the fabric using relax, dry relaxation method. I kept the fabric on the table for 24 hours. And some of the designs which I selected, just to check the shrinkage performance is 1 cross 1 rib.

So, if you remember the rib definitions, double jersey definitions. So here, I was removing 1 needles from the front bed. So here, every alternating needles of front bed is making loops. Similarly, every alternating needles of back bed is making loops. So, that's why, this is 1 cross 1. In fabric B, 2 needles of front bed is making and 2 are not in active position. So, 2 on front and 2 on back; they are making loops alternatively.

In fabric C, 3 are making loops; then 3 are not making. And 3 on the front and 3 on the back, simultaneously. In fabric D, 4 on the front, 4 on the back. So, 4 needles on front side and 4 needles on the back side are left alternatively. So, I created 4 types of fabrics. I also went for 10 cross 10, where 10 on the front side and 10 on the back side. Just to check, the moment I make all of these fabric designs, how much the fabric shrinks.

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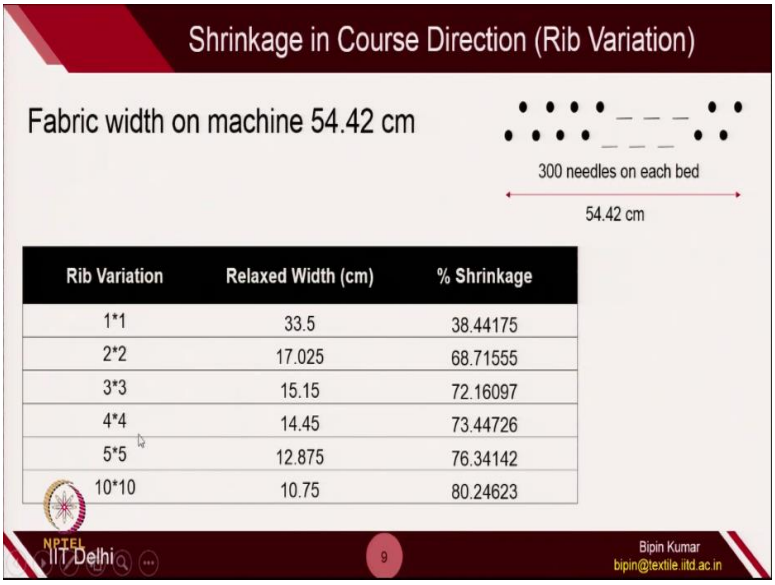

To observe the shrinkage in course direction, what I did was, I used 54.42 centimeter of the machine width on the machine. So, effectively I used 300 needles on the front bed and 300 needles on the back bed. So, the total length on the machine, where the fabric was being formed was 54.42. Because that machine pitch was 1 by 14; so, you multiply 300 into 1 by 14; and then you convert it into 2 centimeter.

So, on the machine, I tried to create 54.42 centimeter. But in reality, once I make all of these variations, I observe the fabric width reduce significantly. So, you can see here, the moment I created the fabric, rib fabric, 1 cross 1; after relaxation, the fabric width reduces from 54.42 to 33.5. So, 38% relaxation was observed in 1 cross 1 rib. In 2 cross 2 rib, from 54.42, it reaches to 17.025; 68.71%.

Then in 3 cross 3, 72% shrinkage was observed. 4 cross 4, 73; 5 cross 5, 76; 10 cross 10, 80.2. So, you can carefully observe this. If you change the fabric design, you will observe different amount of shrinkage. So, you can have the shrinkage from 38% to 80%. So, I have all the fabric sample with me. You can see how much the shrinkage has been happened, although we have used same number of needles for all the fabric samples.

Let’s see this fabric. So, here you can see, I have this fabric samples. So, this is the fabric 3 cross 3. **(Video Starts: 13:45)** Let’s see the difference of 3 cross 3 and 10 cross 10. So, you can see here, the, it is 3 cross 3 fabric and it has been relaxed. So, if you stretch it, you can observe the 3 cross 3. So, if you stretch it, so 3 front loops. And then, between 2 column, there are 3 back loops.

So, this is 3 front loops; and then, this is 3 back loops; then 3 front loops; then 3 back loops. So, you can see, you can stretch very easily. This fabric is highly stretchable; you can see here. So, this fabric is highly stretchable, 3 cross 3. Now, let's go for 10 cross 10, which is even more stretchable. So, if you see 10 cross 10, even a small amount of force you can stretch to almost 400 to 500%.

So here, if you try to observe, this is 10 front loops; then this is 10 back loops. So, 10 needles on the front bed, 10 needles on the back bed; then 10 front, 10 back. Okay. So, if you go for 5 cross 5, So, if you go for 5 cross 5, again, you can see it is highly stretchable fabrics. And if you see 3 cross 3, it is not that, it is also stretchable, but the 10 cross 10 is extremely stretchable with a small force. So naturally, the moment you created this fabric, the moment you created this fabric, you can see how much it has shrink.

Because, the nature of fabric is like this. So, all technical back loop is hidden inside. So, between 2 technical front columns. So, this is 10 columns of technical front. And this is another 10 columns of technical front. So, between that, all 10, so in between, all 10 back loops are hidden. So, this is where all 10 back loops are hidden. So, you can see, this much amount of technical back loops has shrink.

The moment I take out from, this fabric from the machine. If you go for 3 cross 3, again, only 3 needles are hidden here. So, you can, so 3 loops and hidden here. 3 technical, this is technical front, 3 columns; and then, another technical front, 3 column; and in between, 3 columns of technical back loops are hidden. So naturally, the more number of technical front loops and then technical back loops results in higher shrinkage of the **(Video Ends: 16:42)** fabrics, which you can see it from the table also.

So, if you see 1 cross 1, the shrinkage is 38%. But, if you see 10 cross 10, the shrinkage is 80.24. So naturally, with the, with having more and more rib variations, more technical front and back loop alternatively, you can have higher percentage of shrinkage. Shrinkage in wale direction also, I observed. So, for wale direction I created 250 courses. So, I created 250 courses consecutively in a sequential form for all the rib variations.

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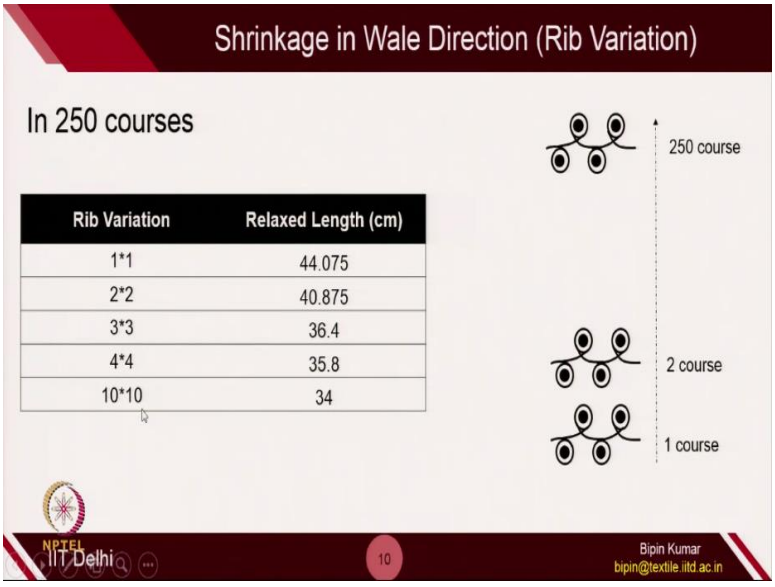

And you can see, in case of the final length which I observed was 44.075 in 1 cross 1 rib, after 250 courses. But for 10 cross 10, the final length was only 34 centimeter, even after I created 250 courses. So naturally, the fabric shrinks again in length direction as well for higher number of technical front and technical back loops. So, both, in course direction and wales direction, if you have more number of technical front followed by more number of technical back loops, the fabric will try to shrink too much in the course as well as wale direction.

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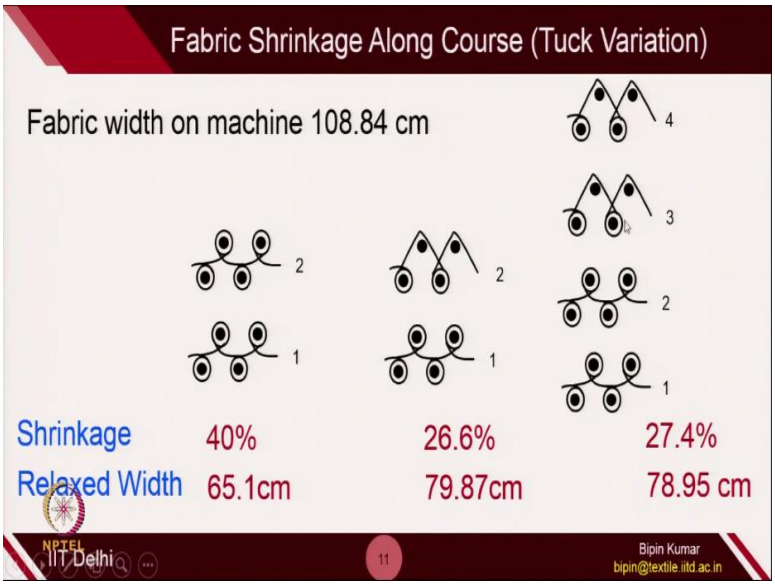

Now, let's see the tuck variation. I also created a fabric on the same machine. And this is the rib where all the needles on front bed and back bed was making the fabric. And here, only the front bed is making all the fabric. The back bed is, in the second course, back bed is making

tuck. Here, 2 rib; and then followed by 2 tuck. So, the more tuck, you can see, the shrinkage has been reduced.

So, in first case, 40% the fabric shrinks. In second case, the fabric shrinks by 26.6%. And another case, 27 percent. So, having more tuck, naturally the fabric shrinkage will reduced. And the final width of the fabric will be more. So, in rib case, only rib or loops in the fabric. The relaxed width was 65.1. But with tuck, you can see, the fabric width was more. And this is obvious.

So, in, if you remember the tuck lecture, where I showed you that, whenever you introduce tuck; so tuck, the legs are open. So, because of that, the fabric width will be more. So, if the fabric width is more, it means the fabric is not shrinking too much because of the tuck loop. So, that's why; so, in tuck fabrics, you can have higher fabric width. Now, if you see the influence of tuck in wale directions.

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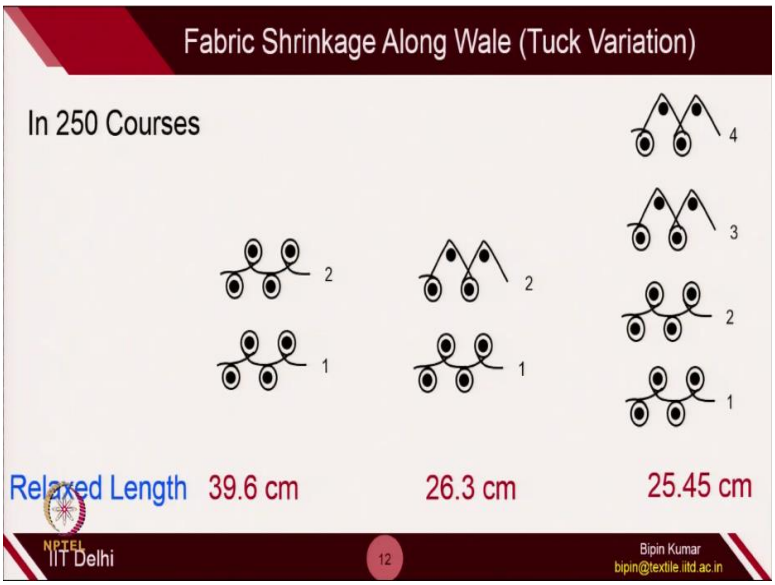

So, in length direction, again I created 250 courses. I observed that, in case of rib fabrics, the fabric length was 39.6 centimeter. But in case of tuck, the fabrics shrinks. So, 26.3; and here 25.4. So, the fabric shrinks and have much lower length. And the reason because, is presence of held loops. So, if you remember, whenever you create tuck, it associated with a much bigger loop which is the held loop.

So, because of the held loop, this, the fabric is highly tension in length direction or wale direction. So, the moment the fabric is released, that held loop will try to relax. And during

that relaxation process, you will observe lot of shrinkage in length direction. Okay. So, that's why, along the wale direction, whenever held loop is present, fabric will always shrink in length direction.

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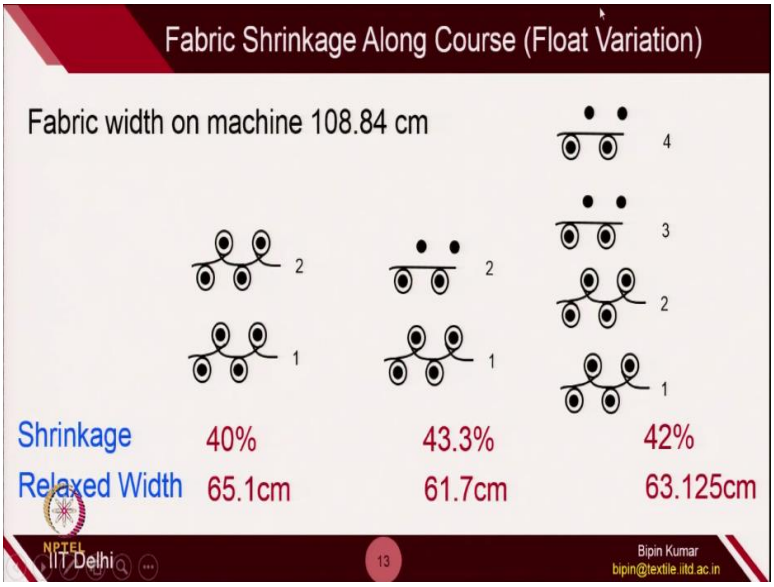

If you see the float variation. So, here I created 3 fabric samples, all rib. And here, the float in one of the bed. So, first course all rib. In second course, front bed is making loop, back is making float. Here, 2 rib followed by 2 float on the back bed. So, you can see here, when, along course direction, whenever you are creating float, the shrinkage is not too much. So, 40% shrinkage was observed in rib, 43.3%.

So, the shrinkage is limited. So, compared to tuck, where the shrinkage was reduced; but here, the shrinkage is more. So, that's why, the float results in higher percentage of shrinkage. So, you can also check the dimension of the fabric. So, in relaxed condition, the width of the fabric was 65.1 centimeter. But here, it is 61.7 and 63.125. So naturally, the fabric has shrink in width direction, which is opposite to the nature of tuck.

So, tuck reduces the shrinkage, but float increases the shrinkage in course direction. In wale direction, it follows the similar nature of tuck, because of the held loop. So, if you see this, the relaxed length along wale direction or length direction. So, for rib, it is 39.6.

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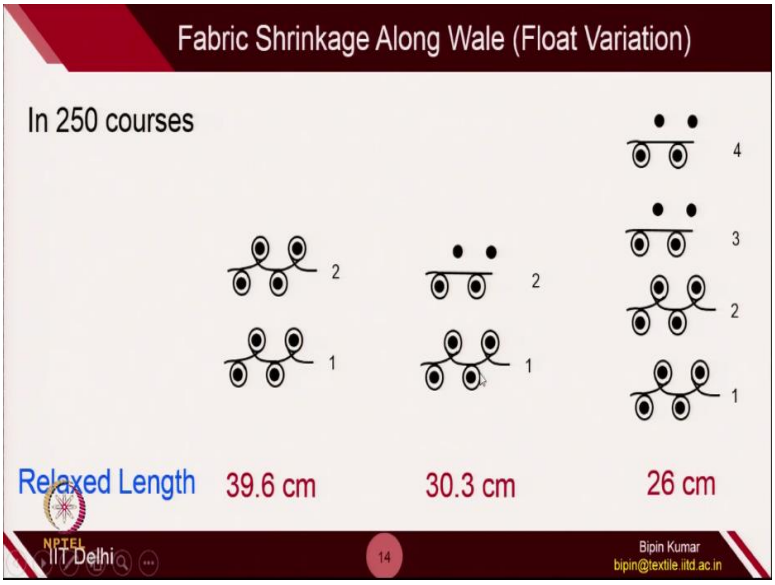

For float variations, these are a 2 float variation fabrics. After 250 courses, we observed 30.3 and 26 for these 2 fabrics, while 39.6 for rib fabrics. So, again the argument can be such that, it is because of the held loop. So, if you see the back bed here, this needle is making the loop, but next course, it is not making loop, it is making float. So, it is still carrying the held loop. So, after third course, when you make the fabric, that held loop will be released.

So, held loop is always in tension. So, the moment you take out the fabric from the machine, it will try to shrink in length directions. So, much bigger held loop, you can observe much more shrinkage. So, here if you see, the, this needle is may holding the loop, but here, it is making float. So, this needle is still holding the loop. This needle is again holding the loop, the same old loop.

So, the same old loop is hold for 3 courses in this fabric. And here, the same needle is holding the held loop for 2 courses. In third courses, it is released. Here, after every 4 course, that held loop is released. So, because of that, the length of held loop is more in case of floats, in this fabric. And the fabric shrinks too much in the wale direction. So, this was obviously, the variations of float and tuck designs are unlimited.

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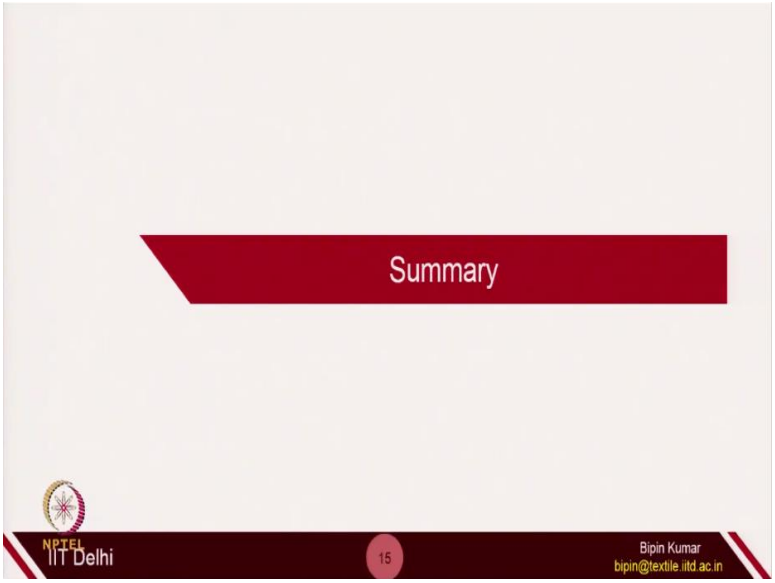

Naturally, whenever a worker is making any particular machines or even any students is making any fabric on a particular machines, you need to be very careful what designs you are making. You need to first make lot of trials, fabric samples and observe the behavior; and then, you can set the machine in a particular sequence. So, once, in reality, whenever a particular machine is making certain dimensions of the fabric in V-bed, that machine is left unchanged, until unless if new design has to be created.

So, either the float will remain same or the tuck sequence will remain same. Because, the moment you change any of the sequence, the fabric dimensions will be different. So, in reality, this is just the influence.

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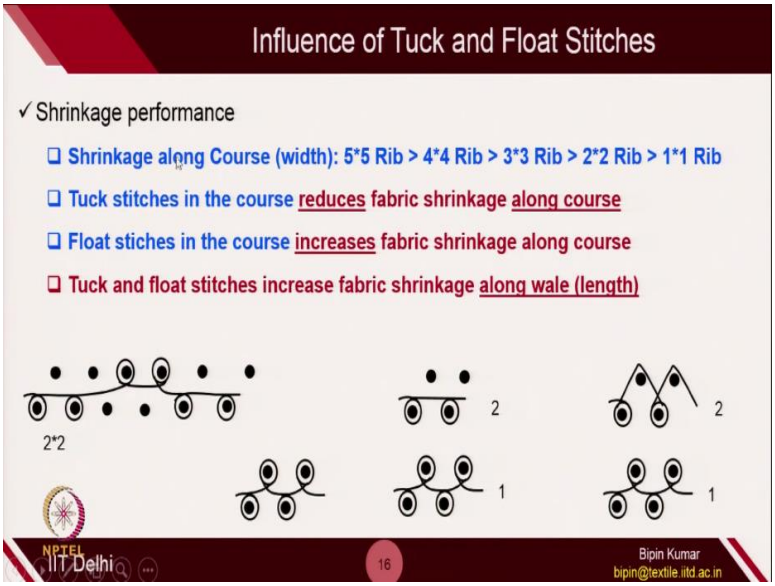

So, shrinkage along course, you can observe more and more technical front loops, followed by technical back loops, results in higher shrinkage of the fabric, in course direction. If you have more tuck stitches in a course, it will reduce the fabric shrinkage and you can expect the fabric width is more. In case of float, you will observe little bit shrinkage along course direction, but not that much significant.

But, naturally when you have tuck and float stitches in a course, it will result in fabric shrinkage along length direction. So, both tuck and float has its own influence on the structure. Also, the technical front and back loops in a course has its own influence on the structure. So, you better be careful whenever you design any fabric and want to create a certain dimensions. I thought, maybe this topic is heavily ignored in literatures.

But whenever you go for design, you should keep all of these things in the mind, whenever you are dealing with any kind of weft knitted samples. So, with this, I am stopping with this lecture. In the next few lectures, I am going to again following some of the important properties, especially the extensibility and the recovery aspects of knitted fabric, which is also very important from design point of view. So, once again, thank you very much.