Science and Technology of Weft and Warp Knitting
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Module - 3
Lecture - 12
Weft Knitting - Double Flat Beds

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Welcome participants. Now, we are moving to lecture number 2 in week 3. Today, the topic of this lecture is Double Flat Beds. So, in this particular lecture, we are going to learn about another aspect of weft knitting technologies, which is related to double flat bed knitting machines. Before we move further, now we need to first understand why there was a need to have double flat bed knitting technologies. So, in the last lecture, I introduced you a new topic related to knitting which was fabric curling.

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Lecture 1 (W3) – Summary

Fabric Curling in Single Jersey

Front to back

Back to front
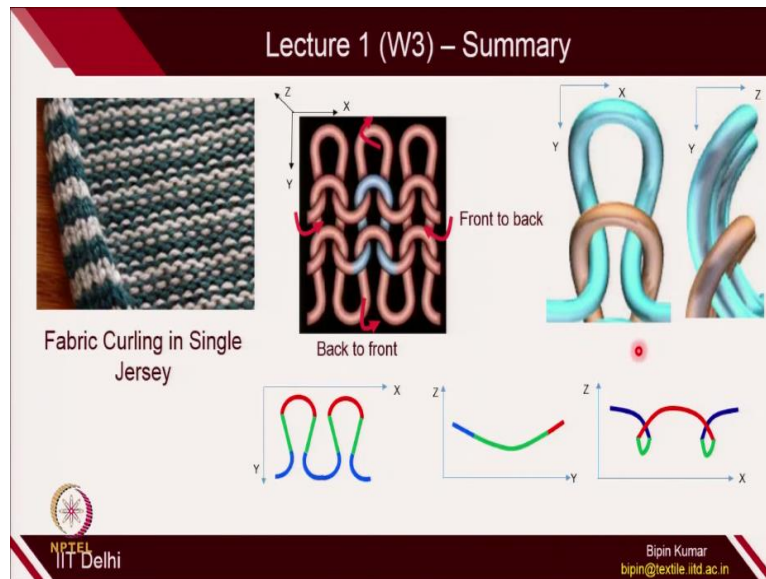
I demonstrated you how a single jersey fabric which is usually produced by single bed machines, used to curls from the edges. And the nature of curling is highly complicated. So, if you see the loop configuration here, the fabric; along the wale line, the loop try to bends from front to back. And along the course line, the loops try to bend from back to front. So, in last lecture, we tried to understand why this phenomena was happening, especially in case of single jersey fabrics.

Because these type of fabric curling creates a lot of problems in fabric handling, especially sewing, garmenting, cutting. So, there is always a kind of problem which you will face while working with single jersey fabrics. So, in last week, we tried to understand why this curling was happening. To understand this, we tried to analyze the projection of these type of loops on 3 different planes.

So, x-z plane x-y plane and y-z plane. And we noticed, usually the yarn which is generally in a straight segment; so, if you take any yarn, it is usually in a straight segment; but once it is there inside the fabric, the nature of yarn is in highly bent state. So, you can see here in x-y plane, the yarn is bent in the form of loop. In y-z plane also, it is bend in certain fashions. So naturally, if this yarn is elastic, it will always try to bend and go back to its straight position.

So, we try to take the projection of these loops in all different planes and we understood how across different edges, it has different nature of curling. So, this is what we covered in the last lecture. Apart from that, we categorized 2 different types of fabric;

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Lecture 1 (W3) – Summary

Single Jersey	O	O	O	O
	O	O	O	O
✓ Made on Single Bed M/C	O	O	O	O
	O	O	O	O

Double Jersey	O	X	O	X
	O	X	O	X
✓ Does not curl	O	X	O	X
✓ Made on Double Bed M/C	O	X	O	X

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One was single jersey fabric, which I just introduced to you, which is usually made on single bed machines. In a single jersey fabrics, you can either see technical back loop on one side of the surface; and if you flip that surface, you will see technical front side. And you can see how difficult it is to work with single jersey fabrics. So, the moment you relax this fabric, it will try to curl from the edges.

To overcome this problem, a new kinds of fabrics was introduced, usually which is called double jersey fabrics. And the nature of double jersey fabric is much more stable. It does not curl from the edges. And the idea for double jersey fabric not to curl from the edges lies in its structure. So, if you see double jersey fabrics, in the same course, you can find technical back as well as technical front loops.
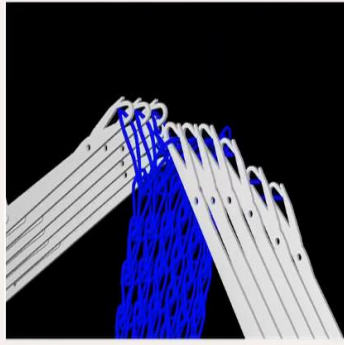
And because of having technical back and front loops on the same side of the fabrics, the curling nature is counteract. So, if, let's suppose technical back loops try to moves in anti-clockwise direction, naturally, that will be counter by technical front loops, which will have counter direction movement. So, in this way, the nature of curling is solved in case of double jersey fabrics.

But to create double jersey fabrics, we need to have double bed machines. And this is how a new kind of technologies was introduced in knitting, which is related to double bed machines. So, in this particular lecture, we are going to focus more on double bed machines.
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Learning outcomes from Lecture 2 (W3)

- Principle of **Double Jersey Fabric Formation**
- Double Flat Beds: **V-Bed M/C**
  - Needle Beds
  - Cam Profile
- Double Flat Beds: **Purl Knitting M/C**

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(Video Starts: 04:41) The first thing what you can expect from this lecture is, what is the principle to create double jersey fabric. Then, we are going to understand the double flat bed machines, especially the V-bed machine which is the most popular one in knitting technologies. In the V-bed machine, we will try to understand how the beds operate; how the needles are placed.

Also, we will look at the profile of the cams which is there for the reciprocative movements of needles. Apart from that, in double bed machines, we will also cover a new kind of machines which is purl knitting machines. So, the idea, understanding or looking to these machine is, how we can create a double jersey fabrics with double beds machines. So, let's move to the first part, what is the principle behind creating double jersey fabrics. **(Video Ends: 05:32)**

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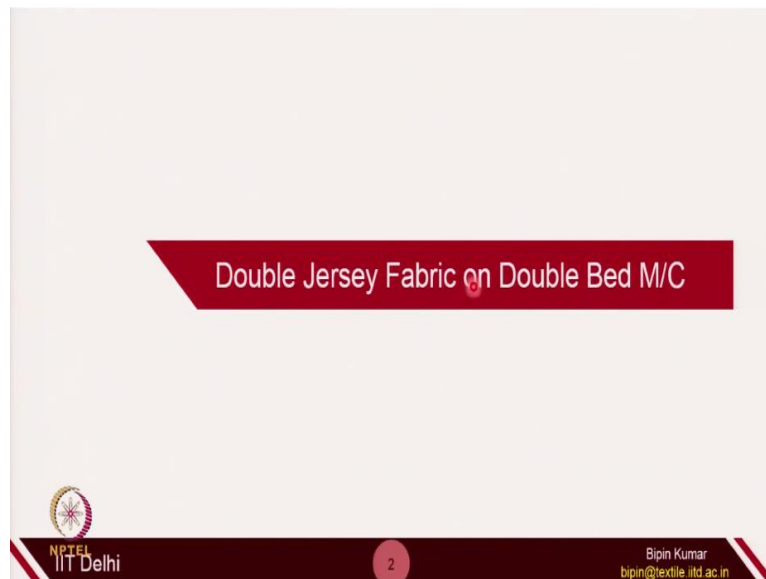
So, first of all, double jersey fabrics can only be created by a double bed machine.

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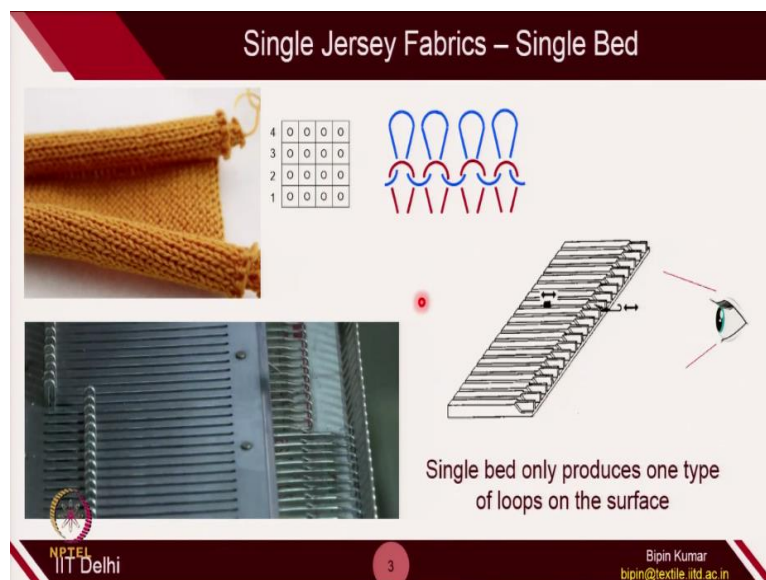
To understand this, if you will see the nature of a single flat bed, it can only produce technical back or front loops on the surface. So, this surface which you are looking at, it is only consist of head and sinker part. So, naturally, this symbol indicates technical back side. So, in technical back sides, all loops which is denoted here in blue segments are going behind the red loops. So, it is being formed on the back side of the loop.

So, if you see the nature of movement of each individual needle of this particular single bed, the nature of movement will be like this. So, it comes out, take the yarn and goes back inside the bed. So, if you are watching in front of the machine, what you will observe that it is catching the yarn and it is making the loop on the back side. Okay. Since all the needles

which is placed on this particular bed has the same nature of movement, so, all the loops which is created by each single needle will have same nature.

Either it will be technical back, if you are watching from this side; or if you are watching from the opposite side, let suppose on this side, it will be having technical front. So, due to the nature of placement of needles on a single bed, single bed can only produce one type of loops on the surface. And such fabrics are called single jersey fabrics.

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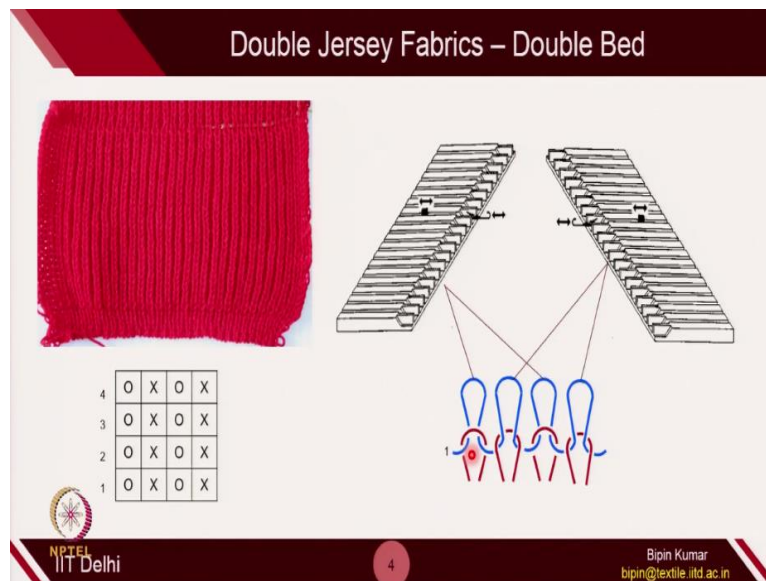
But if you see a double jersey fabrics, the most important difference between a double jersey fabric is, it is having both technical front and back loops on the same side as well. So, if you see the first course, you can see technical back as well as technical front is being formed simultaneously. So, for example, if you see the nature of yarn movement here; so, the first column loops, the blue one, it is being formed on the back side.

After that, in the second column, this loop is being formed on the front side. So, the yarn is same, which is providing yarns to each column along the course, but the nature of loop formation is different. So, the first column is technical back, the second column is technical front. Again, technical back; and then, technical front. So, along the course, back front, back front.

So, in this way, you are creating all set of loops on the same surface. So, to create technical back and technical front using a single bed, it will be impossible. Because, if you look at one bed, the nature of needles on that particular bed will remain same. So, either it will create

technical back loop. So, for example, if you see the blue one, this first column and third column, these 2 loops will be formed by same type of bed having same type of needle movement.

To create this 2 loops, naturally, the position of this bed has to be in opposite direction. Opposite in the sense, the needles should be doing exactly opposite movement of what the first bed set is doing right now. So, to create front loops, the positioning of bed has to be exactly opposite. Okay. So, in this way, you can create technical front loops. So, to have technical back and front loop along the same course, some loops has to be created on this bed in which the needle is moving from left to right and then right to left.

And then, some loops has to be created on this bed where the needle is moving from right to left and then left to right. So, in this way, you can create both technical front as well as technical back, in the same course. So, this is the main principles. We need to have 2 different beds with different reciprocative movements of needle in opposite directions to have both technical front as well as technical back loops.

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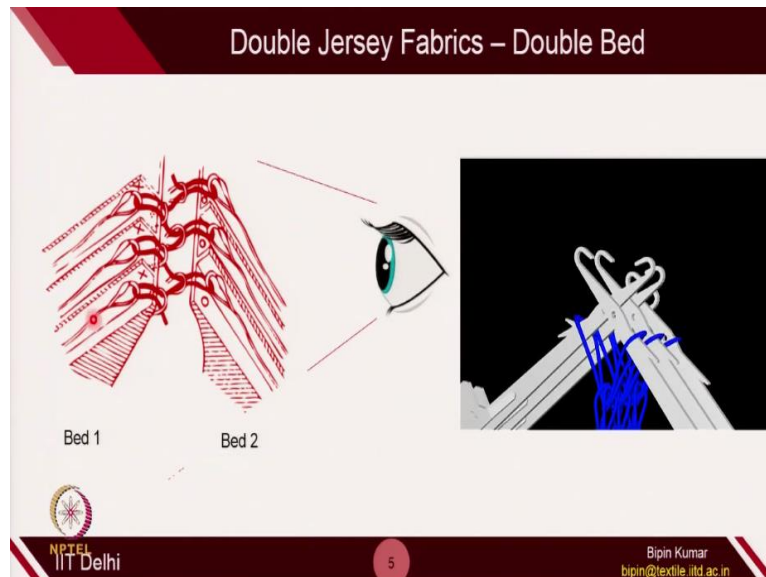
Here you can see the actual, **(Video Starts: 09:57)** how the needles are catching the yarn and they are placed in 2 different beds. So, if you see the bed number 1, you can see here, there is 3 needles being placed. If you see bed number 2, again you can see there are 3 needles being placed. And the nature of movement of these needles are quite opposite. So, if you are standing here, naturally, if you see this 3 needles, it is catching the loop and bringing to your side.

So, these 3 loops, they are actually creating technical front side. But if you see these 3 needles, they are catching the loop and going away from you; so, towards the back side. So, that's why these 3 loops are creating technical back **(Video Ends: 10:40)** loops.

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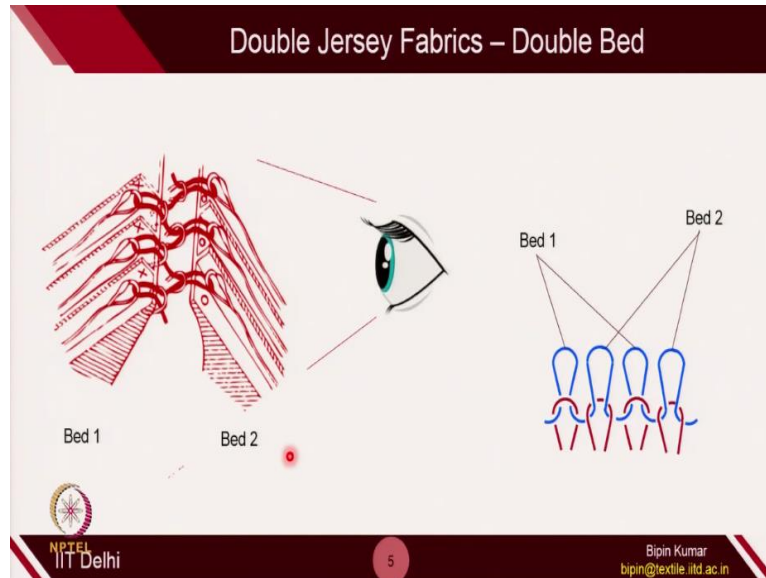
So, in the same course, the bed number 1, the needles with respect to standing position of the observer, the bed number 1 is creating technical back loops and bed number 2 are creating technical front loops. And these 2 beds are simultaneously in operation for creating both technical front and back loops. So, this is how the principle of double jersey formation takes place in a double bed machines. Now, let's see the technologies which is being introduced in case of double bed machine.

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The most popular machine which is used in double bed weft knitting is V-bed machine, especially in the case of flat category. This particular machine is the most popular, even if you can say the single bed is not being used so much, but V-bed machine is the, majority of state rely on this V-bed machine. So, we are going to understand this particular machine in detail, because this is very important from market point of view. So, if you see V-bed machine, this is the actual photo of the machine.

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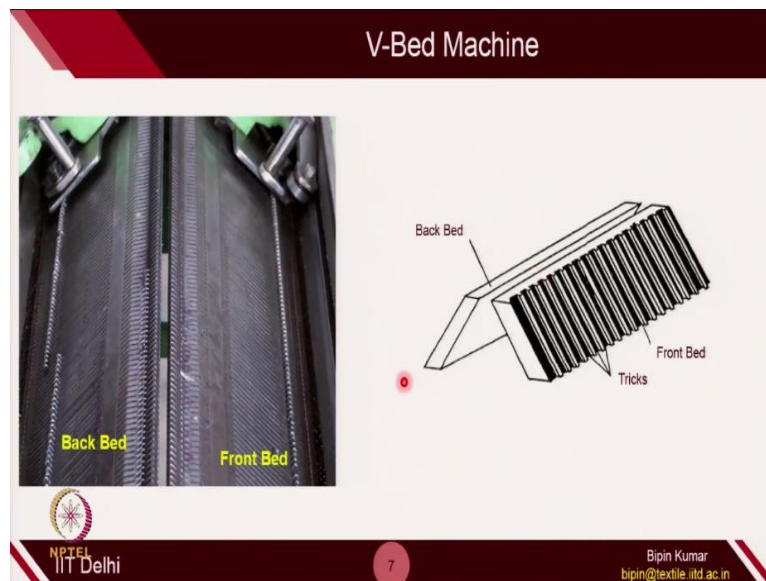
You can see, there are 2 beds; the back bed and the front bed. You can say, either this bed as a front or this as a back. It depends on which side you are in standing. So, this is the front bed and this is the back bed. The nature of placement of needles on this beds are again similar to the single bed where you create tricks or the slot. And in each slot, you place 1 needle, side by side.

So, on front bed also, there are lot of tricks that is being generated. And on each tricks, you can place 1 needle. Similarly, on the back bed, the tricks are there, which is not visible from this side. But you can see here, the tricks are being there and the needle butt you can easily see. So, they are being placed on both the beds. So, there are 2 beds and these 2 beds contains needles according to their, similar to the nature of single bed.

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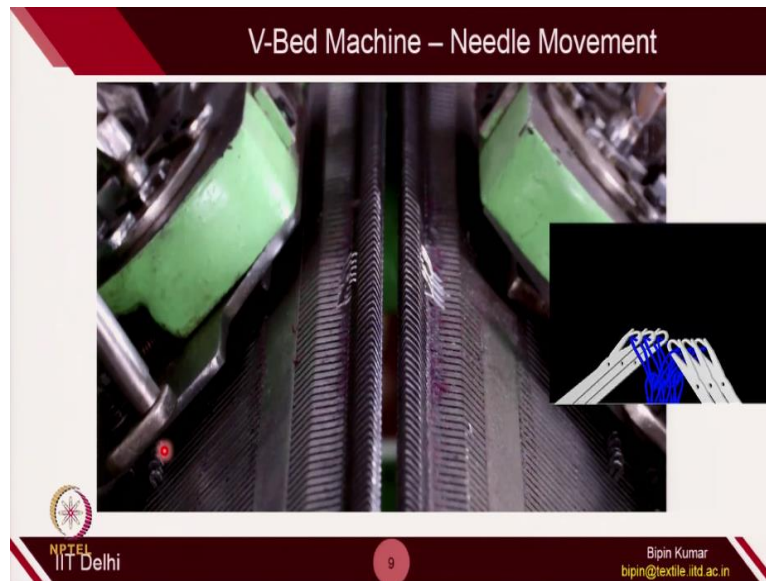
(Video Starts: 12:52) Here is the needle movement. If you will try to observe the movement of needle, it is quite similar. The nature of movement of this needle, the amount of reaching the reciprocative movements or the amount of reciprocative movement by bed number, front bed; and the back bed will remain same. The only difference is, they are moving in opposite directions.

So, let's see this video. So, you can see here, the, this front bed needle is moving from right to left; and left bed needle is moving from left to right. So, this is how needles movement is taking place in both the beds. Again, you see, if you are working with multiple number of needles, the same nature you can observe. So, here I am selecting 4 needles. So, you can see here.

So, all 4 needles on the front bed is moving from right to left. And on the left bed, they are moving from left to right. So, the key point here is, the movement of these needles are opposite to each other. And they are controlled by their **(Video Ends: 14:05)** cam jacket which is responsible for creating reciprocative movements of that particular bed. So, we need 2 cam jacket for operating each individual needles of each bed.

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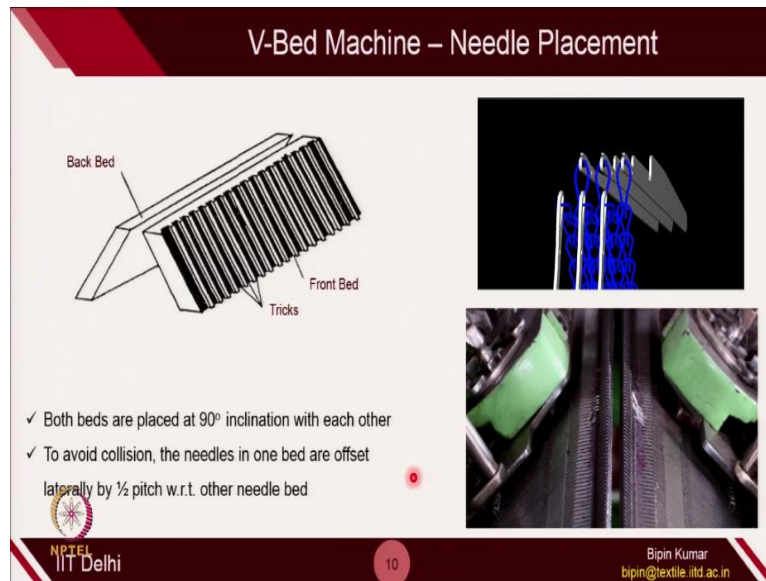
You might have observed that, when these 2 needles was going up, both the needle simultaneously, they are not striking each other. So, there are 2 features which is very important in terms of needle placements on a **(Video Starts: 14:33)** V-bed machine. The first feature is, these 2 beds are not placed in a horizontal plane. They are placed in a certain vertical plane. You can see here, they are placed in a different plane.

They are not placed on a same horizontal plane. So, the nature of their placements results a kind of V shape. So, you can see here, this looks like a V shape. So, that's why, this type of machine is called V-bed machine. So, the first thing is, both beds are placed in a V shape and the angle between the 2 sides of Vs are usually 90 degree. So, 90 degree inclination with each other.

The second thing, to avoid collision, you might have seen here, to avoid collision between the needles, because both the needles are rising simultaneously of each bed; so, to avoid collision, the placement of needles on this bed and the back bed, front and back bed, they are actually offset laterally by half pitch. **(Video Ends: 15:39)** What do you mean by that?

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V-Bed Machine – Needle Placement

- ✓ Both beds are placed at 90° inclination with each other
- ✓ To avoid collision, the needles in one bed are offset laterally by ½ pitch w.r.t. other needle bed

Like, if you take the top view of this particular bed; so, all the needles on the front bed, it will look like this. But if you see the back bed, the needles will be also placed in a parallel fashion, but the entire back bed is shifted by half pitch. And we have already introduced you the pitch. Pitch is actually the distance between 2 consecutive needles of a single bed. So, the pitch here, you can see, this is the distance between 2 needles on the front bed.

And half of this distance, the back bed is shifted laterally. So, this is how, when this particular needle is going away from the bed, it is not actually facing the back bed needle. So, it is not striking. So, each front needle and back needle is actually operating between 2 opposite bed needles. So, this is how the placement is being done in case of V-bed machine.

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V-Bed Machine – Yarn Catching

How it catches the yarn? You can see here. So, we are providing the yarn through a feeder. The feeder is actually in the center. **(Video Starts: 16:56)** And you can see here, how both the beds are catching the yarn. So, you can see here, the needles, they start catching the yarn. This is how they catch the yarn and they create loops. Okay. So, if you see the, actually the yarn is being supplied **(Video Ends: 17:24)** from left to right.

If you say this is the left side and the other side is the right side; so, yarn is first supplied to the front bed needle and then back bed is catching the yarn; then again, front bed is catching the yarn; and then, again, back bed needle is catching the yarn. So, the yarn is being supplied from front to back and then back to front, in the sequence.

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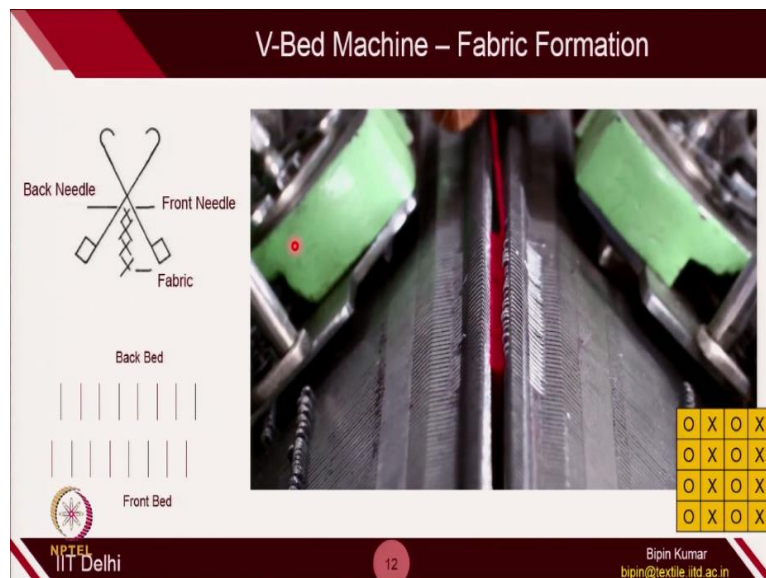
Now, let's move to the fabric formation part; how the fabric is actually being formed. This is the, if you take the side view, the entire bed will look like this. So, the back bed needle is doing the movement along this direction, along this particular line. The front bed needle is doing the reciprocative movements along this direction. And the fabric is being formed at the center of the bed.

So, you can see **(Video Starts: 18:17)** here, this is how it is catching the yarn. And you can see, the fabric is being hanging from the center of the bed; you can see the fabric is hanging here. So, this is the front bed, this is the back bed; and the fabric is being formed exactly at the center of the beds, at the bottom side. So, this bed is creating technical front side and this bed is creating the opposite loops, which is the technical back side. **(Video Ends: 18:55)** Okay.

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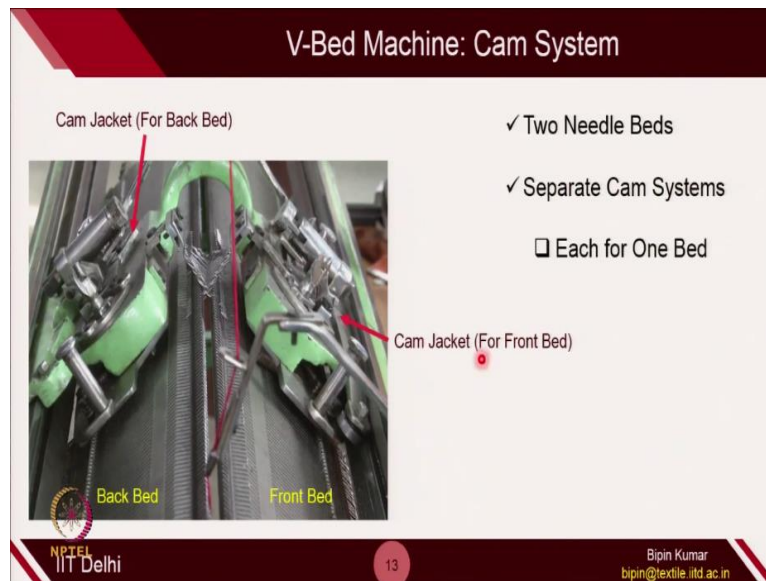
To operate 2 different beds, naturally, we need 2 different cam system. And each cam system will be responsible for needle movement in that particular bed. So, you have front bed, you have a back bed. So, you need 2 cam jacket. Cam jacket 1, this particular cam jacket which is shown in the figure is for front bed and the other cam jacket for back bed. So, you have, you might have seen the cam jacket for a single bed machines in week 2.

So, the nature of these cam jacket is exactly same, they are actually interacting with the butt of the needle and providing reciprocative movements to the individual needles of that particular bed. So, since it has 2 needle beds; so, we need to have 2 different cam system, each for one bed, which is shown here.

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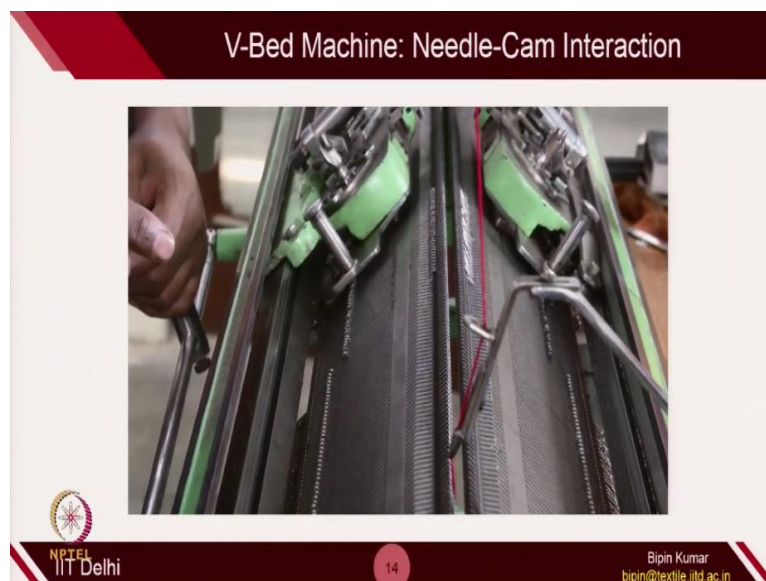
You can, again here, you can see how this cam jacket is responsible for reciprocative moment. So, here I have selected this much needle on the back side; and here, I have selected this much needle on the front sides. **(Video Starts: 20:06)** So, once you traverse this cam jacket; so, the moment this cam jacket interacts with this needles, all the needles is rising. And similarly, when this cam jacket is interacting with the needle butt, the needles of this particular bed are rising.

So, the nature of movement is exactly similar to the single bed machines. One cam jacket and one set of needles, they will be moving in exactly same direction. Since the cam jacket and the beds are placed oppositely, opposite to each other; so, that's why the nature of movement of needles are also opposite for both the beds. **(Video Ends: 20:48)**

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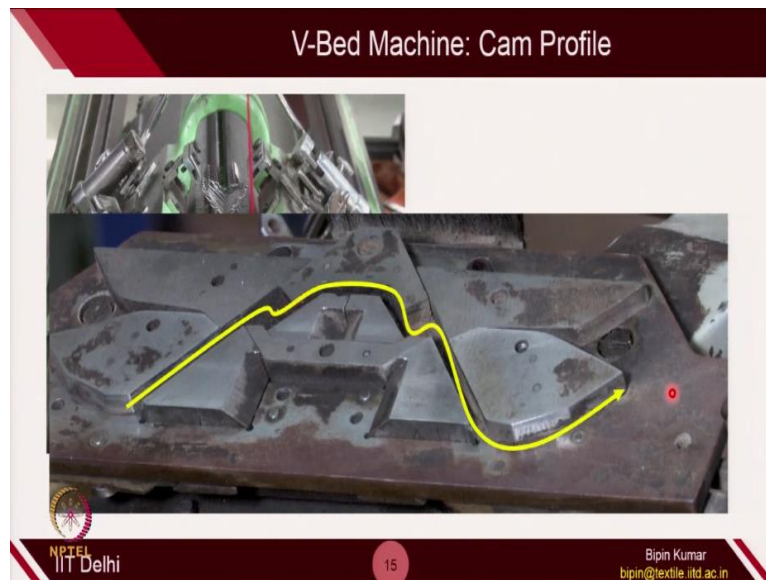
So, now, let's see the cam profile. In week 2 also, we have already given lot of emphasis on the cam path which the needle butt has to follow. So, if you reverse this particular cam jacket, if you flip it down, it consists of a series of metallic blocks which is placed in a certain order to create a cam track. And the needle butt has to follow that cam track to do the reciprocative movement.

So the, this is how, the moment you flip this particular, any one of these cam jacket, the metallic blocks will look like this. And each metallic blocks is called a cam. The placement of these cams actually creates a kind of path for needle movement. So, the butt actually follows this path. So, you can see here, this is the free space. And the needle butt actually follows this track. So, this track is called cam track.

So, this is the movement of needles along this track. The nature is almost similar, so that it can do the clearing; then, it can catch the yarn; then, it can pull the yarn; and then, it can release the old loop. So, the loop formation sequence is exactly same in this case of machine also. And this is how they are, these cams are being placed, so that each process of loop formation takes place in a sequential order; starting from loop clearing; old loop clearing; then catching the new yarn; then pulling; then knocking; and then loop formation.

It is similar to the loop formation on single bed. So, I am not going in details in that. I hope you can revise the lectures of week 2. And then, you can understand the movement of needles in loop formations.

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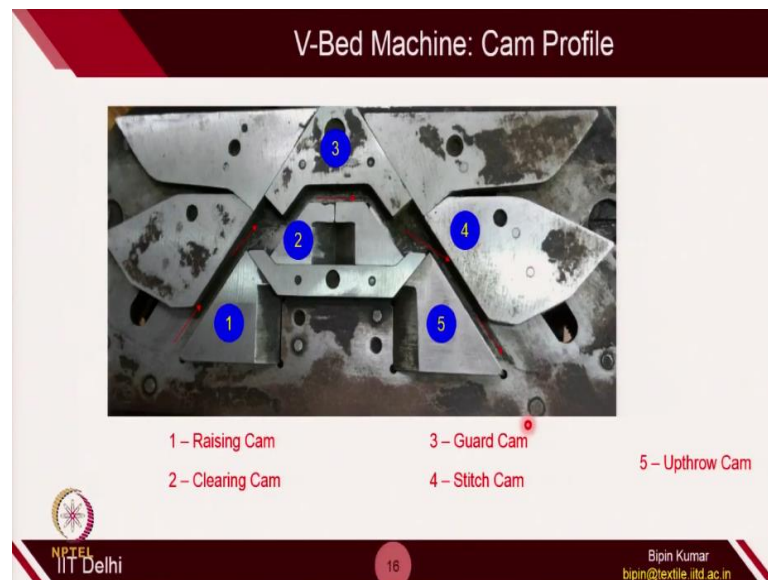
Now, let's see actually, the position of each of these blocks and what are they called. So, if the needle butt is moving from left to right; actually, the needle butt is not moving, rather you can say, when the, when this cam jacket is moving on the bed from right to left, then the butt has to follow this particular path. So, the moment butt strikes with this, it starts rising. So, this particular cam is called raising cam, because it will force the needle butt to rise.

After that, you can see here, it will strike this particular cam. At this particular cam is called clearing cam. So, at this location, the old loop will be cleared from the head and latch interaction of the latch needle. After that, it will reach to highest position. At this position, it will be ready to catch the yarn. And after that, it is going to strike this particular cams, you can see here.

And because of that, the path of the needle start going down. And the moment it strikes this particular cam, it forces the needle butts to go down. The upper one is a guard cam, so that, to protect the needle butt not to go too far from the bed. After that, it is striking this fourth number cam which is the stitch cam, which I have already mentioned earlier. So, stitch cam responsible is like, it is forcing the needle to go inside the bed.

So, during that process, 2, 3 loop formation process takes place simultaneously. The first thing is, it is pulling the yarn. Simultaneously, it, the old loop is closing the latch. Simultaneously, the old loop, once the loop get closed and old loops reaches to the head part, it knocks out from the needle. After that, it actually descend further to create the head and the leg part of the new loop.

So, the stitch cam is responsible for that. And all this downward movement is decided by the setting of this stitch cam. And you can see here, there is a slot. So, you can adjust the position of this stitch cam to decide the amount of downward movements. After that, this particular cam is also called the upthrow cam. So, again, the same 5 cams which we already have seen in case of flat bed machines, these 5 cams are still there; and actively participates in loop formation process.

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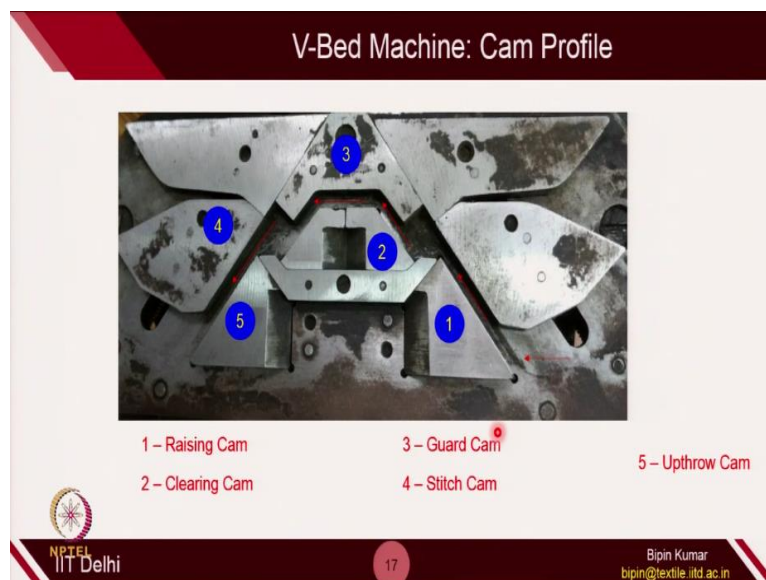
If you reverse the process, if the cam jacket is moving from left to right, the needle has to rise like this. So, the path is created like this. First it will hit here. So, this become then raising cam. And then, it will hit here, to rise again. This become the clearing cam. The position of

guard cam remain same. It is just guarding the needle butt to follow this path. After that, it is striking this particular cam which can be adjusted.

So, this is, the fourth one is the stitch cam. And after that, this fifth one, is just the upthrow cam. So, this is how the cam profile of a V-bed machine is decided. So, since V-bed has 2 beds; so, each of these beds has almost similar type of cam profile.

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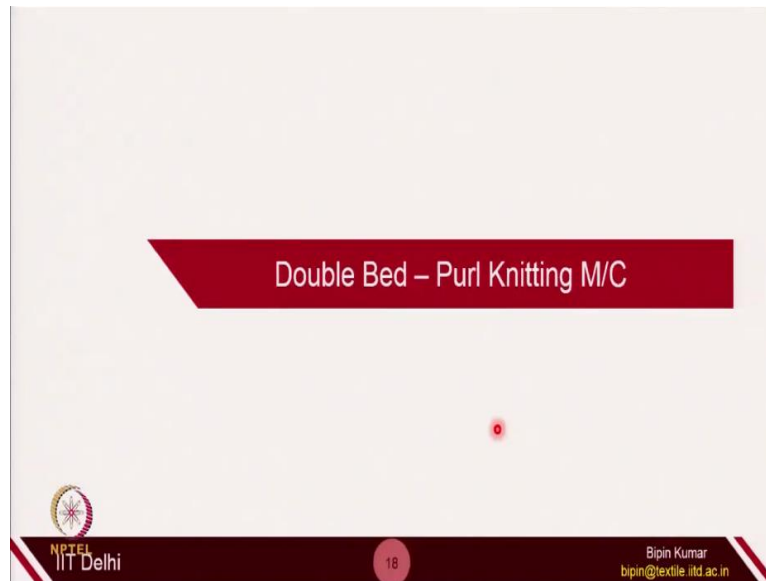
Now, let's move to another category of double bed technologies related to flat bed machines, which is called purl knitting machines. So, in purl knitting machine, it is not that much popular, because nowadays, almost V-bed machines, it is so flexible and so powerful that you can create almost any design. So, purl knitting machine is also one of the categories which was used, but not that much popular nowadays.

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Purl Knitting Machine

✓ Double headed latch needle
✓ Needle move from one bed to another in alternate course
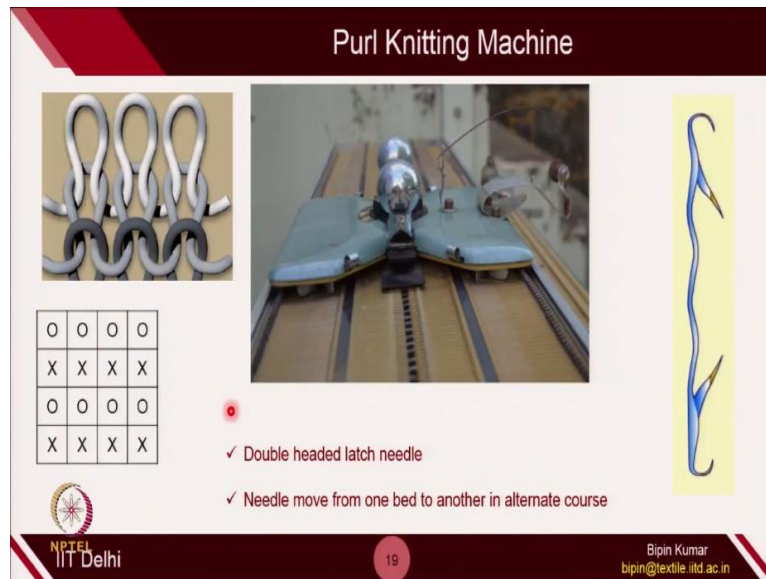
So, let's see what actually, how the needles moves in this particular machine. So, in purl knitting machines, a different scenario may exist in case of fabric nature. So, if you see this particular fabric, the gray loops are actually being formed on the back side. And then, white loops are being formed on the front side. So, technical back and technical front. There are 2 different courses is actually appearing on the fabric surface.

Compared to the previous double jersey fabrics, where we have seen that, in the same course, the technical back and front was present. But here, instead, in the same course, alternating course are giving technical back and front loops. For example, here the first course provides technical front and then technical back; and then technical front and technical back. So, to create this kind of fabric structure, a different kind of machines is being used, which is purl knitting machines.

In purl knitting machines also, there are 2 different beds. So, first bed and 2 beds; you can see here. And to create this type of fabrics, we use double headed latch needles. So, these are the double headed latch needles. So, these latch needles actually create loops one at a time in one bed. So, for example, if it is creating loops on this particular bed, then the other bed is not operational.

After that, the loop is being created on the first bed, the second bed, that particular needle is shifted to the other bed. And that bed is actually operational to create other set of loops. So, needle actually move from one bed to another bed in alternate courses. So, this type of

machines also have 2 different beds, but needle set is just 1. So, at a particular course development, only 1 bed is used.

Once the operation of that particular bed is done, that set of needle is transferred to the other bed to create opposite set of the loops. This is how we created technical back and front loops in alternate courses.

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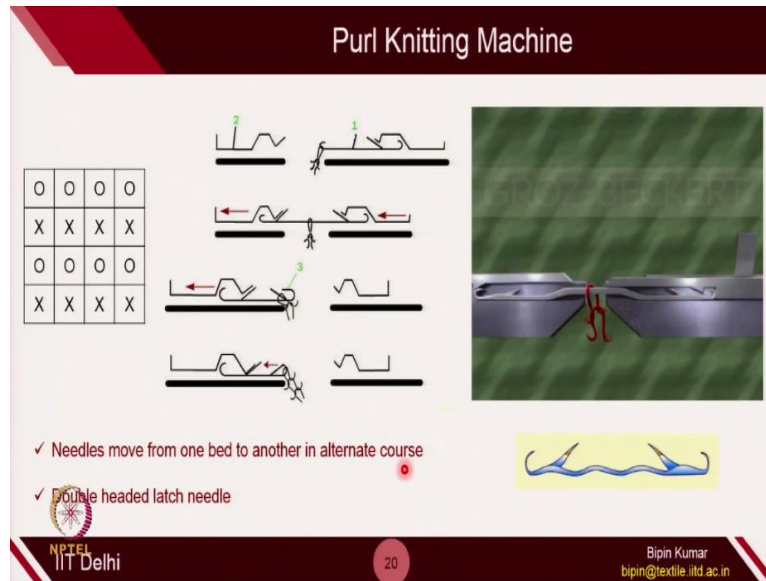
Let's see the, actually, step by movement of this particular nature of the machine. So here, you can see here, the, this is the front bed and this is the back bed. If you see this particular bed at present, one of the head of this double sided needle is catching the yarn. So they, it has created loop towards observer side. So, if observer is standing on the right side; so, it is actually created the loops on this sides.

Since all the needles are there on this particular bed, this bed is not having any needles. In one particular course, this particular set of loops is being formed. After that, once this is done, this latch or you can see this jack is actually pushed. Because of that, this needle shifted from one bed to other bed. During this shifting process, what will happen; automatically, during the shifting process, this old loop actually gets clear from the head of the needle.

So, at present, this is stick with the head of the needle. After that, you can see this old loops comes out from the latch and hook position. Okay. And also, you can see the needle is getting shifted to other side of the bed. So, once this particular needle releases this particular double

sided latch needle, the other bed is actually carrying the latch needles and doing its reciprocative movements.

So, during this leftward movement, the other side of hook is actually catching the yarn and the old loop is getting knocked out from the other side of the needle. The loop formation process is like this. First, the loop is created by the, one side of the head and it is actually getting cleared from the other side of the head, during the transfer process. So, if you see this animations, you will be able to understand.

(Video Starts: 31:18) So, now the loop is getting cleared from the other side. And, so you can see here, first the loop clear. And then, from the other side, it is actually being knocked out. And during this process, the loop is being formed on the left side of the needle. Okay. **(Video Ends: 31:41)**
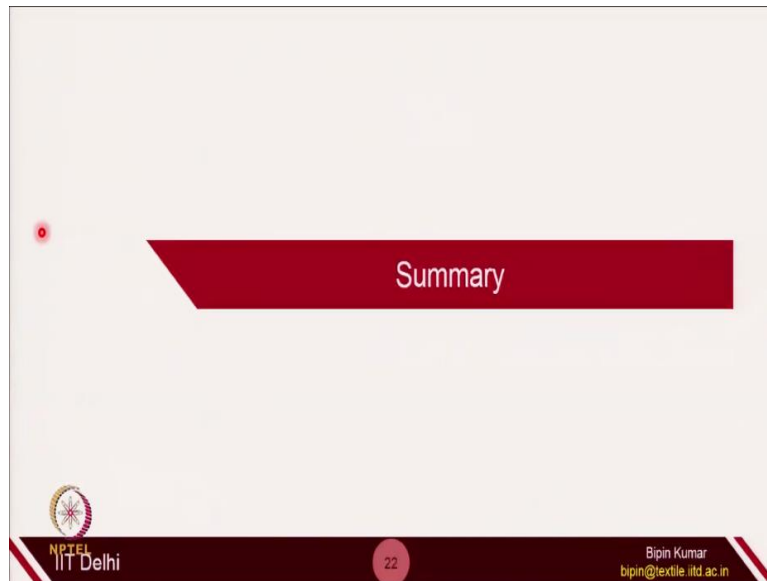**(Refer Slide Time: 31:43)**
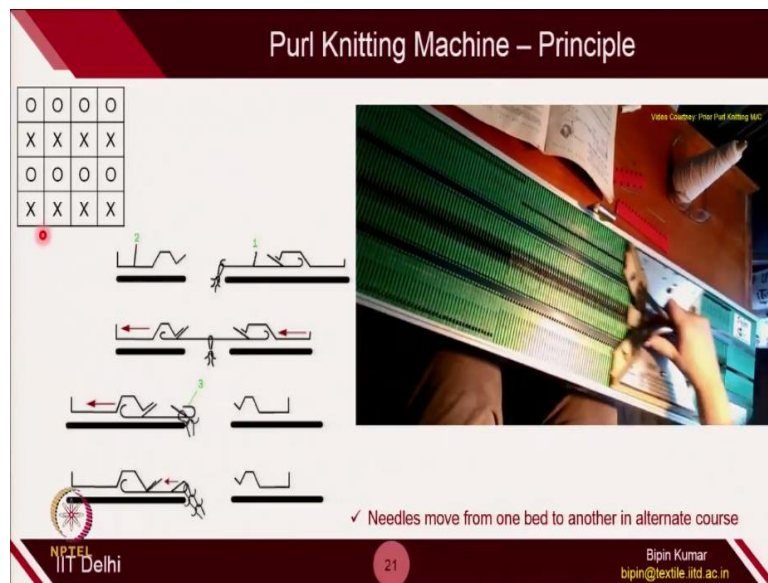
This is the actual working of the machine. You can see here, there are 2 beds; and this jack is there. So, this jack is actually help use to displace the needle from one bed to other bed. **(Video Starts: 31:57)** So, let's see how it works. So, first the loop is being formed on one of the bed. After that, the entire needle is being pushed by this jack to the other bed; and then loops is created.

Once the loop is being created, then from this bed, the needle is transferred by pushing these jacks. So, these jacks is being pushed so that the needle goes to the other side of the bed. Now, the other bed is creating the loops. Again, once this bed is created the loop; from this

bed, we are transferring the needle to the opposite bed. And this process is repeated to create technical back and front loops in alternating courses. Okay. **(Video Ends: 32:54)**

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So now, let's summarize what we learned in this particular lecture. This lecture is all about development of double jersey fabrics on double bed flat knitting machines.

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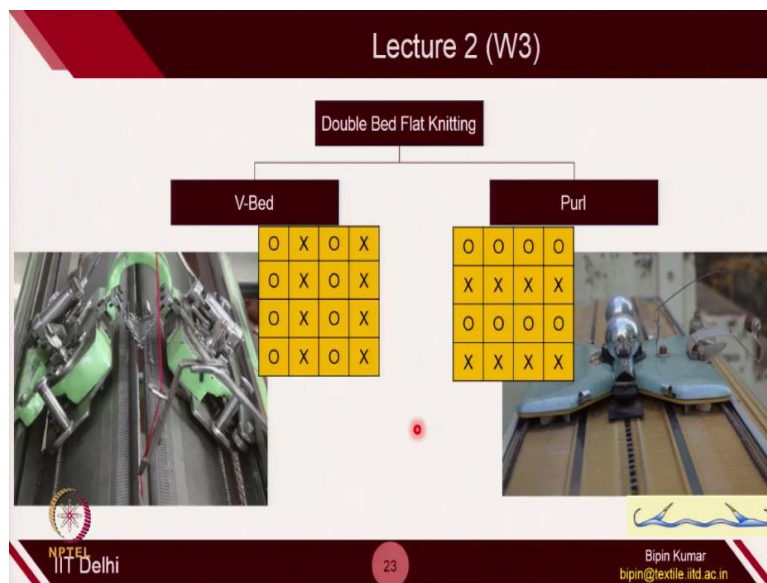
Case of double bed flat knitting machines, we come across 2 type of technologies; one is V-bed knitting machines and the other one is purl knitting machine. So, in V-bed knitting machine, in the same course, we are making technical back and front loops simultaneously. For that, you need 2 different beds. And there are 2 set of needles. And the front bed is creating technical front loops; back bed is creating technical back loops simultaneously.

And you need 2 cam jacket. In case of purl needle, you have 2 beds, but there is just 1 set of needles which has 2 hook and 2 latch. So, if this particular needle is just on 1 bed, it will create 1 set of technical loops, either front or back. Once that hook part is done, then that needles is transferred to the opposite bed and opposite hook and latch gets operations. In this way, in the double bed machines; although it has single set of needles, the needles are actually transferred from, in alternating courses to create technical back and front loops in individual beds.

So, this is all about V-bed and purl knitting machines, which belongs to double bed flat knitting categories. In the next lecture, we are going to learn about double bed circular knitting machines to create these types of fabric structures. Similar to the single bed, you have seen single flat bed and single cylinder circular bed. Similarly, here also, there is a possibilities to create double bed circular knitting machines, where you can have 2 sets of needles placed in a circular fashion to create double jersey fabrics. So, in next class, we are going to learn about that. Stay tuned. Thank you very much for listening. Thank you.