Science and Technology of Weft and Warp Knitting
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Module - 10
Lecture - 41
Warp Knit Structure - Design Principles

Welcome students, to week number 10, lecture 1. In this particular week, I am going to explain you different types of warp knitted structures, which is used for different applications. I will be focusing mainly on the design principles for creating these type of structures; how are they created; what are their lapping plan; what are their lapping diagrams; and what others designs that you can create on warp knitting technologies.

So, in the previous weeks, I just give you the hint how we create simple types of fabric warp knitted structures using tricot machines; what is the role of guide bar. So, I have given more emphasis on the importance of guide bar which provides yarns to individual needles. I given more importance on the overlap and underlap in the previous weeks, because all the designs of warp knitted structures, the basis is how you are doing overlaps and underlaps on the needles during the course.

So, some of the principles I have already explained, but in this entire week, I will be explaining some of the frequently used warp knitted structures. And I will be explaining their overlap and underlap movement, so that you can guess why these structures have been created and what are their roles. And you can also able to appreciate their structure property relationship; if you change overlap and underlap, how the structures and their properties will change. So, before I move on, again, just a quick recap because, as I told, swinging and shogging motion is very, very important for a warp knitted structure.

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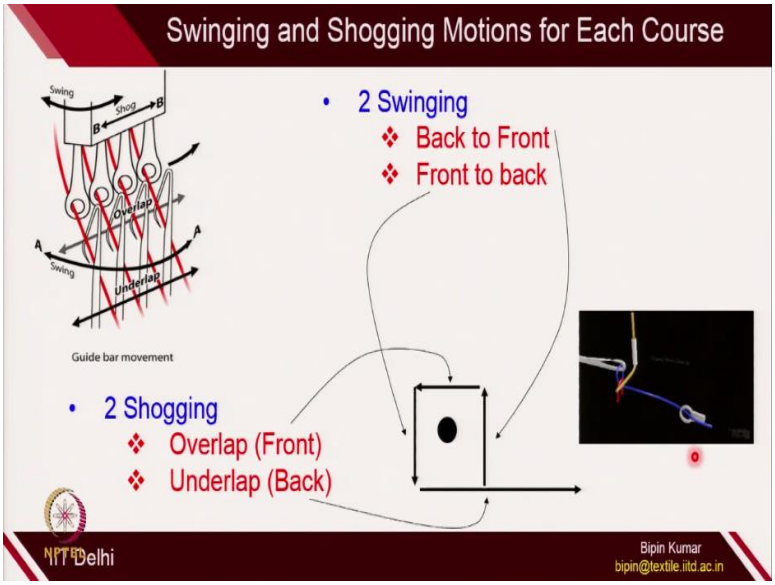

So, swinging and shogging motion is done by the guide bar. And one guide bar consists of many, many guides. And each guides provides yarn to 1 particular needles. So, in the last class, with the help of animation, I showed you what are swinging motions and what are shogging motions. So, swinging motions, I discussed, like the guide bar is moving from back side of needle to front side of the needle; as well as, the guide bar is moving from front side of the needle to back side of the needles.

And in shogging motion, it is the lateral displacement of the guide bar in the direction of axis of needle bar. So, shogging motion was further divided into 2 parts: overlap and underlap. And this is how a simple planar view or the motions of a particular guide with respect to a particular needles can be characterized. So here, you can see the guide bar is standing at the back of the needle.

It is moving from back side to front side. So, this is the swinging motion. So, you can follow the arrow. And the other swinging motion is when the guide bar is moving from the front side of the needle. So, this is the front side. So, from the front side of the needle to the back side. So, in each course, 2 swinging motion has to be there. So, if the guide bar is moving from one side to other side, it has to return back before it starts creating a new course in the fabric.

So, these are the 2 swinging motions. So, in between swinging motions, 2 shogging motions are, has to be happen. So, the first shogging motion is called overlap. In this, the guide bar is moving along the needle bar. You can see at the front side. So, in the front side, the guide bar

is moving from this point to this point. So, this is the lateral shift. And here, actually the guide bar travels some distance in the direction of needle bar.

So, if that distance is on the front side of the needle, this is called overlap. And the second distance in the lateral direction is underlap, which is at the back side of the needles. So, as you know, in each warp knitted structure, the guide bar switches its position from one needle to other needles. So, for switching the position, underlap is very, very important. And for providing the yarn, overlap is very, very important.

So, here is a small animations which combines all of these 4 motions, including 2 swinging and 2 shoggings. So, you can see it here. **(Video Starts: 05:09)** So, first the needle goes front and the guide bar swings; shog; and then swings; and then it changes the different position for next course. So, in each course, 2 swinging motion and 2 shogging motion is must for a course development in a warp knitted structures. **(Video Ends: 05:33)**

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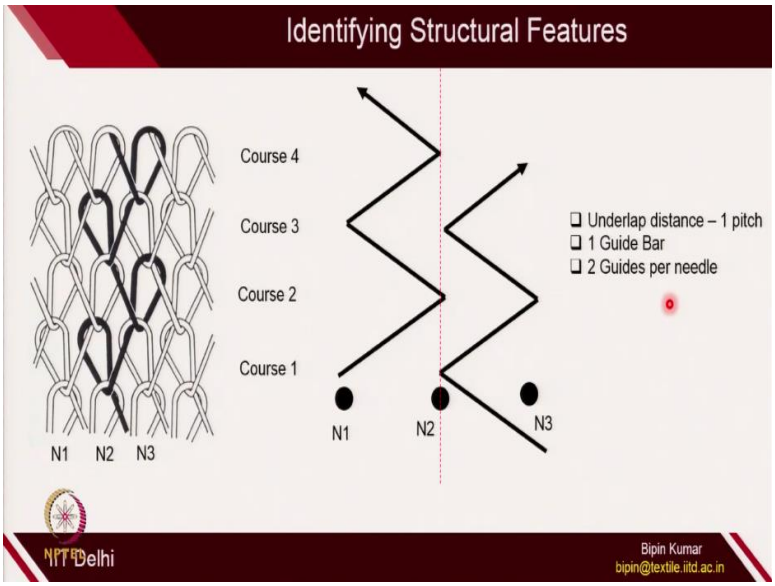

If this thing is clear to you, you would be able to first identify some of the features of any warp knitted structures. For example, how the guide bar is switching from one column to other column; what is the nature of shift; how many guides are actually interacting with individual needles during the fabric formations; how many guide bars are there. So, all those important features, you can extract by looking to the microscopic view of the fabric.

So, I showed you some of the fabric samples also. So, if you take the microscopic view, if you enlarge, you will see the loops exactly in this fashion. And with the help of picking the

movement of one individual yarns, you can get some of the features. So, for each column, you can see, for each needle, that 2 sets of guide bar which is coming alternatively. So, 2 guides per needle is there.

And if you carefully see the movement of all the guides are almost same. So, they, all guides can be attached with a single guide bar. So, that's why, to create this fabric, we just need 1 guide bar. And the last thing; if you want to see the underlap movement, if the, if you want to see the switching from one needle to other needles; you can easily see, it is switching by 1 pitch. So, underlap distance is 1 pitch. So, some of the basic features is very, very important for fabric analysis. And we already have done 5, 6 examples in the previous week.

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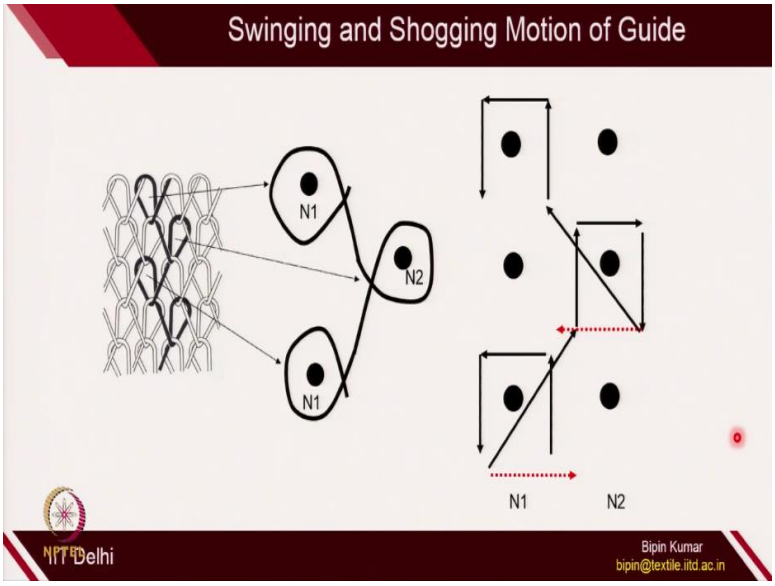

So, further, I tried to explain the fabric with some kind of lapping diagram and some kind of lapping plan, because instead of drawing this so complicated diagrams, we can simply draw the movement of one individual yarns. And we can denote their movement by some numbers. You can see it here. So, first, the loop is being formed by N1 needle. And then, in the second course, the loop is being formed by N2 needle for the same yarn.

In the third course, it is being formed by different needle. So, the same needle, N1 needle. So, in this way, the yarn is shifting from one needle to other needles during the course. And this is the planar view; how the movement actually might have happened on the machines. So, you can see the lateral movement and swinging motions from back side to front side and front side to back side.

And these 2 lateral movements must be happening for each course development. This is a simple lapping diagram and this is the planar view of, which represent the movement of individual guides in each courses. Okay.

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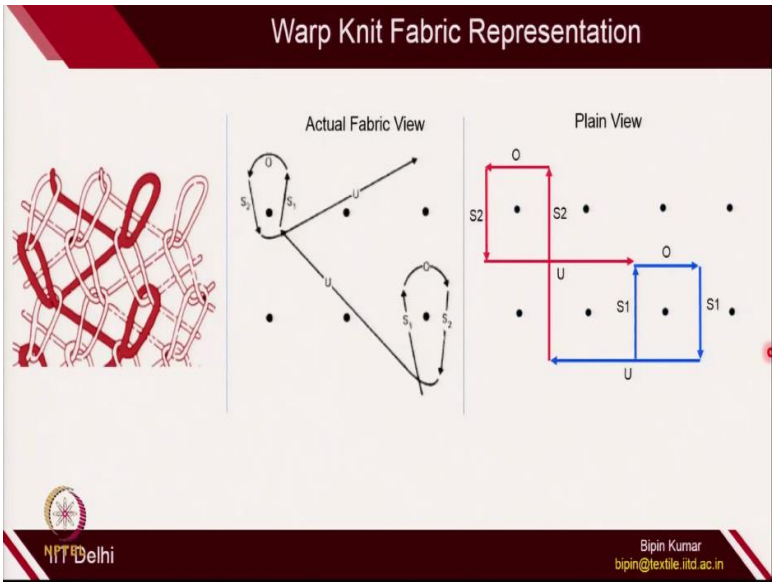

So, to represent a fabric, you need to first go for microscopic view, get the real picture of the fabric. And then, you start following one individual yarns. Because, based on the basic features, if it is having just 1 guide bar fabric, then you can extract the movement of 1 individual yarn. So, this is the actual fabric view where the loops have been created by one individual needle.

So, these 2 loops. So, first loop. And this is the second loop which can be shown here. And the whole fabric is actually repeating after 2 courses. So, which you can see it here. So, the first course, here the loops are being tilted towards right side. And if you see the second course, the loops has been tilted towards left side. And the third course and first course is repeating in terms of loop architecture.

So, naturally, this fabric is repeating every 2 courses. And, if you just represent the movement of 1 yarn for 2 courses, that should be sufficient to represent the entire fabric structures. This is the planar view. In the previous slide also, I explained this. So here, the actually needles start from swinging. So, if you see, follow the blue path; so, the arrow is indicating which motion is happening first.

So, first swinging, then overlap. So, O denotes the overlap. Then, again swinging; and then underlap. So, if the guide bar have done this, it might have formed this particular loop. Okay. After that, the guide bar position shifted laterally at the back side of the needle. So, which you can see it here. So, once the underlap completes, the same guide bar is now reached to a different needle position in the back side of the needle bed.

So, from there, again it starts making the loop for the second course. So here, if you follow the red line; so, this is the first swinging motion; then overlap: then again swinging motion; and then underlap at the back side. So, once this motion of guide bar was done, then it might have created this second loop. And after creating second loop, if you see, if you follow the underlap, it again reaches to its original positions from where it started.

So, it started from this needle position or this guide bar position. And after finishing second course, the same guide is coming to the exact same position. And the similar natures must be happening with other guides. So, that's why, you don't need to explain the movement of each single guide. One guide movement is sufficient to represent the loop formation in a fabric structure.

So, this is the planar view. Other important thing which you might have observed; in actual fabric view, if you see the loops, they are looking like a stable. But in the fabric, you can see the loops are tilted; either right direction or left direction. And the tilting, you can imagine; why it is tilting because the sinker loops; if you see this sinker loop, if you follow this particular loop which is shown by the pointer; so, both the sinker is towards the right side.

So, because of that, it apply forces and bend the loop towards left. So, this might be the reason why loops get tilted. If you want perfectly stable loop, these sinker loops must be in opposite direction. So, compared to a warp knit structure, if you see the sinker loop in between 2 loops, they are in opposite direction. Because of that, the weft knitted is structure is very, very stable.

But in warp knitted structures, the sinker loop is highly unstable position. Either they are coming towards the, from the same directions and leaving also in the same direction. Also, the same sinker loop is connecting with different courses. So, if you see this sinker loop, it is

connecting with the first course. The second course is connecting with the first course, with this straight line which is the sinker loop.

And if you see the third course and second course is connected with this straight line. So here, the sinker loops are connecting courses. But in a weft knitted structure, sinker loops were connecting the loops in the same course. So, that is the fundamental difference between a warp knitted structure or weft knitted structures. And because the connections is different, the geometry of loop is highly distorted.

And you cannot find a very stable loop structure in most of the warp knitted structures. If you really want a perfectly stable loop structure in a vertical direction; then, you need to carefully provide the sinkers which should be countering each other. Okay. Otherwise, every time, most of the warp knitted structure, you will find the loops might be tilted in left direction or right directions.

But for you at this moment, understanding their actual fabric view or planar view is very, very important. Further, these 2 diagrams can be even simplified with the help of simple lapping plan or lapping diagram.

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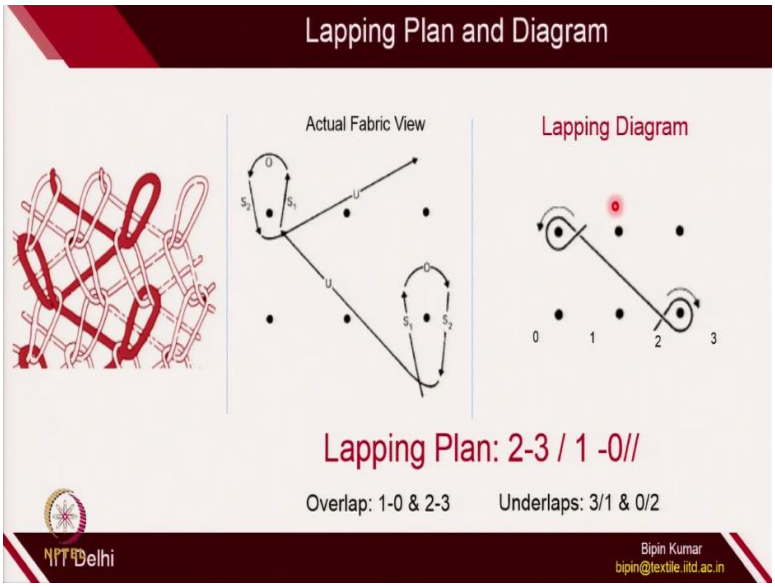

So, lapping diagram, instead of drawing like this, you can simply draw the loops which is connecting one needle with other needles and changing the course. Okay. So, here the overlap, if you see, this is the overlap from second position to third position. The same thing

is happening here. From second to third position, the overlap is happening. And then, from third, it is reaching to first guide bar position which is here.

This is the first guide bar position. So, it is reaching here. So, the underlap which you can see it here; from this point to this point, this is the underlap. So, it is shifting from this guide bar position to this guide bar position. And this is what is shown in simple lapping diagrams. Sometimes, even you can further reduce the representation by simply providing the lapping plan.

So, in lapping plan, you can have, the motions can be represent by some numbers, because it is just a movement from one guide bar position to other guide bar positions. And 0, 1, 2, 3 is actually representing the guide bar position. So, you start from the overlap and then follow the underlap for a course. And then, you keep doing it till you find the repeat design. So, for example, you are starting from second guide bar position; you are going to third.

So, second to third is the overlap position. And from third, you are going to 1, at the back side. So, if you see here, you are standing here and then going at the back side. So, from third position, you are going to first position. And then, you are finishing the first course. So, 2 to 3 is the overlap and 3 to 1 is underlap. And to distinct overlap and underlap, we use different denotations.

So, dash and oblique. Oblique represents the underlap and dash represent the overlap. So, 2, 3, 1; once you complete this, you finish one course. And then, from 1 position, you started making the second course. So, here, from 1 to 0, 1 to 0 is the again overlap. And after that, after 0, you are again going back to second position which is here; so, from 0 to 2. So, the next number which might be coming here is 0, 2, 3, 1, 0 again.

And this sequence will be repeating. So, that’s why you do not need to repeat the same numbers. So, once the number starts repeating and sequence starts repeating, it means the design is repeating. So, you just need to give here 4 digit numbers. And you can further characterize the motion. So here, 1, 0 and 2, 3 is representing overlaps. And 3 to 1 and 0 to 2 are representing underlap.

So, in the entire design, 2 courses need to be done. So, for making 2 courses, 2 overlaps and 2 underlaps has to be created. And this, everything can be explained by lapping plan or lapping diagrams. So, in most of the literature and in resources, you will find some of these denotations in the form of lapping diagram or lapping plan. So, I hope that should be clear to you.

And now, you could be able to apply this for other warp knitted structures which you come across in your life. So, let's go for even more complicated structures. In the previous lecture, I already told you like the structures can be very, very complicated. And you need to be expert in drawing the lapping diagram and lapping plan. So, in the previous class, I was focusing mainly on 1 guide bar, because the movement of all the loops or all the yarns in the fabric was same. So, we just needed 1 guide bar lapping diagram and 1 guide bar lapping plan.

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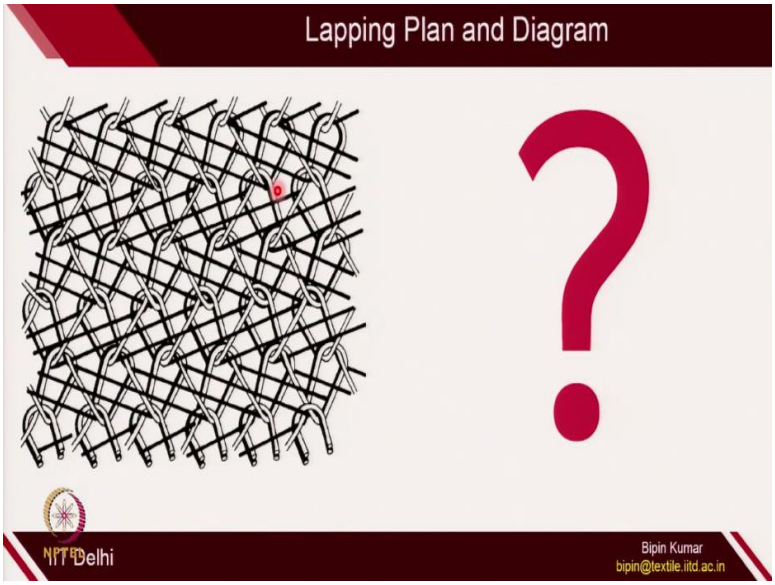

But here, there are 2 guide bar is there, which you can see, because there is a white color of yarn and black color of the yarn. So, there are 2 different yarns are there. And their movements are also different. So, they need to be represented in a different fashion. So, let's see, before I move to the different topics, let's see how we can represent this particular fabric structure. So, this is the fabric structure.

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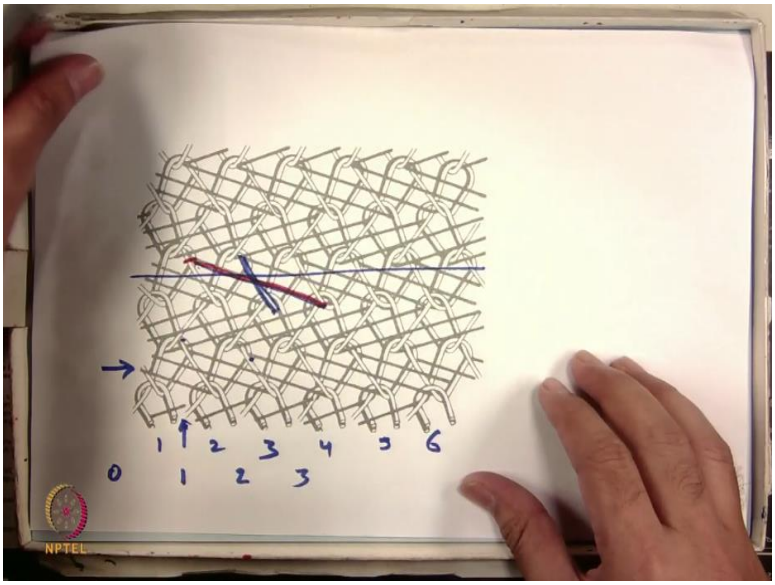

So, the first thing before you move on. You need to find out what is the movement pattern for each guide bar. So, this is a 2 guide bar structure. And how do you find whether it is a 2 guide bar or single guide bar? Between 2 loops, you can find how many floating yarns are there. Okay. So, if you carefully see, between these 2 loops, any 2 loops. So, let's suppose if I am following these 2 loops; so, between these 2 loops, you can see there are 2 floating yarns in different directions.

So, one floating yarn is connecting first column and third column. Okay. So, this is the first column and this is the third column; this floating yarn. And the second yarn, if you carefully see, it is connecting this column to this column. Okay. So, it is coming from this to this. This is the first floating yarn, which is here. Okay. So, first column to fourth column. And second floating yarn, if you see; this is connecting from first column to second column. Okay.

So, here, the underlap is 1 pitch; here, the underlap is 3 pitch. Okay. And as I already mentioned, the overlap is usually 1 pitch. So, you don't need to find the pitch for overlap. In some of the machines, we usually have 2 pitch options. But usually, to make a stable fabric structures, we go for only 1 pitch overlap. It is a underlap which keeps on changing. So, in the same course, if you follow the same course; so, you can find 2 floating lengths, okay, which is shown here.

So, once this is clear to you, you can simply first draw the lapping diagram. So, how to draw the lapping diagram? So, for drawing the lapping diagram for this particular fabric, you first need to define the guide position.

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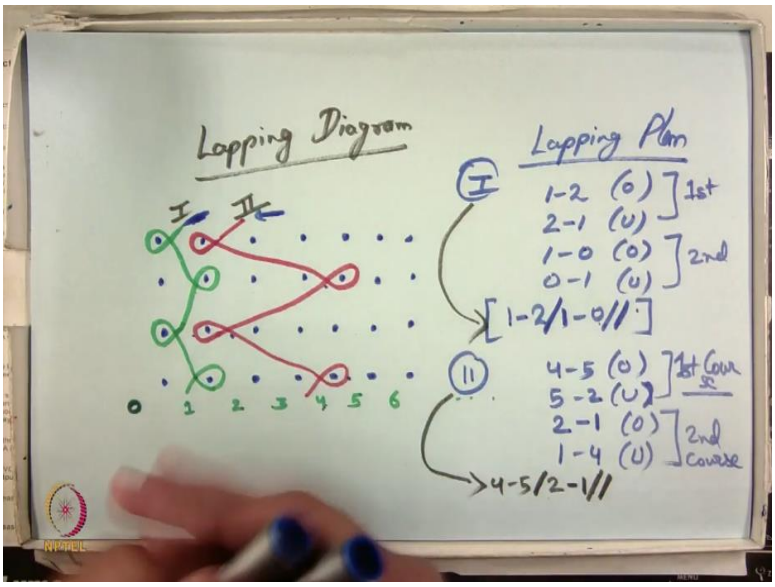

So, to define the guide position, you need to first define the needles. So, these are the needles. And all needles are placed on the same needle bar. And you need to define the guide bar position. So, the first guide is starting from, let's suppose this is the 0 position. Let me write down with a different number. So, 0 position. This is first position; this is second position; this is third position; fourth position; fifth position; sixth position; it depends.

And this guide bar position is actually shifted by half pitch. And why it is so? Because the guide bar has to swing across the needle. So, there should be some spacing when the guide is traveling from the back side of the needle to front side. So, that's why these positions has to be appropriately defined. So, once the position has been defined, if you carefully see, the white color yarn. So, if you see the white color yarn.

If you follow my, the movement of my pen; so, I am following just one white color yarn. So, it is going from third column to second column. Then, from second column to third column. And then, third column to second column. And then, from second column to third column. Okay. So, this is first column, second column, third column, fourth column, fifth column and sixth column.

It depends on your understanding. So, since I followed this 2 and third column; so, that's why the guide bar is shifting from 2 column, 2 alternating columns. So, the each guides which is providing yarn, by white yarn; it is shifting between 2 alternating needles. So, this needles,

we can further represent for 2, 3 courses; 1, 2, 3, 4. So, this is first course. This is for second course.

Then, this is for third course. Then, this is for fourth course. Okay. So, it's keep on moving. So, as if I need to draw the lapping diagram, I can follow any position of the guide. It's not necessary that you only follow the guide which is in, standing at the last or at the end position. You can follow any guide bar position. So, let's suppose I am following second and third position.

So, let's suppose it is starting. So, we are following this particular course. So, it we starting from second position. So, you can see here. This is the first position, because this is 0 position; this is 1 position; and this is second position; this is third position. So, it is starting from 1 position, going to second position. And from second position to, it is going again back to 1 position.

And then, from 1 position, it is going back to 0. And then, in this way it is moving on. So, it is starting from first position and it is moving in this fashion. So, first it is moving from 1 to 2. So, it first makes the loops with this particular needle. And then, it is making loops with this particular needle. And then, it is again making loops with this needle; and again with this needle.

And this is how its keeps on flowing. Okay. So, this is the lapping diagram for one guide which is carrying the white yarn in this particular fabric. Now, let's follow the black yarn. So, as you have chosen the guide; number 1 position. And from here, you followed the white yarn. Similarly, for the black yarn, you can you can start from any position: 0, 1, 2, 3, 4, 5. And you can start following in the same way we followed for white yarn.

So, let's suppose, if we are following from the second position. So, if you see this particularly yarn, this particular. So, it starts from second position, makes the loop with the third needle; then, it is going back to this particular position. But since the fabric is not shown here; so, better we need to find out or start from a positions where I can follow the entire path of the yarn.

So, either you have the full fabric view, then it is fine. If otherwise, if you have a very small sample selected from the fabric surface area; so, you need to be very careful with the position of the guides. So, let's suppose here, I start from this particular position, third position. So, if I start from third position, the black yarn first make the loop in this. So, if you follow this one; so this.

From here it start making. So, this is swinging; then overlap; then again swinging; and then it is doing underlap. Okay. And then, again it is doing swinging; then overlap; then again swinging; and then it is moving to this position. Okay. So, fourth needle and first needle. And the yarn is keep on moving. So, we can start from here. So, let me show you with a different color.

So, fourth needle; and this is the first needle. It first makes the loop with the fourth needle. And then, it is making loop with the first needle. And then, again this needle; and then it is making loop with the first needle. So, this is how it is making. So, once this is clear, now you just need to denote this movement with some numbers. So, this is, let's suppose guide bar 1. And this is guide bar 2. Okay.

So, this lapping diagram for a 2 guide bar structure is available to us. Now, we can simply represent this diagram with some numbers. Okay. So, you not to be get confused that we need to only start from first position or fourth position. You can start from any position of the guide. And the only difference is that the underlap has to be 3 unit for second guide bar. And for first guide bar the underlap should be 1 pitch.

So, this is what you need to only think. Otherwise, every other thing is normal. So, let me represent the lapping plan. So, for lapping plan, we start from here. So, it first go from 1 to 2. This is 1 to 2. This is for first guide bar. So, 1 to 2 is the overlap. And from 2 to 1 is underlap. And after that, from 1 to 0 is again overlap. And from 0 to 1 is underlap. So, 2 courses; this is for second course; and this is for first course. Right.

This is for; and you can simply represent all of these numbers in a sequence. So, 1 to 2, this is overlap; and underlap, 2 to 1. So, which is denoted by oblique. So, 2 to 1 is underlap. Then, 1 to 0 is overlap, by dash. And then, from 0 to 1. So, after 0, this, again this is repeating. So, 0

to 1. So, since it is repeating, so I put it 2 double bar, because our plan is complete. So, 1, 2, 1, 0. So, this is the lapping plan for first guide bar. Okay.

Now, let's see for the second guide bar. So, for the second guide bar, we have chosen the lapping position as the fourth position. Please remember, you do not need to only start from the fourth position. You can start from first position also. And you can follow the lapping plan. But since we have taken the positive numbers, we cannot go to – 1 or – 2. So, that's why, it is better to start with some position where all the numbers should looks positive. Okay.

So, from fourth position to fifth position, it is overlap. So, this is overlap, fourth to fifth position. Then, from fifth to second position is underlap. So, because you have, from the back side if you follow, this is the fifth position. And from fifth position, it is moving to second position. From second position, it is moving to 1 position at overlap; second to 1. And from 1 position, it is moving back to fourth position.

So, 1 to 4 underlap. So again, this guide bar lapping plan is also repeating for 2 courses. So, this is for second course. And this is for first course. Okay. So, if you combine these numbers in a sequence; 4 to 5, this denote an overlap by dash. And by oblique, 5 to 2; this is underlap. And then, from 2 to 1, again overlap. And after 1, 4 is coming, which should be underlap.

So, since we do not need to give the entire, repeat the same numbers; so, we just give the stop signs, after 1 overlap symbol. So, 4, 5, 2, 1 and 1, 2, 1, 0. So, this is for first guide bar; and this is for second bar. So, the entire fabric, if you see this fabric, we can simply denote these 2 guide bar lapping plan. So, guide bar 1 lapping plan; and guide bar 2 lapping plan. And this fabric is more than sufficient to visualize. Okay.

This is how warp knitted engineers works in the factory. They usually follow this type of lapping plan and lapping diagram. So, this is the principle, because once the fabric representation is clear to you, you can go for designing the fabric. So, there are n number of fabric designs that are available in the literature. So, I expect all of you to keep following and doing such kind of practices and learn the lapping plan and lapping diagram.

Now, let's move to the next segment, which is more, more important; is how we design different types of warp knitted structures; what are the different ways for designing warp knitted structures.

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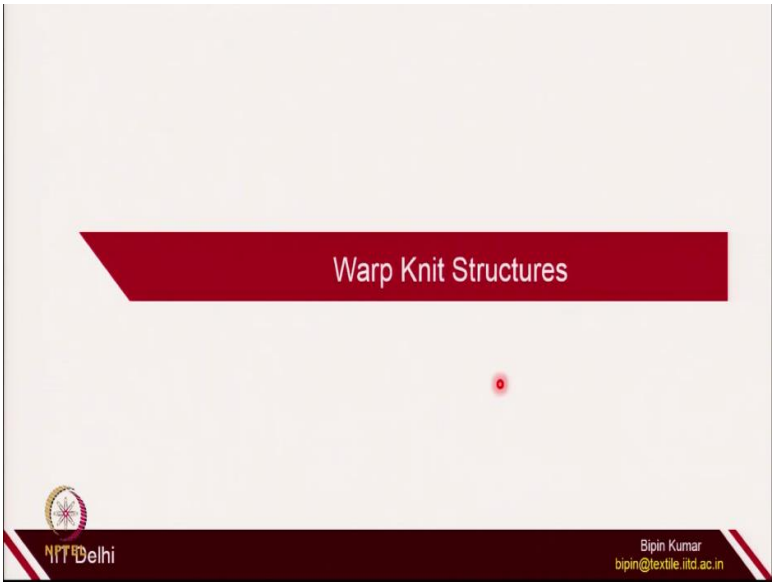

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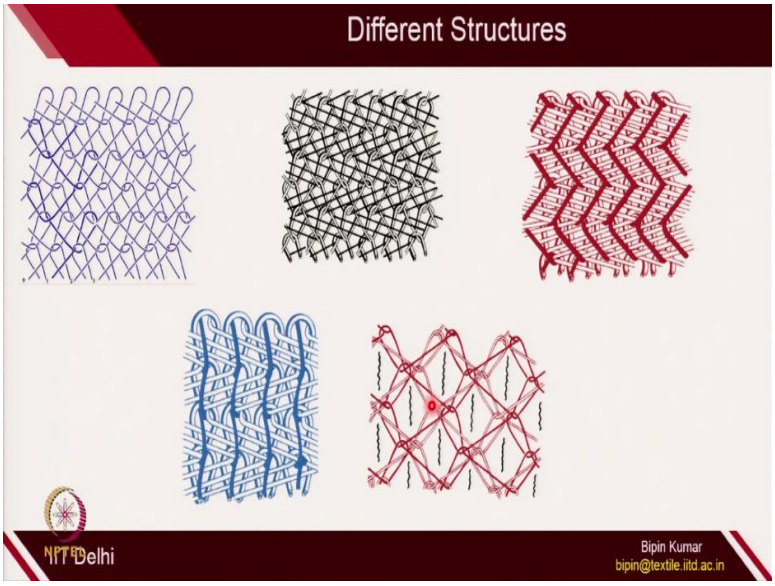

So, some of the structures I already mentioned; single bar structure, double bar structure. This is also double bar structure. This is also double bar structures. This is also double bar structure. So, from technology point of view, how technology actually helps in designing different structures.

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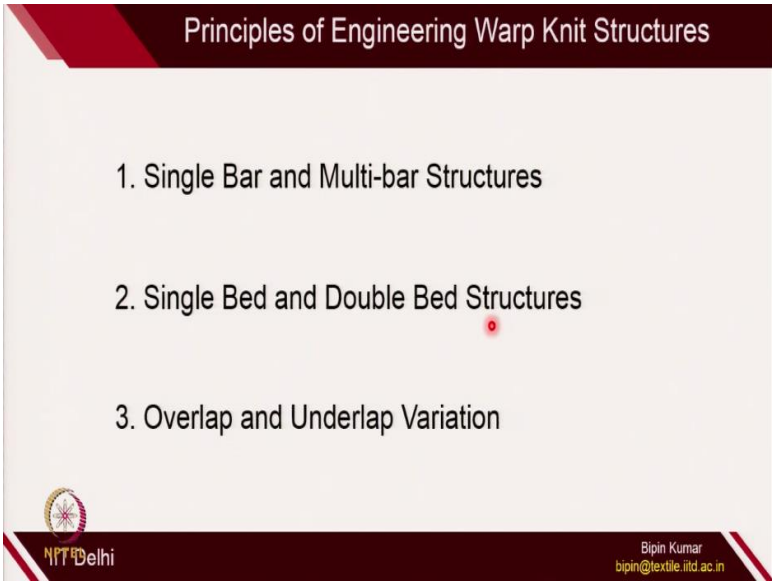

So, they are 3 basic design principle which is there or which is used for engineering warp knitted structures. So, first principle is, whether you are going for single guide bar or multi guide bars. So, for whatever practices we have done so far, either there were single guide bar structures or 2 guide bar structures. But from technology point of view, now the machines are also available which, where you can go up to 8 to 12 guide bars.

So, you can imagine how complicated the yarns movement in the structure could be. So, from technology point of view, you can select single bar or multi-bars. So, the more number of bar you are including in the structure, the different kind of patterns will be created; and their properties will also be different. The other possibilities is, whether you are using 1 needle bed or 2 needle bed.

So, whatever structure I have shown to you so far are single bed structure, where 1 needle bed was used and multiple guide bars were providing yarn to the needles. But there are some machines also. Especially in raschel knitting category, double needle bed is, machines are also available. And which creates entirely a different types of structure. You can also create a tubular structure; you can also create 3D fabric structure.

Especially 3d spaced structure, if you see, it is created on double bed structure. And the last and the most important thing is, how you are playing with the overlap and underlap for each guide bar. Please remember, if you change the overlap and underlap, as I shown, the entire structures can be, have different pattern as well as properties. So, I will be focusing mainly on overlap and underlap.

Other two are just the capability of machine to handle different number of warp yarns with different guide bars. But overlap and underlap is very, very important, which you can only think and design. You can make the plan and then go for the machine to repeat the same sequence. So, let's see one by one.

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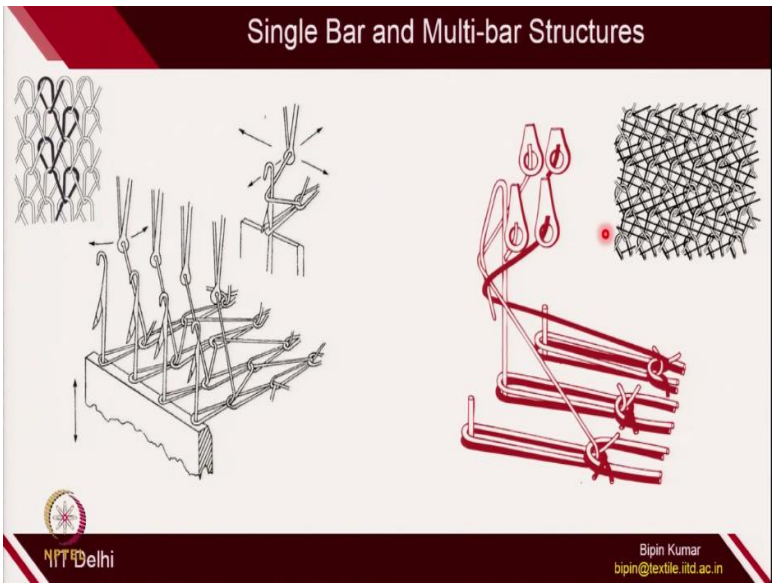

So, this is the single and multi-bar structure. I have already introduced you how we can denote this single bar structure. And this is the double bar structure. Just I showed you. So, single bar and multi-bar structure is like when you are using only one set of guides, which is in, attached with 1 guide bar. Then, it is a single guide bar structure. So, at a same time, only one guide is providing yarn to the needle in each course.

So, that structure is called single bar structure. And you can follow the floating length between 2 column; and you can identify whether it is a single bar structure or multi-bar structure. If more than one guide is providing yarn to the same needle, then it comes under the category of multi-bar structures. So, here is the multi-bar structure. And how can you find out whether it is a multi-bar structure?

You can follow the underlap pattern for, of the floating yarn. Or you can follow the sinker loops. So, if there is 2 floating yarns between 2 columns, you can easily guess it is a multi-bar structure. And if you have 2 guides coming to the same needle at the same time and their overlap and underlap movements are different; then, each of these guides has to be attached with different guide bar.

So, here, these 2 needles, the same needle is having 2 guides. So, the first guide is carrying the white yarn and the second guide is carrying the dark yarn. So, first guide must be connected with the first guide bar; and the second guide must be connected with a different guide bar. So, it's definitely a 2 guide bar structure. Similarly, in many complicated machines, you can go up to 8 guide bar or 12 guide bar.

6 is very widely used in spacer type structures, where 6 guide bars are playing the overlap and underlap movements for designing very complicated structure. Now, the other design principle is, whether you are using a single bed or 2 bed.

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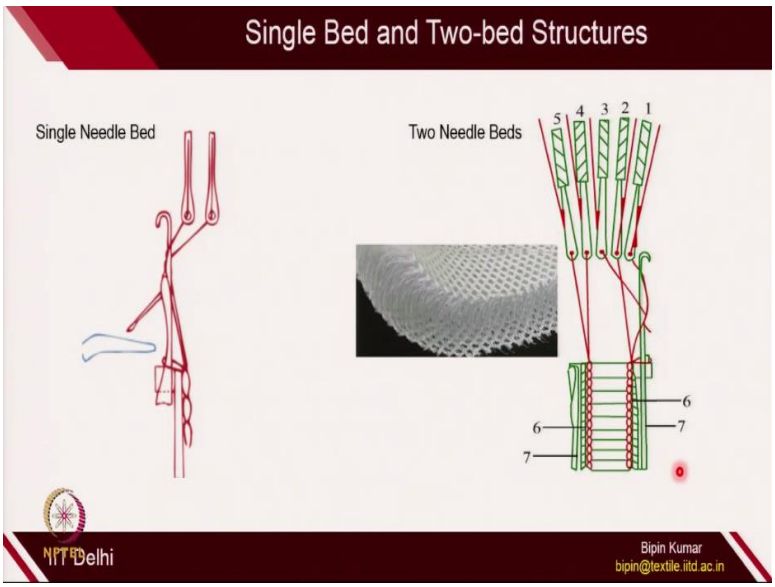

So, in single bed, here only one set of the needles are attached with 1 bed. And different guides are providing yarn to that particular needle bed. But sometimes, 2 needle beds can also be fixed, facing opposite to each other. So, this is the first needle bed; and this is the second needle bed. And you can see all the guides are playing across these 2 needle beds and creating different types of warp knitted structure.

So, whenever these 2 needle beds are used, either you can create a tubular warp knitted structure, which is used in supermarket. So, if you see all those tubular packaging materials for carrying potato or onions; so, all those designs are created on 2 needle bed structure. So, 2 needle bed are required to create a tubular warp knitted structure. Or you can go for creating a 3-dimensional fabric.

So, which is used in cushioning, especially these type of fabric is called 3d spacer fabric, where 2 beds are there. So, one fabric is created on first bed, the second fabric is created on second bed. And these 2 fabrics are connecting with the help of spacer yarn. So, one of the guide will be shifting the yarn from one bed to other bed. And in this way, a 3-dimensional fabric structures can be created.

So, this is also another principle. And once this kind of a structure was created, this structure gives lot of porosity. And it was a revolution in the field of mattresses and cushioning type of material, because it is a very fluffy fabric and highly porous. So, 2 needle bed is, gives you that capabilities to create a 3-dimensional fabric structures. So, in one of the week, probably next week, I will give you some of the design importance; how you can create these type of structure.

But, once lapping plan and diagram to, is clear to you, you just have to write down the notations. And the machine will automatically produce these type of fabric structure. I will give you some hint in next week. So, this is another design principles, where you can use different beds in the machine.

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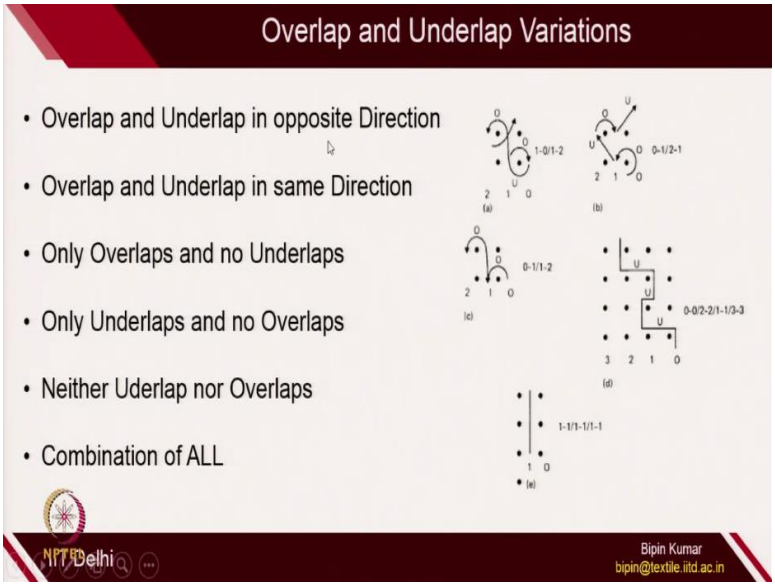

The other, last important design principle is, playing with overlap and underlap. So, I have already told you; overlap and underlap is required during each course formation. So, and these pattern of overlap and underlap has different possibilities. So, for example, you can go for overlap and underlap in opposite direction. So, you can also go for overlap and underlap in same direction.

You can also go for only overlap in the course, no underlap. You can also choose only underlap in a course, no overlap. Or you can also choose not to give any overlap or underlaps on the machine. So, neither underlap nor overlaps. Or you can combine all of these together, to create very complicated structure. So, let me help you understand one by one. And this is actually very, very important.

Why I want to give more emphasis is, if you understand all of these, probably you can generate any type of warp knitted structure depending on your requirement. So, let's go one by one. So, overlap and underlap in opposite directions. So, what does this indicates? So, overlap and underlap in opposite direction.

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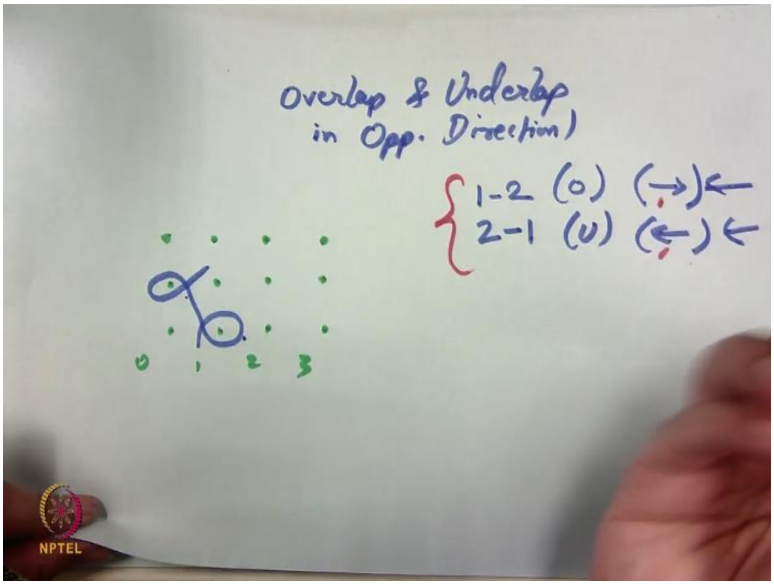

So here, each guide, if had, if it has to give overlap and underlap in opposite direction, then the motion of shogging should be opposite. So, for example, let's suppose you see this example; 0, 1, 2, 3. If you see, particularly this example; 1 to 2 is the overlap which is from left to right direction. But if you see the underlap from 2 to 1; so, in the same course, the underlap is from 2 to 1.

This is underlap. And this is in opposite direction. So, the first shogging motion, the guide bar shifting from left to right with respect to needle bed. And in the second shogging motion in the same course, the guide bar is shifting from right to left. So, the directions are different. So, this is called overlap and underlap in opposite direction. Because for the same course, you can see the directions are opposite. So, one from left to right, another from right to left.

So, this is for opposite direction. Now, let's go for overlap and underlap in the same direction.

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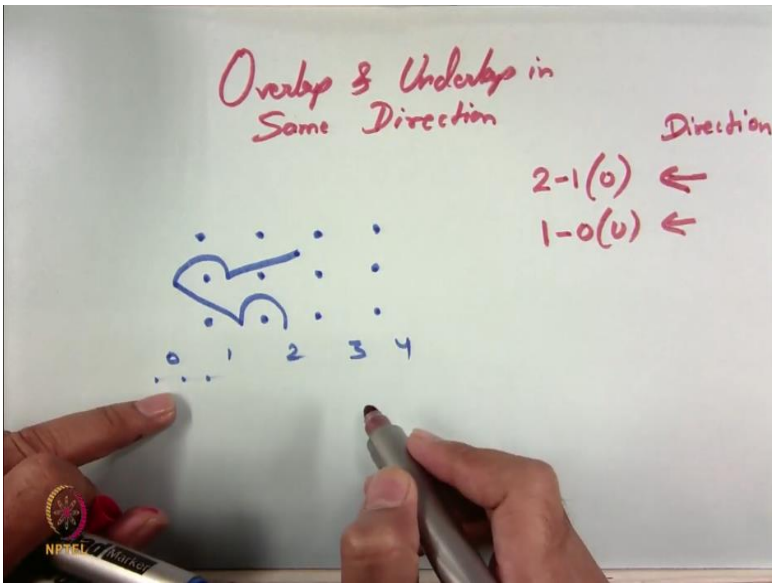

Overlap and underlap in same direction. So, what does this indicates? So, let me give you another example. You can denote the guide bar position. And let's see, what do you mean by overlap and underlap in the same direction. So, for example, you start from second guide bar position. So, this is the overlap for one needle. And you are giving the underlap in the same direction. Okay.

And then, again overlap in the front side of the needle; and underlap also in the same direction. Okay. So, if you note down its lapping plan; so, it is started from 2 to 1, which is overlap. And if you see the direction; so, 2 to 1, it is left direction. And after finishing overlap, it is doing underlap from 1 to 0 position, which is also in the same direction. So, both overlap and underlap in the same course are in same direction. Okay.

And if you see here, if you carefully see this one; in the same course, overlap and underlap are in opposite direction. So, this is fundamentally they are different. It creates different types of loop architecture in the fabric. And also the fabric property will change. Now, let's see another condition.

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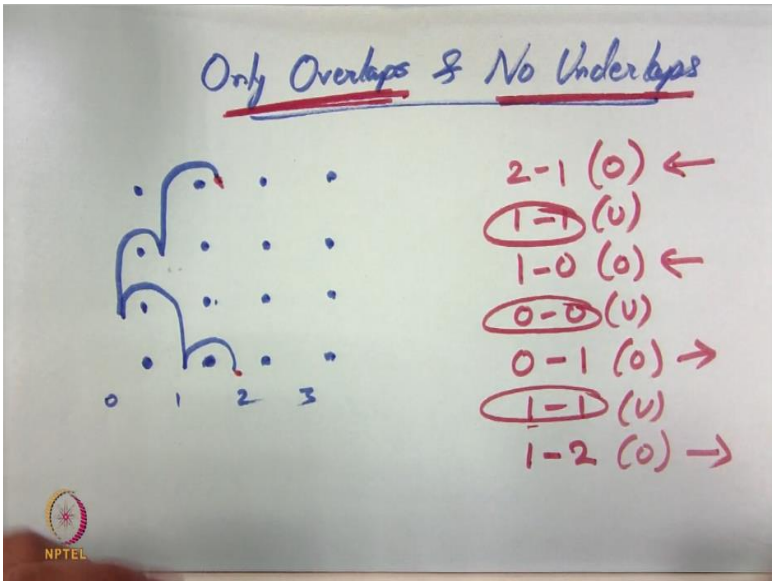

Only overlaps and no underlaps. Okay. So, the guide bar is only providing needle on the front side, it is not doing underlap at all. So, how you can do this? So, let's suppose you have the needle. You have the guide bar position, 0, 1, 2, 3. Okay. So, from, let's start from second position. So, this is the overlap. And since underlap is missing; so, this needle or this needle; let's suppose it is doing the overlap again.

So, let's suppose, if I am doing the overlap again. So here, if you see, if you move from 2 to 1 position, the underlap was missing, because all the movement is on the front side; only overlap is happening. Okay. Similarly, if you want, you can go to the other position. You can go for the other position. So, if you see that this repeat design, only overlap is happening; no underlap at the back side of the needle.

So, if you want to check this with number. So, 2 to 1 is overlap. And direction is, right to left. Then, from 1 to 0 is overlap. It means, underlap is missing. So, 1 to 1 is underlap. So, no underlap. So, because the position remains same. After that, 1 to 0; again overlap. Then, 0 to 0; underlap, again missing. Then, from 0 to 1, overlap. And then, 1 to 1, again underlap which is missing. Okay.

1 to 1 underlap which is missing. From 1 to 1, underlap missing. And then, from 1 to 2 is overlap. Okay. And again, it started from second position, it reached to second position. And then, the same repeat is designing. So, you here you can see, only overlaps are happening, no underlaps, because all the underlaps are having 0 pitch. Okay. So, this is the third condition. It will again create a different type of fabric structure.

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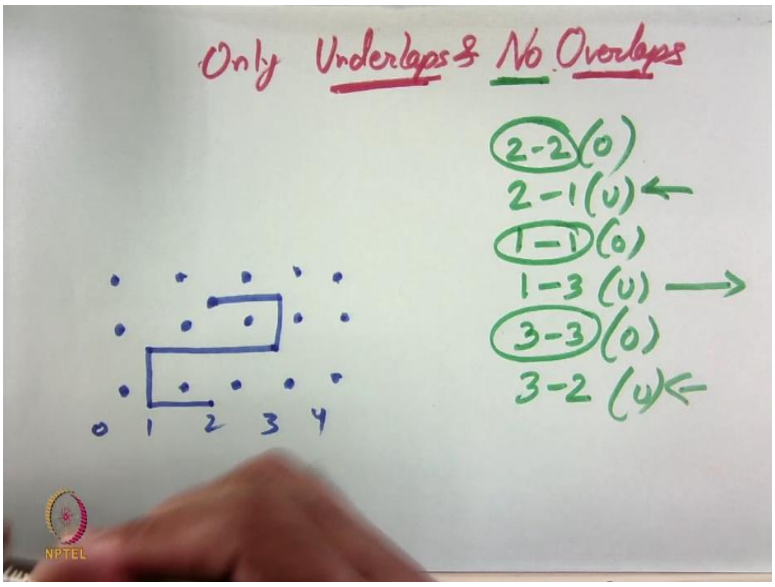

Now, the next thing is, only underlaps and no overlaps. So, let me give you an example, how there will be only underlaps and no overlaps. So, it means, yarn is just floating; it is not being provided to the needle. So, needle is not making any loop at all, if the guide bar is doing this. So, it is just floating at the back side. So, let's suppose we started from any position. Let's suppose you I start from second position.

So, the yarn does not do overlap. So, it remains in the, it remains or it swings, again comes back. And then it is doing the underlap at the back side. Again, it swings on the same position, no overlap to any needle. It again swings to third position. This is the third position. Again it swings, no overlap. And it reach back to second position. So, if you see this, it is just shifting the yarn at the lateral side or the back side of the needle; not providing yarn to the front side of the needle.

Because of this, no loops can be created, if the guide bar is doing this type of function. So, we can see this. So, always, the first thing for any course, it goes from swinging and then overlap; then again swinging; then underlap. So, from second to second is the overlap, which is nothing. And after overlap, there is a underlap, 2 to 1, which is at the right to left side. Okay.

Then again, from 1 to 1 is overlap, because there is no overlap at all. So, the pitch is 0. After that, from 1 to 3 is underlap, which is on the right direction, 1 to 3. Then from 3 to 3 is again overlap, which is nothing. Then 3 to 2 is underlap. So, we started from second position. After

3 course, we reached to the same position. So, this is how you created a fabric structure where only underlaps are there, no overlaps.

So, please remember, we cannot make the fabric only by this type of movement, because the yarn is actually not catching the yarn. So, you need to have different guide bar which should be providing loops on the front side of the needle. So, this is another category, only underlaps and overlaps. So, if you see overlaps; no overlaps means 2 to 2, 1 to 1, 3 to 3. So, there is no difference in the number. It means, it is not shifting on the front side.

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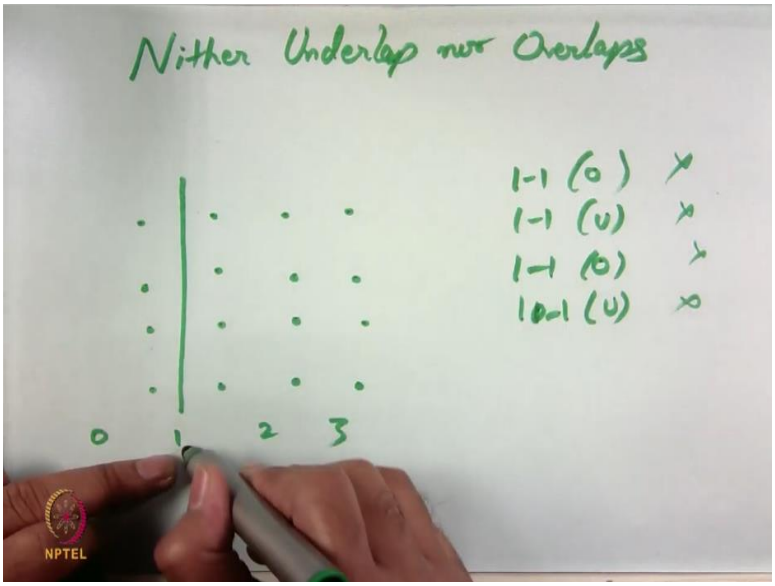

And the last part, neither underlap nor overlaps; nothing is happening. So, if nothing is happening, 0, 1, 2, 3; it means, the yarn is moving completely in a straight fashion in every courses. So, if you see here, we have 1 to 1 is overlap; 1 to 1 is underlap; 1 to 1 is overlap; again 1 to 1 is underlap. So, there is no movement at all. So, the yarn is being provided. The guide bar remains in the same position carrying the same yarn between these 2 needles. Okay.

So, in this case, the yarn which is coming in the fabric will be in a straight fashion. Please note down, we cannot create fabric when there will be no underlap and overlaps. So, there must be different guide bar which will be making some kind of loops. And these floating straight yarns will be inside the fabric structure. So, this is the 5 combination. Other combinations could be the combination of all of these.

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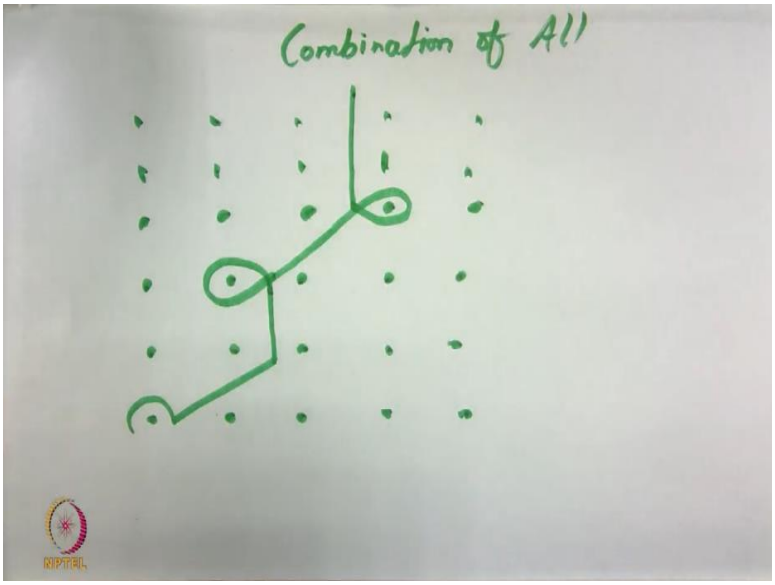

So, I am just giving you hint; combining all, combination of all. So, for example, let's suppose I am doing this. So, here you can see the overlap and underlap are in the same direction. Here you can see overlap from right to left; and underlap, left to right. Here, you can see only floating yarns. So, each course has the combination of different arrangement for overlap and underlap.

So, this is how; once this thing is clear to you, based on your requirement and applications, you can go for overlap and underlap variation. So, these are the 5 design principles based on overlap and underlap combinations, which you can choose for a warp knitted structures. So, once all of these things is clear, you can go for designing. And this is how warp knit structural engineering is done.

In the next lecture, I will be giving more general warp knitted single bar structures and what is their role; what is their properties. So, with this, I am ending this particular lecture. I expect you to please look at different types of warp knitted structure and try to understand these, all of these variations in overlap and underlap. So, thank you very much. Catch you in the next class.