Science and Technology of Weft and Warp Knitting
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Module - 11
Lecture - 46
Warp Knits: Structure-Property Relationship

Welcome participant, to lecture number 3 in week 11. Today, I am going to discuss something regarding a structure-property relationship for different warp knit structure. In the previous 2 lecture, you have seen how pattern drum or pattern chain helps in warp knit designing. But the question is: What is the purpose of having different warp knit design? What additional benefits it provides to the structure?

And how we can control the property if you manipulate the warp knit designs? So, in today's lecture, I am going to give you some hints of how if you change the overlap and underlap, if you change the chain pattern, how different structure will result and how are their property will change in terms of stretchability; in terms of rigidness; in terms of GSM; in terms of porosity; in terms of mesh size; in terms of loop stability.

So, there are so many properties that will change in a warp knit structure if you change the overlap and underlap sequence and the positioning. So, let's start the lecture. Before we move on, a quick recap of what we covered in the last lecture.

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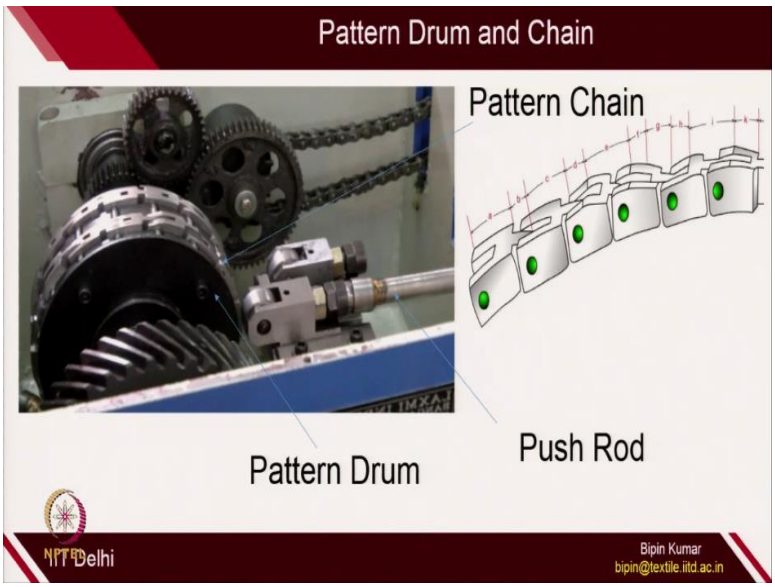

So, in the previous 2 lectures, we have given more emphasis on the pattern drum and pattern chain. This is the basis of how the shogging movement of the guide bar was achieved. So, there is a push rod which is following the path of pattern chain. And this pattern chain is actually, it's a series of different chains which is connected by the bar. So, in the previous lecture also, I have shown you how you connect these chain links and create a pattern chain.

These chain links is actually connected with the lapping plan of a warp knit structure. So, depending on the lapping plan, you have to pick different size of chains and you have to arrange in a sequence. So, because of that, you will get a different kind of elevation and depression on the surface of these chains. And once this follower follows this depression and elevations, the push rod will be shifted either to right or left, due to which shogging moment is given to guide bar.

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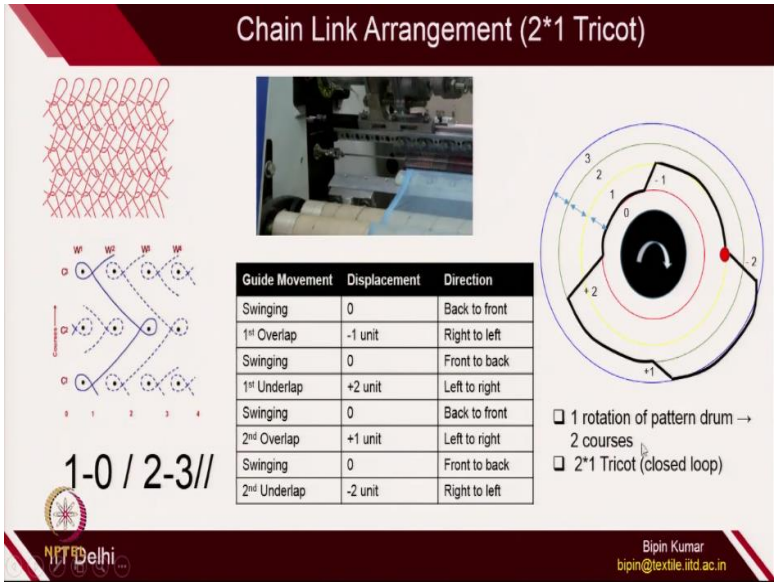

I have also given how you can arrange the sequence. So, you can have 1, 0, 2, 3. This is the lapping plan. So, you can pick the chain link of 1 height, 0 height, 2 height and 3 height. And you can arrange in a sequence. And you can make the chain links. And you can put it on the pattern drum. So, once the follower starts, it will swing; then it will do the shogging; then swing; then shogging, then swinging; then shogging; and then again swinging.

So, depending on what is the repeat pattern, you can put it, **(Video Starts: 03:29)** the chain links in that sequence. And the follower will automatically doing the shogging movement of the guide bar. So, naturally, different structures will have different way of having repeat

sequence or this lapping plan. So, once you change this sequence, a different kind of shogging motion will be results.

And you will get a different types of fabric structure. So, you can see it here. This is the shogging motion happening. And also this is the swinging motion from the other side. **(Video Ends: 04:10)**

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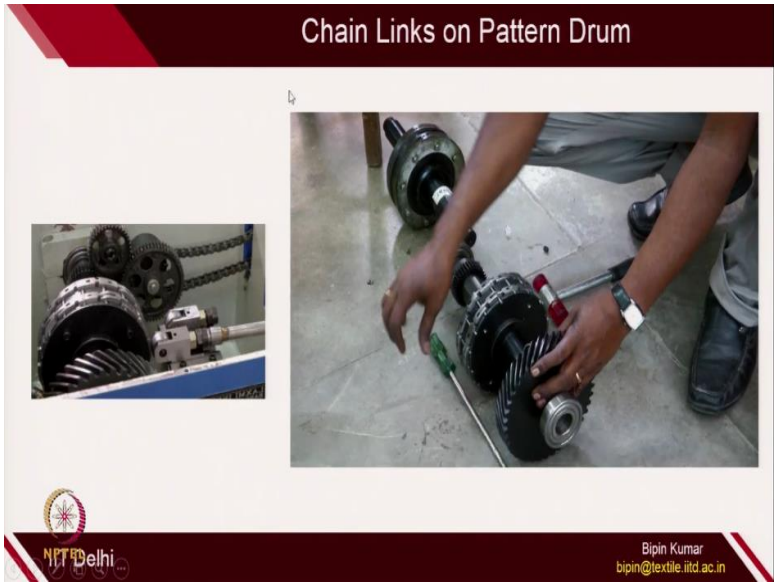

So, once you arrange the chain links, then you can put it on the drum. **(Video Starts: 04:18)** So, this is the drum. So, this is how you are putting the chain links of 2 bar structure on the drum. And once this is fixed; and then, you can take this pattern drum and put it on the machine. Okay. **(Video Ends: 04:48)** So, this is how the arrangement of chain links on the pattern drum is done.

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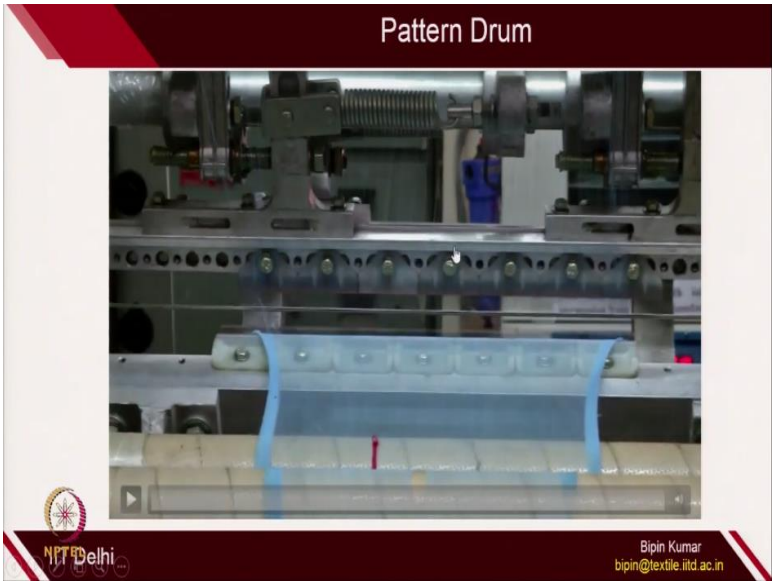

Once the pattern drum has the chain links, the followers **(Video Starts: 04:59)** follows path of chain links which is having different heights, depending on what type of chain you have used. And because of that, you can get the shogging movement of the guide bar. So, we have done this in detail. And swinging motion is also done with the push rod, with the main motor. So, this is how both swinging and shogging motion alternatively is achieved on the machine. And this is where, you can see, this is the swinging motion of the guide bar, as well as **(Video Ends: 05:30)** shogging motion is happening.

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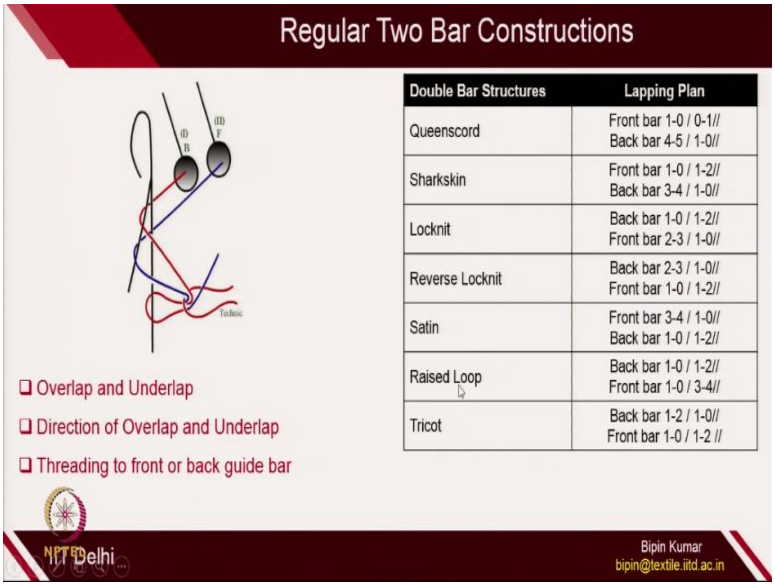

So, in the previous class, I talked about single bar structure and 2 bar structures. So, in 2 bar structure, some of the popular generic names of warp knit structure are queenscord, sharkskin, locknit, reverse locknit, satin, raised loop and tricot. So, although all of these structures is repeating in 2 courses and is made up of 2 guide bar, but the sequence of links

are different and the positioning of threading or threading of the yarns on the back bar or front bar are interchanged.

So, these are the 3 possibilities where you can change and you will get a different types of a structure. So, first of all, overlap and underlap you can change. You can also change the direction of overlap and underlap. So, sometimes underlaps of both the guide bar will be in the same direction. And sometimes the underlaps of both the guides will be in opposite direction.

Similarly, overlap can be happening in left to right or right to left. And you can play with the directions. The third thing is threading of front or back guide bar. So, sometimes you can thread on the back guide bar and front guide bar. And you can also swap their positioning. So, for example, if you see the satin and sharkskin. So, satin, the front bar has 3, 4, 1, 0; and back bar is 1, 0, 1, 2 lapping plan.

But if you see the sharkskin, it has front bar 1, 0, 1, 2; and back bar 3, 4, 1, 0. So, the threading had just been interchanged. And because of that, you will get a different types of properties. So, naturally, we need to understand why there is a different types of properties is achieved when you are changing the overlap and underlap or you are changing the threading position of the yarn, either on the front bar or back bar.

Also, the directions can be changed. If you see the direction of raised loop; if you see 1, 0, 1, 2; 1, 0, 3, 4. And if you see the direction of the raised loop and sharkskin; they are same, only the back bar directions has been changed. So, in the front bar, 1, 0, 3, 4. And if you see the satin, here it has opposite directions. So, because of that, these 2 structure is having different properties.

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So, let's see what is the parameters and what is the principles on which the properties can be changed in a warp knit structure. What are those principles? So, before we move on to the principles on controlling the structure-property relationship, we need to understand simple things.

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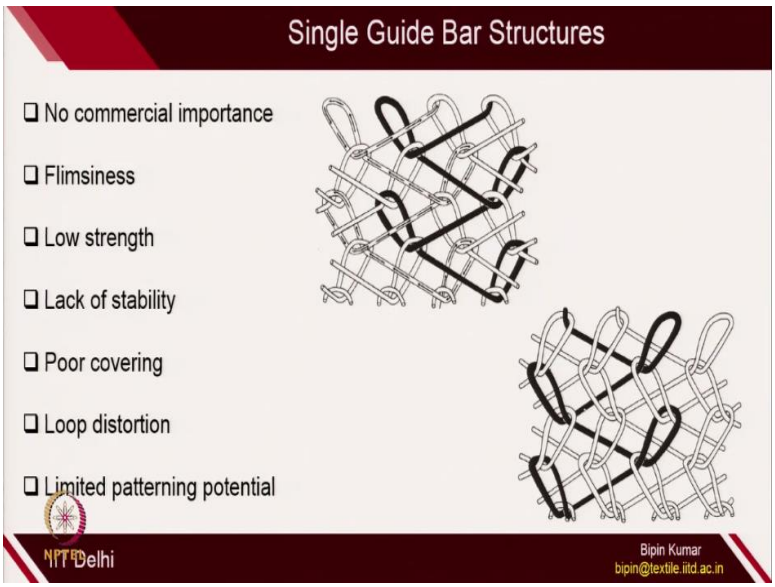

First, if you go for single guide bar structure, here only, you are changing the overlap and underlap. And ideally speaking, single guide bar structure is having no commercial importance, because the fabric is very porous. It's very flimsy, not stable. And the strength is very, very low for such type of a structure. The loops also are very unstable. You will also result very poor covering.

So, the cover aspects of these fabrics are very bad. And also, if you see the loop nature, it's highly distorted. And the reason being, if you follow any of these structures; so, if you see the underlaps or the sinker loop, it is there in the same direction. Because of that, you will result is unequal tension on the loop. And the loop will be tilted. So, loop is always distorted in a single guide bar structure.

And the only problem with single guide bar structure is, you cannot have so many possibilities except changing the overlap and underlap and changing its directions. But if you go for 2 guide bar structure, there are lot of possibilities. But in commercial point of view, single guide bar structure has limited advantages. If you see, I can show you one single guide bar structure.

You can see how unstable it is. **(Video Starts: 09:52)** So, if you see this structure, it is very, very porous. And loops are also in tilted position. The reason being, because both the sinker loop and underlap are in the same direction, due to which there are unequal tension on the loop. **(Video Ends: 10:10)** Let's move to some of the important aspects. If you change the overlap and underlap directions what will happen?

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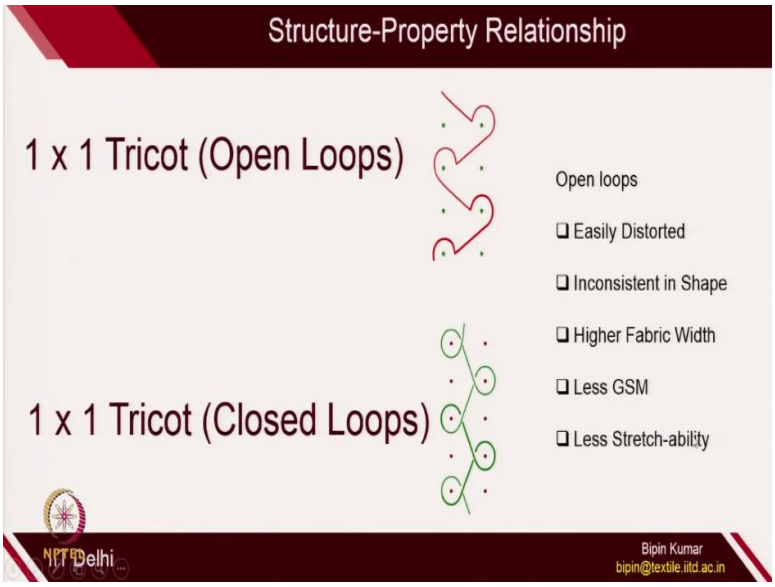

So, if you change the overlap and underlap directions, you can get either open loops or closed loops. I discussed in the previous class. So, open loops usually is more distorted. You will not get proper shape of the loop. The fabric width will be higher, because the loops are open. And you will get more porous structure and less GSM of the fabrics. And also, open loops is

comparatively less extensible compared to closed loop. So, having more and more open loops will results in these type of fabric characteristics.

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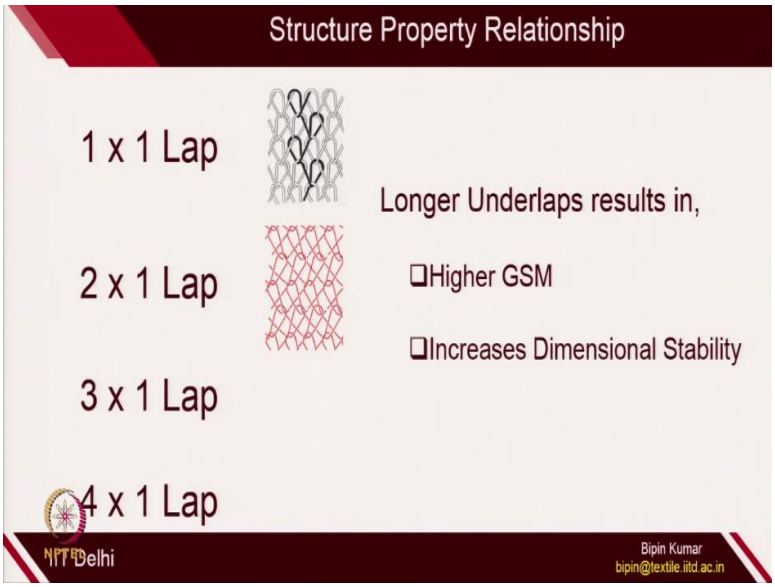

Also, if you change the lapping. So, for example, 1 cross 1 lap, it means, 1 pitch of underlap and 1 pitch of overlap; 2 cross 1 means, 2 pitch of underlap, 1 pitch of overlap; 3 cross 1, 3 underlap, 1 overlap; 4 cross 1, 4 underlap and 1 overlap. So, if we change the overlap, naturally, there will be more floating length or floating sinker loops in the columns. And due to which, you will get higher GSM of the fabrics.

And also, if you have longer underlap, it will results in more dimensionally stable structure. And this is how this overlap and underlap directions, as well as the magnitude, controls the single bar structure-property relationship.

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But our main focus is on 2 bar constructions, because 70 to 80% of warp knitted structures are actually a 2 bar construction. So, where you use 2 guide bar, front guide bar and back guide bar to provide yarn to individual needles. So, before we move on, some quick aspects on how these guide bars are decided.

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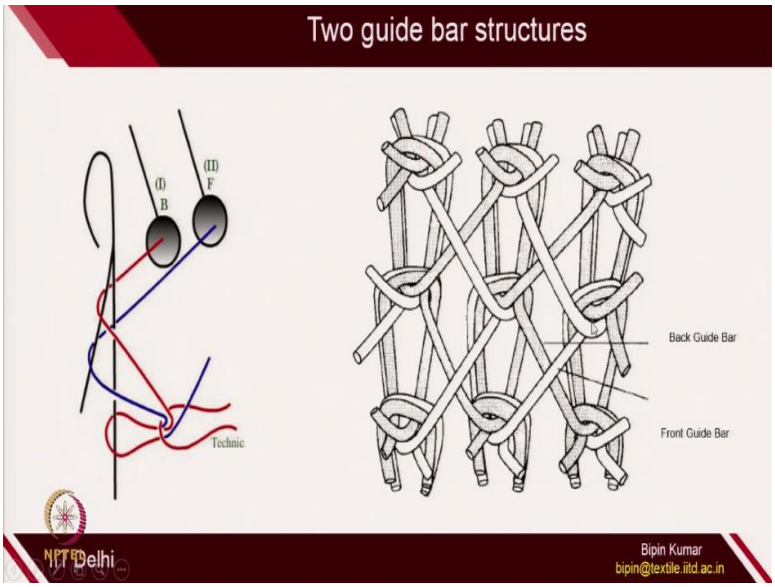

So, on the back side, whichever is close to the needle, that is back guide bar. We call this as a first guide bar. Or whichever is the fastest, we call this as a front guide bar or number 2 guide bar. So, if you see a 2 guide bar structures, naturally, 2 loops are being formed, because there are 2 threads which is provided to each needle. And the, because of the positioning of these threads, you will get different importance.

So, if you carefully see this structure, if you follow the arrow; so the white yarn is actually of front guide bar. So, if you see the sinker loop of front guide bar which is visible on technical back side. And sinker loop of back guide bar is floating underneath of front guide bar yarns. Also, if you see the overlap or the head and the leg position, back guide bar yarn is visible on the overlap position, while the sinker loop of front guide bar is visible on technical back side. Some of the key aspects, if you can take it from here is like;

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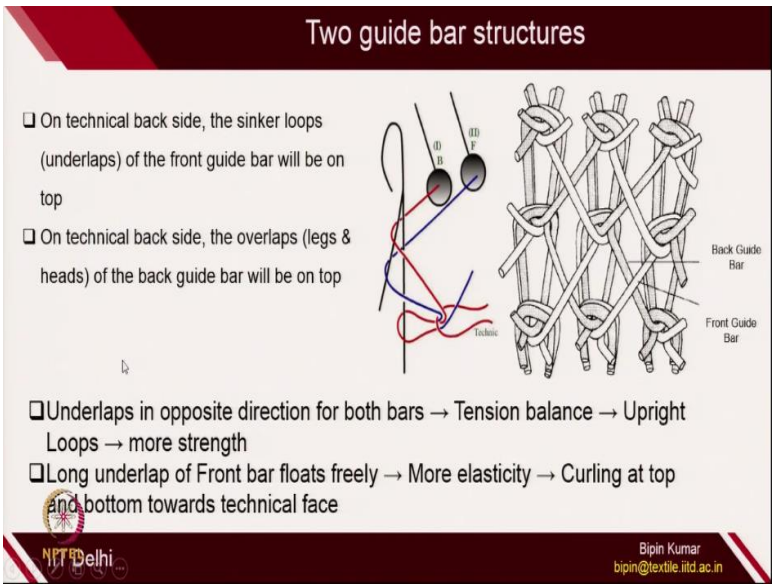

Whenever we make 2 guide bar structure, depending on what type of yarn you are attaching with either back guide bar or front guide bar, a different characteristics or the features of the fabric can be noted down. So, first feature is on technical back side. So, this is your technical back side. The sinker loops of the front guide bar will be on the top. So, if you can see, the sinker loop of front guide bar is on the top.

But on the technical back side, the overlaps, it means the legs and the head of back guide bar will be on the top. So, if you see the overlap, the head and the legs are on the top of front loops. Okay. The other key aspects you can get it from here is: If the underlaps of both the guide bar are in opposite direction during a course; for example, if you are making this particular loop.

So, one yarn is coming from left to right and the other yarn is coming from right to left. So, the underlaps are in opposite directions. So, because of the opposite direction, the underlaps gives equal tension balance. And due to which, you can see the loops are much stable

position. It's in upright position. So, the loops are not tilted in the way it is shown in the previous slides.

So, loops become more stable. And hence, the strength of the fabric will improve. So, depending on the underlap direction of 2 guide bar, some of the key fabric properties can be changed, especially the strength and the stability of the loops. The second aspect is long underlap. So, if you have long underlap of the front bar, then it can float on the technical back side, due to which you will get more elasticity of the structure.

And there will be curling on the top and bottom side of the fabric towards technical face. We will see how the positioning and the magnitude of overlaps and underlaps, also the threading with respect to back and front guide bar of the warp beams influence the fabric properties. So, we are going to see how these 7, 8 generic warp knitted structure changes its properties;

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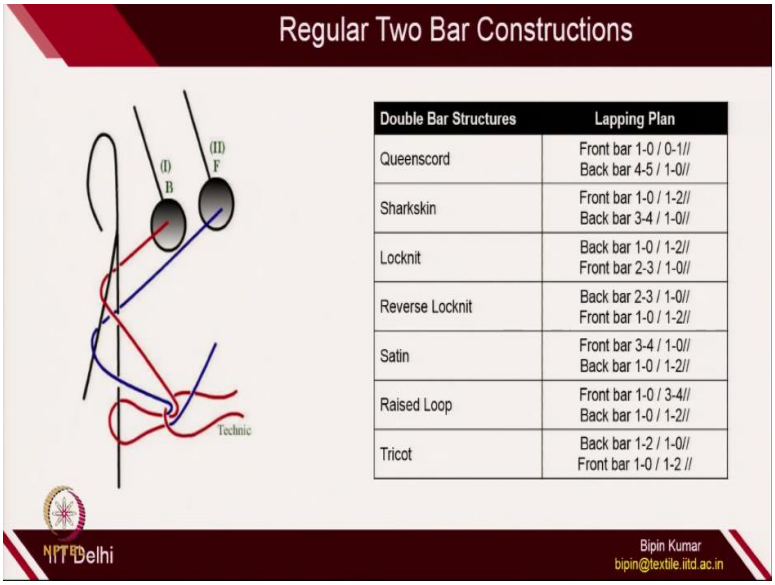

Depending on when we play with the overlap and underlap magnitude directions and threading with respect to back and front bar. So, let's move to the first one.

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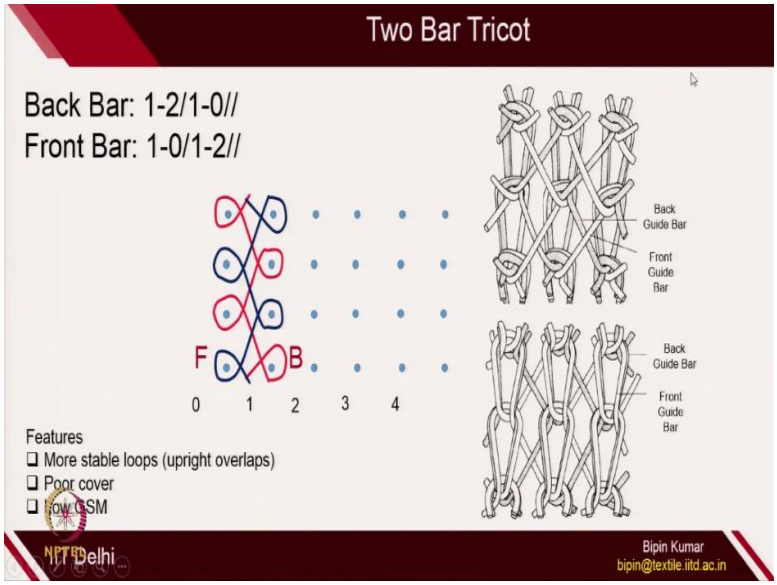

The simplest one is 2 bar tricot. So, this is the semantic of 2 bar tricot. This is technical back side and this is technical front side. So, if you see the lapping plan of back bar 1, 2, 1, 0; and front bar 1, 0, 1, 2. So, this is the back bar lapping plan. And if you see the front bar, this is the front bar lapping plan. Okay. So, this is front and back. So, if you see, at any point between 2 columns, the direction of underlaps are in opposite directions.

So, due to which it will results in uniform tension of in the loops and more stable shape of the loops. So, loops will be in straight position. Also, if you see, this such kind of fabric has very poor cover. Poor cover in the sense, because the underlaps are just floating between 2 columns. So, it is not crossing the columns. Due to which, the covering aspects; so, if you see this figure.

So, the underlaps are just floating between 2 columns. So, the loops are more open. And hence, the cover aspect of the fabric is poor. And also the GSM will be low in case of 2 bar tricot. Now, let's move to the next type of fabric structure, which is locknit.

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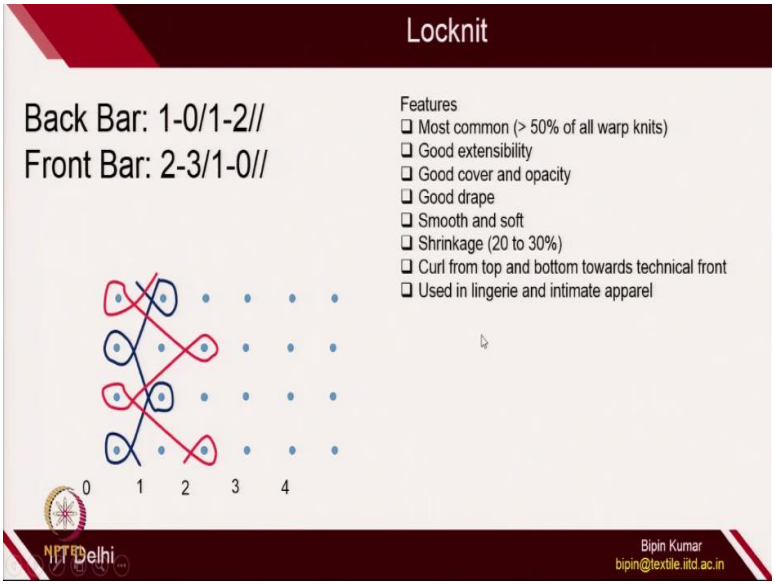

So, locknit is the most common fabric structure. It almost consists of 50% of warp knits. So, how do we make locknit? So, in the locknit, the back bar is having the lapping plan of 1, 0, 1, 2; and front bar is having the lapping plan of 2, 3, 1, 0. So, let's draw its lapping plan. So, if you see the back bar; so, this is your back bar which is 1, 0, 1, 2 lapping plan. And the front bar, 2, 3, 1, 0.

So, this is 2, 3, 1, 0. So, as I showed, the front bar underlaps will be floating on the top of technical back side. So, you can see, the red one is on the top of blue one on the back side of the fabric. So, this, because of this long underlaps, there the fabrics can have more extensibility. So, such type of structure has good extensibility, because it has long underlap of front bar.

Also, it has good cover. The good cover, the reason being, if you see the underlap, it is crossing across column. So, the floating length of the underlap from the front bar is actually passing through the other columns, due to which it is occupying some space in the fabric. So, it has very good cover and opacity. Also, it is having good drape, because it has good extensibility.

The fabric looks very smooth and soft in touch. And if you see the shrinkage; shrinkage you will expect up to 20 to 30%, due to which it will give you lot of extensibility, because it has long underlap. So, once you make the fabric, fabric comes out from the machines and it will shrink by 20 to 30% from its original length. It will also curl from the top and bottom towards technical front side.

The reason being, if you see the nature of underlap, the angle is different. So, naturally, the tension variations in the loops at the ends or at the edges will be different. And due to which, there will be a tendency to curl in the fabric. Most of the times, locknit is used in lingerie and intimate apparel. So, this is the most widely used structure, warp knit structure in the application domain.

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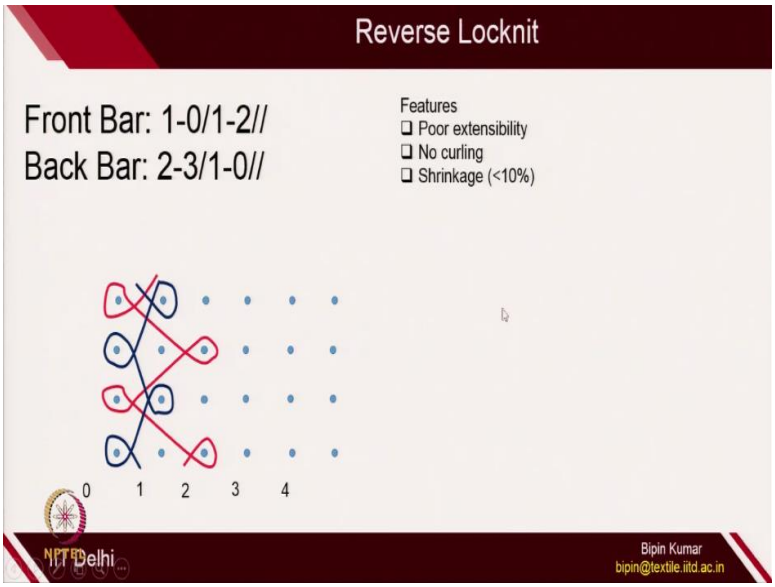

Now, if you see the other structure which is reverse locknit. So here, you have just changed the position of front bar and back bed. So, the threading of the lapping plan has been changed. So, the front guide bar here is now making a smaller underlap, while the back guide bar is making longer underlap. So, now the blue one is on the top of red one, at the back side. So, because of that, since the front bar is holding the underlap behind, at the technical back side; so, the underlap of back bar 3, 1, which is the long float of red one is holded by the underlap of front one.

So, due to which, even though there is a long underlap of back bar, the fabric is not that extensible, because the underlap is hold tightly by the front bar underlaps. So, due to which this fabric has poor extensibility compared to locknit structure. And it will results in no curling comparatively to locknit structure. And also, you will results less shrinkage compared to locknit structure.

And the only difference why we are getting a different results in reverse locknit and locknit is, changing the position of front bar and back bar. So, whatever was the lapping plan of back bar is now shifted to front bar. And whatever was the lapping plan of front bar is shifted to

the back bar. And because of this difference, the underlaps; in one case, the long underlaps are on the top, due to which the fabric was getting more extensibility.

And in second case, the short underlaps are on the top. Because of which, the fabric is more rigid in the nature. So, this is how the changing of lapping plan of front bar and back bar results in a different properties of the fabric. Now, let's move to the next one which is satin.

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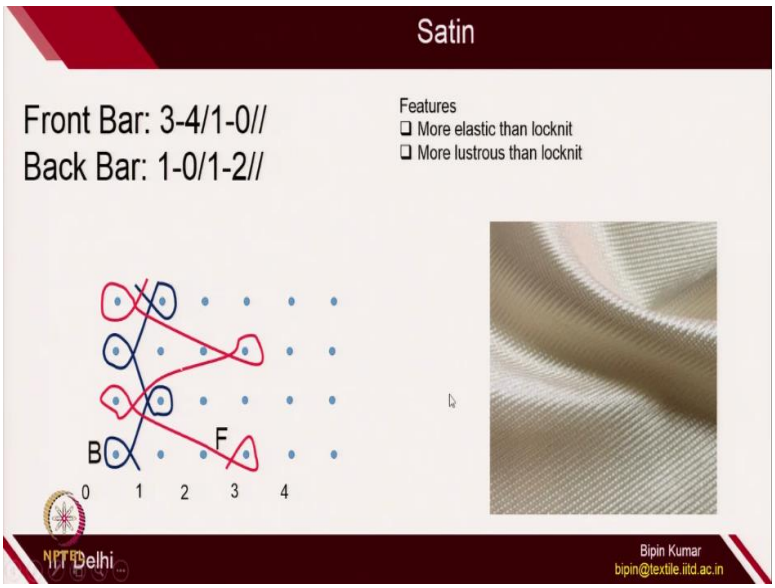

So, in satin, usually the fabric is more elastic than locknit; and more lustrous than locknit. So, what is the main reason? If you see the satin, we usually use satin in woven construction also, where it has long float. So, whenever we have long floats in the fabric, there will be very good reflection. And the fabric will be more lustrous. So, here also, if you see the front bar, the underlap is 4 is to 1.

So, almost 3 pitch underlap. So, back bar is having a 1 pitch underlap, while the front bar is having long underlap. So, this is the long underlap. So, when you have the long underlaps, there will be more flexibility in the fabric structure. And hence it is more elastic in nature. And due to long floats, the reflection properties is of such fabrics is very, very good. And due to which, this fabric looks more lustrous than locknit. Okay.

So, we can have up to 5 pitch underlap or 6 pitch underlap or 3 pitch underlap, which is comes under the category of satin. Naturally, when you have long underlap, there will be very high strain in the needles. So, we usually avoid more than 5 underlaps in case of any warp knitted structure.

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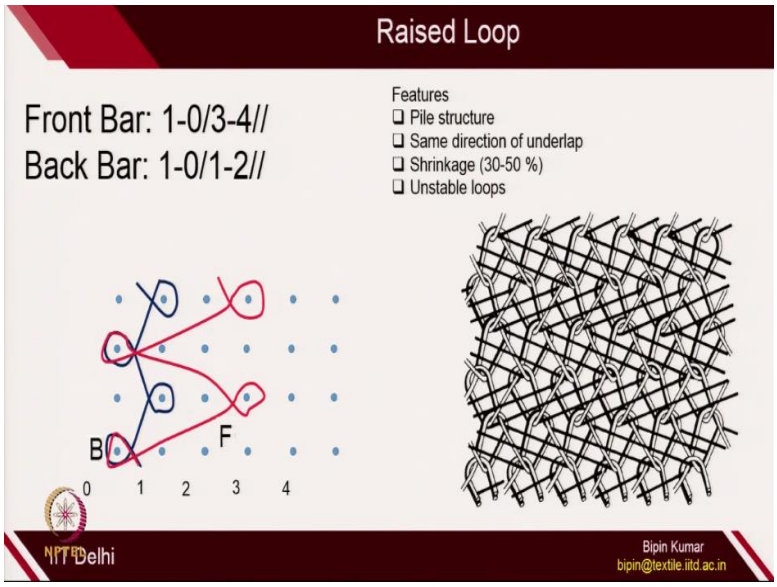

Now, let's move to the raised loop. So, in raised loop, it is similar to the satin. But the only difference is the direction of overlap and underlap are changed. So, if you see the front bar, it has 1, 0, 3, 4. And if you see the back bar, it has 1, 0, 1, 2. So, if you see the overlap, it is having in the same direction at the same time. And also, the underlap is also happening in the same direction in at the same time.

So, the back bar is 1, 0, 1, 2. And also, the front bar is 1, 0, 3, 4. So, since the underlap is now in the same direction in every course; so, if you see here, left to right; and in this course, it is right to left. So, because of this, that there will be unequal tension variation; and the fabric will results in distorted loops. So, the loops will now bend, because the underlaps are in the same direction.

So, there is unequal tension, because both the underlaps will be pushing the loops in the same direction. So, raised loop. Usually, because of this, you will have a kind of pile structure, because it has the long underlaps of the front bar, due to which such loops actually raised from the surface. And it has a pile structure. Usually, it has same direction of underlap. You can see 0 to 3 from left to right; and 0 to 1 also left to right. You will get very high amount of shrinkage, which is around 30 to 50%. And the structure is highly unstable.

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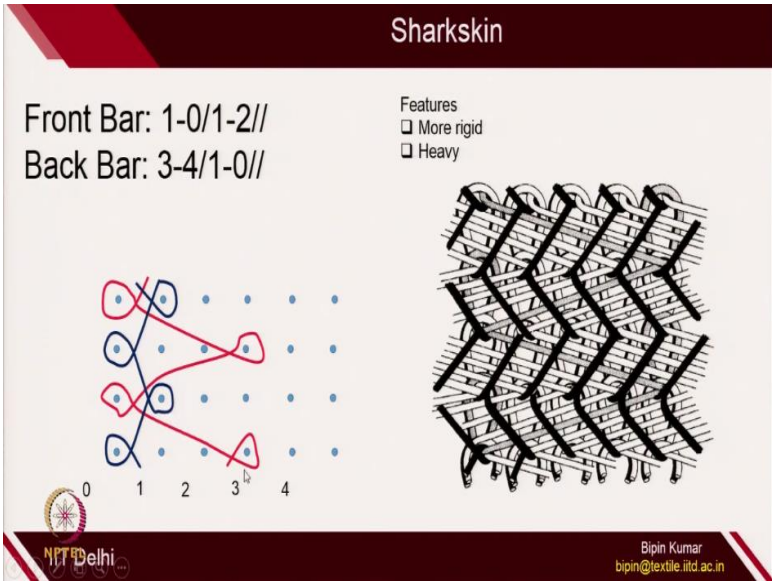

Now, let's go for sharkskin. So, in sharkskin again, the front bar 1, 0, 1, 2; and back bar 3, 4, 1, 0. So, the front bar has short underlap; and back bar is having long float, but at the back side. So, sharkskin is similar to satin, but only the positioning of guide bar has been changed. So, in satin, the front was having 3, 4, 1, 0; and back was having 1, 0, 1, 2. But in sharkskin, front is doing lower underlap; and back is doing higher underlap.

Because of this, such structure, the shorter underlap of front bar provides very rigid structure compared to other longer underlaps of front bar. So, such structure is more rigid, more heavy. You can see it here, long floating lengths. And due to which more cover and more GSM of the fabric. And more rigid, because you have the shorter underlap of front bar. And the longer underlap of back bar is hold tightly by the front bar.

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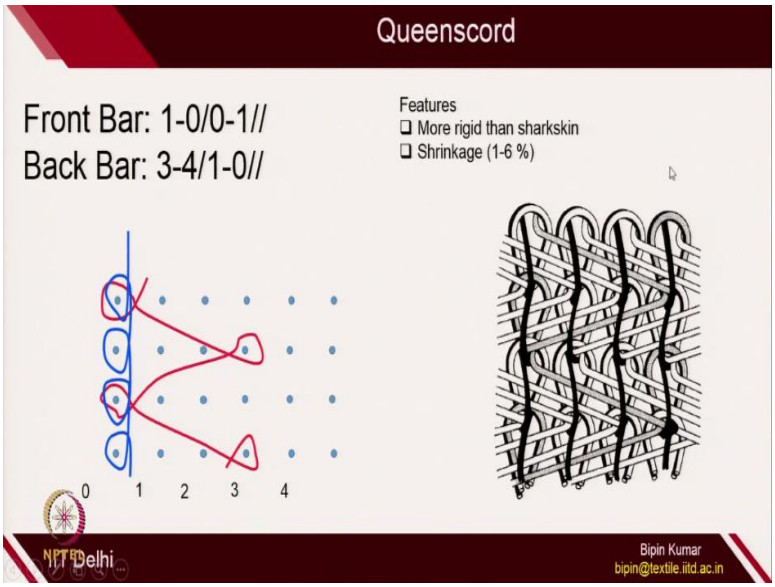

The last one is queenscord. So, in queenscord, one of the bar is having pillar stitch and the other one is having longer underlap. So, if you see the front bar 1, 0, 1, 0. And back bar is having long underlap. So, 3, 4, 1. So, 3 pitch of underlap. And front bar is having overlap of 1, 0, 0, 1. So, such structure, because of pillar stitch, is more rigid than sharkskin. And shrinkage is also very, very limited.

So, I have this structure with me. I can show you how such a structure is very, very tight. **(Video Starts: 27:35)** So, you can see it here. This is, these are all pillars, which is moving vertically. And such a structure is, even if you stretch, very limited amount of stretching is observed. Okay. So, if you see here, so the structure is very, very tight. So, this is the importance of pillar stitch.

So, because of pillar stitch, the loops has limited flexibility. And if it is on the front side, it actually prevents the stretchability of the fabric. If you see another structure. If you see this structure which has a 2 bar structure, but it gives you sufficient stretchability compared to a pillar one. So, the pillar one does not stretch at all, but this one can stretch. So, you can see here.

This one is stretchable, while the pillar one is very limited stretch. Okay. **(Video Ends: 28:53)** So, this is how, in case of queenscord, the property is changed. And it has more rigid than sharkskin. So, now you can understand how positioning of threading of different parts play a important role; how different magnitude of an overlap and underlap plays a different role; and also the direction of overlap and underlap plays a different role.

So, this is how the structure and properties of warp knitted constructions are controlled. So, since most of the warp knitted structure are 2 bar constructions, there are many other complicated structures of warp knit constructions are there. So, in the next class, I will be covering those aspects. But 70 to 80% of warp knit constructions is coming from 2 bar construction which is listed here. And how their properties are changed? I just described to you. So, let’s catch about more complicated structure in the next class. See you soon. Thank you very much.